User Guide

Mentor II

DC Drives
25 A to 1850 A
output

Part Number: 0410-0010
Issue Number: 10

Safety Information

Persons supervising and performing the electrical installation or maintenance of a Drive and/or an external Option Unit must be suitably qualified and competent in these duties. They should be given the opportunity to study and if necessary to discuss this User Guide before work is started.

The voltages present in the Drive and external Option Units are capable of inflicting a severe electric shock and may be lethal. The Stop function of the Drive does not remove dangerous voltages from the terminals of the Drive and external Option Unit. Mains supplies should be removed and left removed for a minimum of 2 minutes before any servicing work is performed.

The installation instructions should be adhered to. Any questions or doubt should be referred to the supplier of the equipment. It is the responsibility of the owner or user to ensure that the installation of the Drive and external Option Unit, and the way in which they are operated and maintained complies with the requirements of the Health and Safety at Work Act in the United Kingdom and applicable legislation and regulations and codes of practice in the UK or elsewhere.

The Drive software may incorporate an optional Auto-start facility. In order to prevent the risk of injury to personnel working on or near the motor or its driven equipment and to prevent potential damage to equipment, users and operators, all necessary precautions must be taken if operating the Drive in this mode.

The Stop and Start inputs of the Drive should not be relied upon to ensure safety of personnel. If a safety hazard could exist from unexpected starting of the Drive, an interlock should be installed to prevent the motor being inadvertently started.

General Information

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

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

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Important! Drive software version

This product is supplied with the latest version of user-interface and machine-control software.
If this product is to be used with other Control Techniques variable speed drives in an existing system, there may be some differences between their software and the software in this product. These differences may cause a difference in functions. This may also apply to variable speed drives returned from a Control Techniques Service Centre.
If there is any doubt, contact a Control Techniques Drive Centre.

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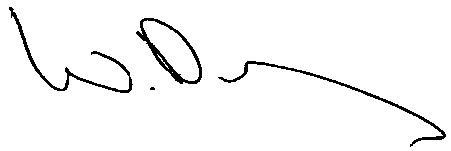
DECLARATION OF CONFORMITY

The DC variable speed drive product Mentor II current range 25A-1850A, single quadrant and four quadrant versions, 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
*CSA C22.2 0-M1982	General Requirements, Canadian Electrical Code , Part II
*CSA C22.2 0.4-M1982	Bonding & Grounding of Electrical Equipment (Protective Grounding)
*CSA C22.2 14-M1987	Industrial Control Equipment
UL508	Standard for Power Conversion Equipment

* Applies to Mentor II current range 900A - 1850A only

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:30 April 1998

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.

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1 Features of Mentor II

1.1 Mentor II parameters

Mentor II is equipped with a range of parameters designed to give the utmost flexibility of application to industrial requirements. The parameters are arranged in menus, as being the most convenient way of making access easy and quick for the user.

Within each menu, those parameters which are needed only for customization of the Drive for the more complex applications have been made invisible that is, they are normally inaccessible except through high level security access. With low level security access, invisible parameters do not appear in the digital display.

This arrangement has the effect of reducing the apparent size of the menus for greater convenience in normal use, and ensuring the maximum protection for the parameters which are specially set up for a particular application or process.

1.2 Supply phase-sequence

Loss of one or more phases of input is automatically detected. Drive will run irrespective of input phase rotation.

1.3 Output

- 6-pulse firing of output thyristors (SCRs). Optionally configurable to (series or parallel) 12-pulse operation.

1.4 Speed feedback

- Motor armature voltage, or
- Tachogenerator (tachometer), or
- Encoder (pulse tachometer).
- PID speed loop algorithm.

1.5 Speed reference

- -10V to +10V
- 0 to 10V
- 4 to 20mA
- 20 to 4mA
- 0 to 20mA
- 20 to 0mA
- Encoder digital input
- Internally-generated digital reference.

1.6 Serial communications interface

- RS485 serial communications port, optically-isolated.

1.7 Current feedback

- Resolution 0.1%.
- Current loop linearity 2%, bandwidth 80Hz.
- Uniform response at all current values.

1.8 Control

- All analog and most digital inputs configurable by the user for specific applications.
- PID speed loop algorithm.
- Provision for encoder inputs for position control.
- On-board provision for tachogenerator (tachometer) calibration.
- Programmable control of field-weakening.
- Phase sequence and phase-loss detection.
- Software includes current loop self-tuning algorithm.
- Menu-driven parameter structure.
- Drive returns to last parameter adjusted in each menu.
- User-defined menu for quick access to most-used parameters.

1.9 Speed resolution

Reference		Feedback		Combined resolution
Analog	0.025%	Armature volts	0.83V	0.83V
Analog	0.025%	Tachogenerator (tachometer)	0.1%	0.125%
Digital	0.1%	Tachogenerator (tachometer)	0.1%	0.2%
Analog	0.025%	Encoder	0.01%	0.035%
Digital	0.1%	Encoder	0.01%	0.11%
Encoder		Encoder		Absolute

2 Safety Information

2.1 Warnings, Cautions and notes

A **Warning** contains information which is essential for avoiding a safety hazard.

A **Caution** contains information which is necessary for avoiding a risk of damage to the product or other equipment.

NOTE

A **Note** contains information which helps to ensure correct operation of the product.

2.2 Electrical safety – general warning

The voltages used in the Drive can cause severe electric shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the Drive.

Specific warnings are given at the relevant places in this User Guide.

The installation must comply with all relevant safety legislation in the country of use.

2.3 System design

The Drive is intended as a component for professional incorporation into complete equipment or systems. If installed incorrectly the Drive may present a safety hazard. The Drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control mechanical equipment which can cause injury.

Close attention is required to the electrical installation and the system-design to avoid hazards either in normal operation or in the event of equipment malfunction. System-design, installation, commissioning and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this User Guide carefully.

To ensure mechanical safety, additional safety devices such as electro-mechanical interlocks may be required. The Drive must not be used in a safety-critical application without additional high-integrity protection against hazards arising from a malfunction.

2.4 Environmental limits

Instructions in this User Guide regarding transport, storage, installation and use of Drives must be complied with, including the specified environmental limits. Drives must not be subjected to excessive physical force.

2.5 Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the cross-sectional areas of conductors, the selection of fuses or other protection, and protective earth (ground) connections.

This User Guide contains instructions for achieving compliance with specific EMC standards.

Within the European Union, all machinery in which this product is used must comply with the following directives:

98/37/EC: Safety of Machinery
89/336/EEC: Electromagnetic Compatibility.

2.6 Safety of personnel

The STOP function of the Drive does not remove dangerous voltages from the output of the Drive or from any external option unit.

The Stop and Start controls or electrical inputs of the Drive must not be relied upon to ensure safety of personnel. If a safety hazard could exist from unexpected starting of the Drive, an interlock that electrically isolates the Drive from the AC supply must be installed to prevent the motor being inadvertently started.

Careful consideration must be given to the functions of the Drive which might result in a hazard, either through their intended functions (eg. Auto-start) or through incorrect operation due to a fault or trip (eg. stop/start, forward/reverse, maximum speed).

Under certain conditions, the Drive can suddenly discontinue control of the motor. If the load on the motor could cause the motor speed to be increased (eg. hoists and cranes), a separate method of braking and stopping the motor must be used (eg. a mechanical brake).

Before connecting the AC supply to the Drive, it is important that you understand the operating controls and their operation. If in doubt, do not adjust the Drive. Damage may occur, or lives put at risk. Carefully follow the instructions in this User Guide.

Before making adjustments to the Drive, ensure all personnel in the area are warned. Make notes of all adjustments that are made.

2.7 Risk analysis

In any application where a malfunction of the Drive could lead to damage, loss or injury, a risk analysis must be carried out, and where necessary, further measures taken to reduce the risk. This would normally be an appropriate form of independent safety back-up system using simple electro-mechanical components.

2.8 Motor

Ensure the motor is installed in accordance with the manufacturer's recommendations. Ensure the motor shaft is not exposed.

Low speeds may cause the motor to over-heat because the cooling fan becomes less effective. If necessary, a separate cooling fan should be used. The motor should be fitted with a protection thermistor.

If a Drive is to be used to control a number of motors, special measures need to be taken to ensure protection of the motors.

2.9 Adjusting parameters

Some parameters have a profound effect on the operation of the Drive. They must not be altered without careful consideration of the impact on the controlled system. Measures must be taken to prevent unwanted changes due to error or tampering.

3 Introduction

Mentor II is the latest family of advanced, fully microprocessor-controlled DC variable speed industrial Drives. The range of output current is from 25A to 1850A. All sizes share control, monitoring, protection and serial communications features.
All units are available alternatively in either single-ended or four-quadrant configuration. Single-ended Drives provide forward run operation only. Four-quadrant Drives are fully-reversible. Both types offer comprehensive control of motor speed and/or torque, the four-quadrant Drives providing full control in both directions of rotation.
Operating parameters are selected and changed either at the keypad or through the serial communications link (interface). Access for writing or changing parameter values can be protected by the three-level security code system.

3.1 DC motor control

The functions of a DC motor which must be controllable for practical use are the speed, the torque delivered, and the direction of rotation. Speed is proportional to armature back-emf and inversely proportional to field flux. Torque is proportional to armature current and field flux. Direction of rotation is simply a matter of the relative polarities of the armature and field voltages. It follows that it is necessary to control:

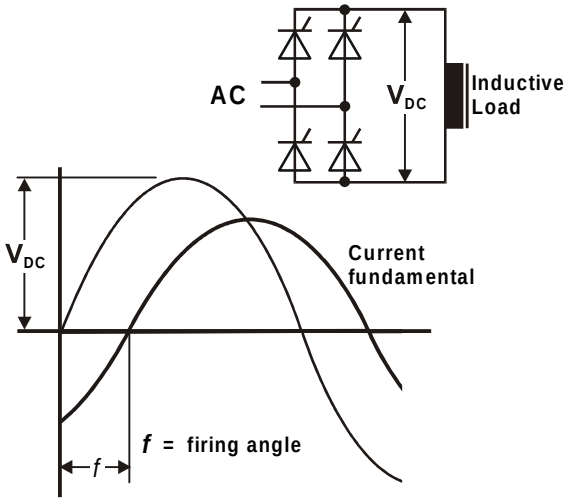
1 The armature voltage; back-emf is a component of armature voltage. Thus, assuming the field to be constant, control of armature voltage provides complete control of speed up to the point where the voltage reaches the maximum value for which the armature is designed. Armature current is also a function of armature voltage, so that within the speed range up to maximum voltage, torque is controlled by voltage also. Provided that the field is fully-excited, the availability of maximum torque is normally maintained from zero speed up to armature voltage maximum (base speed).

2 The field voltage; this determines the field current and, in consequence, field flux. If field voltage can be varied independently of the armature voltage, speed can be increased at full power (full armature voltage) beyond the point where the applied armature voltage and current are at maximum. Since torque is directly proportional to field flux, maximum torque is reduced if speed is increased by weakening the field.

Basically, therefore, a variable speed DC Drive is a means of controlling the voltage applied to the armature of the motor, and thus the current delivered to the motor. The Drive may be equipped with means for control of the field if speeds higher than base speed are required. Separate control of the field within the operating range up to base speed can be exploited also, to obtain extended control of speed and torque for more-complex motor applications. If a suitable feedback is available, position control becomes possible.

3.2 Principles of the variable speed Drive

A single phase voltage applied to a fully-controlled thyristor (SCR) bridge and a resistive load produces an intermittent flow of current which is started by the firing of the thyristor (SCR), and stopped as a result of the supply voltage passing through zero at the end of each half cycle. Maximum voltage is delivered when the firing angle is fully advanced, that is, when f in Fig.1 becomes zero. Retarding the firing angle reduces the current output. When the load is inductive, such as a motor, or the firing angle is sufficiently advanced, current becomes continuous . The fundamental of the current characteristically lags behind the voltage due partly to the inductive nature of the load and partly due to firing angle delay.



Behavior of a single-phase fully-controlled thyristor rectifier (SCR) supplying a highly-inductive load.

