

OZthermTM

Digital Power Controller

F-430

3 PHASE S.C.R. CONTROLLER

INSTALLATION AND COMMISSIONING MANUAL

DESIGNED
and
MANUFACTURED
by

Fastron
TECHNOLOGIES PTY. LTD.

RE: FAN COOLED UNIT

**NOTE: CONNECT NEUTRAL TO
TERMINAL PROVIDED
(MARK "N") IN ORDER TO
OPERATE FAN.**

**HOWEVER, IF NEUTRAL
TERMINAL IS NOT PROVIDED,
THEN NEUTRAL CONNECTION
IS UNNECESSARY.**



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F430 INSTALLATION AND COMMISSIONING MANUAL
REVISION 1.2 NOV 1994

This manual represents your F430 as manufactured at the time of publication.

Every effort has been made to ensure that the information in this manual is complete and accurate.

Fastron Technologies P/L cannot be held responsible for errors and omissions.

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1.0 OZTHERM POWER PRODUCTS

Thyristor based power controllers offer numerous benefits.

They are a reliable replacement for electromechanical contactors , being virtually maintenance free.

Thyristor based power controllers are ideal for controlling complex loads , such as heating elements that change resistance over time or temperature , transformer coupled loads , plating rectifiers and fast systems.

1.1 PRINCIPAL OF OPERATION

Oztherm power controllers consist of two main parts , the control electronics and the power switching electronics.

Thyristors , also known as SCRs , are used as the power switching devices.

A thyristor functions like a diode that can be “turned on” by a momentary pulse to its gate. When a thyristor has been turned on via its gate and its anode is positive relative to its cathode it will conduct.

The thyristor turns itself off when there is near zero current through it.

To control full wave AC over the positive and negative half cycle two thyristors arranged in inverse parallel are required.

The control electronics provide the firing impulses for the thyristor gates. The control input signal is measured and the timing of the gate firing impulses are varied in response to it.

Two types of firing mode are available on Oztherm power controllers.

Phase angle control works by varying the conduction angle of the AC sine wave.

Burst control modulates power by turning the thyristors on and off for whole AC cycles. The control electronics turn the thyristors on at zero voltage and off at zero current. The output is the ratio of OFF time to ON time.

F300 series power controllers use the phase angle firing mode.

F400 series controllers use the burst firing mode.

1.2 SELECTING A POWER CONTROLLER

The following points are important in specifying a power controller for an application.

SELECTING THE CORRECT CONTROLLER FOR HEATING ELEMENT TYPES

Heating elements can be broadly divided into three categories:-

CLASS A

These elements have negligible resistance variation with either temperature or time. Examples include: Nickel/Chromium or similar alloys.

CLASS B

These elements have a low cold temperature resistance that increases greatly at operating temperature. Examples include:

Molybdenum Disilicide

Platinum

Molybdenum Tungsten

Class B elements usually require current limit on start up, as their low cold resistance results in high currents at the operating supply voltage. These elements may also require a stepdown transformer to match the supply voltage to the rated element voltage.

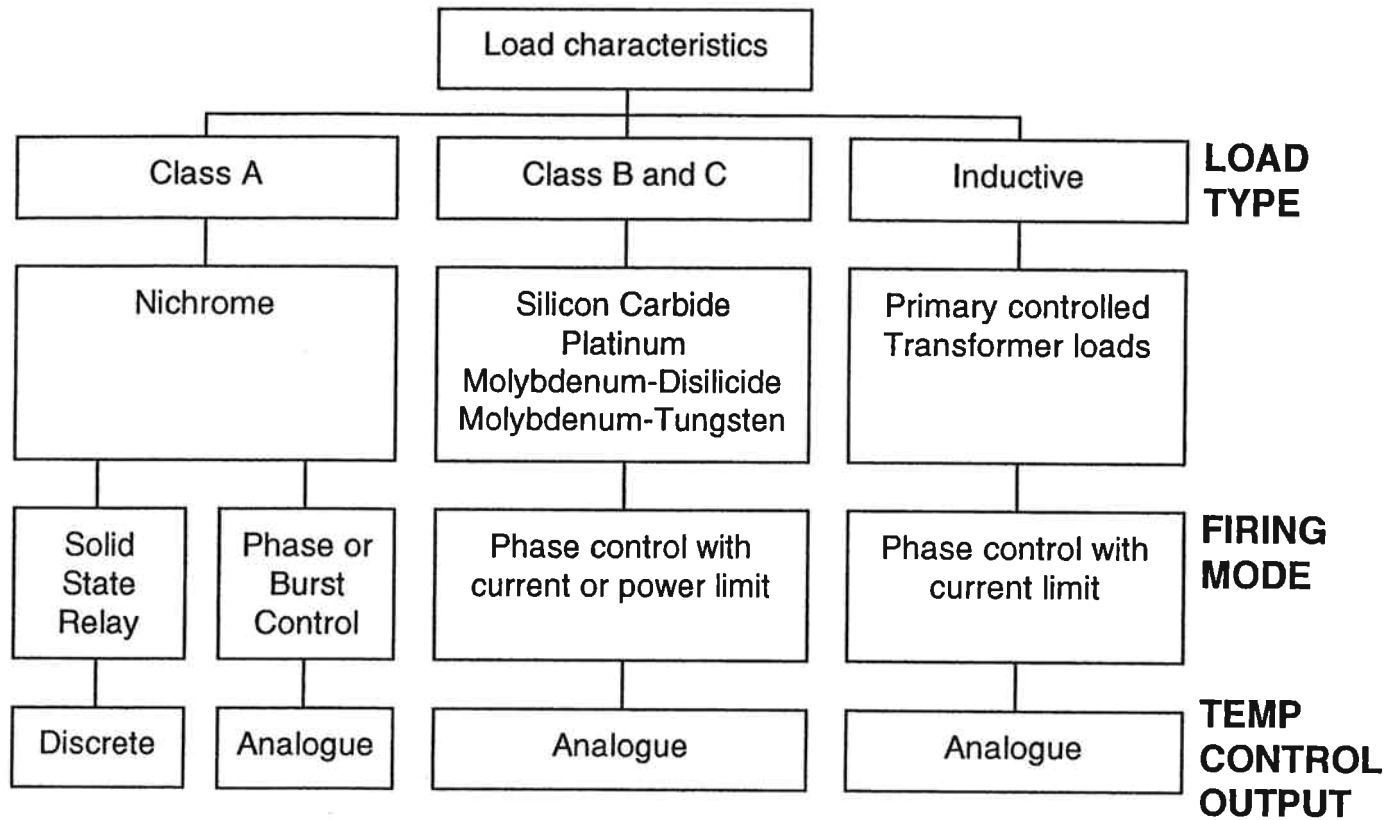
Because current limit is required, and the element voltage ratings are less than line voltage, phase angle control is the recommended firing mode.

