

**OWNER'S INSTALLATION  
AND OPERATING  
MANUAL**

**MENTOR DC DRIVE**  
*for Systems Applications*

For your safety and for proper operation, please take time to carefully read all instructions before installing and operating this unit.

**WARNER ELECTRIC**  
*SECO ELECTRONICS*



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# 1 Introduction

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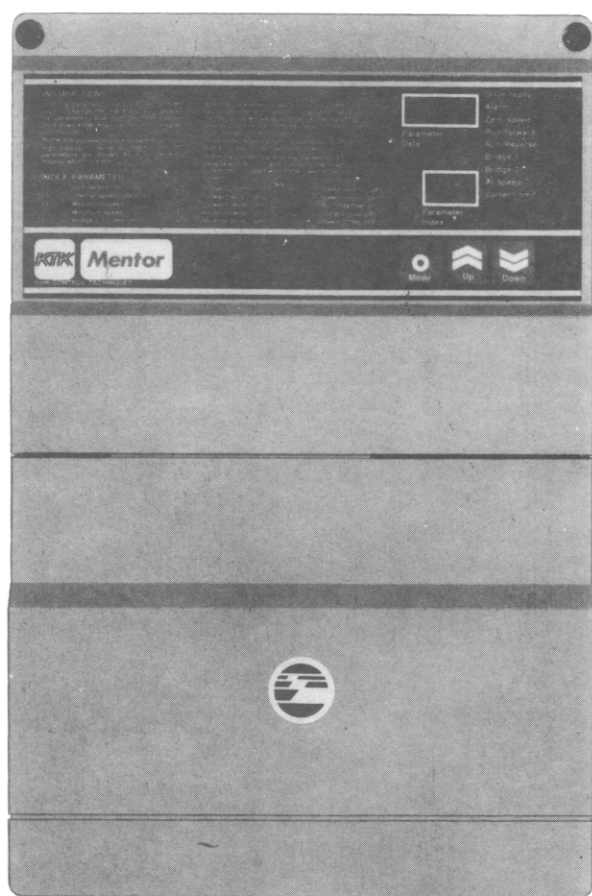
MENTOR is the name given to the very latest family of advanced, fully microprocessor-controlled DC variable speed drive modules covering the output range 7.5 to 750 kW as single-ended converters, and 7.5 to 200 kW in four-quadrant, fully regenerative configuration. The introduction of MENTOR marks a significant achievement in the field of DC drive technology by providing within a compact package all the accuracy and versatility inherent in microprocessor control, whilst remaining competitive in price with conventional analogue drives.

All models feature a fully controlled six-pulse thyristor bridge, comprehensively protected against voltage transients and isolated from the control electronics. Full details of module ratings and dimensions are to be found in sections 2, 3 and 4.

The microprocessor-based control system is programmed and adjusted by means of integral pushbuttons and seven-segment LED displays, which also form part of the powerful inbuilt diagnostic facility.

Options include a second processor to service special application software, and a serial interface for remote control and monitoring.

MENTOR is extremely compact and simple in construction, taking full advantage of modern high-volume production techniques. Access is particularly good, for ease of installation and servicing.



*Fig. 1 MENTOR – fully microprocessor-controlled 3-phase 6-pulse thyristor drive*

# 2 Electrical Specification

## MAIN A.C. SUPPLY:

Supply voltage range: 3 phase, 3 wire	50 Hz	60 Hz
Early modules — (solder link voltage selection)	[ 380v -6% to 440v +6%	460v -10% to 480v +10%
	[ 220v -10% to 240v +6%	230v ±15%
Later modules — (push-on voltage selection)	380v -10% to 415v + 6%	380v - 10% to 415v + 6%
	415v -15% to 440v +10%	460v -15% to 480v +10%

## MAXIMUM RECOMMENDED MOTOR VOLTAGES:

Supply Voltage	Field Voltage	Arm. Voltage Single-Ended (Motor Only)	Arm. Voltage Four-Quadrant (Regenerative)	
380	340	440	400	UK/European Version
415	370	460	420	
440	390	500	460	
460	310	510	480	North American Version
480	320	530	500	

## ENVIRONMENT:

Operating ambient temperature range:  
0 to 60C

Rated ambient temperature:  
35C

Ambient temperature derating:  
Above 35C, derate linearly by 1% per degree C, to a maximum of 25% at 60C.

Overtemperature protection:  
A stack overtemperature thermostat is fitted to all fan cooled models, and should be used in the external control circuit to shut the drive down if the stack overheats.

Switching arrangement: Single pole normally closed.

Switch rating: 5 amps at 240 volts AC.

Storage temperature range:  
-40 to +70C.

Rated maximum altitude:  
1000m.

Altitude derating:  
Derate linearly by 1% per 100m above 1000m.

**Maximum relative humidity:**

85% (non-condensing).

**POWER CIRCUIT:**

**Armature converter:**

3 phase fully controlled six pulse thyristor bridge.

Available in both single ended (6M . . .) six thyristor and fully regenerative four quadrant (6M4Q . . .) inverse parallel twelve thyristor bridge configurations.

**Current limits:**

The maximum current limit of the converter is set by means of parallel-connected current transformer burden resistors on the thyristor power board.

The resistance required is as follows:

$$R = 1630/I \text{ max}$$

**Field supply:**

The internal field rectifier bridge fitted to modules up to 150 kW is rated for a continuous current of 5A. Larger modules require a separate, external field supply.

**Electrical isolation:**

Low voltage control electronics to AC supply and earth:

Impedance isolation of 1M ohm to electronics common.

If desired, the control electronics may be earthed.

**STATUS OUTPUTS:**

**Relay outputs:**

Two relay outputs are provided:

**Relay 1: Drive Ready.**

Switching arrangement: Single pole change over, energised when drive ready.

Terminals: 30 – pole  
31 – N/C  
32 – N/O

**Relay 2: Zero speed**

Switching arrangement: Single pole change over, energised at zero speed.

Terminals: 33 – pole  
34 – N/C  
35 – N/O

**Relay contact rating:**

Current carrying capacity: 110VAC 5A  
250VAC 2.2A  
24VDC 5A

Max. switching capacity: 550VA

**Open collector outputs:**

Five open collector status outputs are provided, requiring an external DC power supply. Two of these outputs are user-programmable.

Term. 25– Drive running

Term. 26– Drive at set speed

Term. 27– Alarm

Term. 28– ST1-user programmable by # 94

Term. 29– ST2-user programmable by # 95

All of the above status outputs may be alternatively configured in software for special applications (See description of parameters # 92 and # 169 in section 10).

## 2 Electrical Specification

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### Open collector output rating:

Max. applied voltage: +24VDC

Max. current sinking capacity: 150mA

### CONTROL INPUTS AND OUTPUTS:

#### Logic inputs:

Eight single bit (high/low) control logic inputs are provided, two of which are user-programmable. Logic inputs may be operated from open-collector outputs or volt-free contacts and are active when pulled low to electronics common (terminal 24).

Internal pull-up resistors are 10K to +24VDC.

Term. 16— Drive enable

Term. 17— Drive start permit (not stop)

Term. 18— FO-user programmable by #67

Term. 19— F1-user programmable by #68

Term. 20— F2 Inch reverse

Term. 21— F3 Inch forward

Term. 22— F4 Run reverse

Term. 23— F5 Run forward

#### Switching characteristics:

Maximum 'low' input: +2VDC

Minimum 'high' input: +4VDC

#### Analogue inputs:

Term. 1— Tachogenerator feedback input:

Type: Bipolar (Displayed with inverted polarity as parameter #3).

Scaling: Dependent on range selection (LK3, 4, 5 on MD20 board) and setting of maximum speed potentiometer (VR2 on MD20 board).

Internal resolution: 0.01%

Input impedance: 10–50 volt range — 6.2k ohms

40–200 volt range — 26.2k ohms

60–300 volt range — 36.2k ohms

Term. 5— Analogue speed demand:

Type: Bipolar

Scaling: +9.77V/0–9.77V DC = +999/0/–999 on #01

Internal resolution: 0.01%

Input impedance: 32k ohms

Term. 6— Programmable analogue input:

Type: Bipolar

Function programmed by: #69

Range programmed by: #193

Scaling: +9.77V/0/–9.77V DC = +999/0/–999 on #06 (#193=0)

+9.77V/0/–9.77V DC = +63/0/–63 on #06 (#193=1)

Internal resolution: 0.1%

Input impedance: 94k ohms

Term. 7— Software configurable general purpose input for use in special applications with optional second processor, or as a monitoring function:

Type: Unipolar

Scaling: 0/+9.77V DC = 0/+999 on #10

Internal resolution: 0.1%

Input impedance: 10k ohms

**Term. 8—** Software configurable general purpose input for use in special applications with optional second processor, or as a monitoring function:

Type: Unipolar

Scaling: 0/+9.77V DC = 0/+999 on #11

Internal resolution: 0.1%

Input impedance: 10k ohms

**Analogue outputs:**

Four analogue outputs are provided, one of which is user programmable.

**Term. 10—** Armature current:

Type: Unipolar

Scaling: 0/+6.52V DC = 0/+999 on #08

Maximum drive capability: 10mA

**Term. 11—** Speed feedback:

Type: Bipolar

Scaling: -9.77V/0/+9.77V DC = -999/0/+999 on #03

Maximum drive capability: 10mA

**Term. 12—** Armature voltage feedback:

Type: Bipolar

Scaling: -9.77V/0/+9.77V DC = -999/0/+999 on #03

Corresponding armature voltage or speed range depends on adjustment of VR1 on MD20 board.

Maximum drive capability: 10mA

**Term. 13—** Programmable analogue output:

Type: Bipolar

Function programmed by: #65

Scaling: -9.77V/0/+9.77V DC = -999/0/+999 on any selected parameter between #01 and #49

Maximum drive capability: 10mA.

**LED status indicators:**

9 LED status indicators, labelled and visible from the front of the module, are provided to indicate the following drive conditions:

Drive ready

Sustained overload alarm

Drive at zero speed

Run forward selected

Run reverse selected

Bridge 1 selected

Bridge 2 selected

Drive at set speed

Drive in current limit

The status LEDs (with the exception of the Drive Ready LED) may be alternatively configured in software for special applications. (See description of parameters #93 and #185 in section 9).

**Note:** the scaling of analogue inputs and outputs is dependent on component tolerances, and is typically subject to a variation of  $\pm 1\%$ .

### 3 Rating Table

Converter Model No.	Typical* D.C. Motor Rating at 400V Arm		Converter Type	Maximum Continuous Current Rating		Recommended Fuse Ratings		Typical** Cable Size AC input and DC Output	Cooling		Approx. Weight
	HP	KW		AC Input	DC Output	AC Input (HRC)	DC Output Fast Fuse † (500 DC rated)		Method	Air Flow	kg
6M7.5	10	7.5	Single Quad	21	25	32	Not Required	4mm <sup>2</sup>	Nat. Conv.	—	10
6M15	20	15	Single Quad	38	45	50	Not Required	6mm <sup>2</sup>	Nat. Conv.	—	
6M30	40	30	Single Quad	60	75	100	Not Required	25mm <sup>2</sup>	Nat. Conv.	—	
6M37.5	50	37.5	Single Quad	88	105	100	Not Required	35mm <sup>2</sup>	Nat. Conv.	—	14
6M56	75	56	Single Quad	130	155	160	Not Required	50mm <sup>2</sup>	Nat. Conv.	—	
6M75	100	75	Single Quad	175	210	200	Not Required	95mm <sup>2</sup>	Built-in Fan	—	21
6M4Q7.5	10	7.5	4 Quad	21	25	32	Not Required	4mm <sup>2</sup>	Nat. Conv.	—	11
6M4Q15	20	15	4 Quad	38	45	50	Not Required	6mm <sup>2</sup>	Nat. Conv.	—	
6M4Q30	40	30	4 Quad	60	75	100	Not Required	25mm <sup>2</sup>	Nat. Conv.	—	
6M4Q37.5	50	37.5	4 Quad	88	105	100	180	35mm <sup>2</sup>	Nat. Conv.	—	15
6M4Q56	75	56	4 Quad	130	155	160	240	50mm <sup>2</sup>	Nat. Conv.	—	
6M4Q75	100	75	4 Quad	175	210	200	315	95mm <sup>2</sup>	Built-in Fan	—	21
6MS125	168	125	Single Quad	292	350	355	Not Required	150mm <sup>2</sup>	Fan Cooled	7.6m <sup>3</sup> /min.	22
6MS150	200	150	Single Quad	350	420	450	Not Required	185mm <sup>2</sup>	Fan Cooled	7.6m <sup>3</sup> /min.	
6MS200	268	200	Single Quad	460	550	560	Not Required	300mm <sup>2</sup>	Fan Cooled		
6MS4Q125	168	125	4 Quad	292	350	355	550	150mm <sup>2</sup>	Fan Cooled	7.6m <sup>3</sup> /min.	23
6MS4Q150	200	150	4 Quad	350	420	450	650	185mm <sup>2</sup>	Fan Cooled	7.6m <sup>3</sup> /min.	
6MS4Q200	268	200	4 Quad	460	550	560	850	300mm <sup>2</sup>	Fan Cooled	17m <sup>3</sup> /min.	
6MD340	455	340	Single Quad	750	900	1000	Not Required	2×240mm <sup>2</sup>	Fan Cooled	20m <sup>3</sup> /min.	70
6MD450	600	450	Single Quad	1000	1200	1250	Not Required	2×400mm <sup>2</sup>	Fan Cooled	20m <sup>3</sup> /min.	
6MD750	1000	750	Single Quad	1540	1850	2000	Not Required	3×400mm <sup>2</sup>	Fan Cooled	20m <sup>3</sup> /min.	

\* This rating may be increased at higher armature voltage (see Recommended Motor Voltages in specification)

\*\* Cable size in 3 or 4 core PVC insulated armoured cable having copper-conductors and laid under defined conditions.

† DC Fuses should be fast, semiconductor type.

