T&R Test Equipment Ltd

OPERATING AND MAINTENANCE MANUAL

Product: ***Digital Voltage Source***

Type: ***DVS3 mk2***

DESIGNED AND MANUFACTURED BY:

T & R Test Equipment Limited

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GENERAL SAFETY STATEMENT


WARNING

The following safety precautions should be reviewed to avoid injury to the user and damage to the product (and other products connected to it). To avoid potential hazards only use this product as specified.

- **Only suitably qualified personnel should use this equipment. Servicing of this product should only be carried out by suitably qualified service personnel.**

To Avoid Fire Hazards and Personal Injury

- Use the correct power supply lead. Only use a suitably rated and approved power supply lead for the country of use.
- Ensure that systems that the unit is to be connected to are dead.
- Do not connect and disconnect leads whilst outputs are switched on. Breaking the output circuit with current flowing may cause arcing.
- Ensure that the product is grounded. To avoid electric shock it is essential that the grounding conductor is connected to the earth ground. An additional earth terminal is unit that must be connected to a local earth. Ensure that the unit is properly grounded before making any connections to inputs or outputs.
- Terminal ratings must be observed to prevent fire hazards and risk of injury to the operator. Consult the product manual for ratings information before making connections to any terminal.
- It is ESSENTIAL to consult the product manual for rating information before making any connection to a terminal or terminal group marked with a warning triangle.
- Only use fuses of a type and rating specified for this product.
- Do not operate the unit out of its case or with any covers or panels removed.
- Do not touch exposed connections and components when power is present.
- Do not operate the product if any damage is suspected. Refer the unit to qualified service personnel to be checked.
- Do not operate the unit in wet or damp conditions
- Do not operate the unit in an explosive atmosphere

If any further queries occur regarding the usage and maintenance of the equipment detailed in this manual, please refer these to the supplier of the equipment in the first case or to the manufacturer, T & R Test Equipment Limited.

SAFETY TERMS AND SYMBOLS

The following safety symbols appear on the equipment:

CAUTION/WARNING – Refer to manual

Mains off

Mains on

The following safety symbols appear in this manual:

CAUTION — This action or procedure may be dangerous if not carried out correctly, and may cause damage to the equipment or connected equipment.

WARNING — This action or procedure may be cause injury or death to the operator or other personnel if not carried out correctly using applicable safety procedures.

CONTENTS

1 DESCRIPTION OF EQUIPMENT

The DVS3 mk2 is a relay test system designed for testing voltage and frequency protection relays and transducers. It generates a three phase voltage output from a single phase supply, and may be used in conjunction with a current source to test directional protection.

1.1 Front Panel Layout

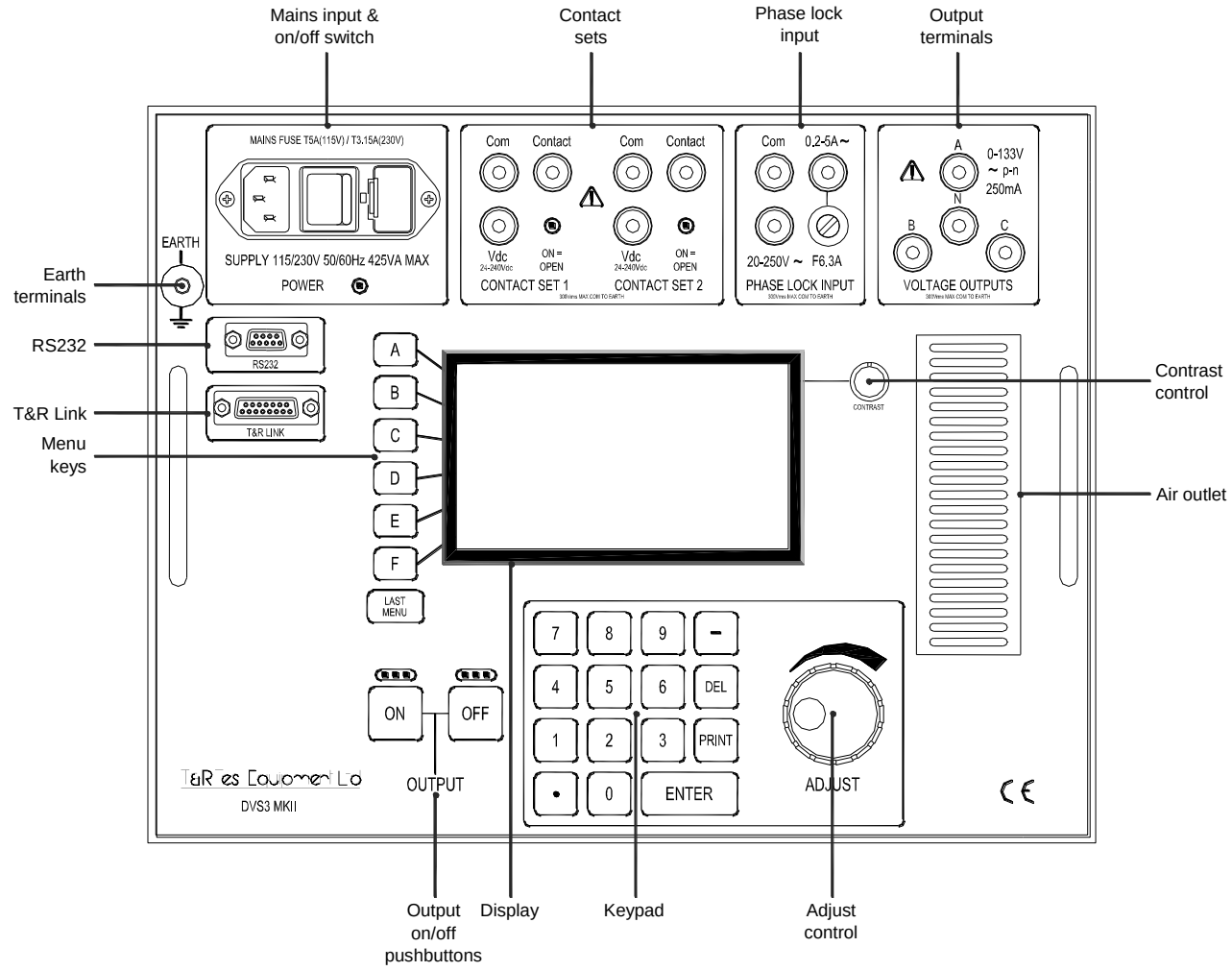

Figure 1.1 DVS3 mk2 front panel layout

1.2 Electrical Specification

1.2.1 Supply Requirements

The DVS3 mk2 requires a single phase 50/60Hz supply of 115V±15% or 230V ±15%. The correct range is automatically selected by the unit. The maximum power requirement of the unit is 425VA.

1.2.2 Outputs

The unit has a three phase star connected output, and each phase has the following rating:

Voltage:	0-133 volts phase-neutral
Current (5 min on/15 min off):	330mA at 133V falling linearly to 200mA at 0.1V*
Current (continuous):	200mA at 133V falling linearly to 120mA at 0.1V*
Phase Lock:	45Hz to 65Hz
Variable Frequency:	40-999.9 Hz
Variable Phase angle:	±180.0º

*All output ratings are based on an ambient temperature of 25°C

1.2.3 Metering Resolution and Accuracy

Parameter	*Resolution*	*Accuracy*
Output voltage (phase-neutral)	0.1V	±0.3% of reading +3 digits
Output voltage (phase-phase)	1V	±0.3% of reading +3 digits
Phase angle adjustment ±180°	0.1°	±0.3° phase-phase ±3° reference to output
Frequency range 40.00 to 99.99Hz	0.01Hz	±0.01% of reading +1 digit
Frequency range 100.0 to 999.9Hz	0.1Hz	±0.01% of reading +1 digit

1.2.4 Timing System Specification

The DVS3 mk2 is fitted with an integrated timing system linked to the main output and the two sets of contacts. Timing is automatically started on entering a new value (when the output of the set is on), and stopped on a change of state of contact set 1 or 2. The maximum voltage appearing on the relay contact test sockets is 24Vdc, and the maximum current flowing in the test circuit when the relay contacts are closed is 20mAdc. The contact test circuit is fully isolated.

The Vdc contact inputs are sensitive to DC voltage in the range 24-240Vdc. A change of voltage from 0 to 24-240V or vice-versa will trigger the timer circuit in the same way as a change of contact state on the contact input. These inputs may be used with ‘wet’ contacts with dc voltage present (+ to Vdc, - to Com).

1.2.5 Phase Lock

The main output may be locked to the following inputs:

- Mains supply lock input
- External reference lock inputs
- T&R link input (from other T&R units)

When the external inputs are selected the main output lock is automatically transferred from the mains supply to the external reference, when a voltage or current at the correct level is applied.

The unit will automatically lock to a valid signal from the T&R link connector when the unit is in phase lock mode, whether the unit is in mains lock or external lock mode. Do not attempt to connect external voltages or currents to the T&R link input - this interface is only for connection to other compatible T&R units.

For the polarity configuration for both inputs with respect to the main output, please see Section 2.3.7.

1.2.5.1 External reference lock ratings

Voltage range:	20-250 Vac rms
Frequency range:	45 to 65Hz
Maximum Burden:	0.25VA
Current range:	0.2-5Aac rms
Frequency range:	45 to 65Hz
Maximum Burden:	3VA

1.2.6 Temperature Range

The operating temperature range for the unit is -0°C to +40°C.
The storage temperature range for the unit is -20°C to +60°C.

1.2.7 Overload Protection

The mains input and phase lock current input are protected by the following fuses:

230V supply	1.25" T3.15A
115V supply	1.25" T5A.
External current input	20mm F6.3A

1.2.7.1 Overcurrent Trip

The main voltage outputs are protected by an electronic over current trip. The trip level is dependent on the output voltage, and varies linearly from 200mA at minimum output voltage to 330mA at maximum voltage.

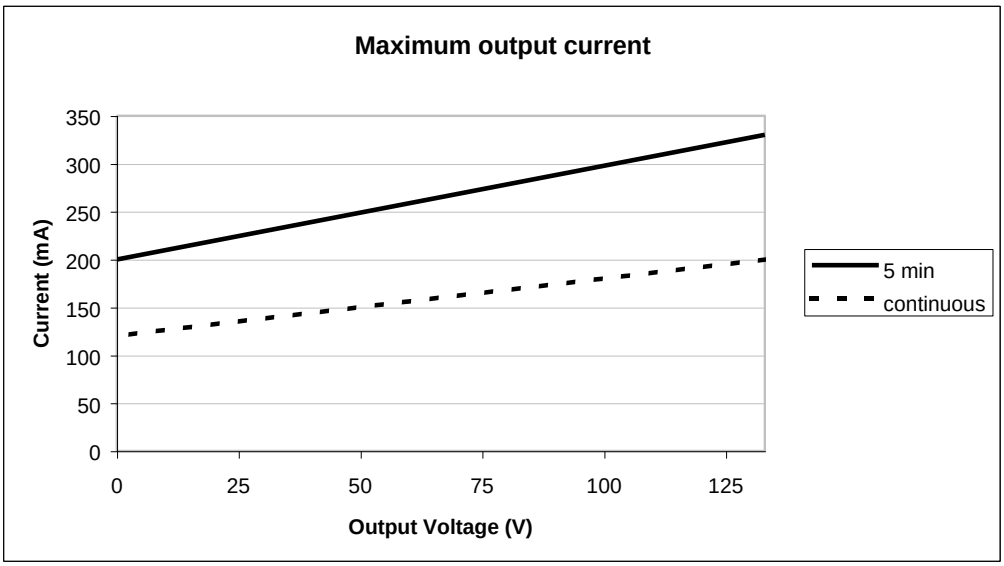

Figure 1.2 DVS3 mk2 maximum output current

The maximum output current at any voltage is available for a maximum period of 5 minutes on followed by 15 minutes off.

An overload on the output is indicated by the message shown in figure 1.3. The ENTER key must be pressed to clear the message before the output may be switched on again.

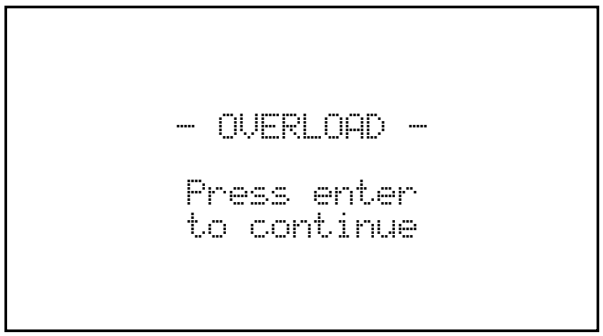

Figure 1.3 Overcurrent trip error message

1.2.7.2 Over Temperature Trip

The unit is fitted with two over temperature sensors which will de-energise the output if the main heatsink or power supply exceeds 65°C. In this situation one of the error messages shown in figure 1.4 is displayed, and the unit must be allowed to cool before the output may be switched back on.