CLASS C

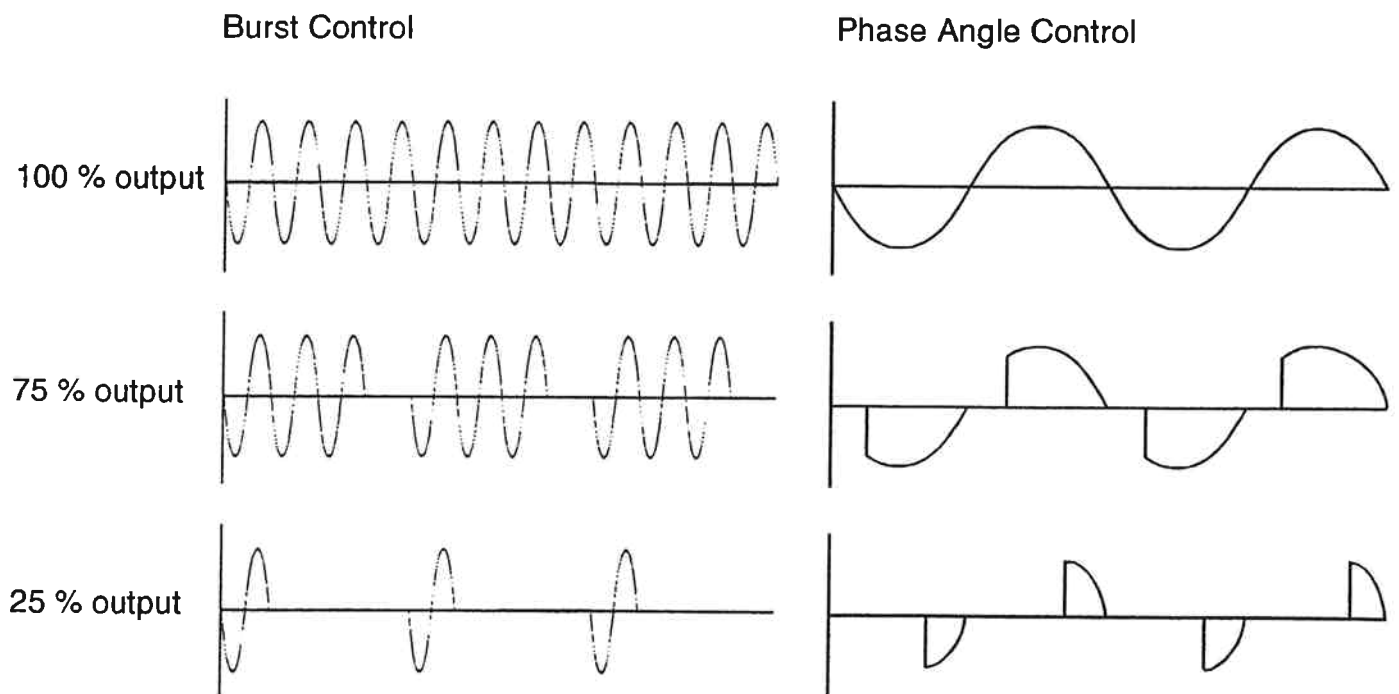
The resistance of these elements increases greatly with time in use (typically 2 to 4 times) and with temperature. Silicon carbide is a common example. The power controller must be sized so that it can deliver the higher currents required to maintain the desired power when the elements are new.

The power limit (PW) option is recommended for this class of element as it compensates for element ageing and limits the maximum load power (see appendix 3).

CONTROLLER SELECTION AND ELEMENT TYPE



VOLTAGE WAVEFORMS FOR BURST AND PHASE ANGLE CONTROL





2.0 DESCRIPTION OF OPTIONAL FUNCTIONS

2.1 CURRENT LIMIT (C)

Current limit is often used with class A heating elements. The current limit option restricts maximum current until the elements reach operating temperature.

F410 and F430 controllers also have a current trip function which disables the controller if the trip current is exceeded. Current transformers are supplied loose with this option.

2.2 SEMICONDUCTOR PROTECTION FUSING (F)

Standard cartridge fuses and circuit breakers are too slow to protect thyristors.

Semiconductor protection fuses are required for thyristor protection. These fuses are for thyristor protection only and do not protect associated wiring except in the case of a short circuit. Wiring protection should also be installed in accordance with local regulations.

Fuses are supplied loose with mounting hardware.

Note: semiconductor fuses will run warm as they are designed for free air installation. They should not be installed in a cartridge type fuse holder.

2.3 AVERAGE CURRENT METER OUTPUT (MI) *

Provides a non isolated 0-1 mA meter output corresponding to the average of RMS output currents in the three phases. Option C required.

2.4 CONTROL SIGNAL METER OUTPUT (MD) *

Provides a non isolated 0-1 mA meter output corresponding to control input signal.

* Options MI and MD are mutually exclusive. Only one of these options may be specified.

2.5 THERMAL CUTOFF (T)

If the safe operating temperature of the controller is exceeded the thermal cutoff disables the unit until the temperature drops. Thermal cutoff is often used to disable a fan cooled unit if the fan is blocked or stopped for any reason. This cutoff will prevent thermal damage to the unit. This option is automatically specified with a fan cooled unit.

2.6 PHASE LOSS (PH)

Provides a volt free relay contact output to indicate supply phase loss. This contact is latched and will indicate a momentary loss of phase.

2.7 PARTIAL LOAD FAILURE (PLF)

Partial load failure detects a reduction in output current level such as occurs if a load element fails open circuit. Partial load failure is signalled by an Led and by a volt free relay contact for external indication.

3.0 INSTALLATION & WIRING

3.1 LOCATION

Power controller mounting location is important.

The controller must be oriented so that the cooling fins are aligned vertically. On fan cooled models the fans should be blowing upward towards the top of the enclosure. Fan inlets should be free from any obstruction.

The enclosure must be adequately ventilated. Maximum ambient temperature at full rated current for F430 controllers is 50 degrees C unless otherwise specified. Some enclosures may require fan forced cooling.

As a rule of thumb about 1 watt of heat is dissipated per amp conducted through the controller.

The controller must not be installed in excessively humid or corrosive atmospheres.

Where excessive vibration is present the controller should be mounted using shock isolation techniques.

3.2 WIRING

All wiring to the controller should comply with AS3000 (or the relevant national standard). Power cable connections must be tight to minimise heating, electrical compound should be used to improve thermal and electrical conductivity.

Refer to diagram for correct power wiring. Note that the phase referencing must be exactly as drawn. If phase referencing is incorrect the POWER OK led will be unlit and the controller will not work.

Control input signal wiring must be run separately from power wiring. Screened cable is recommended for this purpose. If screened cable is not available then a twisted pair should be used.

3.3 TRANSFORMER COUPLED LOADS

The F430 power controller should not be used with primary control of transformer coupled loads.

