Service Handbook

AC Motor Controllers Type VF 075/055 VF 075/075

DENFORD MACHINE TOOLS LIMITED
Registered Office and Works
BIRDS ROYD · BRIGHOUSE ·
WEST YORKSHIRE · HD6 1NB
Telephone · 0484 · 712264 · Telex 517478

1.1 THE VARIABLE FREQUENCY PWM INVERTER.

The VF075 drives utilise a fixed DC link Pulse Width Modulated (PWM) inverter system to produce a variable frequency variable voltage output. This basically means that the mains input is rectified and smoothed to give a DC supply of about 320 volts, and this is then switched onto the motor windings by six high power darlington transistors. The sequence in which these devices are made to switch produces the three phase waveform required by the motor, whilst the relative widths of the pulses is used to control motor voltage. By using a complex sequence of different pulse widths, the current in the motor can be made almost sinusoidal, thus producing smooth torque even at low speeds. In order to keep the switching rates of the devices to a reasonable level without compromising on output waveform, a system of pulse number changing (gear changing) is used. It is also necessary to deviate from the linear frequency/voltage law at low frequencies to compensate for the increased effect of winding resistance, thus a voltage "boost" function is included. In the VF075 design these control functions are peformed by a purpose built large scale integrated circuit (LSI) to simplify and reduce the component count.

1.2 THE MOTOR.

The VF075 type inverters are designed for use with standard 3Phase squirrel cage induction motors of 220/240 volts rating. The motor power must not exceed the inverter nameplate rating. Many motors are dual voltage e.g. 415/220 volts when connected star/delta, in which case the latter connection is used. When a standard type of induction motor is used, the regulation or speed droop on load is determined by the motor slip characteristic which may typically be 4-6% of synchronous speed. There is no limitation on the number of poles in the motor thus allowing a variety of base speeds.

The use of synchronous reluctance motors gives a 0% regulation but, due to the high peak currents taken by this type of motor, it is necessary to use an inverter having double the nominal motor power rating.

2.1 UNPACKING AND STORING.

Keep the equipment in a clean, dry area packed in its original container. Never store where the ambient temperature may exceed 60°C or may fall below 0°C, where humid conditions could cause condensation on the equipment, or where corrosion from the atmosphere is possible.

Correct storage is essential to ensure proper inverter operation and to maintain warranty coverage.

2.2 CABINET MOUNTING.

The cabinet must be mounted on a vertical surface using the lugs provided. This will ensure that a suitable gap exists between the rear of the controller and the mounting surface which is required for cooling. Under no circumstances must this gap be reduced or blocked as damage will inevitably occur to the inverter. Choose an area to mount the cabinet which is not subject to temperatures above 40°C or below 0°C, is clean dry, and vibration free.

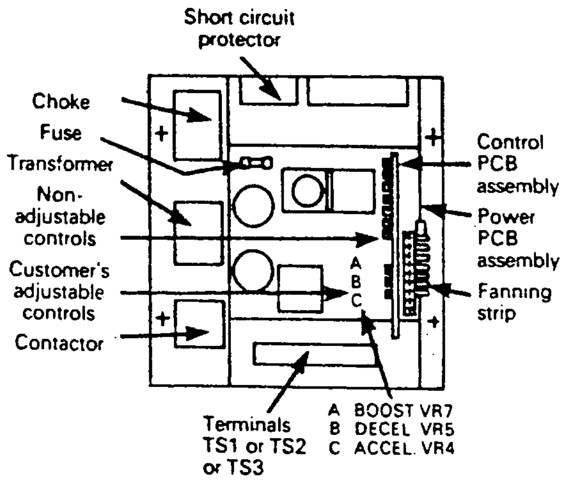
Connect electrical conduit to the holes provided in the cabinet base and proceed to wire according to the section "ELECTRICAL CONNECTION" .

2.3 CHASSIS MOUNTING.

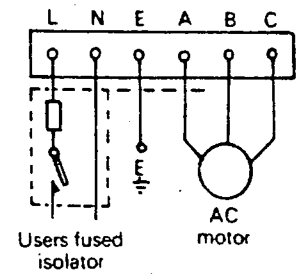
The VF075 chassis unit has a flat heatsink plate which may be clamped directly to a surface from which its heat may be dissipated or mounted away from the surface if free ventilation exists.

There must be adequate ventilation to ensure that the heatsink temperature remains below 85°C. With a chassis mounted in a large volume of air, it is possible to achieve this in ambient temperatures of up to 50°C.

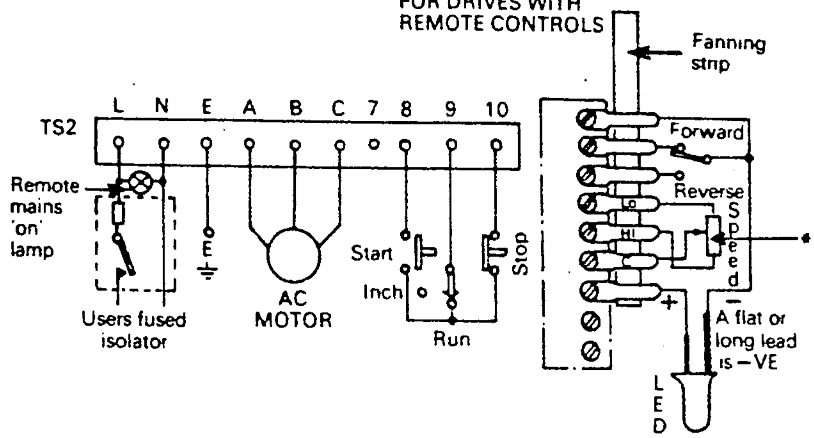
BROWN PESTELL
Power Transmission Technology