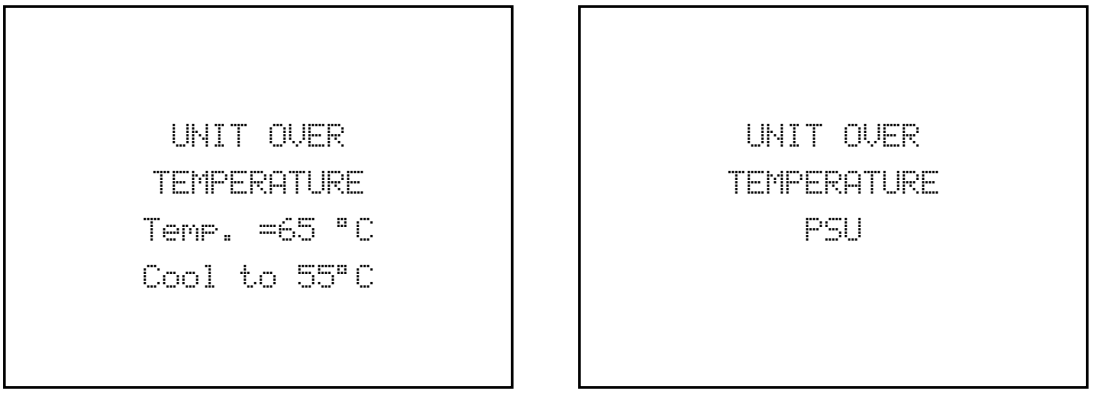

Figure 1.4 Over temperature error messages

The message will automatically clear when the unit has cooled to 55°C.

1.3 Construction

The DVS3 mk2 relay test system is housed in a robust aluminium case fitted with a carrying handle and corner protectors. The front panel of the unit is protected by a hinged cover.

The unit is cooled by a fan with air intake on the rear panel and air outlet on the front panel. **The unit must not be operated with the air vents blocked.**

2 USING THE DVS3 MK2

2.1 Getting Started with the DVS3 mk2

Connect the DVS3 mk2 to a suitable supply (115/230V) using the mains cable supplied. The unit will automatically adjust to the supply voltage. When the set is switched on, the DVS3 mk2 runs a brief test sequence, displays the software version, and then a welcome screen is displayed as shown in figure 2.1.

If the display is not easy to read or is blank, adjust the contrast control.

When the DVS3 is switched on, is displays the screen shown in figure 2.1, and the output cannot be switched on until one of the operational modes is selected.

2.1.1 Menu buttons

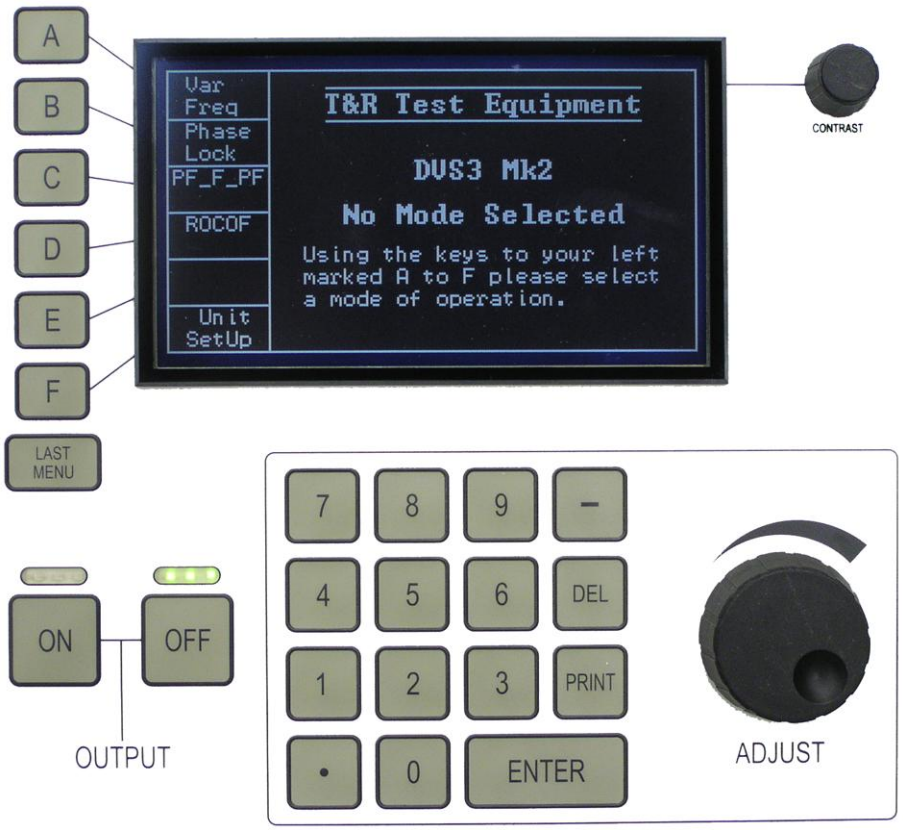

Figure 2.1 Menu buttons

The DVS3 mk2 is controlled via a set of menus, selected by buttons labelled A - F and LAST MENU to the left of the display. The function of buttons A - F is shown on the display, and changes depending on the mode of operation.

2.1.2 Menu structure

The full menu structure of the DVS3 mk2 is shown in figure 2.1.

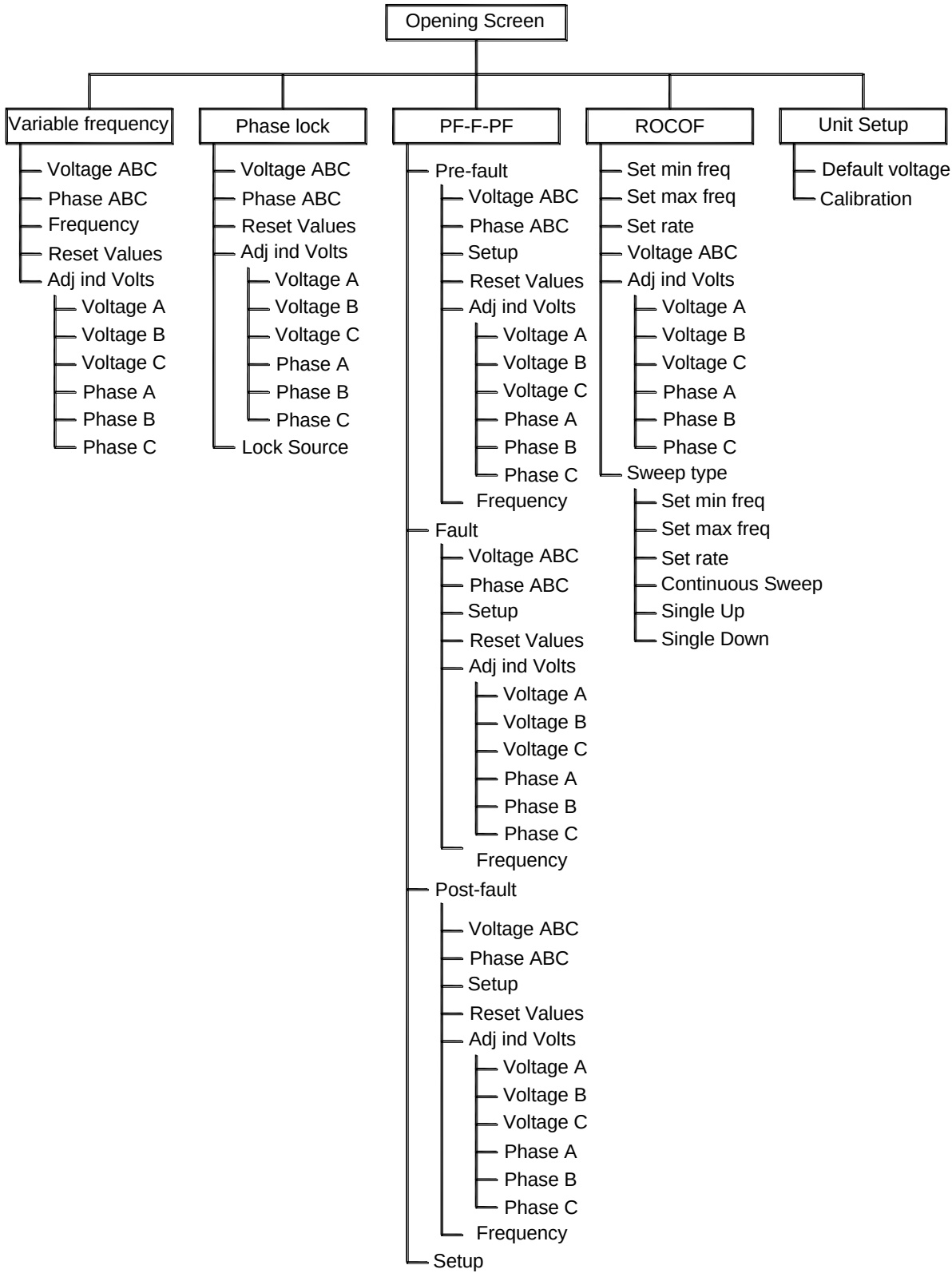

Figure 2.1 Menu buttons

2.1.3 Connections

WARNING

Before making any connections, ensure that the system to be tested is isolated from the supply and earthed. Measure the voltages on the connection points on the object under test to check that there is no voltage present before making any connections. Making connections to the unit with the output switched on may damage the unit.

2.1.3.1 *Star loads*

Star loads are connected to the output of the DVS3 using all four output terminals as shown in figure 2.2. A star load will not function correctly without the neutral connection.

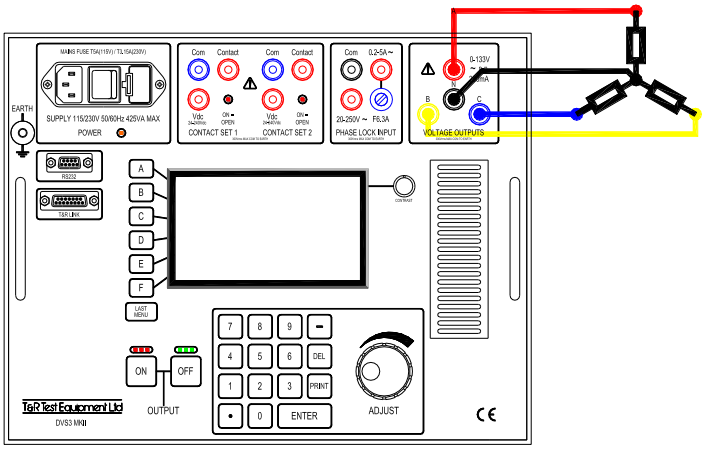

Figure 2.2 Connection of star load to DVS3 mk2

The optional DVS-T VT box may be used to double the output voltage to a star load if a higher voltage is required. The load is connected to the VT box and DVS3 as shown in figure 2.3.

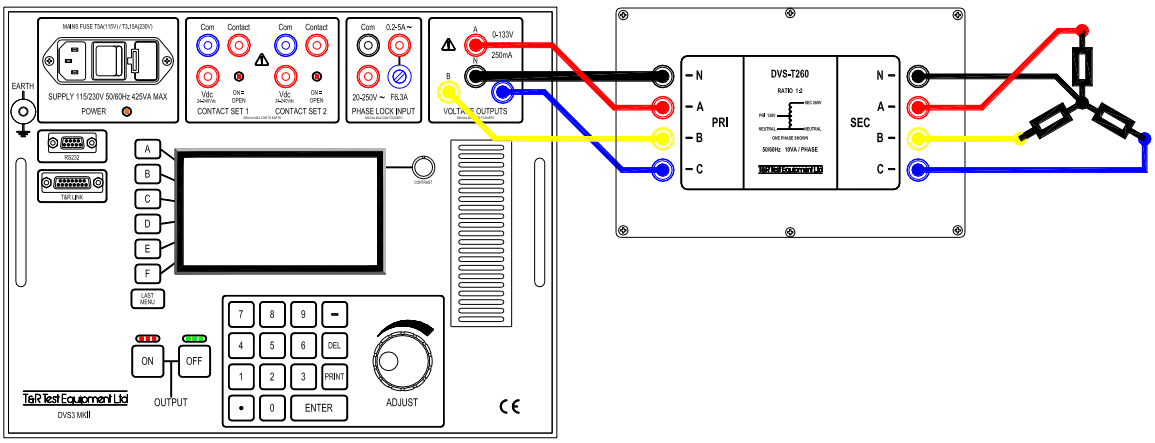

Figure 2.3 Connection of star load to DVS3 mk2

2.1.3.2 *Single phase loads*

Single phase loads may be supplied from the DVS3 mk2 either between any phase and neutral or between two phases. Connecting between two phases is only usually necessary when a higher output voltage is required.

The maximum voltage obtainable is 133V p-n between any phase and N, and 266V between two phases (if the phase angles of the two phases are set to 180° apart).

The optional DVS-T VT box may be used to double these output voltages. Even if a single phase line to line load is connected to the output of the VT box, it is still essential to connect the neutral connection between the DVS3 and VT box.

CAUTION

When using the VT box, ensure that the neutral lead is connected between the DVS3 and VT box at all times, even if the load connected to the VT is connected between two phases.

2.1.3.3 *Delta loads*

Delta loads may be connected directly to the output of the DVS3 as shown in figure 2.4. In this configuration, the neutral is not connected.

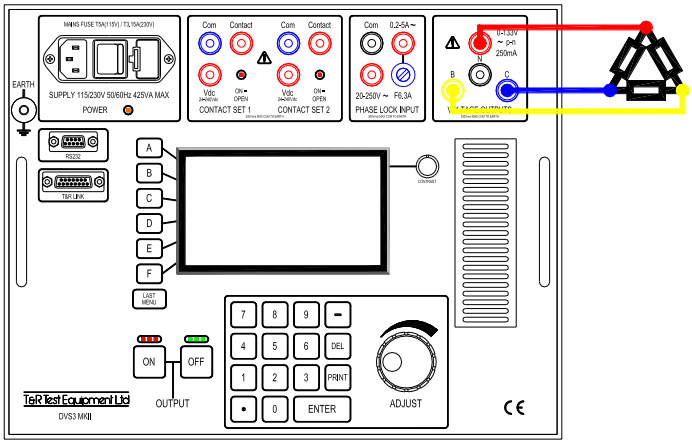

Figure 2.4 Connection of delta load to DVS3 mk2

Delta loads may also be connected to the output of the optional DVS-T VT box. In this configuration the neutral of the DVS3 MUST be connected to the neutral of the VT box as shown in figure 2.5..