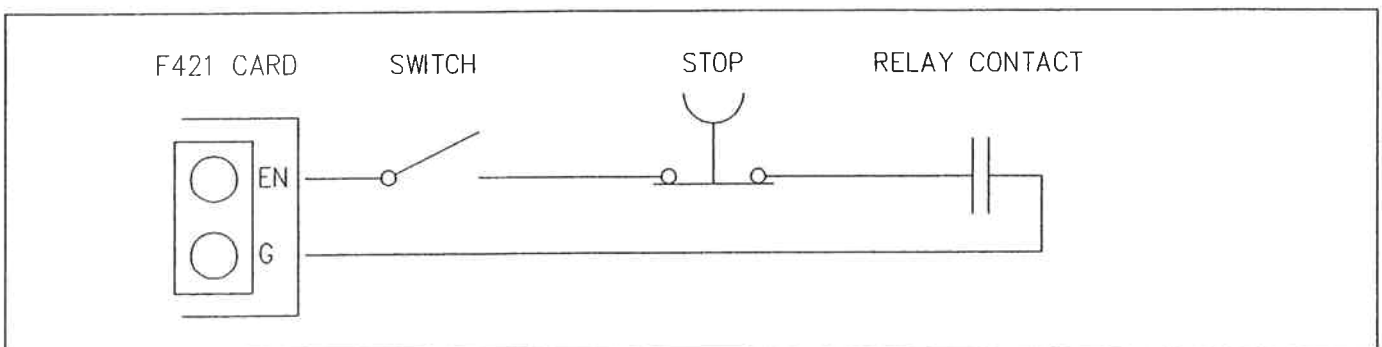
The F430 controller can be run on the secondary of any transformer as long as the voltage on the F430 power controller is the same as the secondary voltage of the transformer.

The current limit option should always be specified due to the high potential fault currents that are possible with transformer coupled loads as a safety measure.

3.4 ENABLE LINK

The ENABLE link must be closed for the controller to operate. The ENABLE link can be conveniently used as an interlock by wiring limit switches, push buttons etc. in series with it.

Note: any interlocks wired to the ENABLE link must be volt free.



3.5 CURRENT TRIP OUTPUT

A volt free change over contact is provided for current trip output. Current rating is 1A @ 240 VAC

3.6 PHASE LOSS OUTPUT

(Applicable to option PH only)

A volt free change over contact is provided for phase loss output. Current rating is 1A @ 240 VAC

3.7 PARTIAL LOAD FAILURE OUTPUT

(Applicable to option PLF only)

A volt free change over contact is provided for partial load failure output. Current rating is 1A @ 240 VAC

3.8 CURRENT TRANSFORMERS

(Applicable to options C only)

CTs must be installed exactly as shown in the diagram.
The polarity of all three CTs must be consistent.

3.9 METER OUTPUT

(Applicable to options MI and MD only)

Note that these outputs are not isolated and must not be commoned up with the control input or any other signals.

3.10 FUSES

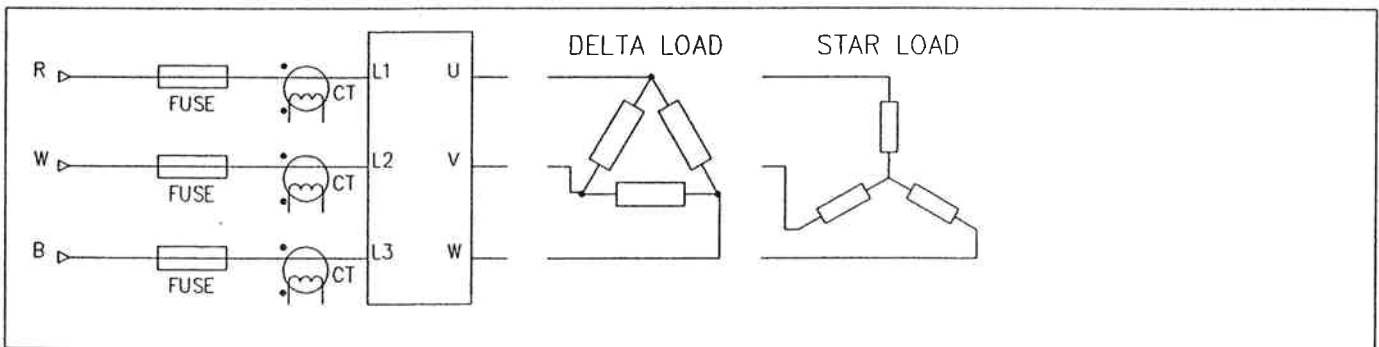
(Applicable to F option only)

Fuses must be installed exactly as shown in diagram.

Fuse ratings are calculated for free air and must be installed on the standoffs provided. Do not use fuse holders.

Semiconductor protection fuses are designed to protect the SCRs in the power controller from surge or ambient currents. They are underrated to prevent nuisance fuse blowing and therefore cannot be relied on for steady state overload protection.

Separate fusing or circuit breakers must be installed to protect wiring.



4.0 ADJUSTMENTS AND CALIBRATION

WARNING-Controller adjustment requires access to control cards with lethal AC voltages present. High voltage sections of the control card are marked. Adjustments must only be made by qualified persons taking the appropriate precautions.

4.1 BEFORE STARTING

With the power off loosen the four half turn captive screws on the controller cover and remove it. The adjustment potentiometers will be found on the circuit card marked F421.

4.2 DUMMY LOAD

To function correctly the controller must be connected to a load. Many heating elements can be damaged by excessive power, voltage or current.

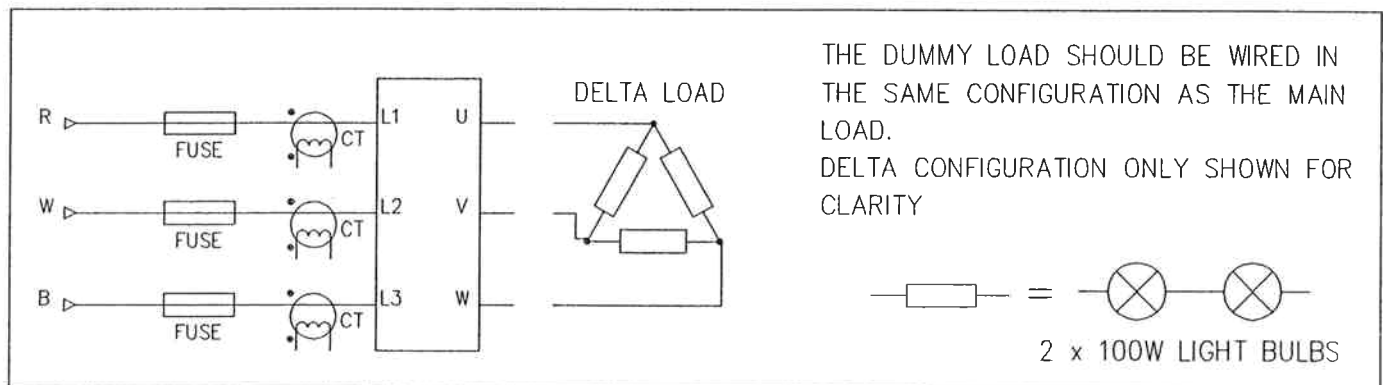
To avoid damage to heating elements it is recommended that for initial adjustment of BIAS, GAIN and RAMP a “dummy” load be connected.

A suitable “dummy” load is six 240V light bulbs wired in delta as per diagram.

After initial adjustment the dummy load can be removed and the working load can be reconnected.

