YASKAWA ELECTRIC

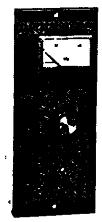
SIE-S616-3C
INSTRUCTIONS

GENERAL PURPOSE TRANSISTOR INVERTER

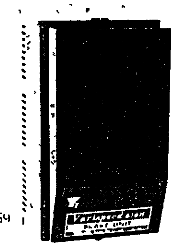
Varispeed-616™

SIMPLE SPEED CONTROL: VS-616G SERIES 200V 3kVA, 5kVA
WIDE-RANGE SPEED CONTROL:
VS-616H SERIES, 200V 3–100kVA, 400V 5–200kVA

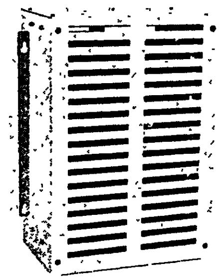
This manual has been compiled to give advanced information on the features, selection, maintenance, and operation of the transistor inverters to assist you in understanding, correct selection, and full exploitation of the VS-616 series.



VS Operator



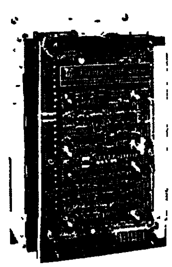
Braking Unit



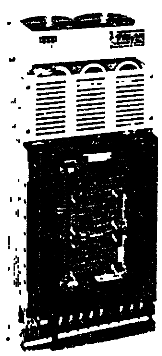
Braking Resistor Unit

VS-616 DRIVE COMPONENTS

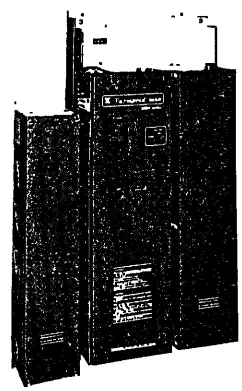
TRANSISTOR INVERTERS *Varispeed-616*



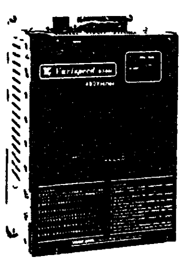
Built-in Type
200V
3, 5kVA



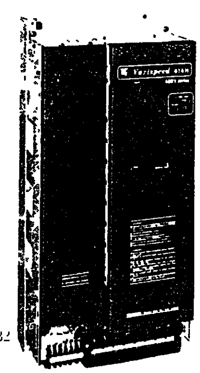
Built-in Type
200V
10–30kVA



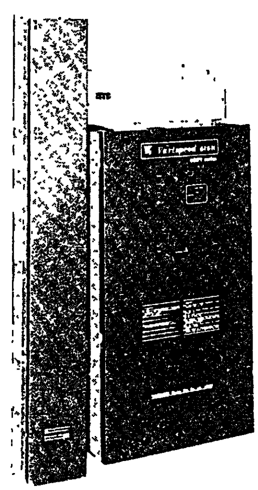
Built-in Type
200V
40–100 kVA



Built-in Type
400V
5–20 kVA



Built-in Type
400V
40, 60kVA



Built-in Type
400V
75–200 kVA

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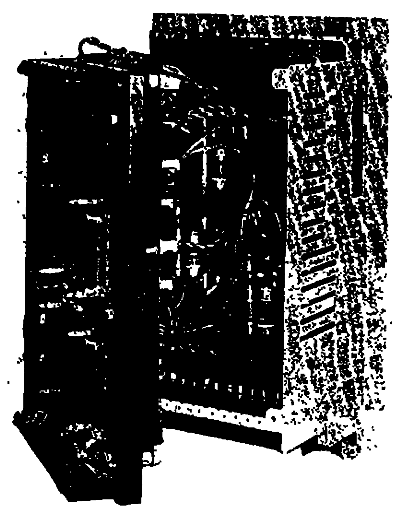
INTRODUCTION

The Varispeed-616 (VS-616) transistor inverters are variable voltage, variable frequency (VVVF) AC power supplies allowing convenient speed control of 3-phase squirrel-cage induction motors.

For diverse control applications, they are available in two series; VS-616G Series for simple variabl speed control, and VS-616H Series for sophisticated, wide-range speed control.

To meet diverse requirements in automated and labor-saving operations, many optional features are available. Especially with the H Series, the combined use with various VS system modules and snap-in modules provides sophisticated control sytem configurations.

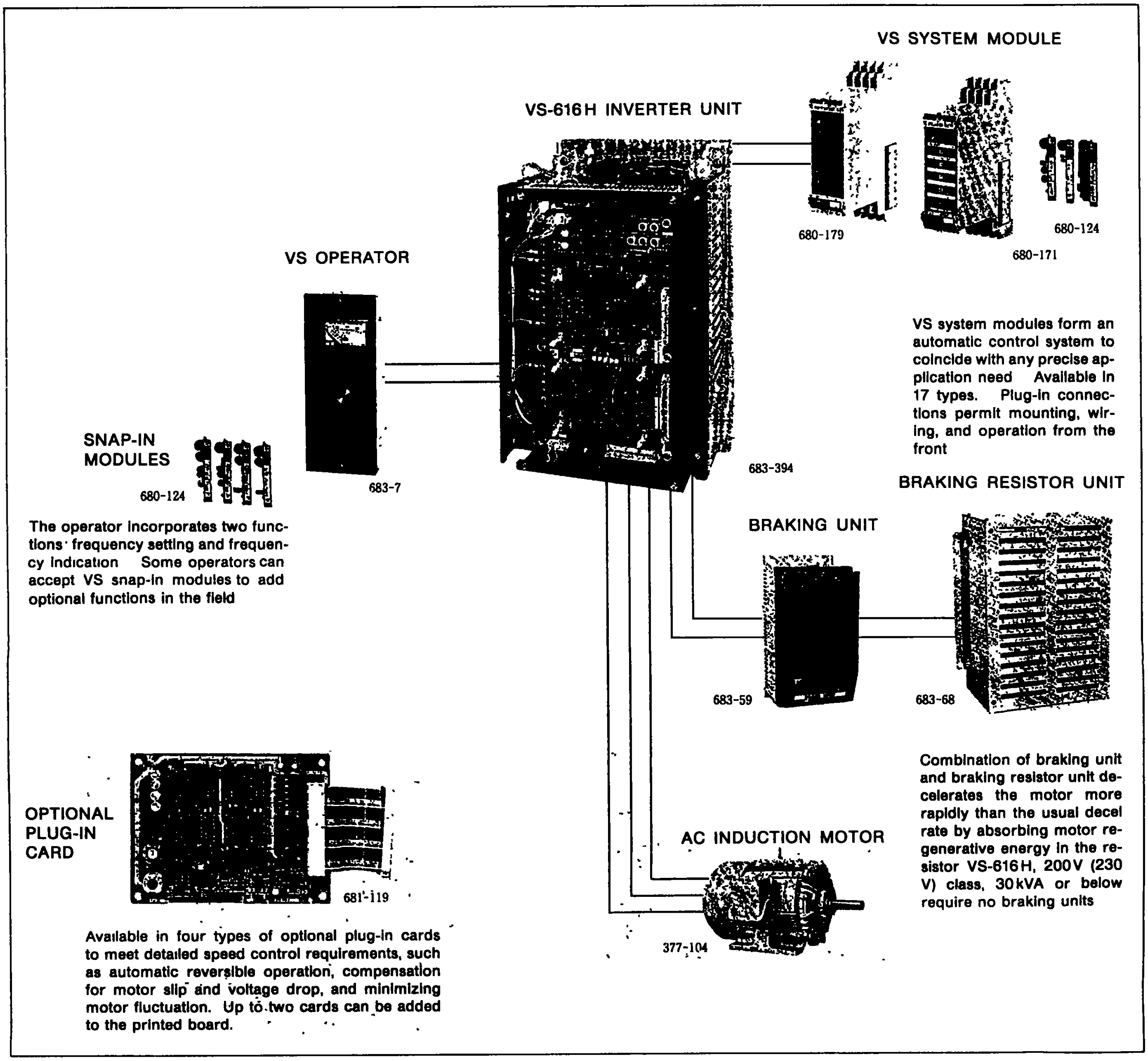
VS-616 inverters find wide ranges of applications in pumps, fans, blowers, textile plants, chemical plants, machine tools, food processing machines and other industrial machines.



VS-H616H Built-in Type CIMP-H7.5H

VS-616H DRIVE SYSTEM

To provide extra facilities, Yaskawa offers these standard, 'add-on' optional items at low cost which can be supplied singly or in any combinations of two or more according to the application mode of control system. Optimum selectior. can achieve the highly sophisticated variable speed drive system exactly matching the control requirements of machines through simple connection features of ancillary equipment.



VS system modules form an automatic control system to coincide with any precise application need Available in 17 types. Plug-in connections permit mounting, wiring, and operation from the front

The operator incorporates two functions· frequency setting and frequency indication Some operators can accept VS snap-in modules to add optional functions in the field

Combination of braking unit and braking resistor unit decelerates the motor more rapidly than the usual decel rate by absorbing motor regenerative energy in the resistor VS-616H, 200V (230 V) class, 30kVA or below require no braking units

Available in four types of optional plug-in cards to meet detailed speed control requirements, such as automatic reversible operation, compensation for motor slip and voltage drop, and minimizing motor fluctuation. Up to two cards can be added to the printed board.

1. OUTLINE OF INVERTER

1.1 MOTOR CHARACTERISTICS

The relationships among the speed, voltage, current, frequency, magnetic flux, torque, and slip frequency of the 3-phase squirrel-cage induction motor are as follows.

$$N = \frac{120f}{P}(1 - S) \quad \cdots\cdots \quad (1)$$

$$\phi = K_1 \cdot \frac{V}{f} \quad \cdots\cdots \quad (2)$$

$$I = K_2 \cdot \phi \cdot f_{SL} = K_3 \cdot \frac{V}{f} \cdot f_{SL} \quad \cdots\cdots \quad (3)$$

$$T = K_4 \cdot \phi \cdot I = K_5 \cdot \frac{V}{f}^2 \cdot f_{SL} \quad \cdots\cdots \quad (4)$$

$$P_0 = K_6 \cdot V \cdot I \quad \cdots\cdots \quad (5)$$

where N = speed, Po = output, f = frequency, V = terminal voltage, S = slip, f_{SL} = slip frequency, P = number of poles, I = motor current, and K_1 through K_6 = constants.

To change motor speeds, according to Eq. (1), the frequency f, the number of poles P or slip S may be changed, and transistor inverters are used to change frequency f (Table 1.1).

Table 1.1 Motor Speed Controlling Method

To be Controlled	Controlling Method	YE Product
Frequency f	Inverter	VS-600 series
Poles P	Changing no. of poles	Pole-change motors
Slip S	Eddy-current coupling	VS-400 series

A 200V Class 3 rating standard motor is designed to operate with the maximum magnetic flux at 200V, 50Hz. Operation with larger magnetic flux will increase the excitation current, and may overheat the motor, making further operation impossible. The motor magnetic flux is proportional to voltage and inversely proportional to frequency from Eq. (2). On the other hand, the motor torque is proportional to the product of flux and current from Eq. (4). Therefore, in controlling the frequency with an inverter, V/f should be controlled at a constant level below 200V/50Hz. That is, when frequency increases, voltage should also be raised, and vice versa.

From the characteristics of an inverter, the output voltage cannot be raised above the supply voltage, so that even when the frequency is raised above 50 or 60Hz, the output voltage remains unchanged. Therefore, as can be seen from Eq. (4), in this area, the torque decreases in inverse proportion to the square of frequency f, and as can be seen from Eq. (5), the output power drops in inverse proportion to the frequency. These relationships are roughly shown in Fig. 1.1.

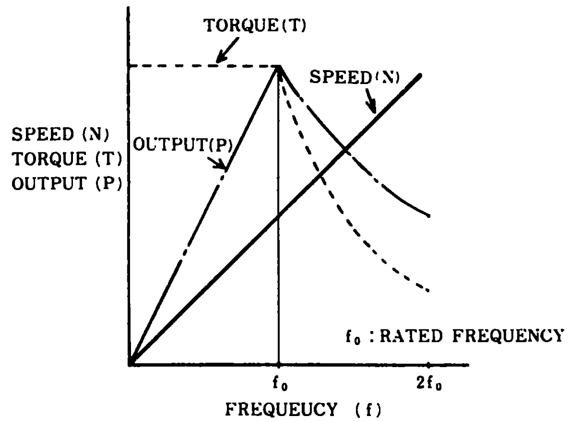


Fig. 1.1 Speed, Torque, and Output

The torque T of motors, with the slip frequency f_{SL} kept constant, is in proportion to $(V/f)^2$, from Eq. (4). When V/f is kept constant, the torque is kept constant. In actual operation, the slip frequency f_{SL} increases above the rated frequency. With motors with the maximum torque over 250% of the rated torque, a constant output power characteristic curve as shown in Fig. 1.2 is obtained.

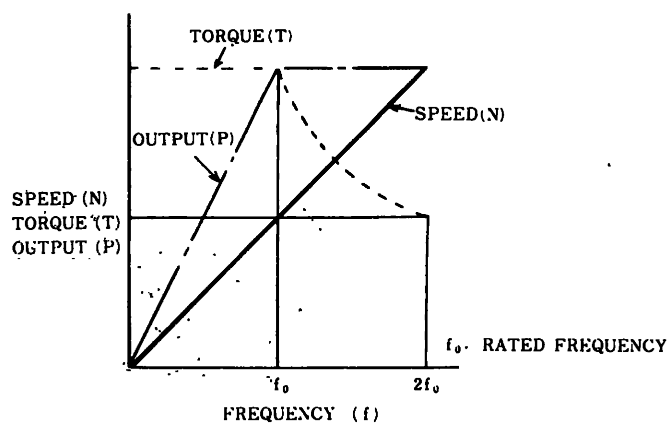


Fig. 1.2 Constant Output Characteristics

1.2 OUTLINE OF INVERTER

The transistor inverter first rectifies the commercial power into DC power (converter section), and then, inverts the DC power into AC power of desired frequency (inverter section) to drive the motor at desired speeds. Fig. 1.3 shows the basic configuration of the transistor inverter and Fig. 1.4 shows its basic operation.

The control circuit controls the output variables to the optimum values to the given frequency command signals for the motor (e.g., V/f = constant.), and make an output AC power in the required frequency output at the terminals U, V and W through controls on the inverter transistors 1Tr through 6Tr as shown in Fig. 1.4.

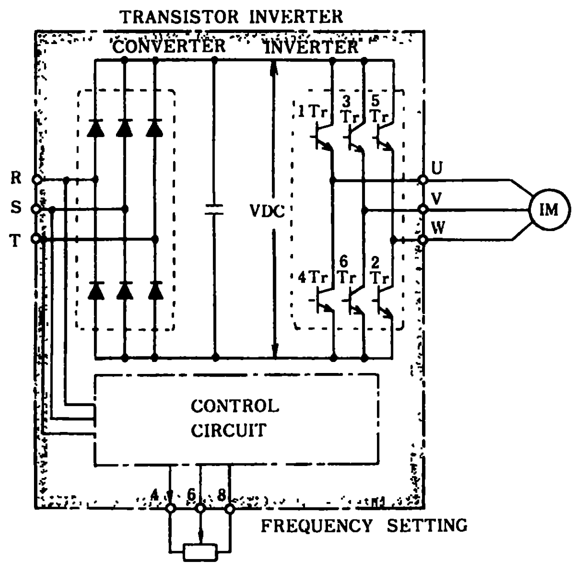


Fig. 1.3 Basic Construction of Transistor Inverter.

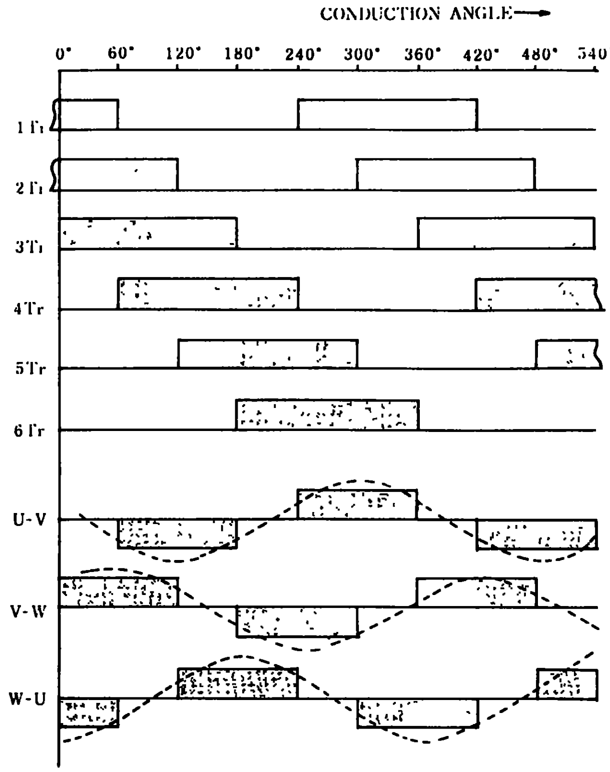


Fig. 1.4 Basic Operation of Transistor Inverter

1.3 OUTPUT VOLTAGE/FREQUENCY(V/f) CHARACTERISTIC

In controlling motor speed by frequency control by transistor inverters, the value of V/f must be kept constant, as shown in Fig. 1.5 by the dashed line, However, if the voltage V at the motor primary terminal is controlled to a constant V/f, the output torque drops at the low speed range due to the large voltage drop by the primary resistance in the low speed range. To compensate for this voltage drop, usually, the voltage is controlled to provide compensation in the low speed range as shown by the solid line in Fig. 1.5

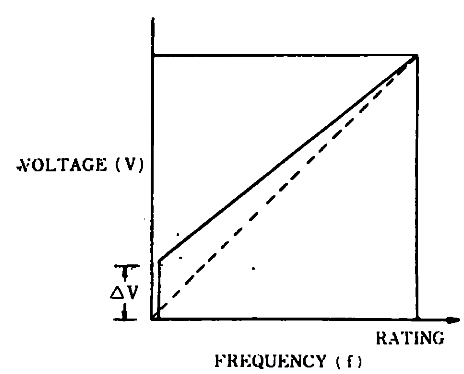


Fig. 1.5 V/f Characteristics

1.4 V/f CHARACTERISTIC AT USE ABOVE COMMERCIAL FREQUENCCY

When a standard motor is used at frequencies above the commercial power supply frequencies to obtain speeds above the rated speed, the output decreases in inverse proportion to the frequency, and the torque in inverse proportion to the square of the frequency. When selecting the motor, this should be well taken into consideration.

Four-pole motors may be used to speed up to 1.5 times the rated speed, but above this, careful studies are required, including the high-speed performance of mechanical components such as the bearings.

The V/f characteristic should be modified so that the rated voltage is obtained at the rated speed, as shown in Fig. 1.6. If this is not satisfied, the rated torque cannot be obtained at the rated speed, because the torque is proportional to the square of the voltage, as shown by Eq. (4). When the speed is raised to 1.5 times the rated speed, the torque would be only $(1/1.5)^2$ times the rated torque.

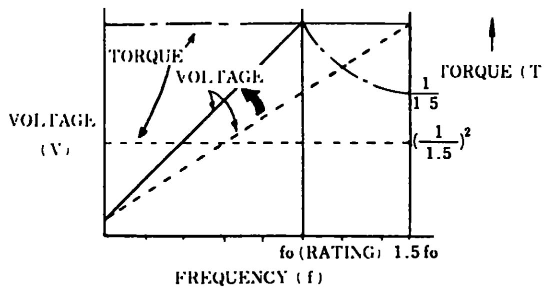


Fig. 1.6 Change of V/f Characteristics

Table 1.2 Merits and Demerits of Various Circuits

Circuit				Merit				Demerit				YE Product
PAM	Squarewave			Less vibration and noise			—	Less response			Low efficiency	—
PAM	Sinewave			Less vibration and noise			High efficiency	Less response			High cost	—
PWM	Square-wave pulse width modulation	Synchronized	Constant carrier system	High response	—	No beating	—	Large noise and vibration	Low efficiency	—	High torque ripples at low speed	—
PWM	Square-wave pulse width modulation	Synchronized	Variable carrier system	High response	—	No beating	Low torque ripples at low speed	Large noise and vibration	Low efficiency	—	—	—
PWM	Square-wave pulse width modulation	Non-Synchronized	Constant carrier system	High response	—		Low torque ripples at low speed	Large noise and vibration	Low efficiency	No beating	—	—
PWM	Sine-wave pulse width modulation	Synchronized	Constant carrier system	High response	High efficiency	No beating	—	Large noise and vibration	—	—	High torque ripples at low speed	VS-616 G series
PWM	Sine-wave pulse width modulation	Synchronized	Variable carrier system	High response	High efficiency	No beating	Low torque ripples at low speed	Large noise and vibration	—	—	High cost	VS-616 H series

1.5 INVERTER CONTROL MODES

As mentioned in Paragraph 1.3, the inverter must control the output voltage in proportion to the frequency to control motor speeds by frequency control. Generally, two output voltage regulating modes are in use; the Pulse Amplitude Modulation (PAM) mode, and the Pulse Width Modulation (PWM) mode.

With the PAM mode, the converter section controls the DC voltage, and the inverter section changes frequency. With this mode, the motor runs quietly and with less vibration, but response is slower and the power factor is lower than with the PWM mode.

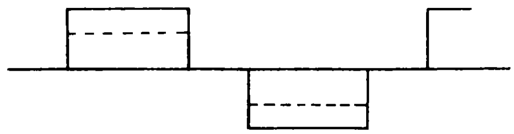
With the PWM mode, the constant DC voltage obtained in the converter section is regulated in frequency in the inverter section, and at the same time, chopped into high frequency pulses to obtain desired mean voltages. With this mode, the motor runs with more noise and vibration, but response is faster. The PWM mode is further subdivided into various modes, and commercially available circuits include the equal pulse width mode, sine wave pulse width mode, synchronous mode, asynchronous mode, constant carrier mode, and the variable carrier mode. The general advantages and disadvantages of these modes are given in Table 1.2.

With the PAM mode, the voltage amplitude is changed as shown in Fig. 1.7 (a). With the uniform pulse width PWM mode, constant DC voltage is chopped by a carrier of constant pulse width, and the number of pulses are changed to obtain the effect of changed output voltage.

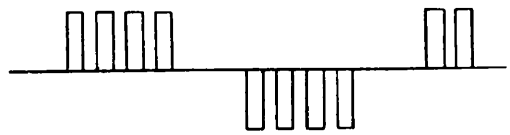
With the sine wave pulse width PWM mode, the carrier pulse width is changed in approximation to a sinusoidal waveform to obtain the effect to changing output voltage.

In the synchronous mode, the carrier and the output voltage frequencies are synchronized. The constant carrier mode contains a constant number of carrier waves in one output cycle, and the variable carrier mode automatically adjusts the number of carrier waves in one output cycle according to the output frequency.

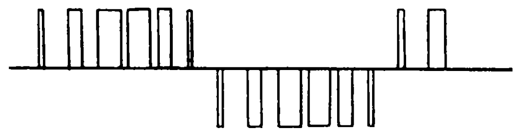
The VS-616G Series uses the sine wave pulse width PWM, constant carrier mode, and the VS-616G Series uses the most sophisticated sine wave pulse width, variable carrier PWM mode.



(a) PAM



(b) Square Wave PWM



(c) Sine Wave PWM

Fig. 1.7 Variable Method of Output Voltage

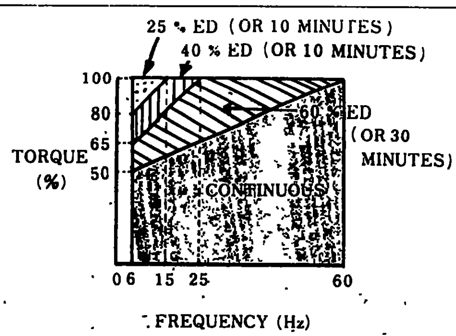
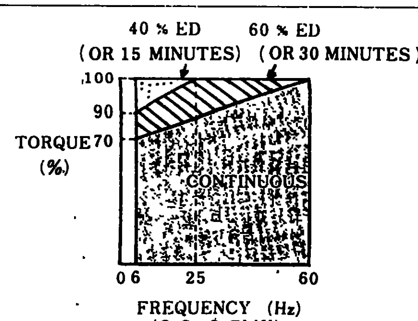
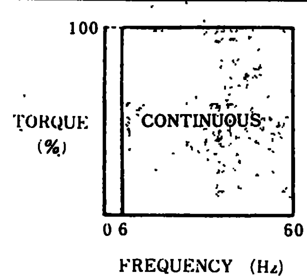
1.6 DIFFERENCE BETWEEN G SERIES AND H SERIES

The VS-616G Series transistor inverters are intended for comparatively simple speed control applications or for comparatively narrow speed control ranges such as for fan drive motors, with emphasis placed on economy, and are available in 3kVA and 5kVA models.

The VS-616H Series inverters are for more sophisticated controls, covering wider speed ranges, and giving higher motor efficiencies. This series allow diverse control types to be configured with the use of selected optional units. The rated speeds are in 6 steps between 60 to 360Hz selectively switched. The 200V series is in 7 output models between 3 and 60kVA, and the 400V series is in 9 output models between 5 and 200kVA.

Table 1.3 summarizes the difference between the G Series and the H Series.

Table 1.3 Comparison of VS-616G Series with H Series

VS-616 Series	G Series	H Series
Rated Output Frequency	60Hz	60, 72, 90, 120, 180, 360Hz tap-change
Rated Output Capacity	3kVA, 5kVA	200V: 3, 5, 10, 20, 30, 45, 60kVA 400V: 5, 10, 20, 40, 60, 75, 110, 140, 200kVA
Frequency Control Range	10 : 1	20 : 10
Command Voltage	10V/100%	10V/100% and 6V/100% tap-change
Auxiliary Command Input Voltage	—	Provided
Frequency Meter Terminal	Provided	Provided
Frequency Monitor	Impossible	Possible
External Base Block	Impossible	Possible
Options	—	Provided
System Module	Applicable*	Applicable
Standard Motor		 (2.2, 3.7kW)
Definite Purpose Motor	—	

* For application of VS system module to G Series, contact the Yaskawa representative office.

2. VS-616H OUTPUTS AND ENCLOSURES

2.1 ENCLOSURES

Table 2.1 Enclosures of 200V and 400V Series

Enclosure		Built-in Type	Enclosed Type			Gasketed Type				
Mounting		Panel-Mounted Type	Wall-Mounted Type		Free-Standing Type	Wall-Mounted Type				Free-Standing Type
Specifications of VS-616H		Inverter Unit Type CIMR-	Inverter Unit Type CIMR-	Inverter Unit+VS Operator* Type CIMR-	Inverter Unit Type CIMR-	Inverter Unit Type CIMR-	Inverter Unit+VS Operator* Type CIMR-	Inverter Unit† Magnetic Contactor Type CIMR-	Inverter Unit+VS Operator* Magnetic Contactor Type CIMR-	Inverter Unit Type CIMR-
200V Range	Braking Function									
2.2kW (3Hp)	—	2.2H	2.2H-11	—	—	†	—	2.2H-23	2.2H-24	—
	Yes	2.2H1	2.2H1-11	—	—	†	—	2.2H1-23	2.2H1-24	—
3.7kW (5Hp)	—	3.7H	3.7H-11	—	—	†	—	3.7H-23	3.7H-24	—
	Yes	3.7H1	3.7H1-11	—	—	†	—	3.7H1-23	3.7H1-24	—
7.5kW (10Hp)	—	7.5H	—	—	—	7.5H-21	—	7.5H-23	7.5H-24	—
	Yes	7.5H1	—	—	—	7.5H1-21	—	7.5H1-23	7.5H1-24	—
15kW (20Hp)	—	15H	—	—	—	15H-21	—	15H-23	15H-24	—
	Yes	15H1	—	—	—	15H1-21	—	15H1-23	15H1-24	—
22kW (30Hp)	—	22H	—	—	—	22H-21	—	22H-23	22H-24	—
	Yes	22H1	—	—	—	22H1-21	—	22H1-23	22H1-24	—
30kW (40Hp)	—	30H	—	—	30H-31	—	—	—	—	30H-41
45kW (60Hp)	—	45H	—	—	45H-31	—	—	—	—	45H-41
55kW (73Hp)	—	—	—	—	55H-31	—	—	—	—	55H-41
75kW (100Hp)	—	—	—	—	75H-31	—	—	—	—	75H-41
400V Range										
3.7kW (5Hp)		H3.7H	H3.7H-11	H3.7H-12	—	H3.7H-21	H3.7H-22	—	—	—
7.5kW (10Hp)		H7.5H	H7.5H-11	H7.5H-12	—	H7.5H-21	H7.5H-22	—	—	—
15kW (20Hp)		H15H	H15H-11	H15H-12	—	H15H-21	H15H-22	—	—	—
30kW (40Hp)		H30H	H30H-11	H30H-12	—	H30H-21	H30H-22	—	—	—
45kW (60Hp)		H45H	H45H-11	H45H-12	—	H45H-21	H45H-22	—	—	—
55kW (73Hp)		H55H	—	—	H55H-31	—	—	—	—	H55H-41
75kW (100Hp)		H75H	—	—	H75H-31	—	—	—	—	H75H-41
110kW (150Hp)		—	—	—	H110H-31	—	—	—	—	H110H-41
160kW (210Hp)		—	—	—	H160H-31	—	—	—	—	H160H-41

* Provided with 60Hz frequency meter as standard. † Available on order.

2.2 TYPE DESIGNATION

C I M R - □□ H □□□

- Inverter
- Voltage
  - Blank 200V range
  - H. 400V range
- Applicable maximum motor output
- High-precision
- Braking function
  - Blank. Without braking function
  - 1: With braking function
- Enclosure
  - Blank Built-in type
  - 1. Enclosed type (Wall-mounted)
  - 2 Gasketed type (Wall-mounted)
  - 3 Enclosed type (Free-standing)
  - 4 Gasketed type (Free-standing)
- Components
  - 1: Inverter unit
  - 2: Inverter unit with VS operator
  - 3: Inverter unit with magnetic contactor
  - 4: Inverter unit with VS operator and magnetic contactor

2.3 DESCRIPTION OF ENCLOSURE

(1) Built-in type

The unit is for installation in the control panel housing. Inadvertent touching of the live parts by the human body is prevented. The installation location in the control panel housing is freely selectable.

(2) Enclosed type (NEMA-1)

The enclosed type enclosure has walls on all the four sides and the top, and is free from openings that admit rods 12.5mm in diameter. This type of enclosure is for indoor use.

(3) Gasketed type (NEMA-1 Gasketed)

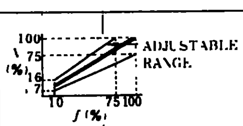
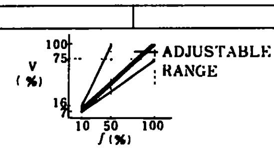
This type of enclosure has walls on all the four sides, and the top, and is free from openings that admit wires 1mm in diameter.
This type of enclosure is for indoor use where the environment is somewhat inferior.

2.4 STANDARD SPECIFICATIONS

2.5 DIMENSIONS

The outline views and the dimensions of the VS-616 Series units are given in APPENDIX Fig. 7 through 42 on page

Table 2.2 VS-616H Ratings and Specifications

Volt Class		VS-616G		200V Class (230V Class)											400V Class (460V Class)								
Type CIMR-		2.2G-	3.7G-	2.2H-	3.7H-	7.5H-	15H-	22H-	30H-	45H-	55H-	75H-	H3.7H-	H7.5H-	H15H-	H30H-	H45H-	H55H-	H75H-	H110H-	H160H-
Output Characteristics	Max Motor Output* kW(Hp)	2.2 (3)	3.7 (5)	2.2 (3)	3.7 (5)	7.5 (10)	15 (20)	22 (30)	30 (40)	45 (60)	55 (75)	75 (100)	3.7 (5)	7.5 (10)	15 (20)	30 (40)	45 (60)	55 (75)	75 (100)	110 (150)	160 (210)
	Inverter Capacity kVA	3	5	3	5	10	20	30	40	60	70	100	5	10	20	40	60	75	110	140	200
	Rated Output Current A	9	15	9	15	30	60	90†	120	180	210	300	9	15	30	60	90	110	160	210	300
	Rated Output Voltage	3-Phase, 200/220V (208/230V)													3-Phase, 400/440V (440/460V)								
	Rated Output Frequency	60Hz		60, 72, 90, 120, 180, 360Hz tap-change																			
Power Supply	Voltage and Frequency	3 Phase, 200V at 50/60Hz, 220V at 60Hz (208V at 50/60Hz, 230V at 60Hz)													3-Phase, 400V at 50/60Hz, 440V at 60Hz (415V at 50/60Hz, 460V at 60Hz)								
	Allowable Voltage Fluctuation	200V 180 to 220V 220V, 198 to 242V (208V 187 to 229V, 230V 207 to 253V)													400V 360 to 440V 440V 396 to 448V (416V 374 to 458V 460V 414 to 506V)								
	Allowable Frequency Fluctuation	±5%																					
Control Characteristics	Control Method	Sine wave PWM		Sine wave PWM (Carrier change)																			
	Frequency Control Range	10 : 1		20 : 1																			
	Frequency Accuracy	±0.5% (25°C±10°C)																					
	Braking Torque	Approx 20% (Without braking function)	Approx 20% (With braking function, 170%)	Approx 20% (With braking function 70%)																			
	Overload Capacity	150% for one minute																					
	Frequency Setting Signal	0 to +10V (Input resistance 15kΩ)		0 to +10V or 0 to +6V (Input resistance 15kΩ)																			
	Accel/Decel Time	3-30sec (Accel/decel time set independently)		0.3-30sec (or 3-30sec) tap change (Accel time and decel time set independently)																			
	Efficiency	Approx 95%													Approx 97% or above								
	V/f Adjustable Range																						
Protective Functions	Instantaneous Overcurrent	Protected by electronic circuit																					
	Overload	—		Protected by electronic circuit (Gate blocked at 150% load for 1 minute)																			
	Overvoltage	Gate blocked if converter output voltage exceeds 395V													Gate blocked if converter output voltage exceeds 770V								
	Undervoltage	Gate blocked if supply voltage drops to 83% or below																					
	Power Failure	Continues system operation during power failure less than 20ms‡																					
	Fin Overheat	—							Thermostat														
	Stall Prevention	Stall prevention at acceleration																					
	Fuse Blown	Fuse blown, if power transistor is damaged, prevents irreparable damage.																					
	Power Charge Indication								Charge lamp keeps ON until converter output voltage drops to 50V or below.														
Environmental Condition	Location	Indoor (protected from corrosive gases and dust)																					
	Ambient Temperature and Humidity	−10°C−40°C (no frozen), 90% RH (no condensation)																					
	Vibration	10−55Hz, full amplitude 0.3mm, for 24 hours																					

* For actual application, motor current should be checked
† 80A for totally-enclosed type
† For 20ms or more of operation time, contact the company

3. DESCRIPTION OF OPERATION

3.1 OPERATION OF SECTIONS

Fig. 3.1 and Fig. 3.2 show the operation principle of the G Series and the H Series respectively.

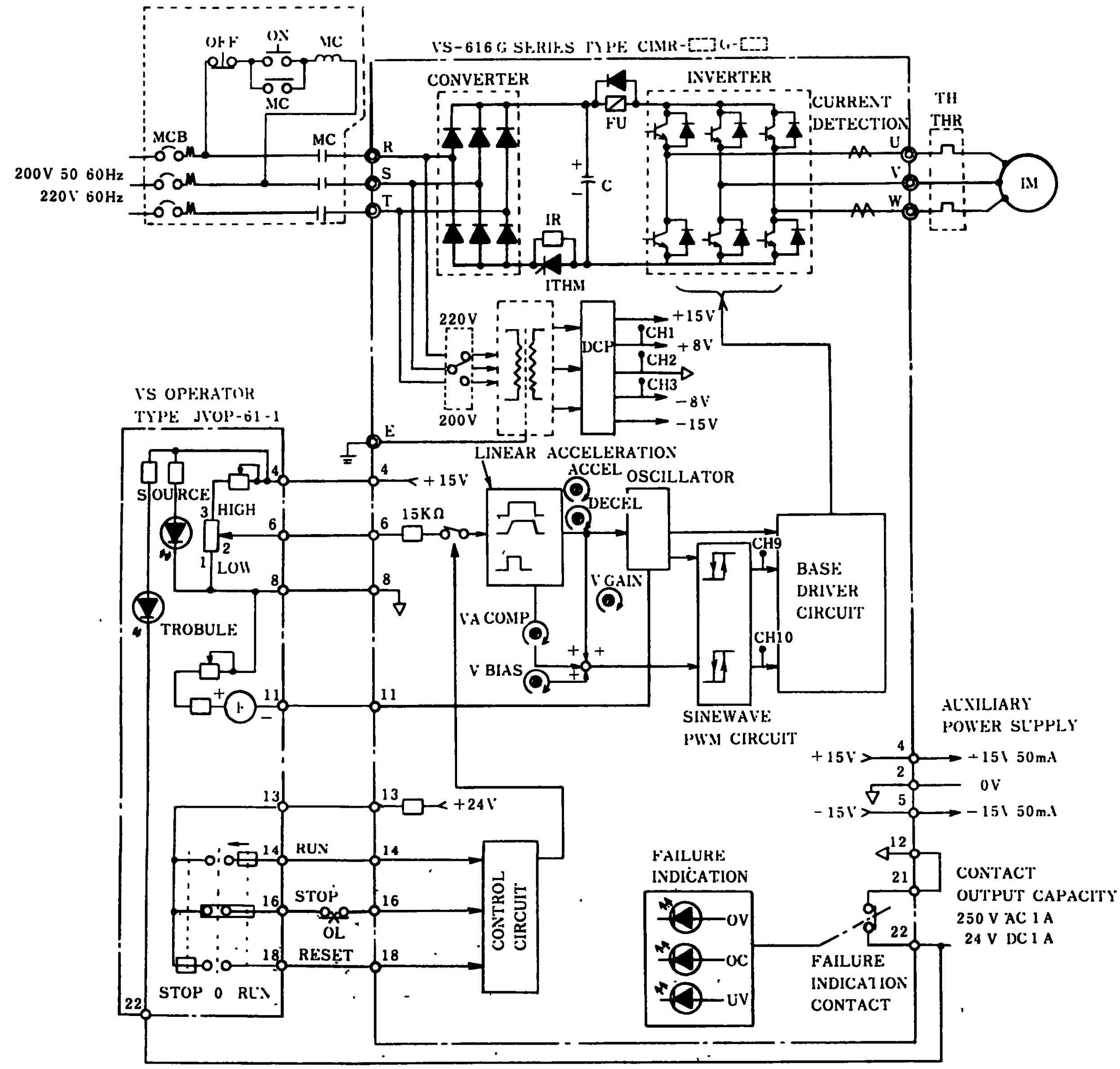


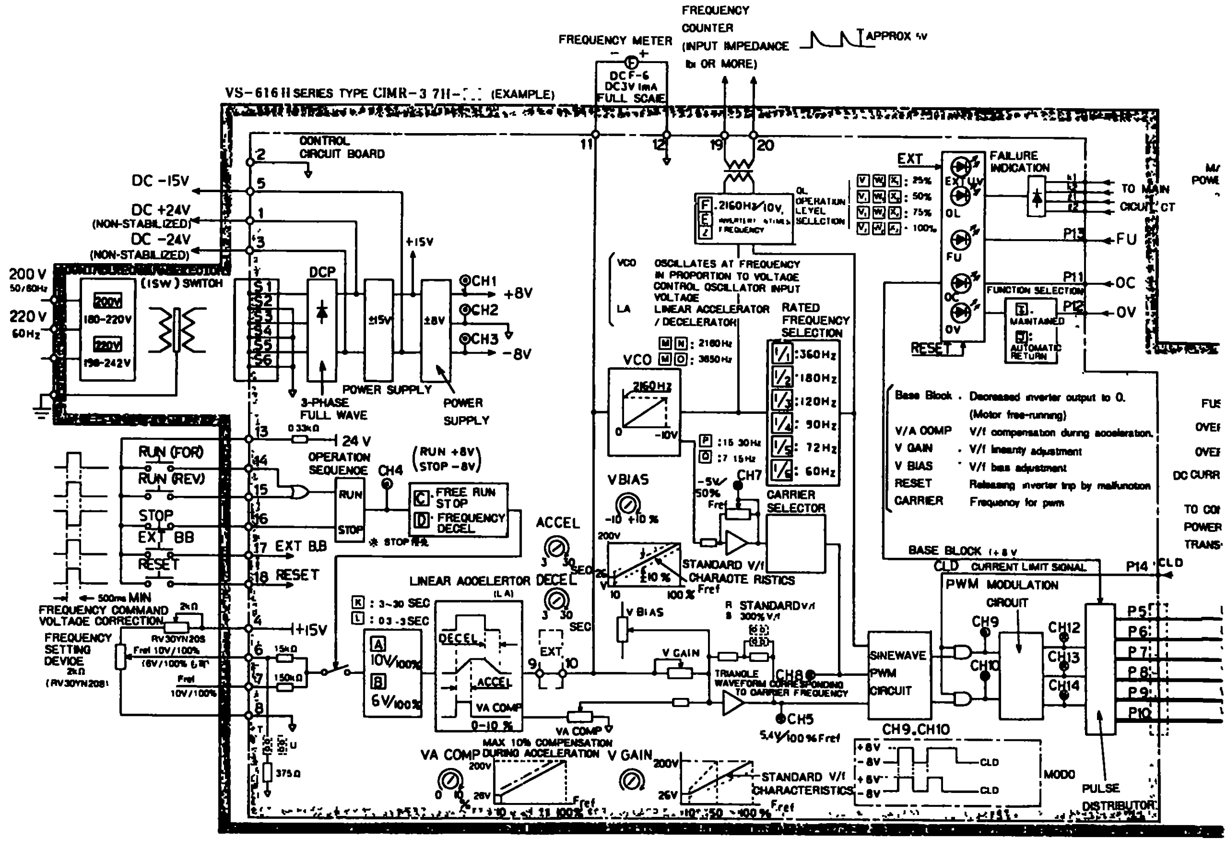
Fig. 3.1 Operational Block Diagram of VS-616G Series

3.1.1 Converter Section

The AC power input to the AC power supply terminals R, S, and T is rectified and the DC voltage is applied to capacitor C. To restrict the rush of charging current flow to the capacitor immediately after switching on, thyristor 1 THM is kept off while the DC voltage is low, lefting the charging current flow through resistor 1R. Thyristor 1 THM is turned on when the DC voltage rises to a preset level.

3.1.2 Inverter Section

The DC voltage smoothened by capacitor C is applied to the inverter section via fuse FU. In the inverter section, the power transistors are turned on and off by sine wave PWM mode base drive signals to output power at regulated frequencies and regulated voltages to the output terminals U, V, and W. Diodes are connected parallel to the power transistors to allow the return current from the motor to flow.



VS-616H Components for 200V,3-30kVA

kVA	Ⓐ Diode Module
3	D10VD60
5	D10VD60
10	S5522 50A 800V
20	RM60DZ-H 60A 800V
30	RM60DZ-H 60A 800V

kVA	Ⓑ Main Circuit
3	400WV 2200μF
5	400WV 1500μF×2
10	WV 2200μF×3
20	400WV 2200μF×6
30	400WV 2200μF×8

kVA	Ⓒ Fuse
3	60FHS-20
5	60FHS-35
10	60FHS-55
20	60FHS-110
30	60FHS-150

kVA	Ⓓ Braking Transistor
3	S2864 30A
5	S2864 30A
10	MG50G1BL1
20	MG100G1AL1
30	MG100G1AL1

Fig. 3.2 Operation of VS-616H(200V,5kVA)

3.1.3 Frequency Setting Circuit

In this circuit, frequency setting signals (0 - 10V) are produced from the DC regulated power supply at +15V at terminal (4) through voltage division by variable resistors 1RH and 2RH (2kΩ, 1W), and the output signals (0 - 10V) are output from terminal (6).

In the YASKAWA standard operators, this circuit is incorporated as a standard element.

3.1.4 Run and Stop Circuit

RUN signals connect the 24VDC power supply output from terminal (13) to terminals (14) and (16) simultaneously. The RUN signals are held on by the logic circuit in the inverter when they continue over 500 ms.

STOP signals disconnect voltage from terminal (16). RESET signals apply +24V signals to terminal (18) to stop the inverter operation, and at the same time, reset fault displays.

This operation sequence circuit is incorporated in YASKAWA standard operators.

3.1.5 Regulated Power Supply

The stable voltage power required by the control circuit is generated by the DCP at ±15V and ±8V. To secure correct operation of this circuit, the selector switch between 220 and 200V AC input power must be correctly set.

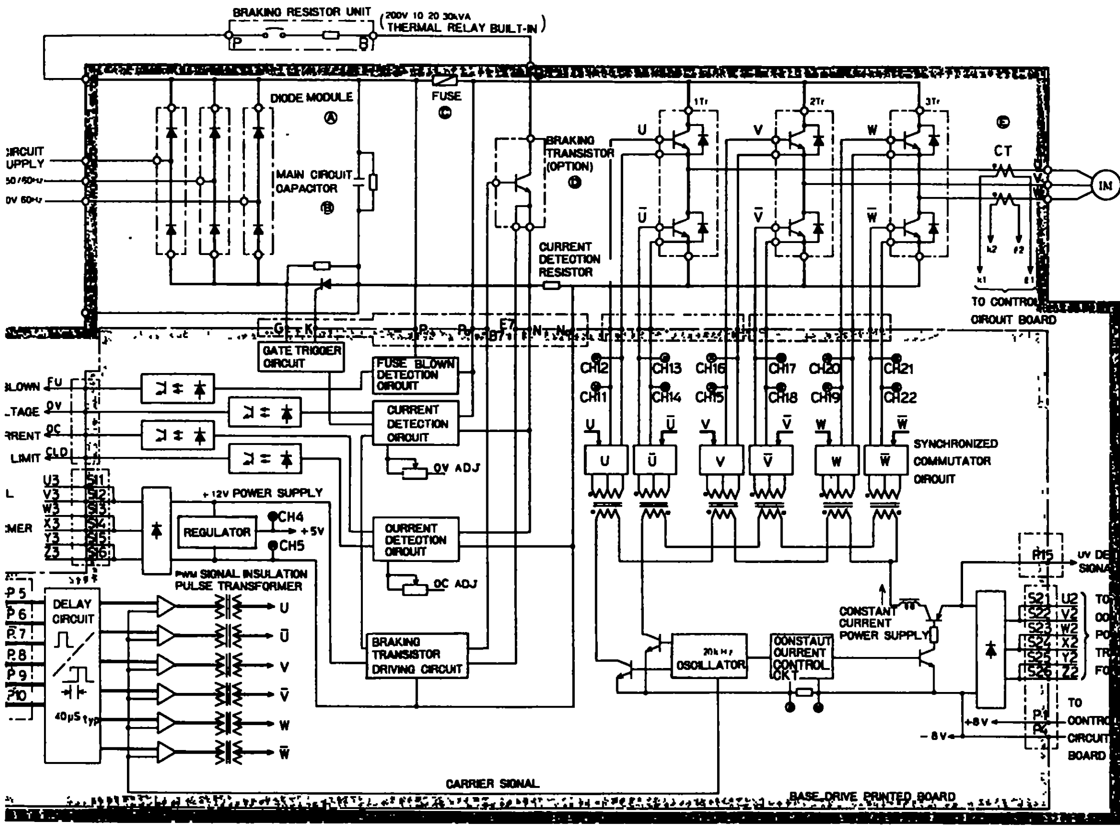
3.1.6 Linear Accelerator

The signals applied to terminal (6) are applied to the linear accelerator. The acceleration time ACCEL and the deceleration time DECEL can be adjusted independently between 3 and 30 seconds. (Adjustable range 0.3 to 3 seconds also available.)

3.1.7 V/f Setting Circuit

In this circuit, the output of the linear accelerator is adjusted for V/f inclination by V GAIN, and the low frequency output voltage is biased by V BIAS.

VA COMP biases the output voltage to only while the linear accelerator gives acceleration commands.



kVA	Ⓔ Current Transformer
3	9A/0.05A
5	15A/0.05A
10	30A/0.05A
20	60A/0.05A
30	90A/0.05A

Inverter Capacity	Braking Resistor Unit	Thermal Relay	Transistor Module
3kVA	LKEB-1.2K(1200W) 32Ω	RH-18/10P 9A	MG30G2CL1 30A
5kVA	LKEB-1.8K(1800W) 24Ω	RH-18/15P 15A	MG50G2CL1 50A
10kVA	LKEB-2.4K(2400W) 32Ω	RH-18/4P 4A	MG100G1AL1 100A 450V
20kVA	LKEB-4.8K(4800W) 16Ω	RH-35/10E 10A	MG200H1AL1 200A 450V
30kVA	LKEB- 9 K(9000W) 6.7Ω	RH-35/20E 20A	QM300HA-H 300A 450V

3.1.8 Oscillator

The oscillator produces saw tooth waves with frequencies proportional to the frequency command voltage output from the linear accelerator.

3.1.9 Sine Wave PWM Circuit

This circuit compares the saw tooth wave and the voltage command to modulate the pulse width to simulate sine waves, and applies the signals to the base drive circuit.

3.1.10 Base Drive Circuit

The sine wave PWM signals are insulated by the transformer, and are applied to the base of the power transistors in the inverter section.

3.1.11 Protection Circuit and Fault Display Lamp

This circuit monitors the current and the voltage in the main circuit, and protects against overcurrent and regenerative overvoltage. With the H Series units, also protection against overloading is provided.

To prevent an eventual transistor failure from adversely influencing other circuit members, a fuse is incorporated in the circuit. When these protective elements trip, respective LED fault lamps light. Table 3.1 shows the protective functions operations and their indicator lamps.

Table 3.1 Protective Functions

Protection	Function	Indicator	Remarks
Overcurrent	Stops inverter at overcurrent. Maintained.	OC	Failure detection output across terms ㉑ and ㉒.
Overvoltage	Stops inverter at overvoltage. Spring-return or maintained.	OV	
Overload	Stops inverter at overvoltage. Spring-return for Type G Spring-return or maintained for Type H.	OL	
Fuse Blownout	Blows out fuse if main circuit power transistor should be broken.	FU	
Under Voltage/Overheat*	Stops inverter at low voltage or cooling fin overheated.	UV/OH	

* For 200V, 3–30kVA, under voltage (UV) protective function only. For 400V, 10–110kVA, both under voltage(UV) and overheat(OH) protective functions provided.
Note: When protective functions operate, reset is made by applying 24V to terminal 18.

3.2 DESCRIPTION OF TERMINALS

3.2.1 Main Circuit Terminals

Table 3.2 Main Circuit Terminal Function and Signal Level

Terminal Symbol G Series	Terminal Symbol H Series	Function	Signal Level 200V Series	Signal Level 400V Series
R	R	Main circuit power input	3-phase, 200V, 50/60Hz 220V, 60Hz	3-phase, 400V (415V), 50/60Hz 440V (460V), 60Hz
S	S			
T	T			
—	r	Control circuit power input	3-phase, 200V, 50/60Hz 220V, 60Hz	3-phase, 440V (415V), 50/60Hz 440V (460V), 60Hz
	s			
	t			
—	r1, s1	External power supply	—	Single-phase, 220V, 50/60Hz (Two VS system modules connectible)
V	V	Inverter output	3-phase, 200/220V	3-phase, 400/440V
W	W			
—	P	Main circuit current power supply	300VDC	600VDC
	N		0V	0V
	B	Braking resistor unit	0 or 300VDC	—
E	E	Grounding	Grounding	Grounding

3.2.2 Control Circuit

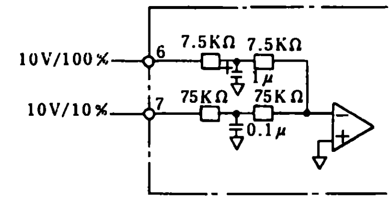
Table 3.3 Control Circuit Terminal Function and Signal Level

Terminal No. G Series	Terminal No. H Series	Function	Signal Level
—	1	Control power (Non-stabilized)	+24 to +26VDC 200mA
2	2	Control power 0V	0V
—	3	Control power (Non-stabilized)	−24 to −26VDC 200mA
4	4	Control power output	+15VDC, 50mA (30mA)
5	5		−15VDC, 50mA (30mA)
6	6	Frequency input	10V/100% (15kΩ) 10V/10% (150kΩ)
—	7	Frequency auxiliary command	
8	8	Control signal 0V	0V
—	9	Linear accelerator output	−10V/100%, 2mA
—	10	Frequency command (without soft starter)	−10V/100% (15kΩ)
11	11	Frequency meter	Approx −10VDC/100%, 2mA
12	12	Control signal 0V	0V
13	13	Control power supply	Approx 24VDC, 20mA
14	14	Operation (Forward)	Operates at closed (Forward)
—	15	Operation (Reverse)	Operates at open (Reverse)
16	16	Stop command	Stop at open
—	17	External base block	Base blocked at close
18	18	External reset	Reset at closed
—	19	Frequency monitor output	Frequency counter (+)
	20		Frequency counter (−)
21	21	Failure detection contact output (1a)	250VAC, 1A
22	22		24VDC, 1A

Note for Table 3.3

(1) 30 mA for 200V Series 40, 60 kVA and 400V Series

(2) The input resistance for frequency command is 15 kΩ at terminal (6), and 150 kΩ at terminal (7) (Fig. 3.3).



- Be sure to apply plus signals to terminal (6).
- Either plus and minus signals can be applied to terminal (7). (Terminal (7) is found only in H Series units.)