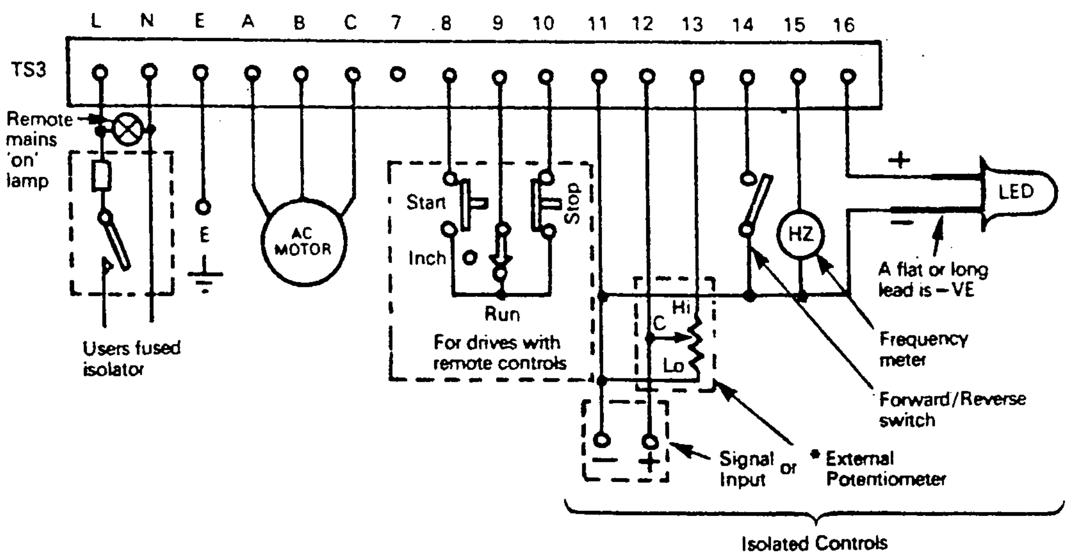
FOR CASED DRIVES WITH INTEGRAL CONTROLS



FOR DRIVES WITH REMOTE CONTROLS



FOR DRIVES WITH ISOLATED INTERFACE



* SEPARATELY MOUNTED POTENTIOMETERS. USE TIGHTLY TWISTED CABLES IN A SEPARATE RUN.

3.4 DECELERATION RATE - VR5

The deceleration rate is controlled in a similar manner to the above but using the deceleration control.
NOTE: DO NOT ATTEMPT TO ACHIEVE HIGHER RATES OF DECELERATION THAN NECESSARY AS EXCESSIVE REGENERATED VOLTAGE CAN OCCUR CAUSING THE TRIP TO OPERATE.

3.5 LOW FREQUENCY VOLTAGE BOOST - VR7

This control, when turned clockwise, increases the voltage applied to the motor at low frequencies to provide greater breakaway torque. If this is required, only small adjustments must be made until satisfactory operation is achieved.

CAUTION: INCREASING THE VOLTAGE BY USE OF THE BOOST CONTROL CAN CAUSE HIGH MOTOR CURRENTS EVEN WITH LIGHT LOAD ON THE MOTOR RESULTING IN EXCESSIVE MOTOR HEATING. IF ADJUSTMENT IS MADE, USE ONLY THE MINIMUM AMOUNT OF BOOST TO SATISFY THE REQUIREMENT. THE ELECTRONIC TRIP MAY ALSO OPERATE IF THIS SETTING IS INCREASED TOO MUCH.

3.6 PREVENTATIVE MAINTENANCE.

Routine maintenance checks on the inverter can be useful in reducing downtime and are generally very simple. The following is a guide to the main points which should be given attention.

Remove the input power from the inverter and leave for at least two minutes before opening the cabinet. Carefully remove any accumulated dust with low pressure air or a soft brush and ensure that the inside of the cabinet is clean and dry. Visually inspect the chassis for any obvious physical problems such as loose circuit boards, loose or broken wires or burn marks on circuit boards. Examine the electrical connections to ensure they are all clean and tight. Check the physical condition of the cabinet paying particular attention to the heatsink at the back to ensure that no obstruction to cooling airflow has occured.

The main functions of the control PCB are listed below in the order in which they will be described in this section. Refer to FIG.4.

NOTE: There are a few references in the following text to 'early' boards. These can be identified by the lack of the suffix 'MOD 1' on the title on the reverse of the board.

a) Power supply
b) Switch on/off sequence control
c) Accelerate/decelerate ramp and reference generation
d) PWM, drive waveform generation
e) Electronic trip and indicator
f) Direction control

4.1 POWER SUPPLY.

The incoming power on pins 1&2 is 15vac from the low voltage transformer. This is rectified and smoothed by RECT2 and C15/16 to give a dc output on pin 16 of approximately 20 volts off load and 15 volts on load to power the drive transformers on the power board. A voltage regulator REG1 produces 12vdc to power the control card circuits. D9 and D10 produce a full wave rectified but unsmoothed output which is applied to R31, the function of which is described later. Early cards used a single diode D7 in series between RECT2 and C15/16 to provide this function with R31 connected to D7 anode.