The dummy load cannot be used to adjust current limit/trip due to the small current it draws.

Dummy load wiring:



4.3 ADJUSTMENTS TO VOLTAGE OUTPUT MODELS

(Applies to all controllers)

Note: ZERO, SPAN, and RAMP adjustments must always be done before current limit is adjusted.

4.3.1 BIAS ADJUSTMENT (ZERO)

Set the GAIN potentiometer fully anticlockwise.

Using a portable calibrator or similar, input the minimum control input signal. Adjust the BIAS potentiometer for zero voltage across the controller output terminals.

4.3.2 GAIN ADJUSTMENT (SPAN)

Wind the GAIN potentiometer fully anticlockwise and apply the maximum control input signal. Adjust the GAIN potentiometer until the maximum desired voltage is measured across the controller output terminals.

Check output voltage at minimum and maximum control input and readjust BIAS and GAIN if necessary.

4.3.3 RAMP ADJUSTMENT

The RAMP potentiometer sets the response of the controller output to the control input signal. Adjust the RAMP potentiometer until the desired level of response has been reached. Response time can be checked by introducing a step control input signal change to the controller and measuring the output response time.

4.3.4 CURRENT LIMIT

(Applies to options C only)

Set the LIM potentiometer fully anticlockwise and the FBG (feed back gain) and TRIP potentiometers fully clockwise. With the control input signal set to maximum gradually turn the LIM potentiometer clockwise until the required current limit level, measured through the load, has been reached. When the controller is limiting the current the LIM led will light.

NOTE: The current wave form through the power controller will be sinusoidal. For accurate current measurement a true RMS meter such as the HEME Analyst 2000P should be used.

If the output oscillates under current limit turn the FB-G potentiometer anticlockwise until the current output is stable.

4.3.5 CURRENT TRIP

With the control input signal set to maximum and the controller outputting full current to the load gradually turn the TRIP potentiometer anticlockwise until the TRIP is activated (indicated by TRIP led). TRIP is now set at maximum current. Turn trip potentiometer another one to two turns clockwise. If the odd nuisance trip still occurs turn the TRIP potentiometer a further half to one turn clockwise. On current trip the trip relay energises and the controller is disabled. Both are latched. Current trip may be reset by opening the ENABLE link or by turning off the mains supply.

4.3.6 PARTIAL LOAD FAILURE

Set the PLF potentiometer fully anticlockwise and the 2 Dip switches to off.

With the control signal at maximum and the controller outputting full power to the load adjust the PLF potentiometer clockwise slowly until the PLF Led lights. The partial load failure current level is now set at the maximum load current. The failure sensing current is less than this so set the switches (7% and 14%) for the reduced current level sensing level. A 21% reduced sensing level is obtainable by setting both the 7% and 14% switches to "on".

4.4 METER ADJUSTMENTS

(Applies to options MI and MD only)

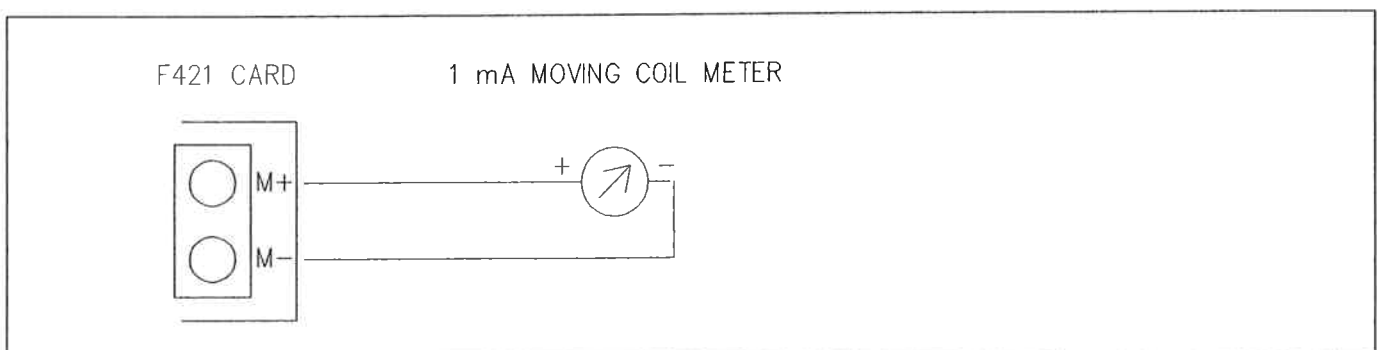
Full scale output is adjusted by the METER potentiometer. There is no zero bias adjustment. Output is 1mA full scale.

4.4.1 OPTION MI

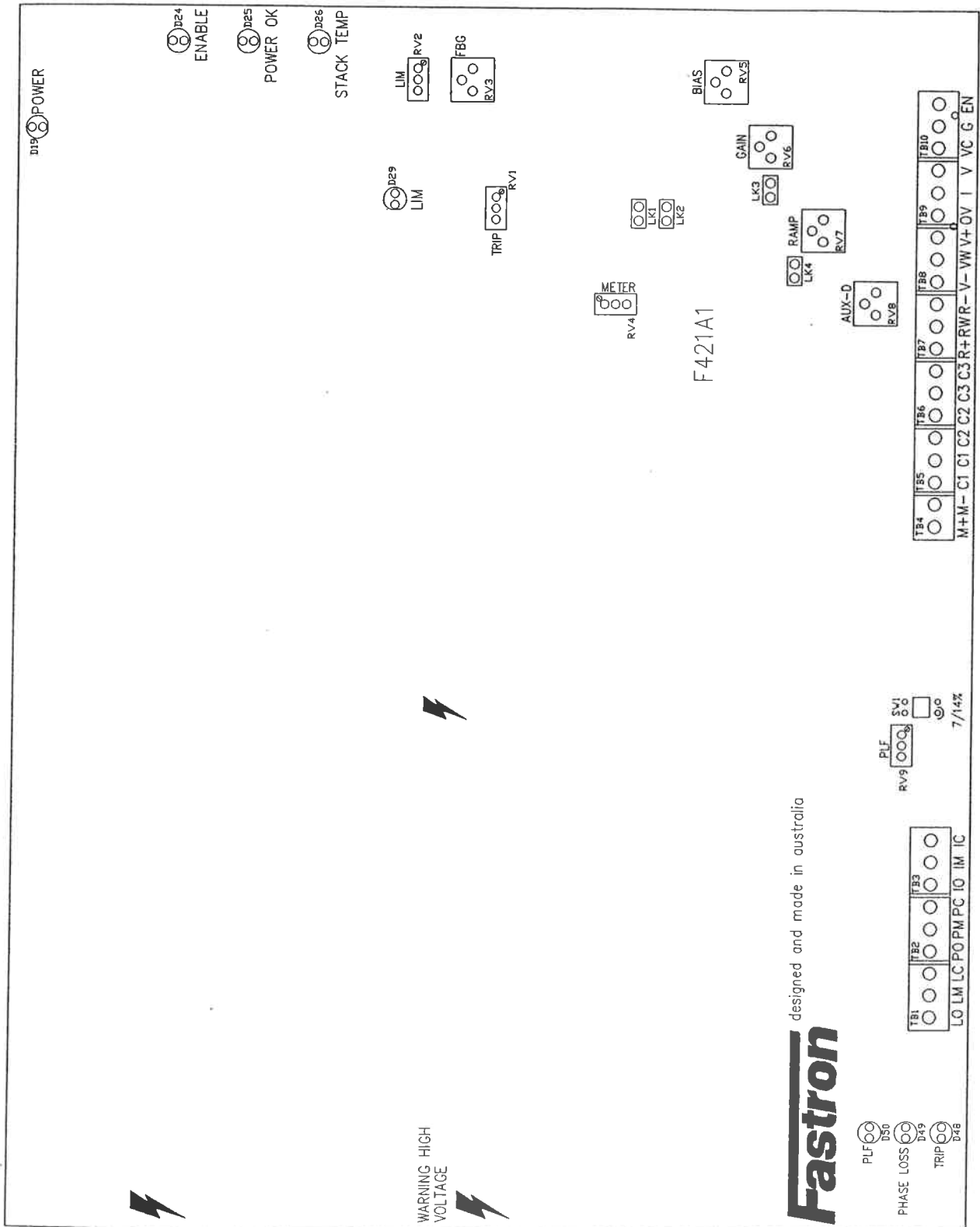
Run the controller up to maximum operating current and adjust the METER potentiometer for full scale meter deflection.