  Fig. 3.3 Description of Terminals (6) and (7)

Fig. 3.3 Terminals 6 and 7

(3) Standard connection for operation

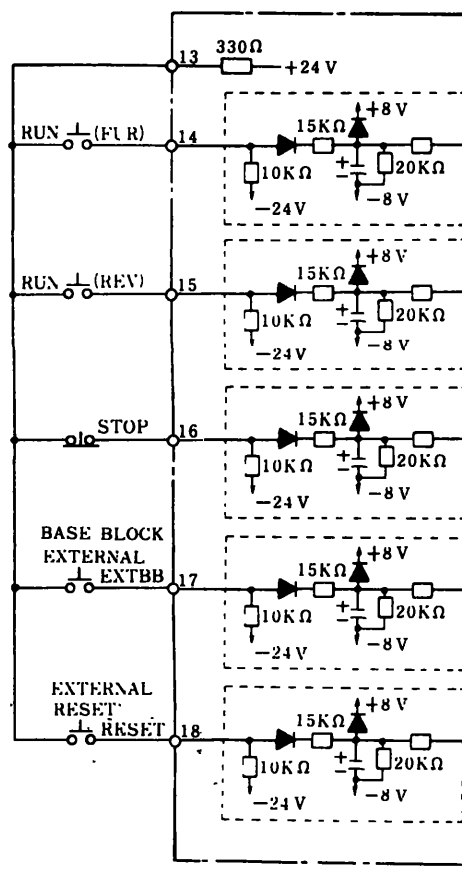


Fig. 3.4 Standard Connection for Operation

3.2 DESCRIPTION OF TERMINALS (Cont'd)

When operation signals to terminals (14), (15) or (16) continue more than 500 ms, the inverter holds them.
Base blocking remains operational only while signals are applied to terminal (17). When a signal is applied to (18), base blocking and resetting are effected simultaneously to clear the signals to make operation possible.

(4) The insulated differential waveforem is as shown below.

(5) "CLOSED" means shorting to terminal (13), and "OPEN" means free state.

4. APPLICATION OF PERIPHERAL UNITS

4.1 MOLDED-CASE CIRCUIT BREAKER

Use the molded case circuit breakers (MCB) listed in Table 4.1, or their equivalent products.

Table 4.1 Molded-Case Circuit Breakers

Inverter Capacity kVA		Type*	Specifications	Code
200V Series	400V Series			
3	5	NF 30-SB	3P, 15A Interrupting at 5kA	MCB 074900
5	10	NF 30-SB	3P, 30A Interrupting at 5kA	MCB 075000
10	20	NF 50-CB	3P, 50A Interrupting at 5kA	MCB 076100
20	40	NF 100-CB	3P, 100A Interrupting at 10kA	MCB 078100
30	60	NF 225-CB	3P, 150A Interrupting at 16kA	MCB 080200
40	75	NF 225-CB	3P, 225A Interrupting at 16kA	MCB 080400
60	110	NF 400-CA	3P, 300A Interrupting at 35kA	MCB 080800
70	140	NF 400-CA	3P, 400A Interrupting at 35kA	MCB 080900
100	200	NF 600-CA	3P, 600A Interrupting at 35kA	MCB 081200

* IEC Standard, not UL approved.

4.2 MAGNETIC CONNECTOR ON POWER SUPPLY CIRCUIT

Unless there is a special requirement, magnetic contactors need not be connected on the power supply circuit. If they are required, use the products listed in Table 4.2, or equivalent.

Table 4.2 Power Supply Magnetic Contactors

Series	Inverter Capacity kVA	Type*	Specifications	Code
200V	3	HI-10-2E/21A2	10A, 200V	MC 002729
	5	HI-20E/22A2	20A, 200V	MC 002733
	10	HI-30E/22A2	35A, 200V	MC 002745
	20	HI-50E/22W2	65A, 200V	MC 002757
	30	HI-80E2/22W2	93A, 200V	MC 002763
	40	HI-100E2/22W2	125A, 200V	MC 002765
	60	HI-200E2/22W2	220A, 200V	MC 002769
	70	HI-300E	360A, 200V	—
	100	HI-500E	600A, 200V	—
400V	5, 10	HI-20E/22A400	20A, 400V	MC 002734
	20	HI-30E/22A400	35A, 400V	MC 002746
	40	HI-50E/22W400	65A, 400V	MC 002758
	60	HI-80E2	93A, 400V	—
	75	HI-100E2	125A, 400V	—
	110	HI-200E2	220A, 400V	—
	140	HI-300E	360A, 400V	—
	200	HI-500E	600A, 400V	—

* IEC Standard, not UL approved.

4.3 INDIVIDUAL PARTS

Use parts listed in Table 4.3.

4.3.1 Frequency Setter

The standard YASKAWA Operator incorporates a frequency setter. When extra setters are to be used, use two variable resistors listed in Table 4.3, and adjust the frequency command range to 0 - 10V.

4.3.2 Frequency Meter

The standard YASKAWA Operator incorporates a frequency meter. When an extra frequency meter is to be usd, a DC voltmeter and a meter adjusting variable resistor listed in Table 4.3 must be connected.

4.3.3 Operation Command Circuit

When operation command circuits are to be assembled with relays, relays with minute signal level contacts or twin contacts must be used.

Table 4.3 Individual Parts

Individual Part	Type	Specifications	Manufacturer	Code No.
Frequency Setting	RV30YN20S	1W 2kΩ	Tokyo Cosmos	RH 000649
Frequency Setting Potentiometer	CM-3S	—	Sato Parts	—
Power ON/OFF Switch	AC134Y	Spring-Return Type	Izumi Electric	CS 000178
Frequency Meter	DCF-6A DC3V, 1mA	75Hz Full Scale	Toyo Meter	FM 000030
		100Hz Full Scale		FM 000056
		110Hz Full Scale		FM 000031
		150Hz Full Scale		FM 000032

4.4 THERMAL RELAY

The VS-616G Series units are not provided with overload protection. To protect the motor, connect a thermal relay between the secondary terminals U, V and W of the inverter and the motor, and connect the NC contact to the STOP signal circuit.

The VS-616H Series units incorporate an overload protection circuit, and therefore, no thermal relay is required to be connected. However, when several motors are driven by one inverter, or motors of different outputs are driven, connect a thermal relay between the inverter and the motors.

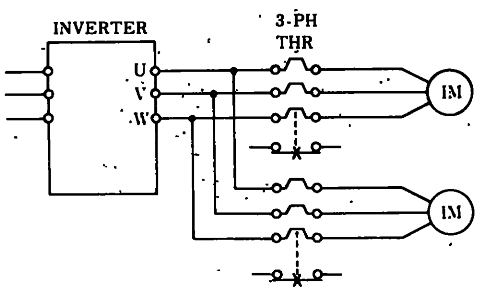


Fig. 4.1 Connections of Thermal Relay

4.5 NOISE PREVENTION

Use shielded leads for the control signal line and the frequency command signal line, and connect the shield to terminals (2), (8) or (12) to the 0V line (Fig. 4.2).

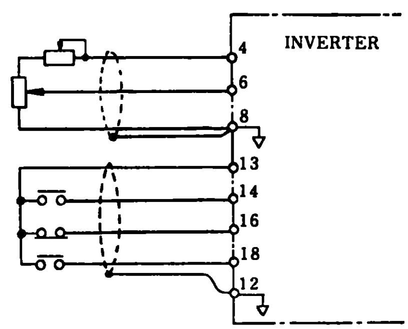


Fig. 4.2 Noise Prevention

4.6 SURGE ABSORBER

For the surge absorbers to be connected to the magnetic contactors or the control relay coils, select products out of the ones listed in Table 4.4.

Table 4.4 Surge Absorbers

Magnetic Contactor and Control Relay		Surge Absorber* Type	Specifications	Code No.
200V Class	HI-10, -20, -26, -35, -50, -65, -80, -125 RA-6E2 RL-33E	DCR2-50A22E	250VAC 0.5μF+200Ω	C002417
	Control Relay LY-2, -3(OMRON) HH-22, -23(Fuji) MM-2, -4(OMRON)	DCR2-10A25C	250VAC 0.1μF+100Ω	C002482
400V Class	400V Circuit	DCR2-50D100B	1000VAC(500VAC) 0.5μF+220Ω	C002630

* Made by MARCON Electronics.

Note: For magnetic contactors and control relays other than listed above, use the surge absorber Type DCR2-50A22 for 200V class, and Type DCR2-50-D100B for 400V class.

4.7 CAPACITY OF TRANSFORMER

When VS-616G or VS-616H transistor inverters are used with power supplies in voltages other than 200 or 400V, select a transformer with a capacity conforming to Paragraph 6.13.

4.8 SELECTION OF AC REACTOR

(1) Once AC reactor for one motor

For motor noise reduction, development of starting torque characteristics, and employment of motors in output exceeding maximum rated values, connections of AC reactor to inverter output is recommended for effective drive operation. Select a reactor giving 3 - 4% voltage drop for the rated current, at the rated voltage.

[Example] Using a 200V motor

$$L = \frac{\frac{200}{\sqrt{3}} \times 0.04}{2\pi f \cdot I} \text{ (H)}$$

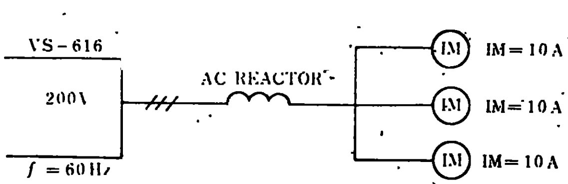
(2) Using two or more motors (equal capacity) for one AC reactor

Connect a reactor with a reactance equal to the reactances for one each motor, and a current equal to the sum of all the motors.

[Example] In this case, the inductance for one motor is:

$$L = \frac{\frac{200}{\sqrt{3}} \times 0.04}{2\pi fo \times 60 \times 10} = 1.2 \text{ (mH)}$$

The rated reactance L = 1.2 mH (for one motor). The current I = 10A × 3 = 30A.
When the number of motors increases, the voltage drop increases. Therefore, attention must be given to the relationship between the output voltage and the rated motor voltage. Decreasing the rated motor voltage, or using one AC reactor for one motor, or other measures may have to be taken.



(3) When two or more motors with different capacities are used with one AC reactor:

The same concept as for (2) applies. However, when calculating the inductance for one motor, the maximum motor capacity is used. The total current is taken as the rated current. Table 4.5 gives the AC reactor (for 60Hz standard Series) on the output side of VS-616 units.

Table 4.5 Output AC Reactors

Rated Voltage V	Inverter Capacity kVA	Motor Output kW(Hp)	AC Reactor: Current A	AC Reactor: Inductance mH	AC Reactor: Code
200	3	0.4(0.5)	2.5	4.2	—
		0.75(1)	5	2.1	—
		1.5(2)	10	1.1	X002489
		2.2(3)	15	0.71	X002490
	5	3.7(5)	20	0.53	X002491
	10	5.5(7.5)	30	0.35	X002492
		7.5(10)	40	0.265	X002493
	20	11(15)	60	0.18	X002495
		15(20)	80	0.13	X002497
	30	18.5(25)	90	0.12	X002498
		22(30)	120	0.09	—
	40	30(40)	160	0.07	—
	60	37(50)	200	0.05	—
		45(60)	240	0.044	—
	70	55(75)	280	0.038	—
	100	75(100)	360	0.026	—
400	5, 10	5.5(7.5)	15	1.42	X002501
		7.5(10)	20	1.06	X002502
	20	11(11)	30	0.7	X002503
		15(20)	40	0.53	X002504
	40	18.5(25)	50	0.42	X002505
		22(30)	60	0.36	X002506
		30(40)	80	0.26	X002508
	60	37(50)	90	0.24	X002509
		45(60)	120	0.18	—
	75	55(75)	150	0.15	—
	110	75(100)	200	0.11	—
	140	110(150)	250	0.09	—
	200	160(210)	360	0.06	—

5. SELECTION OF INVERTER CAPACITY

Matters to be examined in selecting the capacity of a VS-616G or VS-616H inverter for driving a standard motor are described here.

5.1 INVERTER CAPACITY FOR CONTINUOUS OPERATION

The satisfactory inverter capacity is expressed by the following formula.

$$P_{C1} = \frac{1.05 P_M \cdot n_T}{\eta \times \cos\phi} \leqq \text{inverter capacity (kvA)} \cdots\cdots\cdots\cdots (6.1)$$

$$P_{C2} = 1.05\sqrt{3}\ V_M \cdot I_M \cdot n_T \times 10^{-3} \leqq \text{inverter capacity (kV)} \ldots (6.2)$$

$$1.05\ n_T \cdot I_M \leqq \text{inverter rated current (A)} \ldots (6.3)$$

where P_M = Motor shaft output (kW) required by load

nr = Total number of parallel motors

η = Motor efficiency

$\cos\phi$ = Motor power factor

V_M = Motor voltage (V)

I_M = Motor current (A) Note: Value under commercial power

1.05 = Correction factor for waveform factor

5.2 INVERTER CAPACITY REQUIRED FOR STARTING

5.2.1 Case of Frequency Acceleration

The overload capacity of the VS-616G and VS-616H inverters is 150% of the rated current for one minute. To utilize the overload capacity to the full, the exact load torque, motor torque, and GD^2 value must be known. Generally, the inverter capacity must be selected so that the load can be accelerated within the inverter capacity for continuous operation. The inverter capacity must satisfy the following equation.

$$Ps = \frac{1.05 N n_T}{973 \cdot \eta \cdot \cos\phi} \cdot \left(T_L + \frac{GD^2}{375} \cdot \frac{N}{tA}\right)$$

$$\leqq \text{inverter capacity (kVA)} . (6.4)$$

where N = Rated speed (rpm)

GD^2 = Total GD^2 at motor shaft ($kg \cdot m^2$)

nr = Total number of parallel motors

T_L = Load torque

η = Motor efficiency (normally 0.85)

$\cos\phi$ = Motor power factor (normally, 0.75)

t_A = Acceleration time (sec)...(time required by load)

5.2.2 Case of Semi Fixed-Frequency Control

Where motors in a group drive system are started sequentially one or two at a time, the inverter capacity (kVA) and the inverter current must be examined.

$$P_S = \frac{1.05 P_M}{\eta \cos\phi}(n_T + n_s(K_s - 1)$$

$$= PC1\ 1 + \frac{ns}{n_T}(Ks - 1) \ldots\ldots\ldots\ldots (6.5)$$

$$Is = n_T \cdot I_M\ 1 + \frac{ns}{n_T}(Ks - 1) \ldots\ldots\ldots\ldots (6.6)$$

(1) When motor is accelerated within one minute

$Ps \leqq 1.5$ (inverter capacity) (kVA) (6.5-1)

$Is \leqq 1.5$ (inverter rated current) (A) (6.5-2)

(2) When motor is accelerated for over one minute

$Ps \leqq$ inverter capacity (kVA) (6.6-1)

$Is \leqq$ inverter rated current (A) (6.6-2)

where Ps = Inverter capacity (kVA) required for starting

P_M = Motor shaft output (kW) required by load

η = Motor efficiency (normally, 0.85)

$\cos\phi$ = Motor power factor (normally, 0.75)

n_T = Total number of parallel motors

nr = Number of simultaneously started motors

$PC1$ = Continuous capacity (kVA)

Ks = Motor start current/motor rated current

Is = Inverter current (A) required for starting

I_M = Motor rated current (A)

5.3 CALCULATION OF ACCELERATION AND DECELERATION TIME

5.3.1 Frequency Acceleration and Deceleration Time

(1) Acceleration time

$$T_A = \frac{GD^2}{375} \cdot \frac{N}{T_M \times K_A - T_L} \text{(sec)} \quad \text{.........} \quad (6.7)$$

where GD^2 = Total GD^2 ($kg \cdot m^2$) at motor shaft

N = Rated speed (rpm)

T_M = Rated motor torque (kg·m)

K_A = Torque constant (normally, 1.2)

T_L = Load Torque at motor shaft (kg·m)

(2) Deceleration time

$$t_D = \frac{GD^2}{375} \cdot \frac{N}{T_M \times K_B + T_L} \text{(sec)} \quad \text{............} \quad (6.8)$$

where K_B = 0.2 (without braking function)

K_B = 1.7 (with braking function) (for 200V, 3kVA, 5kVA)

K_B = 0.7 (with braking function) (for 200V, 10-100kVA, 400V, 5-200kVA)

5.3.2 Semi-fixed Frequency Control

Acceleration time

$$t_A = \frac{GD^2 \cdot N}{375\left(\frac{T_S + T_{MAX}}{2} - T_L\right)} \quad \text{.....} \quad (6.9)$$

where GD^2 = Total GD^2 ($kg \cdot m^2$) at motor shaft

N = Rated speed (rpm)

T_S = Motor starting torque (kg·m)

T_{MAX} = Motor maximum torque (kg·m)

T_L = Load torque at motor shaft (kg·m)

6. OPERATION SEQUENCE DESIGN

Various operation sequences are conceivable to suit to the system to which VS-616 Series inverters are applied. Basic information for correct use of the VS-616 Series inverters is described here.

Standard operation sequences are available as VS Operators as described under Section 16.

6.1 FREQUENCY SETTING SIGNAL

For frequency setting signals, DC voltages between 0 and +10V are applied across terminals (6) and (8) (Fig. 6.1). For this input, the resistance is 15 kΩ.

H Series inverters are provided with an auxiliary terminal (7), which is for 10V/10% frequency commands.

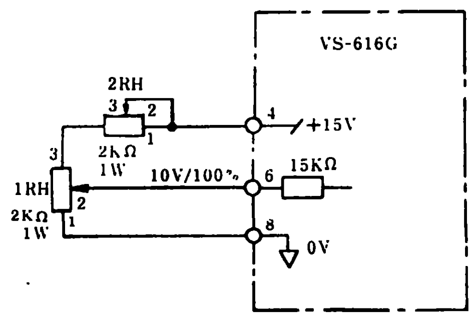


Fig. 6.1 Frequency Setting Signal of G Series

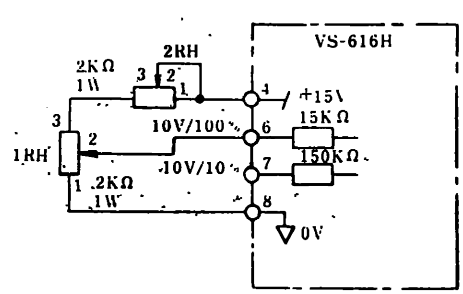


Fig. 6.2 Frequency Setting Signal of H Series

For frequency setting control power, +15V is available at terminal (4), in Fig. 6.2. This voltage is divided by the variable resistors 1RH and 2RH. Adjust 2RH to obtain the maximum output voltage of 10V across 1RH. For both variable resistors 1RH and 2RH, a 2 kΩ 1W resistor should be used. The frequency command voltage across terminals (6) and (8) the inverter output frequency are as shown in Figs. 6.3 and 6.4.

When using with a power supply in 50Hz, adjust the command voltage to 8.33V/100%, and set V GAIN potentiometer at the position of maximum voltage output.

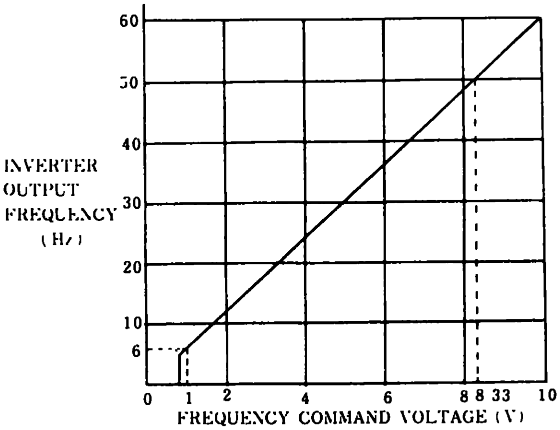


Fig. 6.3 Frequency Setting Characteristics of Series G

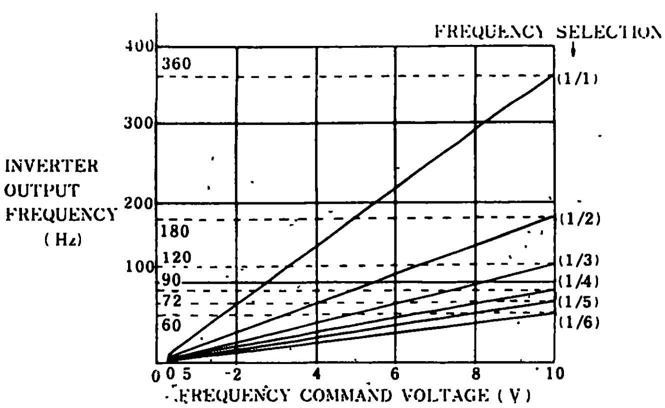


Fig. 6.4 Frequency Setting Characteristics of Series H

6.2 FREQUENCY SETTING SIGNAL SEQUENCE

When presetting the frequencies, and selecting them by relay contacts, pay attention to the following.

(1) Input the contact signal to the control power supply line at terminal (4) (Fig. 6.5).

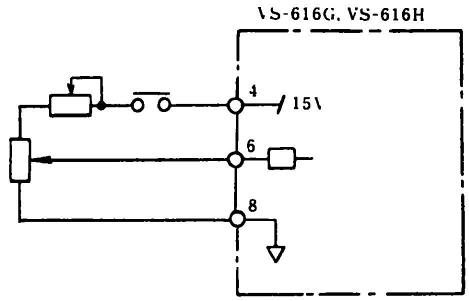


Fig. 6.5 Contact Signal to Terminal ④

(2) When inputting the contact signal to terminal (6), use the lab contact so that a 0V signal is applied to terminal (6) for stopping (Fig. 6.6). (This is to prevent malfunction by induced voltage.)

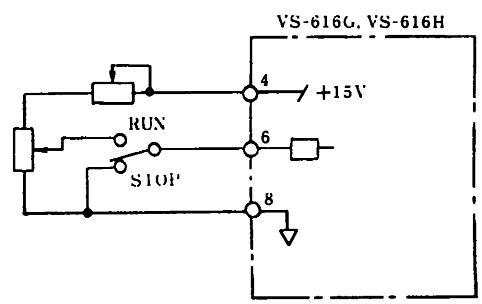


Fig. 6.6 Contact Signal to Terminal ⑥

(3) Use feeble current contacts or twin contacts for the signal ON-OFF relays. If the shielding mesh and the 0V line are grounded, malfunction may be caused by noise. Don't ground them as far as possible.

Signal ON/OFF Relays:

MK Relay (made by Tateish Electric)
HH Relay (made by Fuji Electric)
VS system modules (made by Yaskawa Electric Type JGSM-13, -14.

6.2 FREQUENCY SETTING SIGNAL SEQUENCE (Cont'd)

(4) Inching

To inch the motor, be sure to use RUN and STOP signals, as shown in Fig. 6.14. If the inverter power supply is turned on and off, the inverter will be damaged.

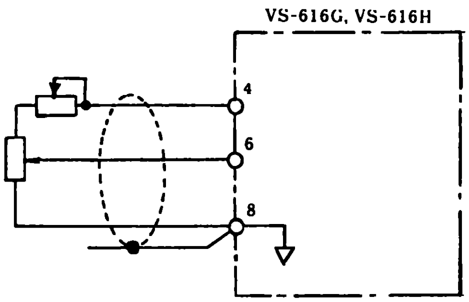


Fig. 6.7 Frequency Setting Signal Connections

6.3 MOLDED-CASE CIRCUIT BREAKER(MCB) AND POWER SUPPLY MAGNETIC CONTACTOR(MC)

(1) Be sure to connect MCBs to protect the circuit. MCs may be connected when required (Fig. 6.8).

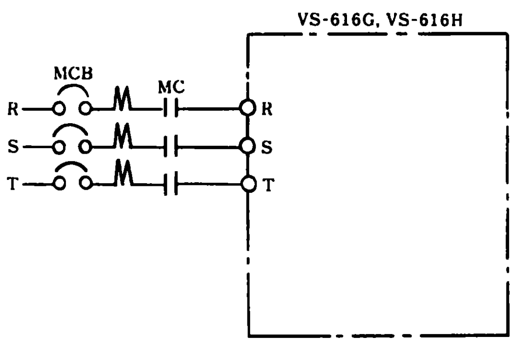


Fig. 6.8 Connections of MCB and MC

(2) When using an H Series unit with the braking function, the use of an MC is imperative. Even when the braking power transistors fail, the thermal relay in the braking circuit will protect the braking resistor against burning (Fig. 6.9).

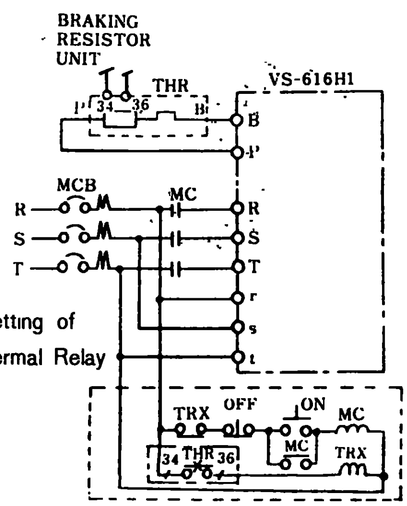


Fig. 6.9 Setting of MC and Thermal Relay

(3) When motor protection thermal relays are used with G Series Units:
Design an interlock sequence using a stop sequence circuit or an MC (Figs. 6.10 and 6.11).

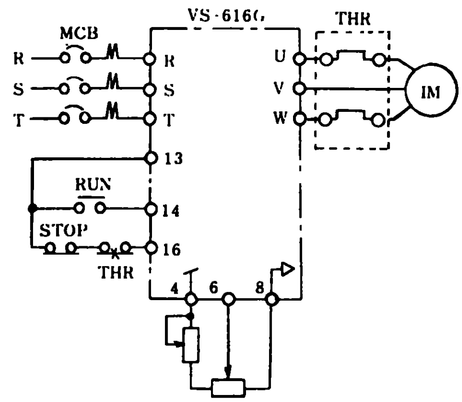


Fig. 6.10 Sequence Circuit for Stopping

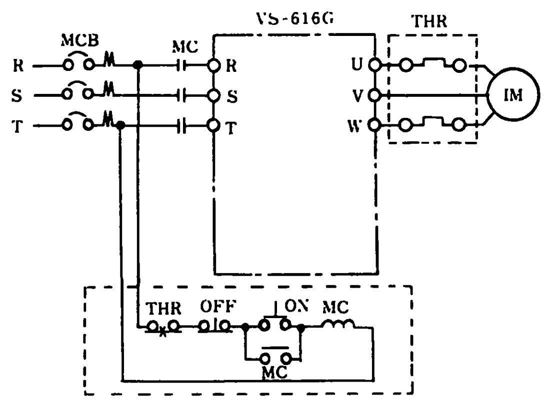


Fig. 6.11 Magnetic Contactor Sequence Circuit

6.4 START AND STOP

To start and stop a VS-616 inverter, RUN and STOP signals are required, in addition to the main circuit power supply and a frequency setting signal.

(1) Standard start and stop sequence(Fig. 6.12)

Starting:
- Energize the main circuit by turning on MCB
- Turn on RUN signal for 0.5 sec. min.
- Input frequency setting signal

Stopping:
- Change frequency setting signal to 0V
- Turn on STOP signal for 0.5 sec min.
- Turn off MCB to deenergize the main circuit

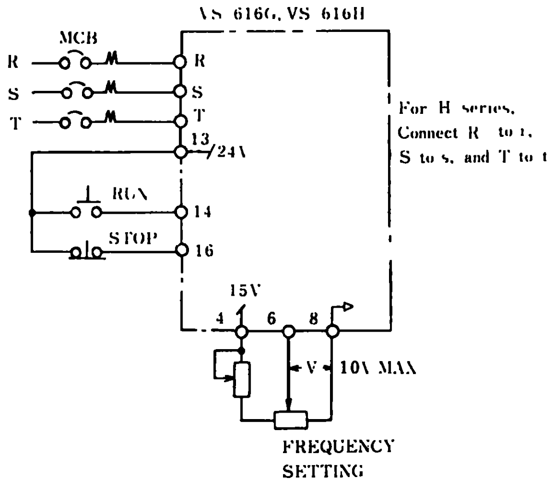


Fig. 6.12 Standard Start and Stop Sequence

(2) Presetting frequency command

The frequency setting may be made beforehand in the sequence (1), and the motor may be started and stopped with only a RUN signal and a STOP signal. In this case, be sure to input a RUN signal approximately 0.2 seconds after energizing the main circuit. Never input a RUN signal first, and energize the main circuit later, because the inverter may be damaged by this practice.

(3) Starting and stopping by relay sequence (Fig. 6.13)

Pushing ON button closes MC to energize main circuit

↓

RUN signal is input simultaneously

↓

Motor runs

↓

Pushing OFF button turns off MC

In this stopping mode, braking force is lost, and the motor is left running free by inertia. To start the motor again, first make sure the motor is stopped. Frequent start/stop should not be performed in this stopping mode.

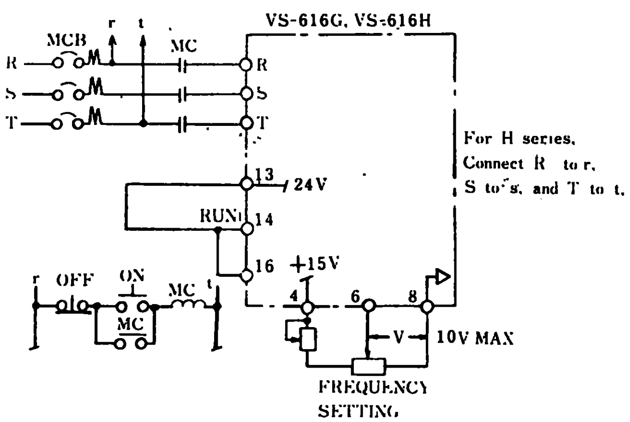


Fig. 6.13 Start and Stop Sequence for Relay Sequence

(4) Inching

For inching operation, use RUN and STOP signals as shown in Fig. 6.14. Turning on and off of inverter power will cause inverter functional failure.

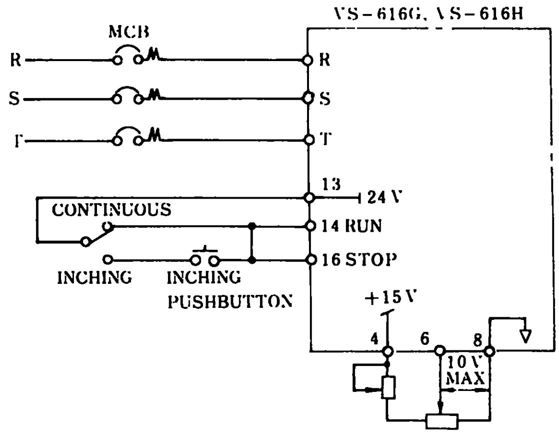
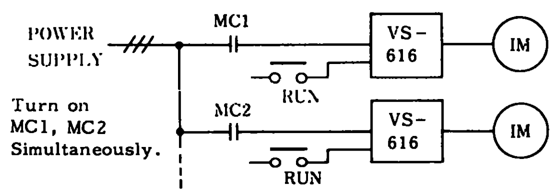


Fig. 6.14 Inching Operation

(5) Starting more than two inverters

To start more than two inverters, the following starting methods are recommended so as to avoid interfering supply voltage waveform strain due to inrush current.

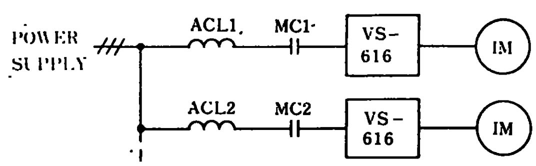
(a) Turn on inverter powers simultaneously and start motors sequentially or simultaneously.



Simultaneous Power Inputting

(b) To turn on inverter power during starting at full load, connect AC reactor to power line.

·For AC reactor selection (ACL), refer to 4.8 on page 16.



Sequential Power Inputting

6.5 FORWARD AND REVERSE RUN

To control motors in forward and reverse run directions, the optional reverse control card (JPAC-C040) must be mounted in the VS 616H inverter. FOR RUN, REV RUN and STOP signals may be applied independently to the inverter. The inverter operation under these signals is shown in Table 6.1.

Table 6.1 Signals and Inverter Operation

Forward	Reverse	Stop	Inverter Operation
OFF	OFF	ON	Stop
ON	OFF	OFF	Forward run
OFF	ON	OFF	Reverse run
ON	ON	OFF	Stop
OFF	OFF	OFF	*
ON	OFF	ON	Stop
OFF	ON	ON	Stop
ON	ON	ON	Stop

* When all signals are off, the signal conditions before this state are kept.
Forward, reverse, and stop signals, when given for 0.5 second or more, will be kept in the reversible controller even if they are interrupted.

Table 6.2 Signals and Contact Operation

Forward		Reverse		Stop	
ON	OFF	ON	OFF	ON	OFF
"F" ON	"F" OFF	"R" ON	"R" OFF	"S" OFF	"S" ON

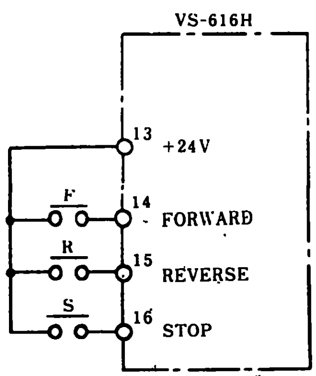


Fig. 6.15 Forward, Reverse, and Stopping Circuit

The meanings of the signals and the actuation of the contacts shown in Table 6.1 are explained in Table 6.2 and Fig. 6.15. The reversing operation is performed as shown in Fig. 6.16. The relevant circuit is shown in Fig. 6.17. For details, refer to Paragraph 15 OPTION CARD.

With a 200V 30kVA inverter or smaller, use Model CIMR[ ]H I with braking function, when short braking deceleration time is desired. Its circuit is shown in Fig. 6.18.

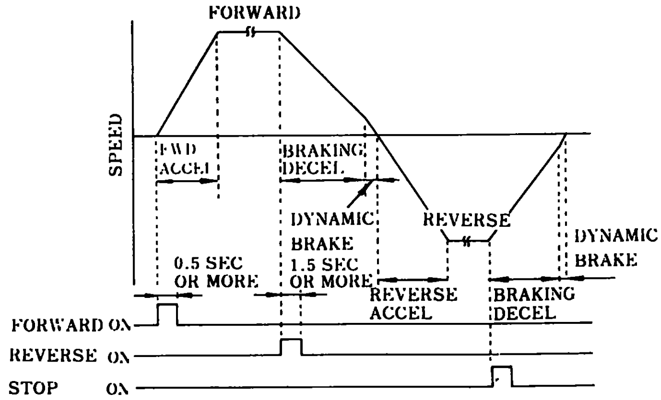


Fig. 6.16 Reversible Operation

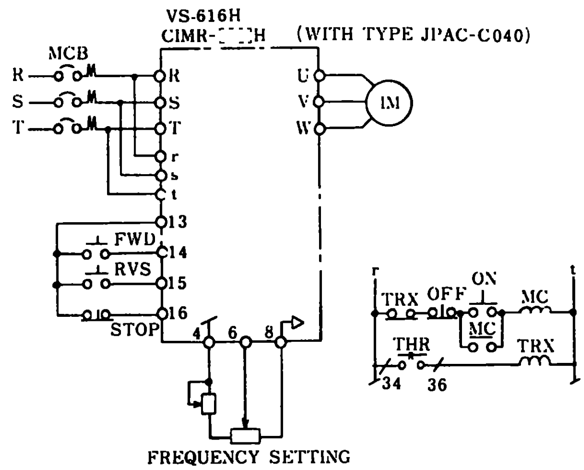


Fig. 6.17 Reversible Operation Circuit

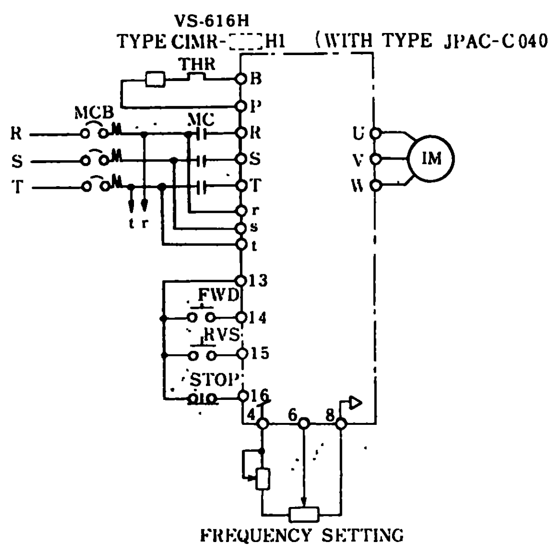


Fig. 6.18 Inverter Reversible Operation Circuit with Braking Function

6.6 EXTERNAL RESET COMMAND

External reset commands are signals to reset the protection functions that are not automatically reset after actuation, as listed in Table 6.3

When the protection functions listed in Table 6.3 are actuated, the respective LEDs light to indicate the fault. Some of these functions are automatically reset when the fault is eliminated, and others remain tripped even when the fault is eliminated. Note that when the control power supply is turned off, all the fault detectors and the displays are reset.

Table 6.3 Protective Functions and Operation

Protective Function	Operation	Indication	Contact Return	Reset
Overcurrent Protection (OC)	Flowing current above set value stops inverter.	"OC" ON	Maintained	Control power OFF or failure reset ON.
Overvoltage Protection (OV)	DC voltage after converter exceeding the set value stops inverter.	"OV" ON	Automatic return and maintained (For H series only)	The same as above (For remained type)
Fuse Blown-out (FU)	Damaged power transistor blows out fuses.	"FU" ON	Maintained	—
Overload Protection (OL)	Overload (150% for 1minute) stops inverter.	"OL" ON	Maintained (For H series only)	Control power OFF or failure reset ON.

When an external reset command RESET is turned on, the tripped functions are reset, and at the same time, base blocking is executed, and when RESET is turned off, the base blocking is cleared to enable operation again (Fig. 6.19).

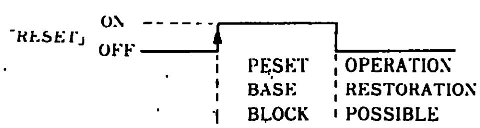


Fig. 6.19 RESET and Operation

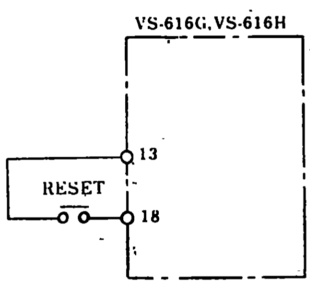


Fig. 6.20 RESET Circuit

With a reset command, the fault lamps are also reset. If the fault lamps must be left on for troubleshooting, a RESET switch is provided on the control board of H Series inverters. When this switch is pushed, the same resetting takes palce as when RESET in Fig. 20 is turned on.

6.7 EXTERNAL BASE BLOCK COMMAND

When the inverter is required to be stopped due to an external cause, without any fauls in the inverter itself, an external base block command may be input to the inverter. Then the inverter stops operation, and the motor is deenergized.

While EXT. BB is kept on, base blocking is applied, and when EXT.BB is turned off, base blocking is cleared (Figs. 6.21, 6.22).

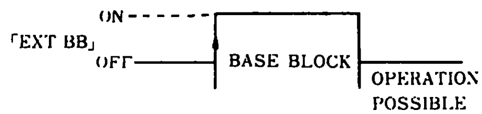


Fig. 6.21 Base Block and Resetting

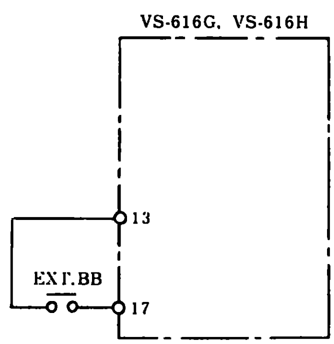


Fig. 6.22 Base Block Circuit

6.8 ALARM CONTACT SIGNAL OUTPUT

When some inverter protection functions are tripped contact signals are output across terminals (21) and (22) for display and sequence control. These contact signals operate in the following cases (Table 6.4).

The contact capacity is 250 V_{AC} 1A, 24 V_{DC} 1A (Fig. 6.23). These contact output signals are turned off by an external reset signal mentioned in Paragraph 6.6.

Table 6.4 Failure Contact Output

Protective Function	Return	Relay Contact	Correct	Failure
Overvoltage Protection (OV)	Automatic return	—	OFF	OFF
	Maintained (H series)	Provided	OFF	ON
Overcurrent Protection (OC)	Maintained	Provided	OFF	ON
Overload Protection (OL)	Maintained (H series)	Provided	OFF	ON
Fuse Blown out (FU)	Maintained	Provided	OFF	ON

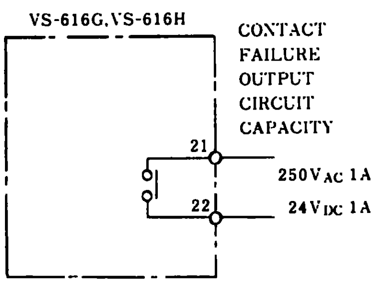


Fig. 6.23 Contact Failure Output Circuit

6.9 FREQUENCY METER

Terminals (11) and (12) are for connecting a frequency meter. While a +10V frequency command voltage is applied to terminal (6), approximately $-10V_{DC}$ (2mA) output is obtained from terminal (11) (Fig. 6.24). Use a 3V, 1mA voltmeter with a frequency scale as the frequency meter.

This signal is in the same polarity for both forward and reverse run. The frequency meter can not be made to indicate forward and reverse run by the pointer deflecting to the right and left directions around the center point.

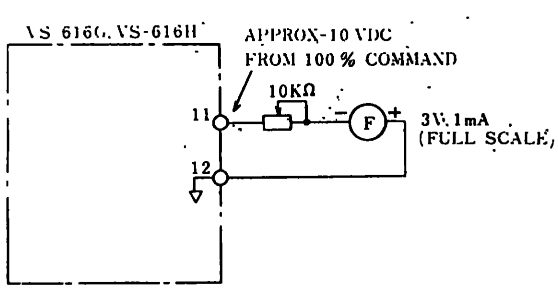


Fig. 6.24 Frequency Output Circuit

6.10 FREQUENCY MONITORING OUTPUT

The H series inverter outputs frequency monitoring signals for counting by a frequency counter (Fig. 6.25). This output is insulated from the inverter control circuit, and the waveform is in positive and negative differential pulses (Fig. 6.26)

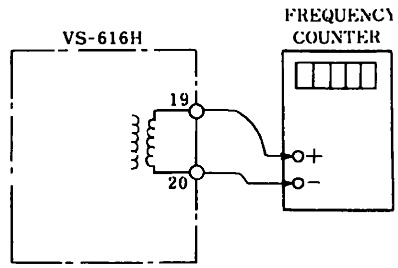


Fig. 6.25 Frequency Monitor Output Circuit

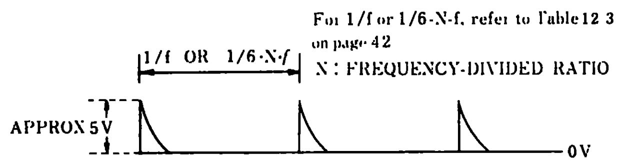


Fig. 6.26 Frequency Monitor Output Waveform

6.11 RESTARTING AFTER STOPPING

Don't restart the motor while the input power supply at R, S and T of the inverter is turned off, or while the motor is running free due to faults. Restart the motor only after making sure that the motor has stopped by itself. If the motor is restarted while it is running idle, the overvoltage protector (OV) or the overcurrent protector (OC) may trip.

6.12 SWITCHING OF OUTPUT U, V, W

The output lines U, V and W of the inverter should only be closed and opened while the motor is still.

(1) Closing output lines

Inverter State	Motor Conditions before Closing Contact	
	During Motor Running (Free Running)	Motor Stopping
Inverter Operating	Closing contact at output side impossible.	Full-voltage should not exceed inverter rated current.
Inverter Stopped	Closing contact at output side impossible.	Closing contact possible. (Recommended conditions for closing contact)

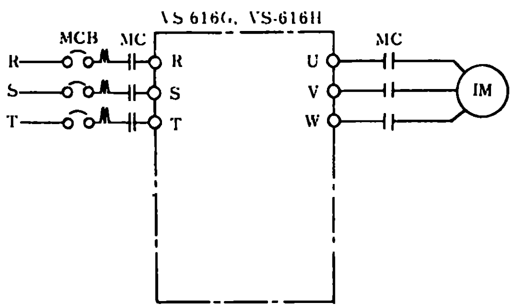


Fig. 6.27 Inverter Main Circuit

(2) Opening output lines

Inverter State	Motor Conditions before Opening Contact		
	During Motor Running	During Motor Running (Free Running)	Motor Stopping
Inverter Operating	Opening contact possible.*	—	—
Inverter Stopped	—	Opening contact possible.	Opening contact possible. (Stopping at this state is best.)

* If inverter malfunctions by noise, refer to 9.2.

6.13 DIFFERENT POWER SUPPLY VOLTAGE

Standard VS-616 inverters can be used with the input AC power supplies with the following voltages only.

180 - 220 V (50 Hz)

180 - 242 V (60 Hz)

When the voltage is outside the above ranges, a transformer is required on the power supply (Fig. 6.28). Table 6.5 shows power supply transformers for various motors.

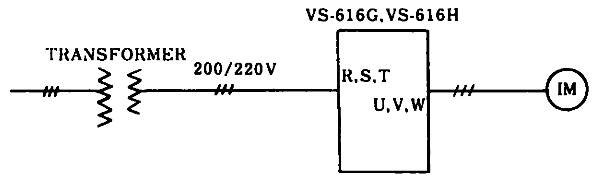


Fig. 6.28 Transformers Connection

Table 6.5 Power Transformers for Supply Voltages

Motor Output kW(Hp)	Inverter Capacity kVA	Power Transformer kVA
0.4(0.5)	3	0.9
0.75(1)		1.5
1.5(2)		3.0
2.2(3)		4.5
3.7(5)	5	7.5
5.5(7.5)	10	10
7.5(10)		15
11(15)	20	20
15(20)		30
22(30)	30	45
30(40)	40	60
37(50)	60	75
45(60)		90
55(75)	75	110
75(110)	110	150
110(150)	140	200
210(160)	200	300

6.14 PARALLEL CONNECTION WITH COMMERCIAL POWER SUPPLY

When the inverter is connected in parallel with the commercial power supply to a motor, be sure to connect two magnetic contactors to turn on only one of them at a time, as shown in Fig. 6.29. If terminals U, V and W are connected to the commercial power supply, the inverter is damaged.

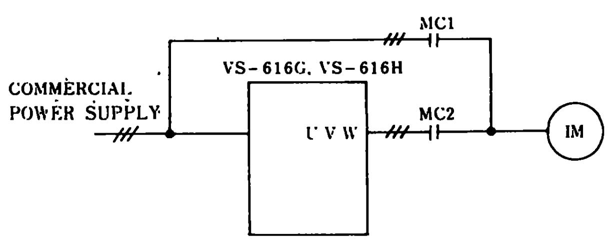


Fig. 6.29 Commercial Power Supply Circuit used as Inverter Power Supply

6.15 INSTANTANEOUS POWER FAILURE

The VS-616 inverter remains operational under an instantaneous power failure within 20 ms. At a power failure over 20 ms, resume the operation after power recovers.

6.16 HOW TO DETERMINE ACCELERATION AND DECELERATION TIME

Determine the acceleration and deceleration time as follows. If these times are not correctly selected, acceleration may fail or the overvoltage protector (OV) may trip during deceleration.

The calculation is based on the following assumptions.

(a) The inverter capacity is equal to the motor capacity.

(b) Inverter is used at an output frequency of 60 Hz.

(c) For inverter output frequencies above 60 Hz, refer to our service organization.

(d) For the braking resistance value, see Table 14.3.

(1) Determine the required acceleration and deceleration patterns (Fig. 6.30).

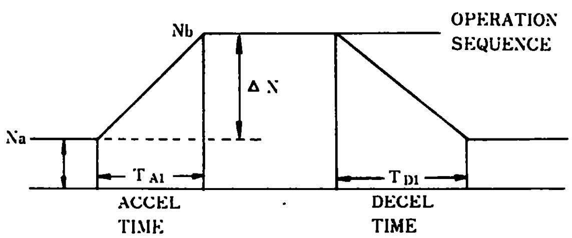


Fig. 6.30 Operation Pattern of Acceleration and Decelecation

(2) Calculate the acceleration or deceleration time on the ground of the load GD^2 and load torque.

Acceleration time $T_{A1} = \dfrac{GD^2 \times \Delta N}{375(T_M \times K_A \times T_L)}$ (sec)

Deceleration time $T_{D1} = \dfrac{GD^2 \times \Delta N}{375(T_M \times K_B \times T_L)}$ (sec)

where T_{A1} = Acceleration time from Na to Nb (sec)

T_{D1} = Deceleration time from Nb to Na (sec)

GD^2 = Motor GD^2 + load GD^2 at motor shaft ($kg \cdot m^2$)

ΔN = Motor speed difference = Nb - Na (rpm)

T_M = Rated motor torque ($kg \cdot m$)

T_L = Load torque at motor shaft ($kg \cdot m$)

K_A = Acceleration torque ratio = 1.2 - 1.3

K_B = Deceleration torque ratio = (Table 6.6)

Table 6.6 Deceleration Torque Ratio

Braking Function		K_B
Without Braking Function		0.2
With Braking Function	3.5kVA	1.7
	10-110kVA	0.7

Note: Accel/decel time taken between zero speed and the rated speed is calculated using the following equation.

$$T_A = T_{A1} \times \frac{N}{\Delta N}$$

$$T_D = T_{D1} \times \frac{N}{\Delta N}$$

N: RATED SPEED

Note:
GD^2 ($kg \cdot m^2$) = 0.042 WK^2 ($lbs \cdot ft^2$)
T (Torque $kg \cdot m$) = 0.139T ($lbs \cdot ft$)

(3) Accelerationtime

After making sure that the acceleration time (T_{A1}) determined in (1) is longer than the calculated time in (2), set ACCEL. If the calculated time is longer, the acceleration torque under the control of the inverter is insufficient, and the intended acceleration pattern is not achieved. Either extend the acceleration time to the calculated time, or use a larger inverter.

(4) Deceleration time

After making sure that the intended deceleration time T_{D1} in (1) is longer than the time calculated in (2), set DECEL to the intended time. If the calculated time is longer, the deceleration torque is insufficient. Either extend the deceleration time or use a larger inverter, or apply harder brake.

7. CHARACTERISTICS USING STANDARD MOTORS

Typical characteristics of systems consisting of standard YASKAWA motors and VS-616 inverters are described here.

7.1 CONTINUOUS PERMISSIBLE TORQUE

The continuous permissible torque for standard motors driven by VS-616 inverters is as shown in Figs. 7.1 and 7.2, where 100% torque means the rated torque at 50/60 Hz.

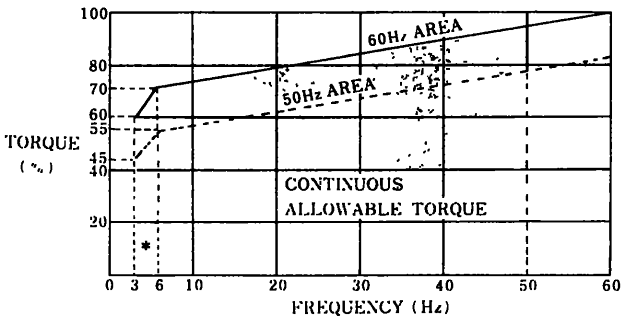


Fig. 7.1 Allowable Continuous Torque of VS-616H Drive

* When continuously driving the motor at frequencies below 6 Hz with a VS-616H, if V BIAS is increased, the motor may overheat through increased current.

Particular care should be taken when the load torque is 20% or less because motor excitation current increases. In this case, use the optional torque compensator card. (See Paragraph 15.2)

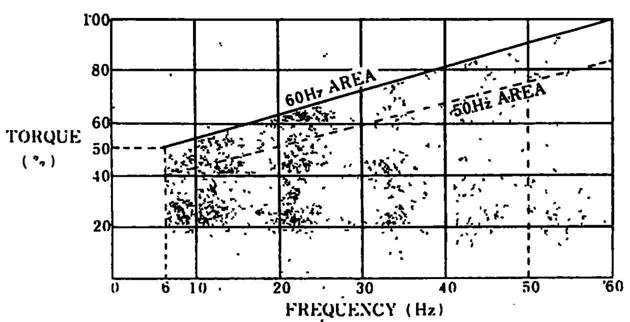


Fig. 7.2 Allowable Continuous Torque of VS-616G Drive

7.2 TORQUE-SPEED CHARACTERISTICS

The torque characteristics of the standard FEQ 3.7 kW, 4-pole motor driven by the 5 kVA VS-616H and by the VS-616G are shown in Figs. 7.3 and 7.4 respectively.