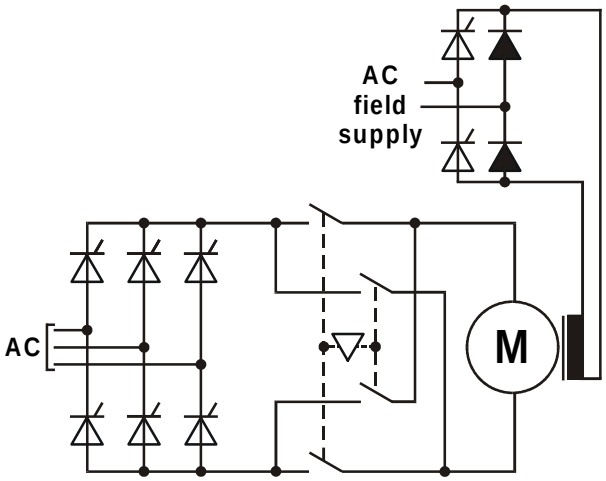
Fig 1

3.3 Reversing

Reversal of rotation is done in one of two ways, dependent on the type of Drive bridge configuration. The simplest fully-controllable arrangement of thyristor (SCR) bridge configuration to operate from a 3-phase AC supply is a full-wave bridge but this is not capable of reversing the output polarity. This type, which is called single-quadrant or single-ended, requires a means of switching the motor terminals externally as shown in Fig.2 if reversing is required. For some applications this simple system is an adequate practical solution.

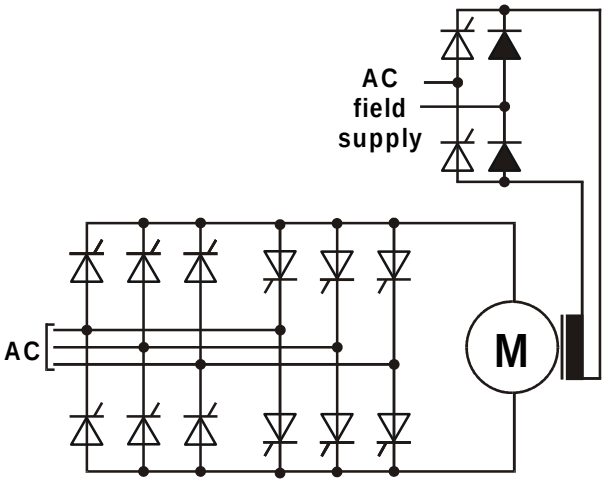
If, however, the motor application is such that it demands complete control of motor operation in both directions, with the ability to reverse motor torque rapidly and frequently, two anti-parallel bridges must be used, Fig.3. This configuration provides full control of forward and reverse Drive and forward and reverse braking without the need for reversing contactors, and is called four-quadrant, Fig.4.

If braking is required with a single-ended Drive, an external circuit has to be provided, Fig.5 (dynamic braking). In this case, deceleration is neither controlled nor linear.



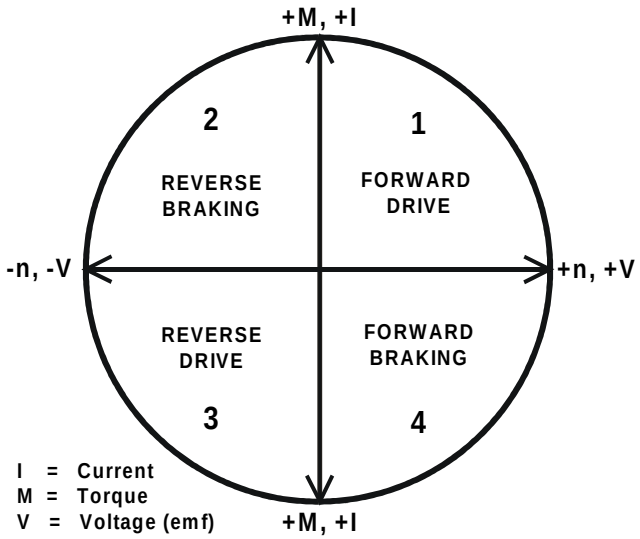
Typical arrangement for reversing a "single-ended" DC drive using an interlocked pair of contactors in the armature circuit

Fig 2



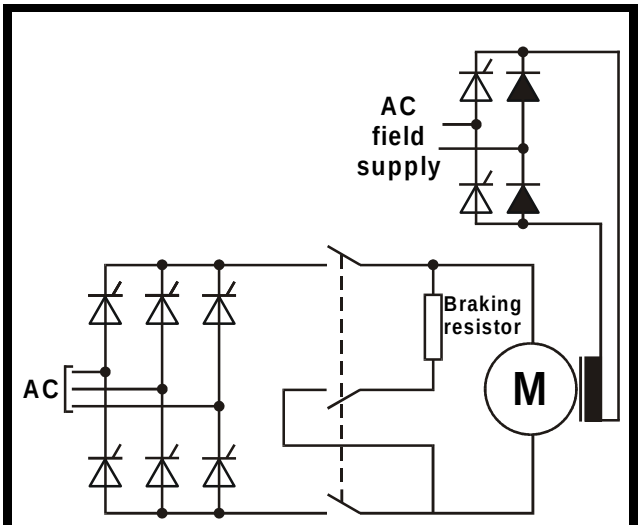
Dual bridge or parallel-pair 3-phase thyristor (SCR) arrangement for a 4-quadrant DC motor drive

Fig 3



The four quadrants of the DC motor torque-speed diagram

Fig 4



Typical arrangement for dynamic (resistive) braking of a "single-ended" DC drive

Fig 5

3.4 Control

Regardless of whether a Drive is single- or four-quadrant, motor response is fundamentally a function of voltage output, which is a function of the firing angle of the thyristor (SCR) bridge, and this can be controlled precisely.

The quality of the response obtained from the motor is, therefore, dependent on the ability of the Drive logic to receive, interpret and process a complete range of data concerning the state of the motor, and the desired state. Some of this data may be from external sources, such as the speed reference (demand), torque reference, motor speed feed-back, and so on; some are derived internally by the Drive logic itself, for example, output voltage and current, and the demand condition of the logic system at various stages.

The logic system requires a set of instructions to allow it to undertake the process of interrogation, processing and signal-generation to control thyristor (SCR) firing. The instructions are provided in the form of data broken down into individual values or parameters for the user to provide in accordance with the particular operations required for the motor application. The behavior of the Drive in terms of any given industrial application is a function of the information it receives for processing from user-written and internally-monitored parameter values.

For this reason, the Mentor II Drive is equipped with a dedicated microprocessor, and with software which is configured by the parameters written to it by the user. The parameters cover every significant factor related to motor performance, so that the user can set the Drive up to meet the application requirements exactly. Further parameters are provided for communications, security and other operational functions.

3.5 Menus

The number of parameters is large, but understanding of them and access to them have been greatly facilitated by arranging them in menus, each menu covering a particular logical or functional grouping. An overview of the control logic system of the Drive and a graphical representation of each individual menu will be found in the set of logic diagrams at the end of Chapter 8.

3.6 Serial Communications

The serial communications link (interface) with which the Mentor II Drive is equipped is a significant feature in relation to operation within an industrial process application. For example, external programmable process logic controllers (PLCs) can be set up with access to the whole or part of the Drive logic, enabling the setting of parameters to be changed, virtually instantaneously, to suit different stages of a duty cycle or different operating conditions in the process.
The serial communications facility also provides for the operation of the Drive to be continuously monitored for control or analytical purposes.

4 Data

4.1 Specifications

Maximum input voltage to Drive (L1, L2 and L3, i.e. main power to thyristor bridge)

480V +10%	standard
525V +10%	optional
660V +10%	special order

Maximum recommended motor voltage

Varm = 1.15 x Vsupply

Input power supply voltage (E1, E2 and E3, i.e. auxiliary power supply)

Balanced 3-phase 3-wire, 45Hz to 62Hz, maximum 480V +10%.

With the higher voltage (525V, 660V) versions the maximum power supply voltage is also 480V +10%.

The input to the control (electronic) circuits is:-

Standard -
2-wire, 220V - 10% to 480V +10%

With North American field bridge -
3-wire, 220V - 10% to 480V +10%

NOTE

E1 & E3 must be connected to the same phases as L1 & L3

Output supplies and references (Short-circuit proof)

10V reference ±5% 10mA Drive capability.
Encoder supply 300mA Drive capability at 5V, 12V or 15V selectable.
+24V supply 200mA Drive capability for relays.

All outputs are wire-proof - unaffected by accidental short circuiting.

Ambient temperature & humidity

Rated ambient temperature 40°C (104°F)
Rated maximum altitude 1000m (3200ft).
Storage temperature range -40°C to +55°C (-40°F to 131°F)
Humidity requirement non-condensing.

Derating

Nominal ratings are affected by:

1) The altitude of the installation.

Where the site is above 1000m (3200ft), reduce the normal full load current by 1.0% for each additional 100m (320ft), up to a maximum of 4000m.

2) The ambient temperature.

Where the local ambient temperature is above 40°C (104°F), derate by 1.5% per °C up to 55°C (0.75% per °F up to 131°F).

Enclosure Ingress Protection

Mentor II Drives are constructed in accordance with European IP00 specification. Mentor II Drives are suitable for mounting in NEMA ingress-protected enclosures.

The Drive must be protected against moisture and conductive contamination. The Drive is intended for use in pollution degree 2 environments.

4.2 Ratings

4.2.1 Current, input and output

CAUTION

Mentor is suitable in a circuit capable of delivering no more than 10000 RMS symmetrical amperes for M25-M210 and M25R-M210R and 18000 RMS symmetrical amperes for M350-M825 and M350R-M825R short circuit current, 480V +10% maximum.

Drive type & model		Typical* ratings				Maximum continuous current rating	
Single Quadrant	Four Quadrant	at 400V (armature)		at 500V (armature)		input	output
		kW	HP	kW	HP	Aac	Adc
M25	M25R	7.5	10	9	12	21	25
M45	M45R	15	20	19	25	38	45
M75	M75R	30	40	38	50	60	75
M105	M105R	37.5	50	47	63	88	105
M155	M155R	56	75	70	94	130	155
M210	M210R	75	100	94	126	175	210
M350	M350R	125	168	156	209	292	350
M420	M420R	150	201	188	252	350	420
M550	M550R	200	268	250	335	460	550
M700	M700R	250	335	313	420	585	700
M825	M825R	300	402	375	503	690	825
M900	M900R	340	456	425	570	750	900
M1200	M1200R	450	603	563	755	1000	1200
M1850	M1850R	750	1005	938	1258	1540	1850

* Motor rating may be increased at higher armature voltages.

Refer to Section 4.1, Maximum Recommended Motor Voltages.

4.2.2 Fuses and cabling

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

Drive type & model		HRC	Recommended fuse ratings Semiconductor (1)		Typical cable size	
Single Quadrant	Four Quadrant	Rated Input AC	Rated Input AC	Rated Output DC	AC input and DC output	
		A	A	A	mm^2 (2)	AWG (3)
M25		32	35	NR	4	10
	M25R	32	35	40 (4)	4	10
M45		50	60	NR	6	6
	M45R	50	60	70 (4)	6	6
M75		100	100	NR	25	2
	M75R	100	100	125 (4)	25	2
M105		100	125	NR	35	1/0
	M105R	100	125	175 (4)	35	1/0
M155		160	175	NR	50	3/0
	M155R	160	175	250 (4)	50	3/0
M210		200	250	NR	95	300MCM
	M210R	200	250	300 (4)	95	300MCM
M350		355	400	NR	150	(5)
	M350R	355	400	550 (4)	150	(5)
M420		450	500	NR	185	(5)
	M420R	450	500	700 (4)	185	(5)
M550		560	700	NR	300	(5)
	M550R	560	700	900 (4)	300	(5)
M700		630	900	NR	2 x 185	(5)
	M700R	630	900	1000 (4)	2 x 185	(5)
M825		800	1000	NR	2 x 240	(5)
	M825R	800	1000	1200 (4)	2 x 240	(5)
M900		1000	1200	NR	2 x 240	(5)
	M900R	1000	1200	2 x 700 (4)	2 x 240	(5)
M1200		1250	2 x 700	NR	2 x 400	(5)
	M1200R	1250	2 x 700	2 x 900 (4)	2 x 400	(5)
M1850		2000	2 x 1200	NR	3 x 400	(5)
	M1850R	2000	2 x 1200	2 x 1000 (4)	3 x 400	(5)

(1) DC fuses must be fast semiconductor type.

Rated voltage -
for 380V supply - 500V DC
for 480V supply - 700V DC
for 525V supply - 700V DC
for 660V supply - 1000V DC

(2) The cable sizes are for 3-core (3-wire) and 4-core (4-wire) pvc-insulated armoured (conduited) cable with copper conductors, and laid in accordance with defined conditions.

(3) Typical wire gauge sizes based on 30°C (86°F) ambient, 1.25 x rated current, 75°C (167°F) copper wire with no more than 3 conductors in a conduit or raceway.
Branch circuit protection must be provided by the user.
All wiring must conform to NEC Art. 310 and applicable electrical codes.

(4) In applications where load inertia is low and regeneration infrequent, DC fuses may not be needed.

(5) Refer to NEC Table 310-16 for wire sizes.