4.4.2 OPTION MD

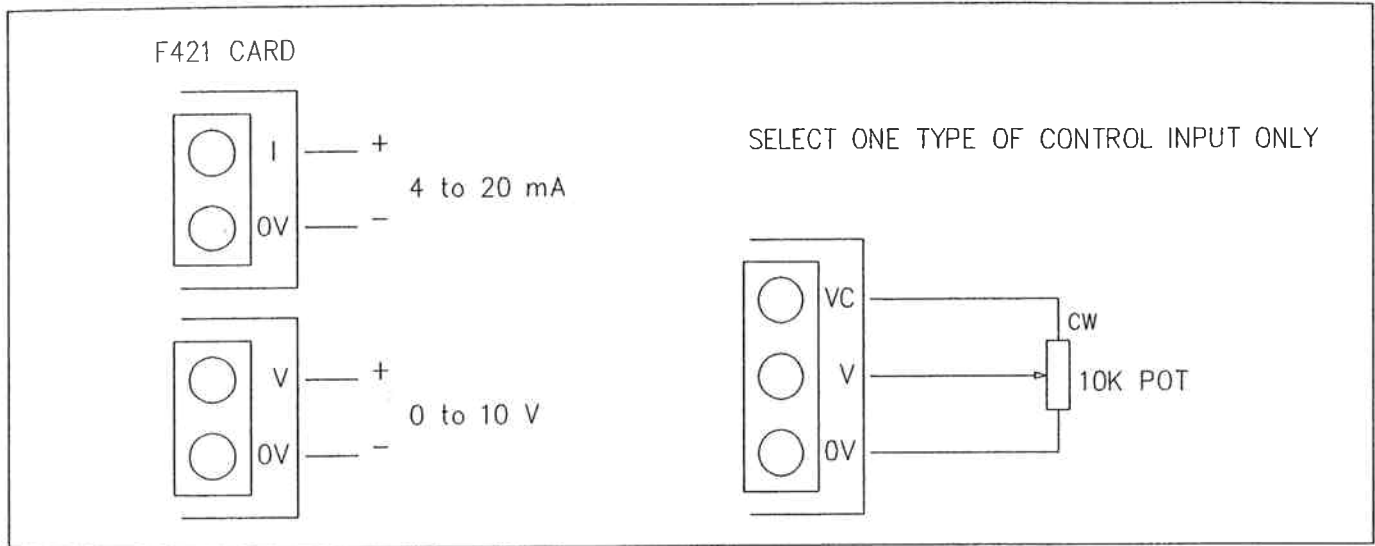
Apply the maximum control input signal and adjust the METER potentiometer for full scale meter deflection.