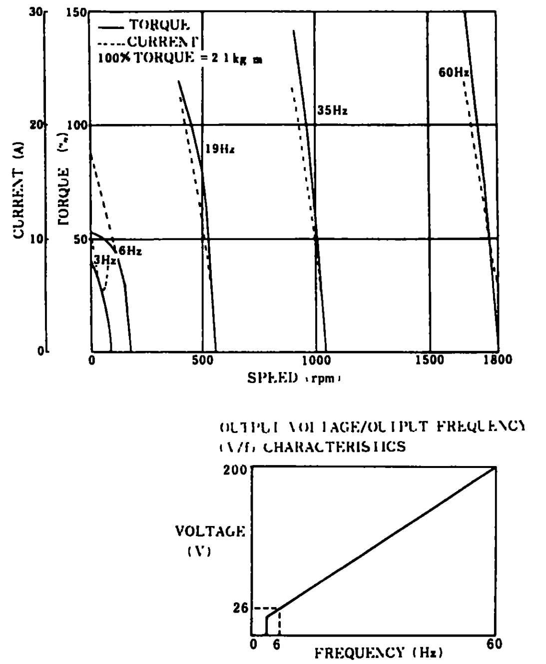


Fig. 7.3 Torque and Current Curve when driven by VS-616H

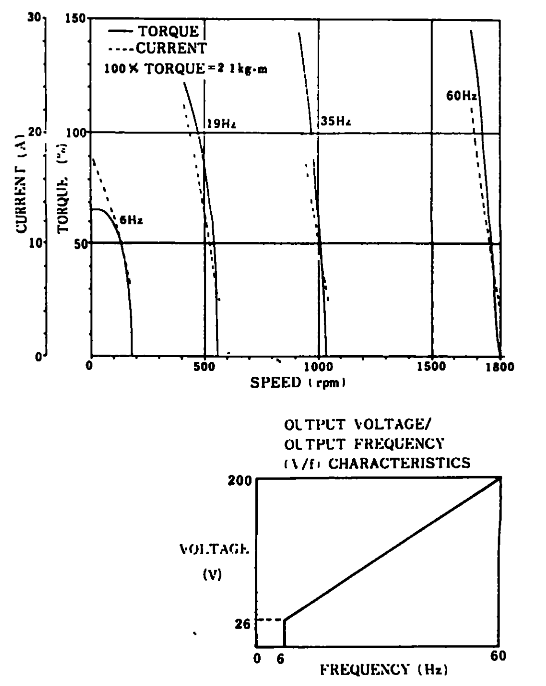


Fig. 7.4 Torque and Current Curve when driven by VS-616G

7.3 EFFICIENCY

The actually measured efficiencies of a standard FEQ, 3.7 kW, 4-pole motor as driven by a 5 kVA VS-616H and by a VS-616G are shown respectively in Figs. 7.5 and 7.6.

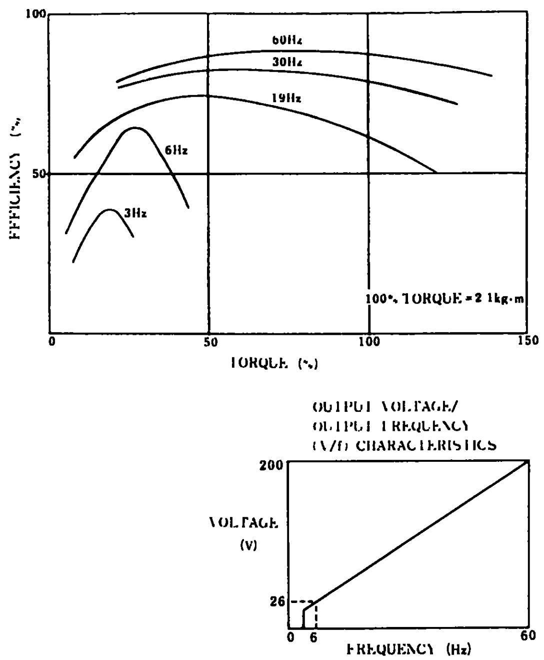


Fig. 7.5 Motor Efficiency when driven by VS-616H

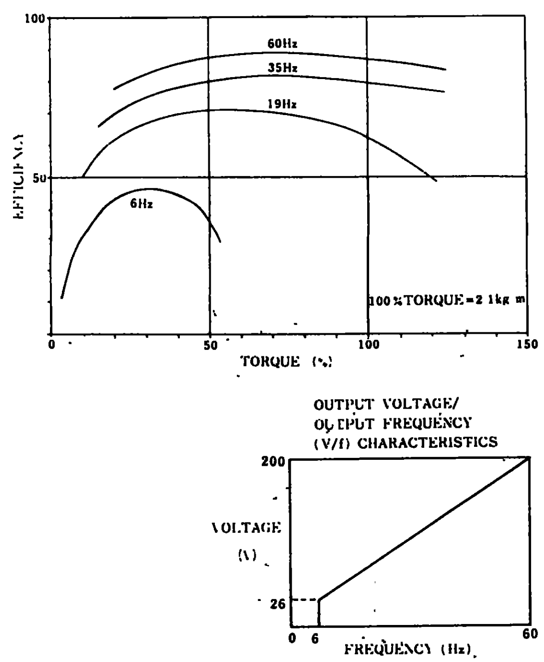


Fig. 7.6 Motor Efficiency when driven by VS-616G

7.4 NOISE CHARACTERISTICS

The actually measured noise characteristics of a standard FEQ, 3.7 kW, 4-pole motor as driven by a 5 kVA VS-616H and by a VS-616G are shown respectively in Figs. 7.7 and 7.8.

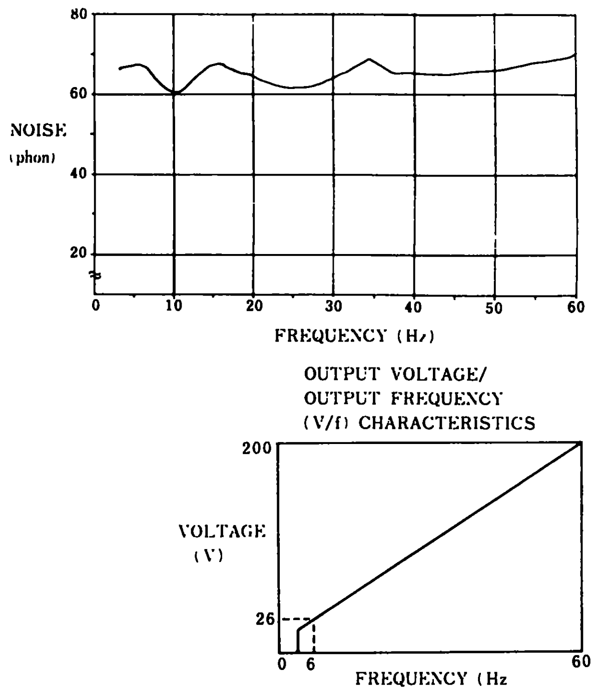


Fig. 7.7 Noise when driven by VS-616H

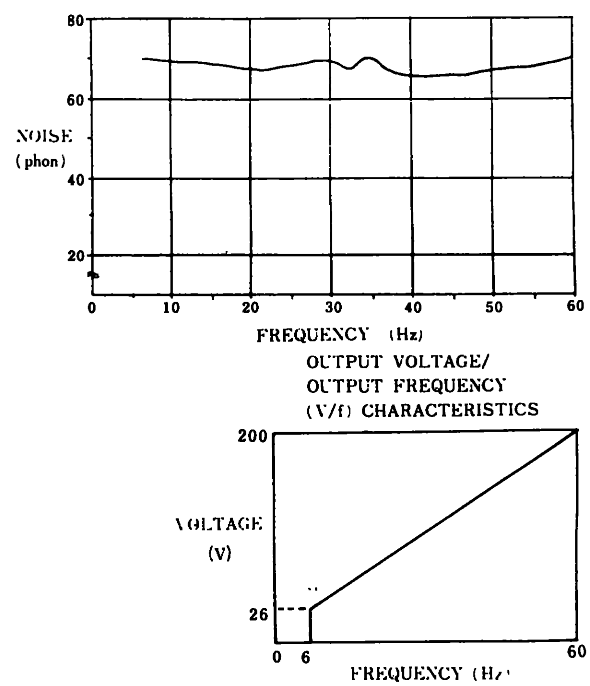


Fig. 7.8 Noise when driven by VS-616G

7.5 VIBRATION CHARACTERISTICS

The actually measured vibration levels of a standard FEQ, 4-pole, 3.7 kW motor as driven by a 5 kVA VS-616H inverter and by a VS-616G inverter are shown respectively in Figs. 7.9 and 7.10.

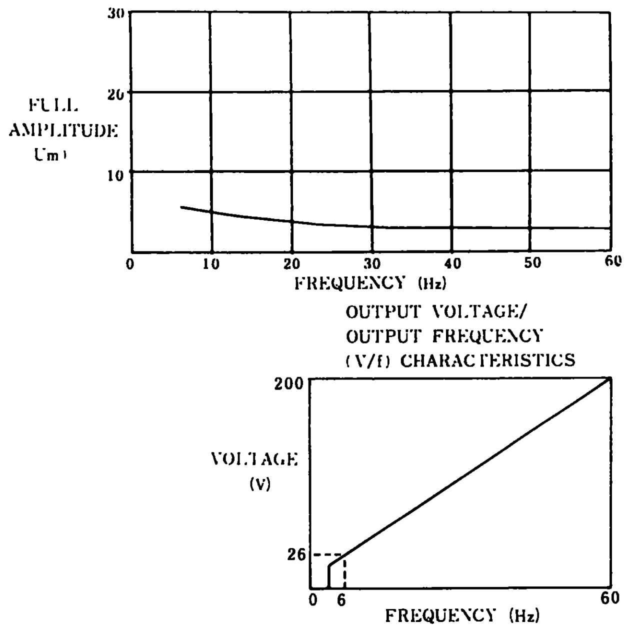


Fig. 7.9 Vibration when driven by VS-616H

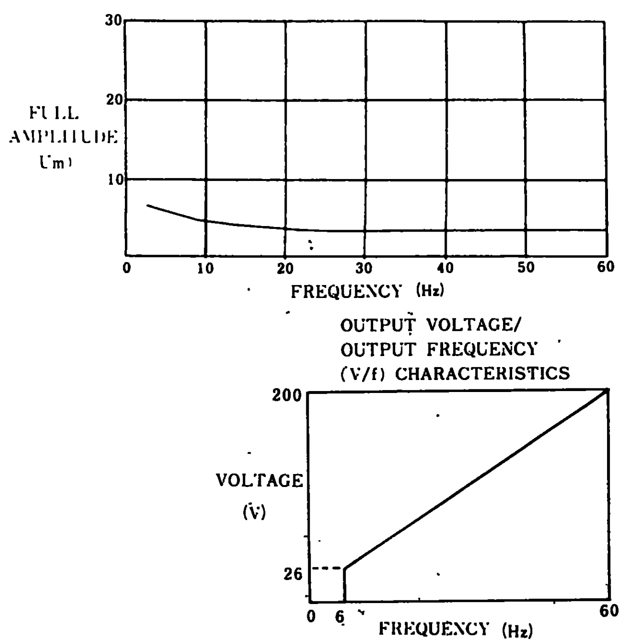


Fig. 7.10 Vibration when driven by VS-616G

7.6 STARTING TORQUE OF STANDARD MOTOR

Generally, the starting current of a standard motor is 5 - 6 times the rated current, and the starting torque is 250 to 350% of the rated torque. When an inverter is used to drive a motor, the starting current is limited by the permissible maximum current of the inverter (150% of the rated current for one minute), and accordingly, the motor starting torque is limited. This is a problem when the inverter capacity is close to the motor output.

The starting torque of the standard 3.7kW, 4-pole, FEQ motor as driven by the VS-616H inverter and by the VS-616G inverter is respectively shown in Figs. 7.11 and 7.12.

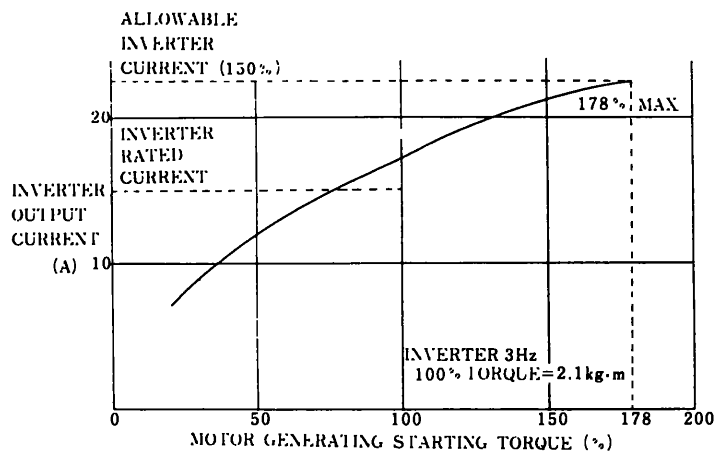


Fig. 7.11 Starting Torque Characteristic of VS-616H

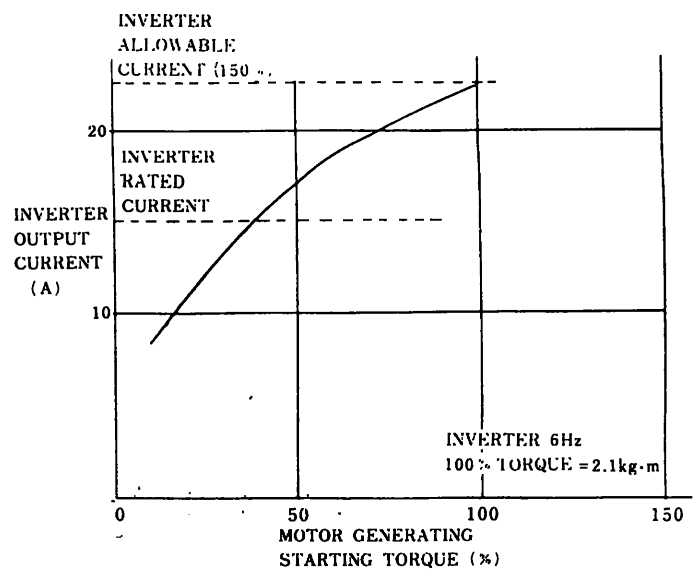


Fig. 7.12 Starting Torque Characteristic of VS-616G

7.7 INVERTER INPUT POWER FACTOR

Inverter input power factor for fundamental wave is approximately 1.

8. CHARACTERISTICS OF CONSTANT TORQUE LOAD MOTORS

The special motors for use with the VS 616 inverters for constant torque loads Type FE[ ]-I). The comparison between the standard motors and the special motors under inverter drive is described below.

8.1 FRAME NUMBERS AND MODELS OF STANDARD AND SPECIAL MOTORS

Table 8·1 Motor Outputs and Frames

Load Torque Characteristics	Variable Torque			Constant Torque		
Motor	Standard			Definite-Purpose		
Frequency Range	6-60 Hz			3-60 Hz		
Motor Output kW (Hp) \ Frame and Motor Type	Frame	Insulation	Type	Frame	Insulation	Type
0.2 (0.25)	63 HJ	E	FEQ	71 HJ	E	FEQ-I
0.4 (0.5)	71 HJ	E		80 HJ	E	
0.75 (1)	80 HJ	E		90 LHJ	E	
1.5 (2)	90 LHJ	E		100 LHJ	E	
2.2 (3)	100 LHJ	E		112 MHJ	E	
3.7 (5)	112 MHJ	E		132 SHJ	E	
5.5 (7.5)	132 SHJ	B	FEF	160 MJ	E	FEF-I
7.5 (10)	132 MHJ	B		160 LJ	E	
11 (15)	160 MJ	B		180 MJ	E	
15 (20)	160 LJ	B		200 LJ	E	
18.5 (25)	180 MJ	B		225 SJ	E	
22 (30)	180 MJ	B		225 SJ	E	
30 (40)	180 LJ	F		200 LJ	E	EEF-* IK
37 (50)	200 LJ	F		225 SJ	E	
45 (60)	200 LJ	F		225 SJ	E	
55 (75)	225 SJ	F		225 SJ	F	
75 (100)	250 MDG	F	FEF-I	250 MDG	F	
90 (110)	280 MCG	F	FEA-I	280 MCG	F	FEK-IK
110 (150)	280 MCG	F		280 MCG	F	
132 (170)	315 MCG	F		315 MCG	F	
160 (210)	355 SBG	F		355 SBG	F	

* Asterisked type for externally fan-cooled type.
Note: Listed values are for totally-enclosed fan-cooled, 4-pole motors.

8.2 CONTINUOUS PERMISSIBLE TORQUE OF SPECIAL MOTORS

The permissible continuous torque range of the special motor as driven by the VS-616H is shown in Fig. 8.1.

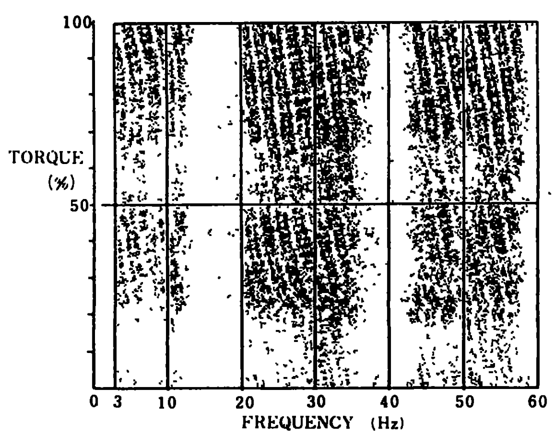
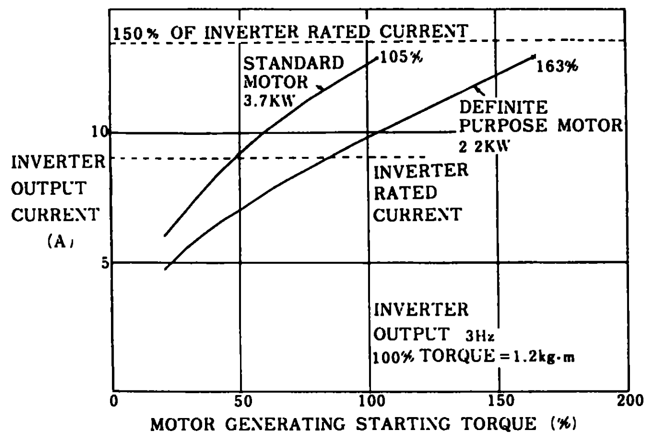


Fig. 8.1 Allowable Continuous Torque of Definite Purpose Motor (VS-616H)

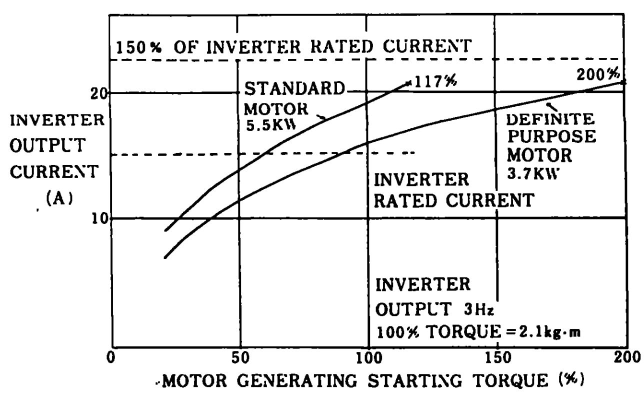
8.3 STARTING TORQUE

If the special motor is not used, but a standard motor larger by one frame size is used instead, driven by an inverter having a capacity close to the motor output, the starting torque of the latter is significantly lower than the former (Figs. 8.2 and 8.3).



- Special motor
  Type FEQ-I, 2.2kW, 4-pole
- Standard motor
  Type FEQ, 3.7kW, 4-pole
- Driving inverter
  VS-616H, 3kVA

Fig. 8.2 Starting Torque when driven by VS-616H, 3kVA



- Special motor
  Type FEQ-I, 3.7kW, 4-pole
- Standard motor
  Type FEQ, 5.5kW, 4-pole
- Driving inverter
  VS-616H, 5kVA

Fig. 8.3 Starting Torque when driven by VS-616H, 5kVA

9. IMPROVEMENT OF CHARACTERISTICS

9.1 IMPROVING VIBRATION AND NOISE

Generally, when 3-phase squireel-cage motors are driven by inverters, vibration and noise tend to be higher than when the same motors are driven by the commercial power supply at a constant speed. PWM mode inverters cause characteristic metallic noise.

To reduce vibration and noise, AC reactors should be connected between the inverter output terminals and the motor as shown in Fig. 9.1. For reactor selection, refer to 4.8 SELECTION OF AC REACTOR.

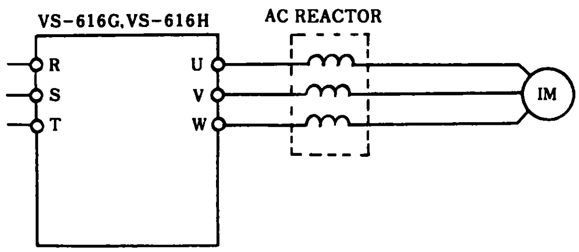


Fig. 9.1 Connections of Reactor

9.2 NOISE INTERFERENCE

9.2.1 Noise of Magnetic Contactor

When transistor inverters and magnetic contactors are installed in the same panel housing, the noise generated by the coils of the magnetic contactors may cause malfunction of the inverters. When this is the case, connect surge absorbers parallel to the coils of the magnetic contactor.

The surge absorbers must be able to absorb the energy accumulated in the coils of the magnetic contactors. For reference, the applicable surge absorbers to YASKAWA magnetic contactors are given in Table 9.1. Never connect the surge absorbers to inverter output terminals u, v, w.

Table 9·1 Surge Absorbers

Magnetic Contactor and Control Relay		Surge Absorber*		
		Type	Specifications	Code No.
200 V Class	HI-10, -20, -26, -35, -50, -65, -80, -125	DCR2-50A22E	250 VAC 0.5μF+200Ω	C002417
	RA-6E₂			
	RL-33E			
	Control Relay LY-2, -3 (OMRON) HH-22, -23 (Fuji) MM-2, -4 (OMRON)	DCR2-10A25C	250 VAC 0.1μF+100Ω	C002482
400 V Coils		DCR2-50D100B	1000 VAC (500 VAC) 0.5μF+220Ω	C002630

*Made by MARCON Electronics
Note: For magnetic contactors and control relays other than listed above, use the surge absorber Type DCR2-50A22 for 200 V class, and Type DCR2-50D100B for 400 V class.

9.2.2 Power Supply Noise

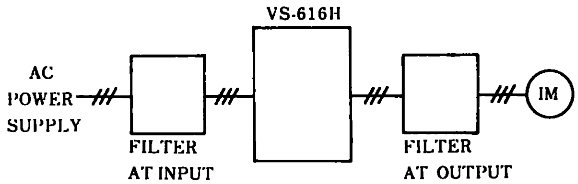
When inverters are used, harmful noise may be released into the power supply circuit. To prevent this, noise filters given in Table 9.2 should recommendably be connected to the power supply terminals R, S and T of the inverter. Note that connecting these filters to the output terminals U, V and W will damage the noise filters.

Table 9·2 Noise Filter Selection
(Made by Tohoku Kinzoku K.K.)

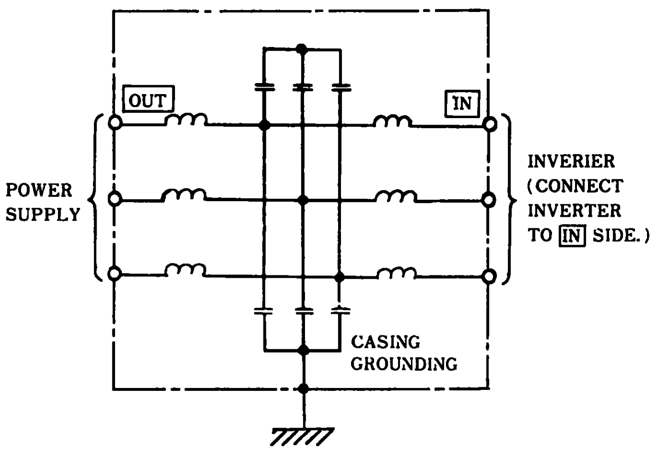
Series	Max Motor Capacity kW (Hp)	Inverter Capacity kVA	Filter at Input		Filter at Output	
			Type	Rated Current A	Type	Rated Current A
200 V	2.2(3)	3	LF-315K	15	LF-310KA	10
	3.7(5)	5	LF-325K	25	LF-320KA	20
	5.5(7.5)	10	LF-325K	25	LF-350KA	50
	7.5(10)		LF-335K	35	LF-350KA	50
	11(15)	20	LF-380K	80	LF-350KA	50
	15(20)		LF-380K	80	LF-350KA×2P	100
	22(30)	30	LF-380K×2P	160	LF-350KA×2P	100
	30(40)	40	LF-380K×2P	160	*	—
	37(50)	60	LF-380K×2P	160	*	—
	45(60)		LF-396K×2P	192	*	—
	55(75)	70	*	—	*	—
	75(100)	100	*	—	*	—
400 V	2.2(3)	5	LF-314K4	14	LF-310KB	10
	3.7(5)		LF-314K4	14	LF-310KB	10
	5.5(7.5)	10	LF-314K4	14	LF-320KB	20
	7.5(10)		LF-330K4	30	LF-320KB	20
	11(15)	20	LF-330K4	30	LF-335KB	35
	15(20)		LF-330K4	30	LF-335KB	35
	22(30)	40	LF-355K4	55	LF-345KB	45
	30(40)		LF-380K4	80	LF-375KB	75
	37(50)	60	LF-380K4	80	LF-375KB	75
	45(60)		LF-3130K4	130	LF-3110KB	110
	55(75)	75	LF-3130K4	130	LF-3110KB	110
	75(100)	110	LF-3190K4	190	LF-3110KB×2P	220
	110(150)	140	LF-3130K4×2P	260	*	—
	160(210)	200	LF-3190K4×2P	380	*	—

* For the asterisked noise filter, contact us.

The circuit connections of the noise filters are shown in Fig. 9.2. Ground the noise filters in the shortest possible distance, securely.



(a) Noise Filter Connections



(b) Type LF Noise Filter Circuit

Fig. 9.2 Type LF Noise Filter Circuit and Connections

9.2.3 Radio Interferance

When an inverter is operated near a radio set, the radio is disturbed by radio waves emitted from the inverter or by the induction from the inverter.

To prevent adverse influence on radio receivers, the noise filters must be connected to the inverter as in Paragraph 9.2.2, and the inverter must be shielded to interrupt radio wave radiation (Fig. 9.3).

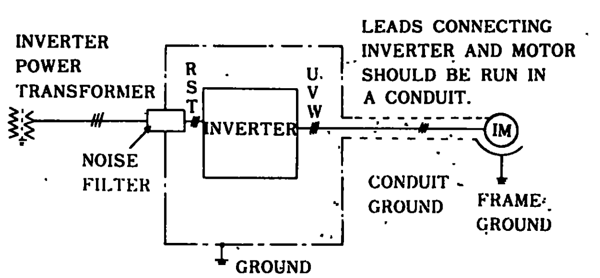


Fig. 9.3 Action for Electronic Wave Interference

9.2.4 Ground FAult Interrupter

Use a ground fault interrupter with well balanced characteristics, and connect it to the power supply side as shown in Fig. 9.4.

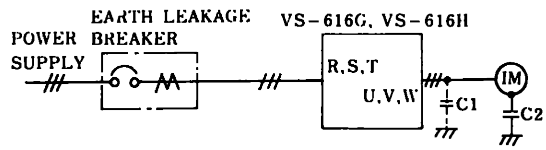


Fig. 9.4 Earth Leakage Breaker Connection

Because of the higher harmonic components in the inverter output voltage, zero phase current may flow through the ground capacitance C1 of the cable between the inverter and the motor, and motor ground capacitance C2 to trip the interrupter unnecessarily. To prevent this, pay attention to the following.

(1) Minimize the steady zero phase current.

- Shorten the cable length between inverter and motor as far as possible.
- Keep the cable between inverter and motor as far from the ground as possible.

(2) Set the rated sensitivity current at a high level (200mA, 0.2 seconds as a guide line Fig. 9.5).

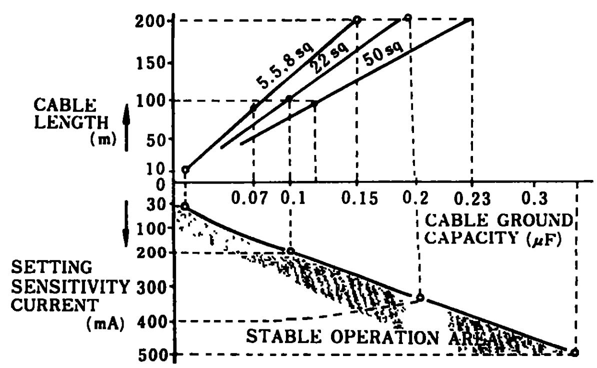


Fig. 9.5 Setting Sensitivity Current

10. CAUTIONS IN USING INVERTERS

10.1 INVERTERS FOR FULL-VOLTAGE STARTING

When magnetic contactors are connected between the inverter and the motor to start the motor at the full voltage, the inverter must be of a rated current that is above the starting current of the motor (normally, 5 - 6 times the rated current). (Fig. 10.1).

If the inverter capacity is close to the motor capacity, excess currents flow through the inverter and the overcurrent protector (OC) is tripped, each time the magnetic contactor is closed. When this is repeated, the inverter will be damaged.

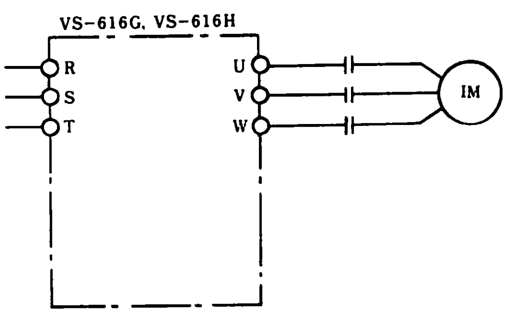


Fig. 10.1 Inverter Selection for Motor Full-voltage Starting

10.2 REMOVING PHASE ADVANCING CAPACITOR

Never connect phase advancing capacitors between the inverter and the motor. When existing motors are to be connected to an inverter, be sure to disconnect the existing phase advancing capacitor. Since inverter provides the power factor of approx 95% or more at any speed, no phase advancing capacitor is required.

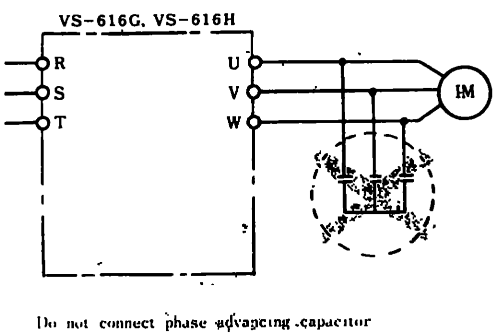


Fig. 10.2 Removal of Phase Advancing Capacitor

10.3 RESIDUAL VOLTAGE AFTER TURNING OFF

Even after turning the power supply off, the electrolytic capacitor retains approximately 300VDC voltage. Don't check the circuit immediately after turning off the power supply, but wait approximately 5 minutes or more.

The residual voltage can be measured across terminals (P) and (N) (Fig. 10.3). Wait until the voltage across (P) and (N) drops below 15V.

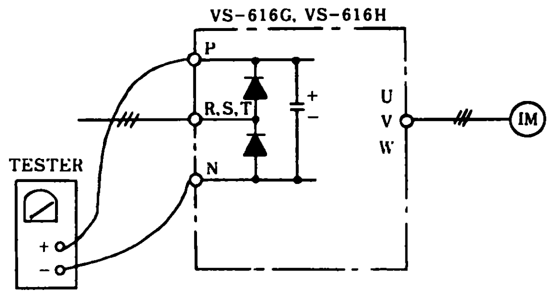


Fig. 10.3 Measurement of Residual Voltage

10.4 NO LOAD OUTPUT VOLTAGE

With the output terminals U, V, and W of the inverter kept open, voltage is output under the following conditions.

(1) When stop signals are on.

(2) While a RUN signal is on, and the frequency setting signal is zero.

(3) While an external base block signal is on.

(4) While base blocking is turned on by a protection function. This voltage is generated by the leak current of the turned off inverter transistors, and becomes zero as soon as the motor is connected (Fig. 10.4).

Note that when a frequency command is given, and in the RUN state, normal voltage is output even while U, V and W are open.

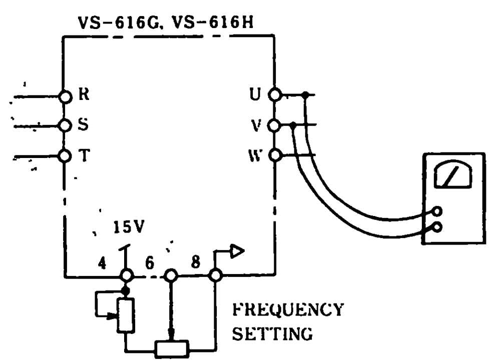


Fig. 10.4 Output Voltage at No-load

11. INSTALLATION AND WIRING

11.1 INSTALLATION LOCATION

Select the installation location where the conditions given below are satisfied. If the temperature is the housing rises above 45°C, force air to cool or expose the cooling fins of the inverter units and maintain the temperature around the exposed fins below 45° C. In this case, the temperature inside the panel enclosure may be allowed to rise up to 55°C.

- The ambient temperature between -10 and +40°C
- The relative humidity below 90%
- Absence of corrosive gas
- Absence of splash of oil or water
- Absence of excessive dust, steel powder, etc. (Use totally enclosed type units where these contaminants are present.)
- Absence of excessive vibration

11.2 INSTALLATION SPACE

To secure the space for opening the control boards for maintenance checks and for cooling effects, give the transistor inverters the space shown in APPENDIX Figs. 7 through 42, and install them vertically for cooling effects.

11.3 INSTALLING INVERTER UNITS IN GASKETED CABINET

When installing inverter units in a totally enclosed control panel cabinet, expose the cooling fins at the rear surface of the inverter units to the outside of the cabinet as shown in Fig. 11.1. This allows the inverter unit to be cooled by the outside air while protecting the units from the adverse ambient conditions by the cabinet.

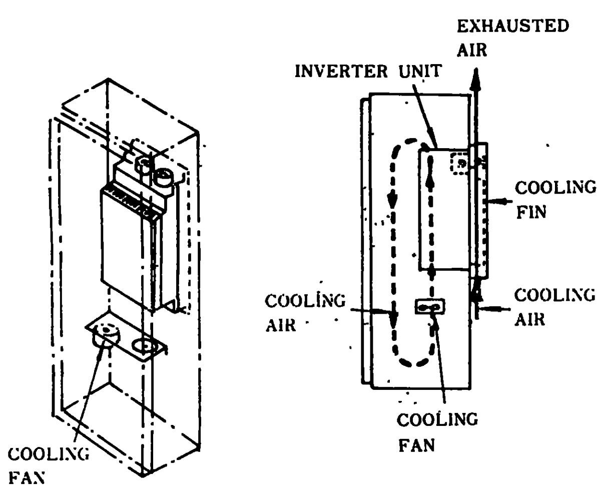


Fig. 11.1 Modification to gasheted Cabinet

11.4 HEAT GENERATION RATE AND COOLING METHOD OF INVERTER UNITS

When installing inverter units in a totally enclosed cabinet, the heat generating rates and the cooling methods listed in Tables 11.1 and 11.2 must be taken into consideration, paying attention to the following.

(1) In addition to the heat generation rate (total heat generation rate with a built-in type inverter unit, and the internal heat generation rate with a totally enclosed unit), also the heat generation rates of peripheral units should be included in the calculation of heat generation rate. Calculation examples are given in Paragraph 11.6.2.

(2) With the built-in type inverter units, determine the cooling fan size on the basis of the total heat generation in the cabinet enclosure, the cooling air flow rate, and the cooling air flow and cooling air pressure loss.

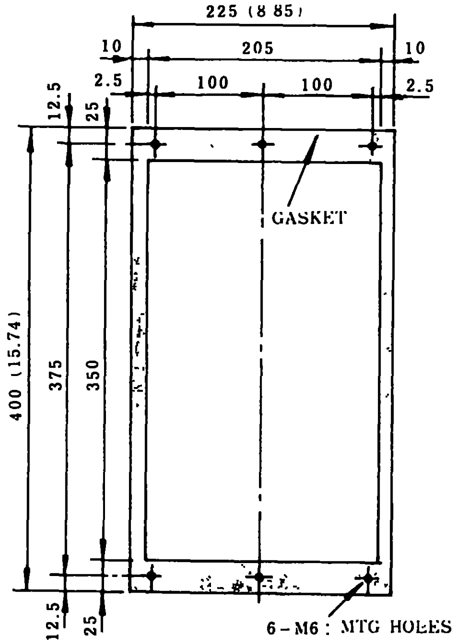
Table 11·1 Generating Heat Quantity and Cooling Method of 200 V Series

VS-616 Capacity kVA		3	5	10	20	30	40	60	70	100
Generating Heat W	Cooling Fin	60	110	215	440	725	1220	1730	3000	4190
	Casing Inside	80	100	205	380	455	580	710	710	710
	Total Generating Heat	140	210	420	820	1180	1800	2440	3710	4900
Cooling	Fin Cooling Method	Self-cooled		Air-cooled					Air-cooled	
	Required Air Flow for Cooling Fin	—	—	3	5	5	8	8	20	20

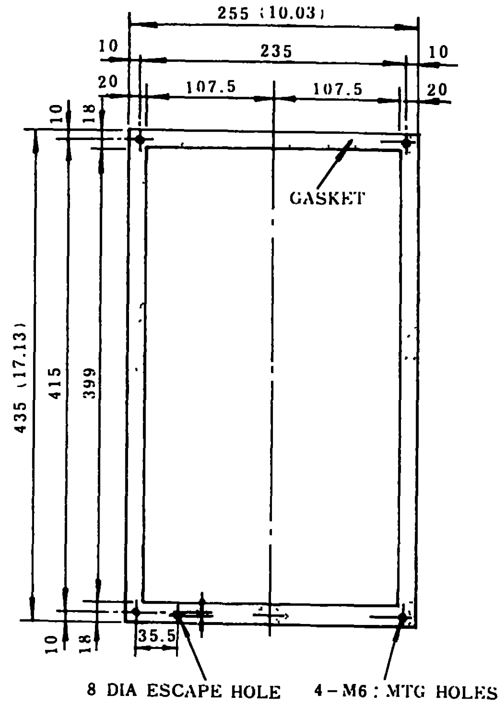
Table 11·2 Generating Heat Quantity and Cooling Method of 400 V Series

VS-616 Capacity kVA		5	10	20	40	60	75	110	140	200
Generating Heat W	Cooling Fin	60	120	255	485	725	1220	1730	2390	4190
	Casing Inside	100	100	215	395	455	580	710	710	710
	Total Generating Heat	160	220	470	880	1180	1800	2440	3100	4900
Cooling	Fin Cooling Method	Self-cooled		Air-cooled					Air-cooled	
	Required Air Flow for Cooling Fin	—	—	3	5	5	8	8	20	20

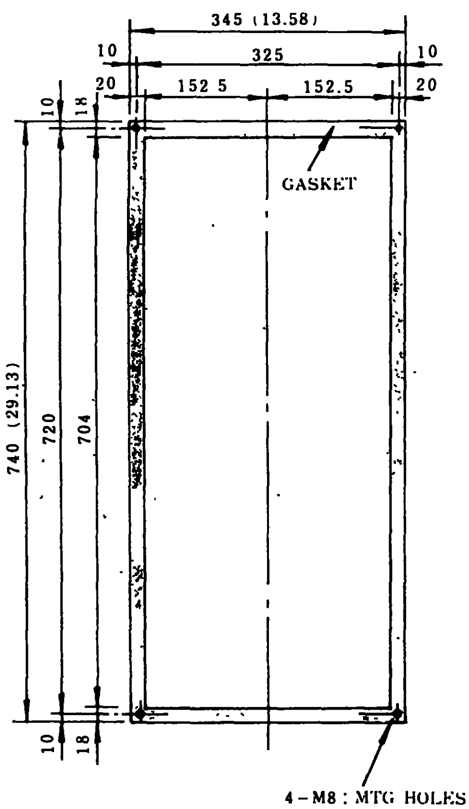
11.5 PANEL CUTTING FOR MODIFICATION TO GASKETED CABINET



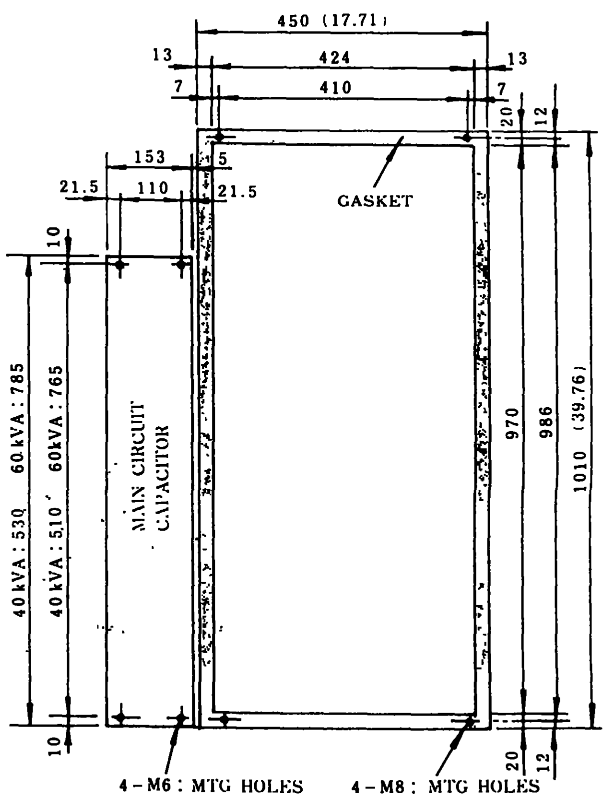
200 V Series 3 kVA, 5 kVA



200 V Series 10 kVA

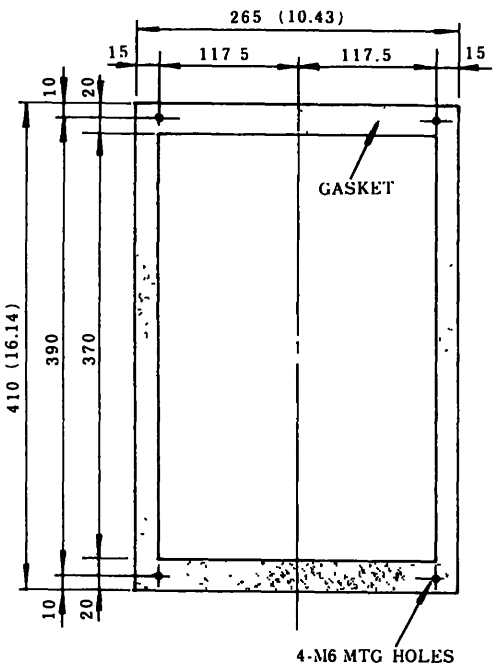


200 V Series 20 kVA, 30 kVA

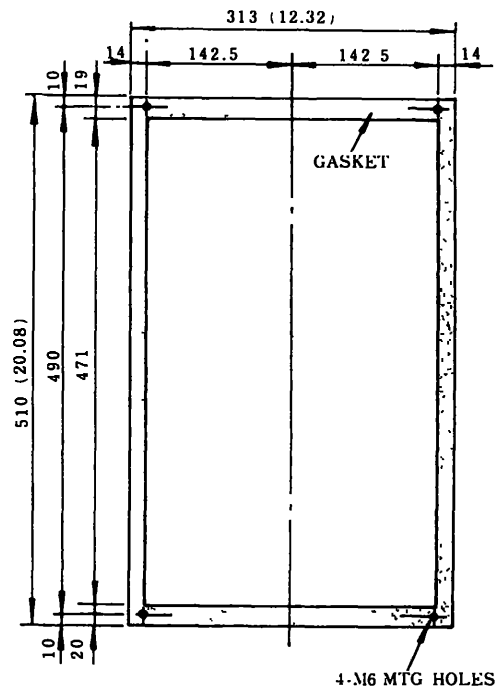


200 V Series 40 kVA, 60 kVA

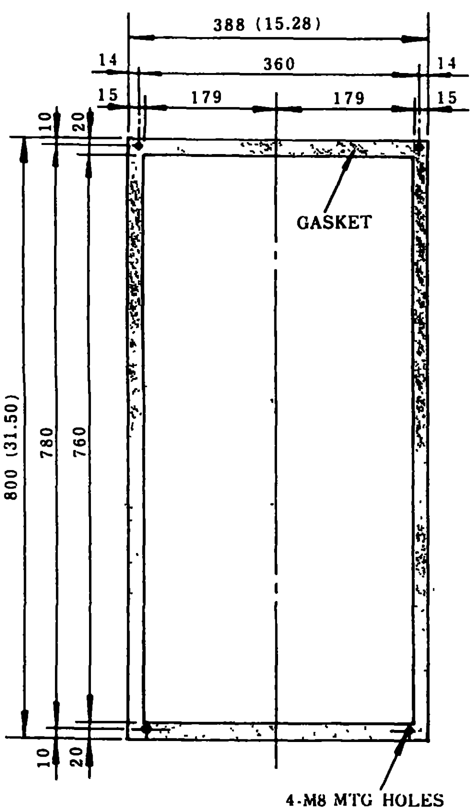
11.5 PANEL CUTTING FOR MODIFICATION TO GASKETED CABINET (Cont'd)



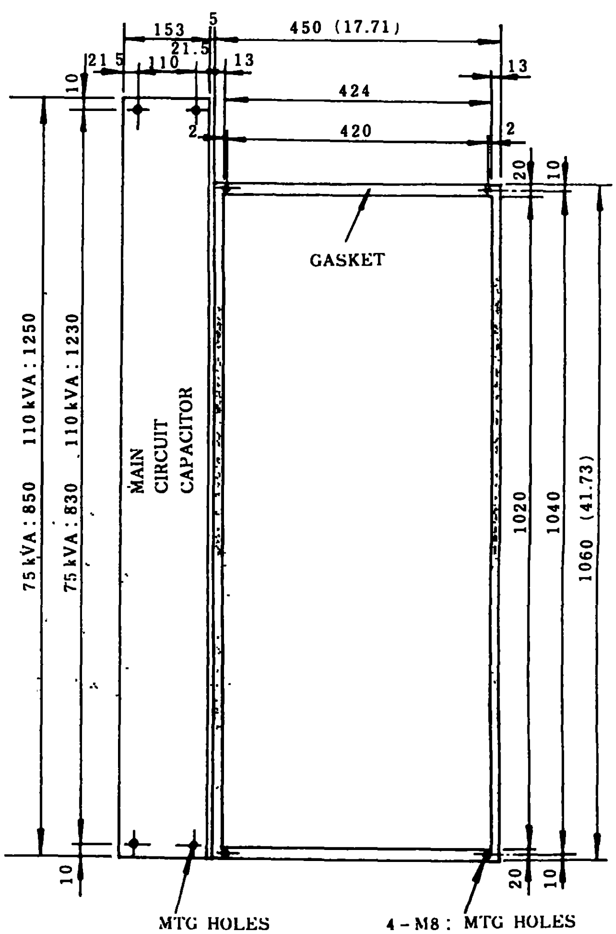
400 V Series 5 kVA, 10 kVA



400 V Series 20 kVA



400 V Series 40 kVA, 60 kVA



400 V Series 75 kVA, 110 kVA

11.6 INSTALLATION IN GASKETED CABINET

11.6.1 Built-in Inverter Unit

The 200V Series 3, 5, 40, and 60kVA units and all the 400V Series units can be installed in a totally enclosed control panel cabinet as shown in Fig. 11.2. For this, remove the air shaft (heat sink) from the inverter unit, mount the unit with the cooling fan extending out through the cutout in the wall of the cabinet and sandwitch the will between the inverter unit and the air shaft with a gasket.

To mount the 200V Series 10, 20, and 30kVA inverter units by this method, an air shaft must be newly made, for that contact our service organization.

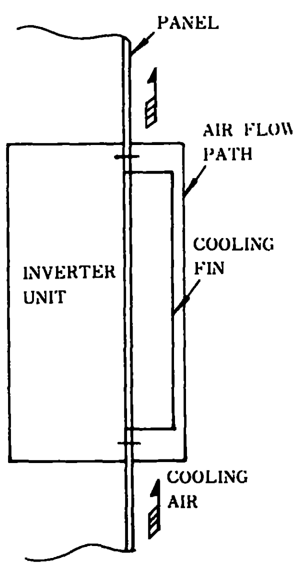


Fig. 11.2 Mounting of Built-in Inverter

11.6.2 Dimensions of Gasketed Cabinet

When installing VS-616 inverter units in a totally enclosed control panel cabinet, its minimum dimension is determined on the basis of the internal heat generation rate and the cabinet surface heat dissipation rate by the following formulas.

$$\Delta T = T_B - Ta \quad \cdots\cdots (1)$$

$$S = \frac{W}{\Delta T \times q} \quad \cdots\cdots (2)$$

where ΔT = Temperature rise in panel cabinet (°C)

T_B = Temperature in panel enclosure (°C).

Ta = Ambient temperature

S = Surface area of cabinet directly in contact with ambient air (m^2)

W = Heat generated within panel cabinet (W)

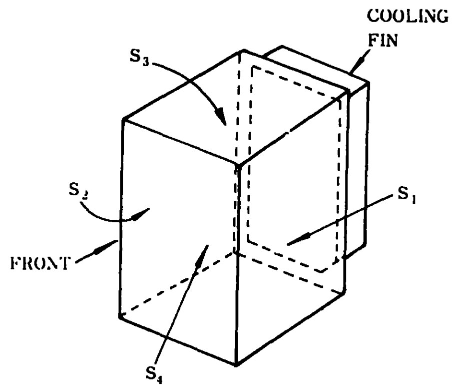
q = Cabinet surface heat dissipation coefficient ($W/°C \cdot m^2$) = $5W/°C \cdot m^2$ (black or nearly black color)

[Example of calculation]

Assumption: Ta = 40°C; T_B = 55°C, W = 150W
From Eq. (1), temperature rise in enclosure
ΔT = 55 - 50 = 15°C

From Eq. (2), cabinet surface area $S = \frac{150}{15 \times 5} = 2\,m^2$

The surface area of the panel cabinet must be at least 2 m^2.



$S = S1 + S2 + S3 + S4$ (Fig. 11.3)

where $S1$ = Right side surface

$S2$ = Left side surface

$S3$ = Top surface

$S4$ = Front door

Note:
1. The bottom and rear surfaces are not taken into calculation, because of the installation requirements and interior units.
2. The permissible temperature in the cabinet in which VS-616 units are installed is 55°C.

Fig. 11.3 Casing Area (S) Calculation

11.6.3 Gasketed Inverter Unit

For information on installing the totally enclosed type VS-616 Inverter units, contact our service organization.

11.7 WIRING

11.7.1 Wire Size

The wire sizes for wiring are given in Table 11.3.

Table 11·3 Lead Size

Circuit	Terminal Symbol	Inverter Series	Inverter Capacity kVA	Lead Size AWG	Lead Size mm²	Terminal Screw	Type of Lead
Main Circuit	ⓇⓈⓉ ⓊⓋⓌ ⒷⓅⓂ	200 V	3 ~ 5	10	3.5~3.5	M 4	Power Cable (600 V Vinyl lead)
			10	8, 6	5.5~14	M 5	
			20	4	14~22	M 8	
			30	2-2/0	22~60	M 8	
			40	2-2/0	30~60	M 8	
			60	1-2/0	38~60	M 8	
			70/100	2/0-4/0	~200	M 12	
		400 V	10	10	3.5~5.5	M 4	
			20	8, 6	5.5~14	M 5	
			40	4	14~22	M 8	
			60	2-2/0	22~60	M 8	
			75	1-2/0	30~60	M 8	
			110	1-2/0	38~60	M 8	
			140/200	2/0-4/0	~200	M 12	
Control Power Circuit	ⓡⓢⓣ	—	—	14-10	2~5.5	M 4	600 V Vinyl lead
External Power Supply Circuit	(r1)(s1)†	—	—	14-10	2~5.5	M 4	600 V Vinyl lead
Frequency Setting Control Command	①~㉒	—	—	20 max	0.5 min	M 4	Shielded lead of Twisted lead

*Main circuit lead should be selected according to current capacity considering ambient temperature and heat resistance of lead.

†External power circuit terminal is provided with 400 V series only.

11.7.2 Wiring Distance

If noise voltage is induced in the frequency command line and control command line, the inverter operation is disturbed. Use shielded wires or twisted wires for these lines, install them apart from the power lines, and limit their length to 100 m. Connect the shielding mesh to the 0V terminals (2), (8) and (12) in Fig. 11.4.

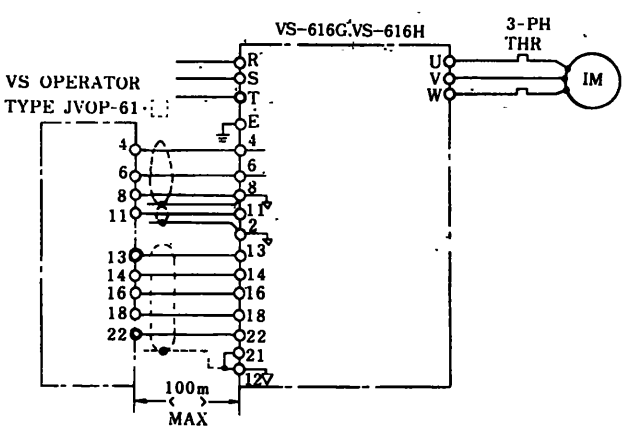


Fig. 11.4 Wiring Distance

11.7.3 Other Cautions

When magnetic contactors are installed in the same panel cabinet with the inverters, connect surge absorbers to the coils of the magnetic contactors. (Refer to 9.2.1)

Install the wires correctly as shown in the system diagrams and standard wiring diagrams.

12. SETTING AND ADJUSTMENT

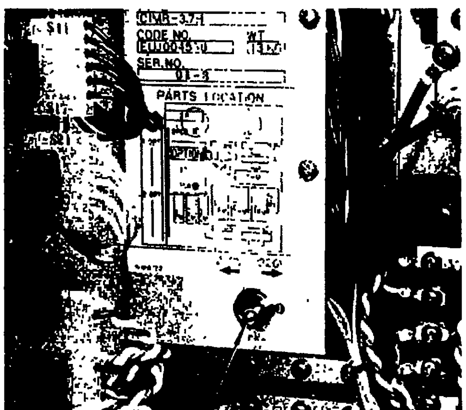
Adjustments required prior to operating the inverters are described in this section.