# 4 Dimensions

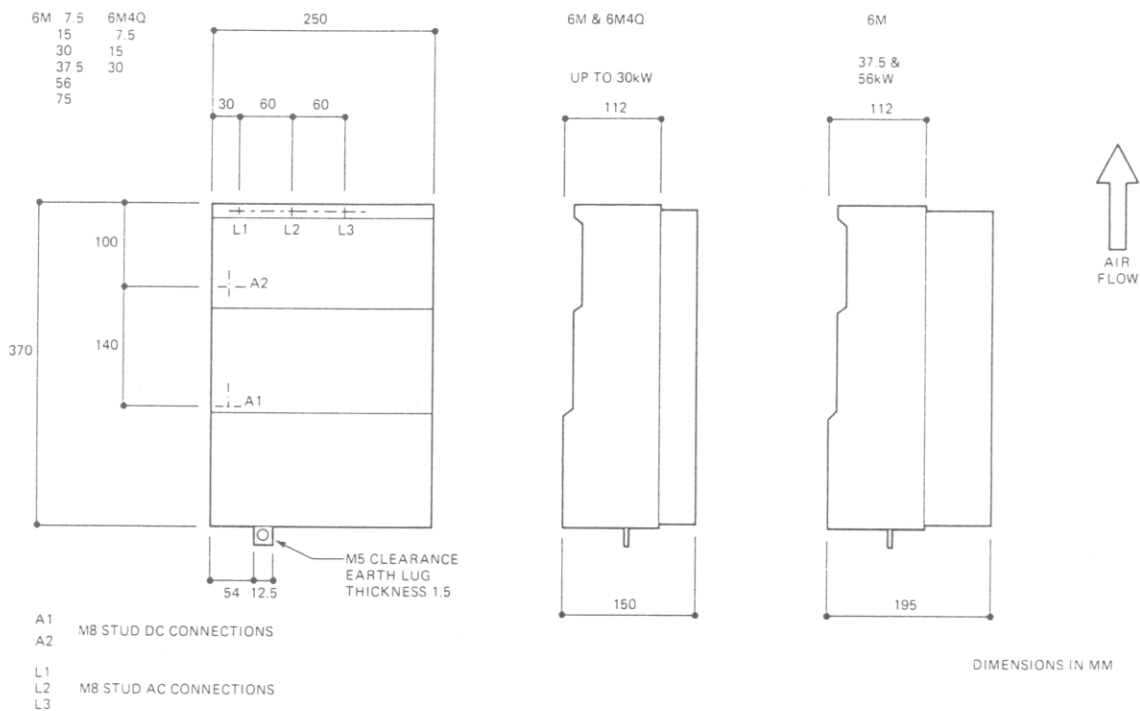


Fig 2. MENTOR 6M/6M4Q

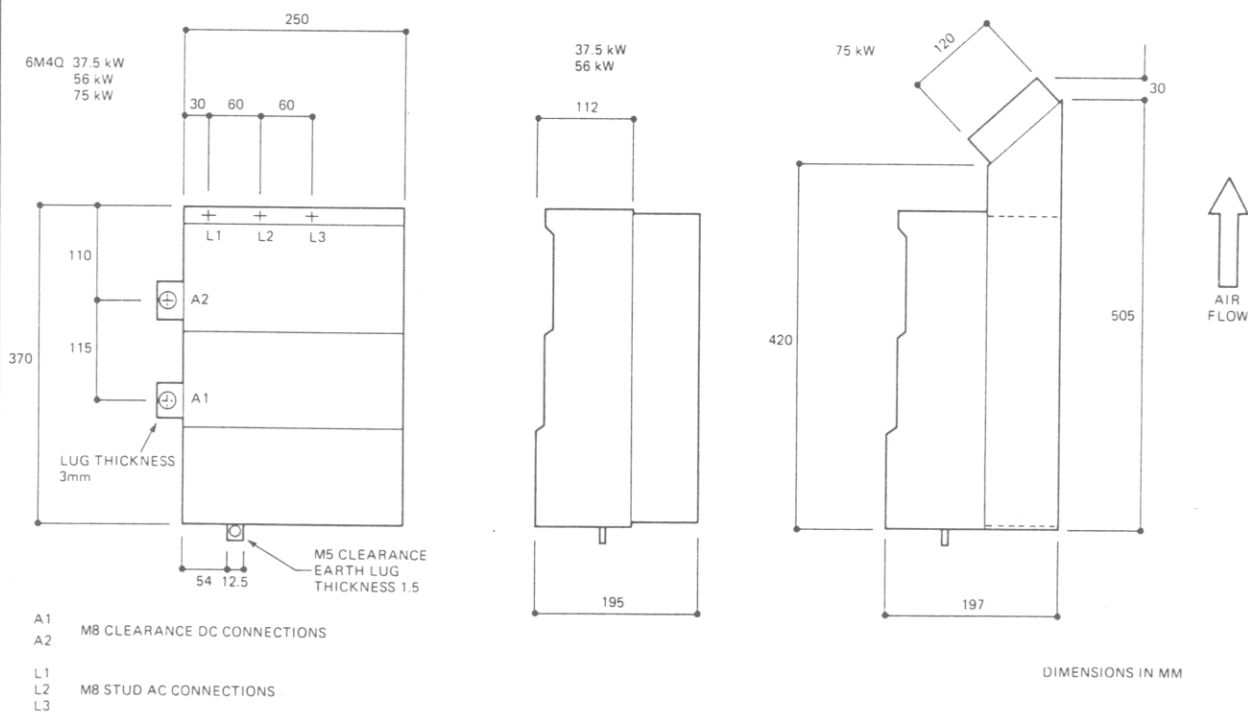


Fig 3 MENTOR 6M/6M4Q

## 4 Dimensions

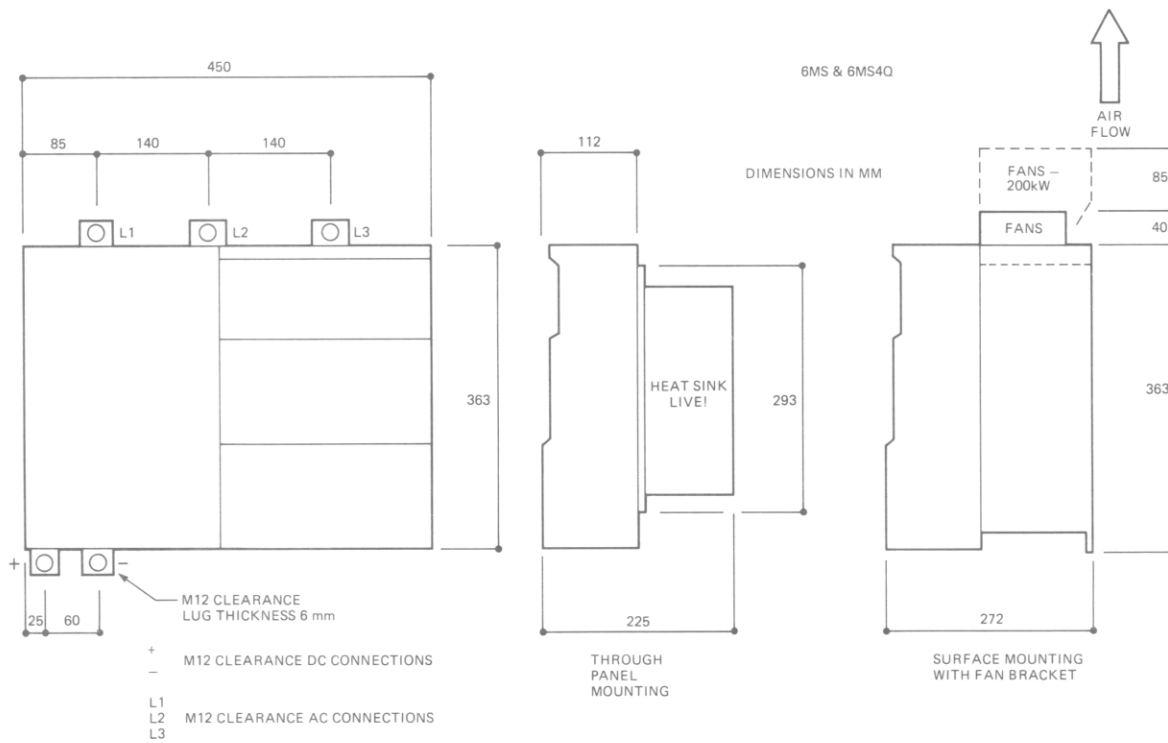


Fig. 4 MENTOR 6MS

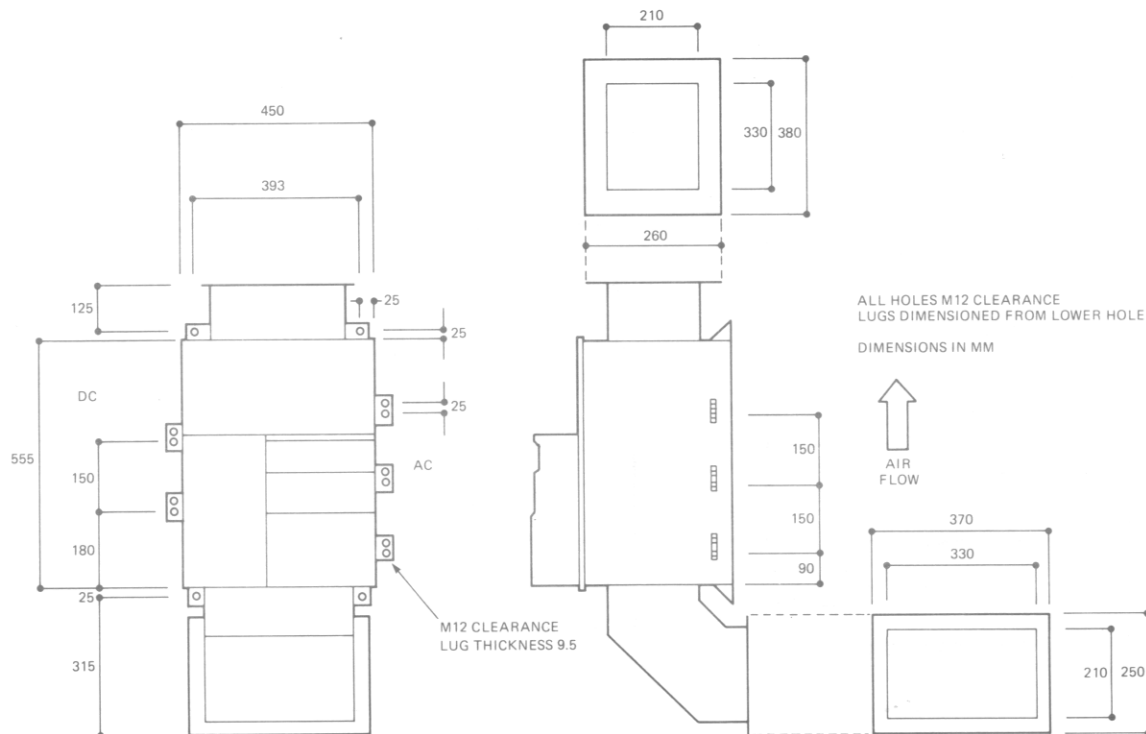


Fig. 5 MENTOR 6MD

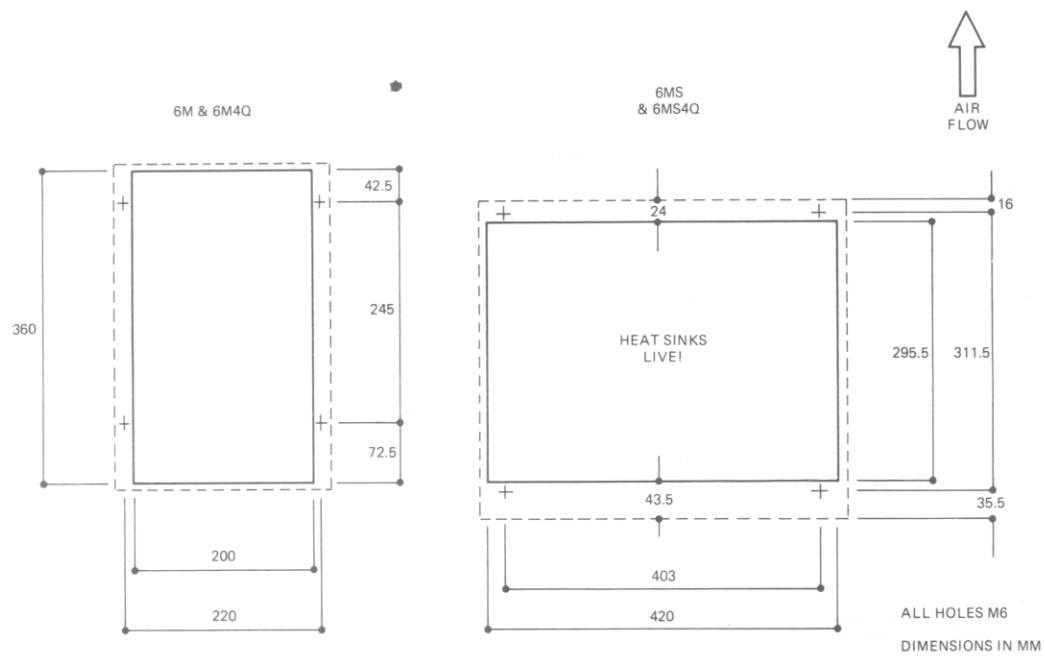


Fig. 6 MENTOR 6m and 6MS cut-outs

## 4 Dimensions

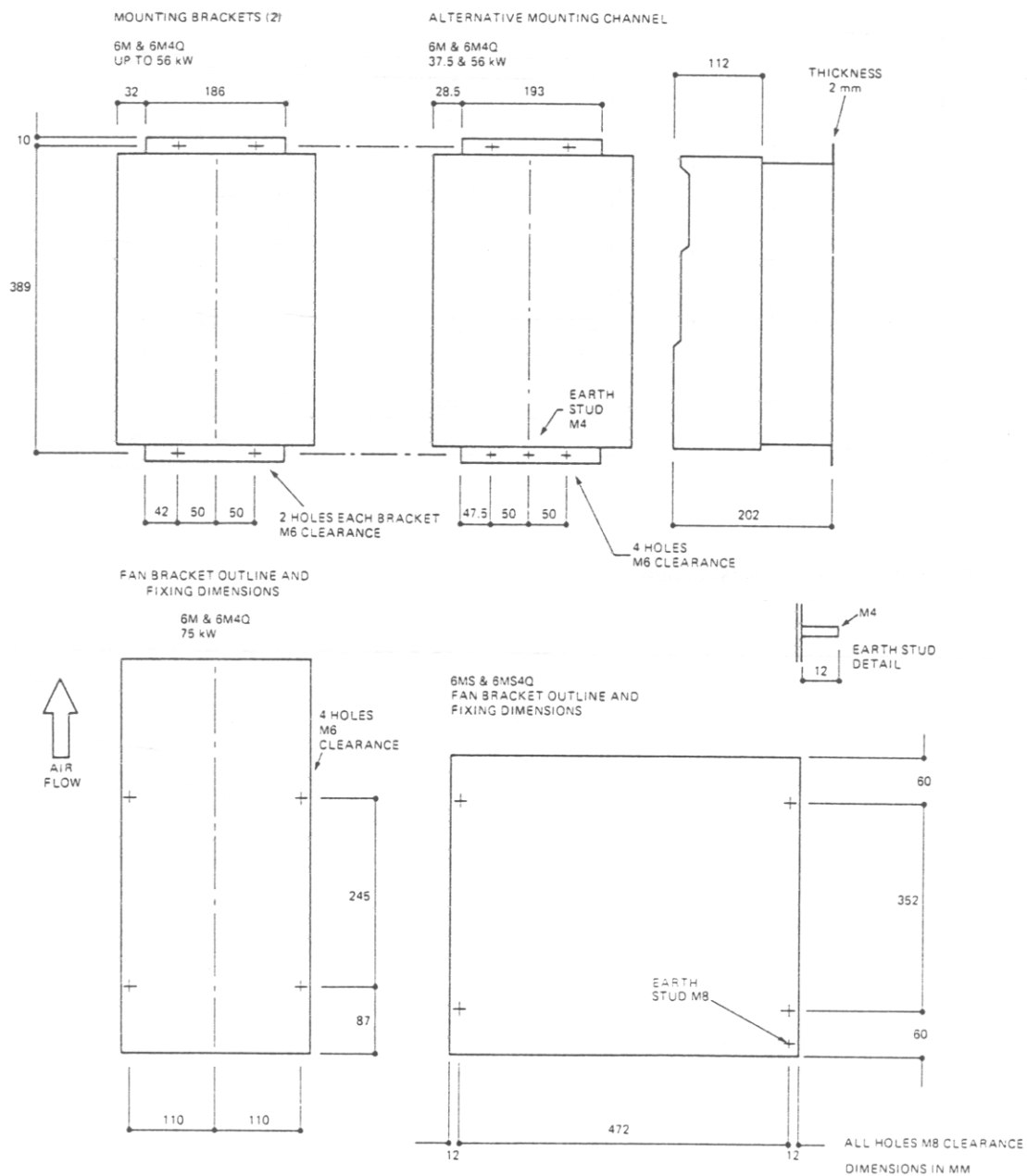


Fig. 7 MENTOR surface mounting arrangements and 6MS fan bracket (fixing holes)

## 5 Mounting the Converter

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Figures 2 to 6 show the overall and fixing dimensions of the four basic module types, details of which are as follows:

### 5.1 6M(30) — Fig. 2

This module type covers the following variants:

6M7.5    6M15    6M30  
6M4Q7.5    6M4Q15    6M4Q30

The above modules are cooled by natural convection and have an isolated heat sink which should be earthed for safety.

The converter may be mounted by either of the following methods:

- a) By means of the two fixing brackets supplied, as shown in Fig. 7.
- b) Through a panel cutout, as shown in Fig. 6, the heat sink projecting into a separate cooling duct.

### 5.2 6M(75) — Figs. 2 and 3

This module type covers the following variants:

6M37.5    6M56    6M75  
6M4Q37.5    6M4Q56    6M4Q75

The above modules have an isolated heat sink which should be earthed for safety and, with the exception of the fan-cooled 6M75 and 6M4Q75, are cooled by natural convection.

The naturally-ventilated converters may be mounted by the means described in 5.1a and b above, or alternatively by means of the optional surface mounting channel, as shown in Fig. 7. The fan-cooled converters are surface mounted by means of the fan housing. Fixing dimensions are shown in Fig. 7.

### 5.3 6MS — Fig. 4

This module type covers the following variants:

6MS125    6MS150    6MS200  
6MS4Q125    6MS4Q150    6MS4Q200

The above modules are cooled by forced ventilation and have **LIVE HEAT SINKS WHICH ARE AT LINE POTENTIAL**.

The converter may be mounted by either of the following methods:

- a) By means of the optional fan adaptor, as shown in Fig. 7.
- b) Through a panel cutout, as shown in Fig. 6, the heat sink projecting into a separate cooling duct which must be fan-cooled to ensure adequate air flow past the heat sink. (See Rating Table section 3, for air flow requirements).

### 5.4 6MD — Fig. 5

This module type covers the following variants:

6MD340 6MD450 6MD750

The above modules are cooled by forced ventilation and have **LIVE HEAT SINKS WHICH ARE AT LINE POTENTIAL.**

The converter is surface mounted as shown in Fig. 5, and features a built-in cooling duct with inlet and exhaust adaptors for forced ventilation. An exhaust fan is supplied as a loose item.



### **DANGER** ELECTRIC SHOCK RISK

Isolate electrical supply  
before working on this  
equipment.

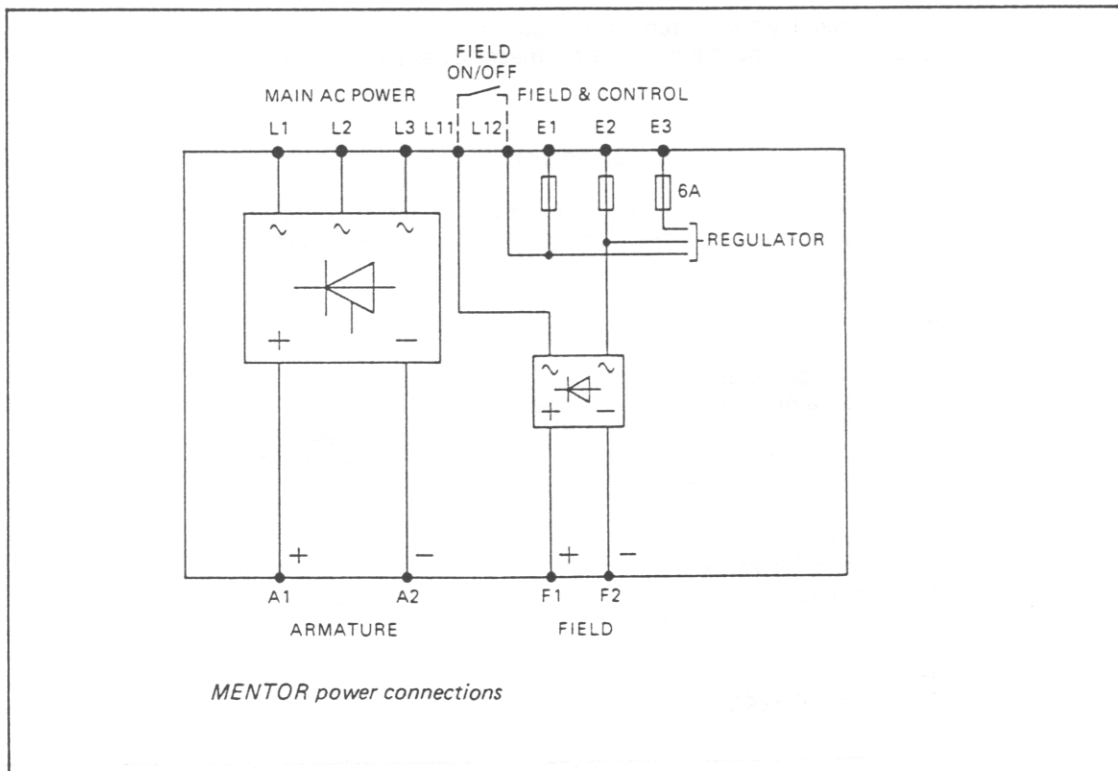
- L1 } main 3 phase AC supply  
L2 } to thyristor stack  
L3 }
- A1 } motor armature connections  
A2 }
- F1 } + motor field connections  
F2 } – (modules up to 150kW rating)
- E1 } auxiliary 3 phase AC supply to field rectifier  
E2 } and control electronics (phase rotation must  
E3 } be as L1, L2, L3) Fused internally at 6A
- L11 } facility for switching AC supply  
L12 } to internal field bridge by means of external contact

#### 41 Way terminal strip (MD20 board)

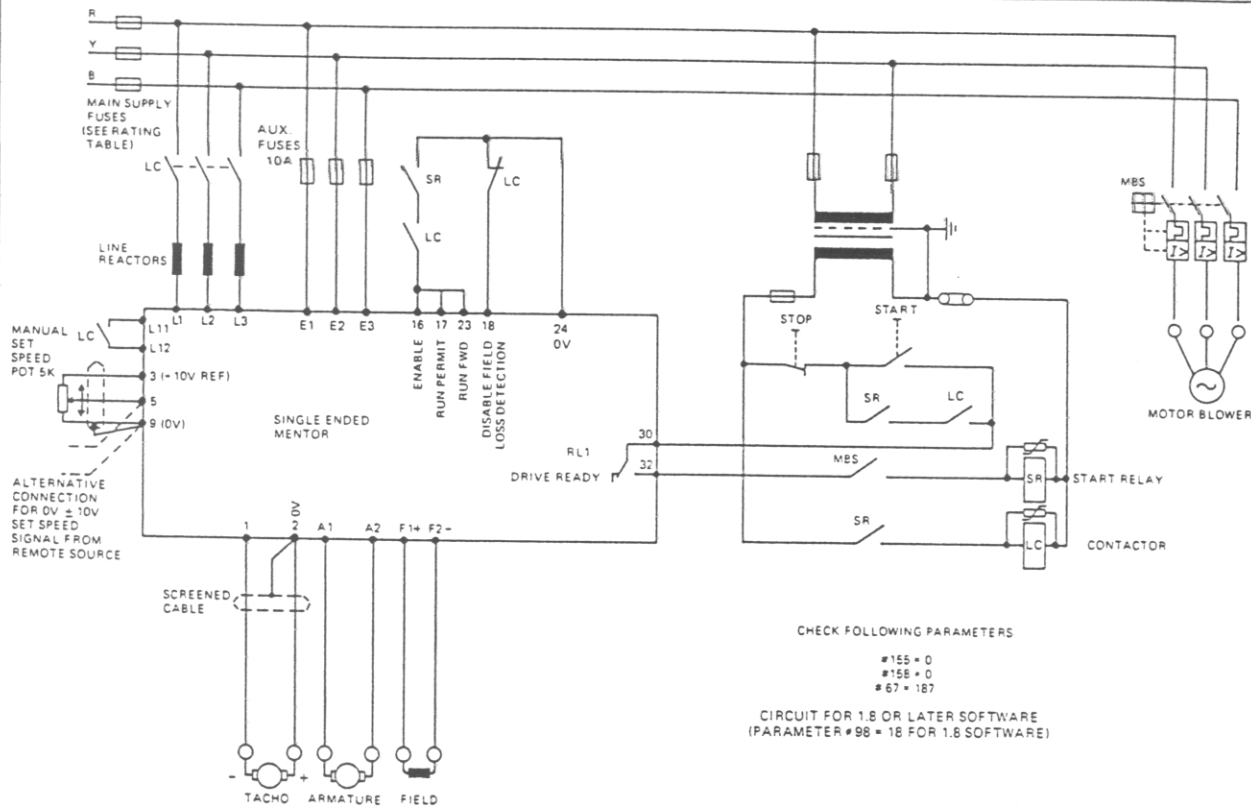
- 1 Signal input –) tacho connections. Polarity indicated for
  - 2 Signal 0V +) forward rotation. Use screened cable
  - 3 +10V reference supply
  - 4 –10V reference supply
  - 5 Analogue speed demand
  - 6 Programmable analogue reference
  - 7 G.P. analogue input 1 (field)
  - 8 G.P. analogue input 2 (temp.)
  - 9 Analogue 0V common
  - 10 Armature current
  - 11 Tacho feedback
  - 12 Armature voltage
  - 13 User programmable
  - 14 Reset
  - 15 Control +24V
- } Analogue inputs  
Use screened cable
- } Analogue outputs  
Use screened cable

## 6 Mentor Connections

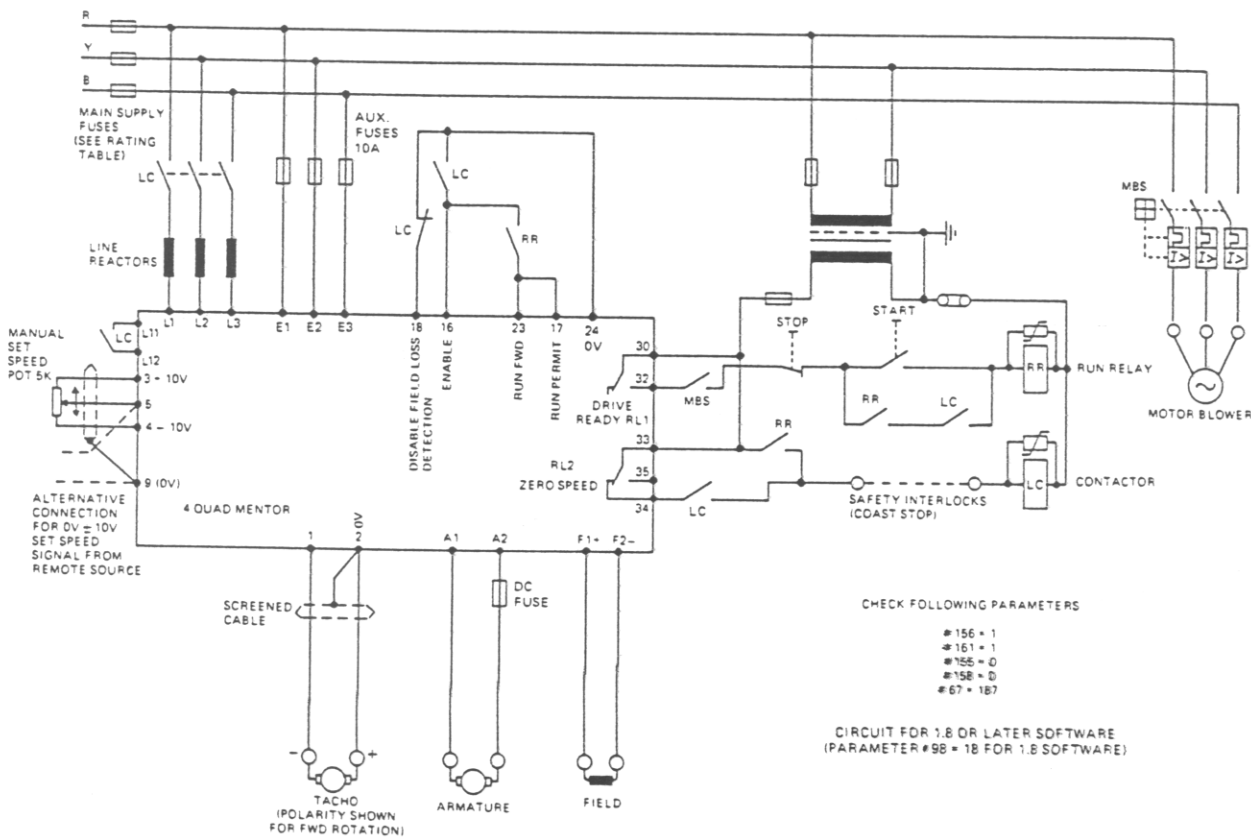
16	Enable	Control inputs
17	Drive start permit (not stop)	
18	Programmable logic input f0	
19	Programmable logic input f1	
20	Inch reverse	
21	Inch forward	
22	Run reverse	
23	Run forward	
24	Control 0V	
25	Drive running	Open collector status outputs
26	Drive at set speed	
27	Alarm — drive overloaded	
28	ST1 programmable status output	
29	ST2 programmable status output	
30	Pole	Relay 1: Drive fault/ drive ready
31	N/C	
32	N/O	
33	Pole	Relay 2: Zero speed
34	N/C	
35	N/O	
36	A	Encoder connections
37	B	
38	$\bar{A}$	
39	$\bar{B}$	
40	+5V	
41	0V	



# 6 Mentor Connections



Typical connection diagram for unidirectional drives



Typical connection diagram for 4-quadrant drives

### 7.1 MD1 LOGIC AND CONTROL CARD

This printed circuit card is the centre of the drive control system and features an 8053 or 8052 processor and various peripheral components. The five bus-connected components can readily be identified from the block diagram Fig. 8 and are as follows:

IC100 Display driver

IC200 Digital output driver

IC300 Analogue data unit

IC400 Digital input device + RAM + Counter

IC500 8053/8052 processor

Components associated with each of the above devices are identified by the first digit of the component number, eg R304 is part of the analogue input circuitry. The following is a description of each of the circuit groups and their functions.