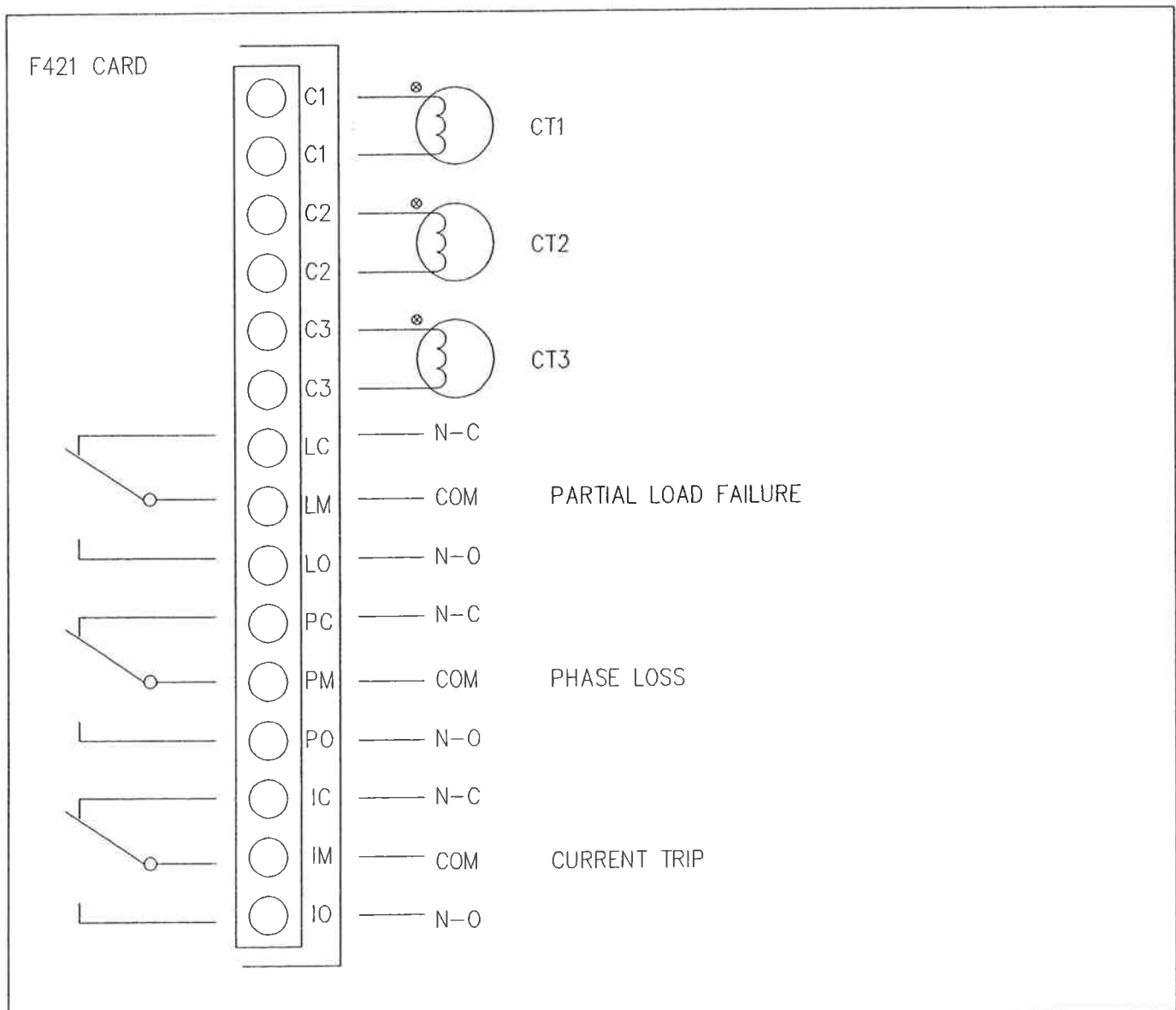
F421 Board potentiometer layout



4.5 CONTROL INPUT WIRING



4.6 RELAY, METER OUTPUT AND CURRENT TRANSFORMER WIRING

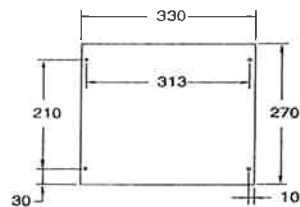


5.0 SPECIFICATIONS

Control Mode	Fast Cycle Burst
Control Range	0 - 100%
Maximum Current	25 - 1100 amperes (higher currents available on request)
Power Supply	110 / 240 / 415 volts A.C . 50 HZ . +/- 10% (60Hz and other voltages on request)
Transient Protection	Internal R.C snubber 68 ohms / .1 micro-farad
Control Input	4 - 20 milliamps (receiving impedance 100 ohms) 0 - 10 volts (receiving impedance 10K ohms) 10K ohms potentiometer
Adjustments	Ramp 1-20 seconds Zero (- 20% to +20%) ; span (0 - full scale)
Ambient Temperture	0 - 50 degrees Celsius (Maximum temperture of cooling air)
Ambient Humidity	0 - 85% relative humidity
Power Factor	Unity

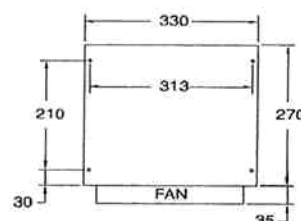
6.0 DIMENSIONS AND MOUNTING DETAILS

Shown mounted vertically in cabinet



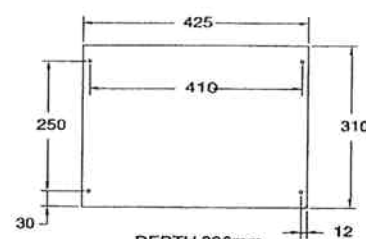
DEPTH 226mm
M6 MOUNT

Fig.4



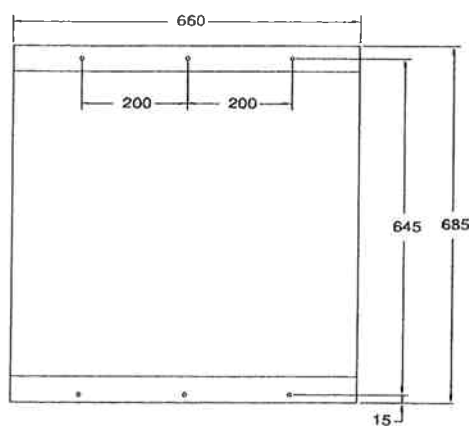
DEPTH 226mm
M6 MOUNT

Fig.5



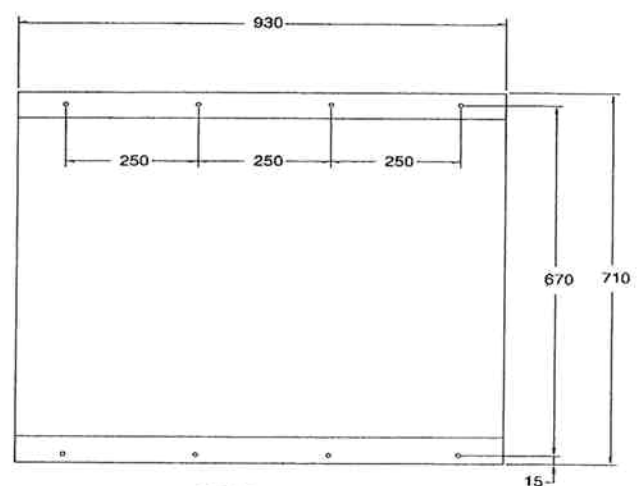
DEPTH 336mm
M6 MOUNT

Fig.6



DEPTH 400mm
M8 MOUNT

Fig.7



DEPTH 465mm
M8 MOUNT

Fig.8

FAULT	POSSIBLE CAUSE	REMEDY
No output from controller	Power wiring incorrect or out of sequence	Check POWER OK led. Swap two input phases if unlit
	ENABLE link open	Close link and check any interlocks wired in series with the ENABLE link
	Over temperature cutout TEMP activated	Turn off power and allow unit to cool down
	No control input signal	Ensure input signal is present and polarity is correct
	Current trip is activated	Check TRIP led. If lit find and correct source of trip. Break and make ENABLE link or turn off power to reset
	Partial load failure activated	Check PLF led. If lit check load with power off. Check current transformers for open or faulty wiring. Break and make Enable link or turn off power to reset
	One input phase lost or missing	Check PHASE LOSS led. If lit determine missing phase and reconnect Check POWER OK led. If unlit, check fuses with power off. Determine cause of blown fuse and replace if necessary
	Load circuit open	Check load circuit continuity and repair if necessary

7.0 TROUBLE SHOOTING GUIDE (continued)

FAULT	POSSIBLE CAUSE	REMEDY
Controller not modulating with respect to control input signal	No control input signal	Ensure input signal is present and polarity is correct
	Current limit set too low	Check current limit LIMIT led and readjust current limit if necessary
	Current transformer disconnected or damaged or incorrectly installed	Inspect current transformer and wiring and correct if necessary
	Load circuit open	Check load circuit continuity and repair if necessary
	Current trip is activated	Check TRIP led. If lit find and correct source of trip. Break and make ENABLE link or turn off power to reset
	Partial load failure activated	Check PLF led. If lit find and correct source of load failure. Break and make ENABLE link or turn off power to reset.
	One input phase lost or missing	Check PHASE LOSS led. If lit determine missing phase and reconnect
Load current not balanced or non zero at minimum control signal level	BIAS and GAIN not set correctly	Readjust BIAS and GAIN if necessary
	Load wiring not correct	Check load wiring with power off and correct if necessary
	Current transformer disconnected or damaged or incorrectly installed	Inspect current transformer and wiring and correct if necessary