12.1 INPUT AC POWER SUPPLY

With the 200V Series unit, control power supply select switch [(a) in Fig. 12.1] is switched over, to suit the 200V and 220V (208 - 230V) AC power supply, input at terminals (r), (s) and (t). With the 400V Series unit, re-connect the control power supply select connector ([(b) in Fig. 12.1] according to the voltage 400 or 440V (415 or 460V).

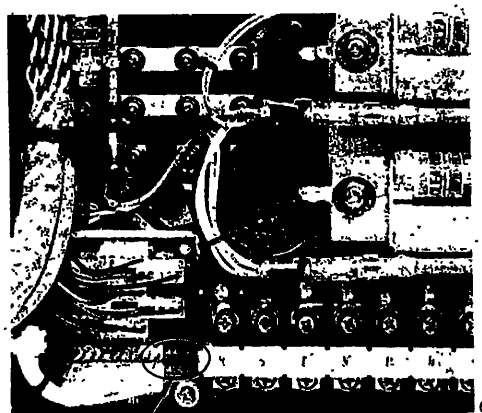
When these settings are correct, the inverters operate properly within a supply voltage fluctuation of ±10%.

Inverters in the 200V Series are set to 220V (230V) when shipped from the factory.
[To access the control power supply select switch, on the control transformer, unscrew the wing nut on the right side wall, and open the control board (Fig. 12.1).]



CONTROL POWER ON/OFF SWITCH

(a) Control power supply select switch for 200V Series



CONTROL POWER VOLTAGE SELECT CONNECTOR

(b) Control power supply select connector for 400V Series

Fig. 12.1 AC Input Power Selection

12.2 INVERTER PERFORMANCE ADJUSTMENT

For optimum operation, the six variable resistors; ACCEL, DECEL, V BIAS, V GAIN, VA COMP and 1RH must be adjusted to suit the operation conditions and load conditions (Fig. 12.2).

The functions of these variable resistors and their setting at the time of shipment from the factory are given in Table 12.1.

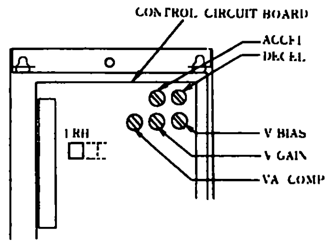


Fig. 12.2 Adjusting Potentiometer

Table 12·1 Potentiometer Function and Characteristics

Potentiometer	Function	Characteristics	Factory-adjusted Value
ACCEL	Acceleration time adjustment	•3 to 30 sec at K selection •0.3 to 3 sec at L selection	5 Scales at K selection
DECEL	Deceleration time adjustment	•3 to 30 sec at K selection •0.3 to 3 sec at L selection	5 Scales at K selection
VA COMP	V/f up during acceleration	0 to +10% voltage compensation	0 Scale
V GAIN	V/f characteristics adjustment	•100% V/41% f to 100% V/100% f at R selection •100% V/29% f to 100% V/100% f at S selection	See Fig. 12.6 (Paint locked)
V BIAS	Bias applied to V/f characteristics	0 to ±20% V	See Fig. 12.6 (Paint locked)
1 RH	Bias applied at 4 to 20 mA of current signal	0 to +30%	0 Scale (Bias: 0)
2 RH	Carrier frequency	•3650 Hz±50 Hz at N, O selection •2160 Hz±30 Hz at M, N selection	2160 Hz at M, N selection
3 RH	Carrier frequency selection		15 Hz, 30 Hz (200 V, 3 to 30 kVA) 9 Hz, 18 Hz (200 V, 40, 60 kVA) 400 V P selection.
4 RH	Bias applied to carrier frequency		Adjusted not to cause an output voltage difference at 15 Hz (9 Hz) of carrier selection.
5 RH	Bias applied to carrier frequency		Adjusted no to cause an output voltage difference at 30 Hz (18 Hz) of carrier selection.
6 RH	Overload protecting operation level	100 to 110% inverter rated current available	107% rated current
7 RH	Current limit level at AC	—	—
8 RH	Low voltage or open phase detecting level	-20 to -12% detecting level available	83% rated voltage
9 RH	Overload protecting operation time	—	OL functioned after 60 to 70 sec at 150% rated current
10 RH	Antihunting circuit operation level	—	—
STL	Stall protection level	60 to 250% inverter rated current available	165% rated current

* For VS-616H rated 200 V, 40 to 100 kVA, 400 V, 5 to 200 kVA, STL potentiometer is located on the base drive PCB.
Note: Potentiometers shown in ▭ have been factory-adjusted before shipping. They should not be readjusted in user's field.

12.3 DEFINITION OF ACCEL AND DECEL

The time required for the motor speed to increase from zero to the goal speed is referred to as ACCEL time*, and that from the goal speed to zero is refered to as DECEL time.

When the motor is driven in the reverse direction with an H Series inverter, also, ACCEL time is for speed increase in the reverse direction, and DECEL time is for speed decrease in the reverse direction (Fig. 12.3).

Time for the command voltage to rise from 0V to 100%.

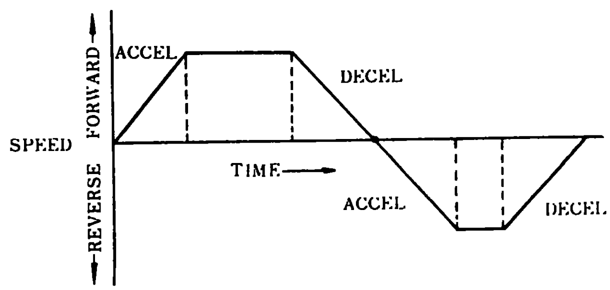


Fig. 12.3 Acceleration and Deceleration

12.4 ACCEL ADJUSTMENT

Adjust the ACCEL VR knob to the desired acceleration time. If the motor pulls out of control and is not accelerated, due to large load torque, adjust the V/f characteristics (12.6), and VA COMP (12.7). If the load torque is still too large to be accelerated, adjust the ACCEL time longer (Figs. 12.4 and 12.5).

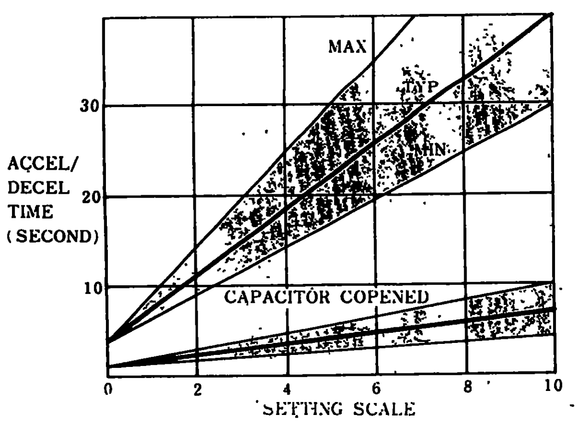


Fig. 12.4 Accel/Decel Characteristics Setting of G Series

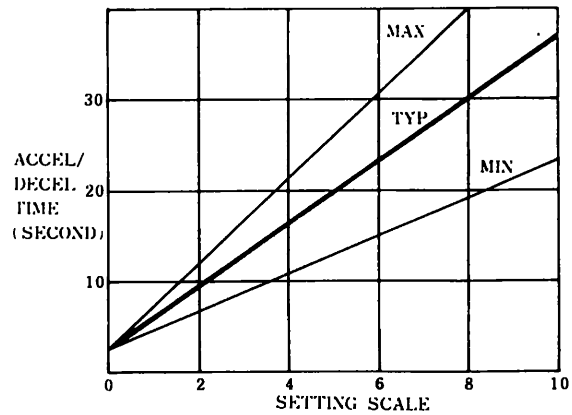


Fig. 12.5 Accel/Decel Characteristics Setting of H Series

12.5 DECEL ADJUSTMENT

Adjust the DECEL knob to the desired deceleration time. If the motor regenerative energy is too large to apply overvoltage (OV lamp on) to the inverter, take corrective measure given in Table 12.2.

Table 12·2 Corrective Actions for Overvoltage

Series	Corrective Action
G series H series without Braking Function	Adjust deceleration time to the range which may not cause overvoltage (0 V).
H series with Braking Function	Connect the braking resistor unit, shown in Table 14·3 on page 53, across terminals Ⓑ and Ⓟ. If overvoltage (0 V) occurs, extend the decel time. For changing braking resistor unit, contact the Yaskawa representative.

12.6 ADJUSTING V/f CHARACTERISTICS

The VS-616 inverter is adjusted to the standard V/f characteristics shown in Fig. 12.6, with the motor torque at 6Hz adjusted to approximately 50%, and the motor voltage at 60Hz to 100%.
V BIAS clockwise, and V GAIN counterclockwise to obtain the characteristic as shown in Fig. 12.7. In this case, take care not to overheat the motor.

To drive standard squirrel-cage 4-pole motors at speeds above 60Hz with an H Series inverter, 120Hz is the upper limit. When the output frequency selection is changed according to Table 12.3, the V/f characteristics are automatically modified to the dash line in Fig. 12.9.
To use the full extent of the rated motor torque, turn V GAIN clockwise and V BIAS counterclockwise to obtain the V/f characteristics respresented by the solid line.

To use at speeds above 120Hz, special motors are required. For these motors, specify the motor characteristics and we will deliver motors with specially adjusted V/f characteristics.

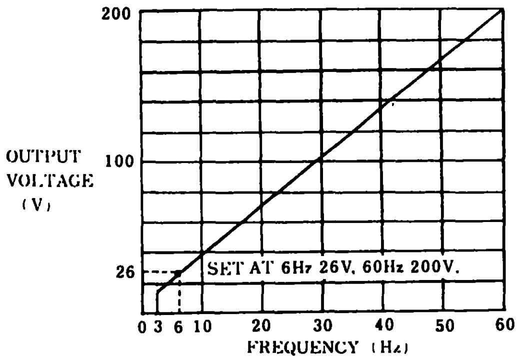


Fig. 12.6 Standard V/f Characteristic Setting

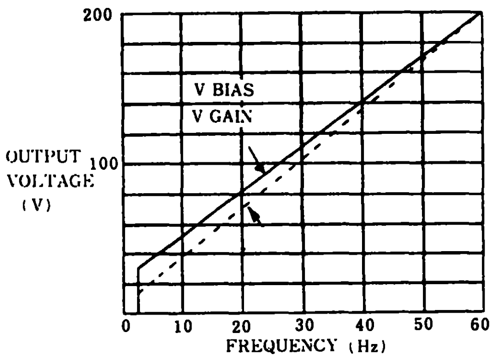


Fig. 12.7 Adjusting of Torque at Low Speed

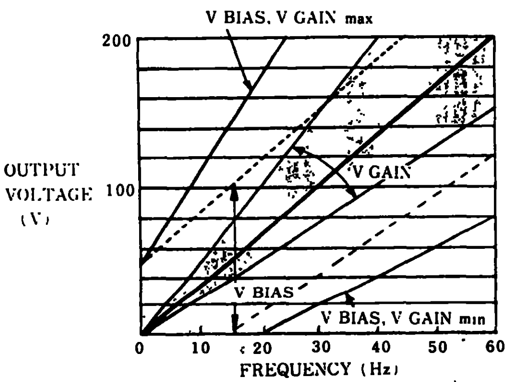


Fig. 12.8 Adjustable Range of V/f Characteristics

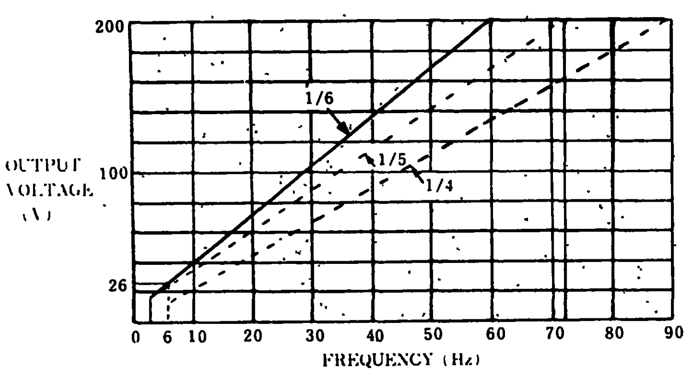


Fig. 12.9 Adjustable Range of V/f Characteristics at Operation at 60 Hz or above

12.7 TORQUE COMPENSATION FOR ACCELERATION (VA COMP)

When the load inertia is large, and extra large torque is required for acceleration, turn VA COMP clockwise. The V/f characteristics are automatically compensated during acceleration as shown in Fig. 12.10 to give large torque.

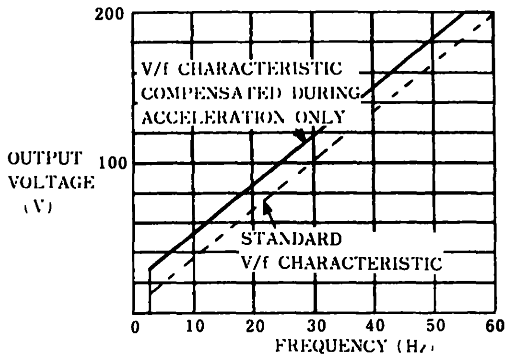


Fig. 12.10 VA COMP Characteristics

12.8 1RH ADJUSTMENT

This adjustment is for biasing current signal. Its adjustment is as follows.

- Connect a current signal source and a voltmeter as shown in Fig. 12.11.
- Change the setting of the shunt connector as follows:
  Set A-B selector to B (6V/100%)
  Set T-U selector to T (current signal input)
- Input 4mA current signal, and turn 1RH (current signal bias) from 0 in the clockwise direction until the voltmeter comes to indicate 0V.

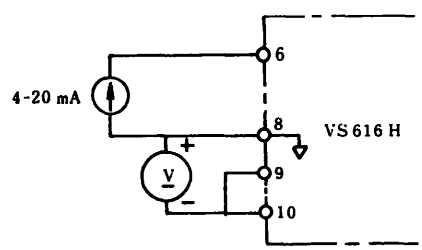


Fig. 12.11 Adjusting at Current Signal

12.9 ADJUSTING OVERLOAD OPERATION LEVEL

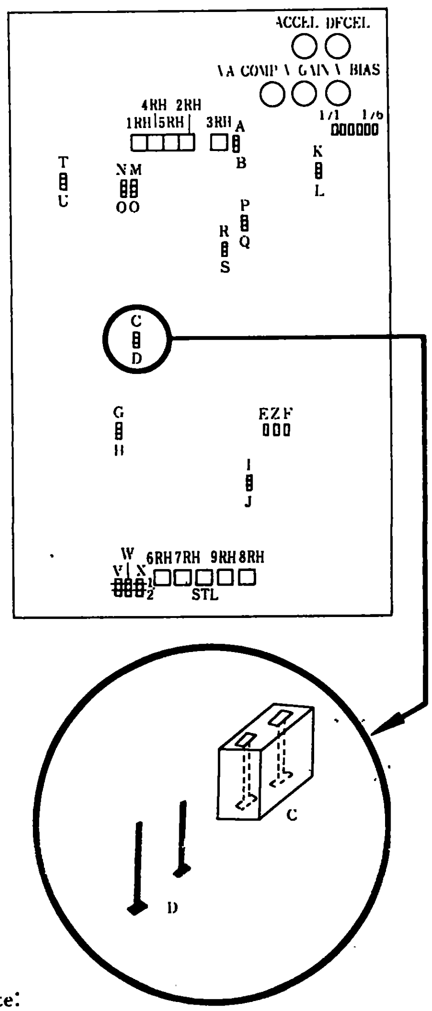
When driving motors smaller in capacity than the maximum applicable capacity of the VS-616H unit used, reset shunt connectors V, W, and X for correct protective coordination (Table 13.3).

For example, when a 2.2kW motor is driven by a CIMR-3.7H (for 5kVA, 3.7kW) inverter, the overload operation level (L) is 2.2kW/3.7kW = 59%. To correct protective coordination, change the setting from V2, W2, X2 (standard) to V1, W1, X2.

12.10 SELECTION OF SHUNT CONNECTOR

For optimum drive performance with wide ranges of applications, the Series H inverters are provided with selection shunt connectors.

Fig. 12.12 shows their layout, and Table 12.3 gives their selective functions.



Note:
1. Shown connector is for VS-616H, 200V series, 3 to 30 kVA.
2. For 200V series, 40, 60kVA and 400V series, 10RH is added and STL is located, on the base drive circuit board.

Fig. 12.12 Shunt Connector Location

Table 12·3 Selection of Function and Characteristic by Shunt Connector

Connector Function Name	Terminal Symbol	Function and Characteristic	Factory Setting
Frequency Input Level (Terms ⑥~⑧)	A	10 V/100 %	A
	B	6 V/100 %	
Stopping	C	Motor is free-running and stopped with STOP signal.	D
	D	Frequency decreases with power off.	
Pulse Selection for Frequency Monitor (Terms ⑲~⑳)	E	Output frequency of VS-616 H	F
	F	6 N times the frequency of VS-616 H	
	Z	6 times the frequency of VS-616 H	
External Base Block Input (Term ⑰)	G	Base blocked to light failure lamp and outputs relay contact.	G
	H	Base blocked	
Overvoltage Protection (0 V)	I	Overvoltage, if occurs, stops VS-616 H	I
	J	After overvoltage is released, normal operation is automatically resumed. (200 V, 3-30 kVA)	
Accel/Decel Time Range Selection	K	3-30 seconds	K
	L	0.3-3 seconds	
Carrier Frequency Range Selection	N, O	3650 Hz ± 50 Hz	M, N
	M, N	2160 Hz ± 30 Hz	
Carrier Selection	P	f=15 Hz, 30 Hz selection (200 V, 3-30 kVA) f=9 Hz, 18 Hz selection (200 V, 40, 60 kVA, 400 V series)	P
	Q	f=7 Hz, 15 Hz selection (200 V, 3-30 kVA) f=5 Hz, 9 Hz selection (200 V, 40, 60 kVA, 400 V series)	
V GAIN Adjustable Range	R	100%V/41%f−70%V/100%f	R
	S	100%V/29%f−100%V/100%f	
Command Signal	T	4-20 mA Current signal input	U
	U	Voltage signal input	
Overload Operation Level (OL)	V_1, W_1, X_1	25 % Inverter rating	V_2, W_2, X_2
	V_1, W_1, X_2	50 % Inverter rating	
	V_1, W_2, X_2	75 % Inverter rating	
	V_2, W_2, X_2	100 % Inverter rating (factory setting)	
Output Frequency	1/1	Rated frequency 360 Hz	1/6
	1/2	Rated frequency 180 Hz	
	1/3	Rated frequency 120 Hz	
	1/4	Rated frequency 90 Hz	
	1/5	Rated frequency 72 Hz	
	1/6	Rated frequency 60 Hz	

*N is the frequency-devided-ratio. (N=1 to 6)
For frequency other than 60 Hz, V/f characteristic should be changed. Then for over 120 Hz, examine the applicable motor characteristics.

13. OPERATION, ADJUSTMENT, MAINTENANCE

13.1 CHECK BEFORE ENERGIZATION

Upon completion of the installation and wiring, make the following checks before energization to ensure safety.

(1) Wrong wiring

Check the numbers on the main circuit terminals, and numbers on the PC board next to the control circuit terminals. Don't check the wired control circuit with a buzzer.

(2) Check the terminals for positive wire connection.

(3) Check the motor and the load machines for readiness for operation.

(4) Unscrew the wing nut on the right side to open the control board, and check the following:

- Control power supply select switch for correct setting to the supply voltage
- Fuse for secure mounting.
- Main circuit parts mounting screws for tightness
- Connectors for proper plugging (Five on base drive board, three on control board)
- Main circuit components for freedom from foreign objects (nuts, washer, screws, lead wire fragments)

(5) Option cards for H Series (if any) for correct mounting location and wiring connector plugging.

(6) The grounding terminal correctly wired? Measure the resistance across the external terminals and the grounding terminal one by one with a multimeter ($\times 10^3$ range), and reading should be ∞

(7) The variable resistors on the control board for correct setting

(8) Adjust the MTR ADJ on the VS Operator so that the voltage for the maximum frequency setting is correctly indicated by the frequency meter. The relationship between command voltage and frequency is shown in Fig. 13.3. Set the frequency meter according to this relationship. Never test the insulation resistance and dielectric strength of the inverter. To test the insulation resistance of the motor, be sure to disconnect the output wires from the inverter terminals U, V and W.

13.2 ADJUSTMENT OF VS OPERATOR

Fig. 13.1 shows the exterior view of the VS Operator. The VS Operator is provided with frequency setting knob FREQ SET and a frequency meter adjuster knob MTR ADJ. Check their correct setting before starting test run as follows:

(1) Connect the VS Operator to the inverter with wires correctly.

(2) Disconnect the motor from the inverter.

(3) Input the main power supply by closing the magnetic switch.

(4) Throw the OPERATION switch to RUN, and turn the FREQ SET knob fully clockwise to HIGH.

(5) Measure and check the voltage across inverter signal terminals (6) and (8) with a DC voltmeter for 10V.

(6) If the voltage is not 10V, turn off the power supply once, open the face plate of the VS operator, and hook it to the left hinge of the case as shown in Fig. 13.2.

(7) Turn variable resistor 1RH in the VS Operator until the voltage across terminals (6) and (8) becomes 10VDC (60 Hz) or 8.3VDC (50 Hz) (Fig. 13.3). The VS Operator is set for the maximum frequency.

Fig. 13.1 VS Operator

Fig. 13.2 VS Operator Internal IRH

13.2 ADJUSTMENT OF VS OPERATOR (Cont'd)

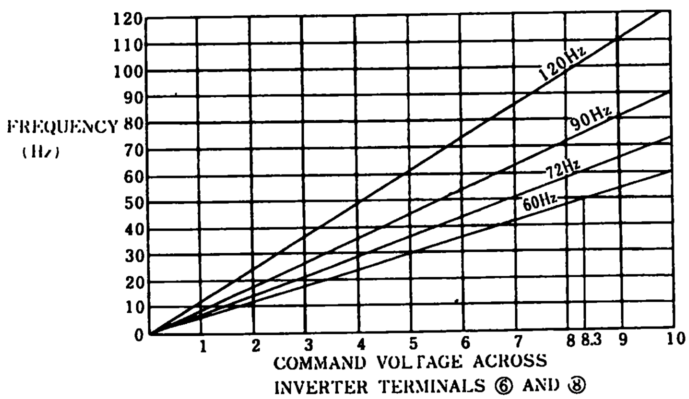


Fig. 13.3 Frequency Meter Correction

13.3 TEST RUN

The test run procedure for a system consisting of a VS Operator, a transistor inverter, and a motor (Fig. 3.1) is as follows. More complicated systems may be tested similarly.

(1) Make sure that the motor is separated from the load machine.

(2) Make sure the system is free from obstructions.

(3) Notify the starting of operation to the personnel in the neighborhood.

(4) Turn the FREQ SET knob to LOW (fully CCW).

(5) Set the OPERATION switch to STOP.

(6) With a VS Operator of the model JVOP-62 or 64, turn off the power supply switch on the VS Operator

(7) Close the MCB for the VS-616H main power supply. Check the SOURCE lamp for lighting.

(8) With a Model JVOP-62 or 64 VS Operator, turn on the power supply switch on the operator. Check READY for lighting.

(9) With FREQ SET left at LOW, flip the OPERATION switch to RUN.

(10) Turn the FREQ SET knob slowly clockwise. As the motor starts to run, check the run direction. If the direction is wrong, turn off the power supply once, and reconnect any two of the terminals U, V and W of VS-616H.

(11) Turn the FREQ SET knob slowly in the LOW direction, and check for smooth deceleration of the motor.

(12) Repeat accelerating and decelerating the motor by turning the FREQ SET knob CW and CCW, and make sure that the fault indicator lamps OL, OV, OC, and FU remain off.

(13) Adjust ACCEL and DECEL to the optimum settings.

(14) Adjust V BIAS, V GAIN and VA COMP. (Normally, the adjustment at the time of shipment need not be changed.)

(15) To stop, flip the OPERATION switch to STOP. To start the motor in the preset mode, follow the processes (1) through (8), and then, set FREQ SET as the 9th process, and then, flip the OPERATION switch to RUN. The motor is star d and accelerated to the preset level.

13.4 PERIODICAL CHECKS

The VS-616 inverters are designed for high reliability with ICs and power transistors and other semiconductor elements, and are almost maintenance-free. For normsl carefree operation, make the following check once in 3 months or so.

(1) Remove dust in the inverter interior.

(2) Check the terminal screws and fuse holders, and tighten if loose.

(3) Check all parts for defects (damage, wire breakage).

(4) Check the cooling fan (only with 10kVA or larger H Series units) for abnormal noise and vibration. (The service life of the fan is 10,0' hours. Have a spare ready, and replace in ti. .)

(5) Don't test the insulation resistance with a megger.

(6) When storing or keeping the inverters out of operation for a long period of time, check the operation once in half a year for operation. The high voltage, large capacity electrolytic capacitors used in the circuit are prevented from aging by charging once in a while.

13.5 MEASURING POINT AND INSTRUMENT

Since the VS-616 transistor inverters utilize the PWM control mode, unless specified instruments are used, correct measurement can not be made.

The measuring points and the measuring instruments are shown in Fig. 13.1 and Table 13.1.

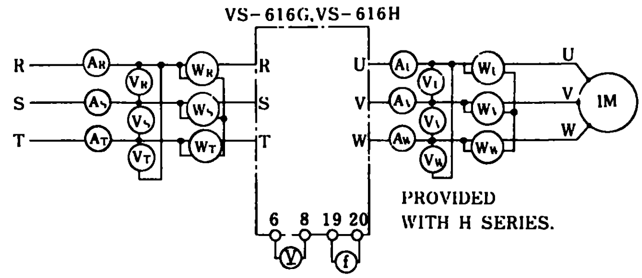


Fig. 13.4 Points for Measurement

Table 13·1 Measuring Points and Instruments

Item	Points	Instrument	Note
Supply Voltage V_1	Across R-S, S-T, T-R V_R V_S V_T	Moving-iron type, or rectifier type voltmeter	—
Power Supply Current I_1	Line current R, S, T A_R A_S A_T	Moving coil type	—
Power Supply Power* P_1	R, S, T and across R-S, S-T, T-R W_R W_S W_T	Electrodynamometer type; Use 3 identical single-phase meters.	$P_1 = W_R + W_S + W_T$
Power Supply Power Factor Pf_1	Calculate from measured supply voltage, supply current, and supply power. $Pf_1 = \frac{P_2}{\sqrt{3} V_1 I_1} \times 100$ (%)		
Output Voltage V_2	Across U-V, V-W, W-U V_U V_V V_W	Rectifier type (YOKOGAWA 2017 or equivalent) Moving iron type can not be used.	300 V full scale for 200 V circuit. 1000 V full scale for 400 V circuit.
Output Current I_2	Line current at U, V, W A_U A_V A_W	Moving iron type	—
Output Current P_2	U, V, W and across U-V, V-W, W-U W_U W_V W_W	Electrodynamometer type, Three identical rating single-phase meters are used.	$P_2 = W_U + W_V + W_W$
Output Power Factor Pf_2	Calculate same as power factor on supply side. $Pf_2 = \frac{P_2}{\sqrt{3} V_2 I_2} \times 100$ (%) —		
Frequency Setting Signal	Across (6)−(8) Across (7)−(8)	Moving coil type (H Series only) (Multimeter is OK)	—
Frequency Monitor	Across (19)−(20)	Frequency counter	See 6·10 on page 24.

* To measure the power, use the power meter incorporating a hall generator: HIOKI TYPE 316 Power meter (made by HIOKI Electric).
Note:
When a 400 V Series inverter is installed in a control panel cabinet, and a voltmeter is to be mounted on the panel surface, the following instruments are recommended. Voltmeter: SCF-12N, 600/150 V, TOYOKEIKI (YASKAWA CODE: VM000502) or equivalent. Instument transformer: UPN-15B, 440/110 V 15 VA (YASKAWA CODE: PT000084)

The output voltage (V_U), (V_V), (V_W) is measured with a YOKOGAWA 2017 (rectifier type) voltmeter before shipping.

Fig. 13.5 shows an example of actually measured output voltage. The two different rectifyer type instruments are giving different readings, what requires careful attention.

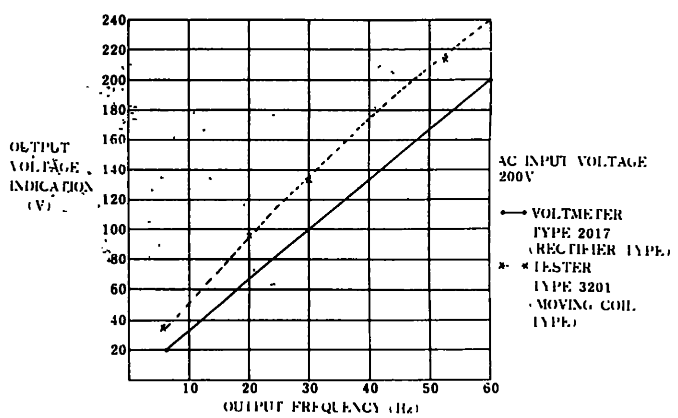
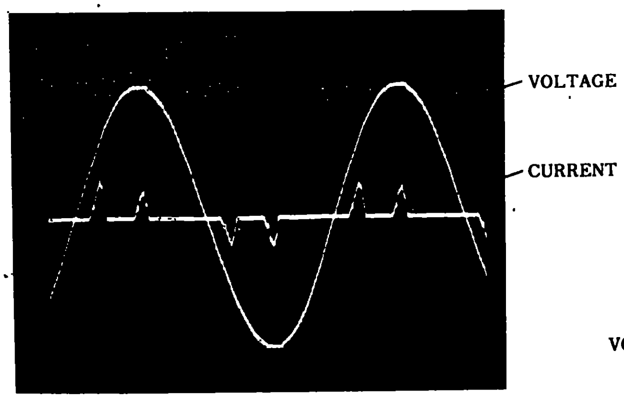


Fig. 13.5 Output Voltage Measurement

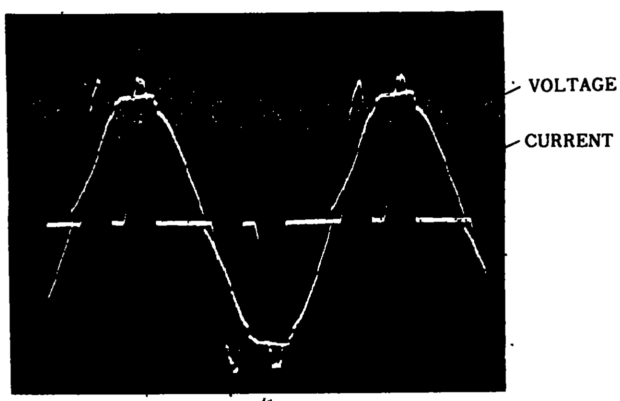
13.6 INPUT VOLTAGE, CURRENT WAVEFORMS

(Figs. 13.6 and 13.7: Example from VS-616G)



Input Voltage	209 V (Phase R-T)
Input Current	3.3 A (Phase R)
Input Frequency	60 Hz
Output Frequency	60 Hz
Output Current	2.7 A (No load)
Output Voltage	209 V
Voltage	100 V/DIV
Current	10 A/DIV

Fig. 13.6 Input Voltage and Current Waveform at No-load

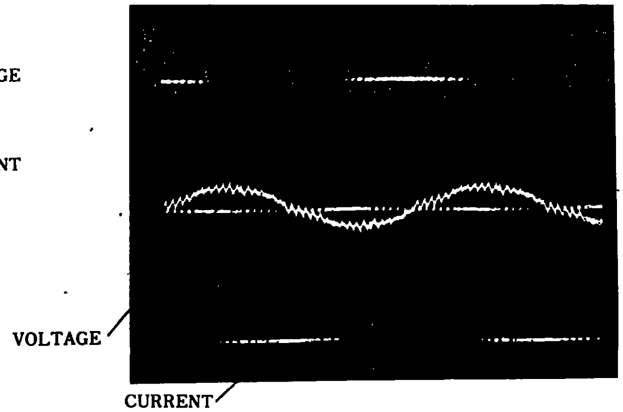


Input Voltage	206 V (Phase R-T)
Input Current	16.6 A (Phase R)
Input Freuquecy	60 Hz.
Output Frequency	60 Hz
Output Current	15 A (100% load)
Voltage	100 V/DIV
Current	10 A/DIV

Fig. 13.7 Input Voltage and Current Waveform at Rated Load

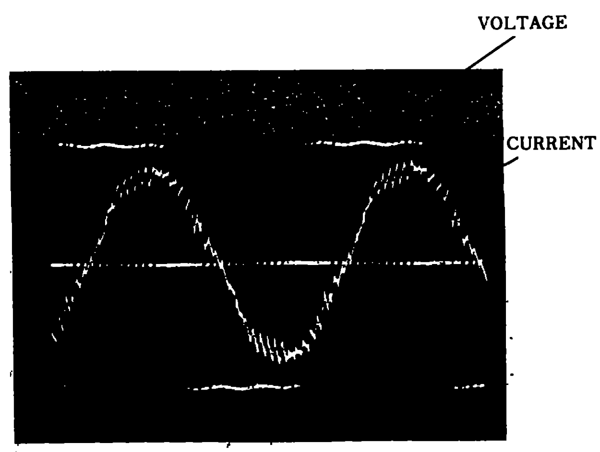
13.7 OUTPUT VOLTAGE, CURRENT WAVEFORMS

(Figs. 13.8, 13.9: Example from VS-616G)



Input Voltage	209 V
Input Current	3.3 A
Input Frequency	60 Hz
Output Frequency	60 Hz
Output Current	2.1 A (Phase R)
Output Voltage	209 V (Phase R-S)
Voltage	100 V/DIV
Current	10 A/DIV

Fig. 13.8 Output Voltage and Current Waveform at No-load



Input Voltage	207 V
Input Current	16.9 A
Input Frequency	60 Hz
Output Frequency	60 Hz
Output Current	15 A (Phase R)
Output Voltage	207 V (Phase R-S)
Voltage	100 V/DIV
Current	10 A/DIV

Fig. 13.9 Output Voltage and Current Waveform at Rated Load

13.8 FAULT INDICATION

When one of the protection functions of the inverter operates, the corresponding fault indicator LED lights. The names and the functions of the fault indicator lamps are given in Table 13.2.

When the fuse blow indicator lights, eliminate the cause before restarting. If only the fuse is replaced, and restarted, the control circuit may be damaged. To reset the operated proetction functions, do the following (Fig. 13.10).

Table 13·2 Failure Indication Lights

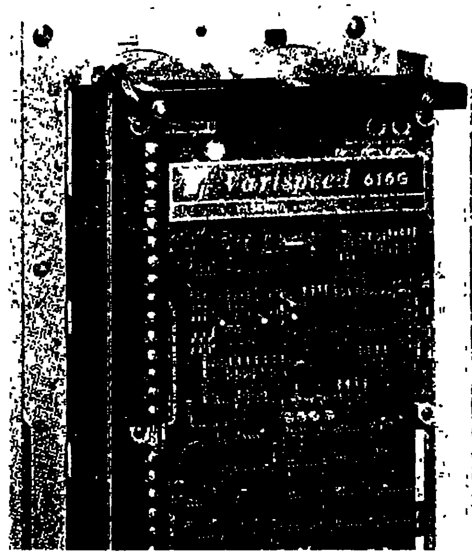
Indication	Series	Function	Reset
FU	G, H	ON by fuse blown.	Maintained
OL	H	ON by overload (For 1 minute of 150% rated current).	Maintained
OV	G, H	ON by overvoltage of DC voltage. (Inverter stops ot 395 V or more or at 770 V or more) across terms P and N.	G series: Spring return H series* Spring return or maintained type selectable
OC	G, H	ON by transistor over-current.	Maintained
UV/OH/EXT	H	For shunt connector G, block input to term ⑰ turns light ON. Low voltage or cooling fin, turns light ON, when heated.	Spring return

*Inverters 200 V, 40-100 kVA and 400 V, 5-200 kVA have maintained contacts.

G Series: Input an external reset signal (terminal 18) or turn off power supply once, and turn on again.

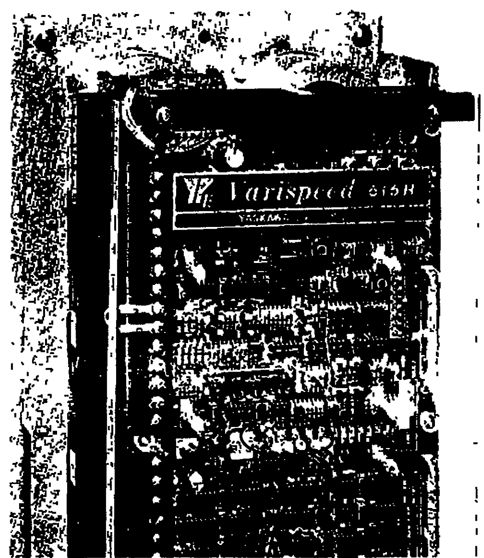
H Series: Input an external reset signal (terminal 18) or push RESET switch on control board, or turn off power supply once and turn on again.

When these fault indicator lamps are turned on, check the cause following the flow charts on the next page.



683-238

(a) VS-616G Series



683-222

RESET SWITCH

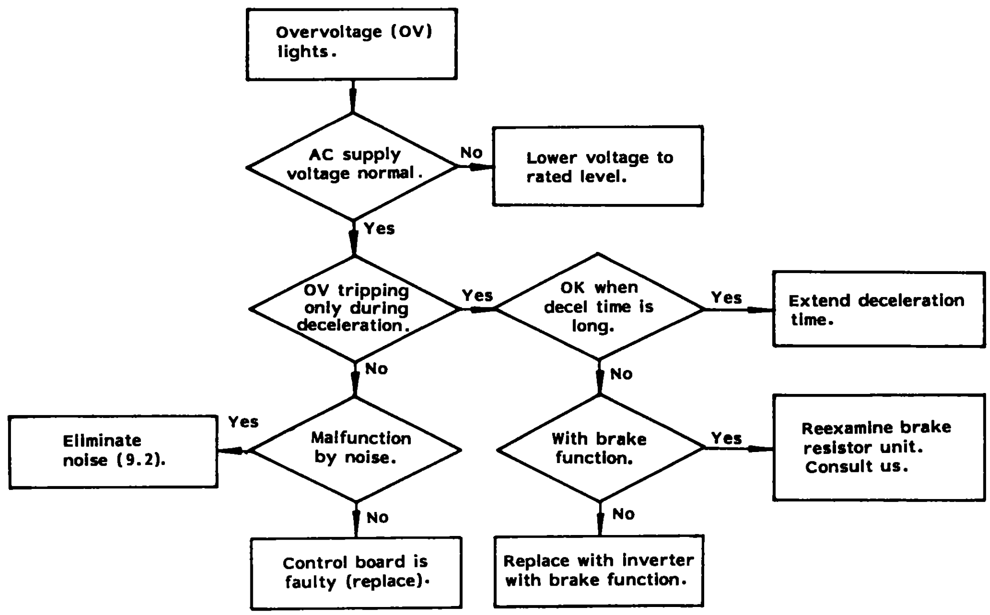
FAILURE INDICATOR

(b) VS-616H Series

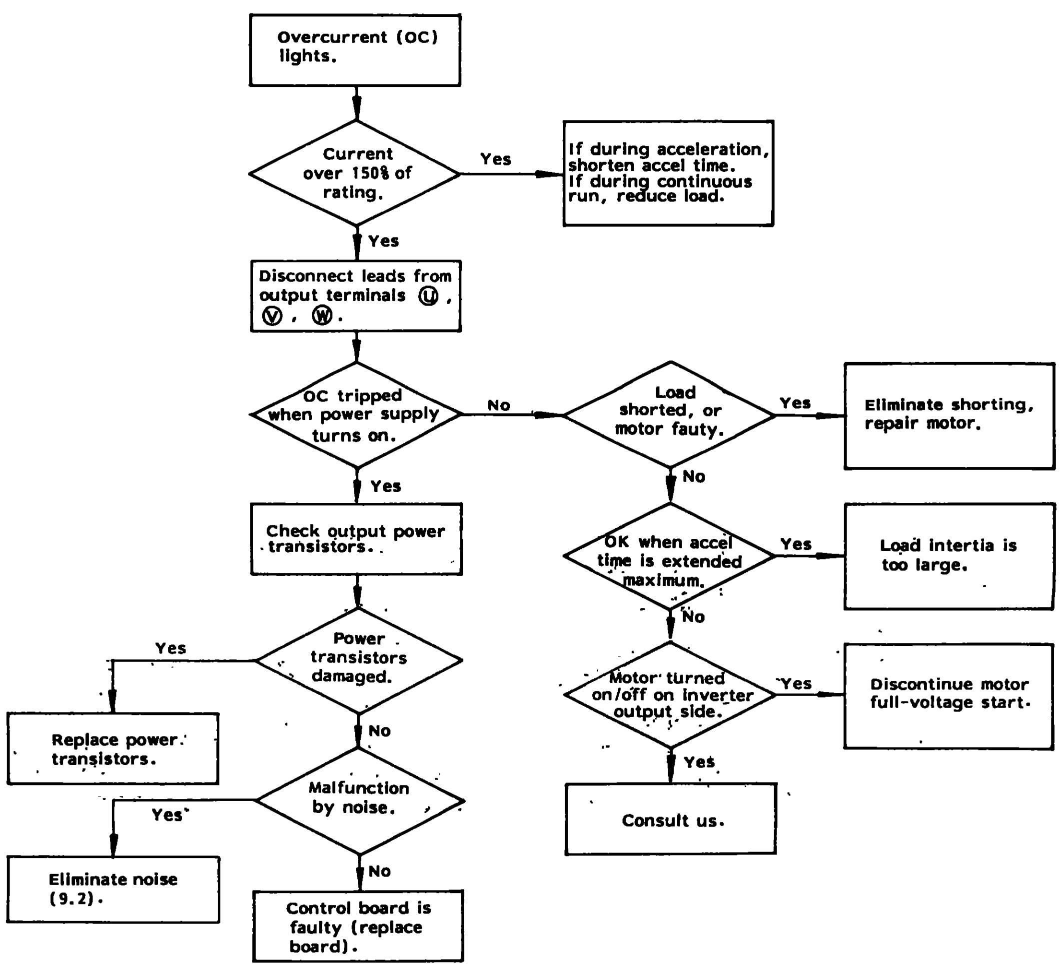
Fig. 13.10 Reset Switch and Failure Indicator Location

13.8 FAULT INDICATION (Cont'd)

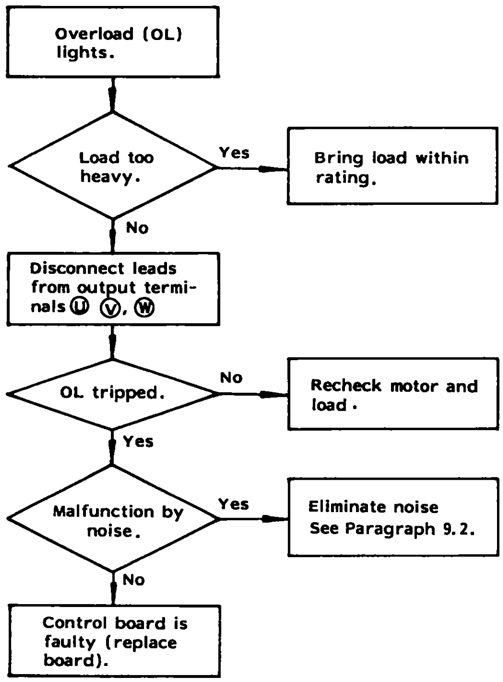
(1) Overvoltage (OV) is turned on:



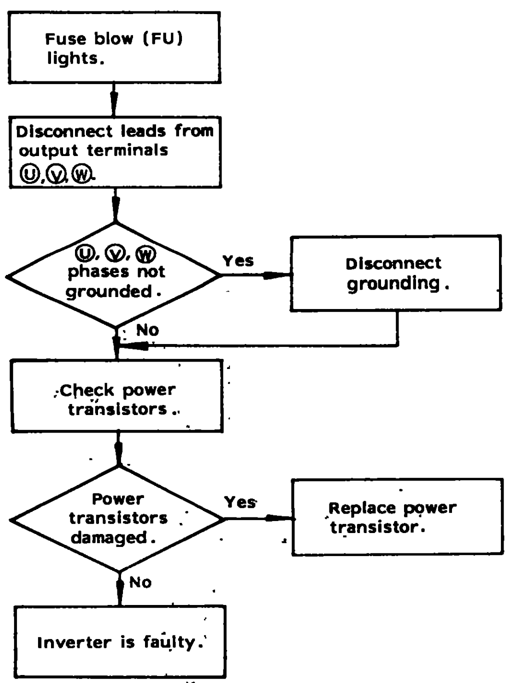
(2) Overcurrent (OC) is turned on:



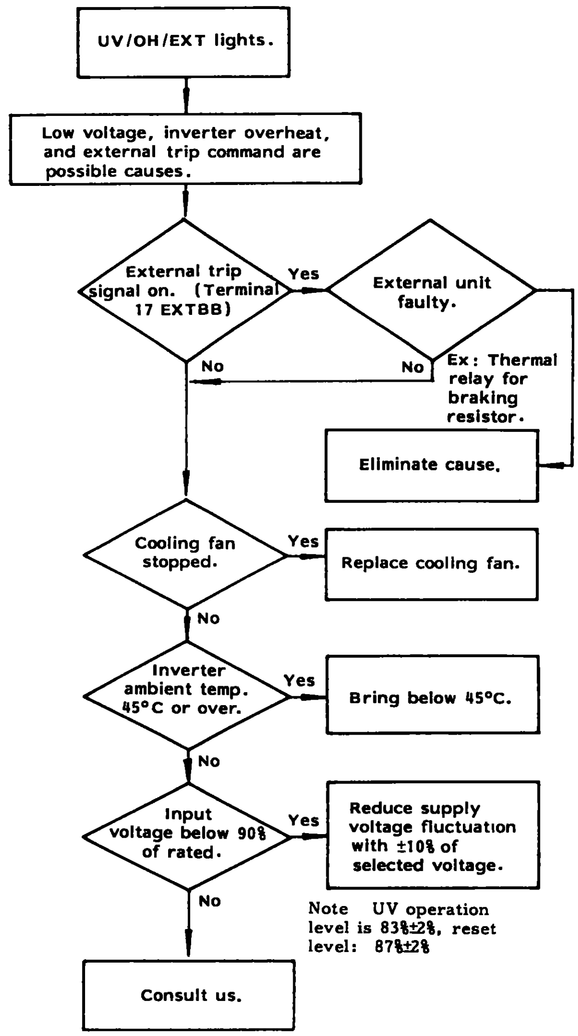
(3) Overload (OL) is turned on:



(4) Fuse blow (FU) is turned on:
When the fuse blows, be sure to check the power transistor, even when the cause is on the load side.



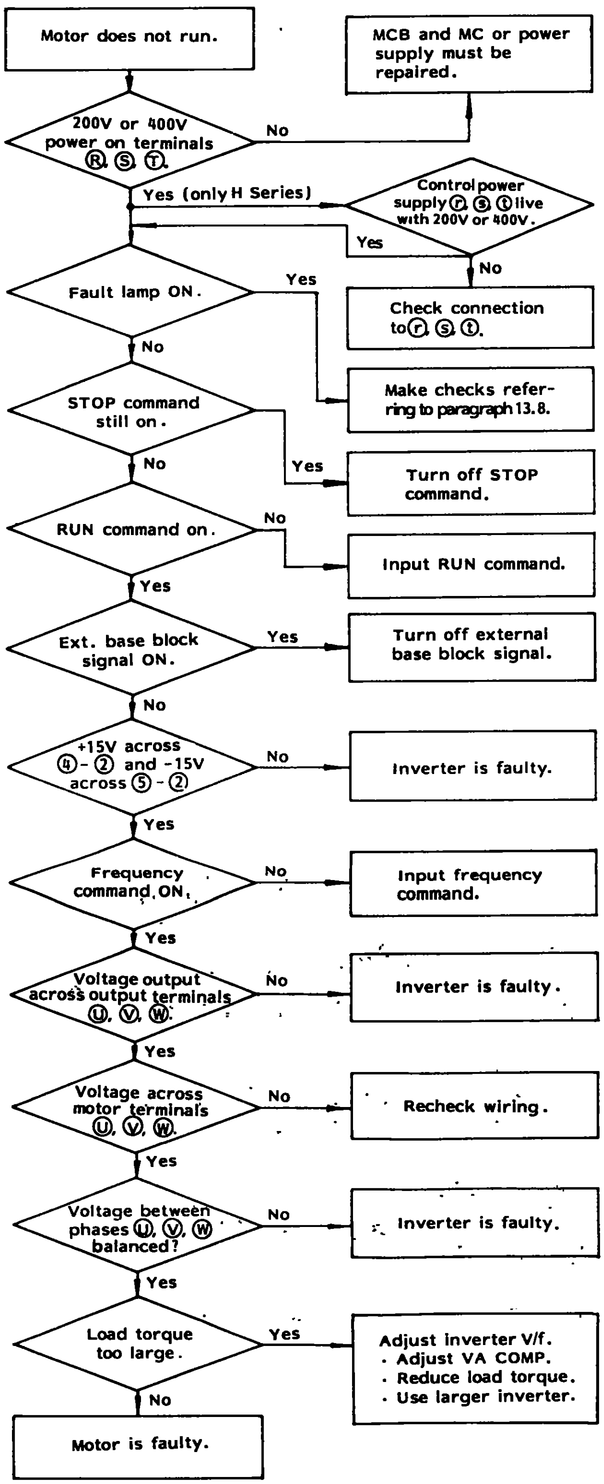
(5) UV/OH/EXT are turned on:



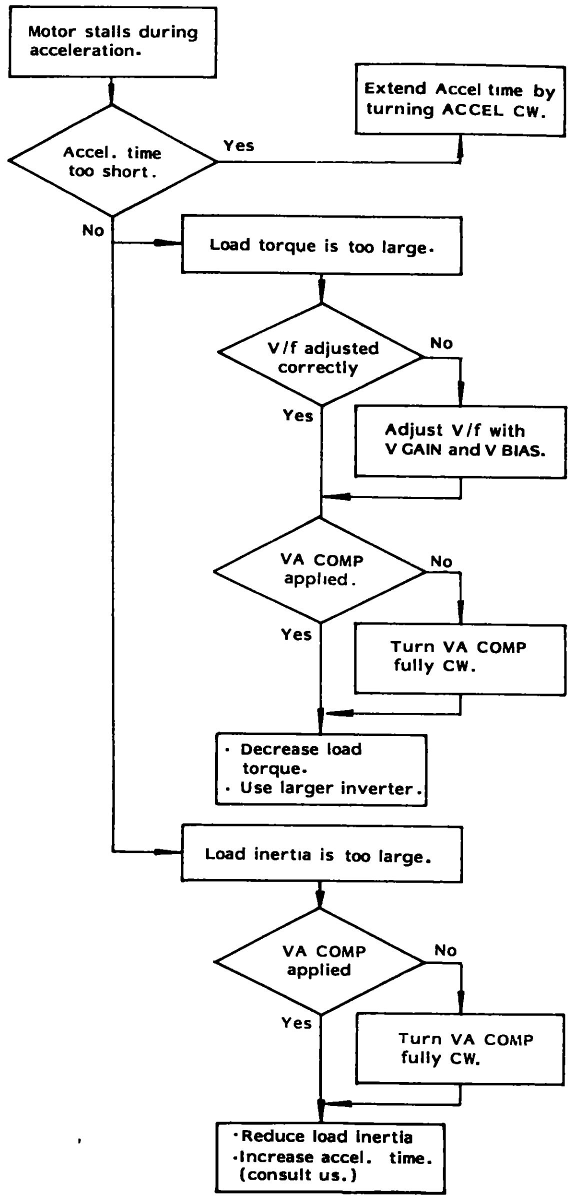
13.9 TROUBLESHOOTING

When the inverter malfunctions, find the cause and eliminate it by following the flow charts given below. If the fault can not be eliminated, parts are damaged, In this and in any other cases, consult our service organization.

(1) Motor does not run.



(2) Motor stalls during acceleration.



13.10 NOTE ON STORAGE

When storing inverters for a long period of time, energize them approximately one hour in every 6 months to prevent the main circuit electrolytic capacitors from deteriorating. The connection for this is shown in Fig. 13.11.

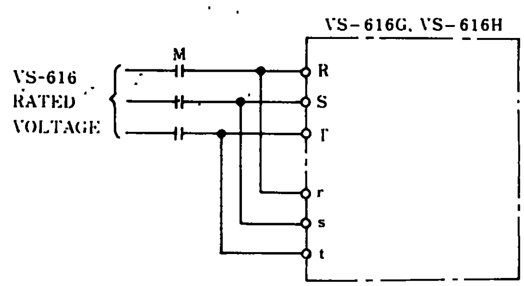


Fig. 13.11 VS-616 Conduction

14. BRAKING

The VS-616 inverter has a braking effect applying a braking torque which is approximately 20% of the rated motor torque. When larger braking torque is required, a braking unit and a braking resistor unit may be additionally connected to obtain a braking torque between 70 and 170% (10 seconds, 10%ED). The braking function is in the following two modes depending on the capacity of the inverters.

(1) VS-616H 200V Series, 3 - 30kVA

In addition to the power transistor (7Tr) braking unit incorporated in the inverter, a separate braking resistor unit may be added to obtain a braking torque between 70 and 170% (10 seconds 10% ED). The model CIMR-[ ]H 1 incorporates this braking function as a standard feature.

(2) 200V Series 70, and 60kVA and 400V Series inverters

A,separate braking unit (CDBR) and braking resistor unit (LKEB) are available for connection to the standard inverter units to produce a braking torque of approximately 70% of the rated torque.