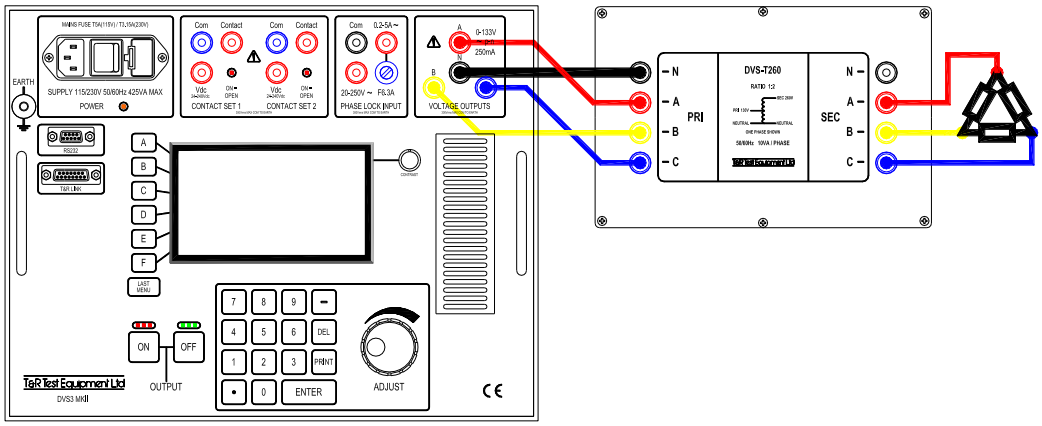

Figure 2.5 Connection of delta load to DVS3 mk2 via VT box

When using the VT box, ensure that the neutral lead is connected between the DVS3 and VT box at all times, even if the load connected to the VT is delta connected.

CAUTION

2.2 Variable Frequency Mode

Variable frequency mode allows control of the output voltage, phase angle and frequency of the three phases either simultaneously or individually. To return to the previous menu, press the LAST MENU key. Please note that the output must be switched off before it is possible to leave variable frequency mode.

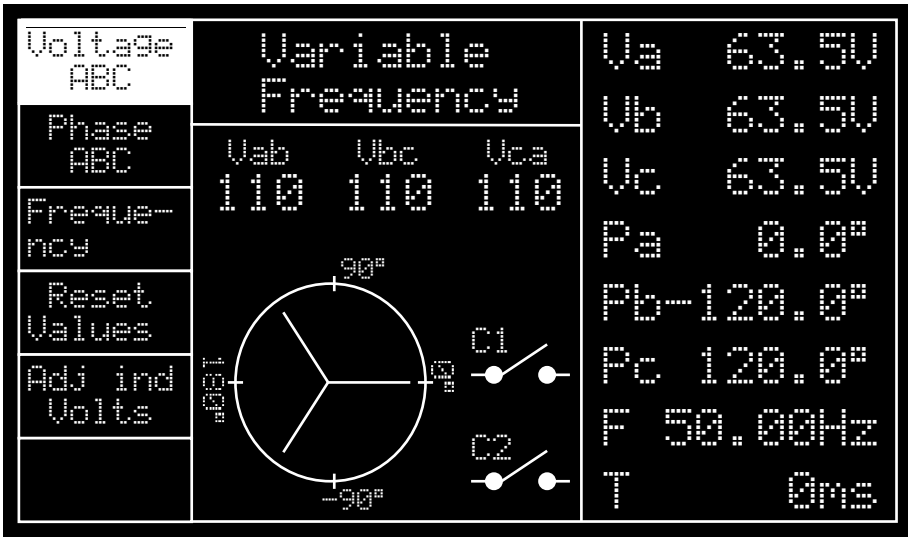

Figure 2.6 Variable frequency mode screen

2.2.1 Output Control

As in any mode on the DVS3 mk2, the output is switched on and off by the large ON and OFF keys. The output is off when the green OFF key is illuminated, and on when the red ON key is illuminated. The voltage shown for Va, Vb, and Vc appears at the output terminals when the output is switched on.

2.2.2 Voltage Control (Voltage ABC)

The voltage may be changed using either the adjust knob or the keypad. To change the output voltage, first highlight Voltage ABC by pressing menu key A. The button text will then highlight as shown in figure 2.6. Whenever a menu option is highlighted, values related to the button may be adjusted with the keypad or adjust control. When the Voltage ABC option is selected, all three output voltages are adjusted together. The output voltage may be pre-set when the output is off, or changed when the output is on.

2.2.2.1 Adjusting Voltage Using the Adjust Knob

Continuous variation of the output may be achieved by rotating the 'adjust' knob - clockwise rotation increases the voltage and anti-clockwise rotation decreases the voltage. If the output is on, the change in output voltage is seen at the output as the control is rotated.

2.2.2.2 Setting Voltage Using the Keypad

Exact voltages may be set by typing a new value on the keypad. Ensure that Voltage ABC is highlighted, and start typing a value (say 100V) on the keypad. The display of Va will change to show the value being typed as shown in figure 2.7.

Figure 2.7 Voltage entry using keypad

The output voltage does not change until the ENTER key is pressed. If an invalid value is entered, the entry box will be cleared and the unit will wait for a valid entry.

Step changes of voltage with timing are easily entered using the keypad.

- Connect the contact output from the device under test to contact set 1.
- Set the output voltage to the step starting voltage, and switch the output on.
- Enter the step final voltage using the keypad. When the ENTER key is pressed, the voltage step is triggered and the timer is reset and started. The timer will stop when either contact set changes state.

2.2.3 Phase Control (Phase ABC)

Control of the output phase works in the same manner as the output voltage control. Select the Phase ABC menu option using menu key B. The output phase may now be rotated using the adjust control, or absolute values may be entered using the keypad. The absolute phase angles in variable frequency mode do not have any significance because there is no fixed phase reference in this mode.

Step changes of phase may be generated using the keypad, and this is very useful for generating step changes of phase to test vector surge relays.

- Set the output phase to zero (typing 0 sets zero phase for phase A, and phases B and C will automatically be set to ±120°).
- Enter the required phase step, for example 6°, by typing 6 followed by ENTER.
- As ENTER is pressed, the timer resets and starts, and a +6° phase step appears on the output.
- A -6° phase step may now be generated by entering a phase angle of zero and pressing ENTER (the output phase steps back from +6° to 0°).

2.2.4 Frequency Control (Frequency)

To vary the frequency, select the Frequency menu option. Frequency is adjusted in the same way as voltage and phase using the adjust control or keypad. The timer operates when a step change of frequency is entered using the keypad.

2.2.5 Reset Values

If the voltages or phase angles have been individually adjusted, the Reset Values key provides a convenient way of resetting the voltage of phase B and C to the same value as A, and the phase angles to 0, -120° and +120° respectively for phases A, B and C.

2.2.6 Individual Adjustment of Phase Magnitudes and Angles (Adj Ind Volts)

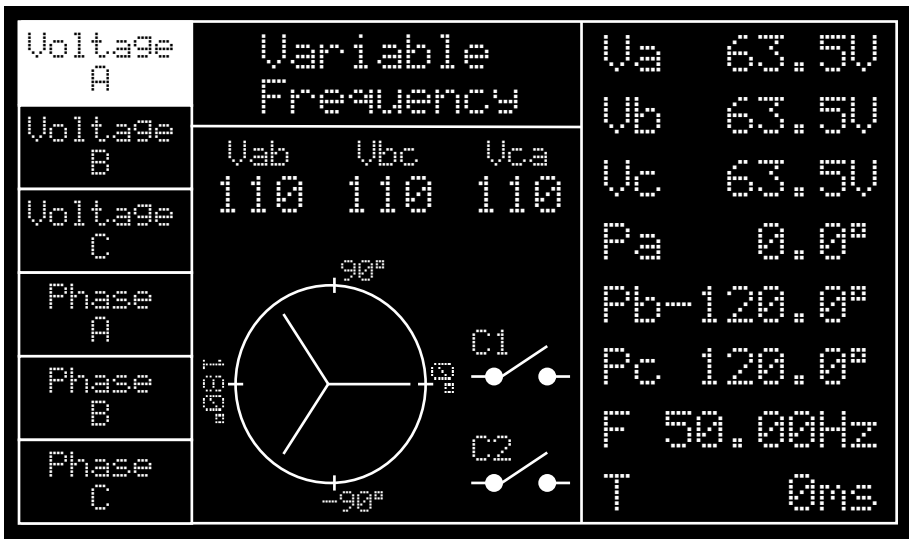

Figure 2.8 Individual adjustment of voltage and phase angle

The voltages and phase angles of phases A, B, and C may be adjusted individually using the Adj Ind Volts menu option. Voltages and phase angles may be entered by selecting the appropriate value to change using menu options [A]–[F] and adjusting the value using the adjust control or keypad. Timing is operational in this mode, and is triggered by a step change of voltage or phase entered via the keypad.

To get back to the previous menu, press the [LAST MENU] key.

2.3 Phase Lock Mode

Phase mode allows the frequency and phase of the output to be locked to the mains or an external voltage or current. Simultaneous or individual control of the output voltage and phase angle of the three phases is possible. On entry to the mode, the output voltage is locked to the mains. By default, phase A is locked to 0° relative to the reference, with phase B -120° and phase C +120°.

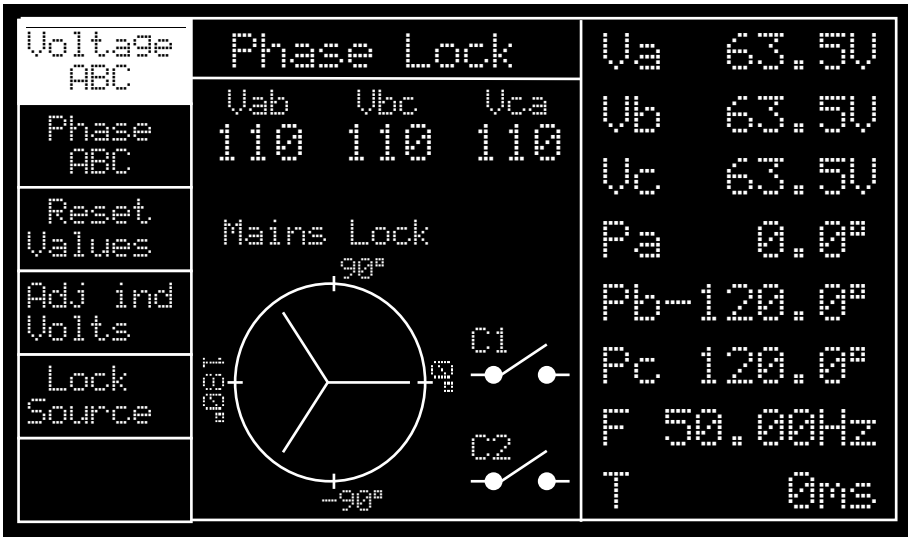

Figure 2.9 Phase lock mode screen

2.3.1 Output Control

As in any mode on the DVS3 mk2, the output is switched on and off by the large [ON] and [OFF] keys. The output is off when the green [OFF] key is illuminated, and on when the red [ON] key is illuminated. The voltage shown for Va, Vb, and Vc appears at the output terminals when the output is switched on.

2.3.2 Voltage Control (Voltage ABC)

The voltage may be changed using either the adjust knob of the keypad. To change the output voltage, first select Voltage ABC by pressing menu key [A]. The button text will then highlight as shown in figure 2.9. Whenever a menu option is highlighted, values related to the button may be adjusted with the keypad or adjust control. When the Voltage ABC option is selected, all three output voltages are adjusted together. The output voltage may be pre-set when the output is off, or changed when the output is on.

The output voltage does not change until the [ENTER] key is pressed. If an invalid value is entered, the value will be cleared, and the unit will wait for a valid value.

Step changes of voltage with timing are easily entered using the keypad.

- Connect the contact output from the device under test to contact set 1.
- Set the output voltage to the step starting voltage, and switch the output on.
- Enter the step final voltage using the keypad. When the [ENTER] key is pressed, the voltage step is triggered and the timer is reset and started. The timer will stop when either contact set changes state.

2.3.3 Phase Control (Phase ABC)

Control of the output phase works in the same manner as the output voltage control. Select the Phase ABC menu option using menu key [B]. The output phase may now be rotated using the adjust control, or absolute values may be entered using the keypad.

Values entered via the keypad will set the angle of phase A relative to the reference, and phases B&C will keep the same phase angles relative to phase A. For example, if phases A, B and C were set to 0°, -120° and +120° respectively, and phase A was then moved to 90°, phases B and C would move to -30° and 210°. See figure 2.10 for details of the screen before and after the phase change.