NR Not required

Mentor thyristors I^2t values for fusing

Drive Model	480V	I^2t (kA^2s)	525V	I^2t (kA^2s)	660V	I^2t (kA^2s)
M25/M25R	Part no 2435-0026	1.03	Part no 2435-2616	0.73		
M45/M45R	Part no 2435-0049	4.75	Part no 2435-9116	14.52		
M75/M75R	Part no 2435-0116	19.1	Part no 2435-9116	14.52		
M105/M105R	Part no 2435-0130	108	Part no 2435-1326	47		
M155/M155R	Part no 2435-0130	108	Part no 2435-1326	47		
M210/M210R	Part no 2435-0130	108	Part no 2435-1326	47		
M350/M350R	Part no 2436-7310	149	Part no 2436-7161	370	Part no 2436-7162	370
M420/M420R	Part no 2436-7310	149	Part no 2436-7161	370	Part no 2436-7162	370
M550/M550R	Part no 2436-7141	370	Part no 2436-7161	370	Part no 2438-3123	370
M700/M700R	Part no 2438-3223	370	Part no 2438-3117	370	Part no 2438-3123	370
M825/M825R	Part no 2438-3223	370	Part no 2438-3117	370	Part no 2438-3123	370
M900/M900R	Part no 2438-3234	5126	Part no 2438-3236	4250	Part no 2438-3236	4250
M1200/M1200R	Part no 2438-3234	5126	Part no 2438-3236	4250	Part no 2438-3236	4250
M1850/M1850R	Part no 2438-3234	5126	Part no 2438-3236	4250	Part no 2438-3236	4250

4.2.3 Ventilation and weight

Drive type & model		Ventilation			Approx. weight	
Single Quadrant	Four Quadrant	Type	Flow			
			$m^3 min^{-1}$	$ft^3 min^{-1}$	kg	lb
M25, M45, M75		1	-	-	10	22
	M25R, M45R, M75R	1	-	-	11	24
M105		1	-	-	14	31
	M105R	1	-	-	15	33
M155, M210	M155R, M210R	2	2	70	21	46
M350, M420		3	7.6	270	22	48
	M350R, M420R	3	7.6	270	23	51
M550		3	17	600	22	48
	M550R	3	17	600	23	51
M700, M825		3	17	600	27	59
	M700R, M825R	3	17	600	30	66
M900, M1200, M1850		4	20	700	70	154
	M900R, M1200R, M1850R	4	20	700	120	264

NOTE

Supply voltages for ventilation fans are as follows:-

Type of Ventilation		
1 Natural convection		
2 Forced ventilation	M155 - M210	24V internally supplied
3 Forced ventilation	M350 - M825	110V / 220V dual voltage single phase
4 Forced ventilation	M900 - M1850	415V AC three phase

4.2.4 Losses

Losses are equivalent to 0.5% of Drive rated output across the range. The following table lists the losses in kW and HP for all models, at 400 V armature voltage.

Drive type & model		Typical motor ratings		Losses	
Single Quadrant	Four Quadrant	kW	HP	kW	HP
M25	M25R	7.5	10	0.038	0.05
M45	M45R	15	20	0.075	0.1
M75	M75R	30	40	0.15	0.2
M105	M105R	37.5	50	0.19	0.25
M155	M155R	56	75	0.28	0.37
M210	M210R	75	100	0.38	0.5
M350	M350R	125	168	0.63	0.83
M420	M420R	150	201	0.75	1
M550	M550R	200	268	1.0	1.3
M700	M700R	250	335	1.3	1.7
M825	M825R	300	402	1.5	2
M900	M900R	340	456	1.7	2.3
M1200	M1200R	450	603	2.3	3
M1850	M1850R	750	1005	3.8	5

The field rectifier is protected by fuses FS1, FS2, FS3 on the power boards.

Before attempting to replace fuses FS1, FS2, FS3 the supply voltages must be removed from the Drive and left removed for at least 2 minutes.

4.2.5 Recommended Line Reactors

To avoid electrical interference and dI/dt stress, do not operate without line reactors. The following table gives typical values to achieve a notch depth of 50%. Where a specific notch depth is required, values must be calculated. Refer to IEC 61800-3 for details of calculation of notching depth.

Drive type & model	Line reactors La, Lb, Lc (µH)
M25, M25R	200
M45, M45R	200
M75, M75R	100
M105, M105R	100
M155, M155R	75
M210, M210R	75
M350, M350R	35
M420, M420R	27
M550, M550R	25
M700, M700R	23
M825, M825R	19
M900, M900R	17
M1200, M1200R	13
M1850, M1850R	8.6

4.2.6 Field Current Rating

Drive type & model	Field Current Rating (A)	Fuse FS1, FS2, FS3
M25, M25R	8 regulated	CT Part number 3535-0010
M45, M45R	8 regulated	
M75, M75R	8 regulated	
M105, M105R	8 regulated	
M155, M155R	8 regulated	
M210, M210R	8 regulated	
M350, M350R	10	CT Part number 3535-0020
M420, M420R	10	
M550, M550R	10	
M700, M700R	10	
M825, M825R	10	
M900, M900R	20	
M1200, M1200R	20	
M1850, M1850R	20	

5 Mechanical Installation

5.1 Dimensions

Principal dimensions are shown in Figs. 8 to 10. Cut-out and drilling dimensions for mounting a Drive with the heatsink projecting through a panel into the space behind are shown in Figs. 8 and 9.

5.2 Mounting

The Drive enclosure conforms to international enclosure specification IP00 and is suitable for mounting in NEMA-rated enclosures.

5.2.1 Location

The Drive should be installed in a place free from dust, corrosive vapors and gases, and all liquids. Care must also be taken to avoid condensation of vaporized liquids, including atmospheric moisture.

If the Drive is to be located where condensation is likely to occur when it is not in use, a suitable anti-condensation heater must be installed. The heater must be switched OFF when the Drive is turned on. An automatic changeover switching arrangement is recommended.
Mentor II Drives are not to be installed in classified Hazardous Areas unless correctly mounted in an approved enclosure and certified. (Refer also to Section 6.1.2, *Hazardous Areas*.)

5.2.2 Mounting and Cooling

There are certain variations across the Mentor II range of Drives, in respect of mounting and cooling arrangements. With most models there is the option of surface or through-panel mounting. The higher-rated Drives require forced ventilation and can optionally be supplied complete with ducted cooling fans.

Alternatively, the installer may arrange to use separately-provided ducted cooling air. Air flow requirements are shown in Table 3. The variants are summarized in the following table.

Mounting arrangements & ventilation

Drive model	Mounting		Ventilation	Heat Sink
	Surface	Through-panel		
M25 to M75	Yes	Yes	Natural	Isolated*
M25R to M75R	Yes	Yes	Natural	Isolated*
M105 and M105R	Yes	Yes	Natural	Isolated*
M155 and M155R	Yes	Yes	Forced (fan built in)	Isolated*
M210 and M210R	Yes	Yes	Forced (fan built in)	Isolated*
M350 to M550	Yes (1)	Yes (2)	Forced	LIVE
M350R to M550R	Yes (1)	Yes (2)	Forced	LIVE
M700 and M825	Yes (1)	Yes (2)	Forced	LIVE
M700R and M825R	Yes (1)	Yes (2)	Forced	LIVE
M900 to M1850	Only		Forced (3)	LIVE (4)
M900R to M1850R	Only		Forced (3)	LIVE (4)

*** Isolated heat sinks must be earthed (grounded) for safety.**

A terminal is provided.

(1) Surface-mounting requires the optional fan ducting, with integral fans, mounting flanges and earthing (grounding) stud.

(2) Adequate forced ventilation must be provided.

(3) A suitable fan can be supplied as an optional extra.

(4) Enclosed.

5.3 Cooling and Ventilation

5.3.1 Enclosure minimum dimensions

Care must be taken that the enclosure in which the Drive is installed is of adequate size to dissipate the heat generated by the Drive. A minimum clearance of 100mm (4in) all around the Drive is essential, Fig. 6. All equipment in the enclosure must be taken into account in calculating the internal temperature.

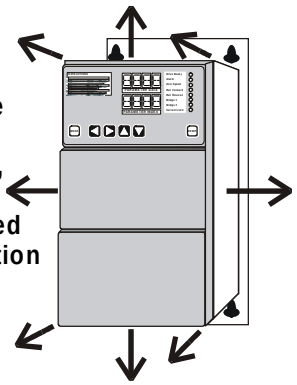


Fig 6

5.3.2 Effective heat-conducting area

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

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

where

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

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

T_i = Max. permissible operating temperature of the Drive in ^oC.

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

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

EXAMPLE:

Calculation of the size of an IP54 (NEMA 12) enclosure for a Drive size M210

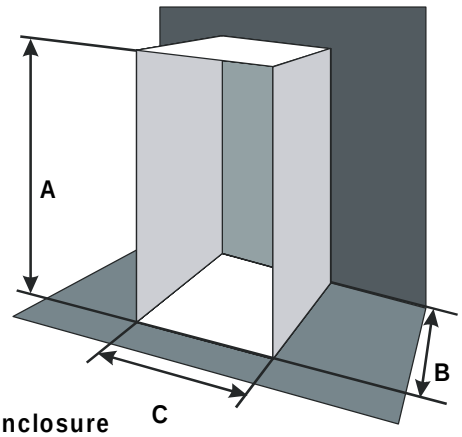
The worst case is taken as the basis of the example, for which the following conditions are assumed -

- The installation is to conform to IP54 (NEMA 12), which means that the Drive and its heatsink are to be mounted wholly within the enclosure, and that the enclosure is virtually sealed and without any ventilation of the air inside. Heat can escape only by conduction through the skin of the enclosure, which is cooled by conduction, convection and radiation to the external air.

- The enclosure is to stand on the floor and against a wall, so that its base and back surfaces cannot be considered to play any part in the cooling process. The effective heat-conducting area A_e is provided by the top, front, and two sides only, Fig. 7.

- The enclosure is to be made of 2mm (0.1in) sheet steel, painted.

- The maximum ambient temperature is 25 ^oC.



Enclosure with typically four surfaces able to disperse heat

Fig 7

To find the effective heat-conducting area

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

P_l = 400W (losses)

NOTE

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

T_i = 40 ^oC (for all Mentor II Drives)

T_{amb} = 25 ^oC

k = 5.5 (typical value for 2mm (0.1in) sheet steel, painted)

$$A_e = \frac{400}{5.5(40 - 25)}$$

$$= 4.85m^2 \text{ (52 ft.sq.)}$$

To find the dimensions of the enclosure

If an enclosure is to be fabricated to suit the installation, there is a free choice of dimensions. Alternatively, it may be decided to choose an enclosure from a range of standard products. Either way, it is important to take into account the dimensions of the Drive, and the minimum clearance of 100mm (4in) round it (Fig. 6).

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

The effective heat-conducting area of an enclosure as illustrated in Fig.7, located on the floor and against one wall is:

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

where A is the enclosure height, B is the depth, front to back, and C the width.

Suppose the enclosure height A is 2.2m (7ft 3in), and the depth B is 0.6m (2ft), as a first estimate. The actual figures chosen in practice will be guided by available space, perhaps, or standard enclosure sizes.

Since A_e, A, and B are known, the dimension to be calculated is C. The equation needs to be rearranged to allow C to be found, thus:

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

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

$$= \frac{4.85 - (2 \times 2.2 \times 0.6)}{2.2 + 0.6}$$

$$= \frac{4.85 - 2.64}{2.8}$$

$$= 0.8m \text{ (2ft 7in) approx.}$$

Clearance on either side of the Drive must be checked. The width of the Drive is 250mm (10in). Clearance of 100mm (4in) is required on either side. So the minimum internal width of the enclosure must be 450mm, or 0.45m (18in). This is within the calculated width, and therefore acceptable. However, it allows limited space for any equipment to either side of the Drive, and this may be a factor in deciding the proportions of a suitable enclosure. If so, modify the calculated value of C to allow for other equipment, and re-calculate either of the other two dimensions by the same method.

If 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 circulation fans with Drives which are not equipped with a built-in fan to ensure air circulation.

Enclosure ventilation

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

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

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

where V is the required air flow in $m^3\ h^{-1}$.