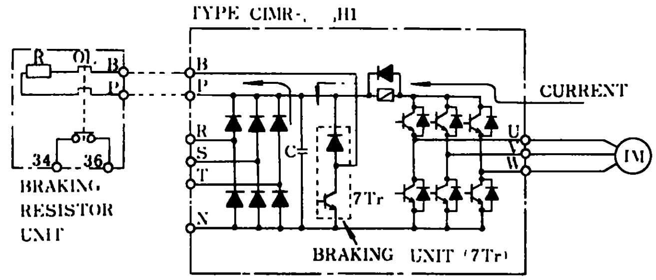
14.1 DESCRIPTION OF FUNCTION

When the motor is decelerated by reduced frequency of the power supply, the inertial energy of the motor and the load is returned to the inverter, with current flowing in the arrow direction in Fig. 14.1, and the capacitor C charged to rise in voltage. If the return energy is too large, the overvoltage protector (OV) of the inverter is tripped to free the motor, and the braking effect is lost.

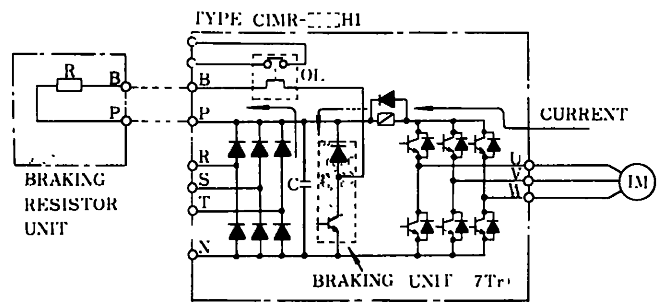
When a braking unit and a braking resistor unit are capacitor C raising the voltage of the capacitor above the tripping levle is discharged through the braking resistor unit, and the voltage protection function (OV) is prevented from tripping, and therefore, deceleration performance is increased.

The overload protection function (OL) and thermal relay (THR) are connected to prevent the braking resistor unit from burning by excess dissipation power. When the OL is tripped, the thermal relay contact closes, and a protection sequence to interrupt the inverter main power supply by this signal must be formed.

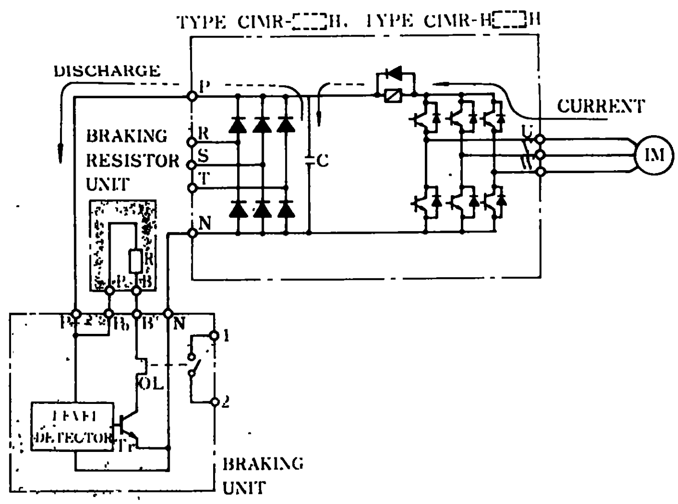
The Model CIMR-[ ]H1 200V Series 3 - 30kVA units incorporate a power transistor (7Tr) for passing the braking current. By turning this 7Tr on, the motor return energy is dissipated in the resistor (R). The thermal unit for protecting the resistor is incorporated in the braking resistor unit with the 3kVA and the 5kVA inverters, and in the inverter proper with the 10 - 30kVA units. Use them in the sequence circuits given in paragraph 14.9.



(a) 200V Series 3kVA, 5kVA



(b) 200V Series 10-30kVA



(c) 200V Series 40kVA, 60kVA and 400V Series
Fig. 14.1 Braking Funcion Block Diagram

14.2 MODEL CODING FOR BRAKING UNIT AND BRAKING RESISTOR UNIT

The braking units and braking resistor units model codes are composed as follows:

(1) Braking unit

TYPE CDBR-□□H

- □□ (second) — APPLICABLE INVERTER CAPACITY
  Ex. 7.5 ······ FOR 7.5 kW (10 kVA)
- □ (first) — BLANK ······ 200 V SERIES
  H ······ 400 V SERIES
- CDBR — BRAKING UNIT

(2) Braking resistor unit

TYPE LKEB-□□K

- □□ (second) — BSAKING RESISTOR UNIT CAPACITY
  Ex. 1.2 ······ 1.2 kW
- □ (first) — BLANK ······ 200 V SERIES
  H ······ 400 V SERIES
- LKEB — BRAKING RESISTOR UNIT

14.3 APPLICATION OF BRAKING UNITS AND BRAKING RESISTOR UNIT

The braking units and the braking resistor units applicable to various inverter models are listed in Table 14.1. Combinations as listed in the table below result in the braking torque shown in Table 14.4. For selection of braking resistor unit and braking unit according to the load, refer to 4.8 CALCULATING BRAKING RESISTOR RESISTANCE.

Table 14·1 Combination of Braking Unit and Braking Resistor Unit with Inverter

Inverter			Braking Unit Type CDBR-	Braking Resistor Unit Type LKEB-
Series	Rated Capacity (kVA)	Type CIMR-		
200 V	3	2.2 H1	*	1.2 K
	5	3.7 H1	*	1.8 K
	10	7.5 H1	*	2.4 K
	20	15 H1	*	4.8 K
	30	22 H1	*	9 K
	40	30 H	15 H×2	4.8 K×2
	60	45 H	22 H×2	9 K×2
	70	55 H	15 H×4	4.8 K×4
	100	75 H	22 H×4	9 K×4
400 V	5 10	H3.7H H7.5H	H7.5H	H1.2K
	20	H15H	H15H	H3K
	40	H30H	H30H	H9K
	60	H45H	H45H	H10.8K
	75	H55H	H30H×2	H9K×2
	110	H75H	H45H×2	H10.8K×2
	140	H110H	H30H×4	H9K×4
	200	H160H	H45H×4	H10.8K×4

* Inverter Type CIMR-□H1 requires no braking units because it incorporates braking function.

† Braking unit Type CDBR-15H or -22H can be combined with inverter Type CDMR-□H 200V series, 20 or 30kVA in order to enhance braking function.

† Two braking resistor units can be operated in parallel.

14.4 RATINGS AND SPECIFICATIONS OF BRAKING UNIT

The braking units are options to obtain large regenerative braking torque, and are used in combination with the braking resistor units.

The 200V Sereis 30kVA and smaller inverters with a braking function incorporate a braking power transistor, and require no braking unit.

Table 14.2 gives the ratings and the specifications of the braking units.

Table 14·2 Ratings and Specifications of Braking Units

Braking Resistor Unit Type CDBR-	15 H	22 H	H3.7 H	H7.5 H	H 15 H	H 30 H	H 45 H	H30 H ×2	H45 H ×2	H30 H ×4	H45 H ×4	Remarks
Max Discharge Current	60 A		40 A			60 A		120 A				10 % Max
Rated Discharge Current	10 A	18 A	2 A		4.7 A	12 A	15 A	24 A	30 A			RMS value
Discharge Starting Voltage	385 V±1 V		750 V±2 V									
Discharge Stopping Voltage	360 V±1 V		700 V±2 V									
Self Heat Generation (at Discharge)	17 W	30 W	26 W		29 W	37 W	40 W	74 W	80 W			
Operating Temperature	−10~40℃											
Storage Temperature	−10~60℃											
Dimensions (W×H×D)	140 mm×280 mm×160 mm							140 mm×280 mm×160 mm×2				
Applicable Inverter	40 kVA*	60 kVA*	5 kVA	10 kVA	20 kVA	40 kVA	60 kVA	75 kVA	110 kVA	140 kVA	200 kVA	

* Asterisked inverters are of 200 V series.

14.5 RATINGS AND SPECIFICATIONS OF BRAKING RESISTOR UNITS

The braking resistor units are housed in steel plate cases(mountable in the upper area of the panel), and the resistor are enameled resistors.

.The ratings and the specifications of the standard braking resistor units are given in Table 14.3. The locations of the thermal relays for protecting the resistors are also listed.

Table 14·3 Ratings and Specifications of Braking Resistor Unit

Inverter Series	Inverter Capacity kVA	Braking Resistor Unit Type	Resistor Specifications	Dimensions in mm (W×H×D)	Code No.	Thermal Reley Location
200 V	3	LKEB-1.2 K	1200 W (300 W×4) 32 Ω	350×325×250	EUX 00157 X	Built-in Braking Resistor Unit
	5	LKEB-1.8 K	1800 W (300 W×6) 24 Ω	350×400×250	EUX 00158 X	
	10	LKEB-2.4 K	2400 W (300 W×8) 32 Ω	350×400×250	EUX 00190 X	Built-in inverter
	20	LKEB-4.8 K	4800 W (600 W×8) 16 Ω	465×520×270	EUX 00191 X	
	30	LKEB-9 K	9000 W (600 W×15) 6.7 Ω	465×820×270	EUX 00192 X	
	40	LKEB-4.8 K×2	9600 W (4800 W×2) 8 Ω (16 Ω×1/2)	465×520×270×2	EUX 00191 X×2	
	60	LKEB-9 K×2	18,000 W (9000 W×2) 3.35 Ω (6.7 Ω×1/2)	465×820×270×2	EUX 00192 X×2	
	70	LKEB-4.8 K × 4	19,200 W (4800 W × 4) 4 Ω (16Ω ×1/4)	465×520×270× 4	EUX 00191 X ×4	
	100	LKEB-9 K × 4	36,000 W (900 W × 4) 1.68Ω (6.7Ω × 1/4)	465×820×270× 4	EUX 00192 X ×4	
400 V	5, 10	LKEB-H 1.2 K	1200 W (200 W×6) 120 Ω	350×400×250	EUX 00201 X	Built-in Braking Unit.
	20	LKEB-H 3 K	3000 W (300 W×10) 50 Ω	350×475×250	EUX 00202 X	
	40	LKEB-H 9 K	9000 W (600 W×15) 20 Ω	465×820×270	EUX 00204 X	
	60	LKEB-H 10.8 K	10,800 W (600 W×18) 16 Ω	465×960×270	EUX 00205 X	
	75	LKEB-H 9 K×2	18,000 W (9000 W×2) 10 Ω (20 Ω×1/2)	465×820×270×2	EUX 00204 X×2	
	110	LKEB-H 10.8 K × 2	21,600 W (10,800 W × 2) 8 Ω (16Ω×1/2)	465×960×270× 2	EUX 00205 X × 2	
	140	LKEB-H 9 K × 4	36,000 W (9000 W × 4) 5 Ω (20Ω×1/4)	465×820×270× 4	EUX 00204 X × 4	
	200	LKEB-H 10.8 K × 4	43,200 W (10,800 W × 4) 4 Ω (16Ω×1/4)	465×960×270× 4	EUX 00205 X × 4	

14.6 BRAKING TORQUE

Table 14.4 gives the motor torques converted from the motor regenerative energy absorbed by the braking resistor units. (The load GD^2 is assumed to be twice the motor GD^2)

14.7 OPERATION FACTOR (%ED)

The braking resistor units can be used at the maximum braking torque up to 10% ED, and can be continuously used for 10 seconds applying the maximum braking torque.

Table 14·4 Converted Value of Braking Torque

Inverter Series		200 V							400 V.							
Resistor Unit Type LKEB-		1.2 K	1.8 K	2.4 K	4.8 K	9 K	4.8 K ×2	9 K ×2	H 1.2 K	H 3 K	H 9 K	H 10.8K	H 9 K ×2	H 10.8K ×2	H 9 K ×4	H 10.8K ×4
Motor Capacity kW (Hp)	0.4 (0.5)	300 %							—							
	0.75 (1)	300 %							—							
	1.5 (2)	220 %							250 %							
	2.2 (3)	150 %							170 %							
	3.7 (5)		150 %						100 %							
	5.5 (7.5)			70 %					70 %							
	7.5 (10)			50 %					50 %							
	11 (15)				70 %					70 %						
	15 (20)				50 %					50 %						
	22 (30)					50 %	60 %				70 %					
	30 (40)						50 %				50 %					
	37 (50)											60 %				
	45 (60)							50 %				50 %				
	55 (75)						50 %						50 %			
	75 (110)							50 %						50 %		
	110 (150)														50 %	
	160 (210)															50 %

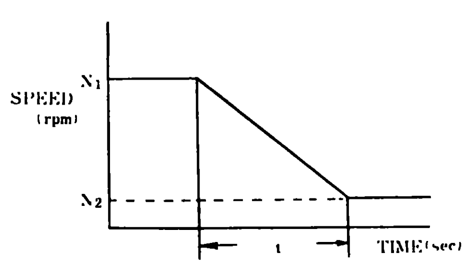
14.8 CALCULATING BRAKING RESISTOR RESISTANCE

The braking resistor units of suitable resistance values are selected for standard use with the respective inverters. The resistors in the braking resistor unit are not adjustable. The procedure of calculating the required braking resistor resistance is described below.

(1) First, required deceleration pattern is determined.

(2) The braking torque required to decelerate according to the determined deceleration pattern is calculated by the following expression.

$$T_B = \frac{GD^2(N_1 - N_2)}{375\ t} - T_L$$



where T_B = Brake torque (kg·m)

T_L = Load torque (kg·m)

t = Acceleration time (sec)

GD^2 = Motor GD^2 + load GD^2 at motor shaft (kg·m²)

(3) Calculate the percentage of the obtained T_B to the rated motor torque.

$$\text{Brake torque \%} = \frac{T_B}{T_M} \times 100$$

where T_M = Motor rated torque (kg·m)

(4) When the value calculated by the method in (3) is smaller than the value given in Table 14.4, deceleration is completed in t seconds. In this case, the deceleration time adjusting resistor DECEL must be set to t seconds.

(5) When some resistance values other than the ones incorporated in the braking resistor units listed in Table 14.3 are required, consult our service organization.

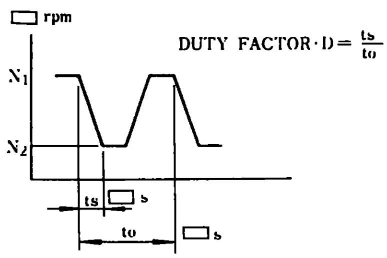
Braking Resistor Unit Selection (Repetitive Deceleration)

(a) Conditions for Braking Resistor Unit Selection

	Type	Output (kW)	Range rpm	Pole (P)	Rated Torque TM(kg·m)	Rotor Inertia GD^2_M(kg·m²)
Induction Motor						

	Kind of Load	Torque Charac-teristic	Load Inertia GD^2_L(kg·m²)	Load Torque TL(kg·m)
Load Specifications				

Deceleration Characteristic



Note: □ is the needed data.

(b) Example Calculation of Braking Resistor Capacity

PROCEDURE 1 CALCULATION OF BRAKE TORQUE (*TB*)

$$T_B\,(\text{kg}\cdot\text{m})=\frac{(GD^2_M+GD^2_L)\times(N_1-N_2)}{375\times t_s}-TL$$

$$=\frac{(\square+\square)\times(\square-\square)}{375\times\square}-\square$$

$$=\square\,\text{kg}\cdot\text{m}$$

IF *TB*< 0, BRAKING OPTION IS NOT REQUIRED.

PROCEDURE 2 CALCULATION OF RESISTANCE (*RB*)

$$R_{min}<R_B<\frac{VC^2}{1.027\times(T_B-0.2\times TM)\times N_1}$$

$$=\frac{\square\times10^3}{1.027\times(\square-0.2\times\square)\times\square}$$

$$=\square\,\Omega$$

IF *TB*< 0.2 *TM*, BRAKING OPTION IS NOT REQUIRED.

$\therefore\ \square\,\Omega<R_B<\square\,\Omega$ .... DATA 1

PROCEDURE 3 AVERAGE POWER DISSIPATION (*Pro*)

$$Pro\,(\text{kW})=1.027\times(T_B-0.2\,TM)\cdot\frac{N_1+N_2}{2}\times10^{-3}$$

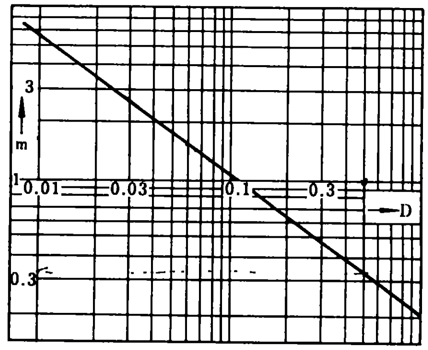
$$=1.027\times(\square-0.2\times\square)$$

$$\times\frac{\square+\square}{2}\times10^{-3}$$

$$=\square\,\text{kW}$$

PROCEDURE 4 REQUIRED RESISTOR NOMINAL WATTAGE (*Pr*)

(i) Determination of Power Increasing Factor (*m*)



(ii) Required Nominal Wattage (*Pr*)

$Pr\,(\text{kW})>Pro/m=\square\,\text{kW}/\square$

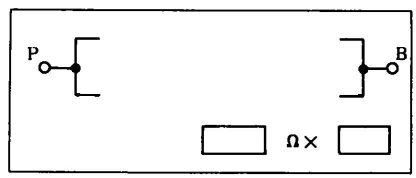
$\therefore\ Pr>\square\,\text{kW}$ .... DATA 2

PROCEDURE 5 SELECTION OF BRAKING RESISTOR USING DATA 1,2

BRAKING RESISTOR; □W □Ω×□本

(PARTS CODE NO.□)

DIAGRAM : □kW □Ω

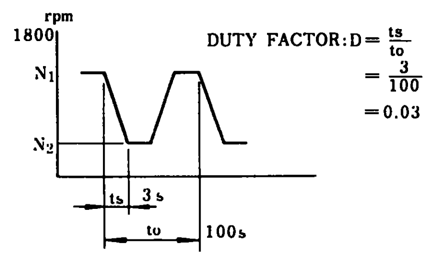


STANDARD RESISTOR

WATTAGE (W)	RESISTANCE (Ω)	CODE NO.
300	2	R002167
	3	R002168
	5	R002169
	8	R002170
	10	R002171
600	4	R002375
600	8	R002374
600	12	R002452

Braking Resistor Unit Selection Example (Repetitive Deceleration)

(a) Conditions for Braking Resistor Unit Selection

Induction Motor	Type	Output (kW)	Range rpm	Pole (P)	Rated Torque TM(kg·m)	Rotor Inertia GD^2_M(kg·m²)
	FE	45	1800–90	4	24.8	1.3
Load Specifications	Kind of Load	Torque Charac-teristic	Load Inertia GD^2_L(kg·m²)	Load Torque TL(kg·m)		
	FAN		10	0.5		
Deceleration Characteristic						

Note: ☐ is the needed data.

(b) Example Calculation of Braking Resistor Capacity

PROCEDURE 1 CALCULATION OF BRAKE TORQUE (TB)

$$T_B\,(\text{kg}\cdot\text{m})=\frac{(GD^2_M+GD^2_L)\times(N_1-N_2)}{375\times t_s}-TL$$

$$=\frac{(\boxed{1.3}+\boxed{10})\times(\boxed{1800}-\boxed{0})}{375\times\boxed{3}}-\boxed{0.5}$$

$$=\boxed{17.6}\ \text{kg}\cdot\text{m}$$

IF $T_B < 0$, BRAKING OPTION IS NOT REQUIRED.

PROCEDURE 2 CALCULATION OF RESISTANCE (RB)

$$Rmin < R_B < \frac{VC^2}{1.027\times(T_B-0.2\times TM)\times N_1}$$

$$=\frac{\boxed{563}\times10^3}{1.027\times(\boxed{17.6}-0.2\times\boxed{24.8})\times\boxed{1800}}$$

$$=\boxed{24.1}\,\Omega$$

IF $T_B < 0.2\,T_M$, BRAKING OPTION IS NOT REQUIRED.

$\therefore \boxed{12.8}\,\Omega < R_B < \boxed{24.1}\,\Omega$ ……………… DATA 1

PROCEDURE 3 AVERAGE POWER DISSIPATION (Pro)

$$Pro\,(\text{kW})=1.027\times(T_B-0.2\,TM)\cdot\frac{N_1+N_2}{2}\times10^{-3}$$

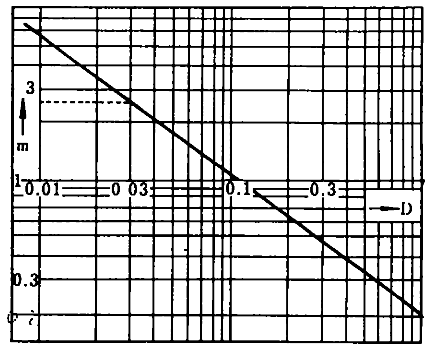
$$=1.027\times(\boxed{17.6}-0.2\times\boxed{24.8})$$

$$\times\frac{\boxed{1800}+\boxed{0}}{2}\times10^{-3}$$

$$=\boxed{11.7}\,\text{kW}$$

PROCEDURE 4 REQUIRED RESISTOR NOMINAL WATTAGE (Pr)

(i) Determination of Power Increasing Factor (m)



(ii) Required Nominal Wattage (Pr)

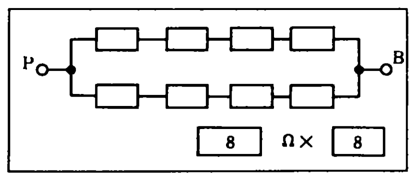
$Pr\,(\text{kW}) > Pro/m = \boxed{11.7}\,\text{kW}/\boxed{2.6}$

$\therefore Pr > \boxed{4.5}\,\text{kW}$ …………………… DATA 2

PROCEDURE 5 SELECTION OF BRAKING RESISTOR USING DATA 1,2

BRAKING RESISTOR: 600 W 8 Ω × 8 pcs (PARTS CODE NO.; R 2374)

DIAGRAM : $\boxed{4.8}$kW $\boxed{16}$Ω



STANDARD RESISTOR

WATTAGE (W)	RESISTANCE (Ω)	CODE NO.
300	2	R 002167
300	3	R 002168
300	5	R 002169
300	8	R 002170
300	10	R 002171
600	4	R 002375
600	8	R 002374
600	12	R 002452

If the standard resistor unit cannot be applied, the other resistor units should be selected.

14.9 SEQUENCE WHEN USING BRAKING RESISTOR UNITS

When the braking resistor unit is used, the Model CIMR[ ]H1-23 inverter connected with main circuit peripheral units, or the Model CIMR-[ ]H1-24 inverter with the main circuit peripheral units and operator should be used. When inverters without peripheral units are used, special sequence circuits are required.

Main sequence circuit examples are shown in Figs. 14.2 through 14.6.

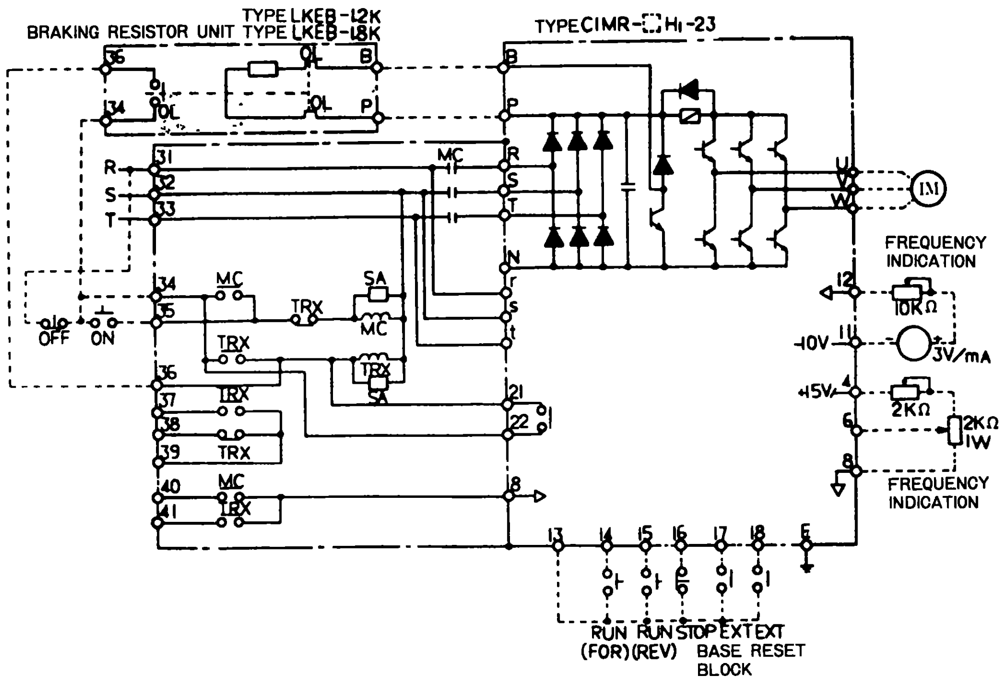
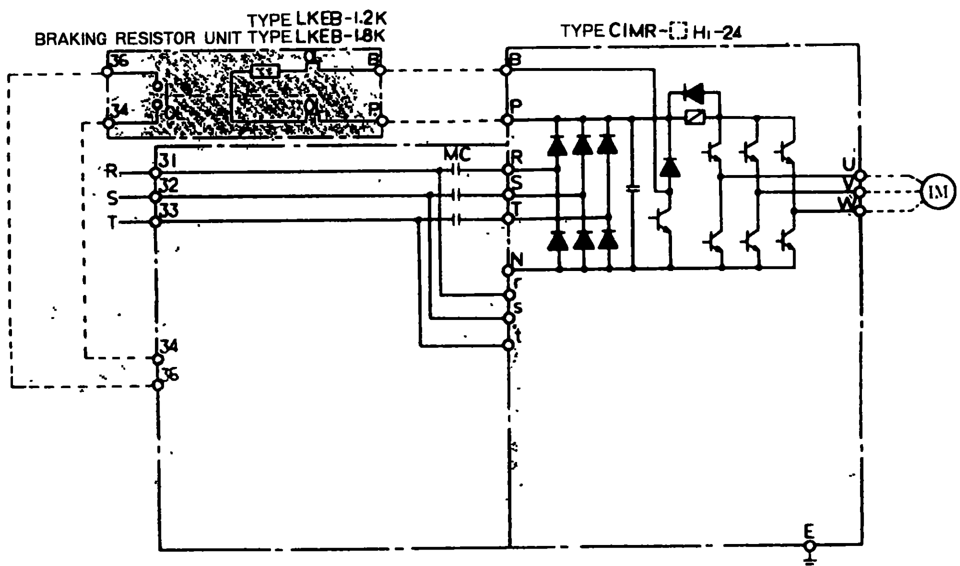


Fig. 14.2 VS-616H Inverter Unit with Main Circuit Ancillary Devices Type CIMR-3.7H1-23



Note : Operation, control, and failure indication sequences are composed in the standard circuit.

Fig. 14.3 VS-616H Inverter Unit with VS Operator and Main Circuit Ancillary Devices Type CIMR-3.7H1-24

14.9 SEQUENCE WHEN USING BRAKING RESISTOR UNITS (Cont'd)

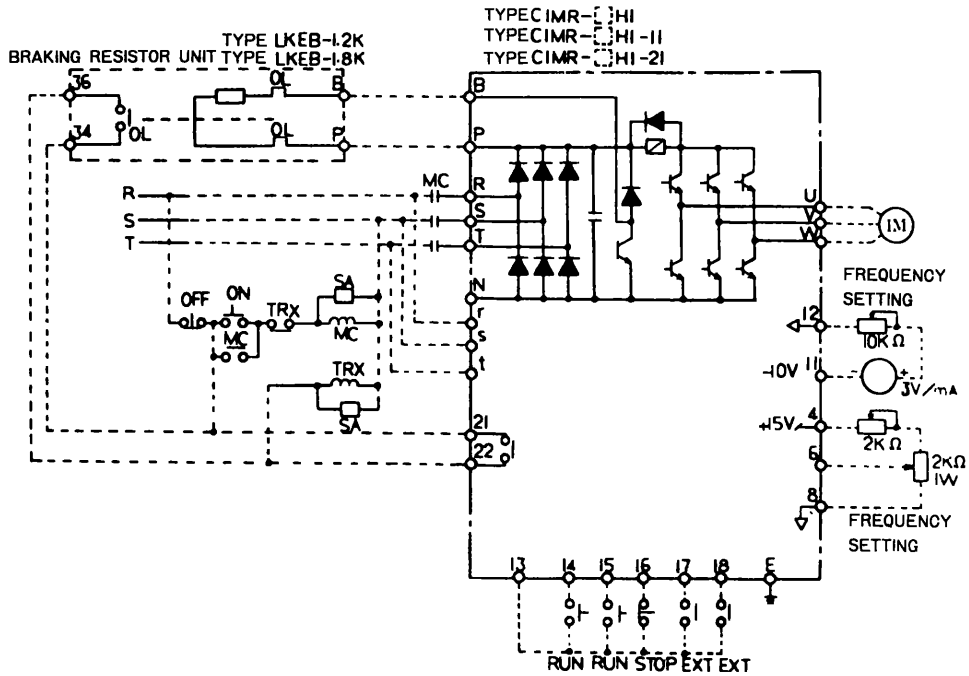


Fig. 14.4 VS-616H Inverter without Ancillary Devices
Type CIMR-3.7H1, -3.7H1-11, -37H1-21

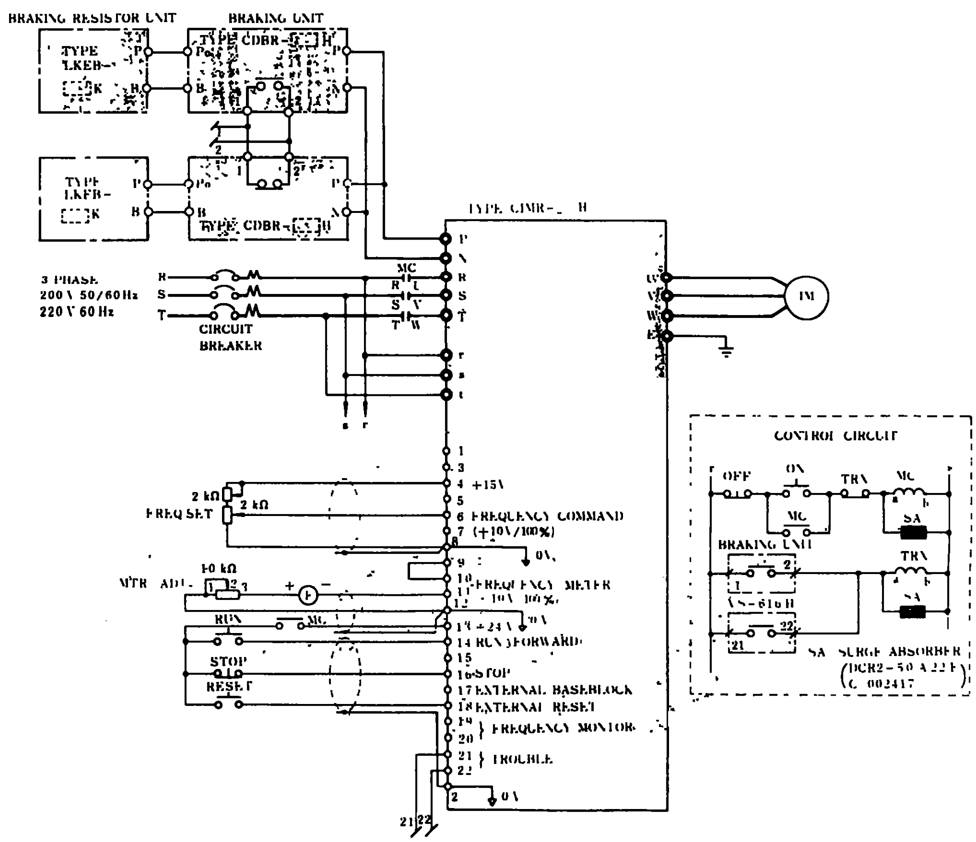
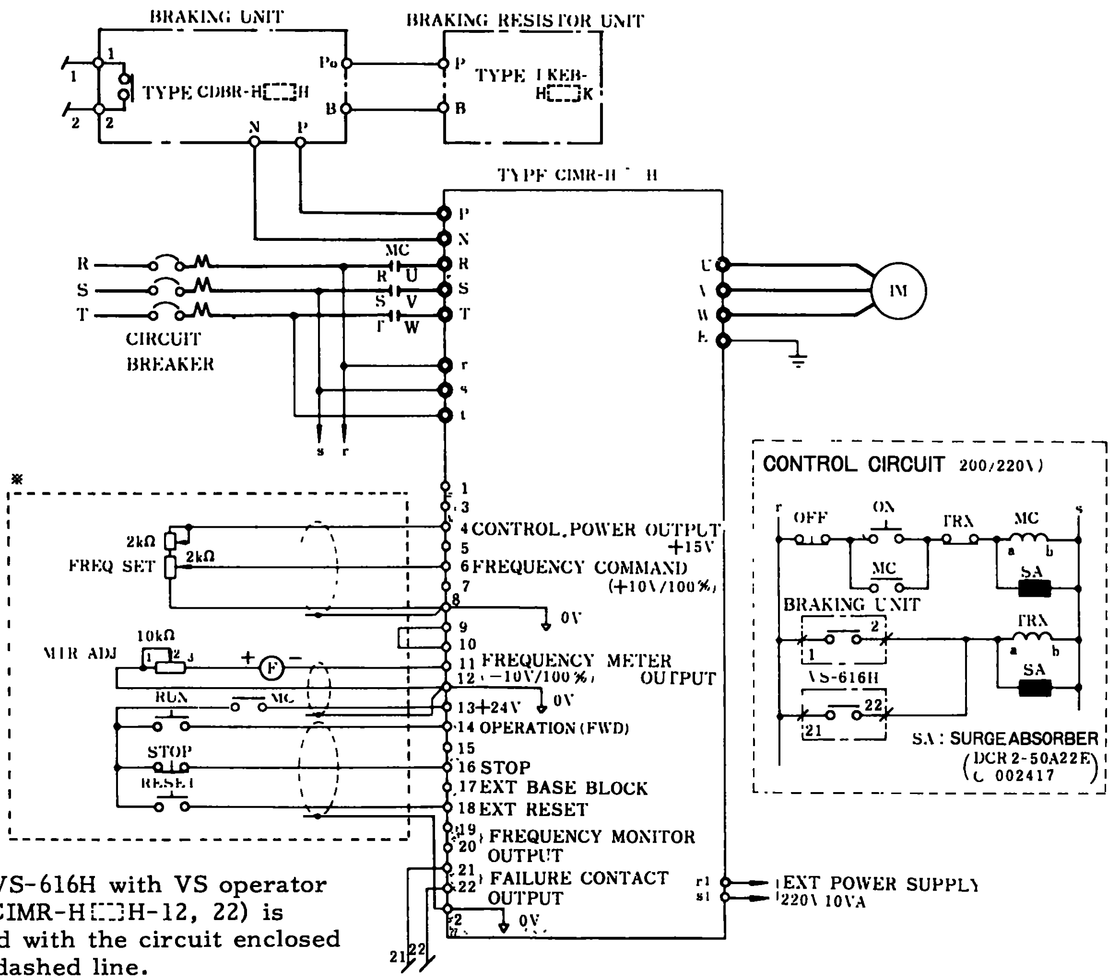


Fig. 14.5 VS-616H Inverter 200V Series, 40,60kVA Type CIMR-□H

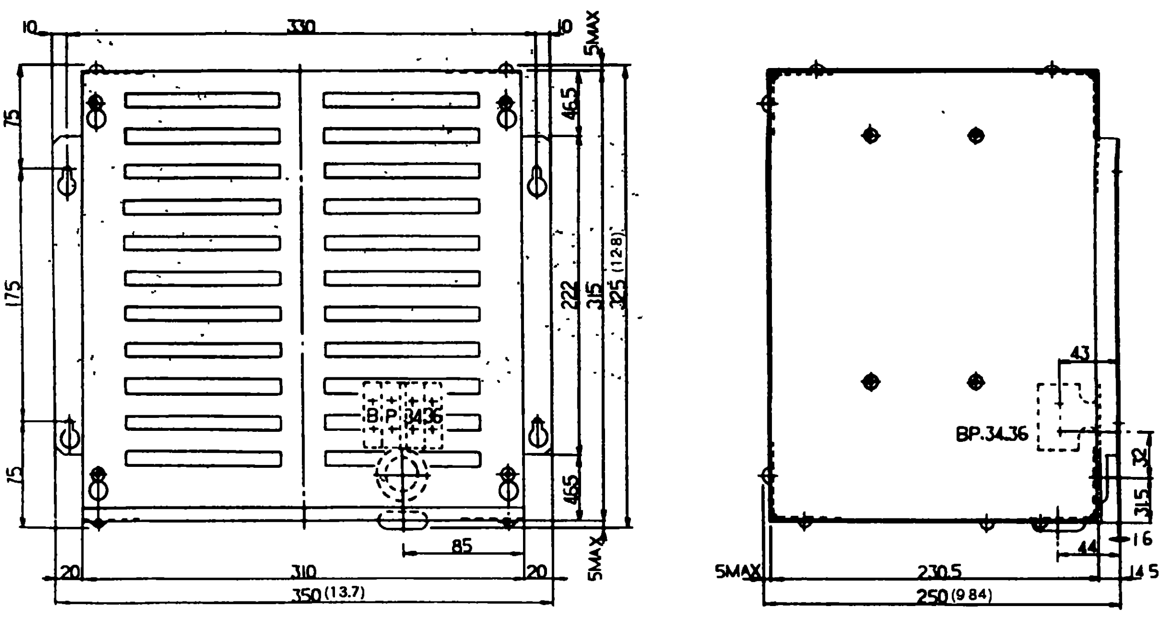


Note: VS-616H with VS operator (Type CIMR-H[ ]H-12, 22) is provided with the circuit enclosed by the dashed line.

Fig. 14.6 VS-616H Inverter 400 V Series, 10-110 kVA Type CIMR-H[ ]H

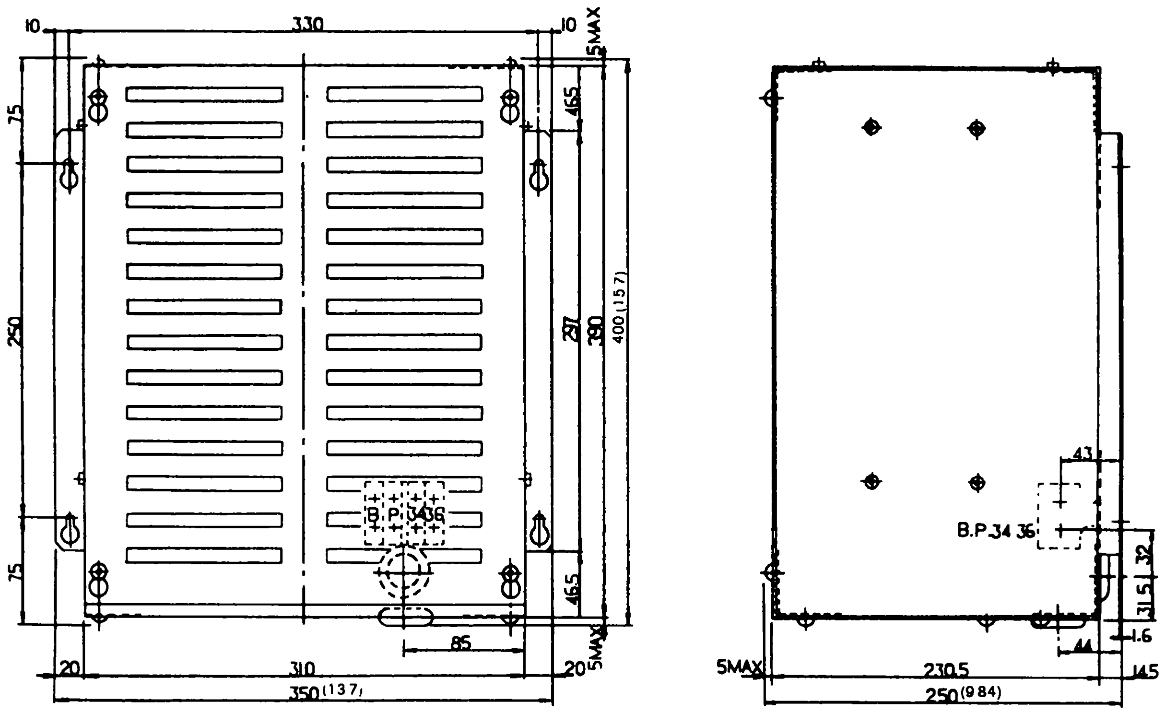
14.10 BRAKING RESISTOR UNIT DIMENSIONS in mm (inches)

Type LKEB-1.2K For 200 V, 3 kVA

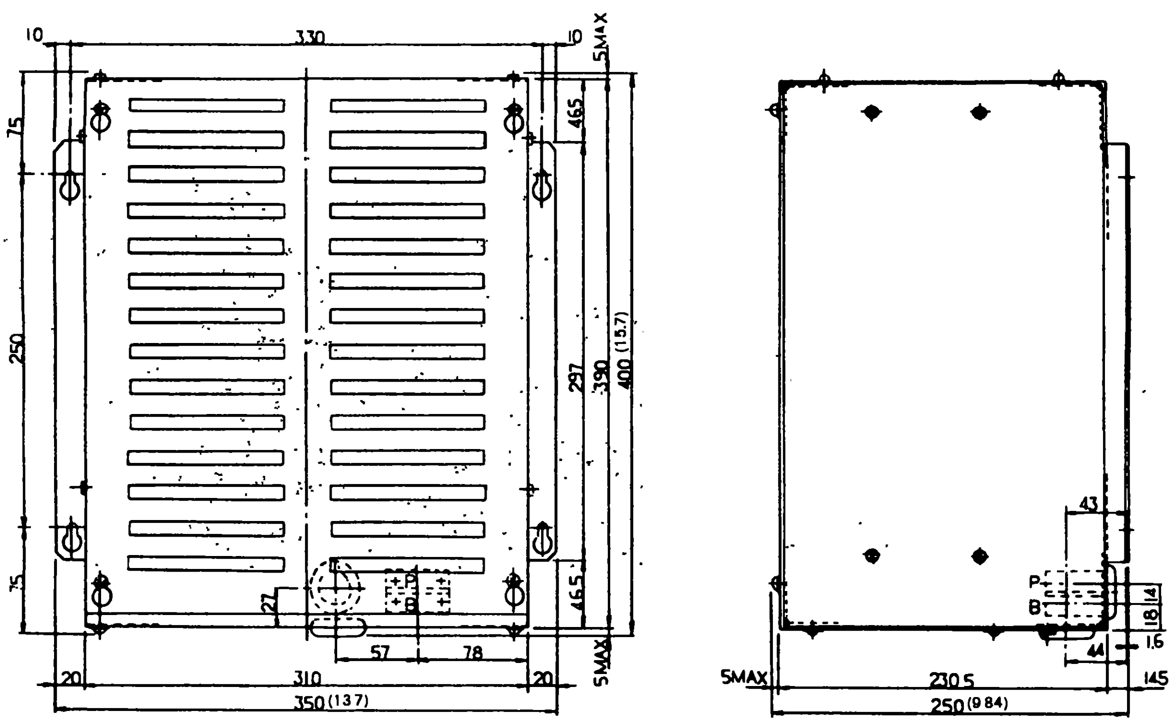


14.10 BRAKING RESISTOR UNIT DIMENSIONS in mm (inches) (Cont'd)

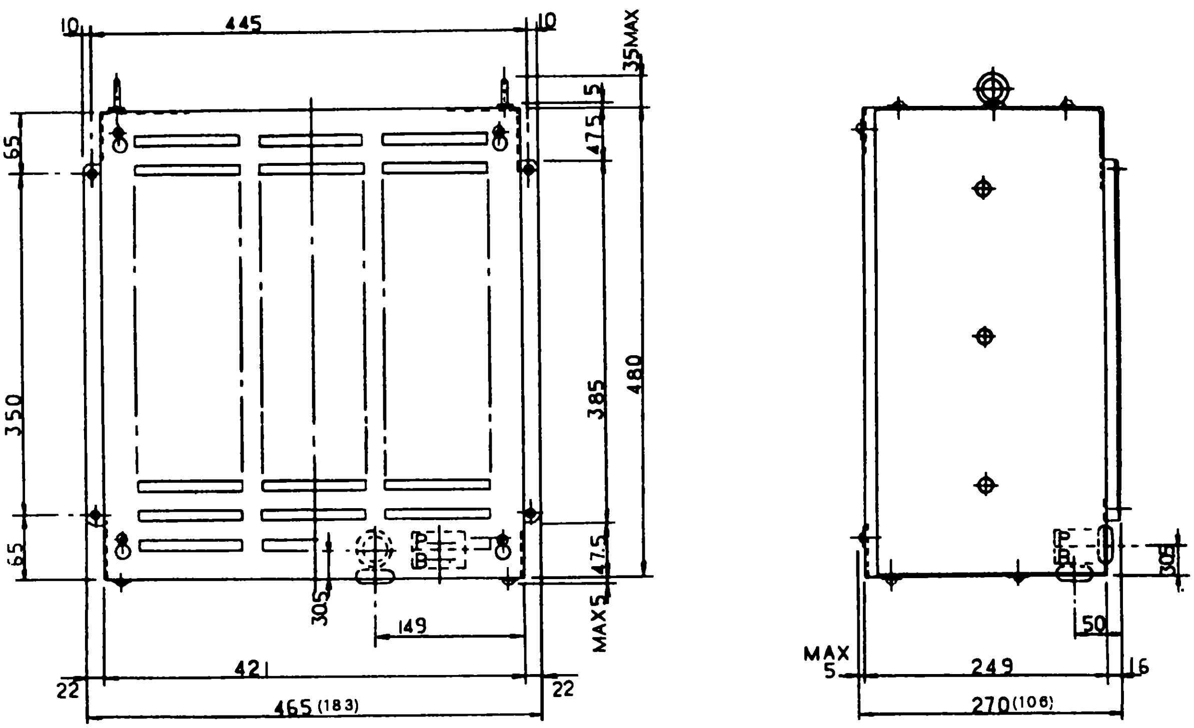
Type LKEB-1.8K For 200 V, 5 kVA



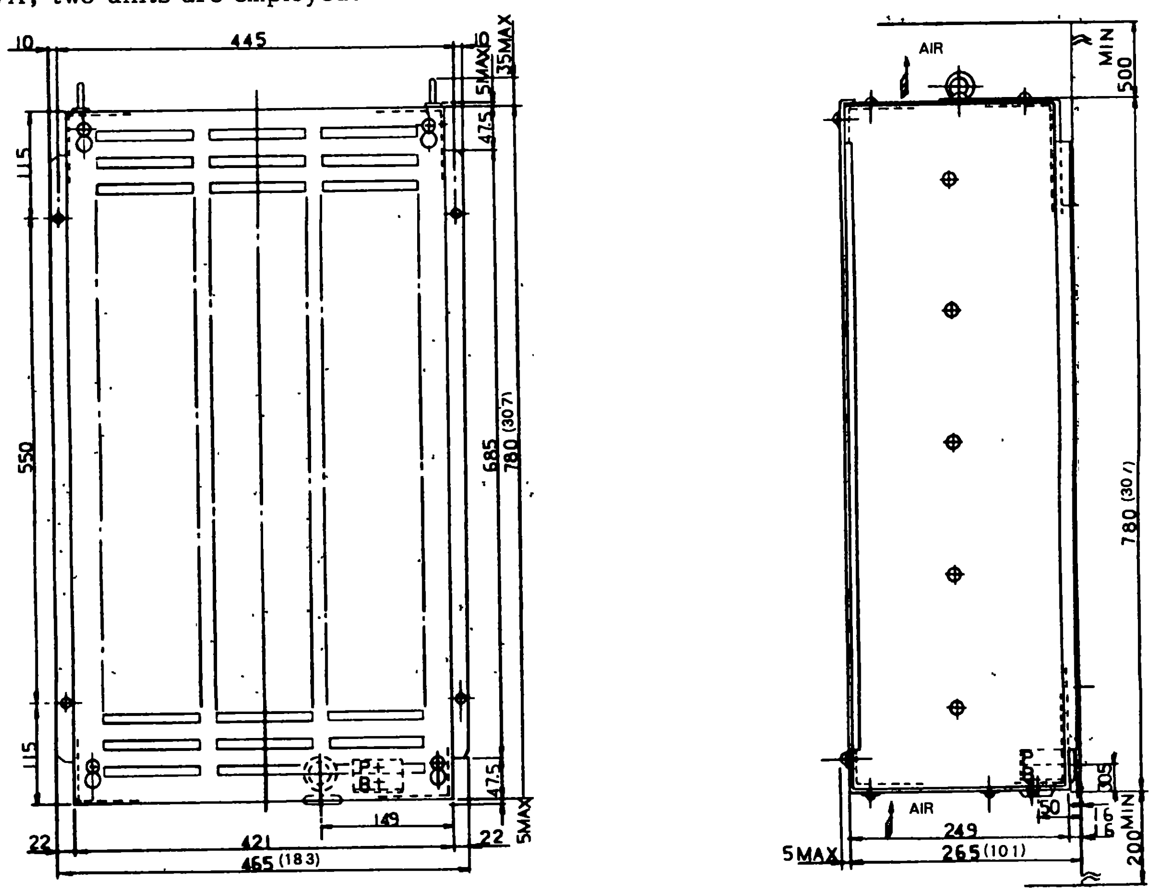
Type LKEB-2.4K For 200 V, 10 kVA



Type LKEB-4.8K For 200 V, 20 kVA and 40 kVA
For 40 kVA, two units are employed.

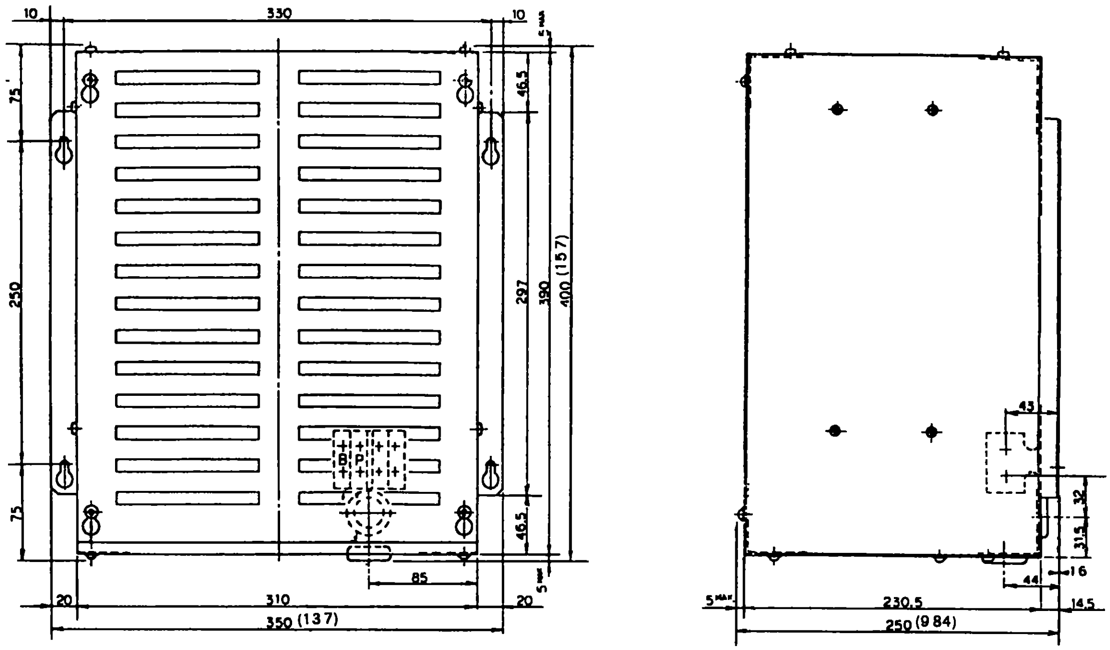


Type LKEB-9K For 200 V, 3 kVA and 60 kVA
For 60 kVA, two units are employed.