4.2 SWITCH ON/OFF SEQUENCE

The unsmoothed rectified waveform described in the previous section is applied to TR7 via R31,32 and C18 which provides a short time constant, holding TR7 in conduction as long as an input waveform is applied. This holds off TR8 and allows C19 to charge via R35 until the voltage threshold of Z3 is reached whereupon TR9 conducts and energises the relay. Thus on initial application of voltage to the card, the relay energises after a short time delay (1-2 secs.) which is to allow for stabilisation of the control circuits before activating the inverter. If, however, the ac waveform on pins 1&2 is lost for longer than the time constant set by C18, R31, 32, then TR7 cuts off allowing TR8 to conduct which rapidly discharges C19 via R34. TR9 is thus turned off and the relay de-energises before the main power supply, which is maintained momentarily by C15/16, is lost. This sequence of delay before closing of the relay with rapid opening on loss of ac power is vital to the correct operation of the power inverter system.

4.4 PWM WAVEFORM GENERATOR (ctd.)

The voltage clock appears on TP5 and is formed by two gates of IC7 plus TR3 and associated components. The two time periods of the square wave are separately produced, one fixed by C26,R66 and the other by C5 and the current produced by TR3 and associated components. At low levels of speed demand voltage, which appears across VR8, TR3 is not conducting and the clock period is determined by VR7 and R13. As the voltage rises TR3 turns on and increases the clock frequency by bypassing VR7,R13. When the input voltage exeeds 1.2 volts the stabistors D3 and D4 conduct and further increases have no effect. Thus the clock frequency at low speeds is low and increases rapidly with speed to a fixed point. Since the LSI produces an output voltage/frequency law dependant on this clock input, this provides the means of applying voltage boost to the motor at low speeds which is necessary to overcome the effect of winding resistance. Normally the output volts per Hertz figure is constant, i.e. the motor voltage is proportional to the frequency. When the voltage clock reduces in frequency, the output volts per Hertz is increased thus producing a higher than normal voltage on the motor.

As already stated the LSI device combines these clocks to produce a PWM waveform. This waveform has a 'dead' period between complementary outputs (i.e. neither is on) but this inverter design requires an overlap, thus IC2 inverts all the outputs to achieve this effect.

4.5 ELECTRONIC TRIP

Pins 10 and 13 on the PCB bring in the current limit and over-voltage signals respectively from the power board and these are applied via TR4 and TR6 to a latch circuit formed by IC6. If either of these were to conduct the latch would engage and TR5 would conduct. Pin 3 takes this signal out to the LED indicator and pin 18 takes it to the shut down circuitry on the power PCB. R17 and C7 ensure that the latch is reset on switch on.

4.6 DIRECTION SELECT

IC1 has the facility to reverse the sequence of its output causing reverse rotation on the motor. Pin 5 on IC1 is the select input and this is fed by a cross latch circuit IC5. This circuit will change states upon setting either pin 7 or 8 on the PCB to 0 volts via the forward/reverse switch, but only if the other input to the latch from the relay is also at 0 volts. Thus the direction can only be changed when the inverter is stopped.

The basic functions of the power PCB are as listed below. Refer to FIG.5 & 6.

a) DC link production.
b) Over-voltage protection.
c) Current sense.
d) Power inverter.
e) Shut down circuitry.

5.1 DC LINK

The incoming mains supply via the start contactor is rectified by RECT1 and charges the main bus capacitors C13 and 14 via L1. The main DC bus is fed through fuse FS1 to the inverter bridge. The function of the choke L1, is to reduce the peak charging current to the capacitors to a safe value for the rectifier.