#### DISPLAY CIRCUITS (IC100)

The seven-segment displays and the discrete LED indicators are driven by IC100 which is updated by the processor twice per supply cycle. The two seven-segment displays are multiplexed so that a complete refresh cycle of both displays occurs once per supply cycle. Note that the displayed data is updated only five times per second in order to make the display readable when monitoring fluctuating variables.

#### OUTPUT CIRCUITS (IC200)

This device selects the thyristors which are to be fired by the next trigger pulse. The outputs are therefore updated once every 60 degree period prior to generation of the trigger pulse.

Other signals updated by this device are the open-collector status outputs and the inputs to the digital-to-analogue converter which drives the programmable analogue output.

#### ANALOGUE INPUT CIRCUITS

The analogue-to-digital converter is a 10-bit, 16-channel device which accepts signals in the range 0 to +5V. The analogue references are all derived from a common +5V reference which, when applied to an analogue channel, will produce a converted result of +1023. In order to make the device usable for analogue signals in the range -10V to +10V, input circuits are provided which halve the input signal, inverting where necessary to give the 0 to +5V signal required. The maximum value that can be displayed is 999 which is slightly less than the full range of the converter (1023). Hence analogue voltages representing full scale are 9.77V, which is  $10V \times (999/1023)$ .

The current feedback signal undergoes a sample-and-hold operation to provide a stable value during the conversion. A peak detection circuit is used to ensure that the maximum value of the current pulse is measured when the armature current is discontinuous.

#### DIGITAL INPUT CIRCUITS AND SYNCHRONISATION (IC400)

Logic inputs for motion control arrive at IC400 together with various other inputs associated with drive protection.

Synchronisation is achieved by a system of two phase-locked loops using the unrectified output of the regulator supply transformer as a reference.

A comparator senses the crossover point of signals AC1 and AC2 from the transformer, and

produces a square wave of line frequency. The first phase-locked loop functions as a filter and reproduces the line frequency square wave, shifted in phase by 90 degrees and free of multiple edges caused by line transients. The second phase-locked loop is a frequency divider which produces clock pulses running at 1536 times line frequency. This provides the processor with a phase range reference with a resolution of 256 steps per 60 degree period and is available as a register in IC400.

The watchdog timer circuit permits controlled recovery from a hardware malfunction and is reset whenever a register of IC400 is accessed. If the processor were to cease executing its normal program IC400 would not be accessed in a regular pattern and the timer would reset the processor after approximately 0.3 seconds. The timer also sets a latch which is polled during the start-up sequence so that a reset generated by the watchdog timer can be detected as a fault condition.

### PROCESSOR AND PULSE GENERATION CIRCUITS (IC500)

The processor is an 8-bit microcontroller of the 8051 type. This may be a mask type (8052H or 8053H), or in some special cases an EPROM type (8752H or 8753H). In either case the parts are functionally identical.

The processor contains on-chip program memory, data memory, clock and timers. Hence most operations are carried out internally with bus operations being relatively infrequent.

The clock frequency for the processor is 12MHz which results in an instruction cycle time of 1 microsecond. This clock frequency does not directly affect any of the timing functions but it does limit the maximum line frequency that can be used. In the worst case this is 62Hz. Exceeding this frequency will cause either late pulse timings or mis-firings of thyristors.

The thyristor firing signals are blocks of pulses generated by a frequency divider driven by the address latch signal from the processor. This signal (2MHz) is divided by a factor of 100 by two decade counters resulting in a 20kHz pulse train with a mark/space ratio of 1 : 4. The second decade counter is gated by an output from the processor so that timing of the pulses can be controlled.

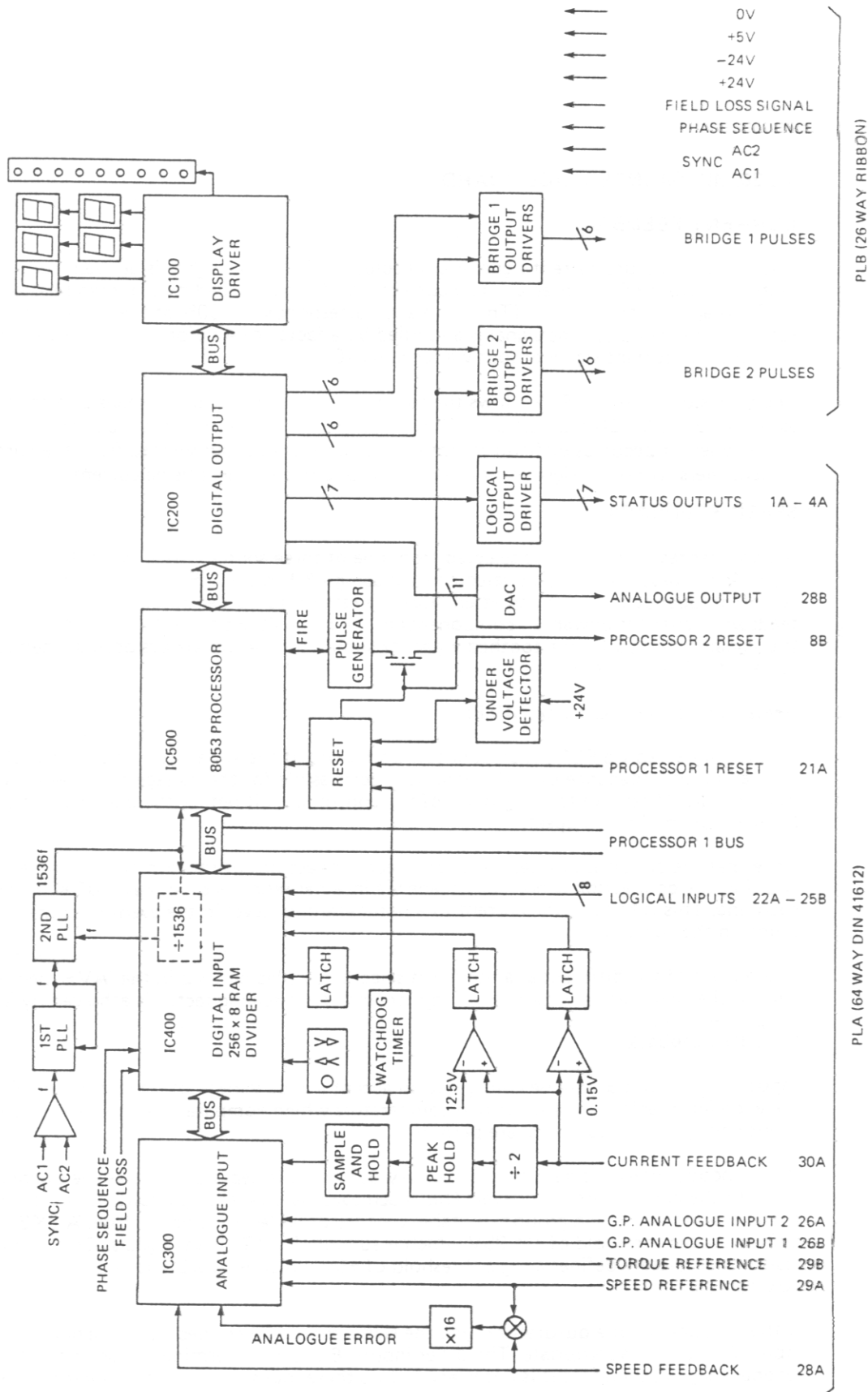


Fig. 8 MDI Logic and control board block diagram

### 7.2 MD20/MD20A INTERFACE BOARD

#### CURRENT FEEDBACK

The motor armature current signal is connected via PL1. This signal is derived from the rectified output of the three a.c. line current transformers scaled by a burden resistor so that 1.63V is applied at full scale. (This normally corresponds to 150% of the maximum continuous rating of the module). The signal is amplified by a factor of 4 before being passed to the MD1 card and the current signal output via terminal 10.

The provision of input IFB2 allows the gain factor to be doubled by means of a connection external to the MD20/MD20A card. This is sometimes necessary for low power (less than 10kW) drives where it becomes difficult to obtain the necessary output voltage from the current transformers without a significant error arising due to the magnetising current.

#### SPEED FEEDBACK

A signal representing speed is selected from one of three sources using movable links LK2 and LK7. A low pass filter may be selected by placing LK1 in the 'LF' position. This filter has a cut off frequency at 25 Hz and attenuates at a rate of 40 dB per decade. It is used when the feedback signal has unwanted components in the range 40 Hz to 400 Hz which can occur when the signal is derived from a toothed wheel or similar device and always occurs when armature voltage feedback is used.

#### a. Armature Voltage Feedback (AVF)

This is connected via PL1 which connects both sides of the armature to a differential amplifier with an input impedance of 1 Megohm. It is permissible for the voltage of either A1 or A2 to deviate  $\pm 600V$  relative to the ground of the control circuit before the operation of the differential amplifier is upset.

Note that the circuit is not designed for direct connections of the armature terminals to PL1 and that the connection is normally made via internal resistors of at least 100 K in series with each line. This is to limit the current to a non-hazardous level in the event of contact with any point on the control circuit.

The output of the differential amplifier is selected by placing LK2 in the 'AVF' position and LK7 in the right-hand position. Fine adjustment of the scaling factor is achieved by VR1.

#### b. Encoder Feedback

Inputs A,  $\bar{A}$ , B and  $\bar{B}$  may be configured to accept a wide variety of signal formats. Essentially the encoder interface consists of two comparators which compare A with  $\bar{A}$  and B with  $\bar{B}$ . Input voltages of up to + 15V are permitted.

If the encoder does not have complimentary outputs it is necessary to bias the unconnected input to the appropriate logic level. This is achieved by connecting a suitable resistor between  $\bar{A}$  and ground and  $\bar{B}$  and ground. Suitable pins are provided for this purpose. A 3K3 resistor defines a logic threshold of + 1.25V which is suitable for TTL level signals. Omission of the resistor completely defines a logic threshold of +5V which is suitable for encoder signals of 10V to 12V.

If the encoder is not a quadrature type the signal should be connected to channel A using inputs A and  $\bar{A}$  as appropriate. The other inputs, B and  $\bar{B}$ , determine the polarity of the feedback signal, therefore it is necessary to bias these inputs so that their levels are different.

## 7 Card Descriptions

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Encoder feedback via an on-board frequency-to-voltage converter, is selected by placing LK2 in the ENC position and LK7 in the right-hand position.

The F to V converter consists of a monostable (IC5) and a network of analog switches (IC4) which is used to generate a stream of constant width pulses triggered by each edge of the incoming waveforms. A D flip-flop is used to sense the direction implied by the phase relationship of the A and B channels. This in turn selects either the positive or the negative reference for the F to V converter by means of the analog switches. The output will therefore have a polarity corresponding to the direction of rotation if a quadrature output encoder is used.

The frequency range of the F to V converter is determined by the position of links LK8 and LK9 which determine the pulse width generated by the monostable. Further adjustment is provided by VR1.

For high-precision speed or position control, the encoder feedback may be used in digital form (i.e. without F to V conversion) by means of the MD22 encoder interface board which expands the capabilities of the MD21 second processor option board.

(The above is detailed in the Digital Speed and Position Loop application leaflet, which is available separately).

### c. Tachogenerator Feedback

Components LK3, LK4, LK5 and VR2 are used to vary the attenuation of the signal applied to terminals 1 and 2. Up to 300V at full speed may be applied but high input voltages lead to substantial dissipation in resistors R28 and R29 and this will cause errors due to thermal drift. The signal after scaling is selected by placing LK7 in the left-hand position and is also available as a buffered output from terminal 11.

### SPEED REFERENCE

The input on terminal 5 can be a  $-10/0/+10\text{V}$  signal or a 4/20 mA current loop. In the latter case it is necessary to place LK6 in the 4-20 mA position so that loop current flows through a burden resistor of 100 ohms and to place LK10 in the 4-20 mA position so that the appropriate scale and offset are applied. The result at TP7 is always a  $-10/0/+10\text{V}$  signal or 0/10V signal. By varying components R27, R64, R65 and R66 it is possible to accept other signal ranges.

### GENERAL PURPOSE ANALOG INPUTS

The signals connected to terminals 7 and 8 must be in the range 0 to +10V. The levels are attenuated by a factor of 2 before passing to the MD1 card. A 10K resistor between each input and ground makes possible the use of a contact between the input terminal and a higher voltage instead of a continuous analog signal.

### NON VOLATILE MEMORY

This device stores all details of the drive configuration when power is removed. The device actually contains two levels of memory, the first of which is a conventional static RAM which is not preserved on removal of power. This level is seen in the **memory map of the processor** on the MD1 card and all read and write operations access this level only. The second level is an image of the first level and is the non-volatile part proper. On power up this part is copied to the static RAM so at this instant the two levels have identical data even though they may have been different on power down. This means that if the drive configuration is changed by varying data in the first level the original setting can always be recalled by temporary removal of power. In order to permanently change the data in the second level it is necessary to initiate a non-volatile store cycle using pin 11. This operation is relatively long (20 ms) and is executed under control of the processor on the MD1 card.

## 7 Card Descriptions

### LOGIC INPUTS

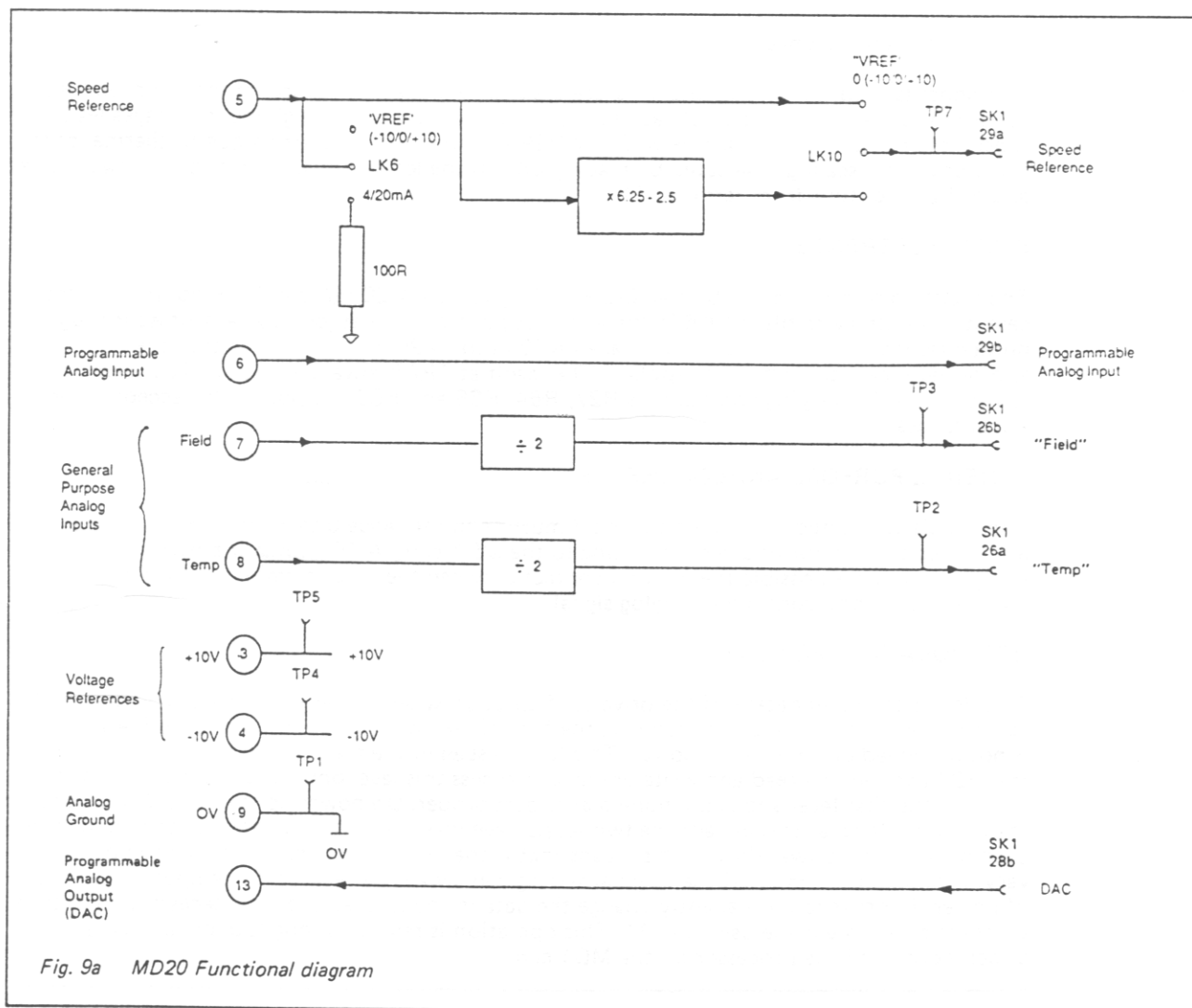
Terminals 16 to 23 are used to interface various logical signals to the 5V levels required by the MD1 card. Each input has a pull-up resistor to +24V followed by a 10 ms RC filter which in turn drives a Schmitt input buffer. The inputs, which have a logic threshold of approximately 2.0V, may be driven by open collector outputs, contact closures or signals from other logic families.

A variation of this input circuit is possible in which the links LK11 and LK18 are removed and opto isolators are fitted. This permits interfacing of 110V a.c. or d.c. control signals to the board.

### LOGIC OUTPUTS

These are open collector outputs having a maximum voltage rating of 24V and able to switch a maximum current of 150mA. They are intended to drive small relays and lamps, other open collector inputs or the inputs of other logic families.

Two relays allow currents of up to 5A to be switched at 110V a.c. (2.2A at 250V a.c.).