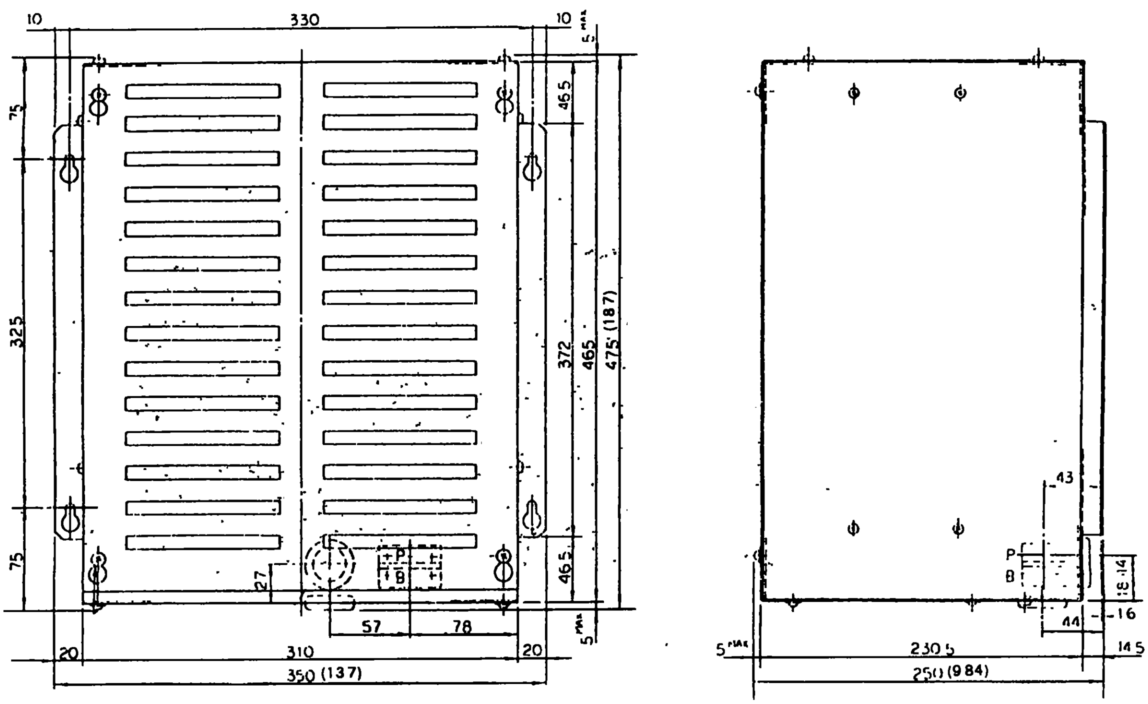


14.10 BRAKING RESISTOR UNIT DIMENSIONS in mm (inches) (Cont'd)

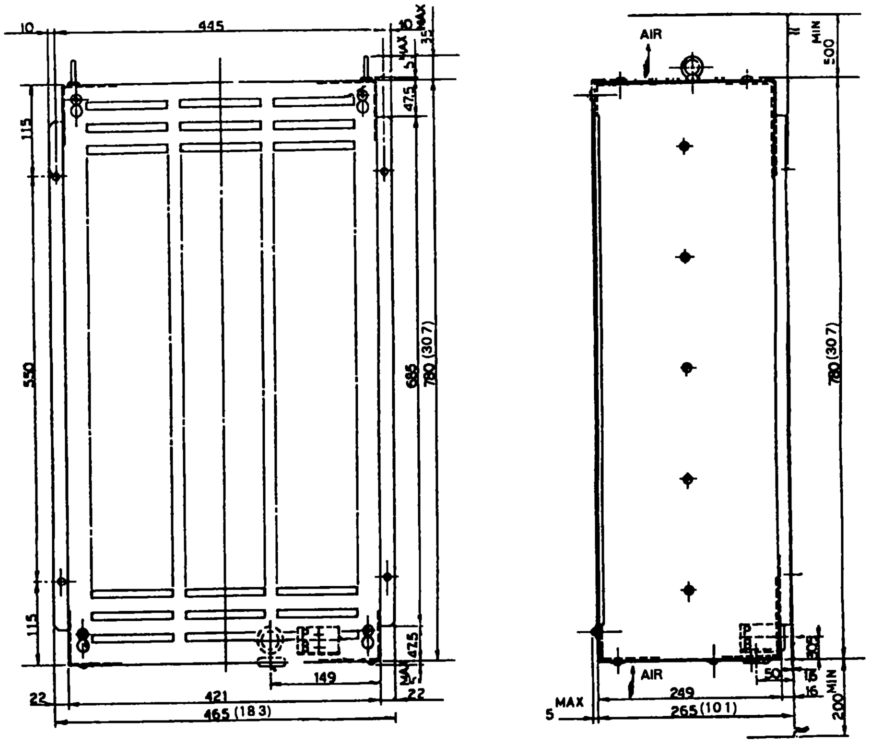
Type LKEB-H1.2K For 400 V, 10 kVA



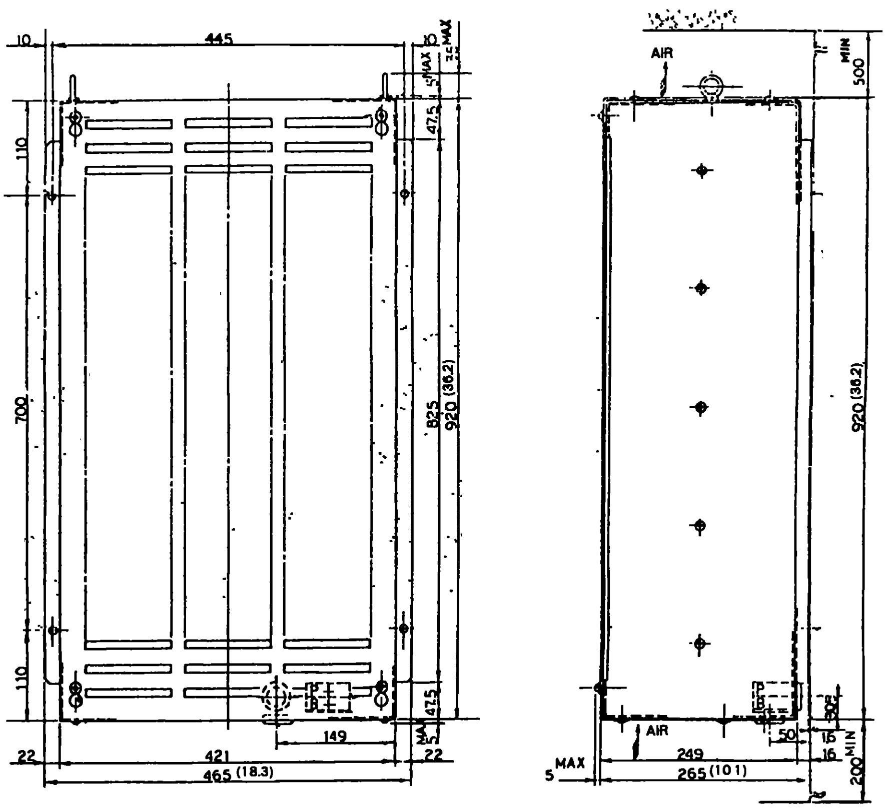
Type LKEB-H3K For 400 V, 20 kVA



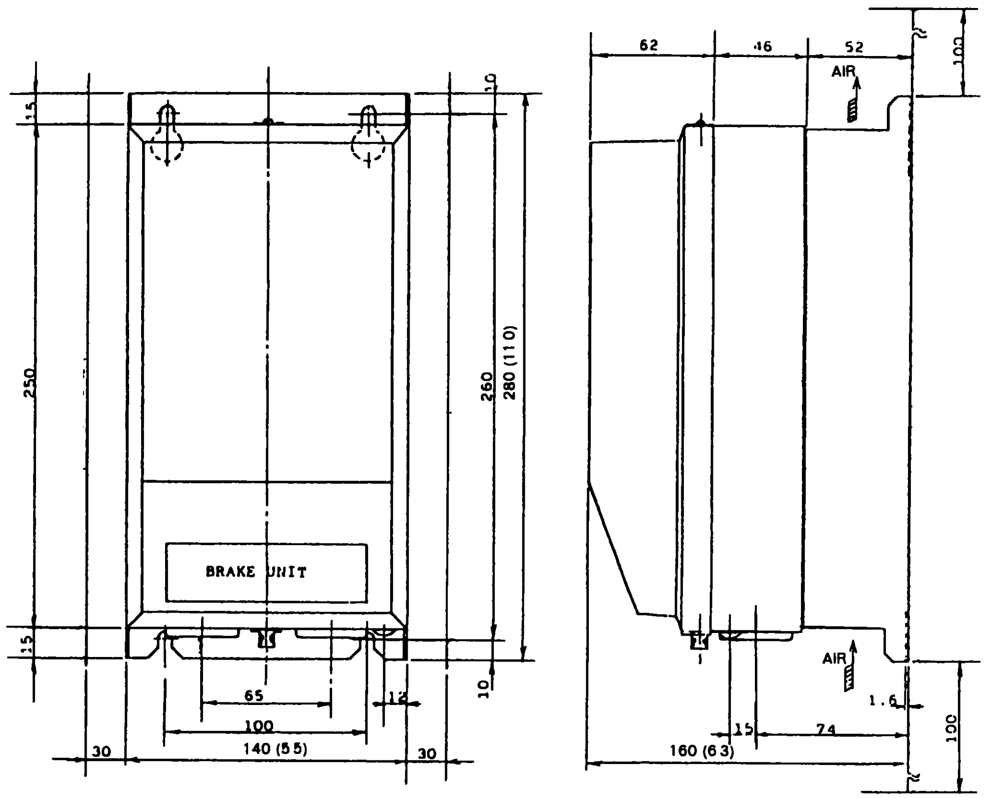
Type LKEB-H9K For 400 V, 40 kVA and 75 kVA
For 75 kVA, two units are employed.



Type LKEB-H10.8K For 400 V, 60 kVA and 110 kVA
For 110 kVA, two units are employed.



14.11 BRAKING UNIT DEMENSIONS in mm (inches)



15. OPTIONAL CARDS

The VS-616H Series inverters are designed to accept various optional cards to be plugged in to the control board for diverse applications, as listed in Table 15.1.

These optional cards can be attached to the control circuit boards by simply snapping in.

Fig. 15.1 shows how optional cards are mounted to the control circuit board.

Table 15·1 Plug-in Type Optional Cards

Optional Card Name	Type JPAC	Code No.	Function
Reversible Controller	-C040	ETC 00530 X	Performs reversible operation fast and smooth. Switches noncontact automatic reversible operation and functions as dynamic braking.
Torque Compensator	-C041	ETC 00531 X	Generates the optimum torque efficiently suited to the load. Detects current torque and controls frequency and voltage so as to compensate for slip and voltage drop.
Speed Controller	-C042	ETC 00532 X	Limits speed fluctuation to ±0.5% by combining tach-gen. AC tach-gen mounted on the motor detects motor speed and compensates for the speed fluctuation by the difference between feedback signal and the detected speed.
Synchronized Starter	-C043	ETC 00533 X	Continues operation at power failure of 20ms or more. Detects the coincidence of motor speed and inverter output frequency and accelerates the stopping motor.

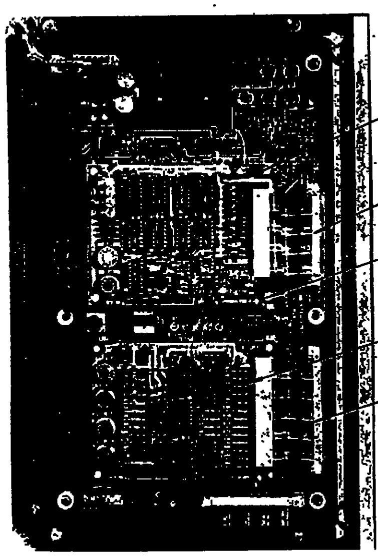


Fig. 15.1 Optional Cards Plugged-in

15.1 REVERSIBLE CONTROLLER (JPAC-C040)

The reversible controller (Fig. 15.2) reverses the inverter output power in the contactless mode, and dynamically brakes the motor in the low speed range to reverse the motor smoothly and quickly. It is designed to be connected and mounted in the card bay No.1 on the control circuit board of the H Series inverter control circuit board by simple snapping.

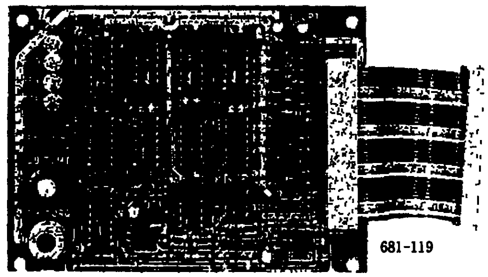


Fig. 15.2 Reversible Controller Type JPAC-C040

15.1.1 Description of Operation

Fig. 15.3 shows the block diagram representing the reversible controller connected to H Series inverter. In this diagram, the motor is driven forward, backward, and stopped by the forward signal F, the reverse signal R, and stop signal S, respectively.

The operation time chart for these control states is shown in Fig. 15.4. When a forward command F is turned on, the motor accelerates to the speed set by a frequency command during the time set by ACCEL, and continues running forward. When a reverse command R is turned on, the motor starts to decelerate by braking and decelerated during the time set by DECEL.

After the lapse of DB time, the reversible controller accelerates the speed to the level set by the frequency command during the time set by ACCEL in the reverse direction. When a STOP signal is subsequently input, the braking deceleration operation takes place to decelerate the motor over the span of time set by DECEL. As the speed drops to that corresponding to 3Hz, the dynamic braking stops the motor.

When the frequency decreases below 3Hz, the motor starts to run free, without a reversible controller, but when a reversible controller is connected, it detects 3Hz, and applies the dynamic braking.

The torque of the dynamic braking is adjusted by DB TORQ on the reversible controller, and its duration is adjusted by DB TIME. The reversible controller, and its duration is adjusted by DB TIME. The reversible controller can be also utilized to apply dynamic braking only in one run direction.

15.1 REVERSIBLE CONTROLLER (JPAC-C040) (Cont'd)

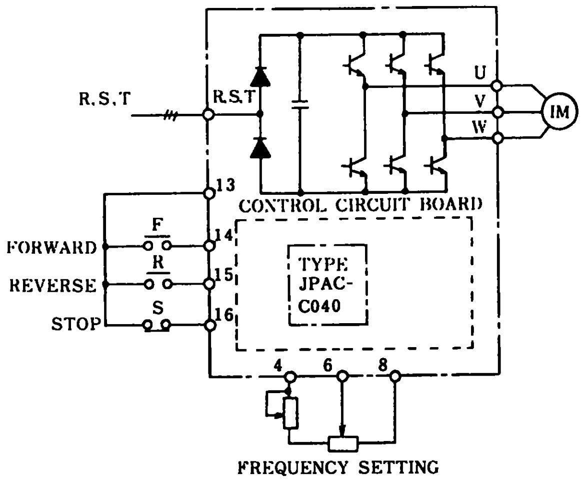


Fig. 15.3 Block Diagram of Inverter with Reversible Controller

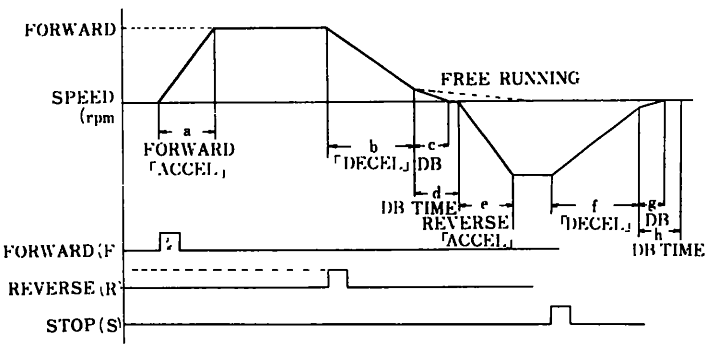


Fig 15.4 Time Chart of Reversible Operation

15.1.2 Adjustment

The dynamic braking torque in the low speed range (3Hz max.) is adjusted by the DB TORQ variable resistor on the reversible controller.

The application time of the dynamic braking is adjusted between 0.2 and 2 seconds by DB TIME. Turning clockwise increases time. The dynamic braking torque varies with the type of motor and the length of wires. Adjust DB TORQ so the motor on hand stops smoothly under the actual load. Adjust DB TIME to the time required for the motor to stop from the starting of the dynamic braking to the step.

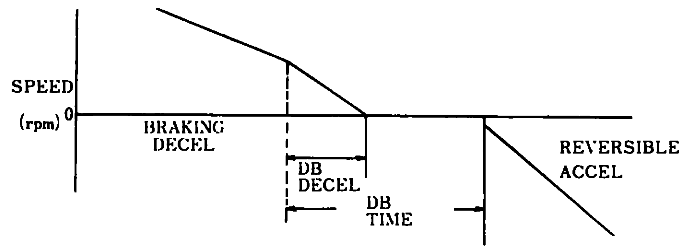
15.1.3 Adjusting Procedure

(1) Turn DB TIME fully clockwise.

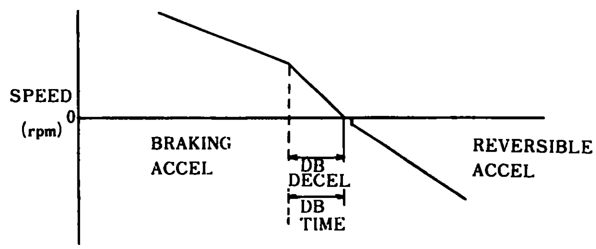
(2) Set DB TORQ so the motor stops smoothly.

(3) Adjust DB TIME to the time required for the motor to be stopped by dynamic braking.

(a) If DB TIME is set too long, time is lost when run direction is reversed.

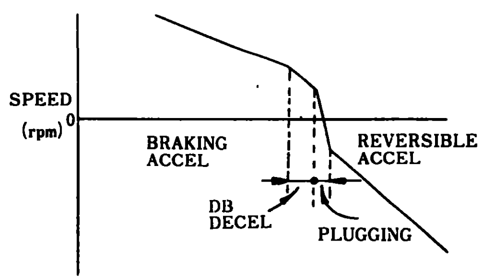


(b) Correct DB TIME



(c) Too short DB TIME

If DB TIME is too short, the motor is plugged, and may be stopped jerkily.



15.1.4 Indicator

The reversible controller is provided with the following LED indicator lamps.

Forward run	FOR turning on
Reverse run	REV turning on
Stop	STOP turning on
Dynamic braking	DB turning on

15.1.5 Function Selection by Shunt Connector

With the reversible controller, the use of no use of the dynamic braking, and the priority to dynamic braking or to operation can be selected with the selective use of shunt connectors A or B, D, as shown in Table 15.2.

When A is selected, the motor becomes free below 3Hz, and when B is selected, it is dynamically braked.

When C is selected, any RUN signal input during dynamic braking has the priority to interrupt the dynamic braking, and the motor start to run. When D is selected, no RUN signal input during dynamic braking has the priority, so that it becomes effective only after the expiration of the DB time.

Table 15·2 Selection of Function by Shunt Connector

Selection of Function	Selection of Shunt Connector	Function		Setting at the Factory
Dynamic Braking Function	A	Without dynamic braking function	Free-run to stop at 3 Hz or below.	B
	B	With dynamic braking function	Dynamic brake to stop at 3 Hz or below.	
Priority of Dynamic Braking or Operation	C	Operation	Operation possible by RUN signal during dynamic braking.	D
	D	Dynamic braking	Operation possible after DB time by RUN signal during dynamic braking.	

15.2 TORQUE COMPENSATOR (JPAC-C041)

The torque compensator (Fig. 15.5) detects the motor current with AC CT, and automatically adjust the inverter output voltage to allow the motor to efficiently develop torque that matches the load.

It can be mounted in the optional card No.2 mount location of the control circuit board of the H Series inverter with a simple snapping.

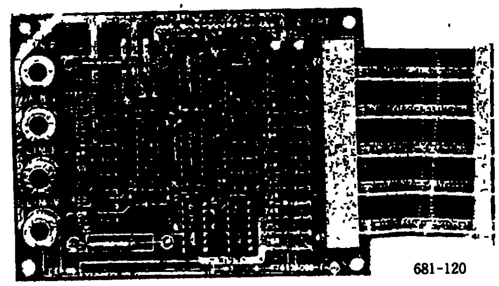


Fig. 15.5 Torque Compensator Type JPAC-C401

15.2.1 Description of Operation

Fig. 15.6 shows the block diagram of JPAC-C 041 connected to H Series inverter.

In Fig. 15.7, the torque characteristics of a 2.2kW standard motor combined with JAPC-C 041 are shown. The dash lines indicate the standard motor output torque characteristics under the control of an inverter without a torque compensator. As can be seen clearly, the output torque drops much in the low frequency range. This is due to the large influence of the motor winding resistance in the low frequency (low voltage) range. The solid lines show the motor otuput torque characteristics of a standard motor combined with an inverter with a torque compensator automatically adjust the inverter output voltage to obtain the rated motor torque even in the low frequency range. The torque compensator is very advantageous when a constant torque load is driven in the low frequency range.

15.2 TORQUE COMPENSATOR (JPAC-C041) (Cont'd)

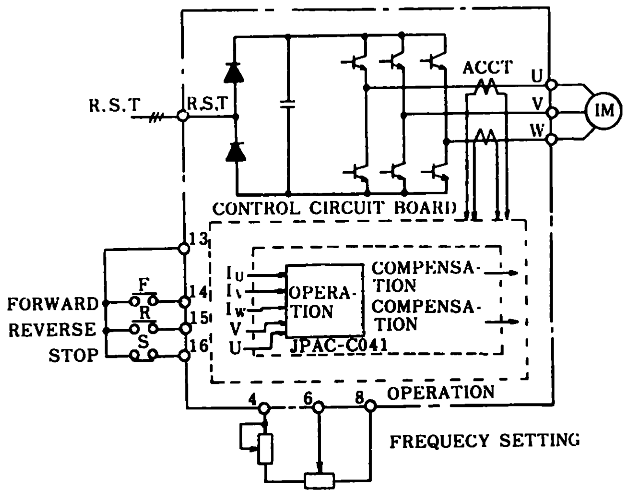


Fig. 15.6 Block Diagram of Inverter with Torque Compensator

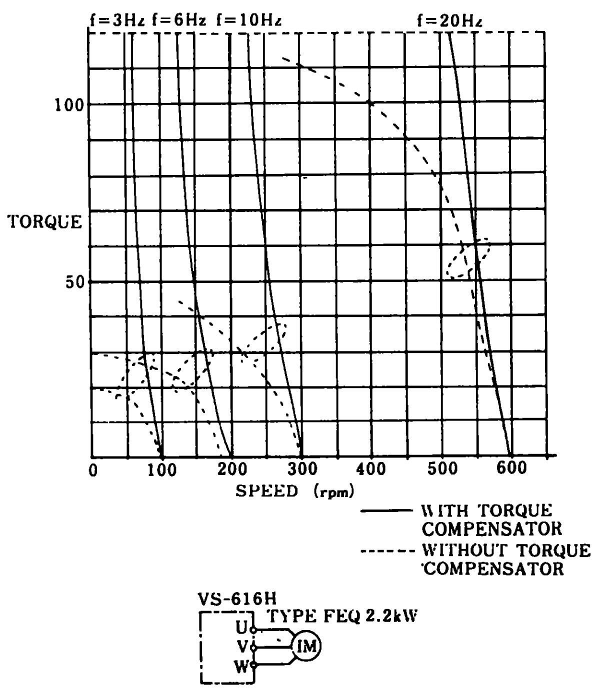


Fig. 15.7 Torque Characteristics of Inverter with Torque Compensator

15.2.2 Adjustment

Factory adjustment is applicable to most of the applications. If adjusting is required, proceed as follows.

The JPAC-C 040 has four variable resistors for adjustment; GAIN F, GAIN V, LIM F, and LIM V. GAIN F and LIM F are for adjusting frequency compensation, but for ordinary applications, they may be left in the CCW end. GAIN V and LIM V are for adjusting the voltage compensation. LIM V is used in the CW end, and GAIN V is to be adjusted to suit the load torque.

When the motor is to be used in the continuous rating, adjust LIM V so that the motor current is limited within the rated current. When the motor is used to drive an interrupt run load, set LIM V to the current permissible from a motor heating calculation. When shipping from the factory, these variable resistors are adjusted as shown in Table 15.3.

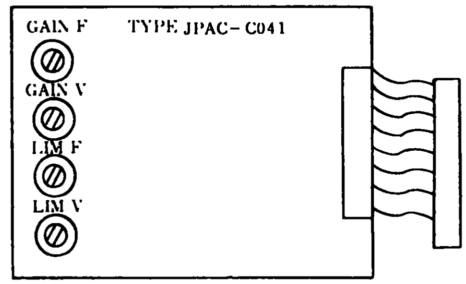


Fig. 15.8 Adjusting Potentiometers with Torque Compensator

Table 15·3 Adjustment of Torque Compensator Potentiometers

Potentiometer	Adjustment	Factory Setting
GAIN F	Factory setting.	Fully CCW
GAIN V	Adjusted according to load.	5 scales
LIM F	Factory setting.	Fully CCW
LIM V	Motor current adjusted within the rating.	Fully CW

15.2.3 Characteristics

The torque characteristics of a standard 2.2kW motor driven by an VS-616 inverter with JPAC-C 040 are shown in Fig. 15.9.

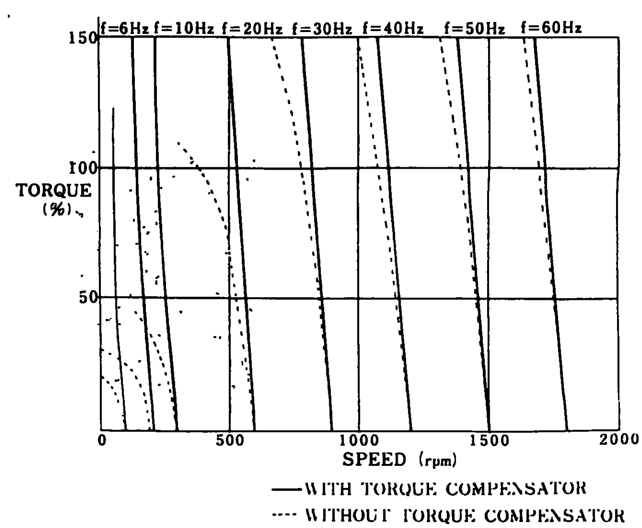


Fig. 15.9 Torque Characteristics of Inverter with Torque Compensator

15.3 SPEED CONTROLLER (JPAC-C042)

When a 3-phase motor is driven by an inverter, slip increases with load torque, and the speed drops several %.

JPAC-C 042 receives the speed feedback signal from the AC tachometer generator mounted on the motor, and compensates for the slip. Fig. 15.10 shows the exterior view of JPAC-C 042. It is mounted to the optional card No.2 mount location on an H Series control circuit board by a simple snapping.

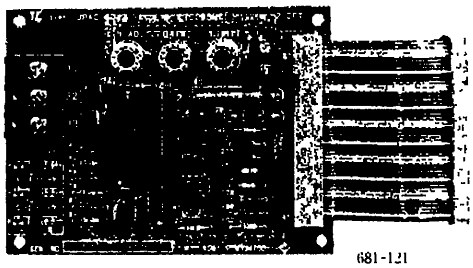


Fig. 15.10 Speed Controller of Type JPAC-C042

15.3.1 Description of Operation

The speed feedback signal generated by the AC tachometer generator mounted to the 3-phase motor is comparted with the speed reference signal based on the frequency command, and the difference is PI-amplified to give compensation signal to the inverter frequency command (Fig.15.11).

With JPAC-C 042, the speed fluctuation of the motor can be limited to 0.5%. As the AC tachometer generator for this application, the Models QVAH-20%, QVAH-20 TB, QVAH-10 TB 3-phase or QAVH-10 single phase standard tachometer generator of YASKAWA may be used.

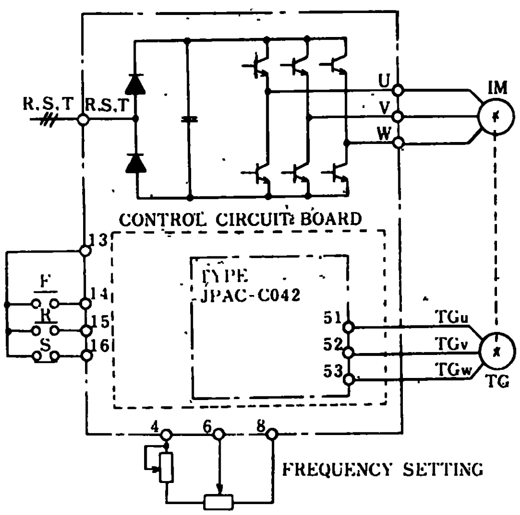


Fig. 15.11 Block Diagram of Inverter with Torque Compensator

15.3.2 Selection of AC Tachometer Generator and Shunt Connector

The shunt connectors of JPAC-C 042 must be correctly selected according to the tachometer generator used, and the rated speed. The available maximum speed ranges for the types of AC tachometer generator, and the shunt connector positions are given in Table 15.4. A tachometer generator can be incorporated in the motor on special order.

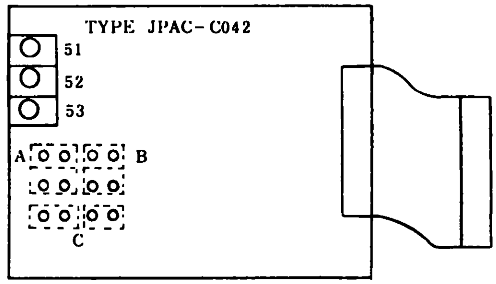


Fig. 15.12 Location of Shunt Connectors

Table 15·4 Maximum Applicable Speed Range

AC Tach-gen Specifications			Shunt Connector Location			Tach-gen Mounting
			Tap A	Tap B	Tap C	
3-phase	QVAH -20T	140 V 2000 rpm	1300 rpm ~ 450 rpm	—	3600 rpm ~ 1250 rpm	Coupling
	QVAH -20TB					Built-in (Available on order.)
	QVAH -10TB	70 V 2000 rpm	3600 rpm ~ 1350 rpm	1400 rpm ~ 480 rpm	—	
Single-phase	QVAH -10	70/35 V 2500 rpm	5000 rpm ~ 1700 rpm	1750 rpm ~ 600 rpm	—	Coupling

Note: Selection of taps A, B, or C must be made through two shunt connectors. Tap A has been selected at the factory.

15.3.3 Connection of AC Tachometer Generator

A 3-phase tachometer generator is connected as shown in Fig. 15.13. Connect a single-phase tachometer generator as shown in Fig. 15.14 to terminals 51 and 53, using the 70V terminal. When the actual motor speed is to be measured with a tachometer (35VAC, 1mA), use the TGu and TGo (35V) terminals of the tachometer generator.

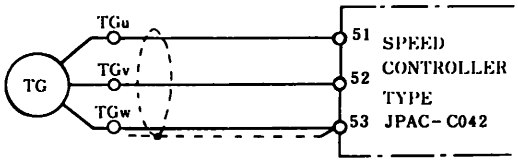


Fig. 15.13 3-phase Tach-gen Connections

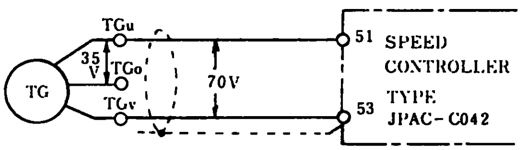


Fig. 15.14 Single-phase Tach-gen Connections

15.3.4 Use of DC Tachometer Generator

Connect a DC tachometer generator as shown in Fig. 15.15. Select the shunt connector taps according to the voltage of the DC tachometer generator as follows.

(1) Tachometer generator voltage 252 - 88V: Tap C

(2) Tachometer generator voltage 91 - 48V: Tap A

(3) Tachometer generator voltage 41 - 17V: Tap B

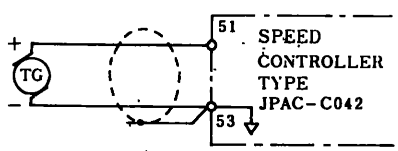


Fig. 15.15 DC Tach-gen Connections

15.3.5 Adjustment

JAPC-C 042 has three adjusting knobs; N ADJ, GAIN, and LIMIT. N ADJ adjusts the speeds feedback rated for speed control, GAIN adjusts the speed loop gain, and LLMIT adjust the speed compensation (Fig. 15.16).

(1) N ADJ

Select the shunt connector tap based on the tachometer generator used, and the rated speed, by referring to 15.3.2. Adjust LIMIT fully clockwise, and set GAIN to scale 5. Adjust N ADJ to bring the motor speed to the rated speed when the frequency is the maximum. Turning clockwise increases speed, and vice versa.

(2) GAIN

Turn GAIN clockwise until the speed difference between the no-load speed and the speed under rated load becomes as desired.

The speed regulation can be controlled to 0.5%. If GAIN is increased too far, hunting may start with some load conditions. Set GAIN shortly before the hunting range.

$$\text{Speed regulation} = \frac{No - N_L}{Ns}$$

where No = No-load speed

N_L = Speed under rated load

Ns = Rated speed

(3) LIMIT

Normally, LIMIT is kept at the CW end. When the motor input current increases above the rated current limit, turn LIMIT counterclockwise to limit the current within the rated level.

(4) Setting before shipping

These VRs are set as shown in Table 15.5 before shipping from the factory.

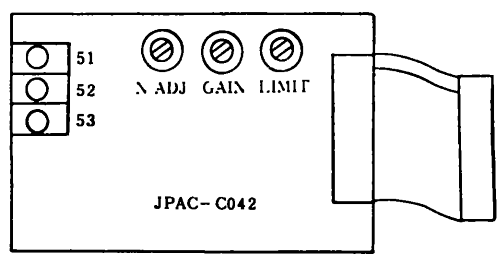


Fig. 15.16 Adjusting Potentiometers of Speed Controller

Table 15·5 Speed Controller Setting

Potentiometer	Factory Setting
N ADJ	Fully CCW
GAIN	5 scales
LIMIT	Fully CW

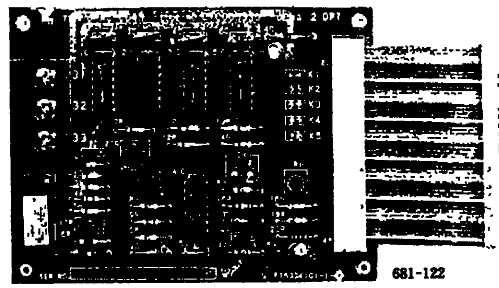
15.4 SYNCHRONIZED STARTER (JPAC-C043)

JPAC-C 043 (Fig. 15.17) is for starting the free running motor at a frequency corresponding to the motor speed. If a low frequency AC power is applied to a free-running motor, the motor is applied to a free-running motor, the motor is regeneratively braked to generate large current to trip the overload protector (OV).

JPAC-C 043 starts from the maximum inverter frequency and decelerates until synchronization with the motor speed. The state of synchronization is detected, and it starts to increase the inverter output frequency again. JPAC-C 043 is mainly used where the load machine is required to keep running even when the power supply fails momentarily, or in controlling fiber winding machines.

[CAUTIONS IN OPERATION]

Synchronized starter Type JPAC-C043 is used to continue automatic operation at power failure. Depending on load, motor is re-accelerated after it stops.

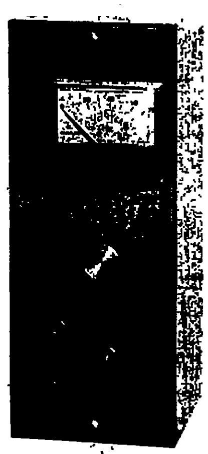


681-122

Fig. 15.17 Sychronized Starter

16. VS OPERATOR

The VS Operator is a standard unit incorporating the operation command, frequency setting, frequency indication and other control functions of the VS-616 transistor inverter (Fig. 16.1).



681-123

Fig. 16.1 VS Operator

16.1 TYPES AND FUNCTIONS

Table 16·1 VS Operators and Functions

VS Operator	Type JVOP	Function
Standard Operator	-61·[ ]	Frequency setting switch RUN/STOP selector switch.
Operator with Power Switch	-62·[ ]	Power ON/OFF switch
Jogging/Thread Operator with Reversing Switch	-63·[ ]	JOG/THREAD selector switch. Revering switch.
Multi-Function Type Operator	-64·[ ]	Power ON/OFF switch. VS snap-in module can be added.

Note: Suffix in [ ] of type name denotes frequency meter type.
1: 60Hz, 2: 72Hz, 3: 90Hz, 4: 120Hz.
For other frequency meters, contact us.

16.2 INTERNAL CONNECTION AND TERMINALS (Fig. 16.2)

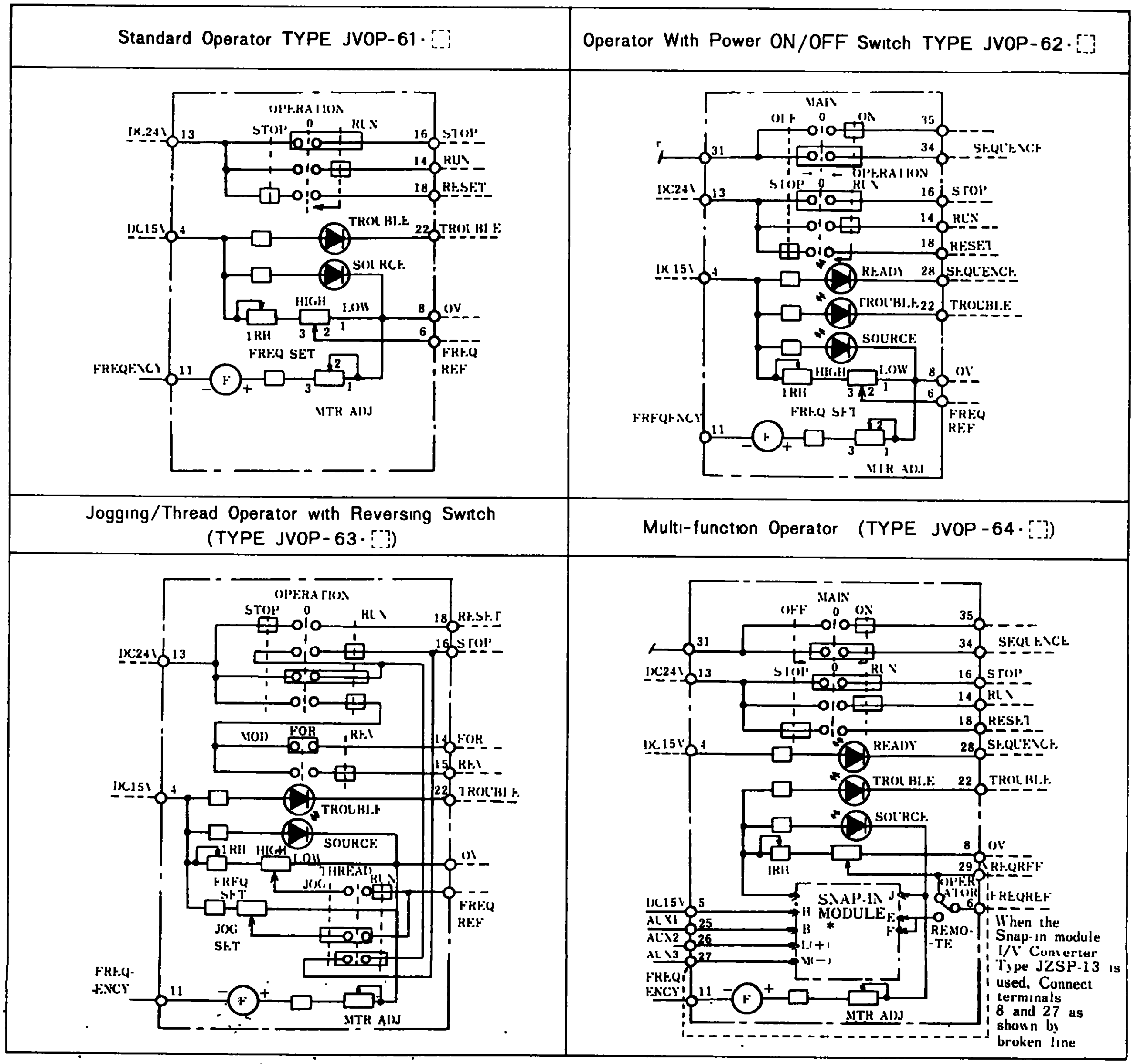


Fig. 16.2 Internal Connections of VS Operator and Terminals

16.3 FUNCTION AND TYPES OF MULTI-FUNCTION VS OPERATOR SNAP-IN MODULES

The snap-in modules mountable to the multi-function VS operator are listed in Table 16.2.

Table 16.2. Types and Functions of Snap-in Modules (Examples)

Snap-in Module	Type	Function
I/V Converter	JZSP-13	Converts current signals into 10 V; 100 % rpm voltage signals for motor speed command. Short across external terminals 8 and 27 of standard 4-20 mA/0-10 V VS Operator JVOP-64 (See dash line in internal connection diagram above.)
F/F Converter	JZSP-14	Converts frequency signal type speed command into 0-10 V voltage signals: Setting of 0-10 V is possible for input frequencies between 0 and 2 kHz.
Tachometer Generator Follower	JZSP-15	Converts the frequency of the main motor tachometer generator into voltage signals for use as the speed command of the controller, in joint operation among several motors: 240-720 Hz frequency can be adjusted to 10 V output.

16.4 RATINGS AND SPECIFICATIONS

Table 16·3 Common VS Operator Specifications

Electrical	
AC Power Supply for Sequence	200-220 V, 50/60 Hz
DC Power Supply for Sequence	Approx 24 VDC (Non-stabilized power supply)
DC Power Supply for Frequency Setting	15 VDC ±0.5 (Stabilized power supply)
Output Voltage for Frequency Setting	+10 V/100 %
Resistance Value for Frequency Setting	2 kΩ, Characteristics B, 1 W
Power Supply Sequence Switch	Conduction capacity: 220 VAC, 30 A Interrupting capacity: 220 VAC, 3 A
Indication	LED (Green or red)
Frequency Meter	3 VDC full scale, 1 mA ①
Insulation Withstand Voltage	Main circuit: 2000 VAC for 1 minute
Mechanical	
Enclosure	Enclosed, wall-mounted type ② (Built-in type available)
Finish	Faceplate: 5 PB 3/9 Casing: 5 Y 7/1
External Terminal	M 4 screw
Ground Terminal Mounting Position	Casing bottom
Weight	Approx 1.7 kg
Environmental	
Storage Temperature	−10 to +55°C ③
Operating Temperature	−10 to +55°C
Altitude	1000 m max
Operating Humidity	Ambient temperature: 40°C ④ Humidity: 95 % RH no condensation
Vibration	10-55 Hz ⑤ Full amplitude: 0.3 mm 24 Hours for 3 directions
Harmful Gas	H_2S: 0.5 ppm max ⑥ 0.1 ppm max as average
Dust	Without harmful dust

① Frequency meter is a voltmeter of 1 mA, 3 VDC full scale, provided with frequency scale. Full scale frequency available in 75 Hz, 100 Hz, 120 Hz, and 150 Hz.

② Modifiable to built-in type by relocating external terminals to the VS operator casing.

③ Special action is necessary for use in cold area of −20°C or below.

④ Special action is necessary for use in high temperature and high humidity (South East Asia or water processing facility)

⑤ The basis for the vibration during transit. Special action should be taken for use in the place subject to vibration. (e. g. vibration-resistant rubber).

⑥ For use in dusty location, dustproof casing should de employed.

16.5 INDIVIDUAL SPECIFICATIONS AND CHARACTERISTICS

Table 16·4 VS Operator Individual Specifications

<table>
<tr><th colspan="3">VS Operator and Type</th><th>Type JVOP-61</th><th>Type JVOP-62</th><th>Type JVOP-63</th><th>Type JVOP-64</th></tr>
<tr><td rowspan="3">Power Supply Sequence Switch</td><td colspan="2">Control Method</td><td rowspan="3">—</td><td>Spring return</td><td rowspan="3">—</td><td>Spring return</td></tr>
<tr><td colspan="2">Conduction Capacity</td><td>220 VAC, 30 A</td><td>220 VAC, 30 A</td></tr>
<tr><td colspan="2">Interrupting Capacity</td><td>220 VAC, 3 A</td><td>220 VAC, 3 A</td></tr>
<tr><td rowspan="2">Operation Sequence Switch</td><td rowspan="9">Control Method</td><td>RUN</td><td>Spring return</td><td>Spring return</td><td>Spring return</td><td>Spring return</td></tr>
<tr><td>STOP</td><td>Maintained</td><td>Maintained</td><td>Maintained</td><td>Maintained</td></tr>
<tr><td rowspan="7">Mode Selector Switch</td><td>FOR</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">Maintained</td><td rowspan="2">—</td></tr>
<tr><td>REV</td></tr>
<tr><td>JOG</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">Maintained</td><td rowspan="3">—</td></tr>
<tr><td>THREAD</td></tr>
<tr><td>RUN</td></tr>
<tr><td>OPERATOR</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">Maintained</td></tr>
<tr><td>REMOTE</td></tr>
<tr><td colspan="3">LED Indication</td><td>SOURCE (Green)
TROUBLE (Red)</td><td>SOURCE (Green)
READY (Green)
TROUBLE (Red)</td><td>SOURCE (Green)
TROUBLE (Red)</td><td>SOURCE (Green)
READY (Green)
TROUBLE (Red)</td></tr>
<tr><td colspan="3">Snap-in Modules</td><td>—</td><td>—</td><td>—</td><td>Type JZSP-13
Type JZSP-14
Type JZSP-15</td></tr>
<tr><td colspan="3">Power Supply for Power Sequence</td><td>—</td><td>250 VAC Max.</td><td>—</td><td>250 VAC Max.</td></tr>
<tr><td colspan="3">DC Supply Current for Frequency Setting</td><td>20 mA</td><td>28 mA</td><td>20 mA</td><td>28 mA</td></tr>
<tr><td colspan="2" rowspan="2">Snap-in Module Power Supply</td><td>Voltage</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">—</td><td>±15 V</td></tr>
<tr><td>Current</td><td>10 mA Max.</td></tr>
</table>

16.6 CAUTIONS IN OPERATIONS

16.6.1 Checks Upon Acceptance

Upon receipt of the products, check them for the following respects, and if anything is not in order, notify our branch or agents immediately.

- Check items against order sheet.
  Especially when snap-in modules were ordered check if they are delivered.
- The instruction manual provided.
- Any damage during transportation.

16.6.2 Installation

Install the VS-616 system where the environment is free from harmful, high temperature, high humidity, vibration and dirt.

16.6.3 Storage

Store the VS-616 Inverters as spare parts in well-ventilated and low humidity place free from high temperature and humidity, and direct sun light.

16.6.4 Wiring

Connect units with wires correctly, referring to the overall system connection diagram, taking care not to connect to wrong terminals.

(1) Wire size

Use 2 mm^2 vinyl covered leads in the AC power supply circuit (wiring to external terminals (31), (34), (35), and use shielded leads for all other lines.

(2) Separation of wires

Bind the weak current signal lines apart from the power circuit (220VAC min.) or relay drive circuit.

(3) Wiring

Use solderless terminals at the ends of wires, crimping the terminal pieces to the wires firmly by using the special pliers.

(4) Grounding

Connect the grounding terminal (lower right of case) to a Class 3 grounding conductor.

(5) Wiring procedure

When connecting wires to the terminals of the VS operator, Pull out the face plate as shwon in Fig. 16.3, and hook it on the left hinge of the case. The terminal numbers are described on the right side of the case.

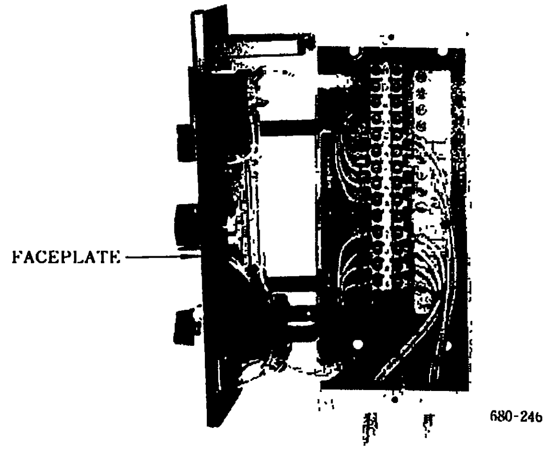


Fig. 16.3 Connections

(6) Megger test and withstand voltage test

No megger test and withstand voltage test are required at trial operation, since they have been performed before being shipped. Exception: if megger test is performed for maintenance operation, test voltage must be 500 V or below and VS operator external terminals be all short-circuited.

16.6.6 Adjustment

(1) Adjustment of frequency meter

The frequency meter is adjusted to rated frequency -10V at the factory before shipment, but slight deviation may take place with some inverters.
To adjust, remove the rubber bushing from MTR ADJ, and turn with a screwdriver (Fig. 16.4).

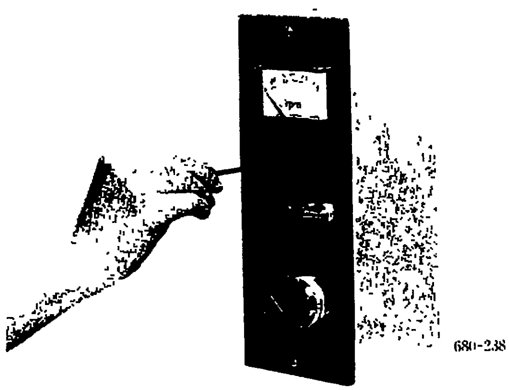


Fig. 16.4 Frequency Meter Adjustment

(2) Adjusting VS snap-in module

When adjusting the variable resistors in the VS snap-in modules, pull out the face plate as shown in Fig. 16.5, and hook it to the left hinge of the case. When extracting the face plate from the case, turn off the power supply in advance.

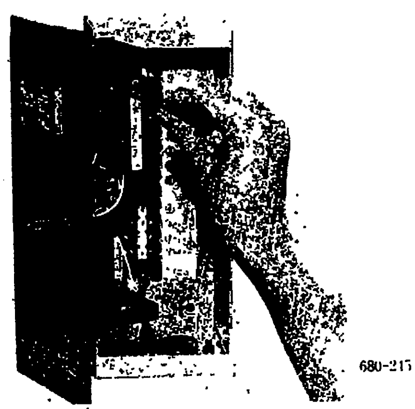


Fig. 16.5 Snap-in Module Adjustment

16.6.7 Mounting and removing Snap-in Module

(1) Mounting

To mount a snap-in module, pull out the face plate and hook it on the left hinge of the case, withdraw the short-circuit board (JZSP-00) and insert it. Insert it fully until the eyelet at the edge of the snap in module clicks (Fig. 16.6).

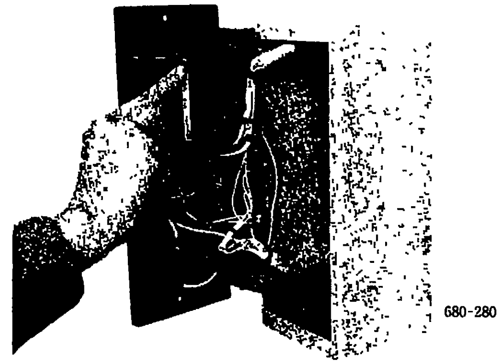


Fig. 16.6 Snap-in Module Plugging

(2) Removing snap-in module

If a snap-in module must be removed, hold the bottom of the face plate and withdraw by slightly lifting. The snap-in module is provided with an eyelet for loosening prevention, and pulling straight backward is not possible.

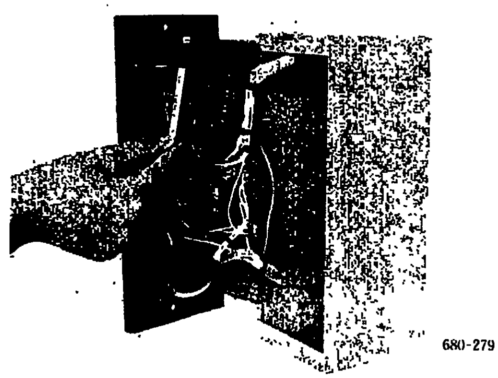


Fig. 16.7 Snap-in Module Removal

16.6.8 Note on Flush-mounting on Panel

The cutout dimensions for flush-mounting the VS Operator on a panel is given in Fig. 16.8. Before mounting, relocate the external terminal block from the interior of the case to area (A) in Fig. 16.9 (c). The case is not used when mounting.