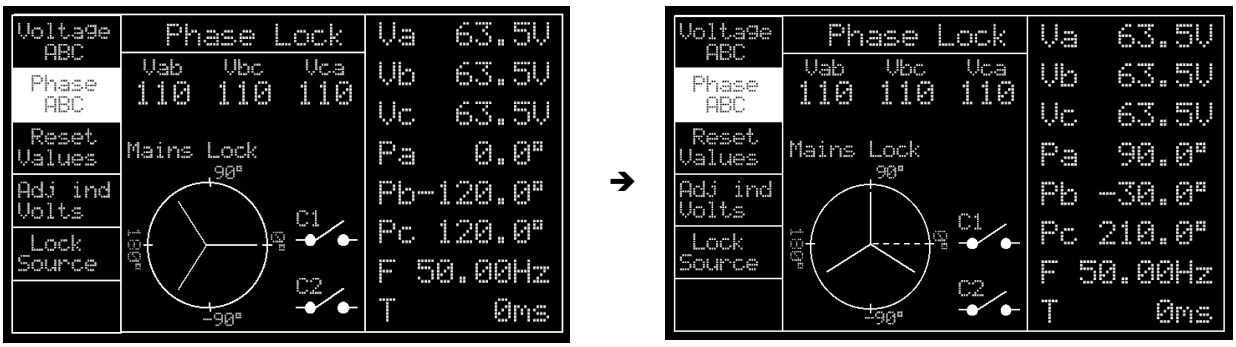

Figure 2.10 Phase change via the keypad

Step changes of phase may be generated using the keypad - see section 2.2.3 for details.

2.3.4 Reset Values

If the voltages or phase angles have been individually adjusted, the Reset Values option provides a convenient way of resetting the voltage of phase B and C to the same value as A, and the phase angles to 0, -120° and +120° respectively for phases A, B and C.

2.3.5 Individual Adjustment of Phase Magnitudes and Angles (Adj Ind Volts)

The voltages and phase angles of phases A, B, and C may be adjusted individually using the Adj Ind Volts menu option. Voltages and phase angles may be entered by selecting the appropriate value to change using menu options [A] – [F] and adjusting the value using the adjust control or keypad. Timing is operational in this mode, and is triggered by a step change of voltage or phase entered via the keypad.

To get back to the previous menu, press the [LAST MENU] key.

2.3.6 Selecting the Phase Lock Source (Lock Source)

The DVS3 is able to phase lock to the following inputs:

- Mains supply
- Voltage external lock input 20-250V
- Current external lock input 0.2-5A
- T&R link input from T&R current sources

Mains lock is automatically selected when the unit enters phase lock mode, and the angle of phase A shown on the display is the phase angle between the mains supply and the phase A output.

Selecting the Lock Source option will toggle between mains lock and external lock. If the external voltage or current reference signal is too small (<0.2A or 20V) the unit will remain locked to the mains until the signal exceeds the threshold.

2.3.6.1 T&R Link Phase Lock Input

If a T&R current source with T&R link phase lock output is connected to the DVS3 mk2 T&R link, the DVS3 will automatically phase lock to the current source when a valid lock signal is available.

2.3.7 Phase Relationship Between Phase Lock Inputs and Output

2.3.7.1 External Lock Voltage Input

The voltage at the phase A output is in phase with the external lock voltage input when the displayed phase angle for the phase A output is 0°.

2.3.7.2 External Lock Current Input

When using the external lock current input, the current flowing from the phase A voltage output is in phase with the current flowing into the external reference common terminal when the displayed phase angle for the phase A output is 0°.

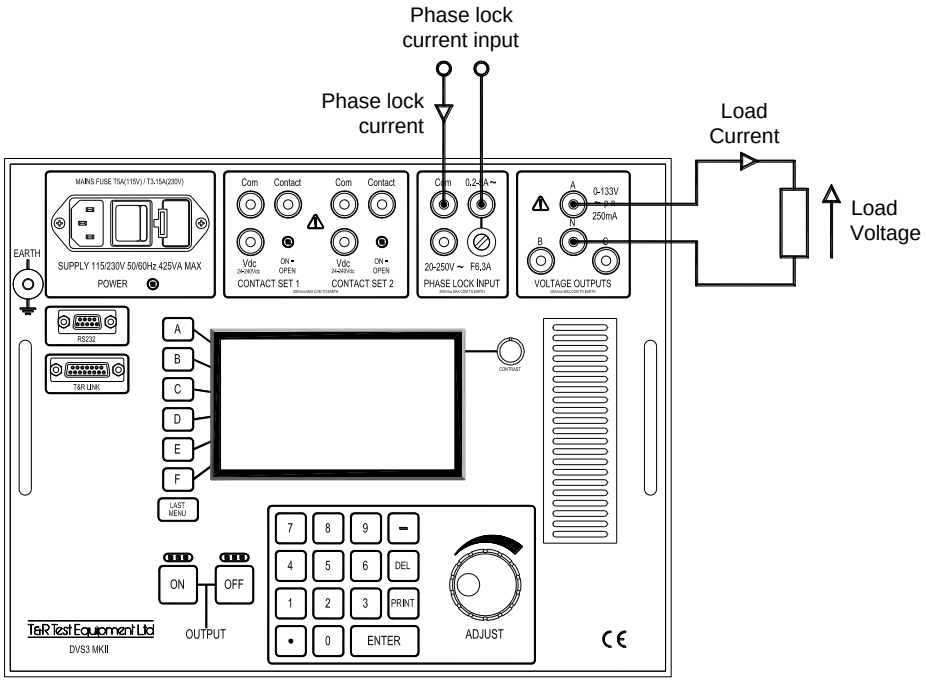

Figure 2.11 Phase lock current input

2.4 Pre-Fault/Fault/Post-Fault Mode

PF-F-PF mode allows complex sequence of events to be programmed. The unit will step between three sets of output conditions when pre-set conditions are met. This mode is used when two or more parameters (e.g. voltage and phase of phase A only) need to be changed simultaneously, and the timer also needs to be triggered.

All output parameters may be pre-programmed for this mode:

- Voltage
- Frequency/phase lock
- Phase angle
- State of relay contact on T&R link socket

Voltages and phase angles may either be set for all three phases or for each phase individually.

The unit will step between conditions when one of the following selectable events occurs:

- Contact change on contact set 1
- Contact change on contact set 2
- Pre-set time elapsed

In addition, the timer may be programmed to start or stop on any of the following events during the test:

- Start of test (output on)
- Pre-fault to fault change
- Fault to post-fault change
- Contact set 1 change
- Contact set 2 change

2.4.1 Main Menu

PF-F-PF mode is controlled via a main menu through which timing functions and the frequency mode are set, and three sub-menus which allow the values to be set for each section of the test (pre-fault, fault and post-fault).

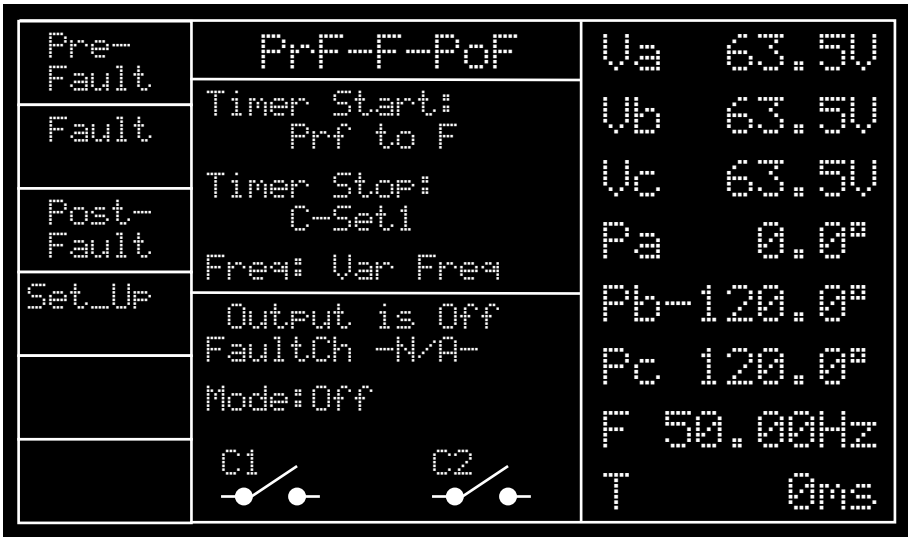

Figure 2.12 PF-F-PF main screen

2.4.2 Setup menu option

The fourth menu option controls the timer start and stop conditions and the frequency mode. Select Set_Up using menu button [D] to enter this mode, and use the [ENTER] key to step between the options shown in figure 2.9.

Figure 2.13 PF-F-PF Timer setup

The timer start condition will then be highlighted, and may be changed between the following events by rotating the adjust control:

- Pre-fault to fault change
- Fault to post-fault change
- Contact set 2 change
- Contact set 1 change
- Start of test (output on)

When the correct start condition is shown, press the ENTER key to move to the timer stop condition. The following options may be selected using the adjust control:

- Pre-fault to fault change
- Fault to post-fault change
- Contact set 2 change
- Contact set 1 change
- End of test (output off)

Pressing ENTER again will move the cursor to frequency setup. The following options may be selected:

- Variable frequency
- Mains lock
- Input lock (from phase lock input)

2.4.3 Pre-fault, Fault and Port-Fault Settings

To set the values for the pre-fault condition, select the Pre-Fault menu option. The screen shown in figure 2.14 will be displayed.

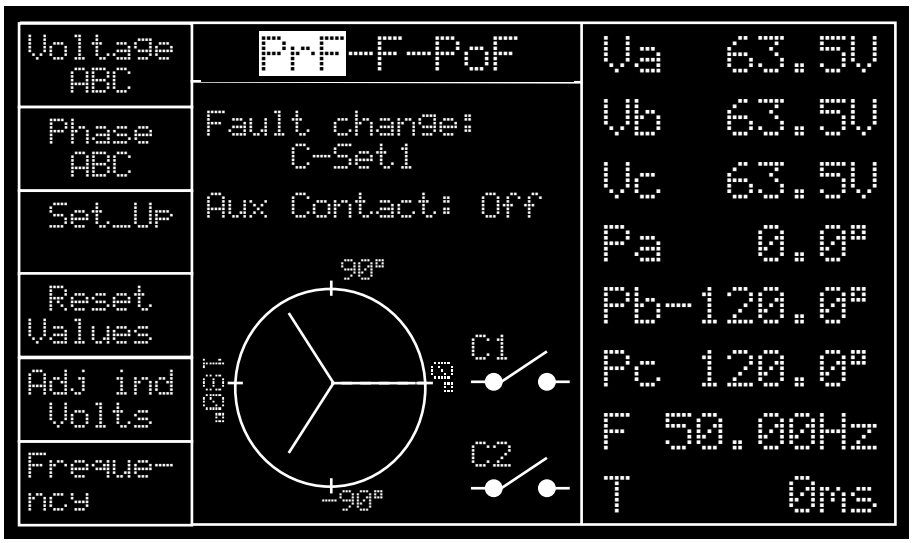

Figure 2.14 Pre-fault screen

The voltage, phase angle and frequency (if variable frequency was selected on the previous menu) for the pre-fault condition may be set on this screen. Voltages and phase angles may be set for the three phases individually using the Adj ind Volts menu option.

The same parameters may be set for the fault and post fault conditions by returning to the main PrF-F-PoF screen using the LAST MENU key and selecting the appropriate menu option.

2.4.3.1 Pre-fault to Fault Change Criteria

The criteria to be met to change from the pre-fault to the fault condition are set here using the Set_Up menu option. The choices available are:

- Time Out - set a specific time in seconds for the unit to remain in pre-fault mode before switching to fault mode.
- Contact set 1 - the unit changes from pre-fault to fault condition when contact set 1 changes state.
- Contact set 2 - the unit changes from pre-fault to fault condition when contact set 2 changes state.

When the pre-fault to fault change criteria has been set, press the ENTER key to move to auxiliary contact setup.

2.4.3.2 Auxiliary Contact Setup

The auxiliary change-over contact on the T&R link connector can be programmed to be on or off for each of the pre-fault, fault and post-fault conditions.

2.4.4 Running the Test

When all options have been set, return to the PrF-F-PoF main screen. When the output is switched on, the test will start and the pre-fault conditions will be applied to the output.

When the pre-fault to fault change criteria is met (contact change or fault time-out expires), the fault conditions will be applied to the output.

The unit will then wait until the fault to post-fault criteria is met, and then apply the fault values to the output. At the end of the test, the output will switch off. The test may be cancelled at any point by switching the output off.

Figure 2.15 shows part of the screen as an example test running, with a time-out of 10s set for pre-fault to fault change, contact set 1 selected for fault to post-fault change, and a time-out of 10s set for the fault condition.

Figure 2.15 Example PF-F-PF test sequence

2.5 ROCOF Mode (Rate Of Change Of Frequency or df/dt)

2.5.1 Introduction

Testing df/dt protection with the DVS3 mk2 is made easy by use of the ROCOF mode. Two basic modes of operation are supported: continuous sweep and single sweep. Continuous sweep mode continuously varies the frequency between pre-set upper and lower frequencies at the desired rate of change. Single sweep mode sweeps the frequency from either the minimum to maximum frequency or the maximum to minimum frequency. In this mode the timer is reset and started when the frequency sweep is started. The timer will stop on a change of state of either contact set.