To find the ventilation required for an M210 Drive

P_l = 400W

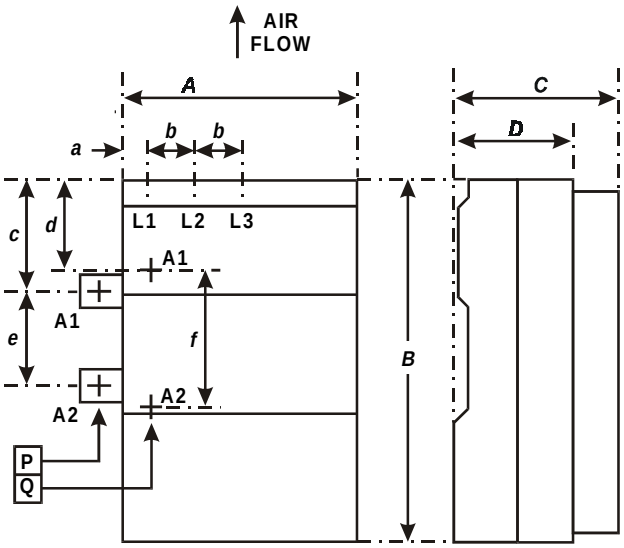
T_i = 40^oC (for Mentor II Drives)

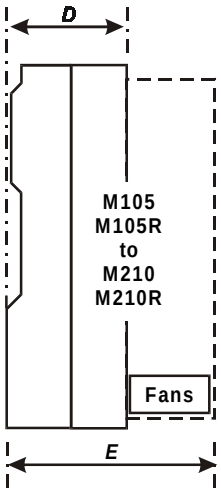
T_{amb} = 25^oC (for example)

Then $V = \frac{3.1 \times 400}{40 - 25}$

= 83 $m^3\ h^{-1}$ (2930 $ft^3\ h^{-1}$)

NOTE
The diagram shows terminals A1 and A2 for FOUR-QUADRANT drives only.
For SINGLE-QUADRANT drives, the locations of A1 and A2 are REVERSED.





Unit Dimensions

	mm	in
A	250	$9\,^{13}/_{16}$
B	370	$14\,^{9}/_{16}$
C	*	**
D	112	$4\,^{7}/_{16}$
E	197	$7\,^{3}/_{4}$

*
For M25 to M75R
C = 150mm $5\,^{7}/_{8}$ in)

**
For M105 to M210R
C = 195mm $7\,^{11}/_{16}$ in)

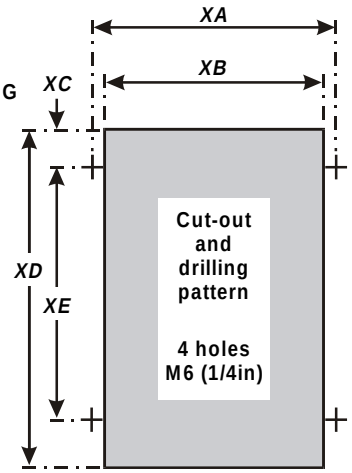
UNIT	TERMINALS A1, A2
M25	Q
M25R	Q
M45	Q
M45R	Q
M75	Q
M75R	Q
M105	Q
M105R	P
M155	Q
M155R	P
M210	Q
M210R	P

TERMINALS L1, L2, L3
- M8 stud
TERMINALS A1, A2
and Earth (ground)
- drilled for M8
($^{5}/_{16}$ in) bolt

Terminal Dimensions

	mm	in
a	30	$1\,^{3}/_{16}$
b	60	$2\,^{3}/_{8}$
c	110	$4\,^{5}/_{16}$
d	100	$3\,^{15}/_{16}$
e	115	$4\,^{1}/_{2}$
f	140	$5\,^{1}/_{2}$
g	54	$2\,^{1}/_{8}$

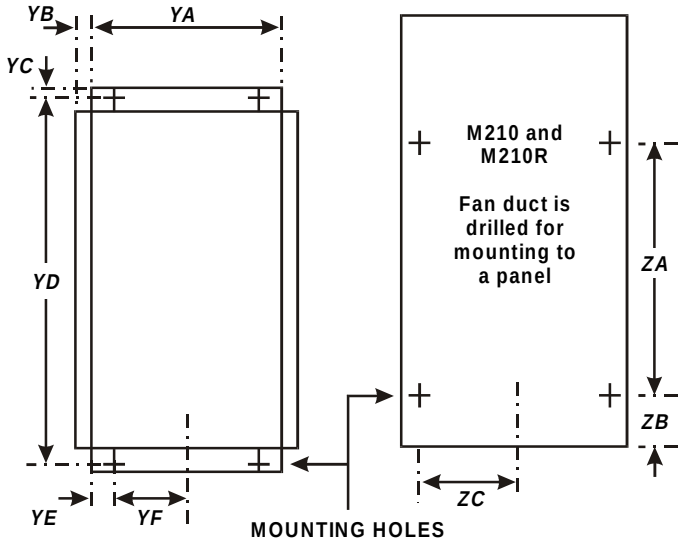
CUT-OUT & DRILLING PATTERN FOR THROUGH_PANEL MOUNTING



Through-Panel Mounting Dimensions

	mm	in
XA	220	$8\,^{11}/_{16}$
XB	200	$7\,^{7}/_{8}$
XC	42.5	$1\,^{11}/_{16}$
XD	360	$14\,^{3}/_{16}$
XE	245	$9\,^{5}/_{8}$

DRILLING PATTERNS FOR SURFACE MOUNTING



Surface Mounting Dimensions

	mm	in
YA	186	$7\,^{5}/_{16}$
YB	32	$1\,^{1}/_{4}$
YC	10	$^{7}/_{16}$
YD	381	$15\,^{5}/_{16}$
YE	42	$1\,^{11}/_{16}$
YF	50	$1\,^{15}/_{16}$

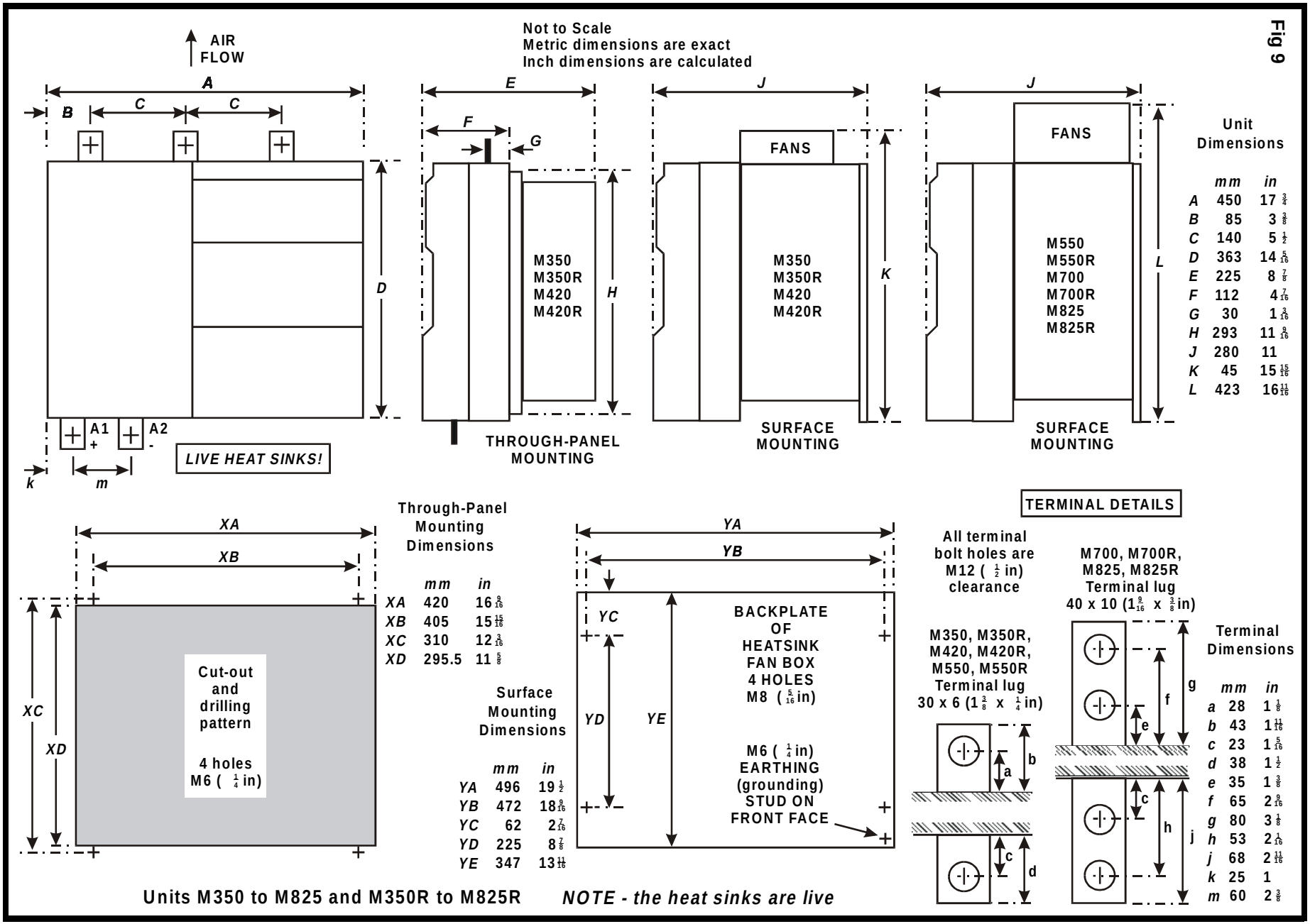
	mm	in
ZA	245	$9\,^{5}/_{8}$
ZB	87	$3\,^{7}/_{16}$
ZC	110	$4\,^{5}/_{16}$

Not to Scale
Metric dimensions are exact
Inch dimensions are calculated

Units M25 and M25R to M210 and M210R (incl) are suitable for both Surface Mounting and Through-Panel Mounting

Fig 8

Fig 9



Unit Dimensions

	mm	in
A	450	17 3/4
B	85	3 3/8
C	140	5 1/2
D	363	14 5/16
E	225	8 7/8
F	112	4 7/16
G	30	1 3/16
H	293	11 9/16
J	280	11
K	45	15 15/16
L	423	16 11/16

Through-Panel Mounting Dimensions

	mm	in
XA	420	16 9/16
XB	405	15 15/16
XC	310	12 3/16
XD	295.5	11 5/8

Surface Mounting Dimensions

	mm	in
YA	496	19 1/2
YB	472	18 9/16
YC	62	2 7/16
YD	225	8 7/8
YE	347	13 11/16

TERMINAL DETAILS

All terminal bolt holes are M12 (1/2 in) clearance

M350, M350R, M420, M420R, M550, M550R Terminal lug 30 x 6 (1 3/8 x 1/4 in)

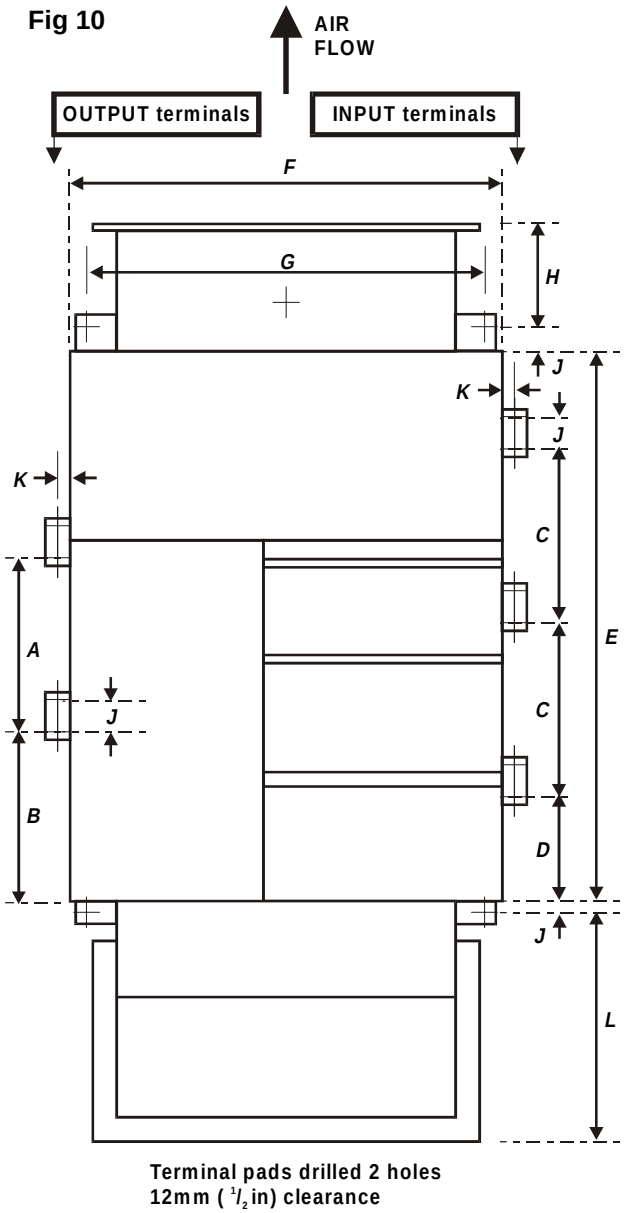
M700, M700R, M825, M825R Terminal lug 40 x 10 (1 9/16 x 3/8 in)