# 7 Card Descriptions

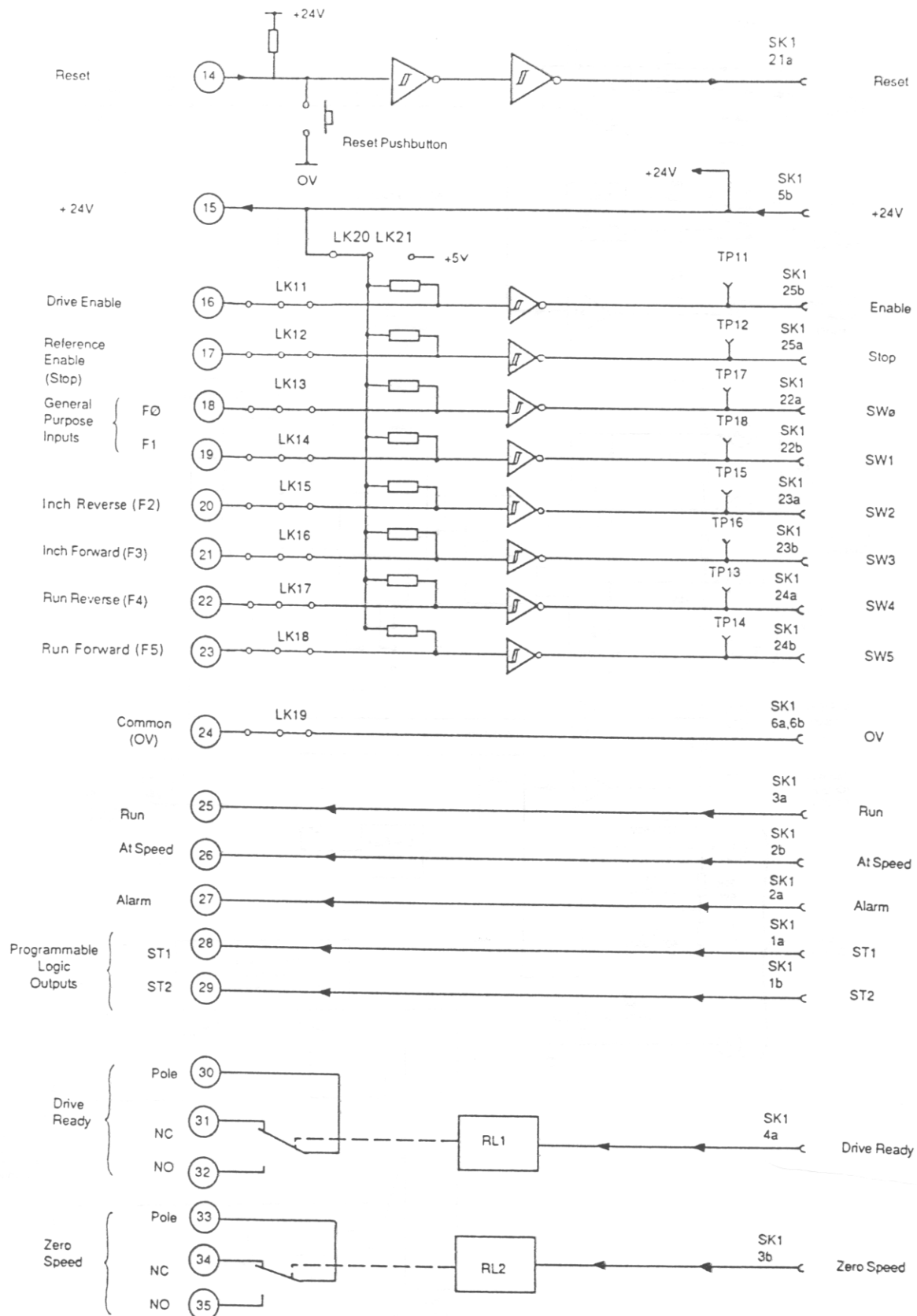


Fig. 9b MD20 Functional diagram continued

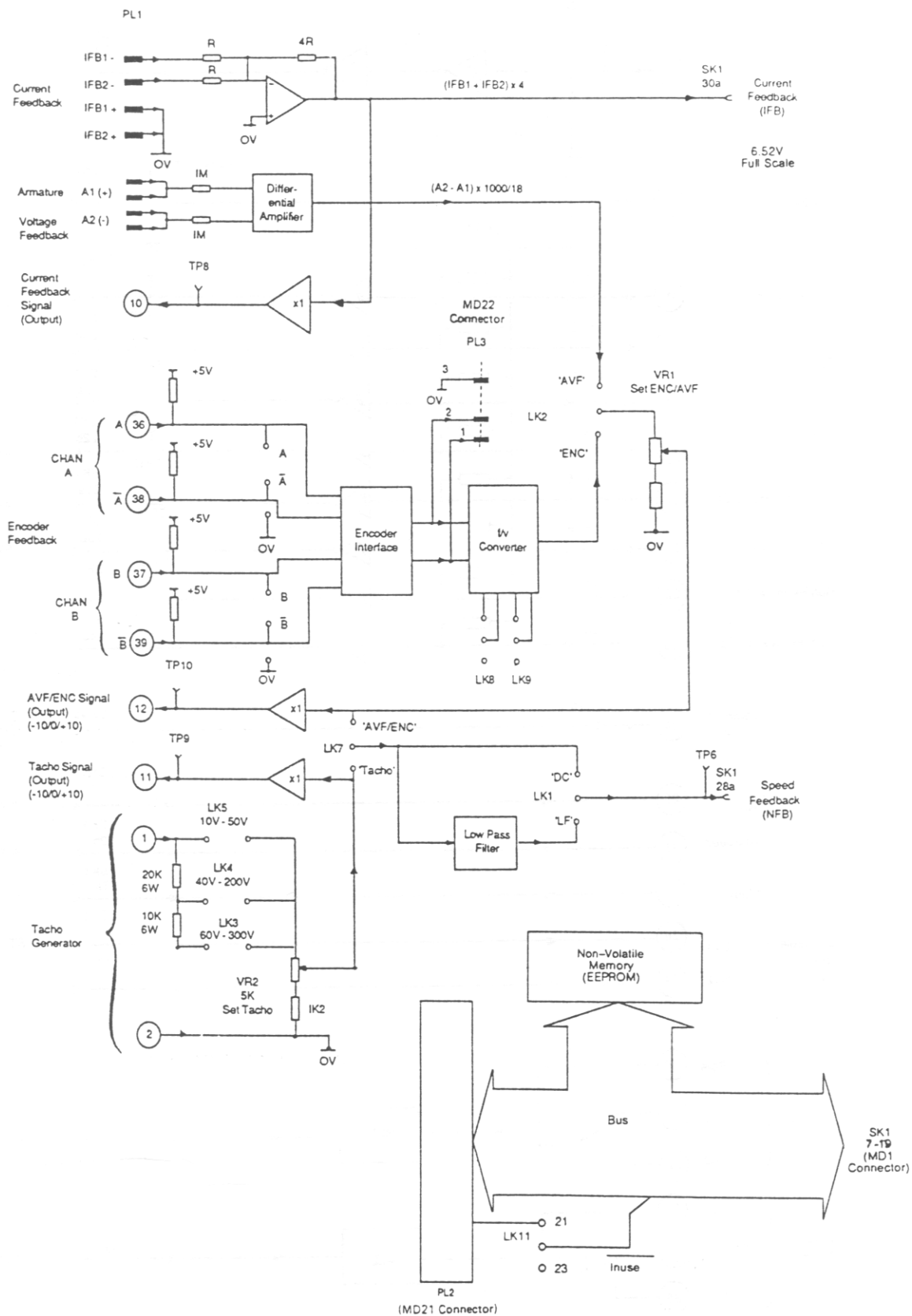


Fig. 9c MD20 Functional diagram continued

## 8 Keypad and Displays

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The Mentor keypad comprises three keys, a 'Mode' key, an 'Up' key and a 'Down' key. Associated with the keypad are two seven-segment LED numerical displays.

The 'Up' and 'Down' keys may be used to select any drive parameter for the purposes of monitoring or adjustment.

The two-digit display, labelled 'index', displays the parameter number, whilst the three-digit display, labelled 'data', displays the value of that parameter. Pressing the 'Up' key increments the parameter number and the 'Down' key decrements it.

To change the value of a read/write parameter from the keypad:

1. Select the required parameter number in the index display using the 'Up' and 'Down' keys.
2. Press the 'Mode' key. The LED indicator in the corner of the 'Mode' key will illuminate to indicate that the parameter change mode has been enabled.  
**Please Note!** If the 'Mode' key LED does not illuminate then check the following:
  - a) Parameter is read-only.
  - b) Level 1 security code has not been entered at #20. (See Section 9 — Mentor Security).
  - c) Level 2 security code has not been entered at #97. (See Section 9 — Mentor Security).
3. Use the 'Up' and 'Down' keys to change the value in the 'data' display. When complete press the 'Mode' key again to return to normal operation. The LED will be extinguished.

When parameter values are changed as described above the drive will respond immediately to the new values, but the original parameter values are restored on the next power-up cycle. This is a useful feature when experimenting with different drive parameter settings, as the original values can very easily be restored by a power-down/power-up cycle. (hard reset).

However, should the parameter changes need to be memorised, a non-volatile store procedure must be performed as follows:  
(continuing from 3. above).

4. Select parameter #150, and set to 1.
5. Wait three seconds.
6. Press the reset pushbutton accessible behind the front cover of the module.

### Note on use of Index display:

The display used to indicate parameter numbers is a two-digit device. When displaying a three-digit parameter the display shows only the last two digits. This apparent ambiguity is easily resolved by reference to the 'data' display.

All parameters below #100 are real or integer parameters with values in the range -999 to +999, 0 to +999 or 0 to +255, necessitating the use of all three digits of the 'data' display. (Leading zeros are not suppressed). However, parameters #100 to #197 are bit parameters with values of either 1 or 0 and using only the least significant digit of the 'data' display. (the other two digits being blanked). For example, parameters #55 and #155 would both appear as 55 on the 'index' display, but the 'data' display might typically show 040 in the first case, and 1 in the second, making it clear which parameter was actually being monitored.

### Level 1 Security:

During manufacture a set of default values is loaded into the non-volatile RAM and security is cleared to permit these parameters to be adjusted by the user.

After completion of adjustments, any further adjustments by unauthorised personnel can be prevented by activating the drive security feature as follows:

### CAUTION!

THE FOLLOWING PROCEDURE CAN ONLY BE REVERSED BY USE OF SPECIAL TEST EQUIPMENT OR A SUITABLE DEVICE CONNECTED TO THE SERIAL INTERFACE.

- 1—Set parameter # 20 to the desired three digit security code.
- 2—Set bit parameter # 150 to 1.
- 3—Set bit parameter # 170 to 1.
- 4—Press the reset button.

This also backs up the non-volatile RAM with any adjustments made to parameters. In order to carry out further changes it is necessary first to set parameter # 20 to the same value as the number entered in the above procedure. If set to any other number the adjustment mode cannot be activated by pressing the mode button, and all parameters therefore become effectively 'read only'.

Note that parameter # 170 cannot be changed back to 0 from the MENTOR keypad, thus preventing the security set procedure from being repeated.

### Level 2 Security:

Parameters other than basic drive setup adjustments are protected by a second level of security. To clear level 2 security in order to change the value of these parameters from the keypad, it is necessary to set parameter # 97 to 149.

# 10 Description of Parameters

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Please refer to control block diagram, Fig. 10, and parameter quick reference guide, Section 14.

Before attempting to adjust parameters, please refer to Section 9 for a description of Mentor Drive Security, and Section 8 for details of use of Keypad and Displays.

Drive parameters are of three basic types as follows:

## Real values:

A real value may be bipolar, in which case its value can range from -999 to +999 or it may be unipolar, in which case its value can range from 0 to +999. Internally within the drive it also has a fractional part. Real values are used to represent such variables as speed, current, overload threshold, phase angle etc.

## Integer values:

An integer value is one represented by an unsigned whole number. Integer values are used to represent such variables as loop gains, acceleration and deceleration rates, current taper slopes etc.

## Bit values:

A bit value is one which can have a value of either 1 or 0 and is therefore reserved for drive status variables which are either true or false, enabled or disabled, etc. Bit values are used to represent such variables as quadrant enable, ramp enable, drive at speed etc.

Each parameter falls into one of two further categories, as follows:

## Read-only values:

Read-only values are ones which are set or measured by the drive itself, either during power-up reset or continuously during drive operation. As the name implies these values may only be read, and allows us to MONITOR ONLY drive status and performance.

## Read/write values:

Read/write values are those which are set by keypad entry, serial interface communication or background programme execution to optimise the drive performance for a given application. Read/write values may also be monitored by means of the keypad and displays or via the serial interface to verify drive status and performance.

The following is a list and explanation of all drive parameters:

## GROUP A: REAL READ-ONLY PARAMETERS

**NOTE :** Please note that in the event of a drive fault trip the values of parameters in this group (#01 to #19) are frozen at the instant of tripping, and will remain in this condition until the drive is reset. This is a very useful aid to diagnostics.

### # 01 Analogue speed demand

Range: -999 to +999

Function: Displays the value of the analogue speed demand signal connected to terminal 5.

Scaling:  $-9.77V/0/+9.77V = -999/0/+999$

## # 02 Final digital speed demand

Range: -999 to +999

Function: Displays the final value of the digital speed demand, after scaling and ramp generation. This final value can originate from one of three sources dependent on the drive configuration:

### i. Terminal 5:

With #155=0 and #164=0, #02 is derived from #01 the analogue speed demand. However, #02 may differ from #01 for several reasons:

- a). The overall scaling factor set by #157 and #57 may be other than unity.
- b). An offset #23 may be present.
- c). The maximum or minimum speed parameters, #24 or #25 respectively, may be imposing a limit.
- d). The ramp hold #168 may be enabled, preventing #02 from achieving its final value.
- e). The ramp is still in progress following a change in reference.
- f). Terminal 17 open circuit, giving a stop command.

### ii. Internal 'Run' speed demand # 22:

With #155=1 and #164=0, #02 is derived from #22 the internal run speed demand, but #02 may differ from #22 for four possible reasons:

- a). The maximum or minimum speed parameters, #24 or #25 respectively, may be imposing a limit.
- b). The ramp hold #168 may be enabled, preventing #02 from achieving its final value.
- c). The ramp is still in progress following a change in reference.
- d). Terminal 17 open circuit, giving a stop command.

### iii. Internal 'Inch' speed demand # 21:

With #164=1, #02 is derived from #21 the internal inch speed demand, but #02 may differ from #21 for four possible reasons:

- a). The maximum or minimum speed parameters, #24 or #25 respectively, may be imposing a limit.
- b). The ramp hold #168 may be enabled, preventing #02 from achieving its final value.
- c). The ramp is still in progress following a change in reference.
- d). Terminal 17 open circuit, giving a stop command.

## # 03 Speed feedback

Range: -999 to +999

Function: Displays the value of the analogue speed feedback signal, derived either from the motor tachogenerator connected to terminals 1 and 2, or from the motor armature voltage, or from an encoder (depending on the setting of links LK2 and LK7 located on the MD20 board). This signal is used for the closed loop speed control of the motor.

Scaling: Depends on setting of links LK3, LK4, LK5 if tacho feedback selected, and setting of maximum speed potentiometer, VR1 or VR2, depending on feedback source.  
For further information on selection and scaling see Section 7.

## 10 Description of Parameters

---

### # 04 Digital speed error

Range: -999 to +999

Function: Displays the speed error, which is the difference between the speed demand (# 16) and the speed feedback (# 03). The number displayed is the actual digital speed difference.

Definition:

$$\# 4 = (\# 16 - \# 03)$$

### # 05 Speed error integral

Range: -999 to +999

Function: Displays the speed error integral term, the result of integrating the speed error after it has been amplified by the speed loop integral gain.

### # 06 Bipolar programmable analogue input

Range: -999 to +999 or -63 to +63

Function: Displays the value of the analogue reference connected to terminal 6. The function of this parameter can be programmed using parameter # 69. It can be programmed to control any of the parameters # 21 to # 30 inclusive, by setting # 69 to the appropriate parameter number then pressing the reset pushbutton. To make this a permanent feature a non-volatile update should be performed (see # 150).

By setting the fine control bit # 193=1, the value of this parameter is divided by a factor of 16 without loss of the 10-bit resolution, thereby facilitating fine control over a reduced range.

Scaling:  $-9.77\text{V}/0/+9.77\text{V} = -999/0/+999$  (# 193=0)  
or:  $-9.77\text{V}/0/+9.77\text{V} = -63/0/+63$  (# 193=1)

### # 07 Current demand

Range: -999 to +999

Function: The current demand signal is the controlling input to the current loop algorithm when in speed control mode. It is the result of the speed loop algorithm acting on the speed error signal # 04.

### # 08 Current feedback

Range: 0 to +999

Function: This is the motor current feedback signal derived from AC current transformers on each of the phases feeding the stack. It is used for the closed loop control of the armature current. An amplified and buffered signal is output via terminal 10.

Scaling: Current feedback 0 to +1.6V = 0 to +999  
Output signal (term. 10) 0 to +6.66V = 0 to +999

## 10 Description of Parameters

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### # 09 Phase angle demand

Range: 0 to +768

Function: The phase angle demand is the input to the firing pulse generation algorithm. It is the result of the current loop algorithm acting on the current demand signal # 07 when in speed control or the torque demand signal # 28 when in torque control. (# 09=768 means that the firing pulses are fully phased back).

Scaling:  $0/180 \text{ degrees} = 0/+768$   
or (phase angle) = # 09x60/256

### # 10 Unipolar analogue input 1

Range: 0 to +999

Function: Displays the value of the analogue signal connected to terminal 7.  
# 10 can be used as a general purpose analogue input for monitoring or for processor 2 special applications.

Scaling: 0 to +9.77V DC = 0 to +999

### # 11 Unipolar analogue input 2

Range: 0 to +999

Function: Displays the value of the analogue signal connected to terminal 8. This parameter can be used as a general purpose analogue input for monitoring or processor 2 special applications.

Scaling: 0 to 9.77V DC = 0 to +999

### # 12 Analogue error

Range: -63 to +63

Function: This parameter is the result of an analogue summing of the speed reference (terminal 5) with the scaled tachometer speed feedback signal, (the amplifier having a gain of 16) followed by A to D conversion.

It is used to derive a high-resolution speed feedback signal, which is used in place of # 3 as an input to the speed loop algorithm when the speed error is small, giving precise speed regulation. The logic which selects the appropriate feedback according to the magnitude of the speed error is the analogue error window flag, # 128. This parameter is described in detail elsewhere.

### # 13 Speed reference (pre-ramp)

Range: -999 to +999

Function: This parameter displays the speed reference immediately before the ramp, but after the various selection and conditioning operations. (eg. scaling, offset, forward/reverse etc.). Please refer to the control block diagram, Fig. 10.

## 10 Description of Parameters

---

### # 14 Sync. staircase

Function: This is a six-step staircase waveform which is used to synchronise and distribute the thyristor firing pulses. It may be monitored by means of an oscilloscope connected to terminal 13, the programmable analogue output, with # 65 set to 14.

### # 15 Torque control variable

Range: -999 to +999

Function: In speed control mode, this is the limiting value of current demand, and is equal to the result of the speed-dependent current taper calculation. (See parameters # 30, # 26, # 27).

### # 16 Speed loop variable

Range: -999 to +999

Function: Displays the value of the digital speed demand input to the speed loop algorithm. The source of this value depends on the states of the reference T switch, # 192, and the reference S switch, # 189 as follows:

# 189	# 192	Source
0	0	# 17 - IR compensation
1	0	# 29 - Hard (direct) speed ref.
0	1	# 2 + # 17 - Ramped speed ref. + IR comp.
1	1	# 2 + # 29 - Ramped speed ref. + hard speed ref.

### # 17 IR Compensation term

Range: -125 to +125

Function: With # 189 set to 0, this parameter provides a correction for the resistive volt drop of the motor armature, thereby improving speed regulation in AVF mode. Derived from IR compensation factor # 58 and speed error integral # 05. Please refer to # 58 for further details.

Definition:

$$\# 17 = \# 05 \times \# 58 / 2048$$

### # 18 Measured acceleration

Range: -999 to +999

Function: Not implemented. Reserved for special applications.

# 10 Description of Parameters

---

## # 19 Overload integration register

Range: 0 to +999

Function: Displays the value of the integrating current-time overload function. When the value reaches the trip point determined by # 33 (overload level) and # 63 (overload integration time) an overload trip occurs.

Where nuisance tripping is experienced, monitoring of this parameter can provide useful information about drive loading and duty cycle.

(See also integrating overload threshold # 33, integrating overload time # 63 and sustained overload # 122).

The overload trip point is defined as:

$$\text{Trip Point} = (1000 - \# 33) \times \# 63 / 409.6$$

## GROUP B: REAL READ/WRITE PARAMETERS

### # 20 Security level 1 key

Range: 0 to +999

Function: Prevents the changing of any parameters from the on-board key pad until the correct code is entered. However, the key pad and display still function in a read-only mode allowing all drive parameters to be monitored.

Refer to Mentor Security, Section 9, for description of level 1 and level 2 security and setting procedures.

Standard default setting: 000

### # 21 Internal 'inch' speed demand

Range: -999 to +999

Function: An internal speed demand value selected as the speed reference when # 164=1. (This reference is inverted when 'inch reverse' is selected).

Standard default value: +050

### # 22 Internal 'run' speed demand

Range: -999 to +999

Function: An internal 'run' speed demand value is selected as the speed reference when # 164=0 and # 155=1. (This reference is inverted when 'run reverse' is selected).

Standard default value: +300

# 10 Description of Parameters

---

## # 23 Analogue reference offset

Range: -999 to +999

Function: An additional speed demand term added to the analogue input # 01 after scaling. (Useful as a speed trim input – from a dancer arm, for example. The input would be connected to terminal 6 and # 69 programmed to control # 23).

Defined by:

$$(\text{speed demand}) = (\# 01 (\# 157 + (\# 57/256))) + \# 23$$

Standard default value: 000

## # 24 Maximum speed

Range: -999 to +999

Function: Determines the maximum (or most positive) limit of speed demand passed to the speed loop algorithm, and causes any demand for speed greater (or more positive) than that limit to be ignored. If this limit is negative, it functions as a minimum speed limit in the reverse direction.

Standard default value: +999

## # 25 Minimum speed

Range: -999 to +999

Function: Determines the minimum (or most negative) limit of speed demand passed to the speed loop algorithm, and causes any demand for speed less (or more negative) than that limit to be ignored. If this limit is positive, it functions as a minimum speed limit in the forward direction.

Standard default value: 000 – 1Q  
-999 – 4Q

## # 26 Speed level 1 sense

Range: 0 to +999

Function: Sets a value of speed feedback threshold beyond which # 126 is set to 1. Mainly used, in conjunction with # 59, for speed profiling of the current limit setting, to limit the maximum available current at high speed with regard to the limits of commutation of the motor. In this instance it defines the motor speed at which the armature current begins to decrease at a rate set by the value of # 59, the taper 1 slope.  
# 26 should be set to +999 if current limit taper is not required.

Standard default value: +999

### # 27 Speed level 2 sense

Range: 0 to +999

Function: Sets a value of speed feedback threshold beyond which # 127 is set to 1. Mainly used, in conjunction with # 60, for speed profiling of the current limit setting, to limit the maximum available current at high speed in the same way as # 26. In this instance it defines the motor speed at which the armature current begins to decrease at a second rate set by the value of # 60, the taper 2 slope.  
# 27 should be set to +999 if current limit taper is not required.

Standard default value: +999

### # 28 Internal torque reference

Range: -999 to +999

Function: This value is the input to the current loop algorithm when operating in a torque control mode. It acts as a clamp on the output of the speed loop algorithm when operating in a torque control mode with speed override.

Standard default value: 000

### # 29 Hard speed reference

Range: -999 to +999

Function: This value is a direct input to the speed loop algorithm when # 189=1, bypassing the scaling, reference limit and ramp functions, which may themselves be disconnected from the speed loop input by setting # 192=0.  
Refer to speed loop variable # 16 for further details.

Controlled in default by programmable reference # 6 (terminal 6) via # 69.

### # 30 Current taper start point

Range: 0 to +999

Function: This parameter provides symmetrical current limiting for bridge 1 and bridge 2, and is the datum level from which the current taper functions operate. (See # 26 and # 27). It is used in applications where motor kW rating is somewhat less than that of the converter, as an alternative to the changing of fixed current feedback burden resistors.

Standard default value: +999

### # 31 Bridge 1 current limit

Range: 0 to +999

Function: Determines the maximum limit of current demand passed to the current loop algorithm when bridge 1, the positive bridge, is conducting, and causes any demand for current in excess of that limit to be ignored.