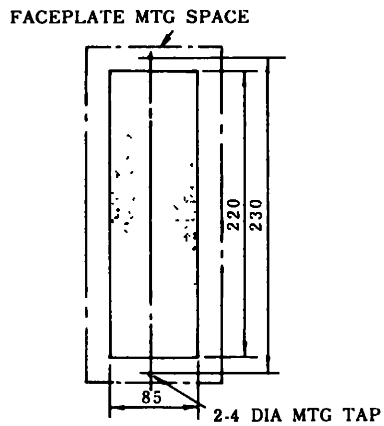


Fig. 16.8 Drilling Plan for Built-in Type

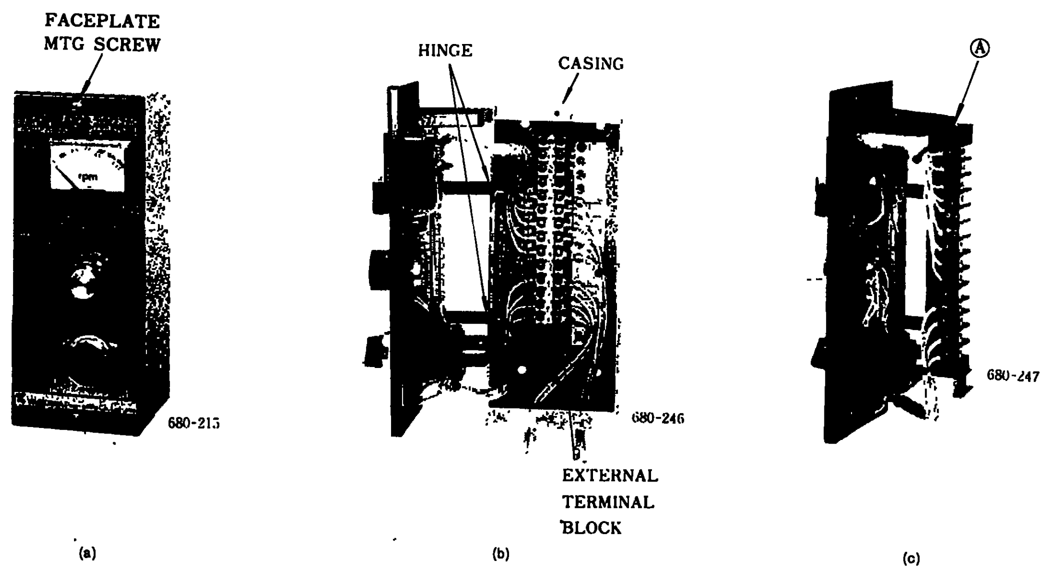
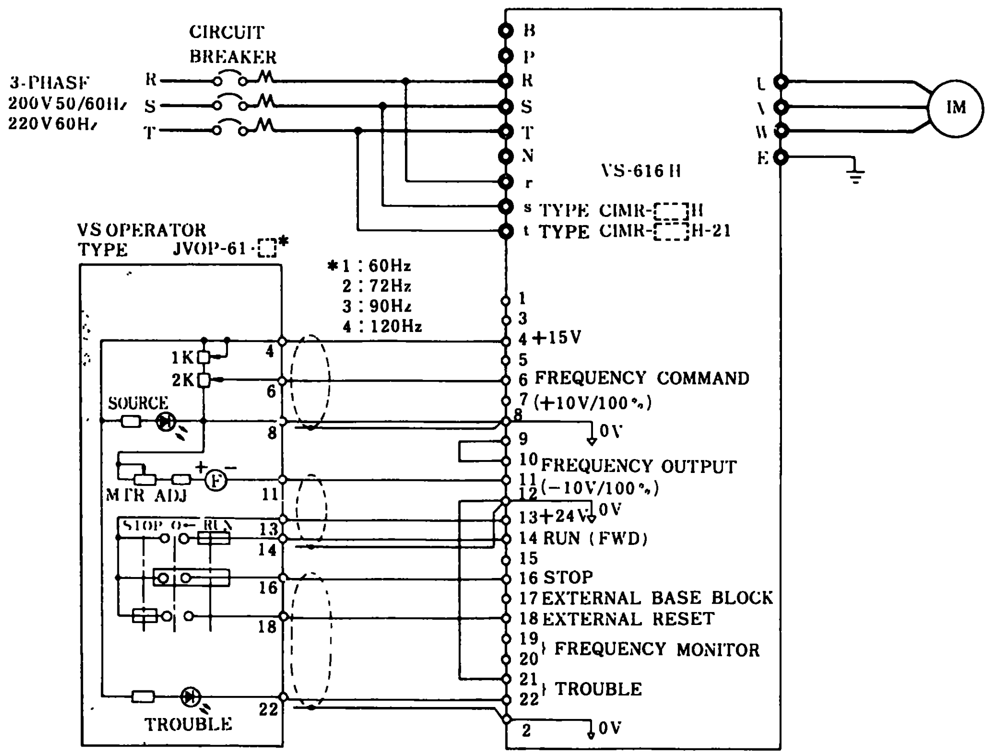


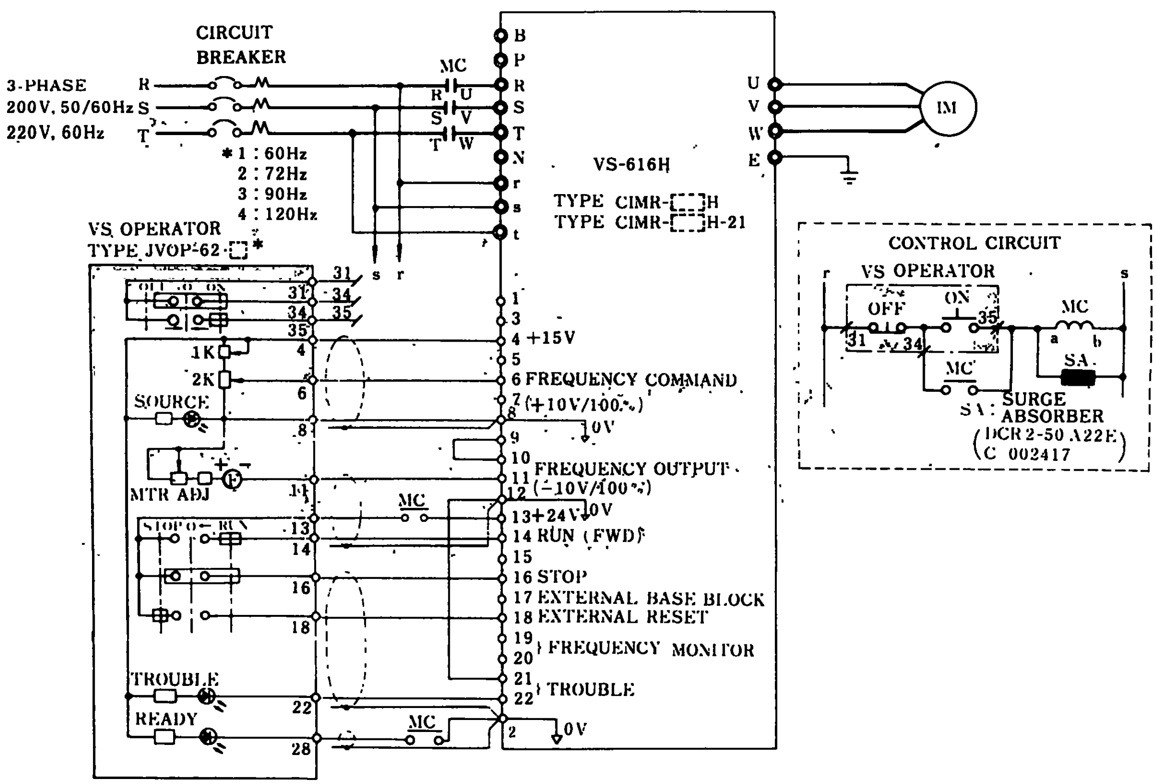
Fig. 16.9 External Terminal Block Relocation

16.6.9 VS-616 Wiring Diagrams

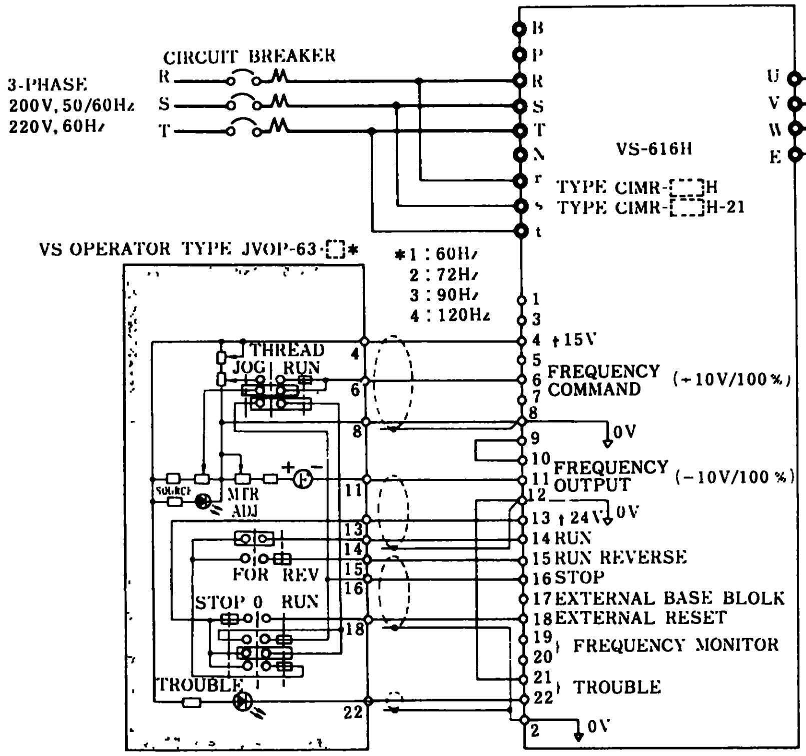
Connections of VS-616H (10 kVA) without Braking Function and VS Operator Type JVOP-61



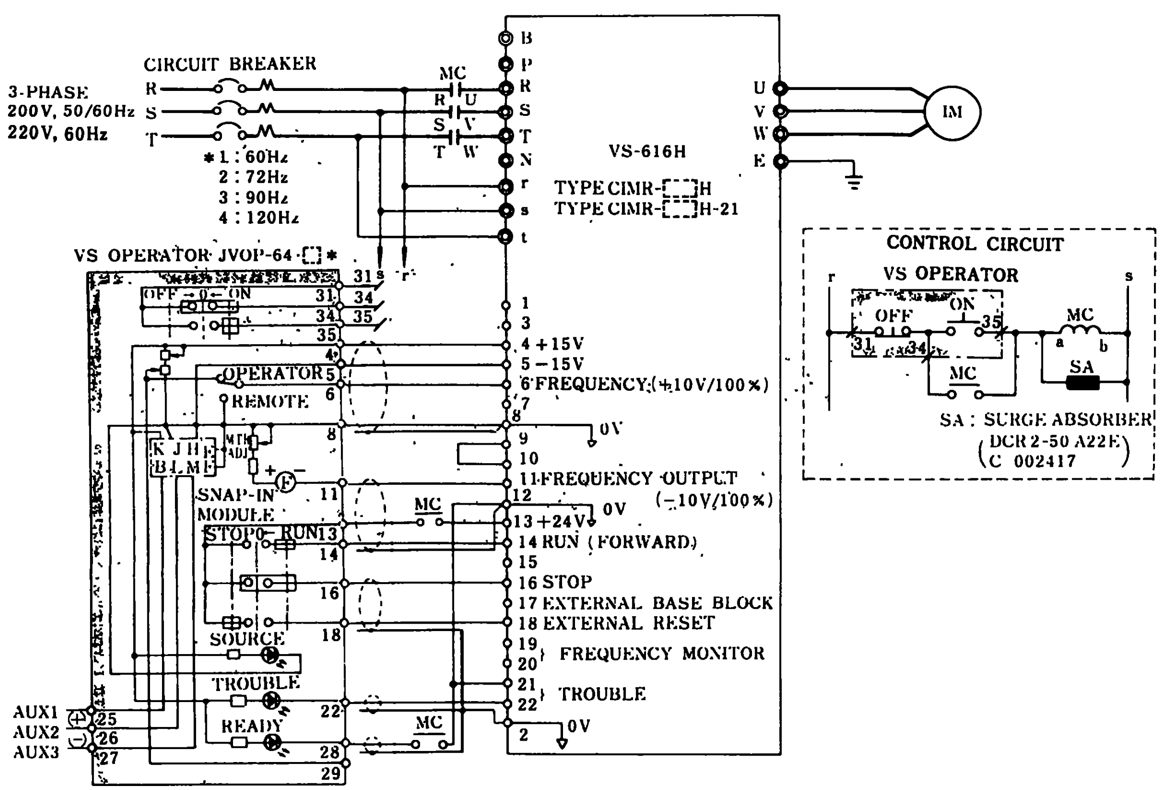
Connections of VS-616H (10 kVA) wihtout Braking Function and VS Operator Type JVOP-62



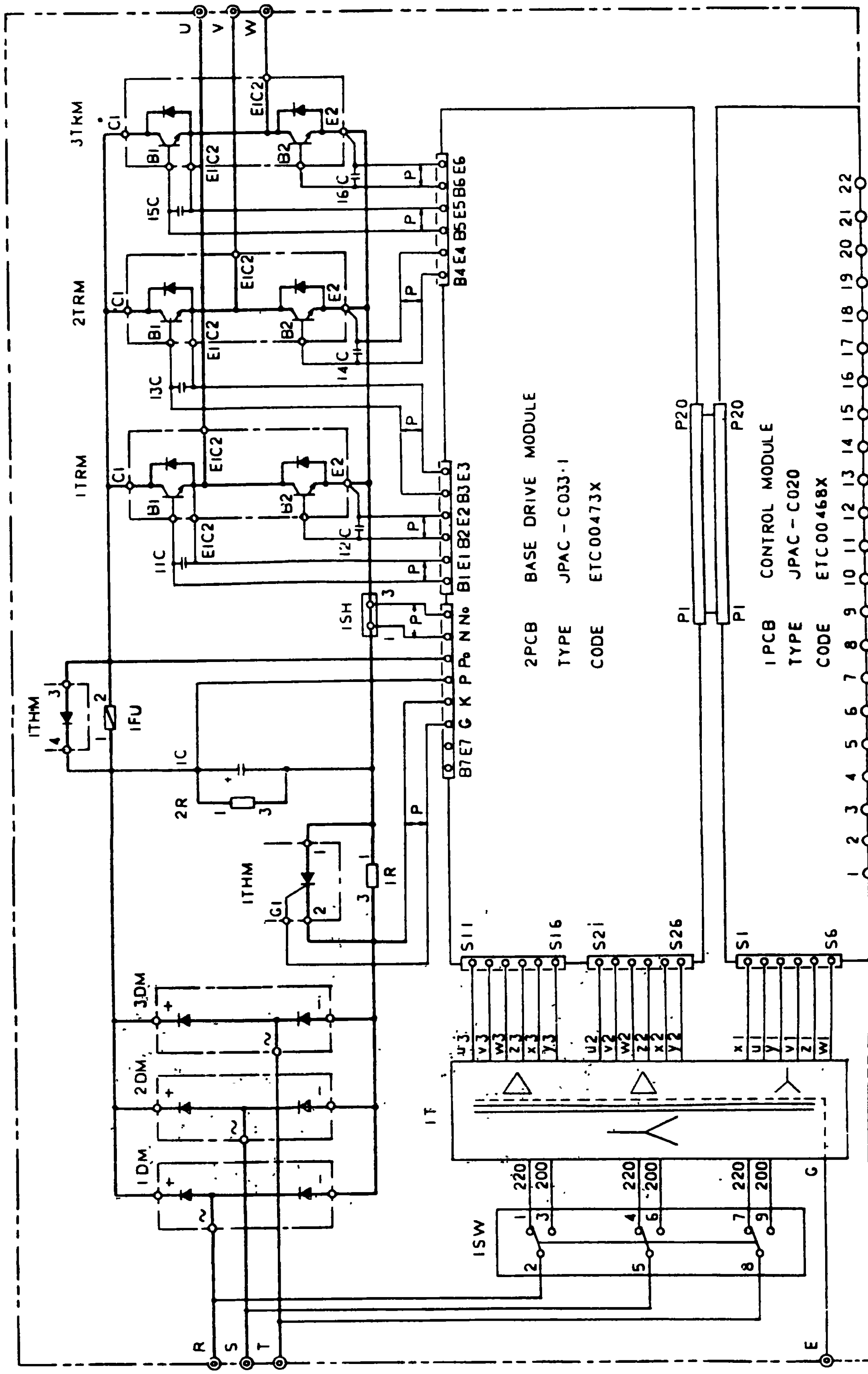
Connections of VS-616H (10 kVA) without Braking Function and VS Operator Type JVOP-63



Connections of VS-616H (10 kVA) without Braking Function and VS Operator Type JVOP-64