Terminal Dimensions

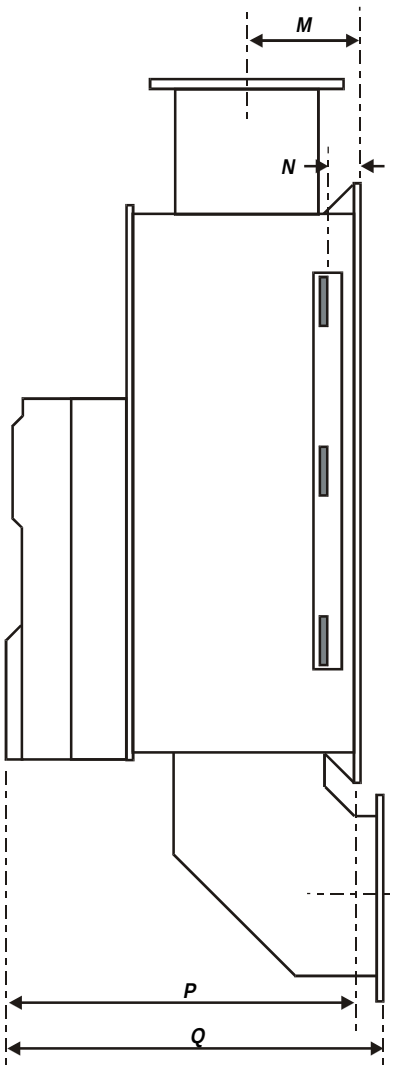
	mm	in
a	28	1 1/8
b	43	1 11/16
c	23	1 5/16
d	38	1 1/2
e	35	1 3/8
f	65	2 9/16
g	80	3 1/8
h	53	2 1/16
j	68	2 11/16
k	25	1
m	60	2 3/8

Units M350 to M825 and M350R to M825R ***NOTE - the heat sinks are live***

Fig 10



Not to Scale
Metric dimensions are exact
Inch dimensions are calculated



Units Mxxx Dimensions

	mm	in
A	175	6 7/8
B	190	7 1/16
C	175	6 7/8
D	90	3 9/16
E	555	21 7/8

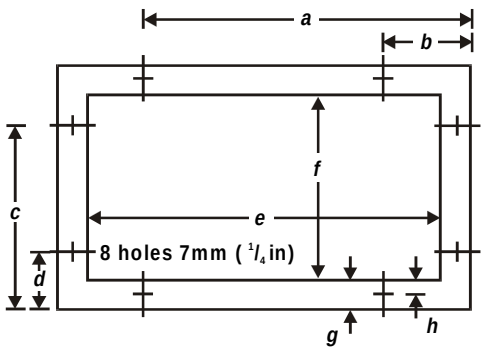
Units MxxxR Dimensions

	mm	in
A	330	13
B	330	13
C	330	13
D	165	6 1/2
E	1015	39 15/16

Common Dimensions

	mm	in
F	450	17 3/4
G	393	15 1/2
H	125	4 15/16
J	25	1
K	30	1 3/16
L	315	12 3/8
M	185	7 5/16
N	48.5	1 15/16
P	470	18 1/2
Q	510	20 1/16

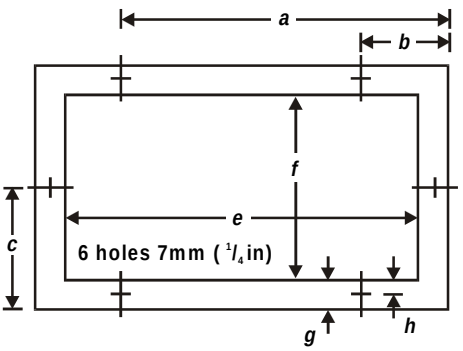
TOP FLANGE



Top Flange Dimensions

	mm	in
a	280	11
b	100	3 15/16
c	200	7 7/8
d	60	2 3/8
e	330	13
f	210	8 1/4
g	25	1
h	15	9/16

REAR FLANGE



Rear Flange Dimensions

	mm	in
a	290	11 7/16
b	80	3 1/8
c	200	7 7/8
d	-	-
e	330	13
f	208	8 3/16
g	20	13/16
h	10	3/8

Units M900 to M1850 and M900R to M1850R are suitable for surface mounting only

NOTE Heat sinks are live

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6 Electrical Installation

6.1 Installation Criteria

6.1.1 Safety

WARNING

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

Electric Shock Risk!

WARNING

Whenever the Drive has been connected to the main AC supply system it must be DISCONNECTED and ISOLATED before any work is done that requires the removal of a cover. A period of 2 minutes MUST elapse after isolation to allow the internal capacitors to discharge fully. Until the discharge period has passed, dangerous voltages may be present within the module.
Persons supervising and performing electrical installation or maintenance must be suitably-qualified and competent in these duties, and should be given the opportunity to study, and to discuss if necessary, this Users Guide before work is started.

Ingress Protection

CAUTION

The Drive enclosure conforms to international enclosure specification IP00 and is suitable for mounting in NEMA-rated enclosures. It is necessary to consider the location of and access to the Drive unit itself in the light of local safety regulations applicable to the type of installation.

6.1.2 Hazardous areas

WARNING

The application of variable speed Drives of all types may invalidate the hazardous area certification (Apparatus Group and/or Temperature Class) of Ex-protected (externally-protected) motors. Approval and certification should be obtained for the complete installation of motor and Drive. (Refer also to Location, Section 5.2.1)

6.1.3 Earthing (Grounding)

Safety

WARNING

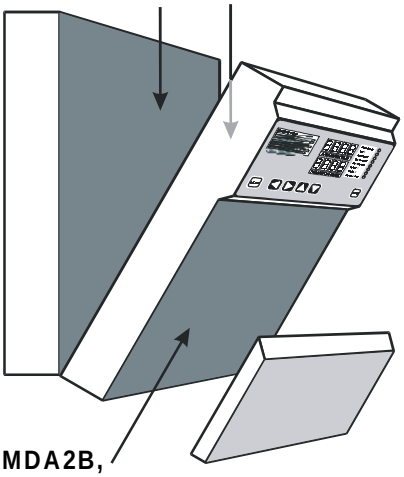
Drives with isolated heat sinks require that the heat sink is earthed (grounded) for safety. (Refer also to Mounting, Section 5.2)
It is recommended that any metal components which could accidentally become live are solidly earthed (grounded).
Earth (ground) impedance must conform to the requirements of local industrial safety regulations and should be inspected and tested at appropriate and regular intervals.

6.1.4 Control System Earthing (Grounding)

External AC control circuits, for example, contactors, should be supplied (from any two phases of the supply) through an isolating transformer equipped with an earthing (grounding) shield (screen) between the primary and secondary as shown in Figs.12 and 13. The control wiring should be connected to the same earthing (grounding) point if possible, or arrangements made to ensure that the earth (ground) loop impedance complies with an authorized code of practice.

6.1.5 Location

The location of principal components is shown in Fig. 11.



Location of principal components

Fig 11

6.2 Power Connections

Refer to Figs.12 and 13.