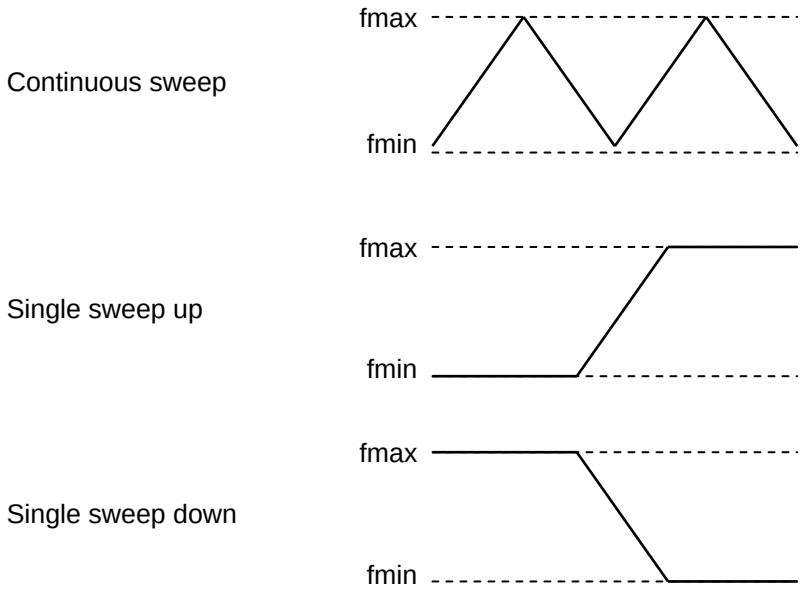

Figure 2.16 ROCOF frequency sweep types

In each of the above cases the rate of change of the frequency is set by the user, and the time taken to complete the sweep is calculated by the DVS3 mk2.

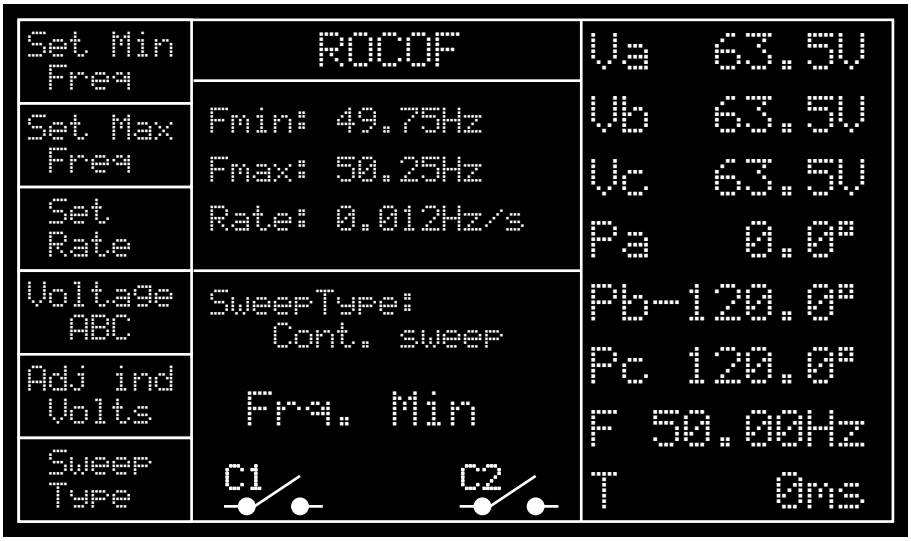

Figure 2.17 ROCOF screen

2.5.2 Continuous Sweep Operation

Operation in the ROCOF mode is controlled by two main screens: the ROCOF screen and the sweep type screen. Testing may be carried out in either mode, depending on the test required.

2.5.2.1 Setting Minimum and Maximum Frequency and Rate

The minimum and maximum frequency for the test are set using the Set Min Freq and Set Max Freq menu options. Values may changed either with the adjust control or by typing on the keypad.

The rate of change of the output frequency is controlled via the Set Rate menu option. This may be either varied slowly using the adjust control to find the operating point of the relay, or entered via the keypad to create steps of rate with timing.

2.5.2.2 Testing Relay Operating Point with Continuous Sweep

The test may now be started if a continuous frequency sweep is required. When the output is switched on, the output will continuously sweep between the preset minimum and maximum values. The sweep rate may be adjusted while the output is on to find the operating point of the relay.

2.5.2.3 Timing Relay Operation with Continuous Sweep

Timing of df/dt relays can be carried out in continuous mode by entering a rate of change value using the keypad. Firstly set a low rate of change that will not trip the relay, and then energise the relay. Then type a new rate of change using the keypad that will definitely trip the relay. When the ENTER key is pressed, the timer will start and the new rate of change will be applied to the output. The timer will stop on a change of state of either contact set.

2.5.3 Single Sweep Operation

2.6.8 Selecting the Sweep Type menu option enters the sweep type screen. This allows single sweeps of frequency to be carried out, either from f_{min} to f_{max} or f_{max} to f_{min}.

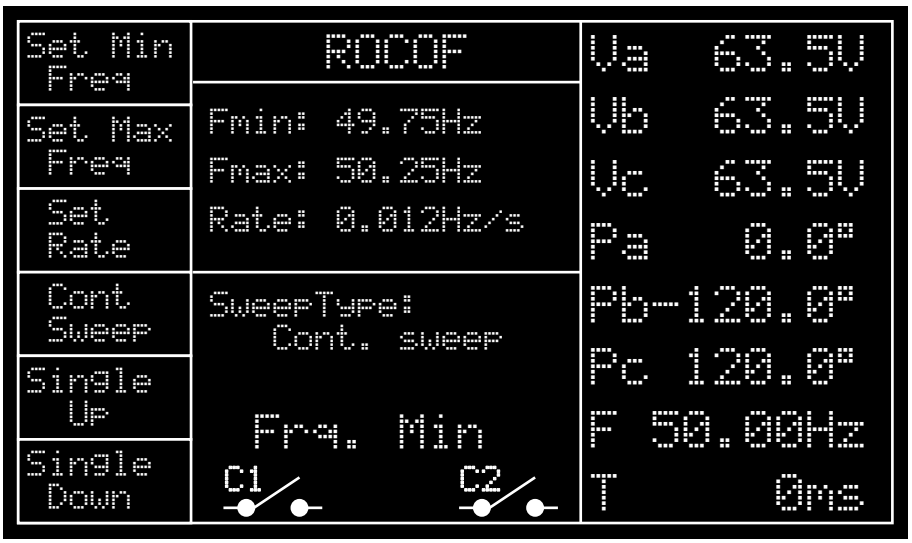

Figure 2.18 Sweep type screen

Single sweeps are started by selecting the “Single Up” and “Single Down” menu options. In each case, the timer is reset and started when the sweep starts. The timer is then stopped by a change of state of either contact set.

After a single sweep the frequency is maintained at the final frequency. If the frequency is already at f_{max}, the “Single Up” button will have no effect, and if the frequency is at f_{min}, the “Single Down” button will have no effect.

Note If the "Single Up" button is pressed with the output switched off, the frequency will reset to f_{min}, ready for a single rising sweep. Likewise, if the "Single Down" button is pressed with the output switched off, the frequency will reset to f_{max}, ready for a single falling sweep.

2.6 Unit Setup

The unit setup screen allows the default output voltage of the unit to be defined. Any new value entered on this page will only be stored when the LAST MENU key is pressed.

2.7 Optional Step-up VT Box

The 0-133V phase-neutral output voltage of the DVS3 may be boosted to 0-266V or 0-292V using the optional DVS-T260 and DVS-T286 VT boxes.

The VT boxes have star-connected inputs and outputs, and the output is NOT isolated from the input.

Figure 2.19 Optional VT box DVS-T260

2.7.1 Specifications

Ratio:	1:2	DVS-T260
	1:2.2	DVS-T286
Maximum output voltage:	266V	DVS-T260
	292.6V	DVS-T286
Maximum load:	10VA per phase	
Accuracy of output voltage:	Class 0.2 (±0.2% of rated voltage) for 2.5-10VA load	

2.7.2 Using the DVS-T VT box

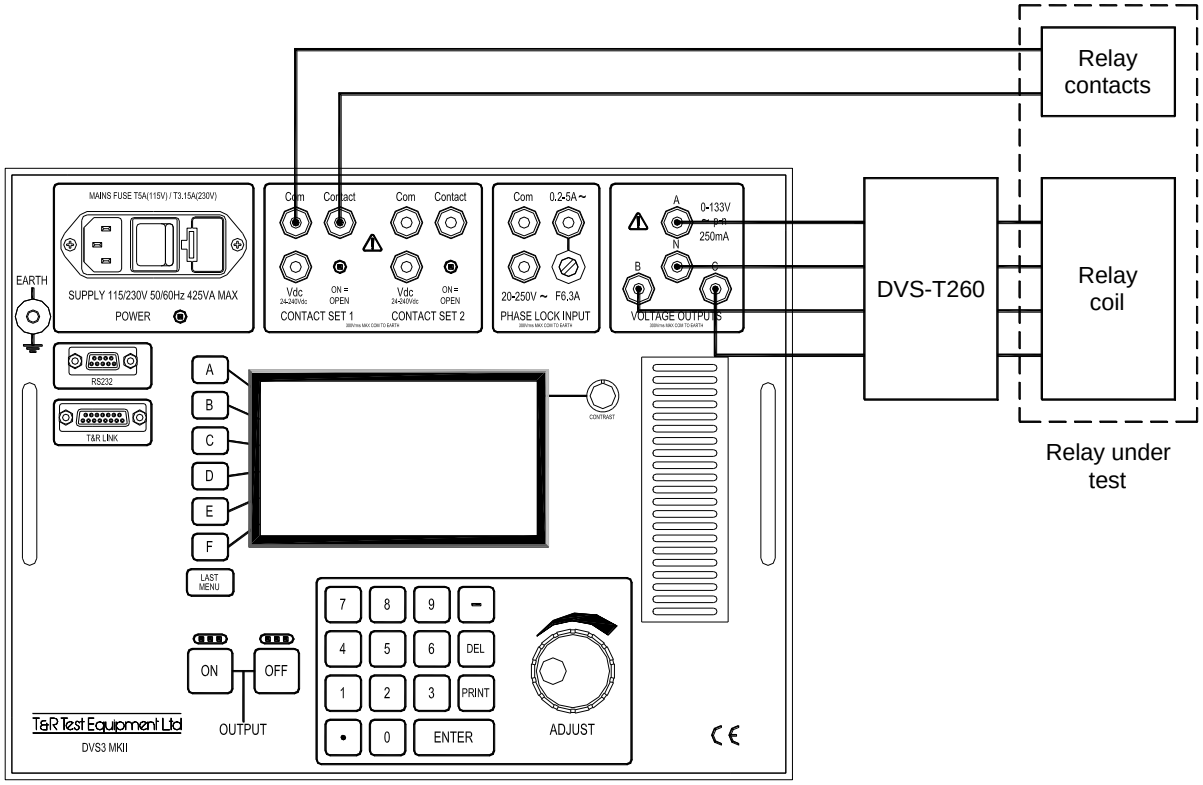

Figure 2.20 DVS-T260/286 connections

When using the VT box, ensure that the neutral connection is connected between the DVS3 and VT box at all times, even if the load connected to the VT is delta connected.

CAUTION

3 TESTING RELAYS WITH THE DVS3 MK2

All of the following examples are a guide to how to test different relay types with the DVS3 mk2. It is essential to check the procedures against those recommended by the relay manufacturer in the relay commissioning/service manual.

The following abbreviations are used is this section to refer to test voltages, currents and frequencies:

V_N Nominal voltage (the rated voltage at the relay coil when the system is operating under normal conditions).

V> Voltage relay over-voltage trip level

V< Voltage relay under-voltage trip level

V_H AVR relay tap change up voltage

V_L AVR relay tap change down voltage

F_N Nominal frequency (the rated voltage at the relay coil when the system is operating under normal conditions).

F> Frequency relay over-frequency trip level

F< Voltage relay under-frequency trip level

f_{min} df/dt minimum frequency

f_{max} df/dt maximum frequency

I_N Current coil rated current (the current at a relay CT input when the system is operating at rated current).

3.1 Automatic Voltage Regulating Relays

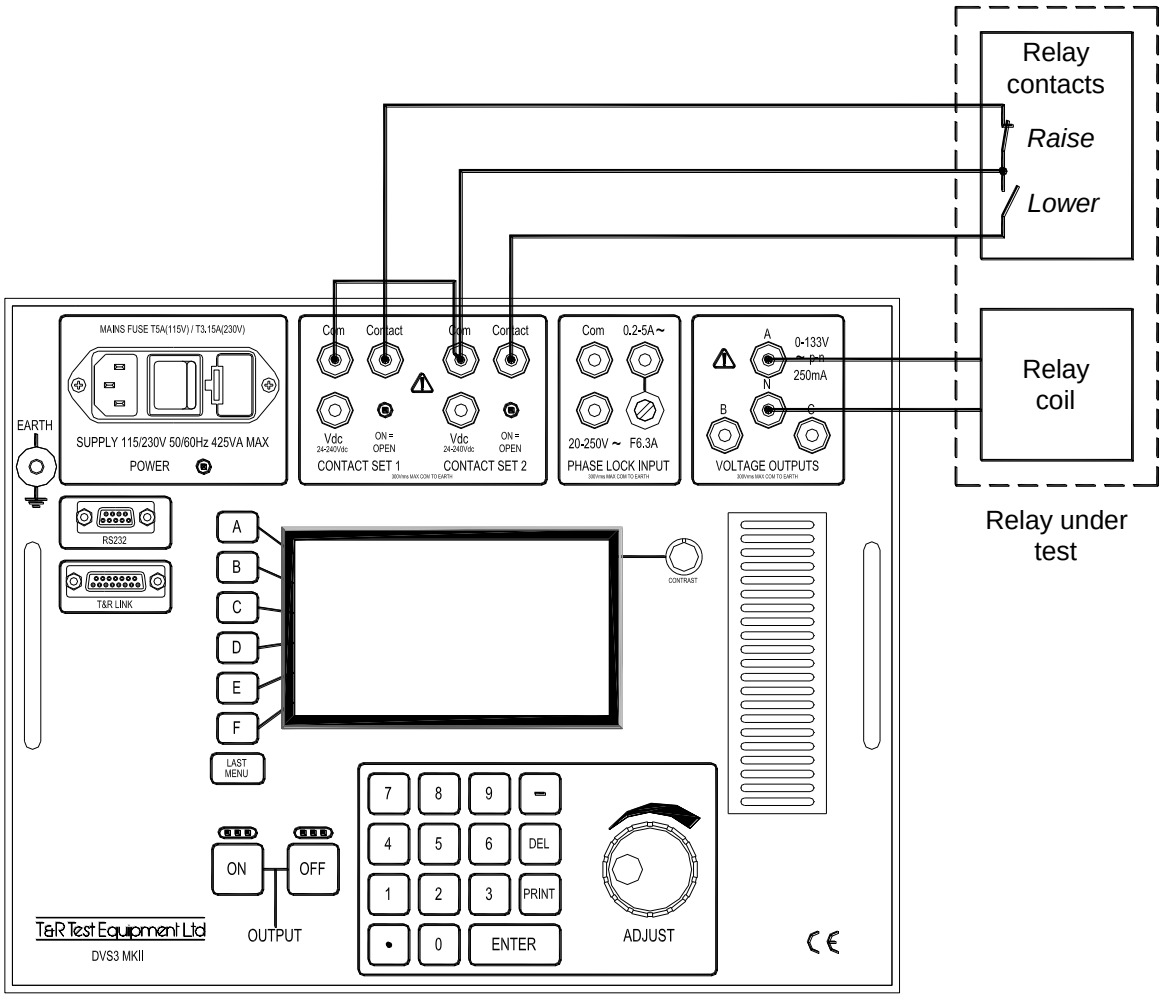

Figure 3.1 Connections for AVR relay

3.1.1 Connections

Ensure that the relay under test is isolated from the supply at all points (including contacts) and power to the DVS3 is switched off before making any connections.