Standard default value: +999

## 10 Description of Parameters

---

### # 32 Bridge 2 current limit

Range: 0 to +999

Function: Determines the maximum limit of current demand passed to the current loop algorithm when bridge 2, the negative bridge, is conducting, and causes any demand for current in excess of that limit to be ignored.

Standard default value: 000 – 1Q  
+999 – 4Q

### # 33 Integrating overload threshold

Range: 0 to +999

Function: Sets the threshold of armature current feedback beyond which the current-time integrating overload algorithm integrates upwards.

Standard default value: +700

# 34 to # 49 are not currently used.

## GROUP C: INTEGER READ/WRITE PARAMETERS

### # 50 Failure mode

Range: 118 to 126

Function: Indicates the cause of a drive fault trip by displaying the appropriate fault code. In the event of a drive fault trip the index display automatically indicates # 50, the failure mode parameter, and the data display shows a fault code which identifies the fault which caused the trip. When the drive is healthy # 50 displays a fault code of 000. # 50 is monitored by the processor, and the drive is immediately tripped if a non-zero value appears via the serial interface or processor 2 special application software.

Furthermore, in the event of a drive fault trip, the values of # 01 to # 19 are frozen at the instant of tripping and remain in this condition until the drive is reset. This is a very useful aid to diagnostics.

(For further information on fault codes see fault status bits # 118 to 126 and 131).

Standard default value: 000

### # 51 Forward acceleration ramp time

Range: 0 to 255

Function: Sets the maximum positive rate of change for positive values of parameter # 02, and hence the acceleration rate of the motor in the forward direction. (Provided this is within the current limit capacity of the drive).

The number displayed is the time taken in seconds if # 191=0, or in tenths of seconds if # 191=1, for # 02 to increase from 0 to +999.

Please refer to parameters # 167 and # 168 as these can both override the ramp function.

Standard default value: 050

## 10 Description of Parameters

---

### # 52 Forward deceleration ramp time

Range: 0 to 255

Function: Sets the maximum negative rate of change for positive values of parameter # 02, and hence the deceleration rate of the motor in the forward direction. (Provided this is within the current limit capacity of the drive).

The number displayed is the time taken in seconds if # 191=0, or in tenths of seconds if # 191=1, for # 02 to decrease from +999 to 0.

Please refer to parameters # 167 and # 168 as these can both override the ramp function.

Standard default value: 050

### # 53 Reverse deceleration ramp time

Range: 0 to 255

Function: Sets the maximum positive rate of change for negative values of parameter # 02, and hence the deceleration rate of the motor in the reverse direction. (Provided this is within the current limit capacity of the drive).

The number displayed is the time taken in seconds if # 191=0, or in tenths of seconds if # 191=1, for # 02 to increase from -999 to 0.

Please refer to parameters # 167 and # 168 as these can both override the ramp function.

Standard default value: 000 – 1Q  
050 – 4Q

### # 54 Reverse acceleration ramp time

Range: 0 to 255

Function: Sets the maximum negative rate of change for negative values of parameter # 02, and hence the acceleration rate of the motor in the reverse direction. (Provided this is within the current limit capacity of the drive).

The number displayed is the time taken in seconds if # 191=0, or in tenths of seconds if # 191=1, for # 02 to decrease from 0 to -999.

Please refer to parameters # 167 and # 168 as these can both override the ramp function.

Standard default value: 000 – 1Q  
050 – 4Q

### # 55 Speed loop proportional gain

Range: 0 to 255

Function: This is the factor by which the speed error is multiplied in the speed loop algorithm to produce the proportional speed error correction term.

Increasing this value increases both the system damping and the transient speed response. However, if taken too far the drive will become unstable. The optimum setting is therefore as large as the system response demands without the onset of instability.

Speed loop optimisation is achieved by the combined effect of parameters # 55 and # 56.

Actual gain = # 55/8

Standard default value: 080

---

## 10 Description of Parameters

---

### # 56 Speed loop integral gain

Range: 0 to 255

Function: This is the factor by which the integral of the speed error is multiplied in the speed loop algorithm to produce the integral speed error correction term. The integral speed error correction term ensures zero speed error during steady state load conditions, and increasing its value results in a more rapid recovery after a transient disturbance such as a sudden load change. However, if this value is increased too far the system tends to become oscillatory. The optimum setting is therefore as large as the system response demands without the onset of instability. Speed loop optimisation is achieved by the combined effect of parameters #55 and #56.

Actual gain =  $6f \cdot (\#56/256)$  where  $f$  is the supply frequency.

Standard default value: 040

### # 57 Analogue reference scale factor

Range: 0 to 255

Function: This value is used in conjunction with # 157 to set the scale factor by which the analogue speed reference # 01 is multiplied to generate the final digital speed reference.

Definition:

$(\text{speed demand} = \#01(\#157 + (\#57/255)))$

Standard default value: 000

### # 58 IR compensation factor

Range: 0 to 255

Function: This factor is used to calculate the IR compensation term # 17 which compensates for the resistive volt drop of the motor armature, thereby improving low speed control in AVF mode. Note that IR compensation is a form of positive feedback, and can give rise to instability if set too high. Furthermore, modern laminated-frame motors typically have a rising load-speed characteristic, unsuited to AVF with IR compensation. A compound-wound machine with a flat characteristic would be more suitable in many AVF applications.

Definition:

$(\text{IR comp. term}) \#17 = \#05 \times \#58/2048$

Standard default value: 000

## 10 Description of Parameters

---

### # 59 Current taper 1 slope

Range: 0 to 255

Function: Sets the rate of change of armature current limit with respect to speed above the speed threshold set by 'speed level 1 sense' # 26 in either direction of rotation.

Taper 1 slope is given by: # 59/128

Standard default value: 000

### # 60 Current taper 2 slope

Range: 0 to 255

Function: Sets the rate of change of armature current limit with respect to speed above the speed threshold set by 'speed level 2 sense' # 27 in either direction of rotation.

Taper 2 slope is given by: # 60/128

Standard default value: 000

### # 61 Current slew rate limit

Range: 0 to 255

Function: Limits the maximum rate of change of current demand to the current loop algorithm. This is a useful feature when retrofitting a modern thyristor converter in place of an MG set for example, to control an old design of non-laminated motor intended for use on a pure DC supply, as it provides a simple means of limiting the maximum rate of change of armature current to a level at which the interpole system is effective. If the armature current were allowed to change too fast the inherent lag of the interpole flux could, in extreme cases, result in a flashover.

Defined as: (slew rate in amps/s) = (maximum current limit in amps) x 6f. (# 61/256)

where f is the supply frequency.

Standard default value: 040

### # 62 Current loop gain

Range: 0 to 255

Function: The factor by which the current error signal is multiplied prior to calculation of phase angle (#09).

The optimum value may be found by slowly increasing the current limit # 30, from zero with the motor stalled, until continuous conduction occurs. The value of # 62 is then calculated as follows:

$$\# 62 = 25500 / \# 30$$

Standard default value: 050

## 10 Description of Parameters

---

### # 63 Integrating overload time

Range: 0 to 255 seconds

Function: The integrating period of the current-time overload function, from the start of a full-scale current limit overload (#07 = 999) to the point at which the drive is tripped.

Standard default value: 030

### # 64 Digital filter response

Range: 0 to +255

Function: A low-pass filter used to filter the speed error signal to reduce interference, for example, from a noisy tacho.

Parameter #04 is the filtered error signal.

$$(\text{filter time constant}) = (1/\#64) \times (1/6f) \times 256$$

where f is the supply frequency.

Standard default value: 128

### # 65 Analogue output select

Range: 01 to 49

Function: This parameter holds the number of the Real parameter (#01— #49) which it is desired to output via the DAC output port (Terminal 13).

Standard default value: 002 (i.e. the speed reference).

### # 66 Speed offset fine

Range 0 to +255

Function: Used as a fine trim on the speed error signal prior to filtering.

$$(\text{actual offset}) = (\#66 - 128)/16$$

This gives a range of:

$$-8 < (\text{actual offset}) < +8$$

Such that: #4 = (speed error) + #66

Standard default value: 128

## 10 Description of Parameters

---

### # 67 Programmable logic input f0

Range: 151 to 197

Function: Used to program the function of control input f0, terminal 18, to control any bit parameter between #151 and #197 inclusive.

Please note that whenever this parameter is changed the new function will only take effect after the reset pushbutton has been pressed.

Example: To program this input to control bit parameter #155

- a). set 67 into the index display
- b). press the mode key
- c). set 155 into the data display
- d). wait three seconds
- e). press the reset pushbutton

Standard default value: 187

### # 68 Programmable logic input f1

Range: 151 to 197

Function: Used to program the function of control input f1, terminal 19, to control any bit parameter between #151 and #197 inclusive.

Please note that whenever this parameter is changed the new function will only take effect after the reset pushbutton has been pressed.

Example: To program this input to control bit parameter #158

- a). set 68 into the index display
- b). press the mode key
- c). set 158 into the data display
- d). wait three seconds
- e). press the reset pushbutton

Standard default value: 168

### # 69 Programmable analogue input function

Range: 21 to 30

Function: Used to program the function of analogue input #6, terminal 6, to control any parameter in the range #21 to #30 inclusive.

Please note that whenever this parameter is changed the new function will only take effect after the reset pushbutton has been pressed.

Example: To program this input to control the internal run speed demand #22

- a). set 69 into the index display
- b). press the mode key
- c). set 022 into the data display
- d). wait three seconds
- e). press the reset pushbutton

Standard default value: 029

---

## 10 Description of Parameters

---

### # 70 Serial network address

Range: 0 to 255

Function: This parameter gives the drive an identity by which it can be addressed in a multi-drive application. Serial commands intended for a particular drive must be preceded by the appropriate drive address. Works in conjunction with parameter # 71 below.

Standard default value: 001

### # 71 Current drive number

Range: 0 to 255

Function: In a multidrive system with several drives connected to a common RS422 serial link, each drive is assigned an address. A serial command is preceded by a drive address which is immediately loaded by each drive into its current drive register # 71. If the contents of registers # 71 and # 70 of a particular drive are the same, the drive recognises that it is being addressed and will respond to the instructions that follow.

When a drive is being addressed it is referred to as the current drive, and remains current until another drive is specifically addressed. Thus a string of commands can be sent to the current drive without the need to precede each instruction with a drive address.

This parameter is not used with the ANSI protocol.

Standard default value: 001

### # 72 Line pacing character

Range: 0 to +255

Function: This is the character that the drive transmits as a line prompt during uploading of basic programmes from a computer via the serial interface. This parameter can be set to any ASCII code, and should be set on the drive before attempting to upload. It is not used with ANSI protocol.

See "Mentor Supplementary Information" for full details.

Standard default value: 000

# 73 to # 89 are not currently used.

### # 90 Application control byte

Function: The bits in this byte correspond directly with individual application programmes residing in the System EPROM on the optional MD21 board. A programme is enabled by setting the corresponding bit to 1.

See "Mentor Supplementary Information" for full details.

Standard default value: 001

## 10 Description of Parameters

---

### # 91 BASIC Auto-boot parameter

Function: The bits in this byte correspond directly with individual BASIC programmes residing in the User EPROM on the optional MD21 board. A program is RUN automatically on power-up by setting the corresponding bit to 1.

See 'Mentor Supplementary Information' for full details.

Standard default value: 001

### # 92 Status output byte

Range: 0 to 255

Function: The individual bits in this byte control the seven status outputs as follows:

Bit	Output	Terminal
7	RL1	33, 34, 35
6	RL2	30, 31, 32
5	Running	25
4	At speed	26
3	Alarm	27
2	ST2	29
1	ST1	28
0	Not used	—

The displayed value of # 92 is the decimal equivalent of the bit pattern.

By setting # 169=1, normal status functions are disabled, and # 92 can be controlled by the serial interface or processor 2 special application software. (See # 169 for further details).

### # 93 LED functions byte

Range: 0 to 255

Function: The individual bits in this byte control the front panel LED indicators as follows:

Bit	LED
7	Alarm
6	Zero speed
5	Run forward
4	Run reverse
3	Bridge 1
2	Bridge 2
1	At speed
0	Current limit

The displayed value of # 93 is the decimal equivalent of the bit pattern.

By setting # 185=1, normal LED functions are disabled, and # 93 can be controlled by the serial interface or processor 2 special application software. (See # 185 for further details).

Note that 'drive ready' is not programmable.

## # 94 Status output ST1 function

Range: 100 to 197

Function: Used to program the open-collector status output ST1 connected to terminal 28. Any parameter in the range # 100 to # 197 can be programmed to control ST1 by loading the required parameter number into # 94.

Example: To program this output to be controlled by parameter # 117

- a). set 94 into the index display
- b). press the mode key
- c). set 117 into the data display
- d). press the mode key

Standard default value: 110

## # 95 Status output ST2 function

Range: 100 to 197

Function: Used to program the open-collector status output ST2 connected to terminal 29. Any parameter in the range # 100 to # 197 can be programmed to control ST2 by loading the required parameter number into # 95.

Example: To program this output to be controlled by parameter # 117

- a). set 95 into the index display
- b). press the mode key
- c). set 117 into the data display
- d). press the mode key

Standard default value: 113

## # 96 Index

Function: Contains the current value of the index display.  
Used for processor 2 special applications.

## # 97 Security level 2 key

Function: Unless the correct code is entered, this level of security prevents the changing of the majority of drive parameters from the keypad, whilst allowing all parameters to be monitored in a read-only mode.

The parameters which remain accessible are those which would be potentiometer adjustments on an analogue drive, e.g. ramp rates, maximum and minimum speeds, current limits etc.  
(For further information on MENTOR security, see Section 9).

Standard default value: 000

## 10 Description of Parameters

---

### # 98 Processor 1 software revision no.

Function: Displays the revision number of the installed processor 1 software.  
For example, version 1.8 software would be displayed as 018.

### # 99 Processor 2 software revision no.

Function: Reserved for processor 2 special application software. (MD21 option board).

## GROUP C: READ ONLY BIT PARAMETERS

### COMMAND BITS:

The following bits monitor the control input terminals 16 to 23, and are activated by connecting the appropriate terminal to control common, terminal 24.

### # 100 Programmable logic control input f0

Function: Monitors control input f0, terminal 18, and indicates its status. Using #67, it can be programmed to control any bit parameter in the range #151 to #197.  
For further information see #67 and Fig. 10.

- 0 — f0 input not active
- 1 — f0 input active

### # 101 Programmable logic control input f1

Function: Monitors control input f1, terminal 19, and indicates its status. Using #68, it can be programmed to control any bit parameter in the range #151 to #197.  
For further information see #68 and Fig. 10.

- 0 — f1 input not active
- 1 — f1 input active

### # 102 Inch reverse

Function: Monitors the inch reverse control input, terminal 20, and indicates its status. The drive will only respond to this input if the external logic controls are enabled by setting parameter #158 to 0.

- 0 — Inch reverse input not active
- 1 — Inch reverse input active

## 10 Description of Parameters

---

### # 103 Inch forward

Function: Monitors the inch forward control input, terminal 21, and indicates its status. The drive will only respond to this input if the external logic controls are enabled by setting parameter #158 to 0.

- 0 — Inch forward input not active
- 1 — Inch forward input active

### # 104 Run reverse

Function: Monitors the run reverse control input, terminal 22, and indicates its status. The drive will only respond to this input if the external logic controls are enabled by setting parameter #158 to 0.

- 0 — Run reverse input not active
- 1 — Run reverse input active

### # 105 Run forward

Function: Monitors the run forward control input, terminal 23, and indicates its status. The drive will only respond to this input if the external logic controls are enabled by setting parameter #158 to 0.

- 0 — Run forward input not active
- 1 — Run forward input active

### # 106 Drive start permit

Function: Monitors the drive start permit control input, terminal 17, and indicates its status. This input performs an overriding drive stop function as follows:  
The input must be active in order to start the drive. If the input then becomes inactive, the speed reference at the input to the ramp is set to zero and the drive will stop, unless ramp hold, #168, is active.

- 0 — Drive stop
- 1 — Drive start enabled

### # 107 Drive enable

Function: Monitors the drive enable input, terminal 16, and indicates its status. This input must be active for the drive to operate.  
When the drive is disabled by disconnecting this input, all firing pulses are switched off. If the drive is running this will produce a coast stop and reset the ramp.

- 0 — Drive disabled
- 1 — Drive enabled.

### NORMAL STATUS BITS:

#### # 108 Forward velocity

Function: Indicates that the motor is turning in the forward direction at more than 1.5% of full speed.

Forward direction is defined as:

Terminal 1 negative with respect to terminal 2 when tacho feedback selected.

Terminal A1 positive with respect to terminal A2 when armature voltage feedback selected.

0 — Drive stationary or running in reverse direction

1 — Drive running in forward direction

#### # 109 Reverse velocity

Function: Indicates that the motor is turning in the reverse direction at more than 1.5% of full speed.

Reverse direction is defined as:

Terminal 1 positive with respect to terminal 2 when tacho feedback selected

Terminal A1 negative with respect to terminal A2 when armature voltage feedback selected.

0 — Drive stationary or running in forward direction

1 — Drive running in reverse direction

Note! If #108 and #109 are both zero then the motor is either stationary or running at less than 1.5% of full speed. In this condition the zero speed LED is illuminated and RL2 is energised.

#### # 110 Current limit

Function: Indicates that either the current demand # 07 or torque demand # 28 is being limited by the current limit override as set by #30, #31 or #32, or by the result of the current taper calculation.

0 — Drive not in current limit

1 — Drive in current limit

#### # 111 Bridge 1 enable

Function: Indicates that thyristor bridge 1 (positive bridge) is being triggered. This bit does not indicate that bridge 1 is actually conducting, since conduction takes place only when the firing angle is sufficiently advanced.

0 — Bridge 1 disabled

1 — Bridge 1 enabled

## 10 Description of Parameters

---

### # 112 Bridge 2 enable

Function: Indicates that thyristor bridge 2 (negative bridge) is being triggered. This bit does not indicate that bridge 2 is actually conducting, since conduction takes place only when the firing angle is sufficiently advanced.

- 0 — Bridge 2 disabled
- 1 — Bridge 2 enabled

### # 113 Electrical phase back (Standstill)

Function: Indicates that the firing pulses are being phased back by the action of the standstill function.

See parameters # 161 and # 162 for explanation of standstill.

- 0 — Firing pulses not phased back
- 1 — Firing pulses phased back (at standstill)

### # 114 At speed

Function: Indicates that the drive has attained set speed when ramp output # 2 is equal to ramp input # 13 (acceptance band 0,3% of full scale) and comparison of speed loop variable # 16 and speed feedback # 03 results in a speed error less than 1.5% of maximum speed.

This condition is also signalled externally via an open collector output connected to terminal 26.

- 0 — Drive not at speed
- 1 — Drive at speed

### # 115 Overspeed

Function: Indicates that the speed feedback signal exceeds  $\pm 999$ . This is a monitor and not a drive trip condition.

- 0 — Motor not overspeed
- 1 — Motor overspeed

### FAULT STATUS BITS:

#### # 116 Drive healthy

Function: Indicates that the drive has not tripped. A drive is healthy as long as none of the following fault conditions has been detected:

118	Field loss
119	Tacho or feedback loss
120	Phase loss
121	Instantaneous overcurrent trip
122	Sustained overload
123	Motor/stack overtemperature
124	Watchdog timer
125	Power supply fault
126	Armature open circuit
131	Processor 2 watchdog

This condition is also signalled externally via the 'drive healthy' LED and the energised state of relay RL1, whose changeover contact is connected to terminals 30, 31 and 32. Detection of any of the above fault conditions results in the immediate shutdown of the drive, which remains disabled until either:

1. Power is removed from the drive then reapplied (hard reset)
2. The reset pushbutton is pressed (soft reset)
3. The system is reset by the optional second processor

In the event of a drive trip the failure mode parameter 50 immediately appears in the index display and the fault code, 118 to 126 or 131 corresponding to the cause of the trip is indicated in the data display. Also, as an aid to diagnostics, the values of the real read-only parameters (#00– #19) are stored at the time of the drive trip. The above conditions are cleared when a hard or soft reset is performed.

- 0 – Drive tripped
- 1 – Drive healthy

#### # 117 Alarm

Function: Indicates that the drive is in an overload condition and will eventually trip on sustained overload #122 unless the overload condition is removed. The time taken to trip is dependent on the setting of parameter #63 and the magnitude of the overload.

Visual indication that the alarm has been activated is provided by a flashing Alarm LED on the front of the drive. An external alarm signal is also provided in the form of an open collector output connected to terminal 27.

- 0 – No alarm condition present
- 1 – Alarm condition present – Impending sustained overload trip.

## 10 Description of Parameters

---

### # 118 Field loss

Function: Indicates that there is no current being drawn from the internal field supply. This condition can be prevented from tripping the drive by disabling field loss detection by setting parameter #187=1, thereby allowing the use of an external field supply.

- 0 — Field healthy
- 1 — Field failed

### # 119 Tacho/feedback loss

Function: Signifies loss or incorrect polarity of speed feedback signal, either tacho or armature voltage, depending on the mode selected.

Loss of feedback is only detected when the firing angle has advanced to the point where the value of #09 is less than 384, at which point a drive fault trip occurs. This condition can be prevented from tripping the drive by disabling tacho loss detection, using #186.

- 0 — Speed feedback present
- 1 — Speed feedback absent or polarity inverted

### # 120 Phase loss

Function: Indicates that a thyristor firing pulse has failed to produce a pulse of output current during continuous-current operation.

The faults which will be detected are as follows:

1. Missing supply phase
2. Missing firing pulse
3. Thyristor gate open circuit

- 0 — Healthy
- 1 — Phase loss

### # 121 Instantaneous overcurrent trip

Function: Indicates that a current peak greater than 2.0 times the maximum current limit level has occurred. This results in suppression of firing pulses and immediate drive shutdown.

- 0 — No overcurrent peak detected
- 1 — Overcurrent peak detected

### # 122 Sustained overload

Function: Indicates that the current feedback #08 has exceeded the overload threshold #33 for a length of time determined by #63, the integration rate, and the magnitude of the overload.