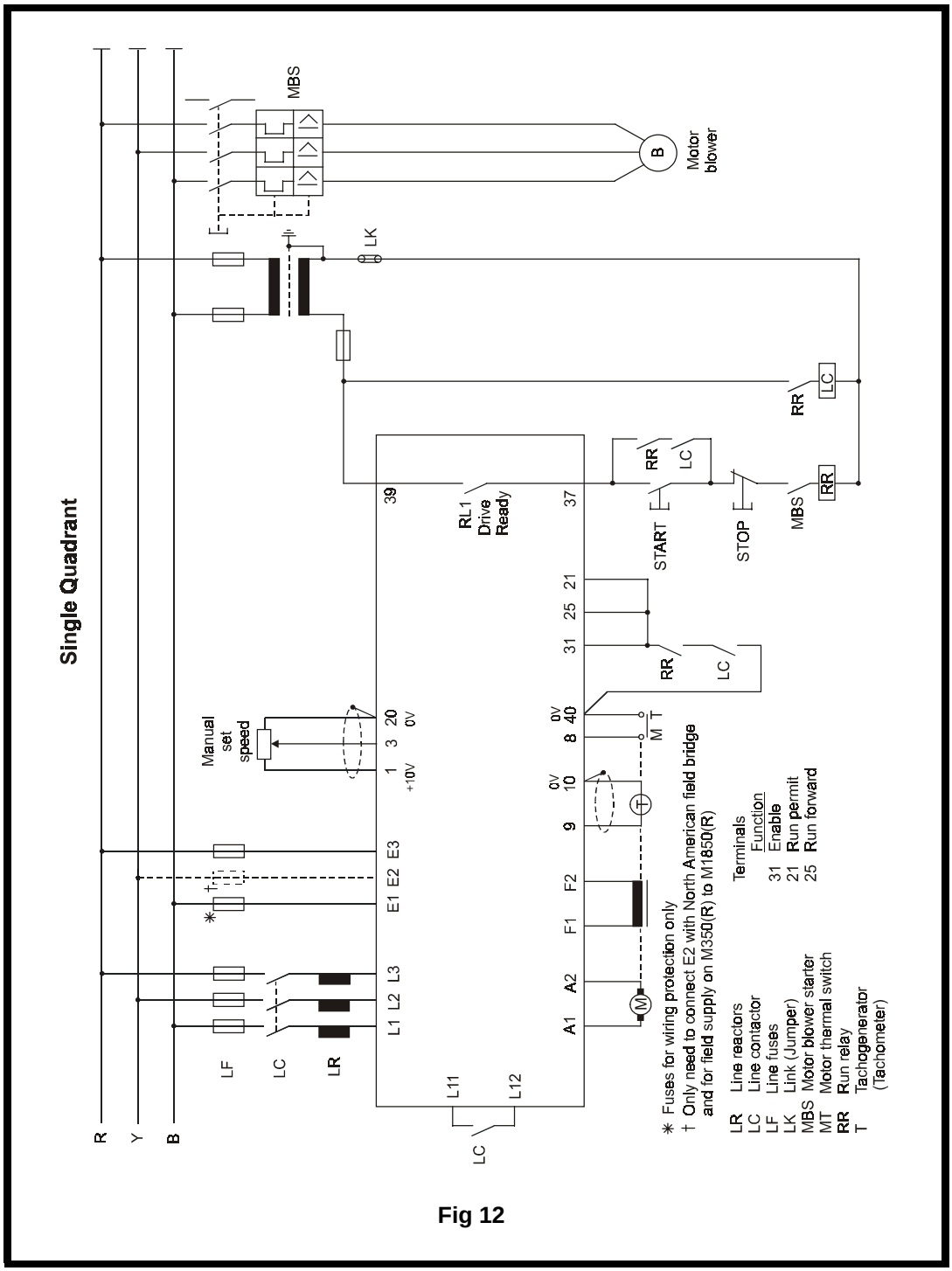


Fig 12

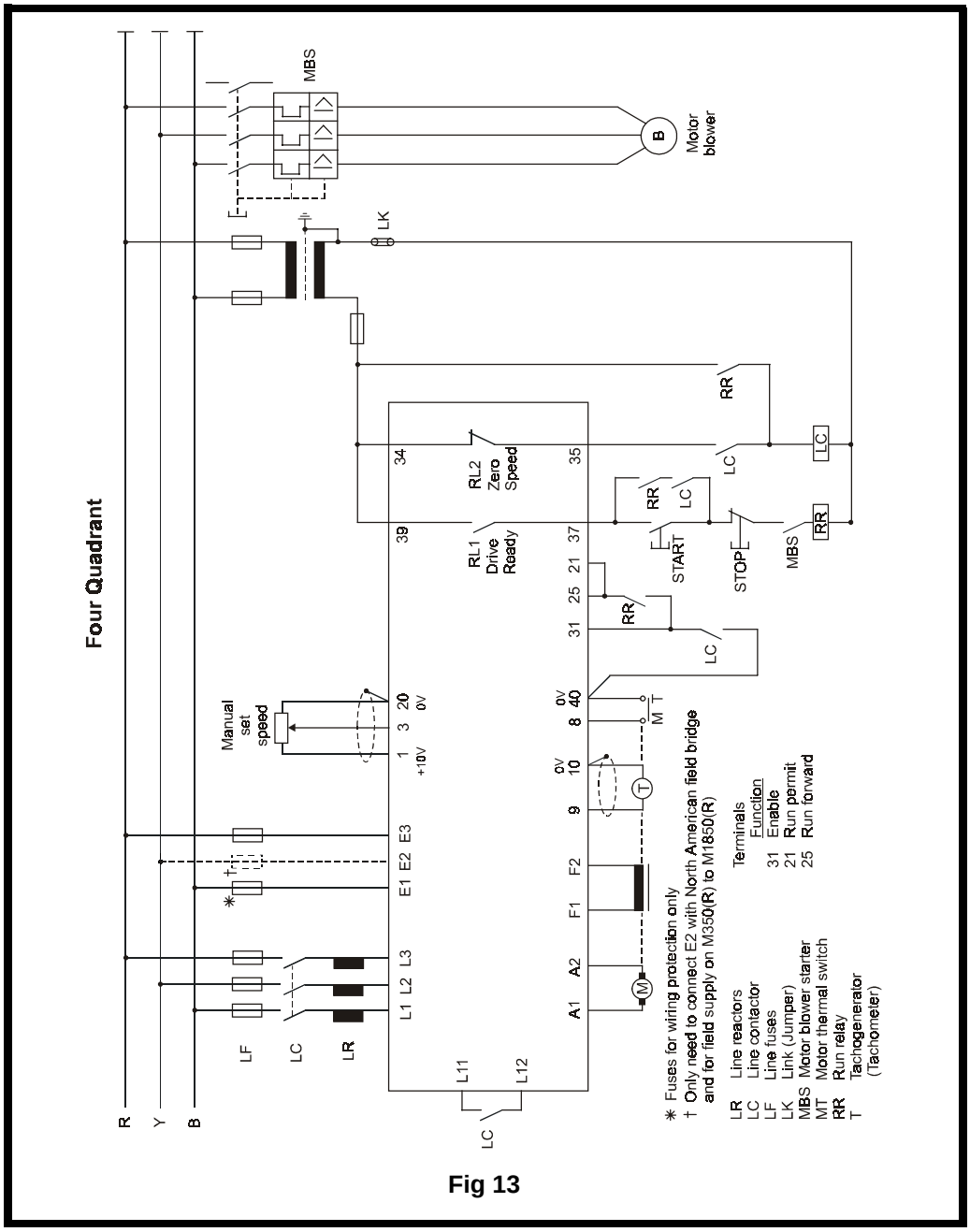


Fig 13

Access to the power terminals of the smaller Drives is gained by opening the front cover, which is secured by two captive screws, one at each upper corner, and hinged at the bottom (Fig. 11). The higher-rated models have externally-accessible terminal lugs.

6.2.1 Motor Rotation

Check that the direction of rotation is as required as soon as the Drive is first turned on. If not, exchange the connections to the armature or the field (but not both). If an encoder or tachogenerator (tachometer) feedback is installed, the sense of the signals to the Drive must be reversed to correspond.

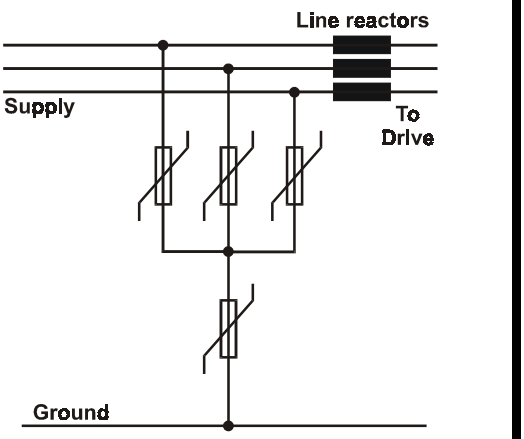
The Drive control options can alternatively be used to reverse the direction of rotation.

6.2.2 Overvoltage suppression

The Mentor II Drive contains overvoltage suppression components to protect the thyristors from high voltage pulses (transients or spikes) appearing between the phases because of lightning strikes etc. It is also designed to withstand pulses of over 4kV between the phases and ground.

In regions of high lightning activity, especially where grounded delta supplies are in use, it is recommended that additional protection should be fitted externally between the phases and ground. This would typically be by using MOVs (varistors).

One possible arrangement is shown in the diagram below:



Overvoltage Suppression

The AC voltage rating of the MOVs can be up to 550V. This is suitable for all supply voltages up to 660V +10%.

Ensure that the MOVs are rated for surge currents of at least 3kA for the standard surge (1.2/50µs voltage or 8/20µs current). The wires to the MOVs should be short (eg less than 6in/15cm) to avoid additional over-voltage caused by wiring inductance with the fast-rising current.

MOVs approved by a safety agency such as UL are recommended, and in some regions this is essential for legal or insurance reasons.

6.2.3 Overvoltage category and voltage surge suppression

The Mentor II Drive contains comprehensive voltage surge suppression and co-ordinated electrical spacings. It is resistant to surges of 4kV between lines and from lines to ground.

The 480V version of the Drive may be connected to a supply system of overvoltage category III (as specified in IEC664-1). This means that it is suitable for permanent connection to any power system other than an outdoor installation. For outdoor installation it is recommended that additional overvoltage protection be provided. The 525V and 660V versions may be connected to a supply system of overvoltage category II. For permanent connection directly to industrial supply systems it is necessary to provide additional surge suppression between lines and ground. Suitable suppression devices using metal oxide varistors (MOVs) are widely available. This is not required where the Drive is provided with an isolation transformer.

The status relay contacts are designed for overvoltage category II at 240V.

Overvoltage categories are as follows:

I	Protected circuits with overvoltage surge suppression
II	General building power supplies for use by electrical appliances
III	Fixed installations with permanent supply connection
IV	Building power incomer (eg utility meter etc.)

6.3 Current Feedback Burden Resistors

To allow the use of a motor which has a lower rating than the Drive, the current feedback has to be re-scaled by changing the burden resistors R234 and R235 (or in the case of Drive size M350 and above, the three resistors R234, R235 and R236) mounted on the power board. The following equations provide the value of the appropriate resistance. Resistors are in *parallel*.

Where Imax is 150% of the rated full load current of the motor:

For Drives M25 up to M210R (up to 210A DC output) and PCBs MDA75, MDA75R, MDA 210, and MDA210R:

$$\text{Rtotal} = \frac{400}{\text{Imax}}$$

For Drives M350 and above, and PCB MDA6, three burden resistors, R234, R235 and R236 are used in parallel:

$$\text{Rtotal} = \frac{1600}{\text{Imax}}$$

Worked Example of Current Feedback Burden Resistor Values

For an M350 Drive:

Full load current output (Table 1) is 350A

Maximum current is 350 x 1.5amps

Total burden resistance:

$$\text{Rtotal} = \frac{1600}{350 \times 1.5} = 3\Omega$$

$$\frac{1}{\text{Rtotal}} = \frac{1}{\text{R234}} + \frac{1}{\text{R235}} + \frac{1}{\text{R236}}$$

If R236 is given a high value, say 390Ω, then:

$$\frac{1}{3} - \frac{1}{390} = \frac{1}{\text{R234}} + \frac{1}{\text{R235}}$$

and :

$$\frac{1}{\text{R234}} + \frac{1}{\text{R235}} = 0.33076\Omega$$

From data tables of standard resistor values, find two which give the closest approximation.

For example, if :

R234 = 5.6 Ω and R235 = 6.8 Ω,

then -

$$\frac{1}{5.6} + \frac{1}{6.8} = 0.32563\ \Omega$$

$$\approx 0.33076\ \Omega$$

The power rating of each burden resistor in turn is calculated from :

$$\text{Power (W)} = \frac{V^2}{R}$$

and where the voltage across the three resistors in parallel is 1.6V, power absorbed is :

R234 $\frac{1.6^2}{5.6} = 0.456\text{W}$

a 0.5W or 0.6W rating is adequate

R235 $\frac{1.6^2}{6.8} = 0.376\text{W}$

a 0.5W rating is adequate

R236 $\frac{1.6^2}{390} = 6\text{mW}$

a 0.25W rating is adequate

NOTE

If the current ripple measured at terminal 11 is less than 0.6V p-p, it is possible to increase the burden resistors (provided that version V5.1.0 (or later) software is used) by a factor of 1.6. If the burden resistors are increased parameter 05.29 must be set to 1.

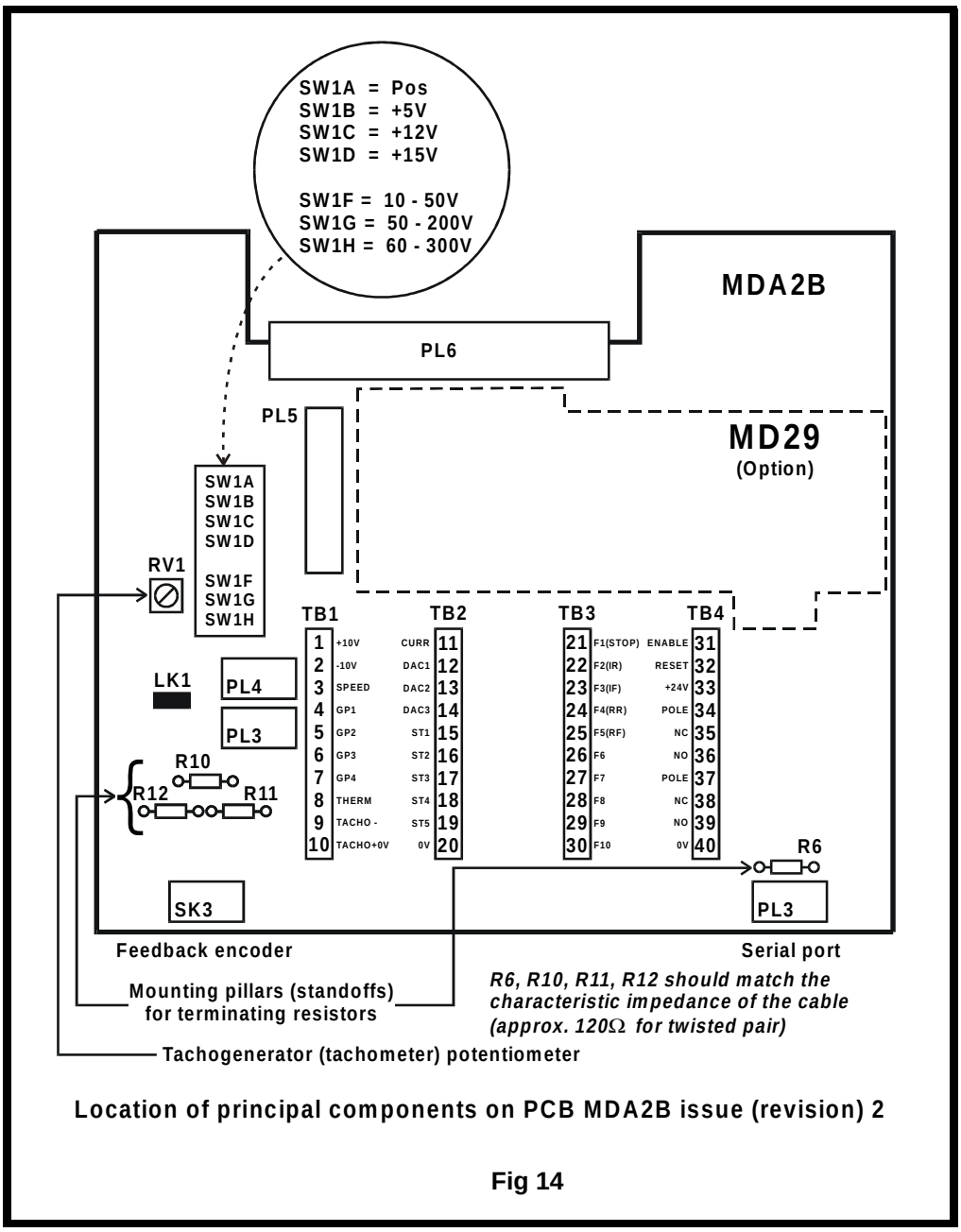
The burden resistor values should not be increased by the factor of 1.6 if the current ripple measured at terminal 11 is greater than 0.6V as the Drive will operate better with the standard values.

6.4 Control Connections

Refer to Figs. 12, 13, 14, and 15.
The Terminals index.
The Classified list of terminals.

Isolation

The control circuits and terminals are isolated from the power circuits only by basic insulation to IEC664-1. The installer must ensure that all external control circuits are separated from human contact by at least one layer of insulation rated for use at the AC supply voltage.