APPENDIX 1

USEFUL FORMULAS

Line voltage $V_L = 1.73 \times \text{Phase voltage } V_P$

Line current $I_L = 1.73 \times \text{Phase current } I_P$

Peak voltage $V_{\text{peak}} = 1.414 \times \text{Rms voltage } V_{\text{rms}}$

Total power delivered to the load $P_{\text{tot}} = 1.73 \times V_L \times I_L$ for balanced 3 wire resistive loads

$$= 1.73 \times V_L \times I_L \times \cos(a)$$

$$= 3 \times V_P \times I_L = 3 \times V_L \times I_P$$

$$= 3 \times V_P \times I_L \times \cos(a) = 3 \times V_L \times I_P \times \cos(a)$$

Line current $= P_{\text{tot}} / (1.73 \times V_L) = P_{\text{tot}} / (3 \times V_P)$

Ohms law : $V = I \times R$

$$P = V \times I = I \times I \times R = V \times V / R$$

Resistors in series: Total resistance $R_{\text{tot}} = \text{resistance one } R_1 + \text{resistance two } R_2 + \dots$

Resistors in parallel: Total resistance $R_{\text{tot}} = 1 / (1 / R_1 + 1 / R_2 + \dots)$

$V_{\text{rms}} = 1.1 \times V_{\text{average}}$ for a pure sine wave

$I_{\text{rms}} = 1.1 \times I_{\text{average}}$ for a pure sine wave

$\pi = 3.1416$

APPENDIX 2

CONVERSION FORMULAS FOR FAN FLOW RATES

FROM	TO	MULTIPLY BY
Cubic m / min	CFM (cubic feet / minute)	35.3
	L / sec (litres per second)	16.67
	m / sec (metres per second) 120 mm fan	1.577
	m / sec (metres per second) 92 mm fan	2.679
	m / sec (metres per second) 80 mm fan	3.579

APPENDIX 3

CONTROLLER USE WITH TYPE B AND C LOADS

Burst controllers such as the F430 are not suitable for control of type B and C loads due to the high possible currents involved.

The OZTHERM F300 series controllers should be used for control of these types of loads.

APPENDIX 4**APPROXIMATE THERMAL CALCULATIONS FOR FAN COOLED ENCLOSURES**

H = heat loss from power controller (kW)

T1 = inlet air temperature (deg C)

T2 = outlet air temperature (deg C)

V = volumetric flow through enclosure, fan flow required (cubic m / s)

Cp = a constant = 1.01 (kJ / kg x K)

P = density of air = 1.13 at 40 deg C and at sea level (kg / cubic m)

1: Calculate H, heat dissipated by power controller and fuses. As a rule of thumb the controller dissipates 1 Watt of heat per amp per phase. The exact figure at full load can be obtained Appendix 5. Fuse heating should be added, see appendix 6.

For a 100 Amp controller $H = 1\text{Watt} / \text{amp} \times 100 \text{ Amp} / \text{phase} \times 3 \text{ phases} = 1 \times 100 \times 3 = 300 \text{ Watt} + \text{Fuse heating of } 3 \times 17 \text{ Watt per fuse} = 351 \text{ Watt}$

from the definitions above, H is in kW so 351 Watt = 0.351 kWatt

2: T1 is the maximum external ambient air temperature. 40 deg C is usually a good conservative number

T2 should be the maximum operating temperature of the F430 power controller. 50 deg C is standard for all OZTHERM power controllers

3: For heat balance:

$$H = V \times P \times Cp \times (T2 - T1)$$

$$\text{or } V = H / (P \times Cp \times (T2 - T1))$$

for the above example:

$$P = 1.13$$

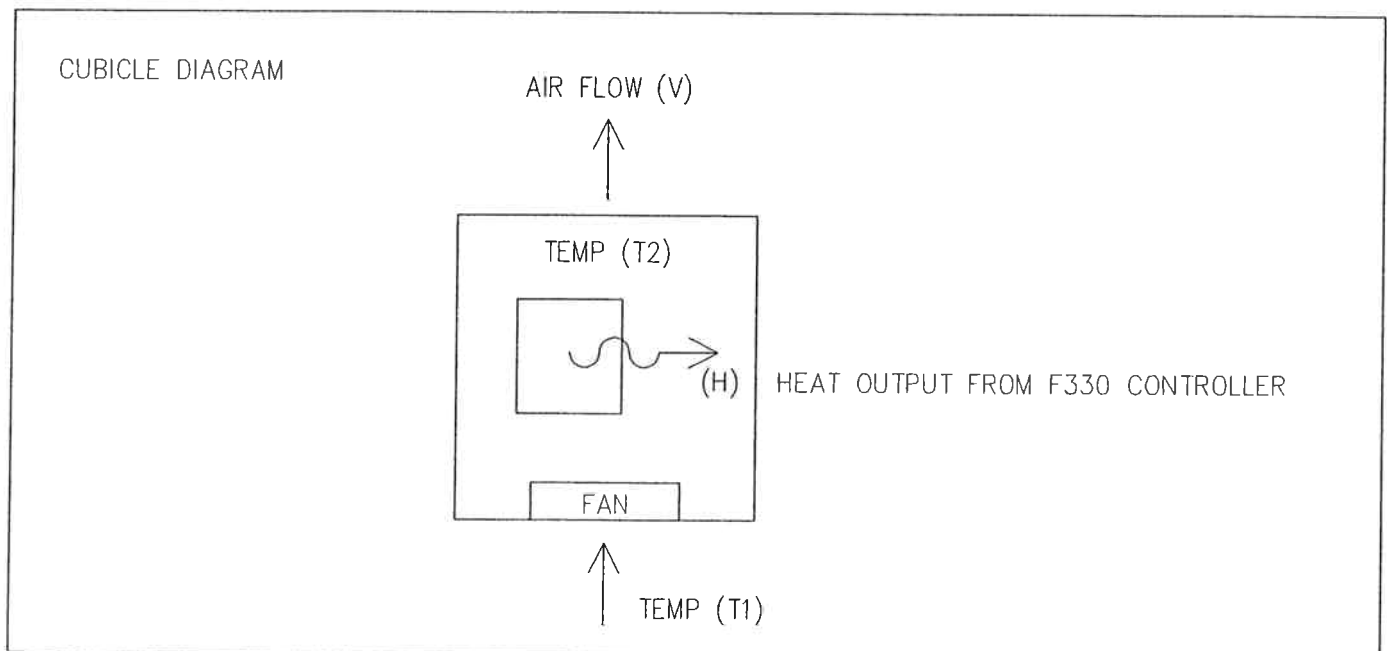
$$Cp = 1.01$$

$$T2 - T1 = 50 - 40 = 10 \text{ deg C}$$

$$H = 0.351 \text{ kWatt from step one}$$

$$\text{so: } V = 0.351 / (1.13 \times 1.01 \times 10) = 0.0308 \text{ cubic m/s}$$