- Connect the output of the DVS3 to the relay coil. Any phase output may be used, or higher voltage relays may be connected between two output phases.
- Connect the two output contacts from the relay to the contact inputs of the DVS3. Contact set 1 will then change state when a 'raise' command is issued form the relay and contact set 2 will change state when a 'lower' command is issued. Contacts with a DC voltage present may be connected between COM and Vdc.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.1)

3.1.2 Determining Operating Points

- Switch on the power to the DVS3 and the relay auxiliary supply (if used).
- Set the DVS3 to variable frequency or phase lock mode.

- Set the output of the DVS3 to V_N (this should be the centre of the relay deadband voltage), and switch on the output.
- Increase the DVS3 output voltage until the 'lower' contact changes state. This is V_L, the voltage at which the relay would request a lower tap voltage.
- Decrease the DVS3 output voltage until the 'higher' contact changes state. This is V_H, the voltage at which the relay would request a higher tap voltage.

3.1.3 Timing Tests

If it is necessary to measure the relay time delay, this may be easily achieved.

- Set the output voltage to centre of the deadband (V_N)
- Type in a voltage above V_H using the keypad. When the ENTER key is pressed, the voltage is stepped to the new value and the timer is reset and started. When the contacts change state to request a higher tap, the timer stops.
- The tap change down output is tested in the same way, but with a voltage below V_L entered via the keypad.

3.2 AVR Relays with Line Drop Compensation

To test an AVR with line drop compensation it is necessary to add a current source to the test circuit to provide a current reference for the relay. A suitable current source for this purpose is the T&R 100ADM or 200ADM.

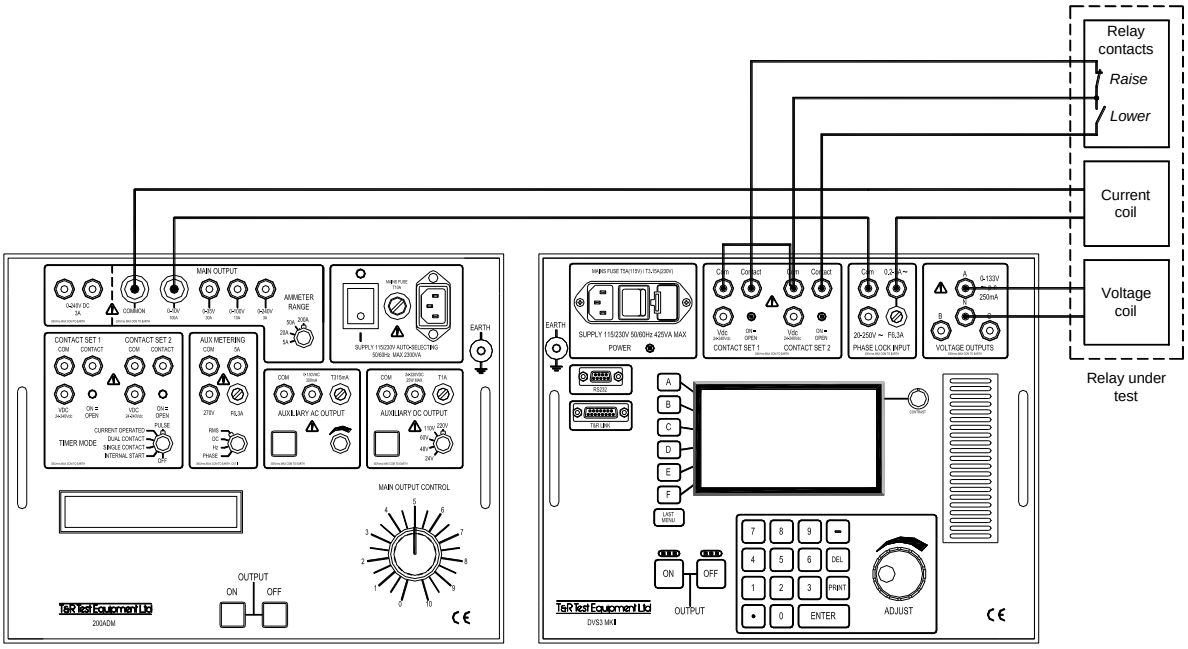

Figure 3.2 Connections for AVR relay with LDC

3.2.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 and 200ADM is switched off before making any connections.

- Connect the output of the DVS3 to the relay coil. Any phase output may be used, or higher voltage relays may be connected between two output phases.
- Connect the two output contacts from the relay to the contact inputs of the DVS3. Contact set 1 will then change state when a 'raise' command is issued form the relay and contact set 2 will change state when a 'lower' command is issued.
- Connect the output of the current source to the current coil of the relay via the phase lock current input of the DVS3, observing polarity.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.2). The auxiliary dc supply output from the 200ADM may be used for this purpose.

3.2.2 Determining Operating Points

- Switch on the power to the DVS3, 200ADM and the relay auxiliary supply.
- Set the DVS3 to phase lock mode, and select 'external lock' using the Lock Source menu option.
- Set the output of the DVS3 to V_N (this should be the centre of the relay deadband voltage), and switch on the output.

- Set the current source output control to zero, and switch on the current source output. Increase the current to the desired level for the test (usually I_N), and check that the DVS3 has locked on to the current (the display will change from 'mains lock' to 'external lock'.
- Set the phase angle between the current and the voltage to the desired value (this is usually 90° to check resistive compensation and 180° to check reactive compensation). Refer to the relay service manual for more information.
- Increase the DVS3 output voltage until the 'lower' contact changes state. This is the voltage at which the relay would request a lower tap voltage (V_L). This voltage will change with changes in phase angle.
- Decrease the DVS3 output voltage until the 'higher' contact changes state. This is the voltage at which the relay would request a higher tap voltage (V_H). This voltage will change with changes in phase angle.

3.2.3 Timing Tests

For details of timing tests, please refer to section 3.1.3

3.3 Under and Over Voltage Relays

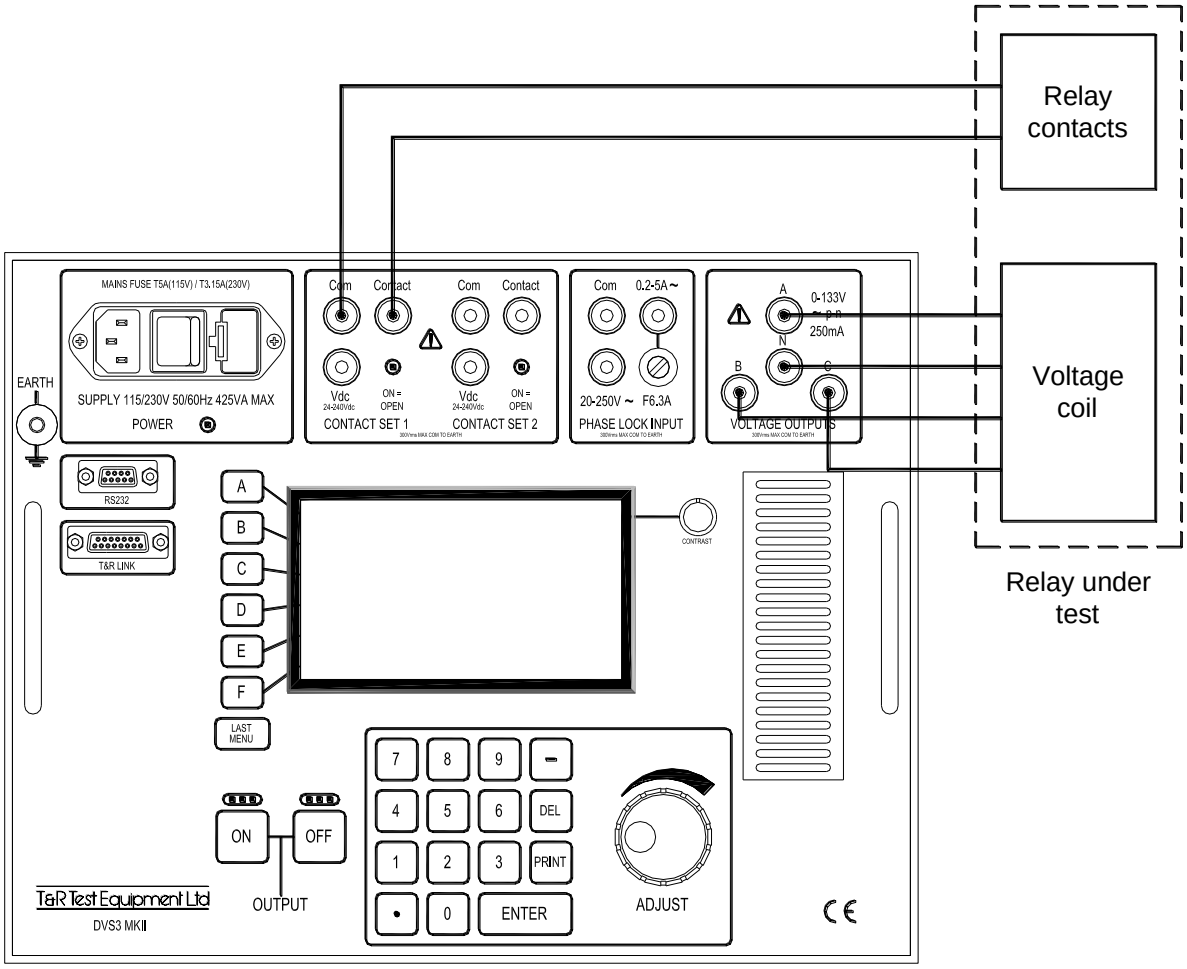

Figure 3.3 Connections for under and over voltage relays

3.3.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 is switched off before making any connections.

- Connect the output of the DVS3 to the relay coil.
- Connect the output contacts from the relay to the contact input 1 of the DVS3.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.3).

3.3.2 Determining Operating Points

- Switch on the power to the DVS3 and the relay auxiliary supply.
- Set the DVS3 to variable frequency or phase lock mode.
- Set the output of the DVS3 to the relay nominal voltage.
- Switch on the DVS3 output, and increase the output voltage using the adjust control until the relay trips (shown by a change on contact set 1). This is the over-voltage trip level, V>.

- Return the DVS3 output to the nominal voltage, and the decrease the output using the adjust control until the relay trips - this is the under-voltage trip level, V<.

3.3.3 Timing Tests

3.3.3.1 Over-voltage operating delay

- Set the output voltage to the V_N.
- Type in a voltage above V> using the keypad. When the ENTER key is pressed, the voltage is stepped to the new value and the timer is reset and started. When the contacts change state, the timer stops.

3.3.3.2 Over-voltage reset time

- Ensure that the voltage is above V>, and the relay is tripped.
- Enter the relay nominal voltage using the keypad. When the ENTER key is pressed, the timer is reset and started, and the voltage steps back to the nominal voltage. When the contacts change state, the timer is stopped, showing the reset time.

3.3.3.3 Under-voltage operating delay

- Set the output voltage to V_N.
- Type in a voltage below V< using the keypad. When the ENTER key is pressed, the voltage is stepped to the new value and the timer is reset and started. When the contacts change state, the timer stops, showing the under-voltage trip delay.

3.3.3.4 Under-voltage reset time

- Ensure that the voltage is below the under-voltage trip level, V<, and relay is tripped.
- Enter V_N using the keypad. When the ENTER key is pressed, the timer is reset and started, and the voltage steps back to the V_N. When the contacts change state, the timer is stopped, showing the reset time.