5.2 OVER-VOLTAGE PROTECTION

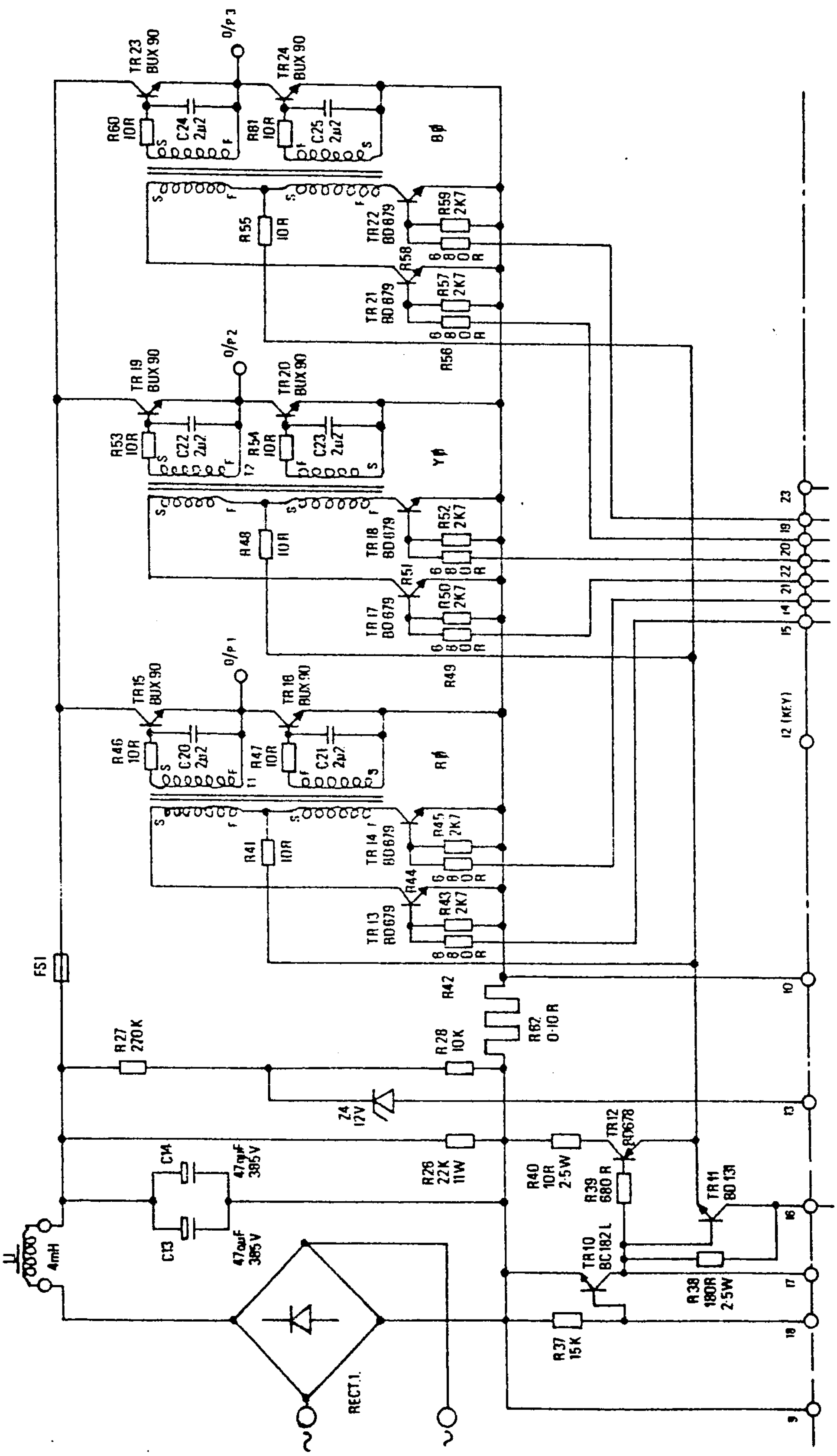
Excess voltage can appear on the bus if the motor regenerates (e.g. if the load overhauls the motor or if the deceleration rate is too high) and this must be protected against.

Resistors R27,28 divide the link voltage down and apply it to Z4. When the threshold voltage of Z4 is reached, it will conduct and activate the electronic trip via pin 13 on the control PCB.

5.3 CURRENT SENSE

It is essential to activate the electronic trip if excessive current flows in the inverter bridge to avoid destruction of the power devices. R62 senses bridge current and the voltage developed across it is applied to the trip circuit via pin 10 on the control PCB.

POWER P.C.B. CIRCUIT DIAGRAM - FIG.5



January 1983

BROWN PESTEL

WARNING: THIS PROCEDURE MUST BE CARRIED OUT WITH THE CONTROL PCB SEPARATE FROM THE INVERTER CHASSIS. THE PCB MUST BE PLUGGED INTO A DUMMY SOCKET WHICH IS WIRED WITH A LOW VOLTAGE POWER SUPPLY AND A CONTROL POTENTIOMETER AS SHOWN IN FIG.7. AN ACCURATE FREQUENCY COUNTER IS REQUIRED AND THIS MUST BE FITTED WITH HIGH IMPEDANCE PROBES (10Mohm) TO AVOID LOADING THE CIRCUITS. IF AN OSCILLOSCOPE IS USED TO VIEW ANY WAVEFORM IT MUST ALSO BE FITTED WITH THESE PROBES.

6.1 INITIAL SETTINGS

VR4,VR5,VR7,VR8 FULLY ANTICLOCKWISE. The other potentiometers may be left unadjusted.

6.2 PROCEDURE

Insert the board in the dummy socket and apply power.

1) Note that after applying power the relay will close after a delay of 1-2 secs. but that on removal of power it must open IMMEDIATELY.

2) REFERENCE CLOCK: Connect counter to TP2 (with reference to 0 volts) and adjust VR10 to give a reading of 290-310kHz.

3) DELAY CLOCK: Connect counter to TP3 and adjust VR11 to give a reading of 490-510kHz.

4) FREQUENCY CLOCK: Connect counter to TP4; with speed demand potentiometer set to minimum adjust VR3 to give a reading of 16-18kHz. Readjust speed demand to maximum and adjust VR1 to give a reading of 165-175kHz. Since there will be some interaction, recheck and adjust if necessary.

5) VOLTAGE CLOCK AND BOOST: Connect counter to TP5; with speed demand at maximum adjust VR6 to obtain a reading of 275-285kHz. With speed demand at minimum adjust VR7 to give a reading of 165-175kHz.

WARNING: THE VF075 INVERTER USES A "LIVE" 0 VOLT RAIL FOR THE CONTROL ELECTRONICS. THIS MEANS THAT ANY TEST EQUIPMENT TO BE CONNECTED TO IT MUST BE UNEARTHED. IT IS RECOMMENDED THAT NO EQUIPMENT BE CONNECTED TO AN INVERTER WHICH IS TO BE RUN.