When the current exceeds the overload threshold, the difference is integrated causing the value of the overload integration register #19 to increase. Conversely, when the current is below the threshold, the value of #19 decreases toward zero. The rate of integration is set by #63, which is the time taken for a drive fault trip to occur with a full scale overload (#08 = 999). The function therefore mimics that of a thermal overload relay.

- 0 — Sustained overload not detected
- 1 — Sustained overload detected

### # 123 Overtemperature

Function: Not implemented

### # 124 Watchdog timer

Function: Under normal drive operation the watchdog timer is reset periodically by processor 1 as a check that the processor and drive program are functioning normally. If a reset does not occur before it has timed out the conclusion is that either the processor has failed or the drive program has crashed, and the result is an immediate controlled drive shutdown and flagging of a watchdog fault.

- 0 — Control system healthy
- 1 — Watchdog trip

Note:

Fault codes 125 and 126: These do not have corresponding read-only bit parameters. Refer to Section 12 for details.

## MISCELLANEOUS READ ONLY BIT PARAMETERS

### # 125 Phase rotation

Function: Monitors and indicates the phase rotation of the A.C. supply on terminals E1, E2, E3 which must have the same rotation and sequence as the main stack connections L1, L2, L3. Therefore, L1 must be connected to the same phase as E1, L2 to the same phase as E2, and L3 to the same phase as E3. If this is not the case, the drive will malfunction.

- 0 — Phase rotation L1, L3, L2
- 1 — Phase rotation L1, L2, L3

### # 126 Speed level 1 exceeded

Function: Indicates that the motor has exceeded the speed set by speed level 1 sense (# 26). Useful in speed dependent current limit profiling to provide a reference point from which the first current taper slope set by parameter # 59 will begin. See parameter # 59.

- 0 — Motor speed less than speed level 1
- 1 — Motor speed greater than speed level 1

### # 127 Speed level 2 exceeded

Function: Indicates that the motor has exceeded the speed set by speed level 2 sense (# 27). Useful in speed dependent current limit profiling to provide a reference point from which a second current taper slope set by parameter # 60 will begin. See parameter # 60.

- 0 — Motor speed less than speed level 2
- 1 — Motor speed greater than speed level 2

## 10 Description of Parameters

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### # 128 Analogue error window flag

Function: To achieve an effective 14-bit resolution with analogue speed reference and feedback, an amplifier is used to derive an amplified speed error signal which, after A to D conversion, is used by the speed loop when the speed error is small, thereby increasing the resolution. (See also #12).

128 is the output of a window comparator monitoring speed error, and is set to 1 when the speed loop is in high-resolution mode.

This mode of operation is not used in the following cases:

- a. Run reverse or inch
- b. Internal reference #22 selected
- c. Speed reference offset #23 in use
- d. Speed reference scale factor #57, #157 in use
- e. Hard speed reference #29 in use

### # 129 Speed loop saturated

Function: Indicates that the output from the speed loop algorithm, from which the current demand signal is derived, is out of range. This may be due to the application of a current limit or a zero-current clamp.

- 0 — Speed loop not saturated
- 1 — Speed loop saturated

### # 130 Zero current demand

Function: Indicates that the current demand signal is being limited to zero. This could result for example when in torque control with speed override, that due to loss of load the motor speed has exceeded the set speed threshold.

- 0 — Current demand greater than zero
- 1 — Current demand zero

### # 131 2nd processor Watchdog

Function: When implemented, is the means by which processor 1 monitors the functioning of processor 2, the special applications processor, on the optional MD21 board. The result of a failure is a controlled drive shutdown and fault indication.

- 0 — Processor 2 healthy
- 1 — Watchdog trip

# 132 to # 149 are not currently used

### GROUP D: READ/WRITE BIT PARAMETERS

#### # 150 Non-Volatile RAM (EEPROM) update

Function: Used to change the default value of a read/write parameter. When a parameter value is changed from the Mentor keypad or via the serial interface, the change is immediately loaded into the drive RAM but not into the EEPROM. This means that the drive will immediately respond to the change but will revert to the stored default parameter on the next power-up cycle.

This has the advantage that one can experiment with different parameter values without losing the original settings, which can easily be recovered by carrying out a hard reset (switch off the supply to the Mentor then power up again).

However, if it is necessary to change the default values, this can be done as follows:

- a. Make all the required parameter changes
- b. Set # 150 = 1
- c. Wait three seconds
- d. Press the reset pushbutton on the MD20 board

Standard default value: 0

#### # 151 Quadrant 1 enable

Function: Indicates that quadrant 1 is enabled. Quadrant 1 operation is defined as motoring in the forward direction.

- 0 – Quadrant 1 disabled
- 1 – Quadrant 1 enabled

Standard default value: 1

#### # 152 Quadrant 2 enable

Function: Indicates that quadrant 2 is enabled. Quadrant 2 operation is defined as regenerative braking from the reverse direction.

- 0 – Quadrant 2 disabled
- 1 – Quadrant 2 enabled

Standard default value: 0 – 1Q  
1 – 4Q

#### # 153 Quadrant 3 enable

Function: Indicates that quadrant 3 is enabled. Quadrant 3 operation is defined as motoring in the reverse direction.

- 0 – Quadrant 3 disabled
- 1 – Quadrant 3 enabled

Standard default value: 0 – 1Q  
1 – 4Q

### #154 Quadrant 4 enable

Function: Indicates that quadrant 4 is enabled. Quadrant 4 is defined as regenerative braking from the forward direction.

- 0 — Quadrant 4 disabled
- 1 — Quadrant 4 enabled

Standard default value: 0 — 1Q  
1 — 4Q

### ANALOGUE REFERENCE CONTROL:

#### # 155 Internal reference select

Function: Determines whether the external analogue speed demand input #01 (terminal 5) or the internal digital reference #22 is selected as the drive speed reference.

- 0 — External run speed demand #01 selected
- 1 — Internal run speed demand #22 selected

Standard default value: 0

#### # 156 Bipolar speed demand enable

Function: When set to 1 the drive will respond to a bipolar analogue speed reference #01, in which case the direction of rotation is determined by the polarity of this signal. A positive polarity causes the drive to run forward and a negative polarity to run in reverse. (Setting the reverse polarity bit #165=1 reverses the above convention).

When set to 0 the drive will respond to a unipolar analogue speed reference, in which case the direction of rotation is determined by the reverse bit #165 only, and all negative values of #01 are treated as zero.

(See also #165).

- 0 — Unipolar reference
- 1 — Bipolar reference

Standard default value: 0 — 1Q  
1 — 4Q

#### # 157 Analogue scale factor range

Function: Determines the range of the analogue reference scale factor #57.

When #157=1, the analogue scale factor covers the range 1 to 2. When #157=0, the analogue scale factor covers the range 0 to 1.

Definition of scaling:

$$(\text{speed demand}) = \#01 \times (\#157 + \#57/256) + \#23$$

- 0 — Scale factor = ( $\#57/256$ )
- 1 — Scale factor =  $1 + (\#57/256)$

Standard default value: 1

## 10 Description of Parameters

---

### MODE CONTROL:

#### # 158 Internal logic control select

Function: Used to disable the external logic control inputs, terminals 20 to 23. In this case control is achieved by writing directly to parameters # 163, # 164 and # 165 either via the on-board keypad or via the serial interface.

- 0 — Enable external logic control inputs
- 1 — Enable internal logic control

Standard default value: 0

#### # 159 Mode control bit 0

Function: Works in conjunction with parameter # 160 to configure the drive for speed control or any of three modes of torque control. See # 160 for full description.

Standard default value: 0

#### # 160 Mode control bit 1

Function: Works in conjunction with parameter # 159 to configure the drive for speed control or any of three modes of torque control as follows:

# 159=0, # 160=0: Normal speed control mode.

# 159=1, # 160=0: Basic torque control. In this mode, parameter # 28 is the input to the current loop algorithm, subject only to the limitations of the current slew rate parameter # 61 and the current limit parameters # 31 and # 32.

# 159=0, # 160=1: Torque control with speed override. In this mode, the output of the speed loop is clamped either to zero or to the value of # 28, depending on the polarities of the speed error signal and # 28. In the motoring quadrants, the speed is limited to the value of the speed loop variable # 16, preventing uncontrolled speed increase on removal of load. In the regenerative quadrants, the current demand set by # 28 is disabled when the speed is less than that set by # 16. This prevents a reversal of rotation on loss of input torque.

# 159=1, # 160=1: Coiler/Uncoiler mode. This mode is the same as combined torque and speed control, except that when the sign of the torque reference # 28 is opposite to the sign of the speed feedback # 03, the speed reference is treated as zero. Therefore, this mode allows torque to be applied in either sense for acceleration and deceleration, whilst preventing uncontrolled speed increase or reversal in the event of material breakage.

Standard default value: # 159=0  
# 160=0

### # 161 Enable standstill logic

Function: Enables the drive standstill logic which, when the drive is stopping and the speed has fallen below 0.8%, causes the firing angle to be phased back fully, thereby preventing creep. After a delay the firing pulses are then inhibited. This condition is indicated by the standstill logic flag, # 113.  
(See also # 162).

- 0 — Standstill logic disabled
- 1 — Standstill logic enabled

Standard default value: 1

### # 162 Standstill logic mode

Function: If standstill logic is enabled ( # 161=1) this bit determines the mode of operation. If # 162=0, standstill is detected at 0.8% speed following either a 'stop' command ( # 163=0) or setting of the external reference on terminal 5 to zero.  
If # 162=1, standstill is detected at 0.8% speed following a 'stop' command ( # 163=0) but not when a stop is achieved by setting the external reference to zero. This mode allows creep speeds, shaft orientation and other functions which take place close to zero speed.

- 0 — Standstill after 'stop' or zero ref.
- 1 — Standstill after 'stop' only

Standard default value: 0

## REMOTE CONTROL:

### # 163 Go (not stop)

Function: When this bit is set to 1, the speed reference is applied to the input of the speed ramp. The conditions necessary for this to take place are as follows:

- a. Drive enabled  
( # 107=1 — terminal 16 grounded)
- b. Drive start enable selected  
( # 106=1 — terminal 17 grounded)
- c. Inch selected ( # 102=1 or # 103=1)
- d. Run selected momentarily ( # 104=1 or # 105=1)

When a stop is called for, either by removing the inch command ( # 102=0, # 103=0) if inching, or by removing drive start enable ( # 106=0) if running, # 163 is set to 0, which sets the ramp input to zero. (Note that 'run' is a latching function, and removing the run command has no effect).

- 0 — Drive stop
- 1 — Drive go

Standard default value: 0

## 10 Description of Parameters

---

### # 164 Inch (not run)

Function: Selects either run mode or inch mode. If run mode is selected, the source of the speed reference is determined by #155. If inch mode is selected, the speed reference is #21.

- 0 — Run reference selected
- 1 — Inch reference (#21) selected

Standard default value: 0

### # 165 Reverse (not forward)

Function: Used to select forward or reverse rotation. If forward mode is selected (run forward or inch forward) the speed reference polarity is unchanged. If reverse mode is selected (run reverse or inch reverse) the speed reference polarity is inverted.

- 0 — Speed reference normal
- 1 — Speed reference inverted

Standard default value: 0

### # 166 Miscellaneous inhibit

Function: Disables thyristor firing. This bit may be controlled via the optional serial interface or by processor 2 special application software.

- 0 — Enables thyristor firing
- 1 — Disables thyristor firing

Standard default value: 0

### # 167 Ramp enable

Function: Enables the speed control ramp function. The effect of disabling the ramp function is to bypass the ramp, giving zero ramp time. This may be used, for example, in applications which call for regenerative emergency stop at current limit.

- 0 — Ramp disabled
- 1 — Ramp enabled

Standard default value: 1

### #168 Ramp hold

Function: Setting this bit to 1 causes the ramp output, #2, to be held at its current value regardless of the value of the ramp input. This facility may be used, for example, in conjunction with 'run' and 'drive start enable' to give a digital reference ramp function, controlled by external 'increase' and 'decrease' pushbuttons.

- 0 — Ramp function active
- 1 — Ramp held

Controlled in default by programmable bit function 1 (terminal 19) via #68.

### # 169 Programmable status outputs

Function: Disables the normal functions of the dedicated status outputs, and renders them programmable by means of the status output byte # 92, which is accessible via the serial interface or processor 2 special application software.

- 0 — Status outputs dedicated
- 1 — Status outputs programmable

Standard default value: 0

### # 170 Security

Function: This parameter is used in the initial setting of level 1 security, and cannot be altered from the keypad once set, thereby preserving the security code. Section 9 gives full details of Mentor security.

- 0 — Security level 1 not set
- 1 — Security level 1 set

Standard default value: 0

### # 171 Firing angle control

Function: Allows direct control of the thyristor firing angle by applying the digital reference # 02 (normally speed demand) to the input of the firing stage.

This mode is useful for fault finding since it allows the drive to operate without the influence of either the speed loop or the current loop. However, care must therefore be exercised when using this facility, since there is **no protection** against excessive acceleration or current except instantaneous overcurrent trip.

- 0 — # 02 = Speed demand
- 1 — # 02 = Firing angle reference

Standard default value: 0

### SERIAL INTERFACE CONFIGURATION PARAMETERS:

Function: Parameters #172 to #181 are used to configure the serial interface. Refer to Section 11 for full details of the serial interface option.

### # 172 Line feed enable

Function: Enables the sending of line feed characters via the serial interface.

- 0 — Disable line feed
- 1 — Enable line feed

Standard default value: 1

### # 173 Prompt enable

Function: Enables the sending of the prompt via the serial interface.

- 0 — Disable prompt
- 1 — Enable prompt

Standard default value: 1

### # 174 Length of data frame

Function: Selects the number of data bits in a transmitted word.

Changes made to this bit do not become effective until a reset is carried out.

- 0 — Ten bit data frame
- 1 — Eleven bit data frame

Standard default value: 0

### # 175 Parity enable

Function: Enables the parity bit in the transmitted word.

Changes made to this bit do not become effective until a reset is carried out.

- 0 — Disable parity
- 1 — Enable parity

Standard default value: 0

### # 176 Parity type

Function: Selects the type of parity (even or odd).

Changes made to this bit do not become effective until a reset is carried out.

- 0 — Parity even
- 1 — Parity odd

Standard default value: 0

### # 177 XON/XOFF enable

Function: Enables the XON/XOFF handshaking.

- 0 — Disable XON/XOFF
- 1 — Enable XON/XOFF

Standard default value: 0

## 10 Description of Parameters

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### # 178 Baud rate bit 0

Standard default value: 1

### # 179 Baud rate bit 1

Standard default value: 0

### # 180 Baud rate bit 2

Standard default value: 1

These three bits allow the data transmission rate to be selected from the table below:

bit 2	bit 1	bit 0	Baud rate
1	1	1	19200
1	1	0	9600
1	0	1	4800
1	0	0	2400
0	1	1	1200
0	1	0	600
0	0	1	300
0	0	0	150

Note that changes made to the above parameters ( # 178, # 179, # 180) do not become effective until a reset is carried out.

### # 181 Checksum enable

Function: Enables checksum function in ANSI communications protocol

- 0 — Checksum disabled
- 1 — Checksum enabled

Standard default value: 0

### # 182 Adaptive control enable

Function: Causes the gain of the current loop to change at the point of transition between continuous and discontinuous current. This is necessary for four-quadrant applications.

- 0 — Adaptive control disabled
- 1 — Adaptive control enabled

Standard default value: 1

### # 183 High current loop integral gain

Function: Doubles the gain by which the current integral term is multiplied in the current loop algorithm. In some single ended applications it may be desirable to detune the current loop by setting this parameter to zero.

- 0 — Low integral gain
- 1 — High integral gain

Standard default values: 0 — 1Q  
1 — 4Q

### # 184 Fast current reversal

Function: Following a bridge changeover, the firing pulses must be phased forward to the point at which conduction begins. At high speed, the conduction angle is large, and hence a considerable delay can result while this takes place. By calculating the required firing angle and initiating firing at that angle, the delay is eliminated. For loads having short time constant  $L/R$ , this function should be disabled.

- 0 — Fast reversal disabled
- 1 — Fast reversal enabled

Standard default value: 0 — 1Q  
1 — 4Q

### # 185 Programmable LED functions

Function: Disables the normal functions of the front panel LED indicators (except 'drive ready') and renders them programmable by means of the LED functions byte # 93, which is accessible via the serial interface or processor 2 special application software.

- 0 — LED functions dedicated
- 1 — LED functions programmable

Standard default value: 0

### # 186 Tacho detection off

Function: Disables the tacho loss detector #119. This may be necessary if, for example, the feedback signal #03 represents a quantity other than motor speed, and can be zero when the firing angle is advanced.

- 0 — Tacho loss detection enabled
- 1 — Tacho loss detection disabled

Standard default value: 0

## 10 Description of Parameters

---

### # 187 Field loss detection off

Function: Disables the field loss detector # 118. This facility is used when an external field supply is employed, or field reversal is used with a single quadrant drive to give a regenerative stop. Under these conditions a drive fault trip would otherwise result.

- 0 — Field loss detection enabled
- 1 — Field loss detection disabled

Controlled in default by programmable bit parameter 0 (terminal 18) via # 67.

### # 188 Overtemperature detection off

Function: Disables the overtemperature detector # 123.

- 0 — Overtemperature detection enabled
- 1 — Overtemperature detection disabled

Standard default value: 1

### # 189 Reference S switch

Function: Selects either the IR compensation term # 17 or the hard speed reference # 29 as a direct input into the speed loop algorithm, bypassing the speed ramps and limits. See speed loop variable # 16 for further information.

- 0 — IR compensation # 17
- 1 — Hard speed reference # 29

Standard default value: 0

### # 190 Zero reference interlock

Function: Inhibits starting of the drive until the analogue speed reference # 01 is near zero, such that:

$$-16 < 01 < +16$$

- 0 — Zero reference interlock disabled
- 1 — Zero reference interlock enabled

Standard default value: 0

### # 191 Ramp x 10 select

Function: Changes the range of the speed ramps # 51, # 52, # 53, # 54 such that the ramp times are set in increments of 0.1 second rather than 1 second. In this mode the minimum ramp time is 1s, and the maximum 24.5s.

- 0 — Ramp time increment 1s
- 1 — Ramp time increment 0.1s

Standard default value: 1

## 10 Description of Parameters

---

### # 192 Reference T switch

Function: Applies the ramped speed reference # 2 to the input of the speed loop algorithm. See speed loop variable # 16 for further information.

- 0 — Speed loop variable excludes # 2
- 1 — Speed loop variable includes # 2

Standard default value: 1

### # 193 Fine control select

Function: causes the value of the analogue signal connected to terminal 6 to be divided by a factor of 16, giving # 6 a reduced range of  $-63$  to  $+63$ , but with the same 10-bit resolution as the normal range.

- 0 — Normal control
- 1 — Fine control

Standard default value: 0

# 194 — # 197 Not used.

## 10 Description of Parameters

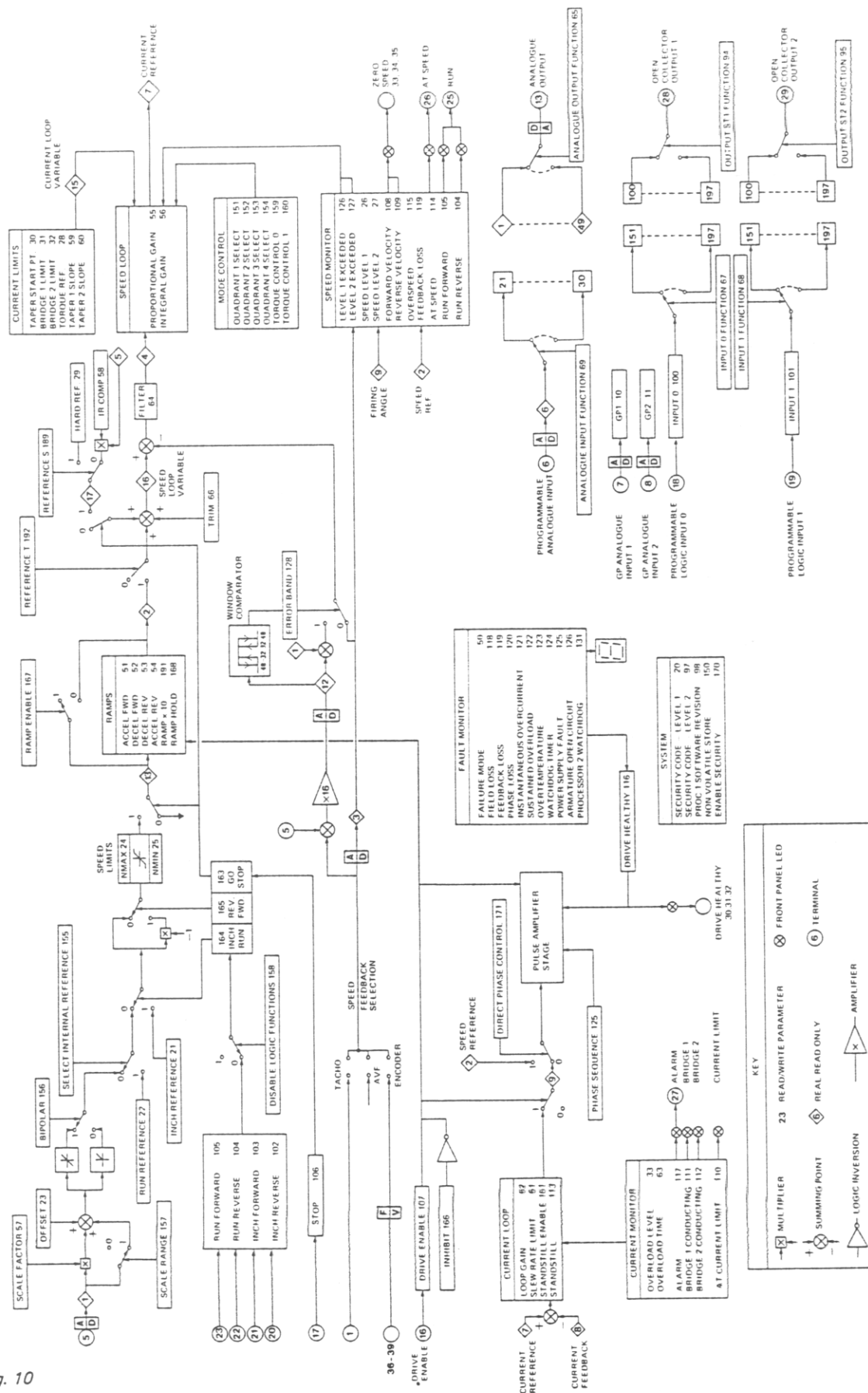


Fig. 10

## Introduction

The serial interface is a powerful extension of the Mentor's total capability, since it facilitates direct interfacing with other computer equipment for remote programming, process control, remote diagnostics and data logging.