Location of principal components on PCB MDA2B issue (revision) 2

Fig 14

1 Terminals index

Terminals are located on PCB MDA2B, Fig 11 and Fig 14

Terminal		Description	Type	Programmable
Block	Number			
TB1	1	+10V	Reference supply	
	2	-10V	Reference supply	
	3	Speed reference	Analog input	Yes
	4, 5, 6, 7	General purpose GP1, GP2, GP3, GP4	Analog inputs	Yes
	8	Motor thermistor (thermal)	Analog input	
	9	Tachogenerator (tachometer) negative	Analog input	
	10	Tachogenerator (tachometer) positive (0V)	Analog input	
TB2	11	Current	Analog output	
	12	DAC1	Analog output	Yes
	13	DAC2	Analog output	Yes
	14	DAC3	Analog output	Yes
	15, 16, 17, 18, 19	ST1, 2, 3, 4, 5	Open collector outputs	Yes
	20	0V		
TB3	21	F1 Run permit	Digital input	
	22	F2 Inch reverse	Digital input	Yes
	23	F3 Inch forward	Digital input	Yes
	24	F4 RUN reverse (latched)	Digital input	Yes
	25	F5 RUN forward (latched)	Digital input	Yes
	26, 27, 28, 29, 30	F6, 7, 8, 9, 10	Digital inputs	Yes
TB4	31	ENABLE	Digital input	
	32	RESET	Digital input	
	33	+24V relay supply		
	34	Pole	Relay output (ST6)	Yes
	35	Normally closed contact	Relay output (ST6)	Yes
	36	Normally open contact	Relay output (ST6)	Yes
	37	Pole	Drive ready relay	
	38	Normally closed contact	Drive ready relay	
	39	Normally open contact	Drive ready relay	
	40	0V		

PL5

Number	Function	Number	Function	Number	Function
1	+10V	11	Current	21	F1
2	-10V	12	DAC1	22	F2
3	Speed ref	13	DAC2	23	F3
4	GP1	14	DAC3	24	F4
5	GP2	15	ST1	25	F5
6	GP3	16	ST2	26	F6
7	GP4	17	ST3	27	F7
8	Thermistor (thermal switch)	18	ST4	28	F8
9	NC	19	ST5	29	F9
10	0V	20	0V	30	F10
				31	ENABLE
				32	RESET
				33	External 24V
				34	0V

2 Terminals classified

Analog outputs

Terminal block TB2, terminals 11 to 14 inclusive.
Armature current indication, 5mA Drive capability.
Three undedicated outputs, 5mA Drive capability.
Output voltage range -10V to +10V.

Analog inputs

Terminal block TB1, terminals 3 to 10 inclusive.
Five undedicated inputs, impedance 100kΩ. Input voltage range -10V to +10V.
Dedicated inputs for motor thermistor (thermal) or thermostat (trip level 3kΩ, reset 1.8kΩ approx.) and tachogenerator (tachometer) feedback.

Digital outputs

Terminal block TB2, terminals 15 to 19 inclusive.
Terminal block TB4, terminals 34 to 39 inclusive.
Five undedicated open-collector outputs.
Maximum current-sinking capability 100mA.
One undedicated relay output.
Dedicated Drive ready relay output.
Maximum relay current at:

250V AC	2.2A
110V AC	5A
5V DC	5A

Digital inputs

Terminal block TB3, terminals 21 to 30 inclusive.
Terminal block TB4, terminals 31, 32.
Nine undedicated inputs, impedance 10kΩ.
Drive enable signal - operates directly on the output gate-pulse circuits for safety. Delay 30ms between removal of enable signal and inhibit firing. Drive enable control is internally interlocked with fault detection signals for maximum safety.
Run Permit
Drive reset input for external control.
Input logic selectable - active high or active low.
Circuit voltage +24V.
Provision for inputs from two encoders.
Run Forward and Run Reverse, latched.

Programmable outputs

Terminal block TB2

Terminals 12 to 14 inclusive Analog
Terminals 15 to 19 inclusive Open collector (digital)

Terminal block TB4
Terminals 34 to 36 inclusive Relay

Programmable inputs

Terminal block TB1
Terminals 3 to 7 inclusive Analog

Terminal block TB3
Terminals 22 to 30 inclusive Digital

Encoder (pulse tachometer) - Reference & Feedback

Channel A must lead channel B for forward rotation.

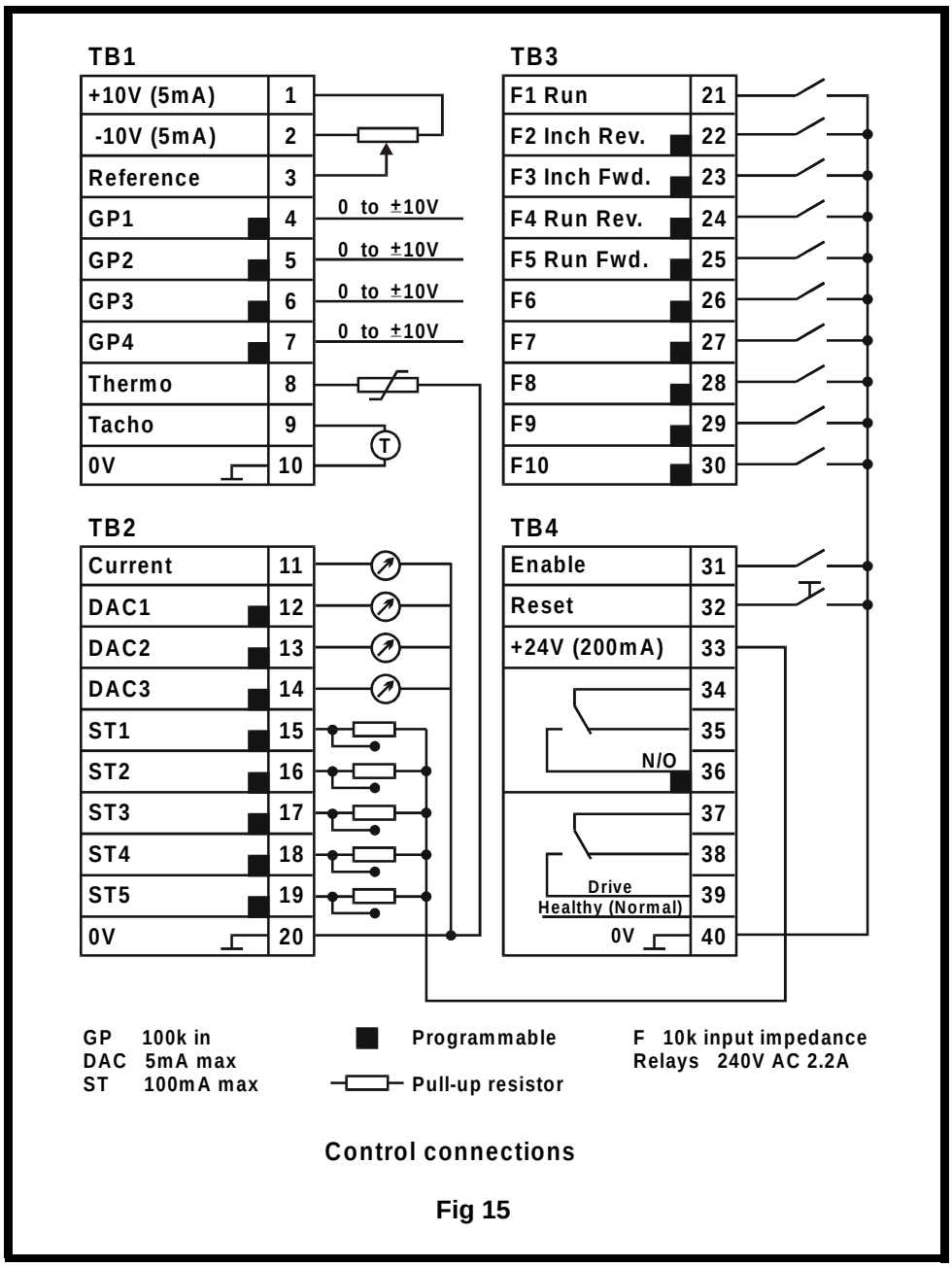
Connections for:

Pin	Encoder		Serial Comms.
	Reference PL4	Feedback SK3/PL3*	PL2
1	0V	0V	0V isolated
2	NC	Supply	/TX
3	A	A	/RX
4	/A	/A	NC
5	B	B	NC
6	/B	/B	TX
7	NC	NC	RX
8	C	C	NC
9	/C	/C	NC
10	0V	0V (NOT SK3)	

* PL3 is connected in parallel with SK3

PL4 is a 10-way header for the Reference Encoder.

SK3 is a 9-way D-type female socket for the Feedback Encoder.



Control connections

Fig 15

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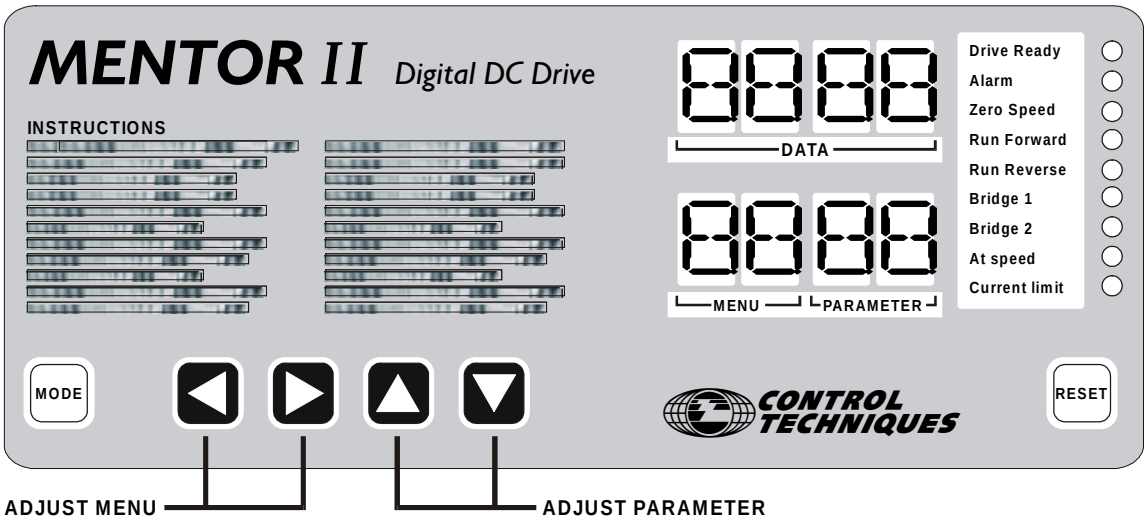
7 Operating Procedures

7.1 Keypad and Displays



Keypad

Fig 16

The keypad serves two purposes:

1 It allows the operator to configure the Drive to match particular applications and to change its behavior in a variety of ways, for example by altering the times of acceleration and deceleration, presetting levels of protection, and so on.

Subject to safety considerations, adjustments may be made with the Drive running or stopped. If running, the Drive will respond immediately to the new setting.

2 It provides full information about the settings and the operational status of the Drive, and extensive diagnostic information if the Drive trips.

For parameter adjustment, the keypad has five keys, Fig. 17. Use the *LEFT* or *RIGHT* keys to select a Menu (functional group of parameters). The menu number appears to the left of the decimal point in the Index window.

Use the *UP* or *DOWN* keys to select a Parameter from the chosen menu. The parameter number appears to the right of the decimal point in the Index window, and the value of the chosen parameter appears in the Data window.

Press the MODE key once to access the displayed parameter value for adjustment. The value flashes if access is permitted.

Use the *UP* or *DOWN* keys to adjust the value. To adjust rapidly, press and hold a key.

Press the MODE key again to exit from the adjustment mode.

Store (make permanently effective) parameter values after changes, otherwise the new values will be lost when the Drive is powered-off. To store, set Parameter 00 = 1 and press RESET.

DISPLAYS

1 Index

The lower four-digit display indicates menu number to the left of the (permanent) decimal point, and parameter number to the right.

2 Data

The upper four-digit display indicates the value of a selected parameter. The present value of each parameter in turn appears in the data display as parameter numbers are changed. Numerical parameters have values in ranges of 000 to 255, 000 to +1999, or 000 to 1000. Refer to Chapter 6 for parameter unit values, e.g. volts, rpm, etc.

Bit parameter values are displayed as 0 or 1, preceded by a b. The first digit for integer parameters (0 to 255) is a □ .

3 Status Indicators

Nine LED's to the right of the parameter data and index panels present information, continuously updated, about the running condition of the Drive and enable basic information to be seen at a glance.

LED Illuminated	Information
Drive ready	The Drive is switched on and is not tripped
Drive ready flashing	The Drive is tripped
Alarm flashing	The Drive is in an overload trip condition or is integrating in the I x t region
Zero speed	Motor speed < zero speed threshold (programmable)
Run forward	Motor running forward
Run reverse	Motor running in reverse
Bridge 1	Output bridge 1 is enabled
Bridge 2	Output bridge 2 is enabled. (Inactive in 1-quad Drives)
At speed	Motor running at the speed demanded by the speed reference
Current limit	Drive running and delivering maximum permitted current

7.2 Setting Up to Run

Install the Drive and make electrical power and control connections in accordance with Chapter 8, and Figs. 12, 13, 14. Before attempting to run the Drive, there are further connections and settings - some optional - to make or to be considered.