If a new or re-calibrated control PCB is fitted or if repairs have been made, the inverter should be run with a motor load having an AC ammeter in one line. DO NOT USE A CLIP-ON TYPE AMMETER AS THE READINGS AT LOW FREQUENCY WILL BE INCORRECT.

Ensure that at low speeds the current is always within the nameplate rating. If as the speed is increased this figure is exceeded, the boost threshold must be reduced by VR8 to remove the boost earlier. Load the motor and check that the electronic trip activates at 150% of motor nameplate current. If this is not so the inverter should be switched off and adjustment made to VR9 on the control PCB (VF075). Run the inverter and recheck the setting. DO NOT ADJUST CONTROLS WITH THE INVERTER RUNNING. Check the operation of the ramp controls and set to a suitable level.

These settings give the motor a reasonable amount of low speed boost and should give enough low speed torque for most applications. If higher boost settings are required, VR7 would be adjusted but only the minimum amount necessary for the application must be used as high peak motor currents will result causing extra motor heating. The electronic trip may also activate if the boost is set too high.

8.1 SHORT CIRCUIT PROTECTION - FIG.11

A small PCB is mounted on a bracket from the upper heatsink and two flying leads from it are wired in place of a link wire on the power PCB (FIG.12). The board contains a small inductor and a snubber network which are effectively put in series with the DC link to the inverter. This has the effect of slowing down the rate of rise of fault currents so that the electronic trip can act in time to protect the inverter. This will not, however, protect against earth faults.

8.2 REVERSING

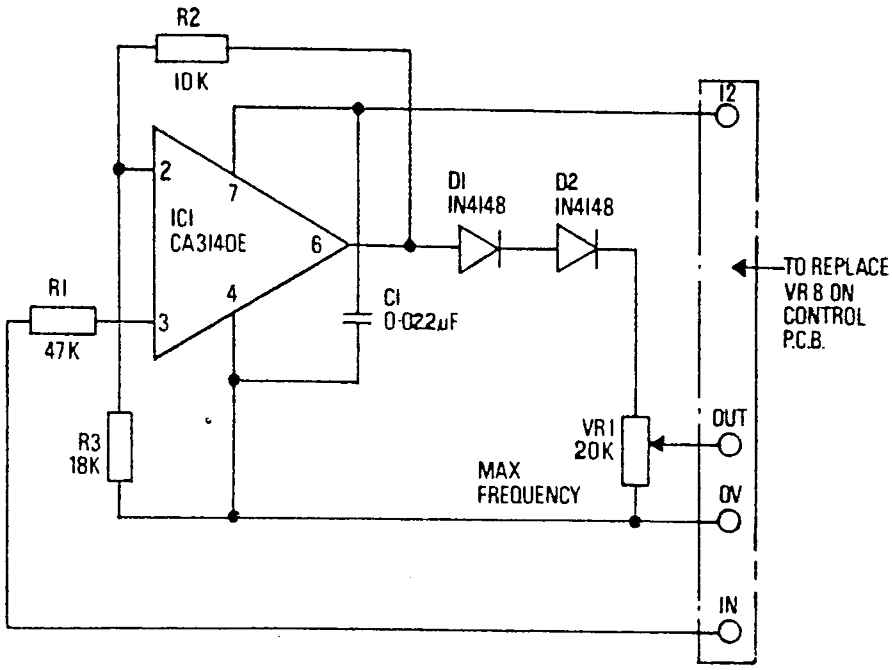
Provision is made on the fanning strip on the right of the chassis, numbers 7, 8 and 9 (FIG.2), for a reverse switch to be fitted. If no switch is fitted, a link must be installed between 8 and 9 on the fanning strip. The control logic is interlocked so that the direction can only be changed after the drive has been stopped.

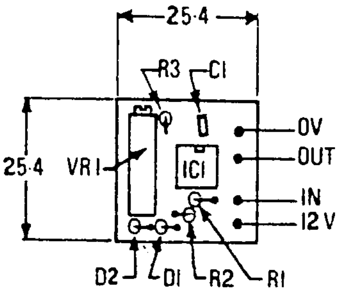
8.3 OVER TEMPERATURE TRIP

A simple thermostatic switch is fitted to one of the transistor heatsink plates and is wired into the main stop button circuit. The switch is set at 95°C.