$$\text{multiply by 60 for cubic m / minute} = 1.85 \text{ cubic m/min}$$



APPENDIX 5

PART NUMBER BREAKDOWN

F430	-	-	-	DESCRIPTION	Fuse Rating	Case Size	Weight KG	Cable Termination mm ²	Dissipation Watts	I ² t Thyristor Rating
1				110 volt A.C line input						
2				240 volt A.C line input						
4				415 volt A.C line input						
25				25 amperes A.C line current	25	fig.4	10	2.5 - 6.	96	610
40				40 amperes A.C line current	45	fig.4	10	10 - 16.	136	1,060
50				50 amperes A.C line current	55	fig.4	10	10 - 16.	144	2,300
65				65 amperes A.C line current	75	fig.4	10	10 - 25.	172	5,000
75				75 amperes A.C line current	90	fig.4	10	10 - 25.	188	9,100
100				100 amperes A.C line current	125	fig.4	10	10 - 25.	222	16,200
110				110 amperes A.C line current	125	fig.4	10	M10 bolt	244	27,600
125				125 amperes A.C line current	150	fig.4	10	M10 bolt	248	97,000
150F				150 amperes A.C line current - fan	150	fig.5	12	M10 bolt	352	16,200
180F				180 amperes A.C line current - fan	225	fig.5	12	M10 bolt	388	84,000
200F				200 amperes A.C line current - fan	225	fig.5	12	M10 bolt	408	97,000
240F				240 amperes A.C line current - fan	250	fig.6	23	M10 bolt	506	97,000
280F				280 amperes A.C line current - fan	300	fig.6	23	M10 bolt	667	168,000
340F				340 amperes A.C line current - fan	375	fig.6	23	M10 bolt	680	245,000
400F				400 amperes A.C line current - fan	400	fig.7	40	M10 bolt	1072	106,000
500F				500 amperes A.C line current - fan	500	fig.7	40	M10 bolt	1193	238,000
650F				650 amperes A.C line current - fan	350x2	fig.7	40	M10 bolt	1597	781,000
750F				750 amperes A.C line current - fan	400x2	fig.7	40	M10 bolt	1661	2x10 ⁶
900F				900 amperes A.C line current - fan	500x2	fig.8	66	M10 bolt	2361	781,000
1100F				1100 amperes A.C line current - fan	600x2	fig.8	66	M10 bolt	2553	2x10 ⁶
C				Current limit and trip.						A.C. current measurement.
F				High speed fuses.						
MD				Meter output of input control signal.						
MI				Meter output of average current.						Requires C option.
PH				Phase loss output.						Requires C option.
PLF				Partial load failure.						Requires C option.
T				Thermal cutout.						Standard on fan models.

APPENDIX 6

FUSE HEATING AND DIMENSIONS

CONTROLLER CURRENT	FUSE	WATTS PER FUSE	TOTAL 3 PHASE WATTS
25 AMP	25 AF	12	36
40 AMP	45 AF	12	36
50 AMP	55 AF	16	48
65 AMP	75 AF	17	51
75 AMP	90 AF	17	51
100 AMP	110 AF	17	51
110 AMP	125 BF	31	93
125 AMP	150 BF	33	99
150 AMP	150 BF	33	99
180 AMP	225 BF	37	111
200 AMP	250 BF	37	111
240 AMP	250 BF	37	111
280 AMP	300 BF	39	117
340 AMP	375 BBF	66	198
400 AMP	400 BBF	75	150
500 AMP	500 BBF	75	150
650 AMP	350 BBF x 2	150	300
750 AMP	400 BBF x 2	150	300
900 AMP	500 BBF x 2	150	300
1100AMP	600 BBF x 2	150	300

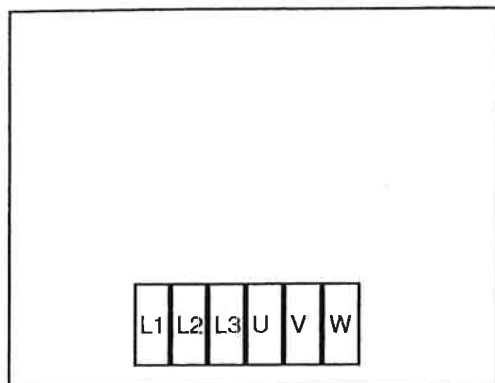
FUSE SIZE	MOUNTING CENTRES	BOLT SIZE	HEIGHT	WIDTH	DEPTH
AF	63.5 mm	M5 - M6	76 mm	17 mm	20 mm
BF	86 mm	M8 - M10	113 mm	38 mm	43 mm
BBF	86 mm	M8 - M10	113 mm	38 mm	86 mm

APPENDIX 7

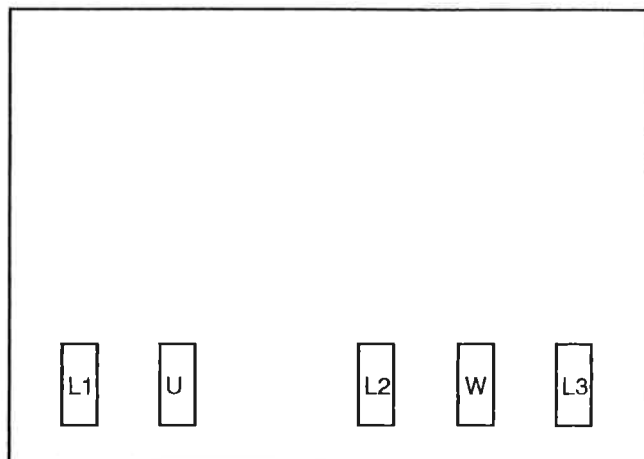
MAINS TERMINAL LAYOUT

Shown mounted vertically in cabinet

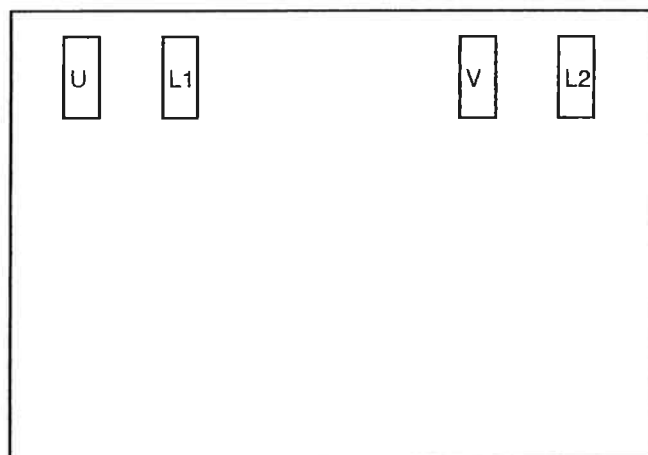
25 to 200 Amp controllers



240 to 340 Amp controllers



400 to 1100 Amp controllers



Controllers up to 340 amp have bottom entry for cable connection and top cable entry for controllers over 400 amp. Appendix 5 (page 17) has information regarding cable termination in square mm, and section 6 (page 12) has external dimensions for the F330 power controllers.

All control wiring (including Current Transformer and Hall Effect Sensor wiring where appropriate) is bottom entry direct to circuit board.

Fuses are external to the F430 power controller and should be mounted using the standoffs provided (option F only) for controllers up to 340 amp and internal for controllers over 400 amp.

Airflow to the F430 power controller should not be obstructed and if mounting the F430 power controller in an enclosure then Appendix 4 (page 16) has details on heat loss and enclosure sizing.

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