When fitted, the serial interface hardware is located on the optional MD21 card which also carries the necessary additional software.

### 11.1 Transmission standards:

The Mentor serial interface is designed to be compatible with the following communication standards:

1) RS232C: This is a two wire system in which one line is held at ground potential while the other is switched to either +5V or -5V. Its susceptibility to noise limits its use to distances up to approximately 10 metres.

2) RS423: This is a similar standard to the RS232 described above, but with some improvements that extend its range to approximately 100 metres.

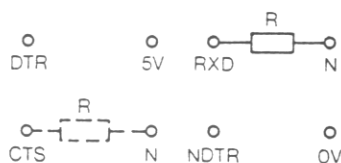
3) RS422: This is a balanced system in which each of the two signal wires is switched between 0V and +5V. This allows a line receiver with a high degree of common mode rejection to be used. Since the transmission is not affected by small differences in ground potential between transmitter and receiver, reliable transmission over distances up to 1000 metres can be achieved.

Since the transmit and receive I/O can be tri-stated this standard also permits multidrop operation with several drives and host computer connected onto a single serial communication link.

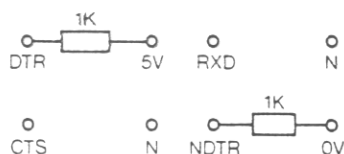
RS422 standard is selected by placing link PL5 (MD21) in the upper position. The lower position selects RS232/RS423 standard.

When an RS422 multi-drop network is in use, the control lines may be terminated/biased by fitting resistors to the terminal posts above the D-type connector as follows:

- a. If the line length exceeds 300m, the RXD line of the most distant drive should be terminated with a resistor whose value equals the characteristic impedance of the line (the CTS line may be similarly terminated, but this is seldom necessary).



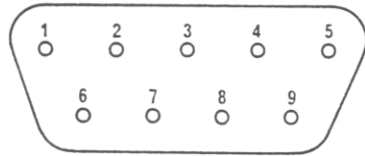
- b. Where hardware handshaking is used, the DTR and NDTR lines should be biased such that they revert to the 'true' state when the transmit buffers are disabled. It is **important** to ensure that only one drive on a network is fitted with bias resistors.



# 11 Serial Interface

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## 11.2 Connector Pinout:



Serial Interface D-type connector  
pin numbering

The serial interface connector is a standard 'D' type 9 pin male plug-in connector located at the bottom right hand corner of the MD21. The connections to this plug are as follows:

PIN	CIRCUIT REFERENCE		TYPE	ACTIVE	FUNCTION
	RS232C/ RS423	RS/422			
1	0V	0V	common		
2	T x D	NT x D	output	high	transmit data
3	R x D	NR x D	input	high	receive data
4	DTR	NDTR	output	high	data terminal ready
5	CTS	NCTS	input	high	clear to send
6	NT x D	T x D	output	low	transmit data
7	NR x D	R x D	input	low	receive data
8	NDTR	DTR	output	low	data terminal ready
9	NCTS	CTS	input	low	clear to send

DTR and CTS signals are true while the active high pin is more positive than the active low pin.

Transmit and receive signals are at logic 1 when the active high pin is more negative than the active low pin.

Pins 1 – 5 should be used for RS232C/RS423 transmission.

Pins 1 – 9 should be used for RS422 transmission.

## 11.3 Communication format:

Several different formats are available.

For full details, please refer to the leaflet "Mentor Supplementary Information".

# 11 Serial Interface

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Default parameters configure the drive to operate in the 'Basic Serial Comms' mode.  
Reading and writing of parameters is as follows:

1. To read a selected parameter transmit to the drive a #character followed by the selected parameter number followed by CR. On receipt of CR the current drive returns the value of that parameter followed by a READY and prompt.

Exchange example:   1>   #22   <CR>  
                          476  
                          READY  
                      1>

2. To write a selected parameter (ie. change its value) transmit to the drive a #character followed by the selected parameter number followed by a comma character followed by the new value followed by CR. On receipt of CR the current drive writes the new value to the selected parameter then issues a READY and prompt.

Exchange example:   1>   #55, 40   <CR>  
                                  READY  
                      1>

## 11.4 Serial Interface Parameters:

The following parameters are used in the configuration of the Serial Interface. Please refer to Section 10 for full details.

#71	Current drive number	] — Not used with ANSI protocol
#72	Line pacing character	
#172	Line feed enable	
#173	Prompt enable	
#174	Length of data frame	
#175	Parity enable	
#176	Parity type	
#177	XON/XOFF enable	]
#178	Baud rate bit 0	
#179	Baud rate bit 1	
#180	Baud rate bit 2	
#181	Checksum enable	



### **DANGER** ELECTRIC SHOCK RISK

Isolate electrical supply  
before working on this  
equipment.

The MENTOR, as a digital drive, has an unprecedented number of diagnostic facilities to assist fault finding.

The following sections describe how these facilities can be used manually to identify a fault. However, it must be remembered that all the information indicated can also be data-logged via the optional serial interface.

#### **CONTROLLING THE DRIVE FROM THE KEYPAD**

To assist in fault finding it is often better to control the drive from the local keypad, thereby eliminating the external control wiring. This is done as follows:

Terminal 16 (enable) and 17 (stop) must be grounded (connect to 0 Volts; Terminal 24).

To inhibit the external control of run/inch/reverse functions change parameter #158 to 1.

Change parameter # 155 to 1. This selects the local speed control reference (parameter # 22).

Changing parameter # 163 to 1 starts the drive. The speed may be varied by means of parameter # 22.

The motor may be reversed by changing parameter # 165 to 1 (if 4Q Drive).

The internal inch reference (parameter # 21) may be selected by changing parameter # 164 to 1.

To return the above parameters to the original settings press the reset button.

## 12 Fault Finding

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### FAULT INDICATION

In the event of a fault the drive ready relay is de-energised, also the parameter index window displays 50 and the data window indicates the type of fault as follows:

**118 — Field loss:**

Indicates that there is no current flowing in the motor shunt field.

**119 — Tacho loss/feedback loss:**

Indicates that the drive has lost its speed control feedback.

**120 — Phase loss:**

Indicates the loss of a supply phase or failure of a thyristor to conduct.

**121 — Overcurrent:**

Indicates that the armature current has exceeded twice the maximum current limit level.

**122 — Sustained overload:**

Indicates that the drive has been overloaded for a time determined by the integrating overload protection.

**123 — Over temperature:**

Indicates a thyristor overtemperature condition.

**124 — Watchdog timer:**

Indicates a microprocessor hardware or software fault.

**125 — Power supply fault:**

Indicates that power supplies are out of tolerance as follows:

+24V Overvoltage

+/-15V Over- or under-voltage

+5V (logic) Over- or under-voltage

**126 — Armature open circuit:**

Indicates that firing pulses have been phased forward without causing current to flow.

**131 — 2nd Processor watchdog**

Indicates a hardware or software fault in optional processor 2.

### LED DIAGNOSTICS

**Drive Ready:**

Indicates that the drive electronics has completed its power-up self-test routine. (Relay RL1 also energises at this time).

Flashes in the event of a fault.

**Alarm (flashing):**

Indicates that the drive is overloaded and that the integrating overload will eventually trip, de-energising RL1.

**Run Forward:**

Indicates that the drive is running in the forward direction.

**Run Reverse:**

Indicates that the drive is running in the reverse direction.

**Bridge 1:**

Indicates that thyristor bridge 1 is selected.

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### Bridge 2:

Indicates that thyristor bridge 2 is selected.

### At Speed:

Indicates that the drive has attained its set speed.

### Current Limit:

Indicates that the drive is in a current limit condition.

## MONITORING KEY DRIVE PARAMETERS

Parameters # 1 — # 19 are read-only variables and indicate the following:  
(For full particulars see Section 10 and Fig. 10).

- # 01 — indicates the speed reference voltage derived from the speed control potentiometer.  
999 = 9.77V (Terminal 5).
- # 02 — indicates the speed demand signal after the ramp function.  
999 = maximum speed.
- # 03 — indicates the value of the tacho or armature voltage feedback.  
999 = maximum speed (tacho).  
999 = up to 600V (AVF) depending on setting of VR1 on MD20 board.
- # 04 — indicates the speed error.
- # 05 — indicates the speed error integral.
- # 06 — indicates the external analogue reference (Terminal 6).  
999 = 9.77V.
- # 07 — indicates the armature current demand signal.  
999 = current limit set by burden resistors.
- # 08 — indicates the actual armature current.  
999 = current limit set by burden resistors.
- # 09 — indicates the output of the current amplifier and is equivalent to the firing angle of the thyristor converter.  
768 = 180 degrees.
- # 10 — indicates the analogue voltage of terminal 7.  
999 = 9.77V.
- # 11 — indicates the analogue voltage of terminal 8.  
999 = 9.77V.
- # 12 — indicates the value of the analogue speed error signal.
- # 13 — indicates the value of the speed reference before the ramp.  
+/-999 = max. ref.
- # 14 — synchronising staircase waveform for thyristor firing sequence.
- # 15 — indicates the value of the torque control variable.  
+/-999 = max. torque demand.

## 12 Fault Finding

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- # 16 — indicates the value of the speed reference at the speed summing point.  
+/-999 = max. speed demand.
- # 17 — indicates the value of the IR compensation term.  
+/-125 = +/-12.5% compensation.
- # 18 — not used.
- # 19 — indicates the value attained by the overload integration function.

IN THE EVENT OF A FAULT THE ABOVE PARAMETERS ARE FROZEN AT THE INSTANT OF THE FAULT AND CAN THEREFORE BE READ AFTER THE EVENT, GIVING VALUABLE INFORMATION ABOUT THE OPERATING CONDITIONS WHICH EXISTED WHEN THE FAULT OCCURRED. THIS FEATURE IS OF GREAT ASSISTANCE IN DETERMINING THE PRECISE NATURE AND CAUSE OF THE FAULT. REFERENCE SHOULD BE MADE TO THE CONTROL BLOCK DIAGRAM (Fig. 10) WHEN ANALYSING THE ABOVE PARAMETERS.

### FAULT FINDING CHART

The following chart is intended to assist with fault finding on a typical drive. Whilst not exhaustive, it indicates the general procedure to be adopted.

## 12 Fault Finding

SYMPTOM	INDICATIONS	ACTION
MOTOR DOES NOT ROTATE	Drive ready LED off	Check regulator supply voltage on terminals E1, E2, E3  Check regulator/field fuses FS1, FS2, FS3. If failed, suspect short circuit in field circuit or faulty field bridge BR1.
	Drive ready LED flashing:  118 displayed	FIELD LOSS: Check field connections. Check fuses FS1 & FS2 and field bridge BR1.
	121 displayed	INSTANTANEOUS OVERCURRENT TRIP: Check phase sequence & rotation: L1 same phase as E1 L2 same phase as E2 L3 same phase as E3 Check for short circuit or earth fault on output terminals A1, A2.
	125 displayed	POWER SUPPLY FAULT: Replace MD1 PCB.
	126 displayed	ARMATURE OPEN CIRCUIT: Check motor connections and brushes.
	Drive ready and run LED on:	
	Current limit LED off	DRIVE NOT ENABLED: Connect ENABLE terminal 16 to 0V terminal 24.  NO SPEED DEMAND: Check reference on terminal 5 if used, and parameters #1 and #2.
	Current limit LED on	MOTOR MECHANICALLY STALLED or FAULT IN FIELD CIRCUIT.
	Drive ready LED on. Run and inch LEDs off.	Check control wiring. Check #158 – refer to Section 10.

## 12 Fault Finding

SYMPTOM	INDICATIONS	ACTION
MOTOR STARTS BUT STOPS IMMEDIATELY	<p>Drive ready LED flashing:</p> <p>119 displayed</p> <p>120 displayed</p> <p>121 displayed</p>	<p>TACHO LOSS: Check tacho connections and polarity.</p> <p>PHASE LOSS: Check 3-phase supply and line fuses. (See below) Ensure thyristor gate leads correctly connected.</p> <p>INSTANTANEOUS OVERCURRENT TRIP: Check 3-phase supply and line fuses (See below). Ensure thyristor gate leads correctly connected. Check phase sequence and rotation: L1 same phase as E1 L2 same phase as E2 L3 same phase as E3</p>
	Line fuse blown	<p>SHORT CIRCUIT ON OUTPUT: Check connections between A1 and A2 and motor. Test motor for armature short circuit, short circuit between interpole and field, and earth fault.</p> <p>FAULTY THYRISTOR: Replace (See Section 13).</p> <p>INTER-BRIDGE FAULT (4Q ONLY): Replace MD1 PCB.</p>
MOTOR RUNS FOR A SHORT TIME AND STOPS	Alarm LED flashing whilst motor runs: 122 displayed	SUSTAINED OVERLOAD: Check mechanical load. Check field supply at motor field terminals.
MOTOR SLOWS DOWN UNDER LOAD	Current limit LED on	DRIVE IN CURRENT LIMIT: Compare DC current with drive rating. Check mechanical load. Check current limit settings, # 30, # 31, # 32, # 28 if used. Check current taper, # 26 and # 27. Check field supply at motor field terminals.

## 12 Fault Finding

SYMPTOM	INDICATIONS	ACTION
DEFECTIVE SPEED CONTROL	Speed range limited	<p>SPEED REFERENCE RANGE INCORRECT: Check range of potentiometer or internal reference. Check reference scaling # 57 and # 157.</p> <p>SPEED CLAMPS OPERATING: Check max and min speed # 24 and # 25.</p> <p>OFFSET PRESENT: Check # 23.</p> <p>FEEDBACK INCORRECT: Check setting of feedback selector SW400 and max. speed potentiometer.</p>
	Speed unstable or overshoot excessive.	<p>SPEED LOOP GAINS INCORRECTLY SET: Adjust # 55, # 56.</p> <p>CURRENT LOOP GAIN INCORRECTLY SET: Adjust # 62.</p>
	Motor runs only at top speed.	<p>INCORRECT SPEED REFERENCE: Check potentiometers # 1 and # 2.</p> <p>TACHO LOSS: (If tacho loss detector inhibited) Check tacho connections and polarity.</p> <p>DRIVE OPERATING IN CURRENT CONTROL: Check setting of parameters # 159 and # 160.</p>
MOTOR COMMUTATOR SPARKING		<p>ARMATURE VOLTAGE TOO HIGH: Tacho feedback: Reduce field current. Armature voltage feedback: Reduce speed reference (use scaling # 57 and # 157). Weaken field if necessary to restore speed.</p>
	Sparking on acceleration	<p>CURRENT LIMIT TOO HIGH: Check parameters # 30, # 31, # 32.</p> <p>CURRENT SLEW RATE TOO HIGH: (eg. solid-frame motor) Check parameter # 61.</p>
	Brushes and/or commutator worn	<p>Replace brushes and/or overhaul commutator. If wear was rapid, check for contamination by oil mist or corrosive vapours.</p>



### **DANGER** ELECTRIC SHOCK RISK

Isolate electrical supply  
before working on this  
equipment.

Replacing components on the converter module.

The following chapter outlines the correct method for replacing components such as pcb's, thyristors, field rectifiers, etc., after location by fault diagnosis.

#### i MODEL 6M and 6M4Q

**WARNING:**  
THE DRIVE MAIN ISOLATOR MUST BE SWITCHED OFF BEFORE COMMENCING REPAIR WORK.

#### 1 Inspection

To open the unit for inspection, undo the two screws securing the hinged lid moulding (Figure 12) and swing front panel forward.

#### 2 Personality Board — removal (Figure 12).

With hinged lid closed, remove the clip-on inspection cover by pressing sides apart and unscrew the four self tapping screws which secure the board to the moulding. Unplug the 10-way ribbon cable connector, then ease the personality board gently out of the 64-way socket which connects it to the control board MD1.

#### 3 Control Board MD1 — removal (Figures 12 & 13).

To simplify this operation, the lid moulding should first be separated from the base moulding by removing the two hinge screws from the base moulding. Next, disconnect the 10-way and 26-way ribbon cables at PLE and PLB on the thyristor board and remove the whole lid to a suitable work surface. Extract the five self tapping screws securing the board to the moulding and gently ease the Control Board out of the 64-way plug which attaches it to the Personality Board (unless this has already been removed).

Note: The multi-way connectors are polarised.

#### 4 PCB Thyristor Board MD330/430/375/475 — removal (Figure 13).

- 4.1 Unplug the 10-way and 26-way connectors and remove the whole lid assembly as described in Subsection 3 above.
- 4.2 Unscrew the single self tapping screw at the bottom centre of the pcb.
- 4.3 Taking care, pull off the thyristor gate leads that link through the pcb. The use of pin nosed pliers is recommended.
- 4.4 Carefully disconnect Faston connectors from the field rectifier situated under the pcb at the bottom end of the unit.
- 4.5 Remove the nine or eighteen screws securing the pcb to the thyristor modules below.
- 4.6 Remove the three M8 nuts and washers from terminals L1, L2, L3 at top of board.
- 4.7 Unplug the three KK plugs, PLF – PLG – PLH, at top of board connecting it to the current feedback transformers.
- 4.8 Remove the thyristor board.

### 5 Thyristor Board – replacement.

- 5.1 Visually check the new board to ensure that the current transformer burden resistors R31 and R32 match those on the existing (removed) board.
- 5.2 To fit replacement board, reverse steps 4.1 – 4.8 above. The recommended tightening torque for the securing screws on the thyristor terminals is 4.5NM (40 LBF ins.).
- 5.3 Take care to connect KK sockets to PLF – PLG – PLH in same sequence as the current transformers on L1, L2, L3.
- 5.4 Take care also to connect gate leads correctly to corresponding thyristor gates.
- 5.5 Carefully replace Faston connectors to field rectifier through hole in pcb, ensuring correct connections.
- 5.6 On models above 30kW, fit the three varistors to the lower three studs, retaining each with a second M8 nut. Ensure that they are connected in the sequence L1–L2, L2–L3, L3–L1.

### 6 Thyristor Module – replacement (Figure 14).

- 6.1 Remove thyristor pcb as described in Subsection 4.
- 6.2 Use a 13mm socket spanner to loosen off stud bolts so that busbars can be swivelled away from the thyristor to be replaced. (Not applicable to 6M4Q 30 models).
- 6.3 Using a 4mm Allen key, (5mm above 30kW), remove the hexagon socket cap screws securing the module to the heatsink and remove the module.
- 6.4 To replace the module, first clean off compound from heatsink.
- 6.5 Check that part number of replacement module matches that of faulty component.
- 6.6 Smear a thin layer of heatsink compound on base of module and mount loosely on heatsink using the hexagon socket cap screws. Do not tighten. Ensure module has thyristor gate connections the same way around as adjacent thyristor modules.

- 6.7 Replace thyristor pcb as described in Subsection 5 above, ensuring correct positioning of all busbars. Tighten thyristor terminal screws to recommended torque of 4.5 NM (40 LBF ins.).
- 6.8 Tighten the socket cap screws on the thyristor module to the recommended torque of 4.5 NM (40 LBF ins.) via the access holes provided in the thyristor pcb.

### 7 Field rectifier — changing.

- 7.1 This can be done without removing the thyristor pcb. Simply undo the screw in the middle of the component and lift out through square hole in pcb.
- 7.2 Clean all old compound from the heatsink.
- 7.3 Check that the part number of the new component is compatible with the old one.
- 7.4 Smear a thin layer of heatsink compound on the base of the rectifier and secure it to the heatsink.

### ii MODEL 6MS & 6MS4Q

#### WARNING

THE DRIVE MAIN ISOLATOR MUST BE SWITCHED OFF BEFORE COMMENCING REPAIR WORK.

### 1 Inspection.

To open the unit for inspection, undo the two screws securing the right hand lid moulding (Figure 3) and swing front panel forward. The left hand side cover moulding is secured by four M4 screws at its corners.

### 2 Personality Board — removal (Figure 12).

With lid closed, remove the clip-on inspection cover (Figure 2) and unscrew the four self tapping screws which secure the board to the moulding. Unplug the 10-way ribbon cable connector, then ease the Personality Board gently out of the 64-way socket which connects it to the Control Board MD1.

### 3 Control Board MD1 — removal (Figures 12 & 13).

To simplify this operation, the lid moulding should first be separated from the base moulding by removing two M4 screws, in the face of the base moulding, which trap the lid hinging bar. The lid can now be removed. Next, disconnect the 10-way and 26-way ribbon cables at PLE and PLB on the auxiliary control thyristor board MD6 and remove the whole lid to a suitable work surface.

Extract the five self tapping screws securing the board to the moulding and gently ease the Control Board out of the 64-way plug which attaches it to the Personality Board (unless this has already been detached).

Note: The multi-way connectors are polarised.

### 4 MD5 R—C Network PCB — replacement (Figure 15).

- 4.1 Disconnect the ¼" Faston connectors from the +VE and —VE busbars.
- 4.2 The board is held in by two M4 screws along the bottom edge, and three M5 nuts and washers at the top edge, which connect the board electrically via brass pillars to L1, L2 and L3.
- 4.3 A varistor may be changed by removing its ¼" Faston connector and undoing the M5 bolt holding it to the MD5 pcb.
- 4.4 Replacing the board is the reverse of steps 1 and 2 above.