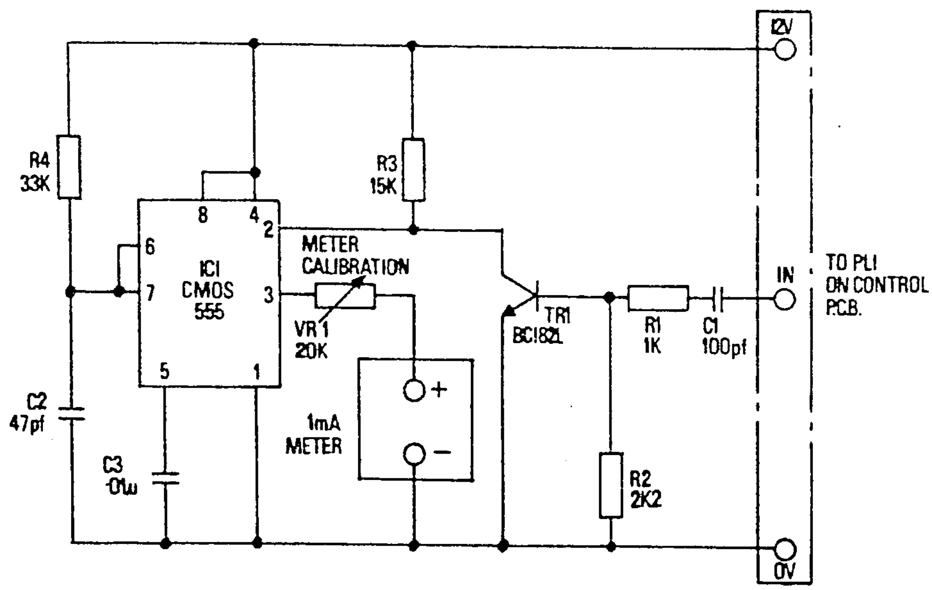
8.4 EXTENDED FREQUENCY RANGE - FIG.8

If an extension to the frequency range to 75 or 100Hz is required a small amplifier board is fitted in place of VR8 on the control PCB. The purpose of this is to amplify the voltage to the boost circuit so that the boost is still removed at the same frequency. A smaller value capacitor is fitted as C4 and the frequency clock is set to a proportionally higher value. Resistor R3 in the ramp circuit is changed as shown to avoid too rapid a deceleration from the increased speed.