These are summarized below:

Action	Reference
Preset the link (jumper)LK1 and switches	7.2.1 below
Preset the adjustable potentiometer if tachogenerator (tachometer) feedback selected	7.2.2 below
Adjust operating parameters as appropriate to the application	Section 8.1
Autotune current loop	parameter 05.09
Adjust field feedback scaling	parameter 06.11
Allocate security code optional	Section 8.2

7.2.1 Link LK1 (Jumper) and Switches

The link LK1 (jumper) and switch block are located on PCB MDA2B (Fig. 14), accessible when the lower, snap-on front cover is removed (Fig. 11).

Control	Purpose	
SW1A	Logic input polarity. MDA2B is marked POS. and NEG. to indicate the positions of SW1A. Pos. = 24V Neg. = 0V.	POWER-OFF BEFORE CHANGING
SW1H	60V to 300V	Tachogenerator (tachometer) feedback range*
SW1G	50V to 200V	Tachogenerator (tachometer) feedback range*
SW1F	10V to 50V	Tachogenerator (tachometer) feedback range*
LK1	Tachogenerator (tachometer) potentiometer calibration adjustable link (jumper)	
SW1D	+15V	Encoder supply voltage selector*
SW1C	+12V	Encoder supply voltage selector*
SW1B	+5V	Encoder supply voltage selector*

* ONE ONLY to be selected

7.2.2 Potentiometer RV1

Refer to Fig. 14.

Pot.	***Purpose***
RV1	Tachogenerator (tachometer) feedback adjustment

Procedure for Adjustment

1 Select the appropriate tachogenerator range using SW1.

2 Set LK1 in the ADJUST position.

3 Adjust RV1 until the value of parameter 03.02 (Speed Feedback) is:

$$03.02 = \frac{10\,000}{Vmax}$$

where Vmax = Tach. voltage at full speed.

4 Set LK1 in the FEEDBACK position and fine tune RV1 with the motor running at between half to three-quarter speed.

7.3 Getting Started

Essential data
Before attempting to tune a Mentor II to operate a particular load, collect the following information from the nameplate of the motor, manufacturers data, and other sources.

Data values are given here for the sake of the worked examples which follow.

- Armature full load amps 67A
- Armature voltage 500V DC
- Field current 1.85A
- Field voltage 300V DC
- Base speed 1750rpm
- Maximum permissible speed with weakened field 2500rpm
- Mentor II Drive model number M75
- The method of delivering speed feedback data to the Drive - various examples are considered below

WORKED EXAMPLES

7.3.1 Armature current

Current Limit

Current limit is set in parameter 04.05 only if the Drive is not regenerative, and in *both* 04.05 and 04.06 if it is regenerative.

An M75 Drive is rated at 75A full load current. The default value (1000) of parameter 04.05 (and 04.06) allows a maximum current limit of 150% of full load current, which would be 1.5 x 75 = 112.5A.

Full load current for the selected motor is 67A, and if its maximum current limit is 150%, which is normal, the maximum current that it may experience is 100.5A.

Accordingly, the Drive must be adjusted to correspond, or the motor will be damaged.

Calculate the ratio from :

$$\text{Motor full load current} = \frac{67}{75} = 0.89$$
$$\text{Drive rating}$$

The full-scale value of the Current Limit parameters, corresponding to 150% of full load current of the motor, is 1000. The actual setting of the Current Limit parameters is, therefore :

1000 x 0.89 = 890

Set 04.05 = 890.

If the Drive system is regenerative,

set 04.06 = 890 also.

NOTE

Current resolution
The rating of the selected Drive is typically higher than the rating of the motor, but it should not be very much higher. It would not be prudent to select a Drive-to-motor ratio less than 2/3 (current limit parameter setting 600).Current feedback resolution at any lower ratio would be unable to give good current loop control.

Although full scale resolution can be achieved by changing the burden resistors of the Drive current transformer, this would create a non-standard Drive that is not a stock item. The risk is that the Drive might be replaced by a standard Drive of the same nominal rating; the motor could be permanently damaged. Special modifications of this nature should always be supported by thorough documentation, and the non-standard Drive should itself be indelibly tagged in some way.

Current Overload I x t

The threshold at which I x t integration begins in parameter 05.06 is typically 105%.
The parameter full-scale value is 1000, corresponding to 150%, so that :

$$05.06 \text{ threshold} = \frac{105}{150} \times 1000 = 700$$

This value, as with the Current Limit, must be adjusted to take account of the actual motor full load amps by applying the factor already calculated for Current Limit, namely, 0.89. The actual value required for this motor and Drive combination is therefore :

$$700 \times 0.89 = 623$$

Set 05.06 = 623.

Access to these parameters

To gain access to these parameters and set the values select parameter 00 and enter 200.

This permits access to all required parameters.

7.3.2 Speed feedback

Armature Voltage Feedback

For armature voltage feedback, set parameter 03.13 = 1.

For practical applications a small tolerance of 2% or 3% above the nameplate voltage should be allowed. For an armature voltage of 500V, set parameter 03.15 = 510 or 520.

Analog Speed Feedback

For analog tachogenerator (tachometer) feedback, set parameter 03.13 = 0 (default setting).

The default values of the speed loop proportional and integral gains are usually satisfactory for analog feedback.

Depending on the application the characteristic behavior of the load adjustment of the speed loop gains may be needed to obtain the optimum dynamic performance and speed-holding.

Encoder (pulse tachometer) Speed Feedback

For encoder (pulse tachometer) feedback, set parameter 03.12 = 1.

The scaling parameter, 03.14, must be adjusted to correspond with the encoder PPR (pulses per revolution) and the intended maximum speed of the motor in rpm :

$$03.14 = \frac{750 \times 10^6}{PPR \times \text{Max. rpm}}$$

For example :

Encoder (pulse tach.)	240 PPR
Motor rated max. speed	1750 rpm
Motor max. speed required	1710 rpm

$$03.14 = \frac{750 \times 10^6}{240 \times 1710} = 1827$$

NOTE

When this type of feedback is applied there are several additional factors to consider. The instrument should be a dual-channel quadrature type with line driver outputs (using RS485 line drivers).The Mentor II on-board power supply for the encoder (pulse tachometer) is selectable to 5V, 12V or 15V by means of the red DIP switch on PCB MDA2B. (Refer to Fig. 14.) This supply can deliver 300mA. It is not isolated from the Drive. Transmission line terminating resistors should be installed on the mounting pillars (stand-offs) provided at the lower left-hand corner of the PCB, Fig. 14. These resistors help to prevent line reflections and to reduce noise pick-up into the differential receiver on the Drive.
When an encoder (pulse tachometer) is employed, the P and I gains should be adjusted to the following suggested values as a starting point

03.09 = 15
03.10 = 5

Connection of the marker pulses is only necessary if the Drive is being used in an application which requires position control such as digital lock or spindle orientation. If marker pulses are used then the encoder must have 1024 pulses per revolution.

7.3.3 Field current

First enable the Field Controller.
Set parameter 06.13 = 1.

Current Range

The Mentor II M75 provides for a field current range of either 2A maximum or 8A please refer to the table in the description of parameter 06.11. In the example chosen, the maximum field current is 1.85A. This is >1.5A and <2A.

Set 06.11 = 204 to select the correct range.

Maximum Field Current

The full-scale value of the Max. Field Current parameter 06.08 is 1000. The maximum field current of the chosen example is 1.85A. The setting for parameter 06.08 is:-

$$\frac{\text{Motor max. field current}}{\text{Field range}} = \frac{1.85}{2.00} \times 1000 = 925$$

Field Weakening

Since field weakening is not employed in this particular example, set 06.07 = 1000 (default).

For details of settings and calculations for field weakening, please refer to *section 7.3.4, Field weakening*

Field Economy

For applications which involve the Drive being at zero speed no-load (i.e. motor stopped but on stand-by) for periods in the duty cycle, provision is made to economise on the field current. The user can set the value of the reduced field current (parameter 06.09) and the period of time before field current is reduced (parameter 06.12).

To employ field economy, the following settings are required:-

Field Economy Time-out Enable - set 06.15 = 1

Field Economy Current

Suppose the chosen value of the reduced field current is 0.5A :-

$$\frac{\text{Motor reduced field current}}{\text{Motor max. field current}} = \frac{0.5}{1.85} \times 1000 = 270$$

Set 06.09 = 270.

Test the effect by temporarily setting the Field Economy Time-out, 06.12, to 2 seconds (06.12 = 2).Disable the Drive and monitor the current value at parameter 06.03. Two seconds after the Drive is disabled, 06.03 will be seen to reduce to the selected value of 06.09.

NOTE

Internal Field Regulator
If Mentor II is supplied with the Internal Field Regulator, field economy is under automatic control of the software and an external field ON-OFF control switch (Figs. 12 and 13) is not required. Link out (jumper across) terminals L11 and L12 with wire which is capable of carrying the field current.

7.3.4 Field weakening

In the example, the maximum armature voltage is 500V DC. If field weakening is required, a typical practical setting for the back-EMF cross-over point 06.07 would be 15 to 20 volts below the maximum armature voltage.

For example, set 06.07 = 480.

At the reduced voltage, the field would begin to weaken progressively down to the value set by parameter 06.10. Since the field current feedback setting 06.11 in this example is 204 - 2A range - the minimum is a selected percentage of it. Suppose 90% is selected. Then :

$$\frac{\text{Selected value}}{\text{Feedback setting}} = \frac{0.9}{2.0} = 0.45$$

The setting for minimum field current is :

$$06.10 = 0.45 \times 1000 = 450$$

For correct operation, field weakening requires speed feedback. (Armature voltage feedback would not be adequate to ensure control.) Therefore, 03.13 would be set to 0 for AC or DC tach. feedback, and speed scaling 03.16 would be set to 250, corresponding to 2500rpm maximum permissible motor speed. Parameter 03.03 will then correctly read out the actual motor rpm.

If an encoder (pulse tach.) were to be employed, parameter 03.12 would be set to 1 and the encoder scaling 03.14 would need to be set accordingly. The value of 03.14 is dependent on :
The maximum motor speed required, and
The number of encoder (pulse tach.) pulses per revolution.

7.3.5 Current loop self-tuning

NOTE

The following procedure is optional, and for most general applications is not required. However, if optimum dynamic response is desirable, the current loop, which is the innermost control loop, must be set up to enable the outer control loop (such as the speed loop) to function correctly. The dynamics of the current loop are principally a function of the electrical characteristics of any particular motor.

The Mentor II has a built-in self-tuning procedure.

First, the motor rotor must be locked or the field disconnected to allow the Drive to inject armature current and determine the electrical characteristics of the armature. The rotor must not be allowed to rotate during the self-tuning procedure. (Normally, if the field is disconnected, the rotor of a shunt wound motor will not move.)

Mentor II units from M25 through to M210 contain an internal field regulator and do not require the field to be disconnected.

Self-Tuning Procedure

1 Power-up the Drive.

2 Set parameter 00 = 200 to satisfy security.

3 Set 05.09 = 1

4 Enable the Drive connect terminal TB4-31 to 0V

5 Perform a Save parameter values procedure before disconnecting the Drive. The parameters affected by the self-tuning procedure are 05.12 to 05.15.(For the save procedure, refer to last section in 8.1 - *Procedures for selecting and changing parameters*

6 The Drive also has the facility to carry out a continuous autotune by setting parameter 05.27 which will adjust the current loop gains to keep the current loop performance optimised in the case of varying load conditions.

7.3.6 User-defined parameters

Although the following parameter settings are optional it is desirable to set them because doing so allows the user to view various critical Drive values without having to run through several menu sets to find them. All are collected together in Menu 00

Parameter	Drive quantity	Setting	Accessed at
11.01	Armature voltage	03.04	00.01
11.02	Armature current	05.02*	00.02
11.03	Motor rpm	03.03	00.03
11.04	Speed reference	01.02	00.04
11.05	AC line voltage	07.06	00.05

*A direct armature current reading can be read on parameter 05.02 if 05.05 is set with the appropriate scale factor. Using the same figures as before, for an M75 Drive, in this instance the setting would be 150% of 75A, 05.05 = 113.

As for the motor and Drive configuration parameters, perform a “Save parameter values” procedure before disconnecting the Drive; refer to last section in 8.1 - *Procedures for selecting and changing parameters*