### 5 MD6 Auxiliary Control Board — removal (Figure 15).

- 5.1 Unplug the 10-way and 26-way ribbon cable connectors.
- 5.2 Unplug the KK plugs, three to current transformers along top edge of the board, six (or 12 on 4Q drives) to thyristors along bottom edge, and one to thermostat at right hand end of board.
- 5.3 The pcb is retained by five M4 Posidrive pan head screws.

### 6 MD6 Auxiliary Control Board — replacement.

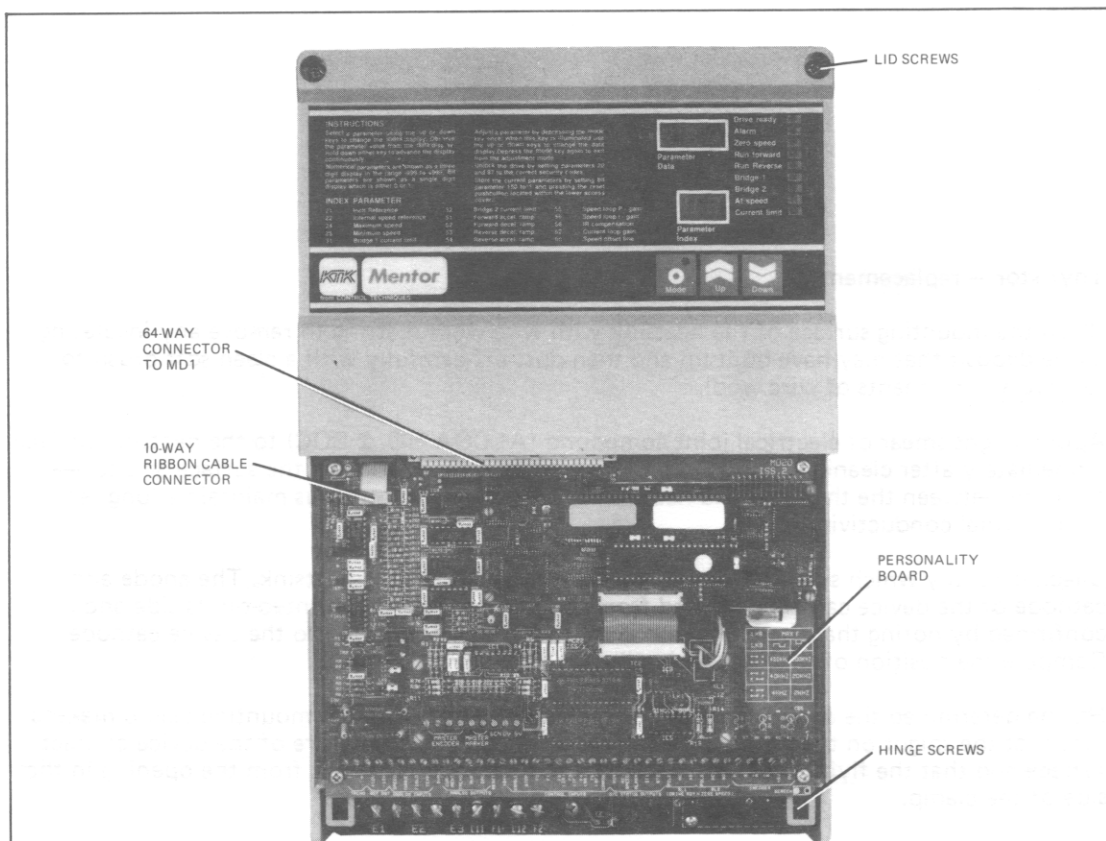
- 6.1 Visually check the new board to ensure that the current transformer burden resistors match those on the existing (removed) board.
- 6.2 Replacing the board is now the reverse of steps 5.1 — 5.3 above.
- 6.3 Care should be taken to connect the six (or twelve) gate leads to the appropriate plugs.

### 7 Thyristor — removal.

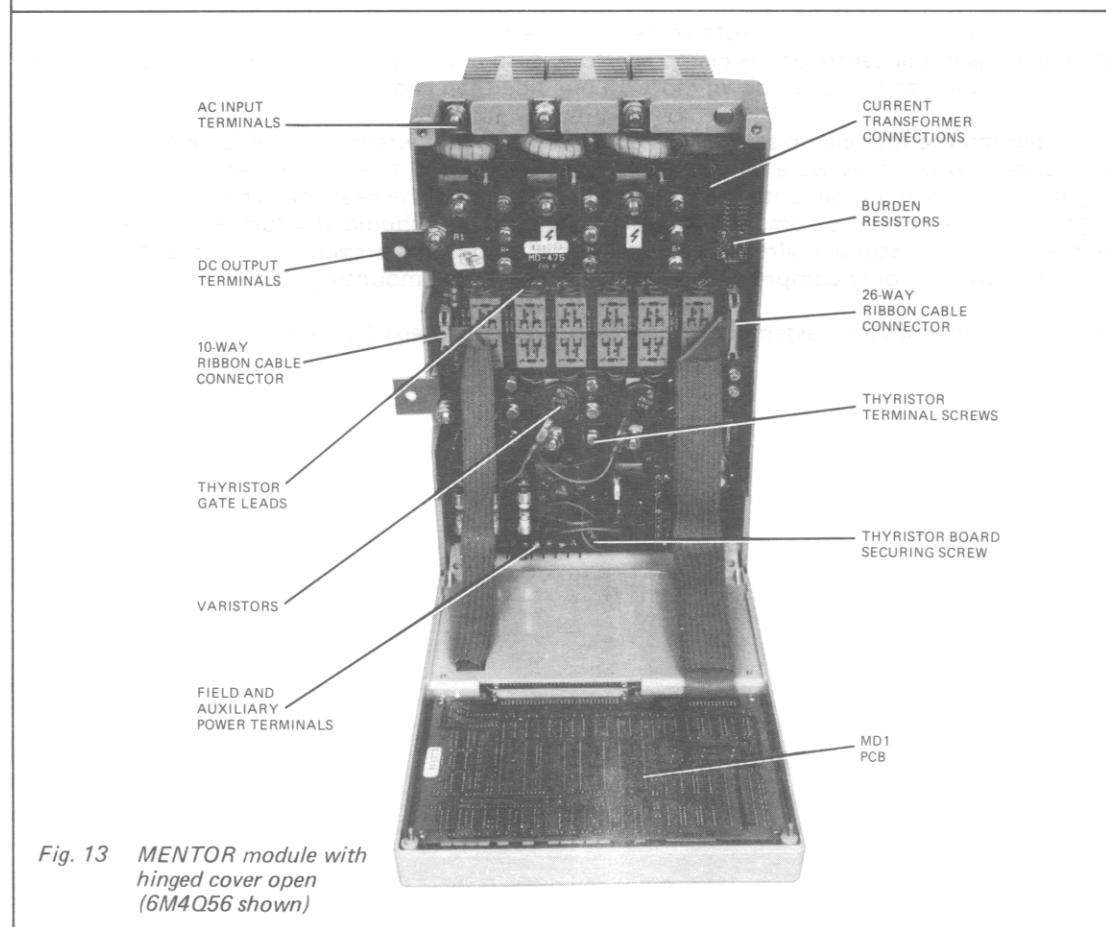
- 7.1 Remove the main dc connections A1+ and A2— from the converter.
- 7.2 Remove both parts of the lid, and the perspex shield beneath the hinged section.
- 7.3 Remove the +VE and/or —VE dc busbar assembly depending on the number and position of the faulty thyristors in the stack. This is done by first disconnecting the flying leads from the MD5 pcb to the busbars, then removing the three (or six on 4Q drives) M10 nuts and flat washers which secure the busbars to the thyristor clamps, and finally removing the M6 screws from below the busbars where they protrude through the bottom edge of the base moulding. The L-shaped busbar assemblies can then be removed intact.
- 7.4 Pull the gate/cathode leads on the faulty thyristor off the KK connector along the bottom edge of the MD6 pcb.
- 7.5 Now carefully remove the appropriate thyristor clamp by removing the four hexagon socket screws securing the clamp to the heatsink below. Screw pressures should be relieved evenly by unscrewing in a diagonal sequence, a maximum of one quarter of a turn each time until the screws are finger tight. The screws can then be fully unscrewed and the clamp and thyristor fully removed from the converter.

### 8 Thyristor — replacement

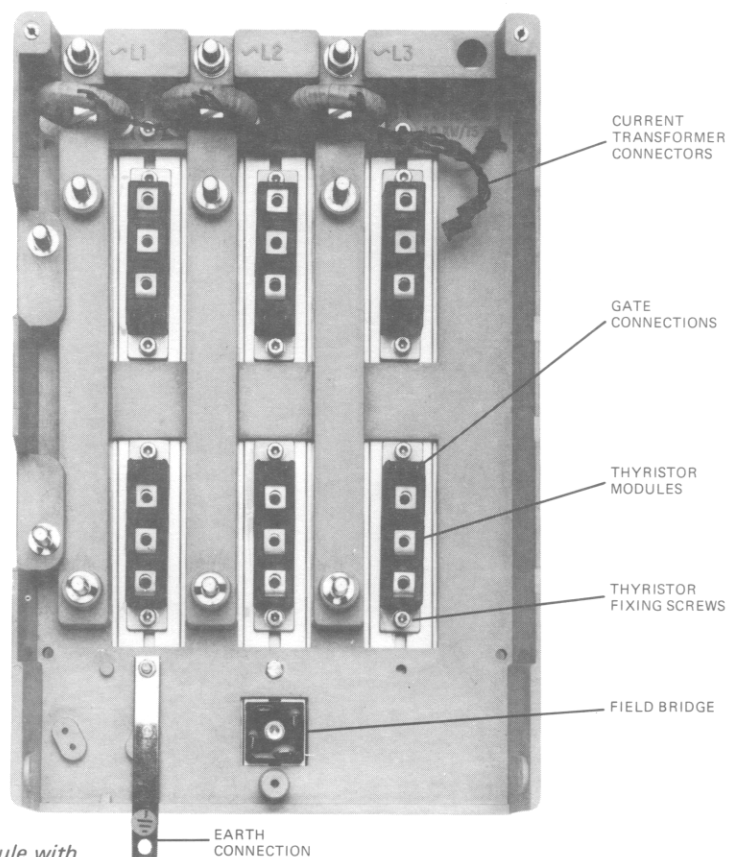
- 8.1 Clean the mounting surface of the heatsink with wire wool matting to remove any insulating oxide deposit that may have built up and then dust off carefully with a clean soft brush to remove any remnants of wire wool.
- 8.2 Apply a light smear of electrical joint compound (ALCOA NO. 2 EOC) to the heatsink surface immediately after cleaning. This is important to prevent oxidation of the surface and to seal the joint between the thyristor and heatsink against moisture and thus maintain a long term high thermal conductivity joint.
- 8.3 Check carefully which side of the thyristor should be against the heatsink. The anode and cathode of the device can be identified from the thyristor symbol printed on its side and confirmed by noting that there is an auxiliary flying lead connected to the device cathode. Compare the position of this lead with adjacent thyristors.
- 8.4 Having determined the correct way up for the device, insert into the mounting clamp making sure that the spigot on the clamp enters the location hole in the centre of the device contact surface and that the flying leads from the gate and cathode come out from the opening in the side of the clamp.
- 8.5 Now offer the device and clamp up to the heatsink with the assembly aligned such that the flying gate/cathode leads come out in the direction indicated by the screen printing on the base panel. Secure in place by tightening up the mounting clamp screws finger tight.
- 8.6 At this stage the device can be rotated beneath the clamp to centralise the flying lead connections in the centre of the clamp aperture. Also ensure that the clamp is set squarely on the device and not tightened down more on one side than another.
- 8.7 Now tighten the four clamp screws, using a hexagon socket wrench, in the same diagonal sequence in which they were released, making sure that each screw is rotated no more than one eighth of a turn at a time, until the clamp is right down on the heatsink. The screws will go tight when the clamp bottoms and under no circumstances should any further torque be applied. The thyristor will already be under correct mounting pressure and further tightening of the screws will only compress, and eventually crack, the mounting clamp.
- 8.8 From here on, converter assembly is the exact reversal of steps 1 to 4 of its dismantling.



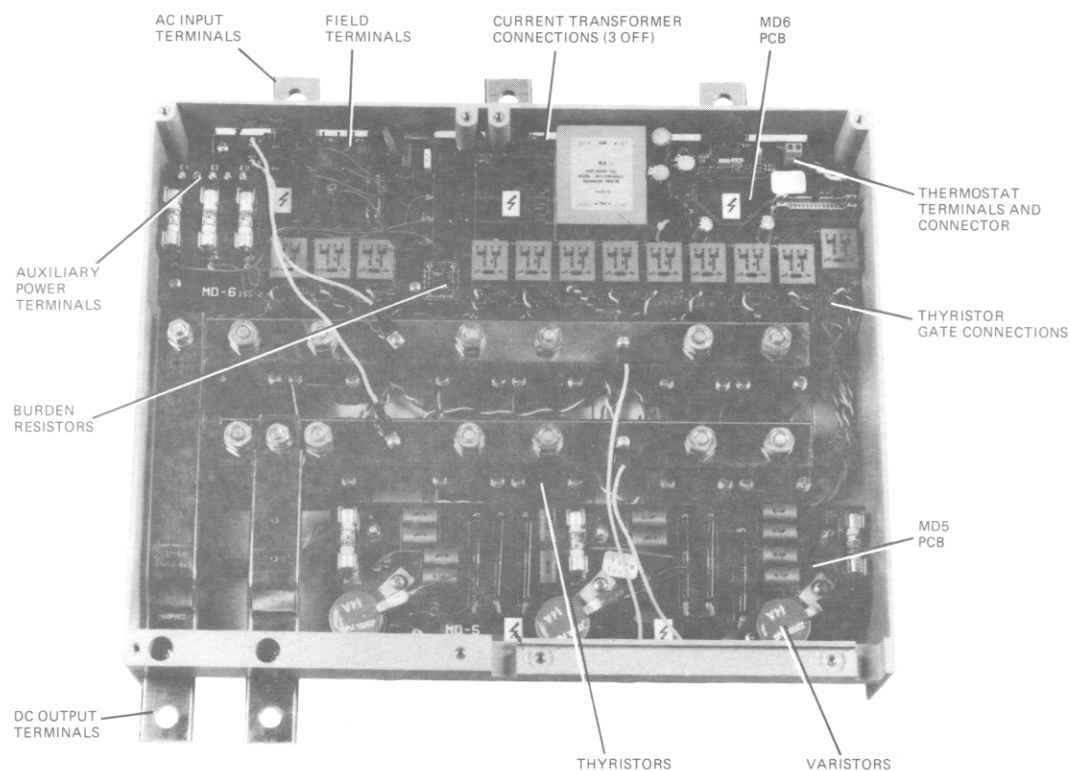
**Fig. 12** MENTOR module with inspection cover removed



**Fig. 13** MENTOR module with hinged cover open (6M4Q56 shown)



**Fig. 14** *MENTOR module with thyristor board removed (6M4Q30 shown)*



**Fig. 15** *MENTOR module 6MS4Q with covers removed*

## 14 Drive Parameters – (Quick Reference Guide)

NO.	KEY	SETTING	FUNCTION	DEFAULT
Real, read-only parameters:				
# 01			Analogue speed reference	
# 02			Speed reference	
# 03			Speed feedback	
# 04			Speed error	
# 05			Speed error integral	
# 06			Analogue reference (Term. 6)	
# 07			Current reference	
# 08			Current feedback	
# 09			Firing angle	
# 10			Analogue input (Term. 7)	
# 11			Analogue input (Term. 8)	
# 12			Analogue speed error	
# 13			Speed reference (pre-ramp)	
# 14			Sync. staircase	
# 15			Torque control variable	
# 16			Speed loop variable	
# 17			IR compensation term	
# 18			Measured acceleration	
# 19			Overload integration register	
Real read/write parameters:				
# 20	0		Security code	000
# 21	1		Preset speed 1 (inch)	+050
# 22	1		Preset speed 2 (run)	+300
# 23	2		Analogue reference offset	000
# 24	1		Max speed	+999
# 25	1		Min speed	000–1Q –999–4Q
# 26	2		Speed level 1 sense	+999
# 27	2		Speed level 2 sense	+999
# 28	2		Preset torque reference	000
# 29	2		Hard speed reference	(# 69)
# 30	2		Current taper start point	+999
# 31	1		Bridge 1 current limit	+999
# 32	1		Bridge 2 current limit	000–1Q +999–4Q
# 33	2		Integrating overload threshold	+700
# 34 – # 49			Reserved	

## 14 Drive Parameters – (Quick Reference Guide)

NO.	KEY	SETTING	FUNCTION	DEFAULT
Integer read/write parameters:				
# 50	—		Fault code	000
# 51	1		Acceleration forward ramp time	050
# 52	1		Deceleration forward ramp time	050
# 53	1		Deceleration reverse ramp time	000–1Q 050–4Q
# 54	1		Acceleration reverse ramp time	000–1Q 050–4Q
# 55	1		Speed loop proportional gain	080
# 56	1		Speed loop integral gain	040
# 57	2		Analogue reference scale	000
# 58	1		IR compensation	000
# 59	2		Current taper 1 slope	000
# 60	2		Current taper 2 slope	000
# 61	2		Current slew rate limit	040
# 62	1		Current loop gain	050
# 63	2		Integrating overload time	030
# 64	2		Digital filter response	128
# 65	2		Analogue output select	002
# 66	1		Speed offset fine	128
# 67	2		Programmable bit function 0	187
# 68	2		Programmable bit function 1	168
# 69	2		Programmable reference function	029
# 70	2		Serial network address	001
# 71	2		Current drive number	001
# 72	2		Line pacing character	000
# 73 – #89			Reserved	
# 90	2		Application control byte	001
# 91	2		Basic auto–BOOT	000
# 92	2		Status output byte	
# 93	2		LED functions byte	
# 94	2		Status output ST1 function	110
# 95	2		Status output ST2 function	113
# 96	—		Index	—
# 97	1		Security level 2 key	000
# 98	—		Processor 1 software revision	
# 99	2		Reserved	

## 14 Drive Parameters – (Quick Reference Guide)

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NO.	KEY	SETTING	FUNCTION	DEFAULT
Command bits:				
# 100			Software input 1	
# 101			Software input 2	
# 102			Inch reverse	
# 103			Inch forward	
# 104			Run reverse	
# 105			Run forward	
# 106			Drive start permit	
# 107			Drive enable	
Normal status bits:				
# 108			Forward velocity	
# 109			Reverse velocity	
# 110			Current limit	
# 111			Bridge 1 selected	
# 112			Bridge 2 selected	
# 113			Electrical phase back	
# 114			At speed	
# 115			Overspeed	
Fault status bits:				
# 116			Drive healthy	
# 117			Alarm	
# 118			Field Loss	
# 119			Tacho/feedback loss	
# 120			Phase loss	
# 121			Instantaneous overcurrent trip	
# 122			Sustained overload	
# 123			Overtemperature	
# 124			Watchdog timer	
(125)			Power supply fault code	
(126)			Armature open circuit fault code	

## 14 Drive Parameters – (Quick Reference Guide)

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NO.	KEY	SETTING	FUNCTION	DEFAULT
Miscellaneous read-only status bits:				
# 125			Phase sequence	
# 126			Speed level 1 exceeded	
# 127			Speed level 2 exceeded	
# 128			Analogue error window flag	
# 129			Speed amplifier saturation flag	
# 130			Zero current limit flag	
# 131			Processor 2 watchdog	
# 132 – # 149			Reserved	
Bit read/write parameters:				
# 150	0		NVRAM update	0
# 151	2		Quadrant 1 enable	1
# 152	2		Quadrant 2 enable	0–1Q 1–4Q
# 153	2		Quadrant 3 enable	0–1Q 1–4Q
# 154	2		Quadrant 4 enable	0–1Q 1–4Q
# 155	1		Internal reference select	0
# 156	2		Bipolar reference enable	0–1Q 1–4Q
# 157	2		Analogue scale factor range	1
# 158	1		Internal control select	0
# 159	2		Torque control bit 0	0
# 160	2		Torque control bit 1	0
# 161	1		Enable standstill logic	1
# 162	2		Standstill logic mode	0
# 163	0		Run (not stop)	0
# 164	0		Inch (not run)	0
# 165	0		Reverse (not forward)	0
# 166	2		Miscellaneous inhibit	0
# 167	2		Ramp enable	1
# 168	2		Ramp hold	(# 68)
# 169	2		Programmable status outputs	0
# 170	1		Security bit	0
# 171	2		Direct firing angle control	0
# 172	2		Line feed enable	1

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## 14 Drive Parameters – (Quick Reference Guide)

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NO.	KEY	SETTING	FUNCTION	DEFAULT
# 173	2		Prompt enable	1
# 174	2		Length of data frame	0
# 175	2		Parity enable	0
# 176	2		Parity type – odd	0
# 177	2		Enable XON/XOFF	0
# 178	2		Baud rate bit 0	1
# 179	2		Baud rate bit 1	0
# 180	2		Baud rate bit 2	1
# 181	2		Checksum enable	0
# 182	2		Adaptive control enable	1
# 183	2		High current loop integral gain	0–1Q 1–4Q
# 184	2		Fast current reversal	0–1Q 1–4Q
# 185	2		Disable normal LED functions	0
# 186	2		Tacho loss detection off	0
# 187	2		Field loss detection off	(# 67)
# 188	2		Overtemperature detection off	1
# 189	2		Reference S switch	0
# 190	2		Zero reference interlock	0
# 191	2		Ramp x 10 select	1
# 192	2		Reference T switch	1
# 193	2		Fine control select	0
# 194 – # 197			Reserved	