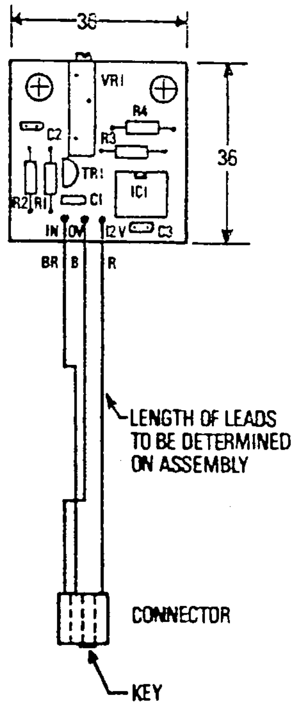




P.C.B. ASSEMBLY



P.C.B. ASSEMBLY

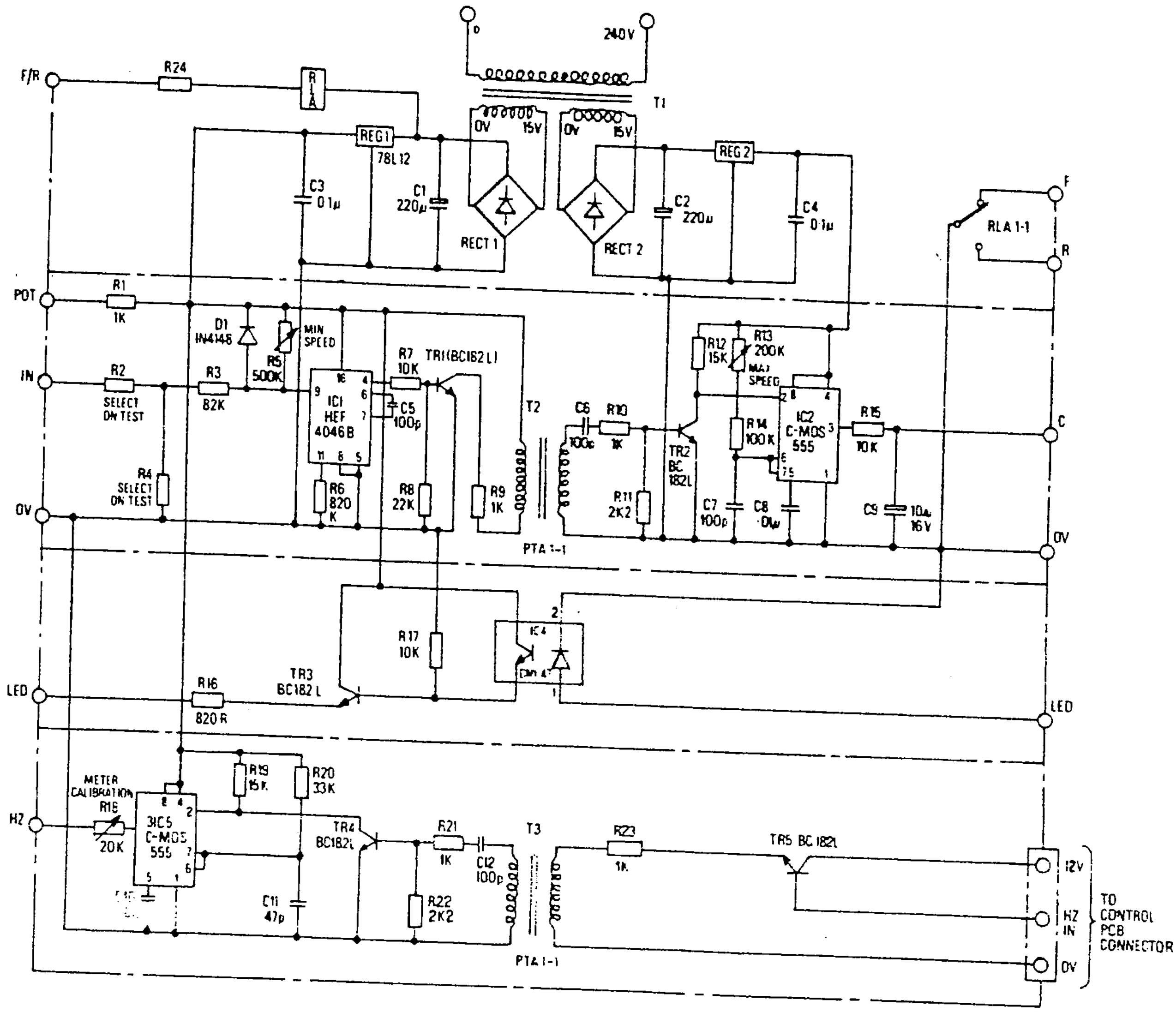


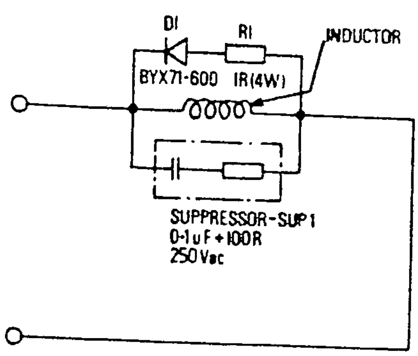
0-5V
R2 = 1k2
R4 = 10k

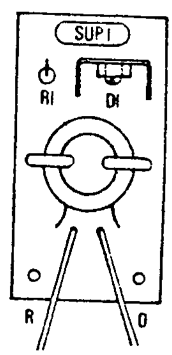
4-20mA
R4=270R
R2=link

Pot.
R2=link
R4=Open

VF075	INTERFACE P.C.B. & CIRCUIT DIAGRAM - FIG.10 (ctd.) SHORT CIRCUIT PROTECTOR - FIG.11







January 1983

BROWN

VF075	9: FAULT FINDING GUIDE

If the inverter should fail to operate, a basic sequence of checks should be made to enable the general area of the fault to be located.

CAUTION: VERY HIGH VOLTAGES EXIST WITHIN THE CONTROLLER AND THESE CAN BE PRESENT FOR SOME TIME AFTER SWITCH OFF. DO NOT TOUCH ANY INTERNAL CIRCUITRY EXCEPT WITH INSULATED TEST PROBES AND IN ACCORDANCE WITH THE GUIDE BELOW. IT SHOULD ALSO BE NOTED THAT THE VF075 INVERTER CONTROL ELECTRONICS ARE AT MAINS POTENTIAL AND MUST NOT BE EARTHED BY ANY EQUIPMENT CONNECTED TO THEM.

1: Check the incoming mains supply to the unit and ensure it is within specification.

2: Ensure that the mains contactor operates - otherwise check contactor coil, pushbuttons [illegible]ring.

3: With contactor energised check for DC link voltage from -ve terminal of main rectifier (-ve) to fuse on power PCB (+ve). Should be approx. 325 volts dc. If not, suspect rectifier bridge. Test to both sides of fuse to ensure fuse is intact. If fuse is blown, proceed to inverter checks.

4. Check whether relay on control PCB energises after a short delay - if not, check voltage across capacitors C15/16 on control PCB (FIG.3) which should be approx. 15v dc. If this is not so, suspect the supply transformer which is mounted on the chassis.

5. REMOVE ALL POWER AND WAIT FOR SEVERAL MINUTES TO ENSURE DISCHARGE OF BUS CAPACITORS.
The inverter power devices may be checked by using an AVO or other suitable multimeter with an ohms range. The checks rely on detecting "diode action" which means that a resistance measurement is made, and then a second reading is taken with the AVO probes reversed. "Diode action" has been detected if one reading is below approx. 1000 ohms and the other is above approx. 10,000 ohms. Disconnect the motor leads at the terminal strip and, with the AVO on an ohms range, measure between the terminal "A" on the strip and the -ve terminal on the main rectifier. The result should be "diode action". Repeat for the terminals "B" and "C". Check again from terminals "A", "B" and "C", this time with respect to the fuse on the power PCB with the same expected result. If any of these six readings is not correct, it is prob[illegible] a power device has failed. If further action is to be [illegible], it will be necessary to remove the devices for individual testing to determine which has failed and to test the associated snubber components which are likely to have been damaged.