3.4 Under and Over Frequency Relays

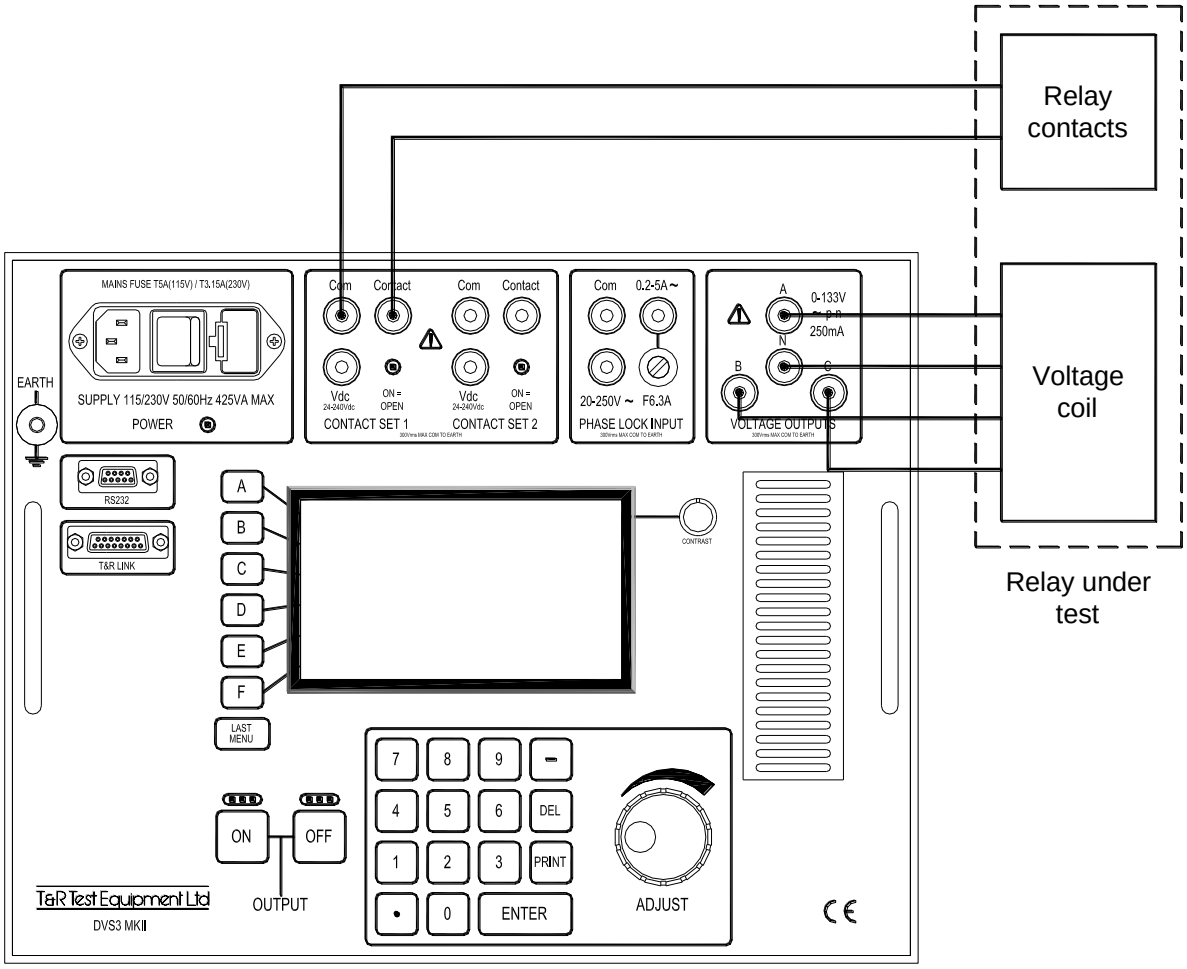

Figure 3.4 Connections for under and over frequency relays

3.4.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 is switched off before making any connections.

- Connect the output of the DVS3 to the relay coil.
- Connect the output contacts from the relay to the contact input 1 of the DVS3.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.4).

3.4.2 Determining Operating Points

- Switch on the power to the DVS3 and the relay auxiliary supply.
- Set the DVS3 to variable frequency mode.
- Set the output voltage of the DVS3 to V_N, and set the output frequency to the nominal system frequency, F_N.
- Switch on the DVS3 output, and increase the output frequency using the adjust control until the relay trips (shown by a change on contact set 1). This is the over-frequency trip level, F>.

- Return the DVS3 output to the nominal frequency, and the decrease the frequency using the adjust control until the relay trips - this is the under-frequency trip level, F<.

3.4.3 Timing Tests

3.4.3.1 Over-frequency operating delay

- Set the output voltage to V_N and the frequency to F_N.
- Type in a frequency above F> using the keypad. When the ENTER key is pressed, the frequency is stepped to the new value and the timer is reset and started. When the contacts change state, the timer stops, showing the over-frequency trip delay.

3.4.3.2 Over-frequency reset time

- Ensure that the frequency is above F>, and the relay is tripped.
- Enter F_N using the keypad. When the ENTER key is pressed, the timer is reset and started, and the frequency steps back to F_N. When the contacts change state, the timer is stopped, showing the reset time.

3.4.3.3 Under-frequency operating delay

- Set the output voltage to V_N and the frequency to F_N.
- Type in a frequency below F< using the keypad. When the ENTER key is pressed, the voltage is stepped to the new value and the timer is reset and started. When the contacts change state, the timer stops, showing the under-frequency trip delay.

3.4.3.4 Under-frequency reset time

- Ensure that the frequency is below the under-voltage trip level, and the relay is tripped.
- Enter F_N using the keypad. When the ENTER key is pressed, the timer is reset and started, and the frequency steps back to F_N. When the contacts change state, the timer is stopped, showing the reset time.

3.5 Directional Overcurrent Relays

To test a directional relay it is necessary to add a current source to the test circuit to provide a current reference for the relay. A suitable current source for this purpose is the T&R 100ADM or 200ADM.

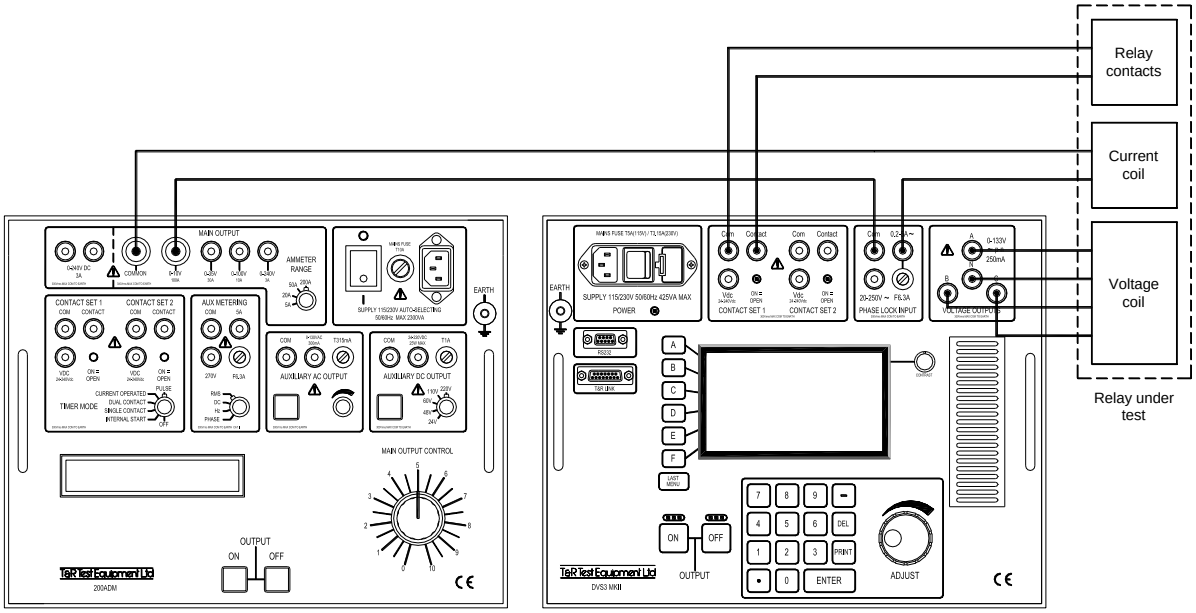

Figure 3.5 Connections for directional relays

3.5.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 and 200ADM is switched off before making any connections.

- Connect the output of the DVS3 to the relay voltage coil.
- Connect the output contact from the relay to contact set 1 of the DVS3.
- Connect the output of the current source to the current coil of the relay via the phase lock current input of the DVS3, observing polarity.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.5). The auxiliary dc supply output from the 200ADM may be used for this purpose.

3.5.2 Determining Operating Points

- Switch on the power to the DVS3, 200ADM and the relay auxiliary supply.
- Set the DVS3 to phase lock mode, and select 'external lock' using the Lock Source menu option.
- Set the output of the DVS3 to V_N.
- Set the current source output control to zero, and switch on the current source output. Increase the current to the desired level for the test (usually I_N), and check that the DVS3 has locked on to the current (the display will change from 'mains lock' to 'external lock'.

3.5.2.1 Restraint angles

- Set the phase angle between the current and the voltage to 0°, and check that the output contact is in the correct state.
- Rotate the voltage phase angle (select the Phase ABC menu option, and use the adjust control).
- The contact will change state as the relay enters and leaves restraint.

3.6 df/dt (ROCOF) relays

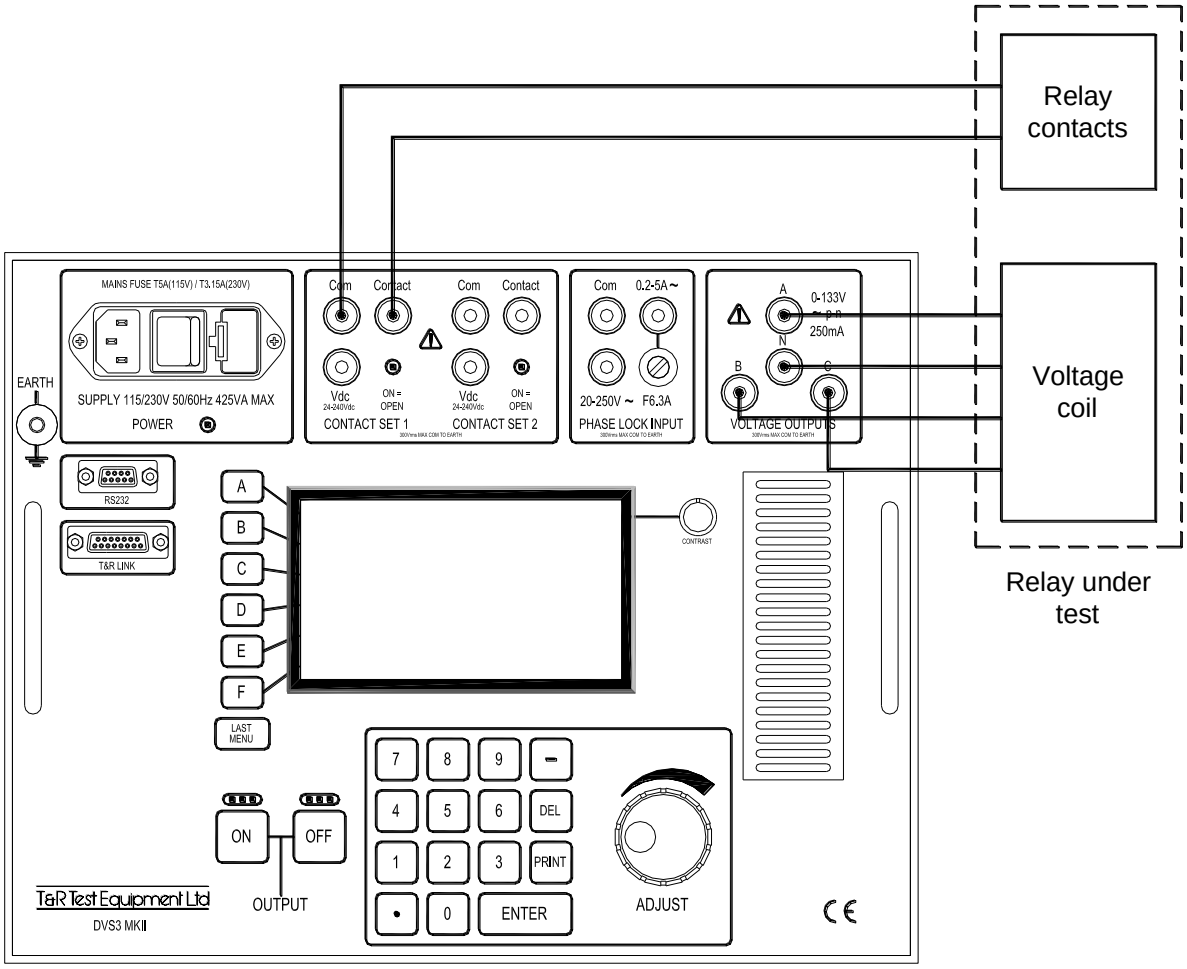

Figure 3.6 Connections for df/dt relays

3.6.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 is switched off before making any connections.

- Connect the output of the DVS3 to the relay coil.
- Connect the output contacts from the relay to the contact input 1 of the DVS3.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.6).

3.6.2 Determining Operating Points

3.6.2.1 Continuous Sweep Method

This method of finding the operating point of the relay can be prone to error because of tripping delays and differences in sensitivity to rising and falling frequencies in some relays.

- Switch on the power to the DVS3 and the relay auxiliary supply.
- Set the DVS3 to ROCOF mode.

- Set the output voltage of the DVS3 to V_N, and set the minimum and maximum output frequency to the desired test values (often $F_N \pm 0.25$Hz).
- Set the rate of change to a value that will not trip the relay.
- Switch on the DVS3 output, and gradually increase the rate of change using the adjust control until the relay trips (shown by a change on contact set 1).