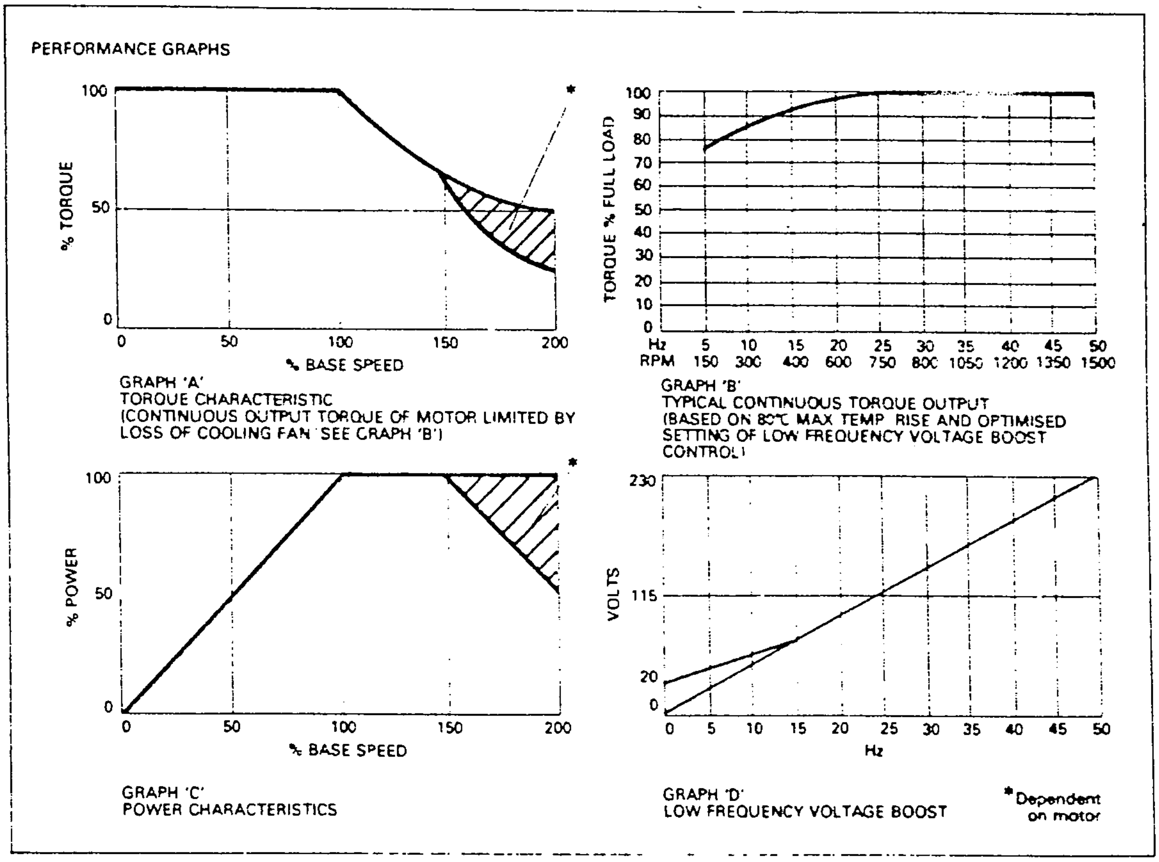
MODEL	POWER	INPUT CURRENT (MAX.) RMS	OUTPUT CURRENT (CONT.) RMS
VF075/055	0.55kW	6 Amps	3 Amps
VF075/075	0.75kW	8 Amps	4 Amps

INPUT POWER SUPPLY.	220/240 volts 1Phase 50Hz.
CONTROLLER OUTPUT.	20/240 volts 3Phase Variable frequency.
OUTPUT FREQUENCY.	5-50Hz Standard. 5-75 or 5-100 Hz. Optional.
OUTPUT TORQUE.	Constant torque 5-50 Hz. Constant power 50-100 Hz.
SPEED DROOP ON LOAD.	4-6% of sync. speed (induction motor) 0% (synchronous reluctance motor).
STARTING TORQUE.	Up to 150% full load torque.
ACCELERATION RATE.	2-20 seconds adjustable.
DECELERATION RATE.	2-20 seconds adjustable.
PROTECTION.	Over current/excess regeneration trip. Output short circuit protection (option). Over temperature cut out (option).
CONTROLLER MAX.LOAD.	150% full load for 1 minute.
AMBIENT TEMP.RANGE.	0-40°C (cased unit) 0.55°C (chassis unit-freely ventilated).
ALTITUDE LIMIT.	1000 meters.
LOW SPEED VOLTS BOOST.	Adjustable 0-20 volts.
REGENERATIVE PERFORMANCE	Unit trip when regenerative current causes 115% of normal operating voltage to occur on the inverter rails.
AUX. CONTACTS.	1N/O, 1N/C on main contactor rated 10 amp 250 volts ac.
INDICATORS.	Trip (LED), Mains on (neon).
ENCLOSURE.	To IP44 (high standards optional).

OPTIONS.

Reversing, Inching, Speed indication,
Multiturn speed demand control,
Overtemperature trip,
Extended frequency range (100Hz max.)
External reference signals,
External signal isolation.

PERFORMANCE GRAPHS



GRAPH 'A'
TORQUE CHARACTERISTIC
(CONTINUOUS OUTPUT TORQUE OF MOTOR LIMITED BY LOSS OF COOLING FAN SEE GRAPH 'B')

GRAPH 'B'
TYPICAL CONTINUOUS TORQUE OUTPUT
(BASED ON 80°C MAX TEMP RISE AND OPTIMISED SETTING OF LOW FREQUENCY VOLTAGE BOOST CONTROL)

GRAPH 'C'
POWER CHARACTERISTICS

GRAPH 'D'
LOW FREQUENCY VOLTAGE BOOST

*Dependent on motor

Brown Pestell Limited,
Lordswood Ind. Est., Chatham, Kent ME5 8UD.
Tel: (0634) 687141 (10 lines) Telex: 966219
Chesterfield Ind. Est., Chesterfield, Derbyshire S41 9RQ.
Tel: (0246) 452393 (8 lines) Telex: 547580
Westfield Ind. Est., 23 Deerdykes View,
Cumbernauld, G68 9HN. Tel: (02367) 36981 Telex: 777617