3.6.2.2 Single Sweep Method

This method is slower, but accurate, and allows the difference in operating point for rising and falling frequency to be ascertained.

- Switch on the power to the DVS3 and the relay auxiliary supply.
- Set the DVS3 to ROCOF mode.
- Set the output voltage of the DVS3 to V_N, and set the minimum and maximum output frequency to the desired test values (often $F_N \pm 0.25$Hz).
- Select the Sweep Type menu option.
- Set the rate of change to a value that will not trip the relay.
- Press the Single Up sweep button and wait for the frequency reach the maximum value. Press the Single Down sweep button and wait for the frequency to reach the minimum.
- If the relay has not tripped, increase the rate of change, and repeat until the process until the relay does trip.

3.6.3 Timing Tests

3.6.3.1 df/dt Delay using single sweep

This is the most accurate way of timing the df/dt delay.

- Select the Sweep Type menu option.
- Set the rate of change to a value that **will** trip the relay, and press the Single Up button with the output switched off to set the output frequency to the minimum frequency.
- Switch on the output of the DVS3.
- Press the Single Up sweep button. The sweep will start, and the timer will reset and start. When the relay trips the timer is stopped.

The same process may be used with a falling frequency sweep.

3.6.3.2 df/dt Delay Using Continuous Sweep

- Select the Cont. sweep menu option.
- Set the rate of change to a value that will not trip the relay.
- Switch on the output of the DVS3.
- Enter a rate of change that will trip the relay. When the ENTER key is pressed, the new rate of change will be applied to the relay and the timer will be started. The timer will stop when the relay trips.

3.7 Vector Surge (Step change of phase) relays

The DVS3 mk2 can be used to test a vector surge relay by applying a series of increasing phase steps to the relay. The unit can also be used to time the response of the relay to a tripping condition.

A phase step is generated from the DVS3 mk2 by shifting the phase by a set amount using the keypad whilst in variable frequency mode. It is important to understand that phase angles are entered and shown on the DVS3 mk2 relative to a notional 0° phase reference. Therefore if the display is showing 5° for phase A, and a new phase of 7° is entered, a phase step of 2° is generated. The easiest way to carry out the tests is to enter a value for a phase shift, and set the phase back to zero before the next shift.

For example, start off with the DVS3 mk2 in variable frequency mode, and select the Phase ABC menu option. The display will currently be showing a phase of 0° for phase A. Type in 6 and press ENTER, and the DVS3 mk2 will generate a 6° phase step. Typing in 0 and pressing ENTER will set the phase shift back to 0°, generating a -6° phase step in doing so.

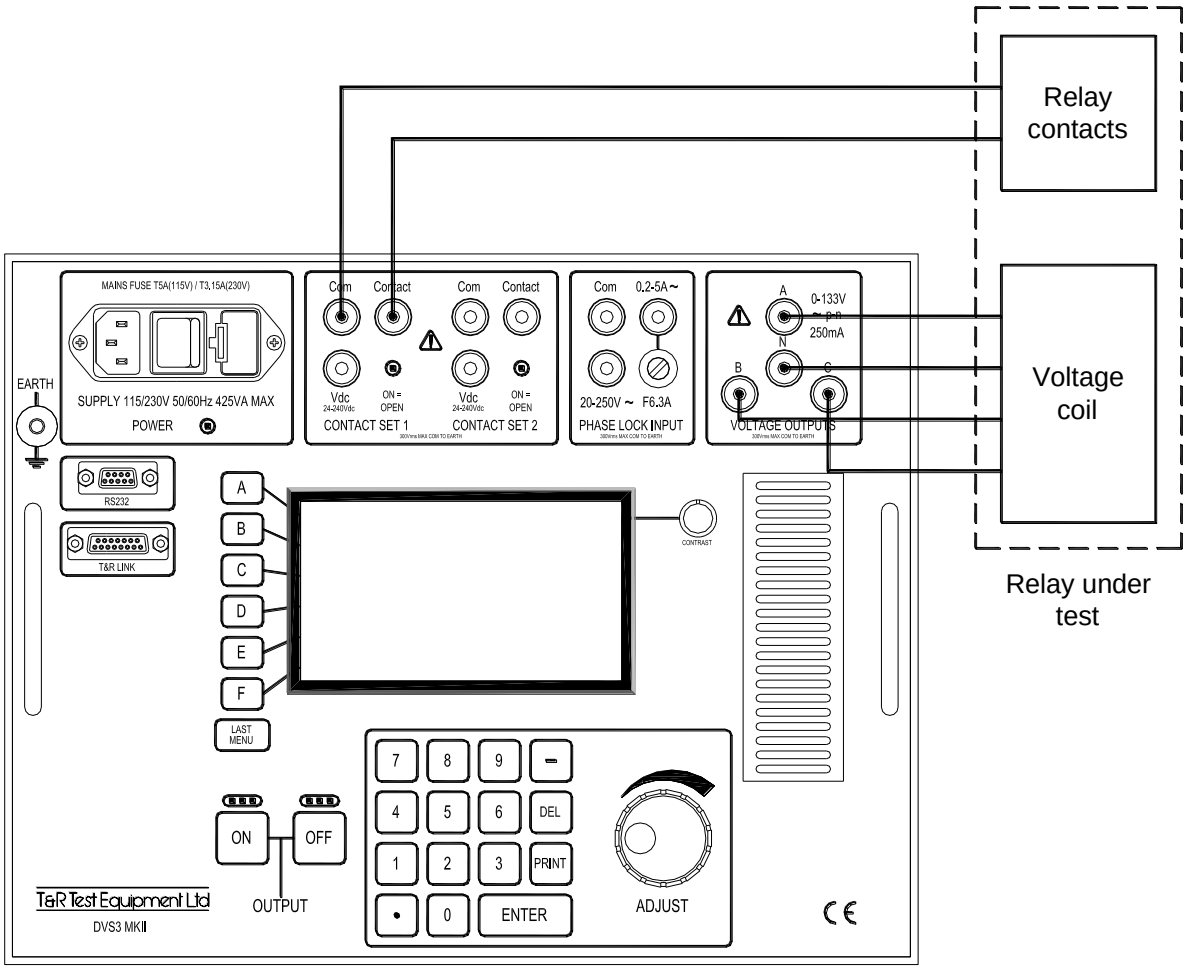

Figure 3.7 Connections for vector surge relays

3.7.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 is switched off before making any connections.

- Connect the output of the DVS3 to the relay coil.
- Connect the output contacts from the relay to the contact input 1 of the DVS3.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.7).

3.7.2 Determining the Operating Point

- Switch on the power to the DVS3 and the relay auxiliary supply.
- Set the DVS3 to variable frequency mode.
- Set the output of the DVS3 to V_N.
- Switch on the output of the DVS3, and select the Phase ABC menu option.
- Enter a phase step that should not trip the relay, for example 5°. Check to see if the relay has tripped, and then set the phase angle back to zero. If the relay has tripped, reset the relay and try again with a smaller phase step. If the relay has not tripped, apply gradually increasing steps to the relay until it does trip.

3.7.3 Timing Tests

- When the operating point of the relay has been ascertained using the procedure above, the relay response can then be timed.
- Start with the phase angle set to zero. Type in a new phase value which is at least 2° greater than the trip value measured above. The timer will start when the phase step is applied to the relay, and will stop when contact set 1 on the DVS3 changes state.

3.8 Check Synchronising Relay

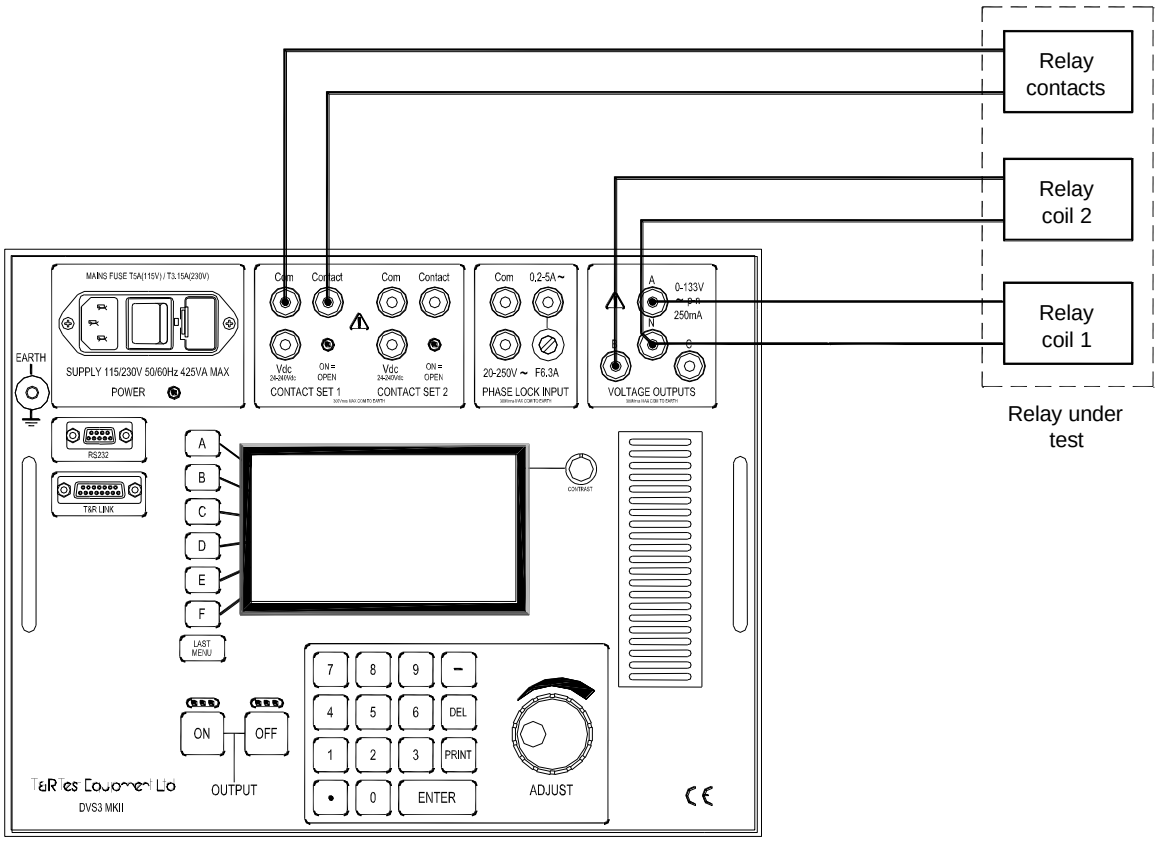

Figure 3.8 Connections for check synchronising relays

3.8.1 Connections

Ensure that the relay under test is isolated from the supply at all points and power to the DVS3 is switched off before making any connections.

- Connect the output of the DVS3 to the relay coils.
- Connect the output contacts from the relay to the contact input 1 of the DVS3.
- Connect an auxiliary supply to the relay if required (not shown in figure 3.8).

3.8.2 Determining Operating Points

- Switch on the power to the DVS3 and the relay auxiliary supply.
- Set the DVS3 to variable frequency mode.
- Set the output voltage of the DVS3 to V_N, and set the output frequency to the nominal system frequency, F_N.
- Select the `Adj Ind Volts` menu option, and use the `Phase B` option to set phase B to 0°. Phase A and phase B should now be in phase.
- Switch on the DVS3 output. The relay contacts should close.
- The relay operating phase angle may now be found by altering the phase angle of phase B until the relay trips.

3.8.3 Timing Tests

- Set the output voltage to V_N, the frequency to F_N, and the phase angle of A & B to 0°.
- Enter a value of phase angle for phase B that will trip the relay using the keypad. When the ENTER key is pressed, the phase angle is stepped to the new value and the timer is reset and started. When the contacts change state, the timer stops, showing the trip delay.

4 MAINTENANCE

Before removing the unit from its case, ensure that the unit is disconnected from the mains. Under no circumstances connect the unit to the mains whilst it is removed from its case.

The DVS3 mk2 requires no maintenance as the unit is completely solid state. It is suggested that the unit is returned to T&R Test Equipment for calibration and safety checks as part of your scheduled calibration timetable.

4.1 Removal of the DVS3 mk2 From Case

To remove the instrument from its case, the following procedure should be used:-

a. Remove the lid from the case, and place the unit on its face, such that it is resting on the handles on the front panel.
b. Remove the four fixing screws from the base of the unit.
c. Lift the case from the unit.

5 STANDARD ACCESSORIES

5.1 Types of fuses supplied

a.	2 off **T3.15A**	1¼ inch (230V supply)
b.	2 off **T5A**	1¼ inch (115V supply)
c.	2 off **F6.3A**	20mm

5.2 Standard Accessories Supplied with Unit

a. Mains input lead.

b. 2-core lead, 3 metres long, 4mm plugs each end.

c. 3 phase 4 wire output lead, 3 metres long, 4mm plugs each end.

d. 6 crocodile clips, 2-black, 4-red. (connect on to 4mm plug)

e. Cable bag.

f. Operating & Maintenance Manual.

6 OVERALL PERFORMANCE SPECIFICATION

Insulation Resistance at 1000V DC

The insulation resistance will not be less than 10 megohms, between mains input to frame and all isolated outputs, and all combinations of isolated output to isolated output.

Applied Voltage Test

Mains input to frame and all isolated outputs 2kVdc for 1 minute.

All combinations of isolated output to isolated output 1kVdc for 1 minute.

Isolated output to frame 1kVdc for 1 minute.

Accuracy of Instruments

See **Section 1.2**.

7. REVISION

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Drawings Required

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