17. VS-616 ELEMENTARY DIAGRAMS



NOTE NC: NO CONNECTION

Fig. 17-1 Connections of VS-616 Type CIMR-2.2G

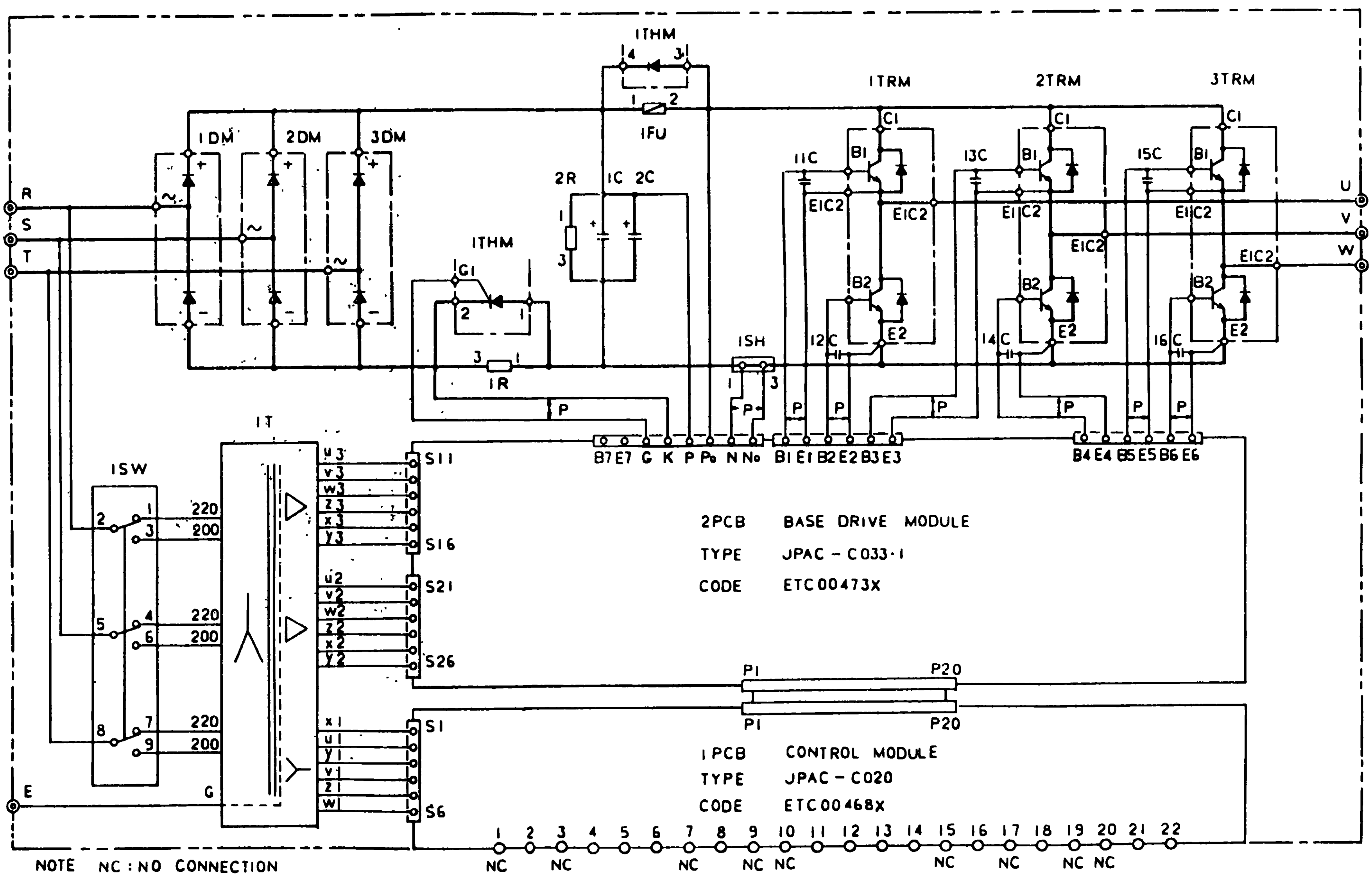


Fig. 17-2 Connections of VS-616 Type CIMR-3.7G

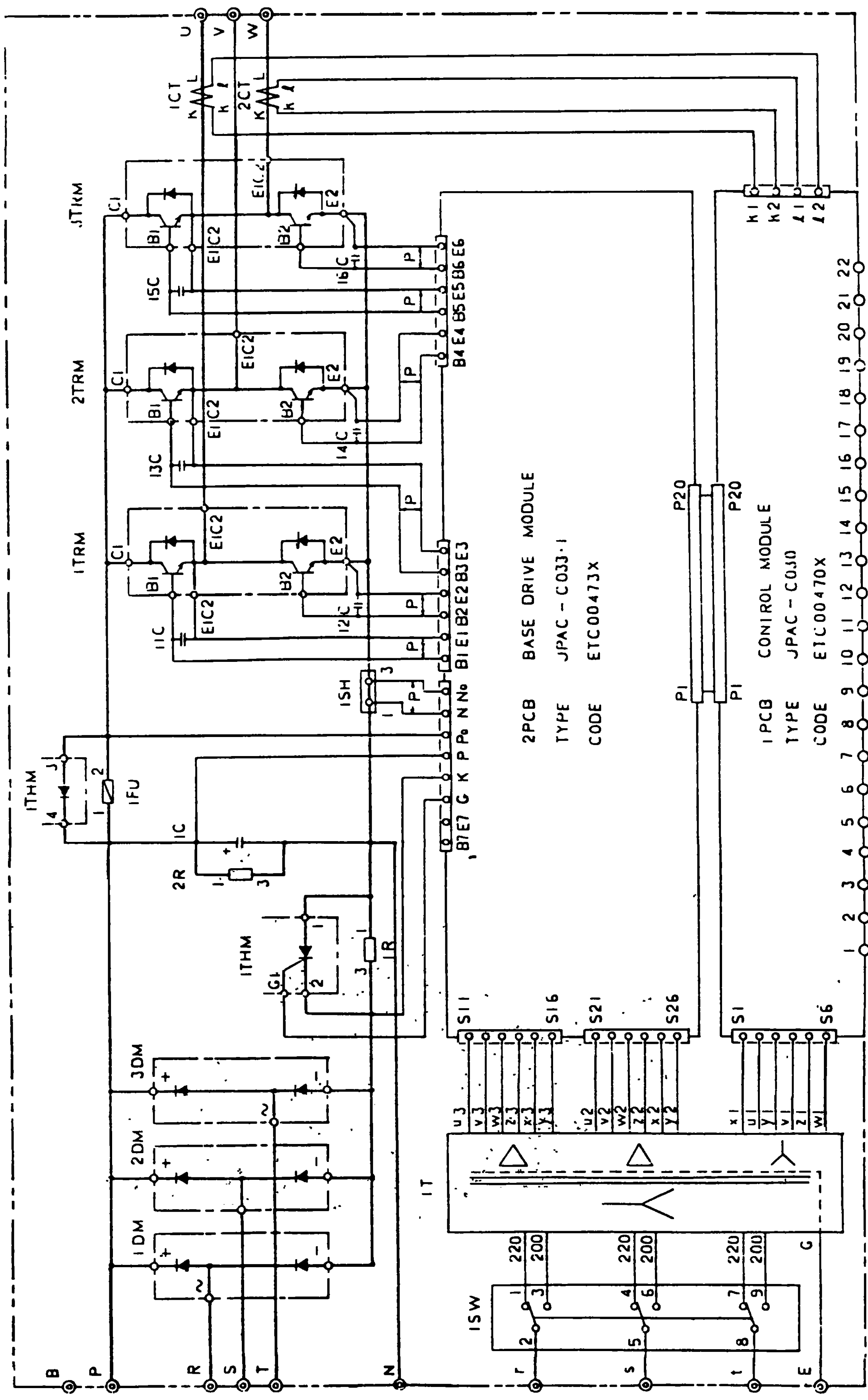


Fig. 17-3 Connections of VS-616 Type CIMR-2.2H

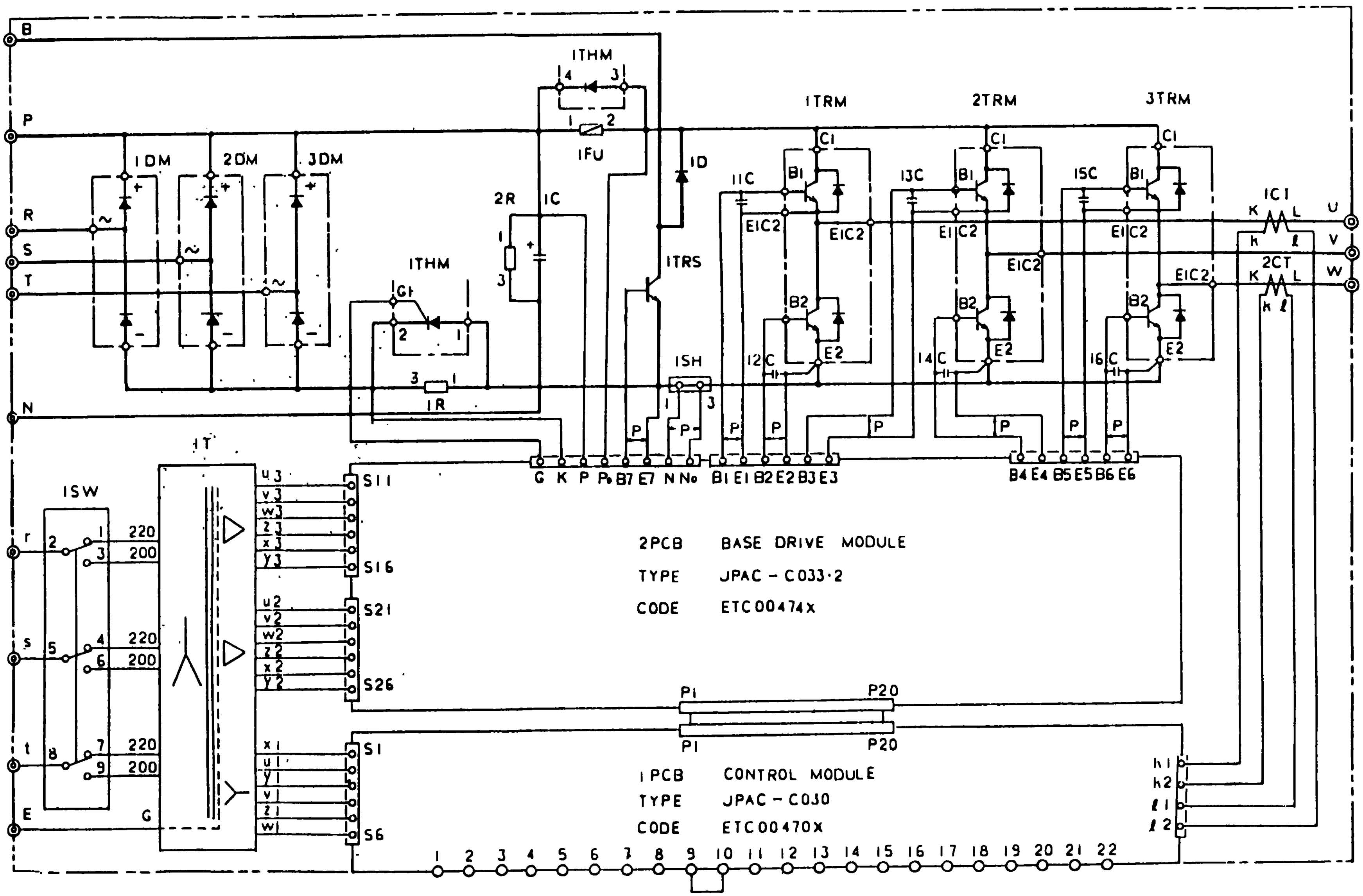


Fig. 17-4 Connections of VS-616 Type CIMR-2.2H1

17. VS-616 ELEMENTARY DIAGRAMS (Cont'd)

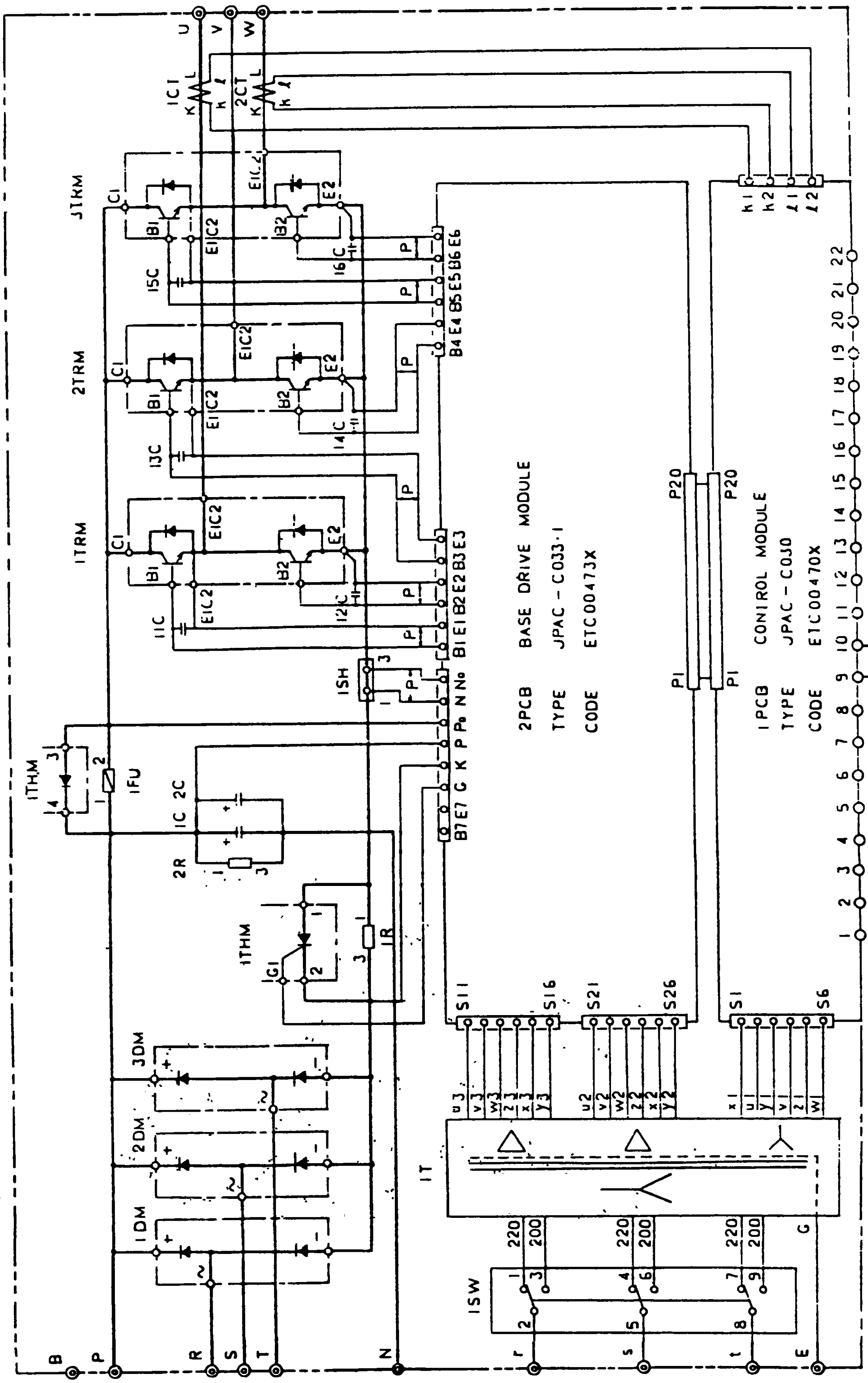


Fig. 17-5 Connections of VS-616 Type CIMR-3.7H

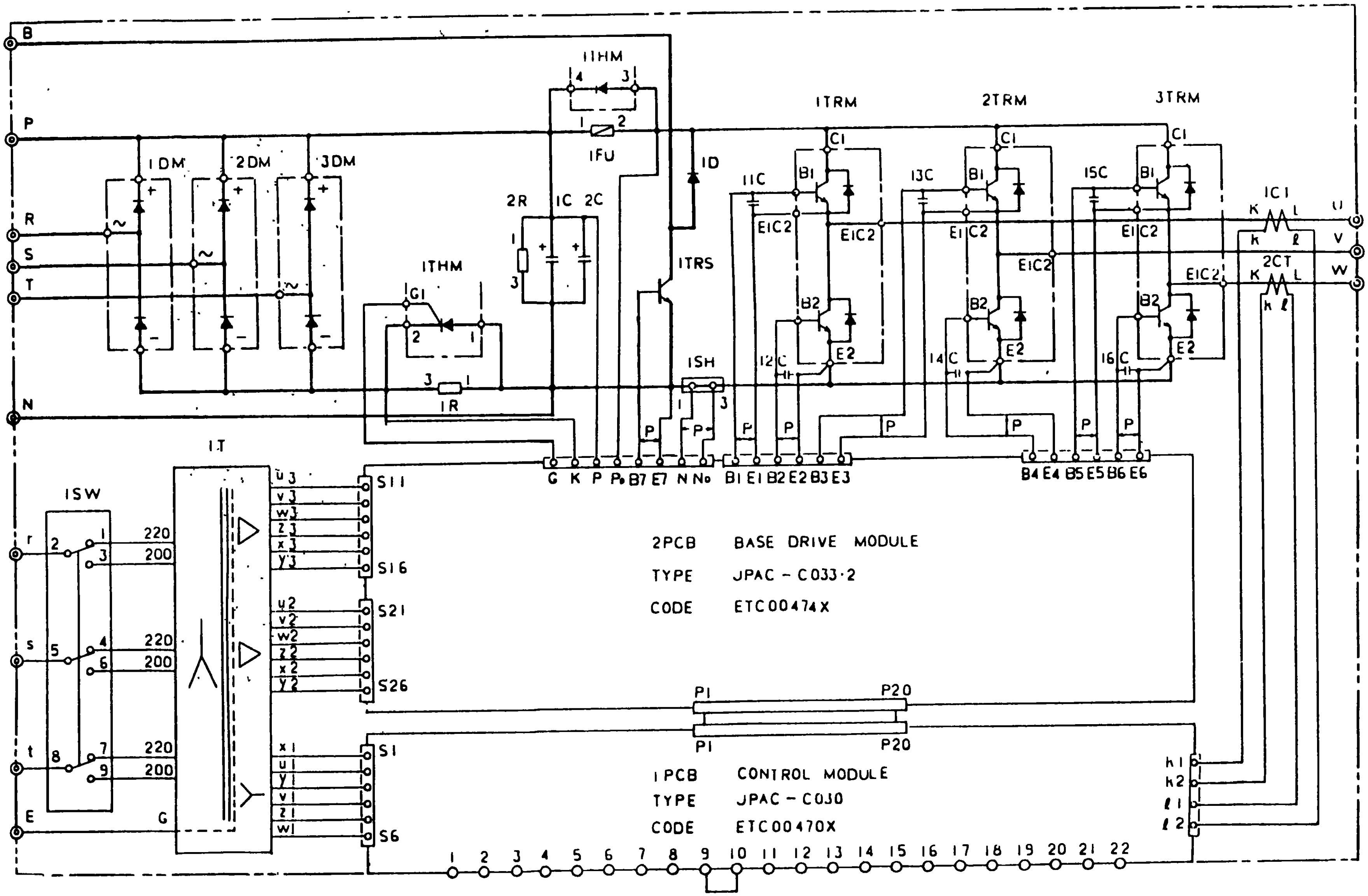


Fig. 17-6 Connections of VS-616 Type CIMR-3.7H1

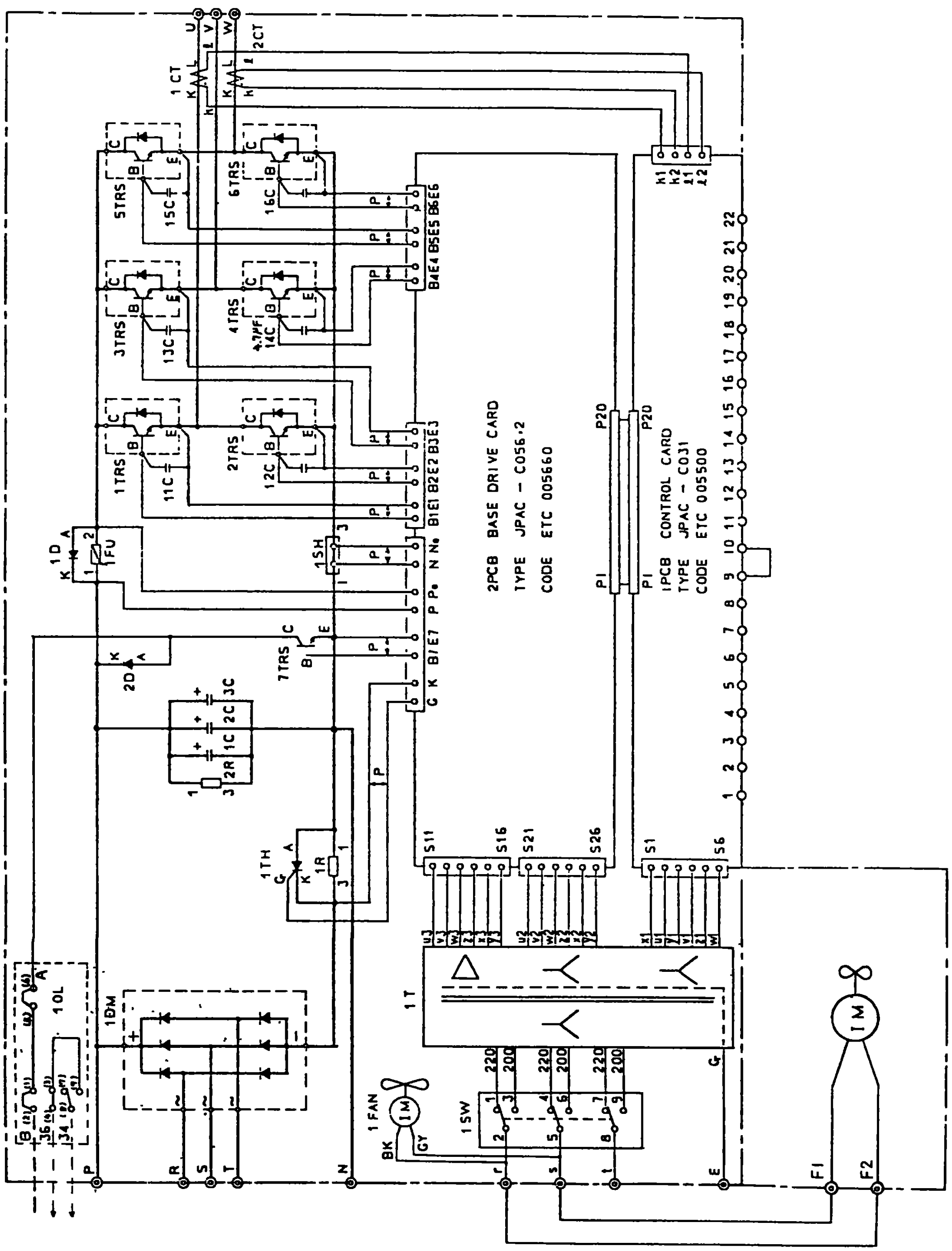


Fig. 17-7 Connections of VS-616 Type CIMR-7.5H1

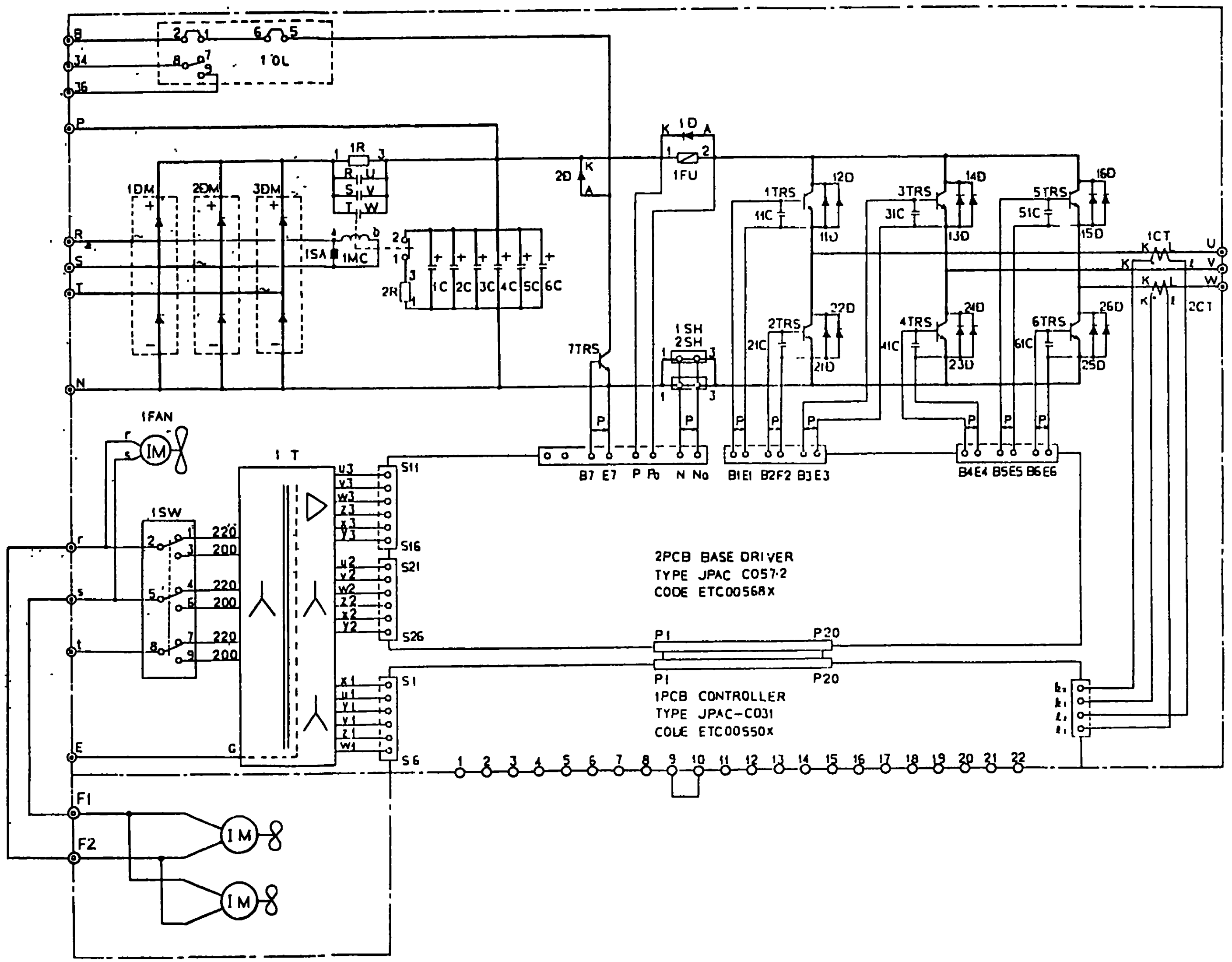


Fig. 17-8 Connections of VS-616 Type CIMR-15H1

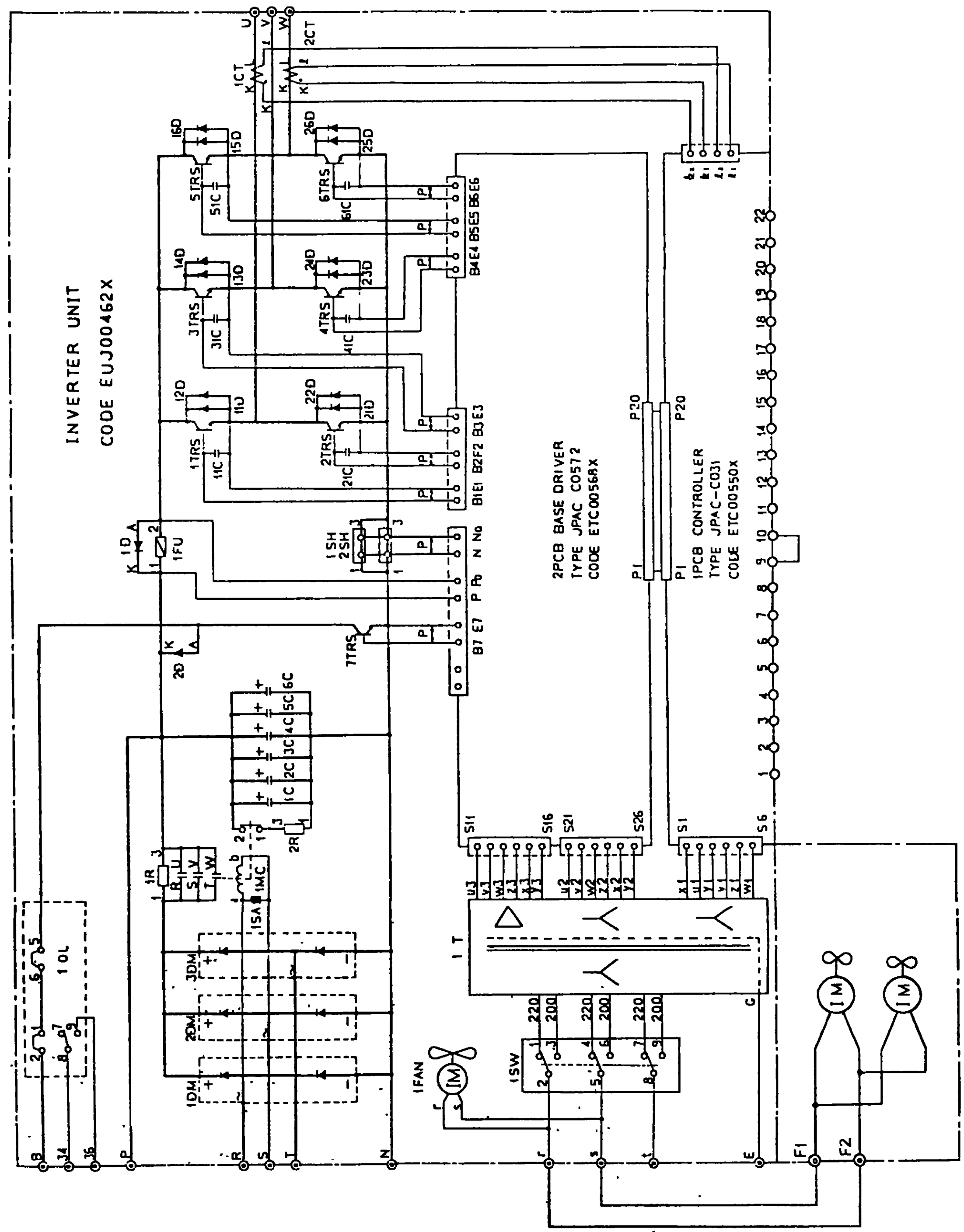


Fig. 17-9 Connections of VS-616 Type CIMR-22H1

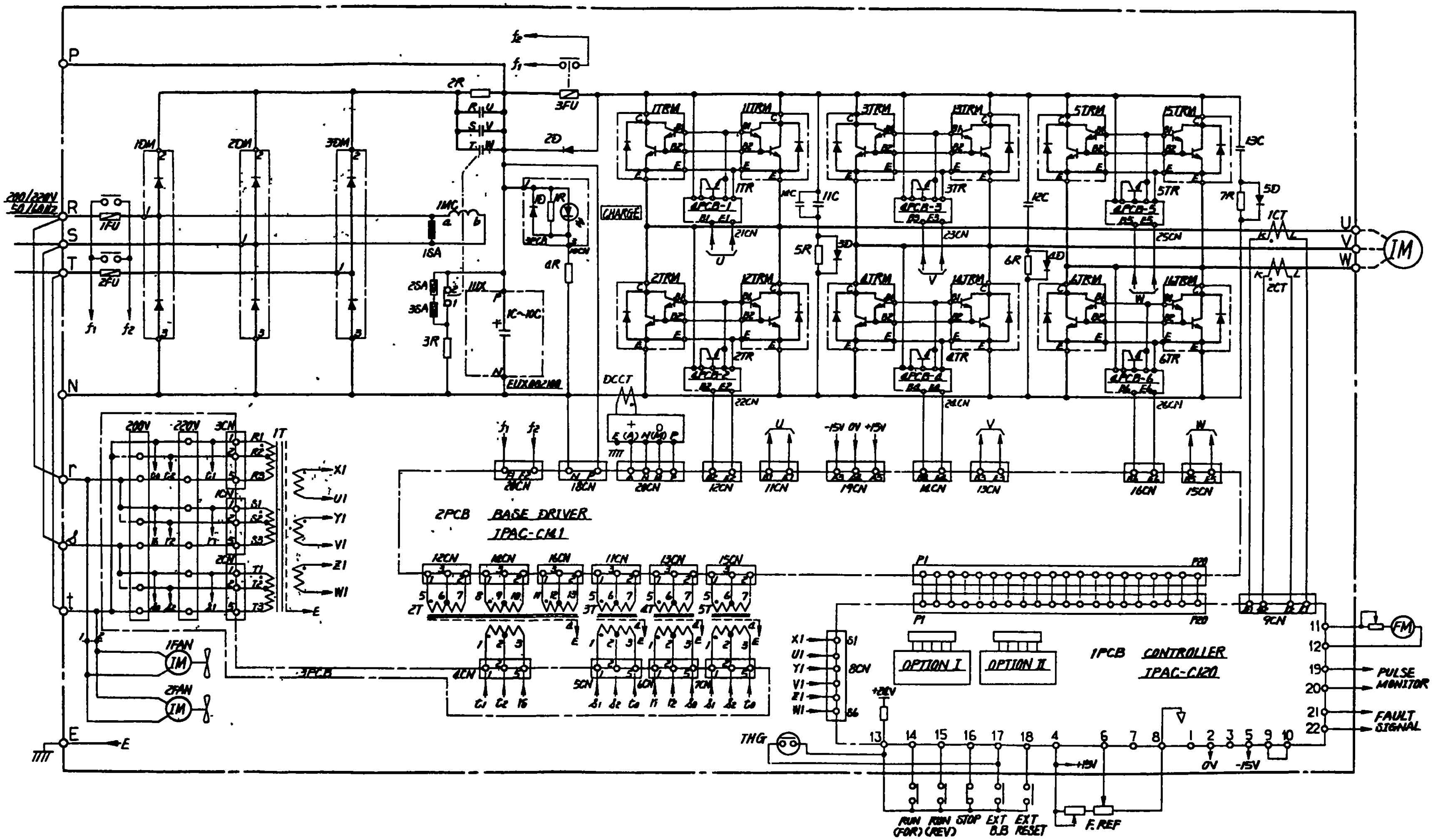


Fig. 17-10 Connections of VS-616 Type CIMR-30H

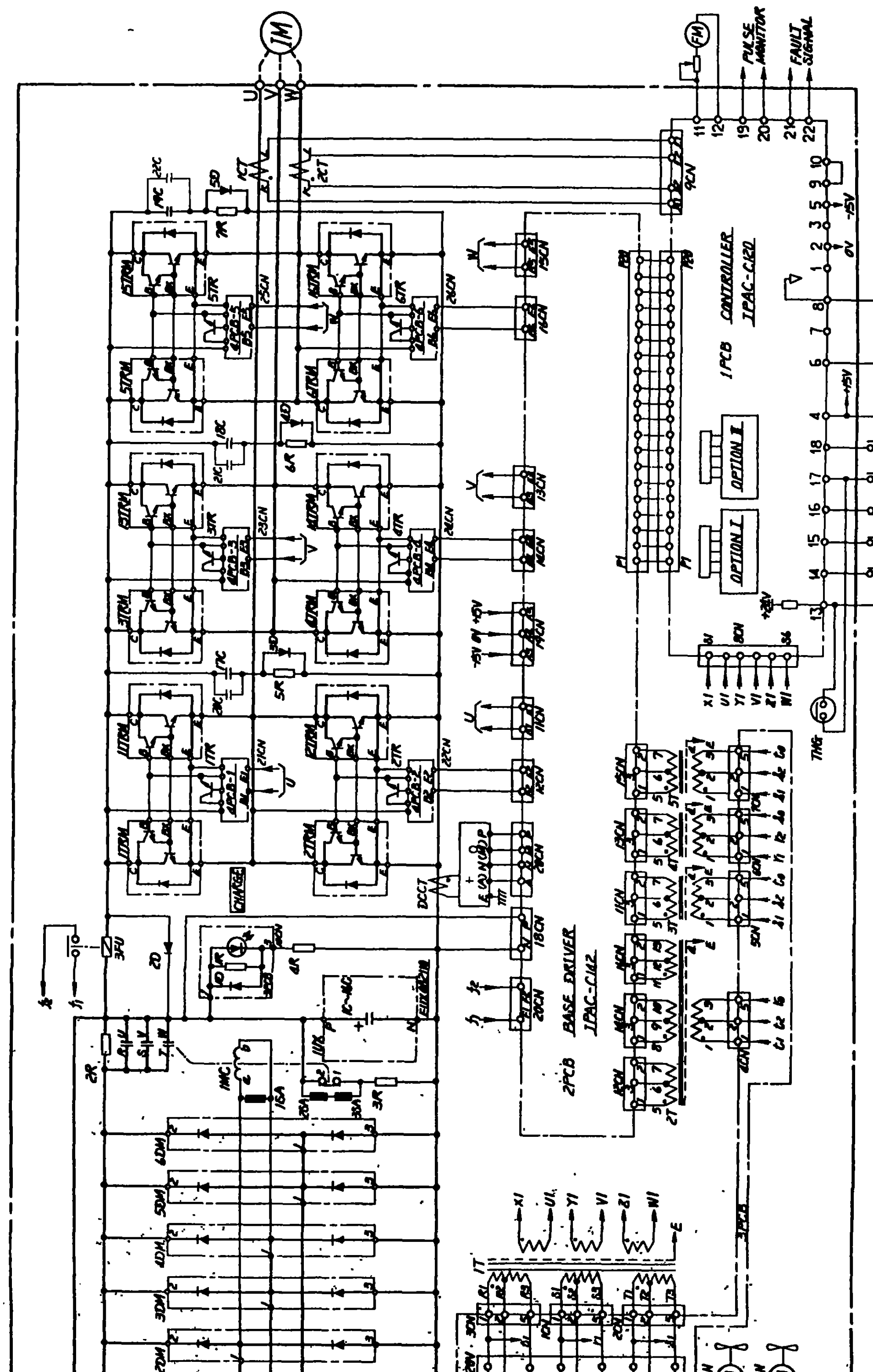


Fig. 17-11 Connections of VS-616 Type CIMR-45H

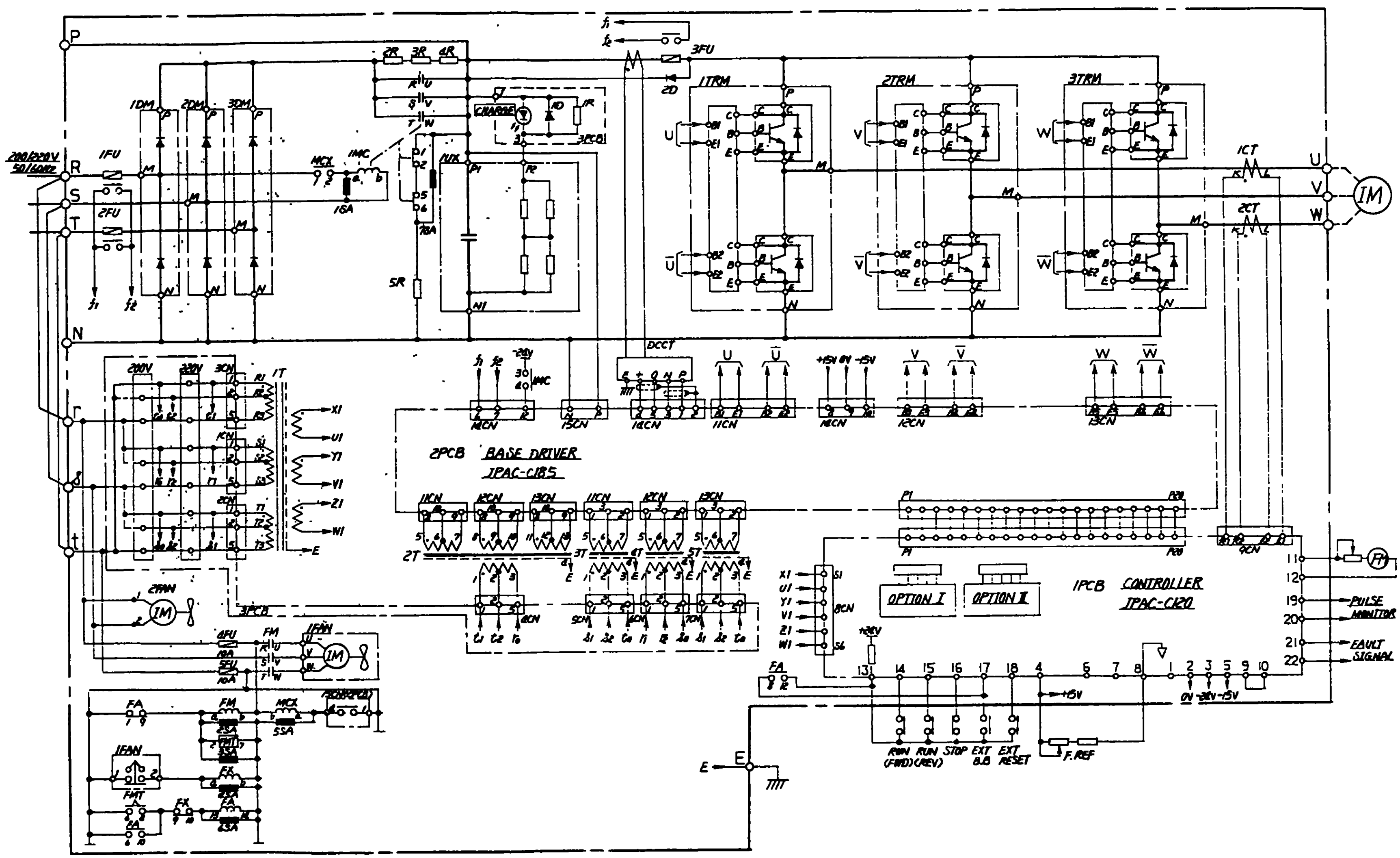


Fig. 17-12 Connections of VS-616 Type CIMR-55H

17. VS-616 ELEMENTARY DIAGRAMS (Cont'd)

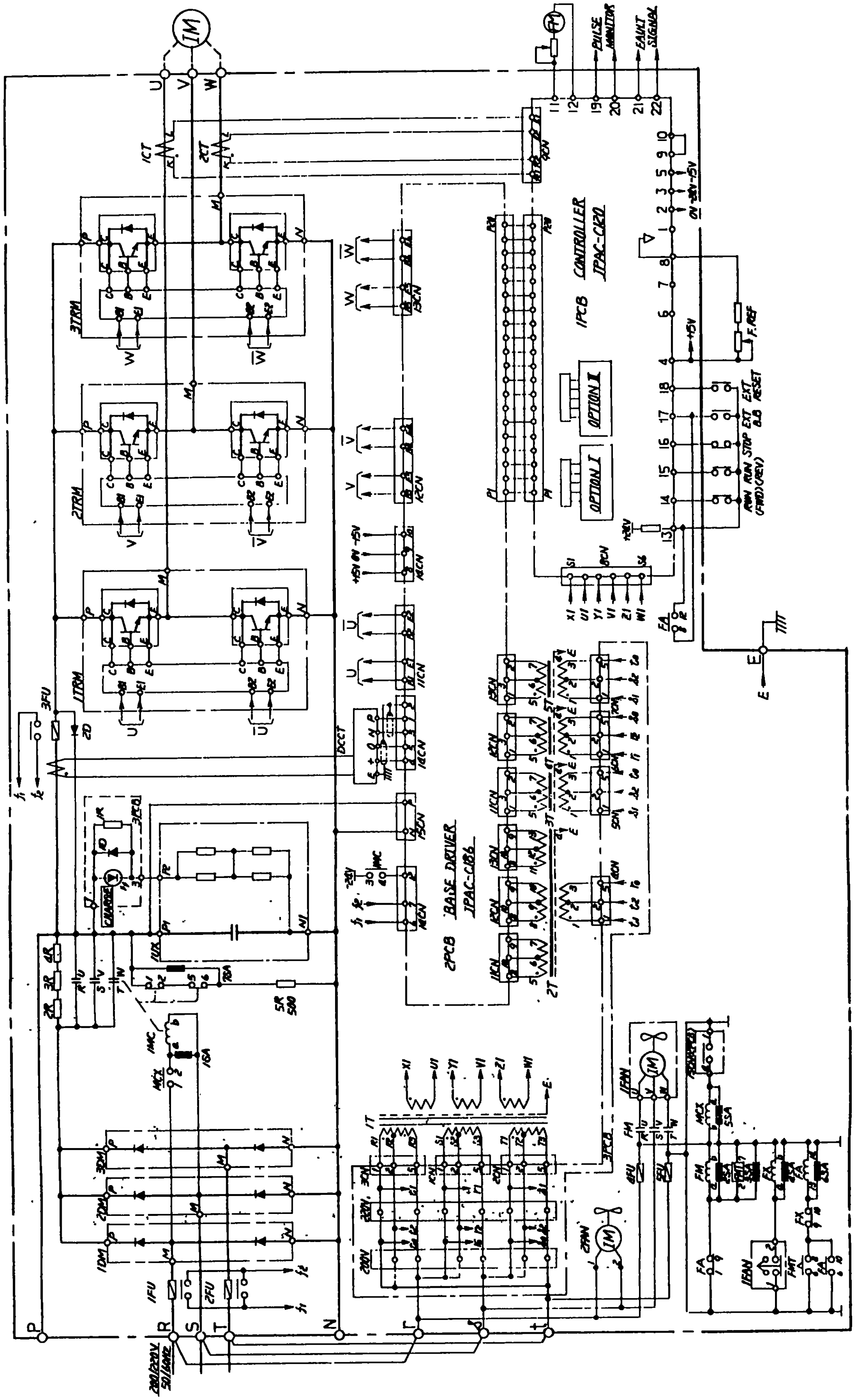


Fig. 17-13 Connections of VS-616 Type CIMR-75H

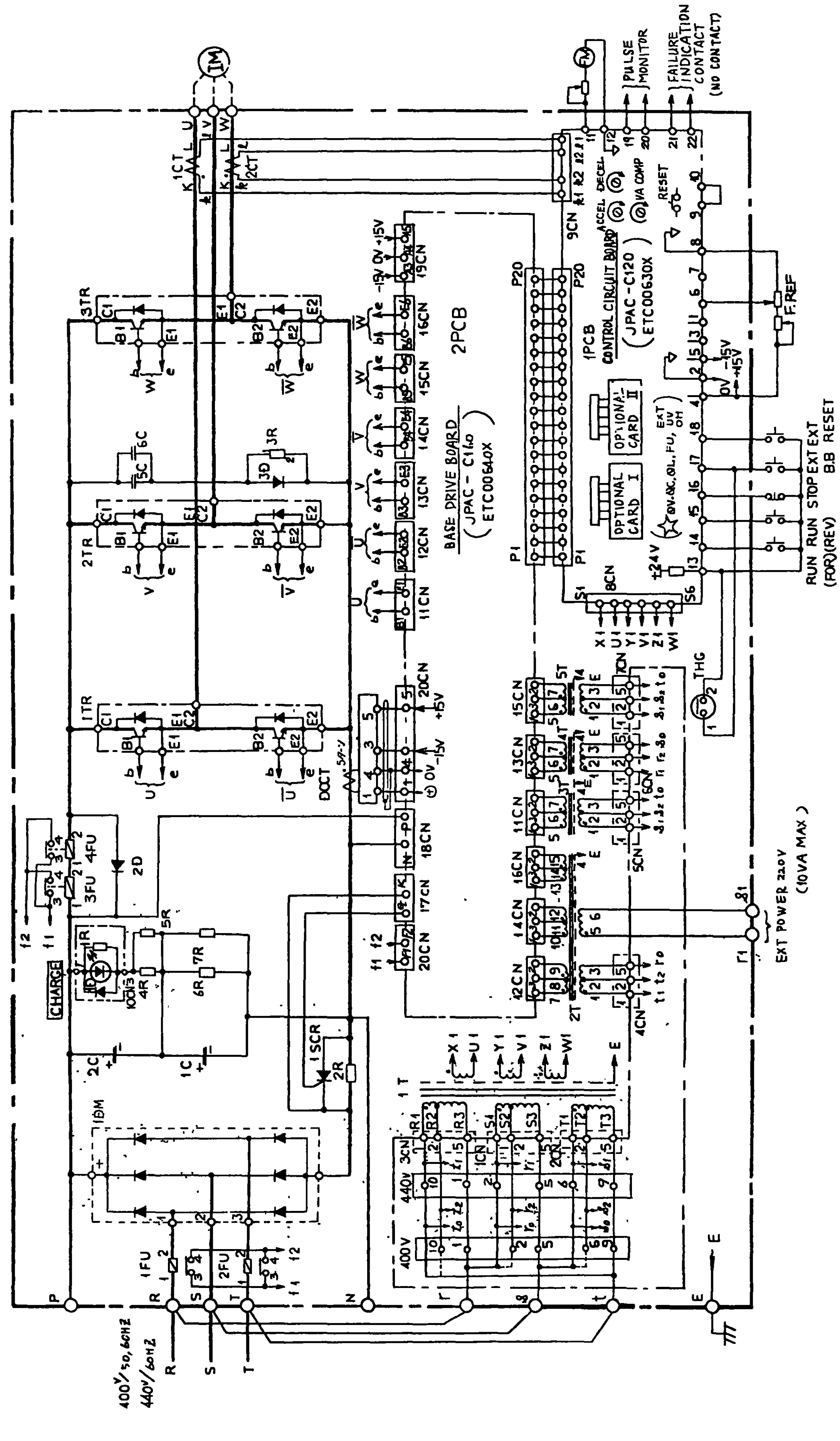


Fig. 17-14 Connections of VS-616 Type CIMR-H3.7H

17. VS-616 ELEMENTARY DIAGRAMS (Cont'd)

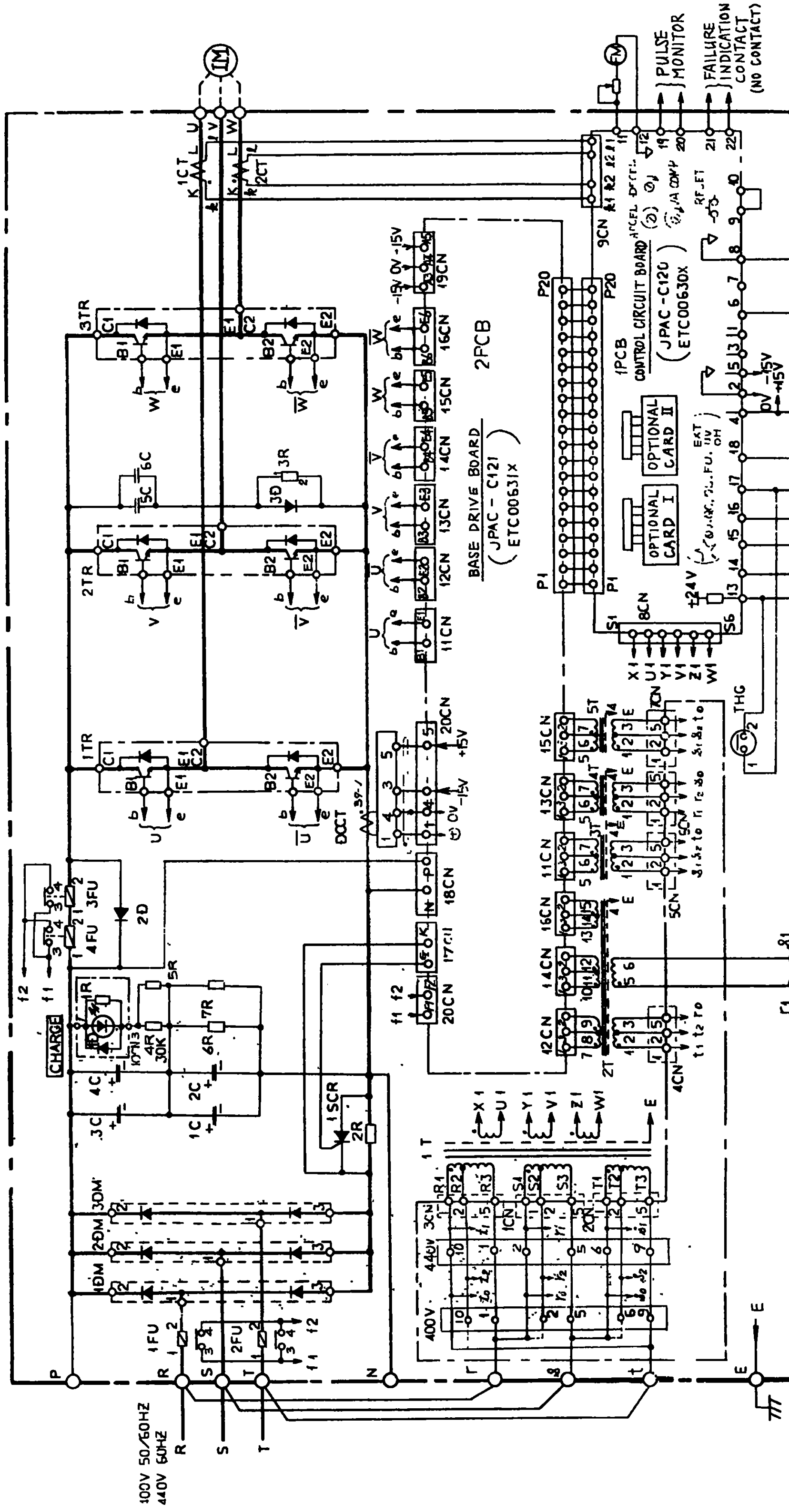


Fig 17-15 Connections of VS-616 Type CIMR-H7.5H

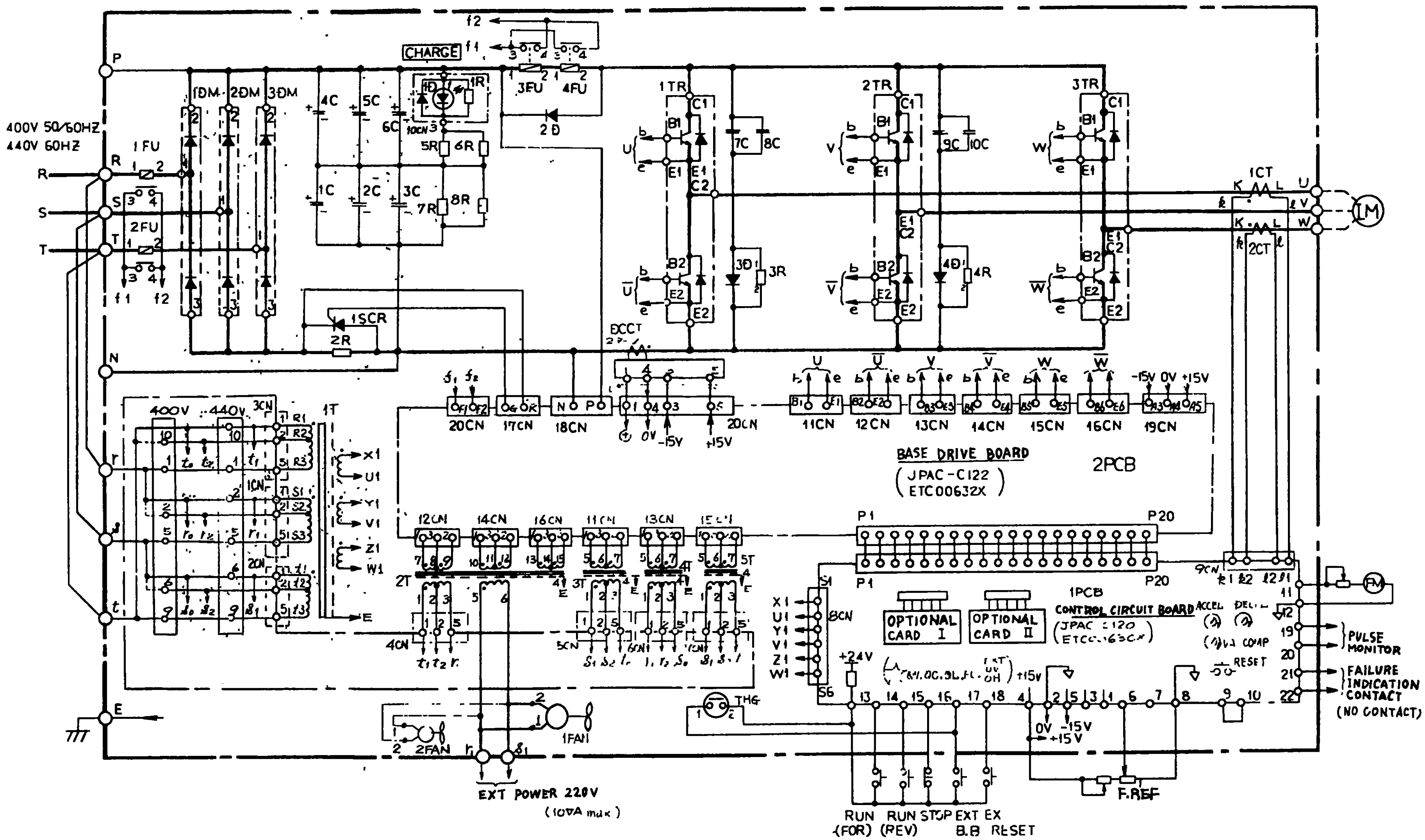


Fig. 17-16 Connections of VS-616 Type CIMR-H15H

17. VS-616 ELEMENTARY DIAGRAMS (Cont'd)

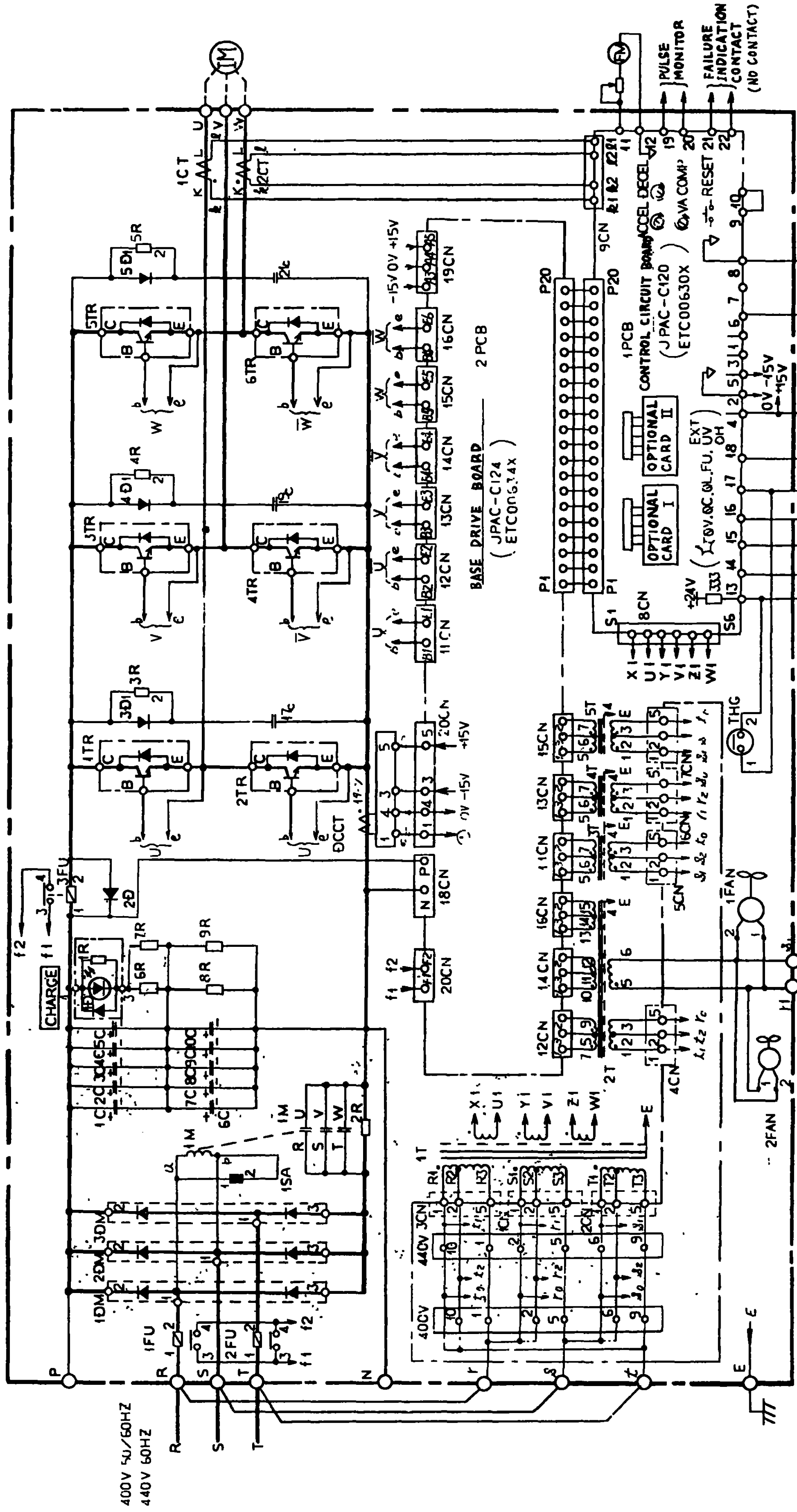


Fig. 17-17 Connections of VS-616 Type CIMR-H30H

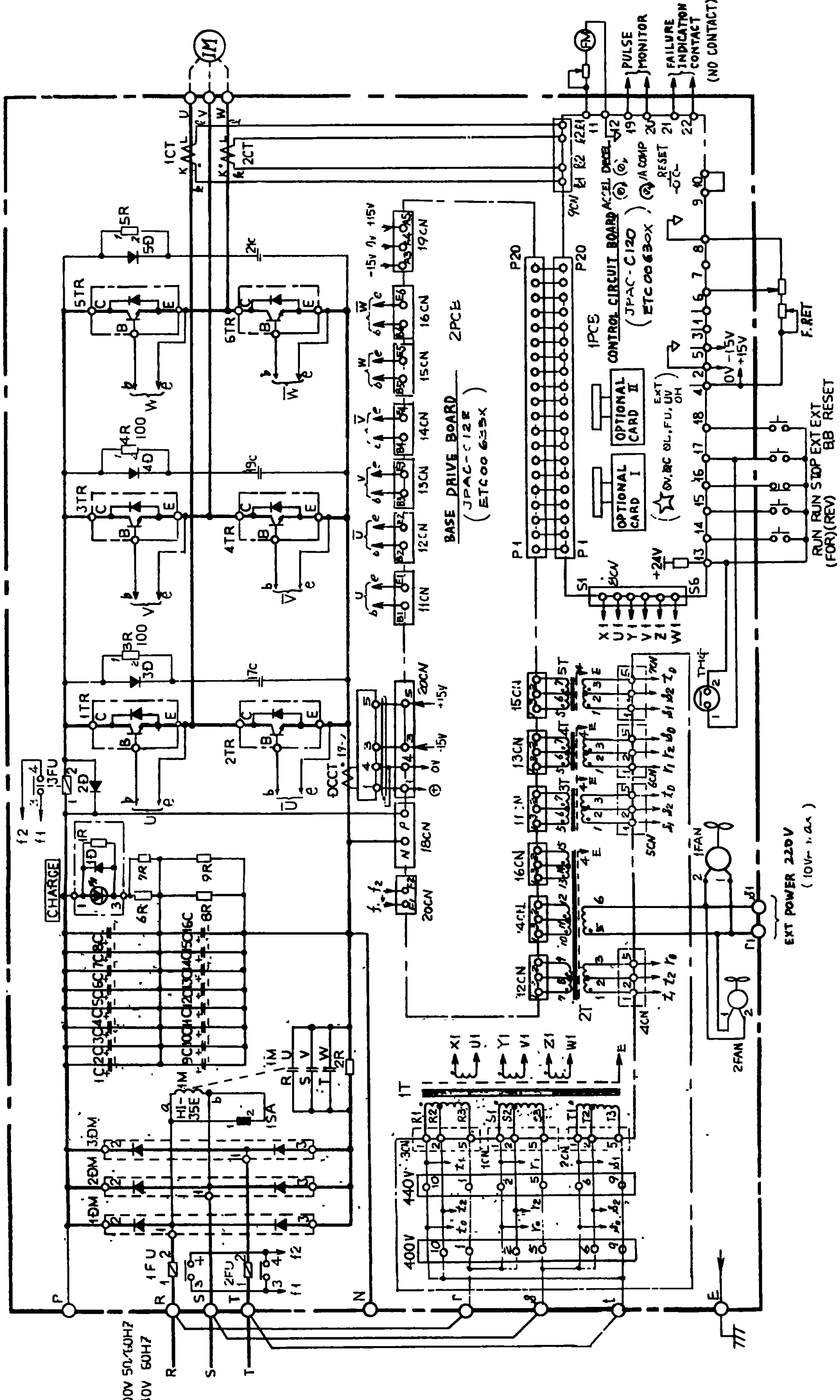


Fig. 17-18 Connections of VS-616 Type CIMR-H45H

17. VS-616 ELEMENTARY DIAGRAMS (Cont'd)

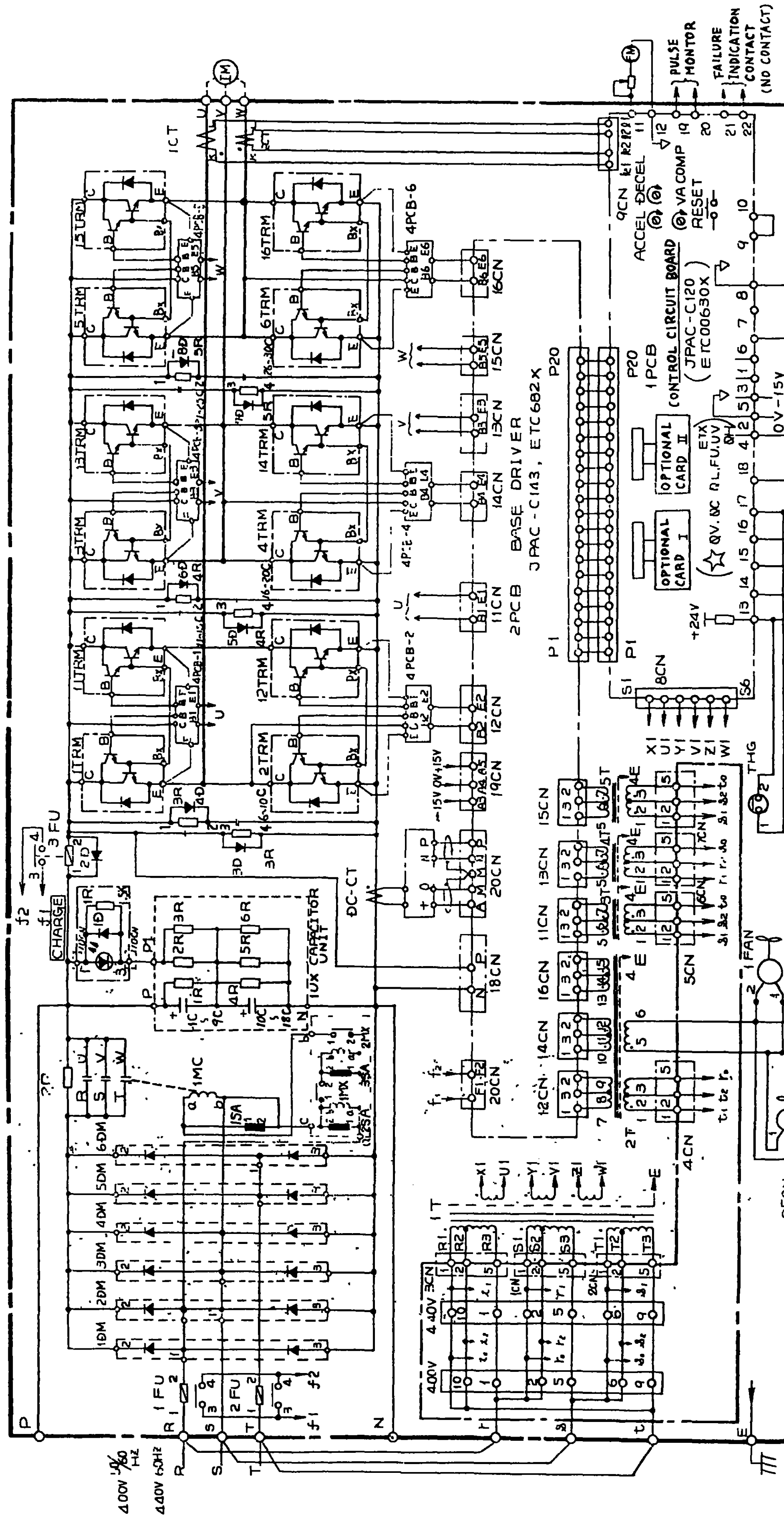


Fig. 17-19 Connections of VS-616 Type CIMR-H55H

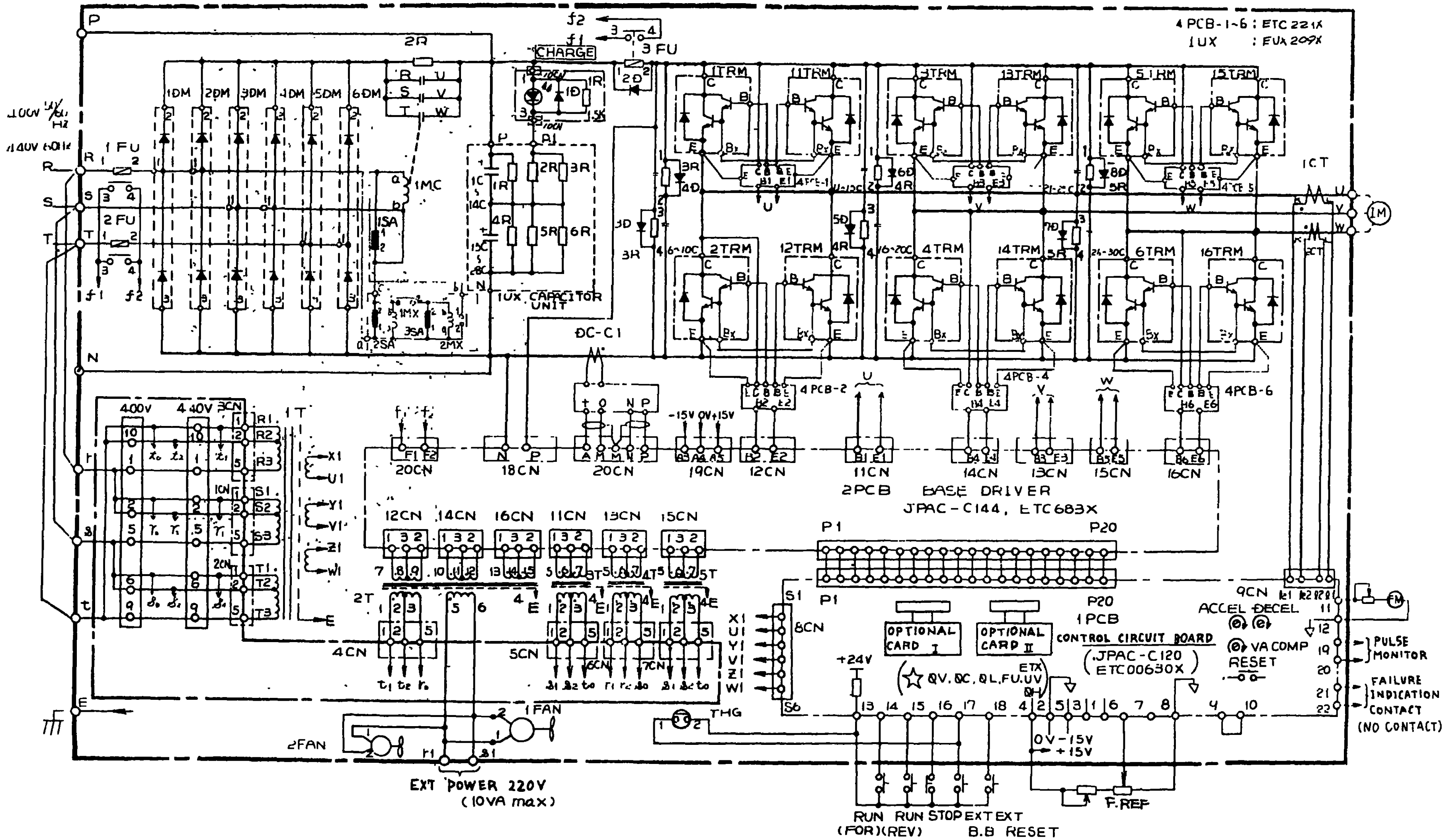


Fig. 17-20 Connections of VS-616 Type CIMR-H75H

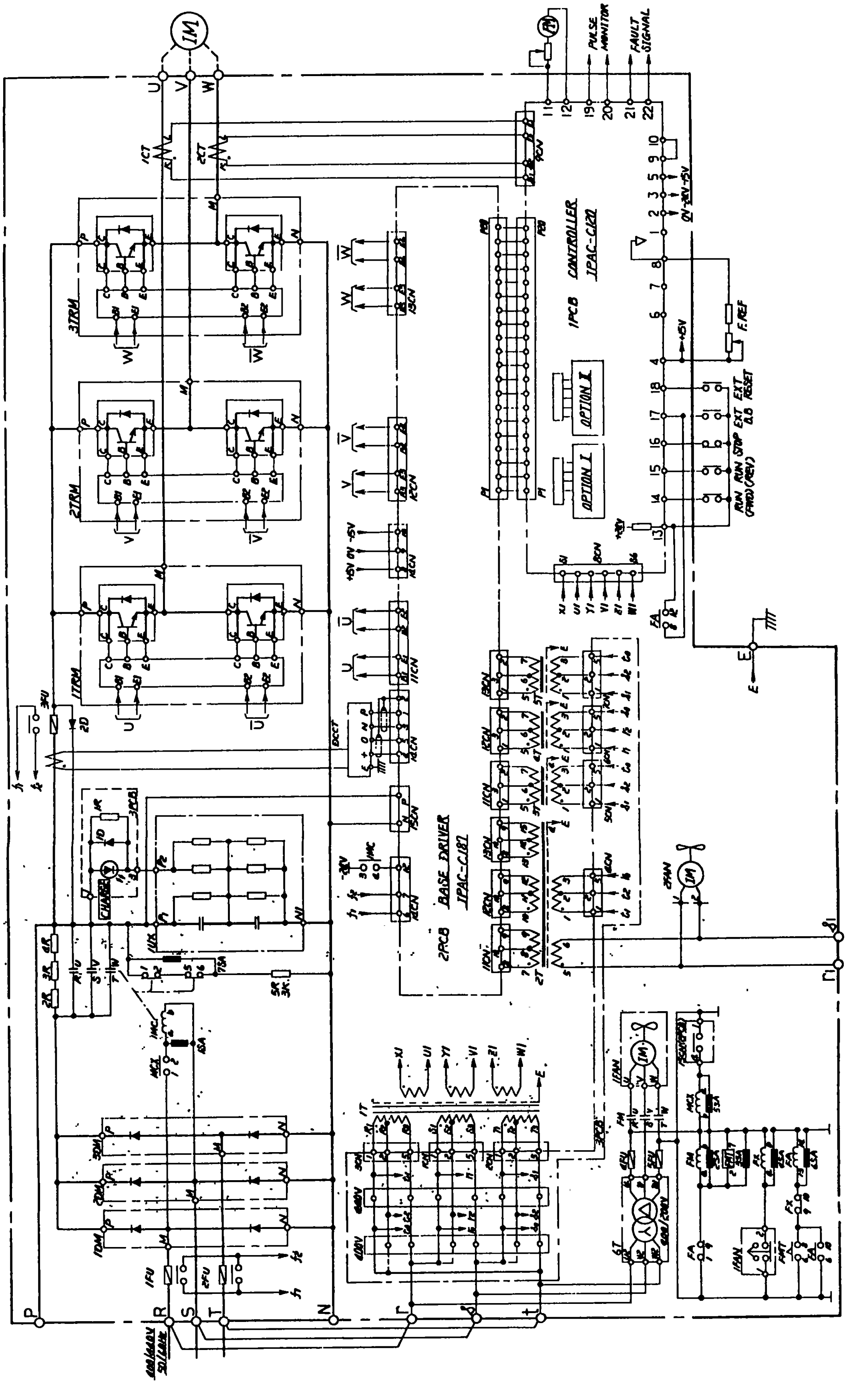


Fig. 17-21 Connections of VS-616 Type CIMR-H110H

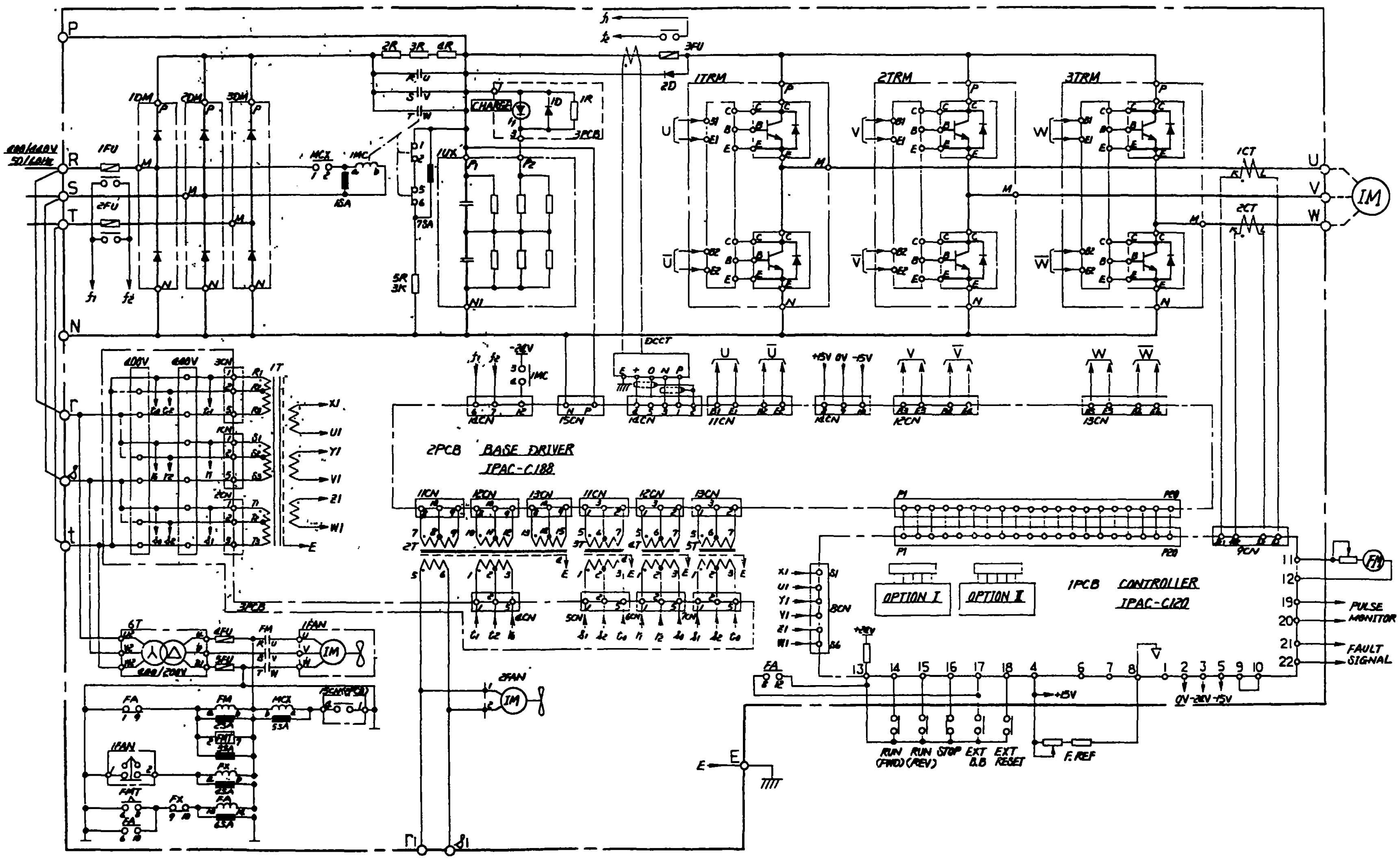


Fig. 17-22 Connections of VS-616 Type CIMR-H160H

18. VS-616 DIMENSIONS in mm (inches)

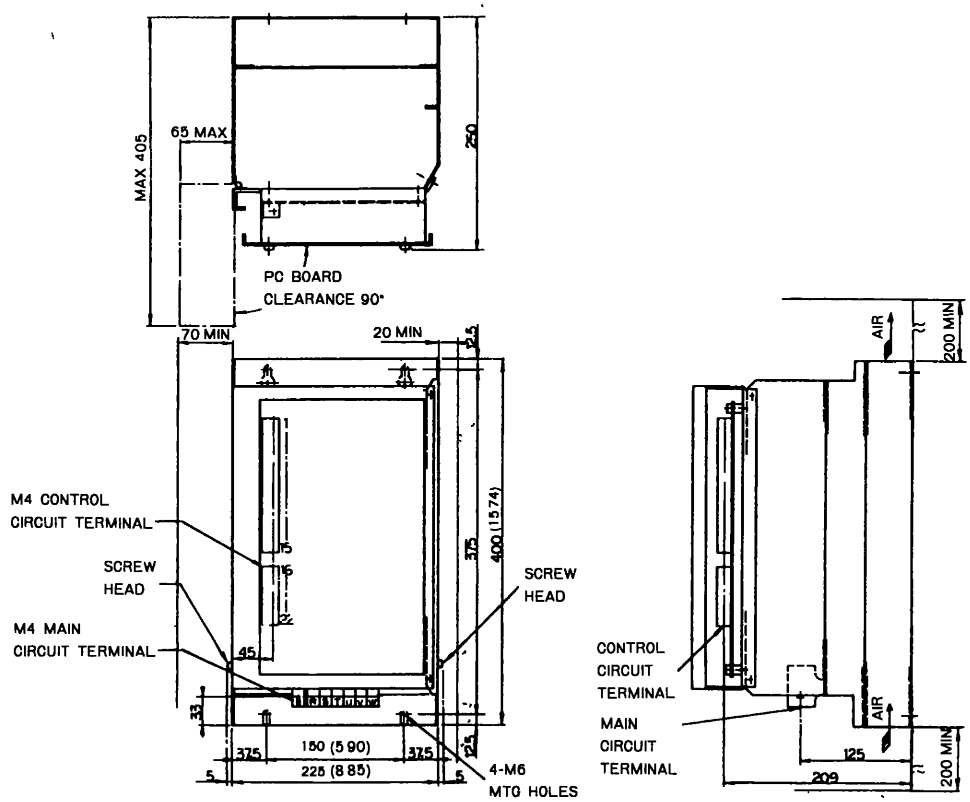


Fig. 18-1 Built-in Type CIMR-2.2G APPROX WEIGHT: 14kg

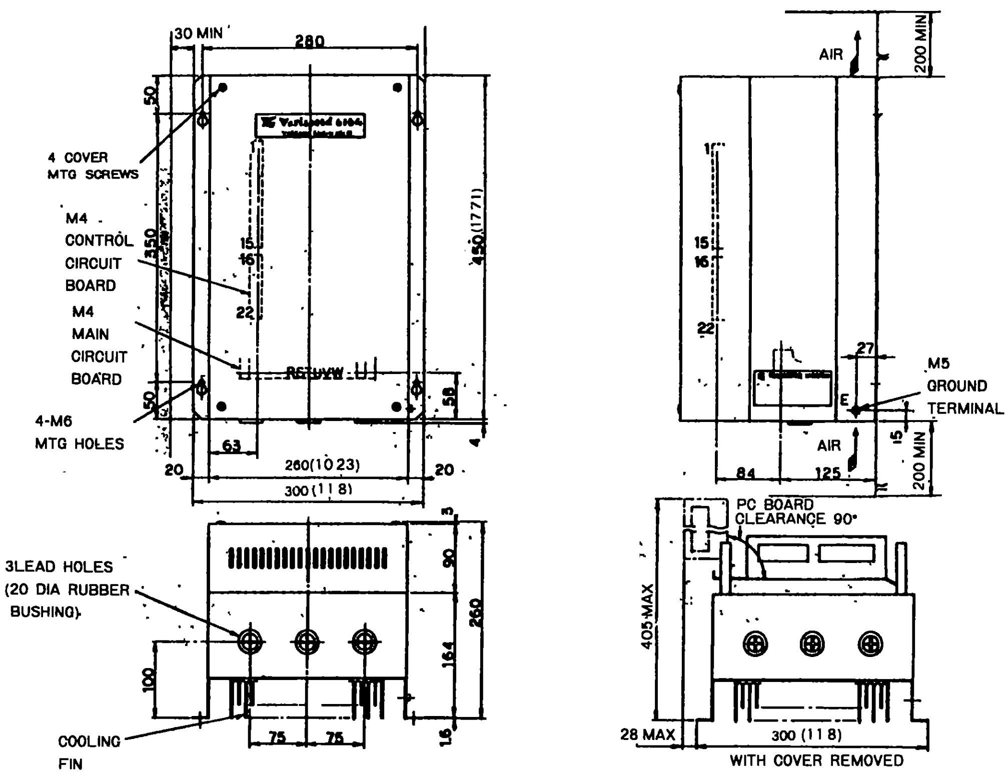


Fig. 18-2 Gasketed Wall-mounted Type CIMR-2.2G.11 APPROX WEIGHT: 14kg

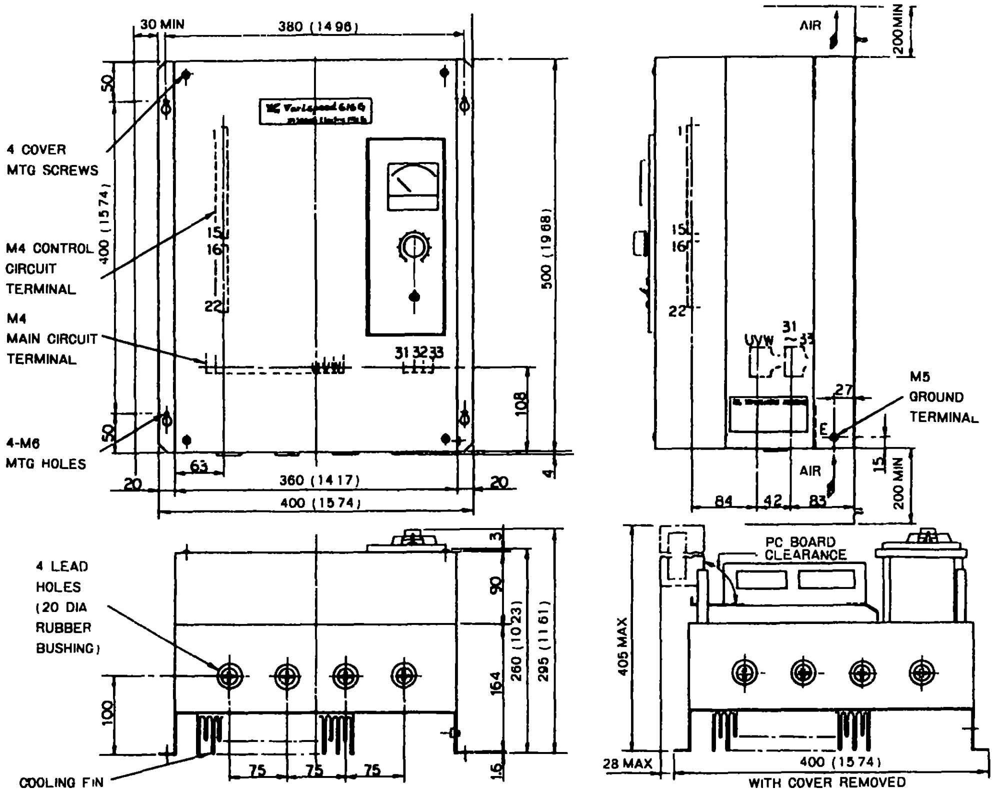
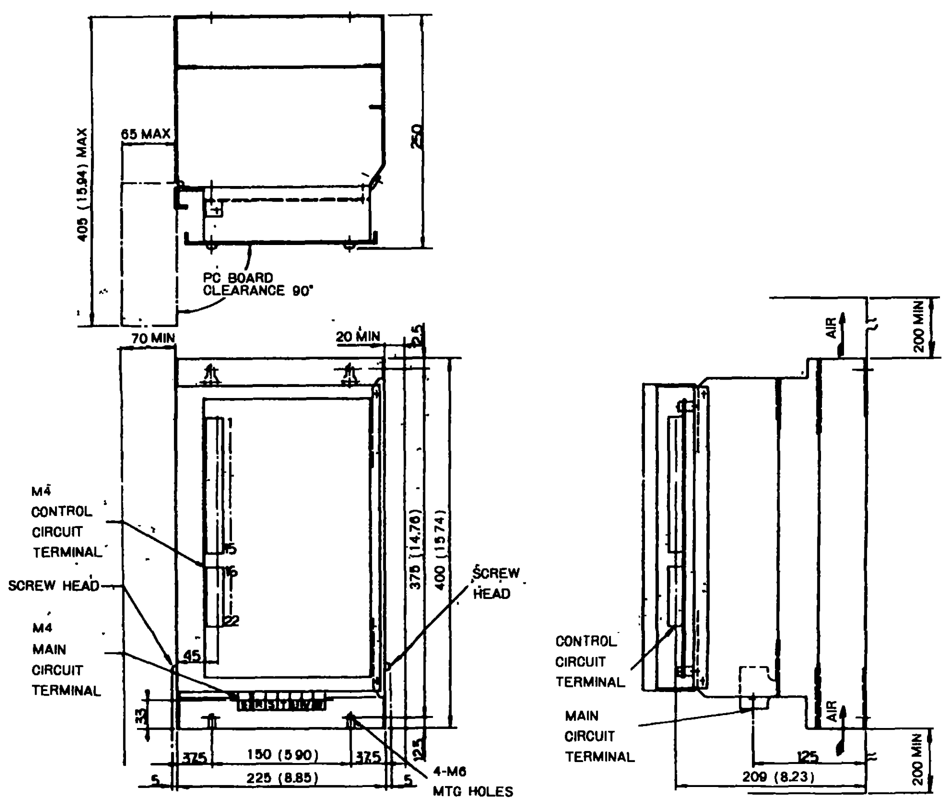


Fig. 18-3 Gasketed Wall-mounted Type CIMR-2.2G-22 APPROX WEIGHT: 22kg



Appen Fig. 18-4 Built-in Type CIMR-3.7G APPROX WEIGHT: 14kg

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

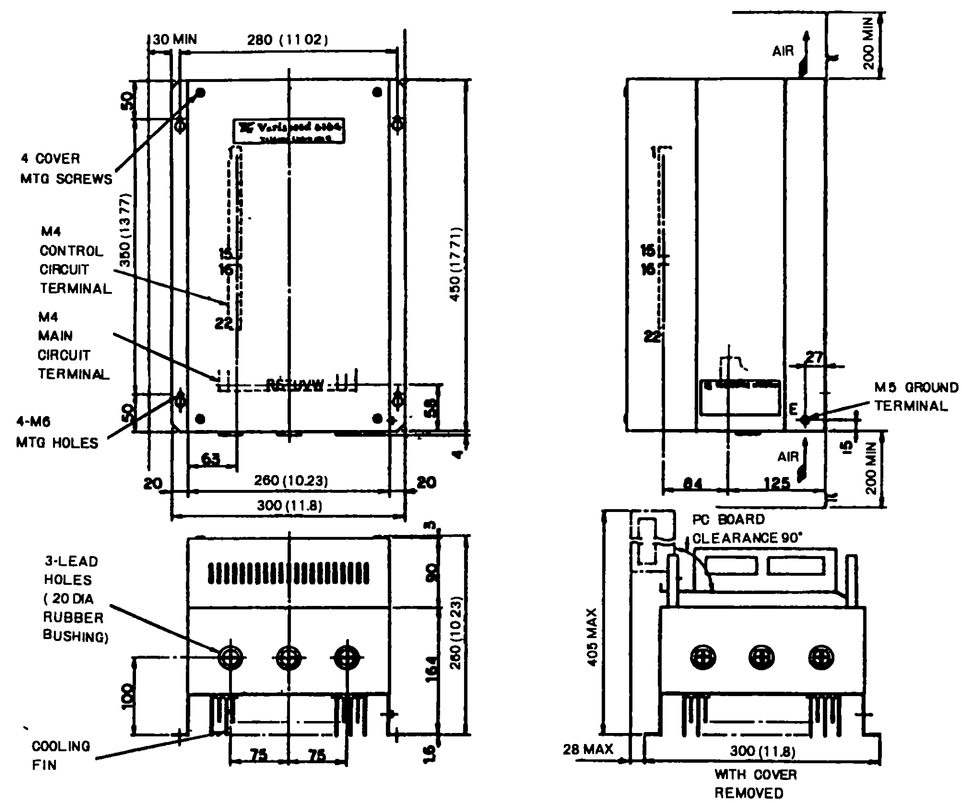


Fig. 18-5 Gasketed Wall-mounted Type CIMR-3.7G-11 APPROX WEIGHT: 17kg

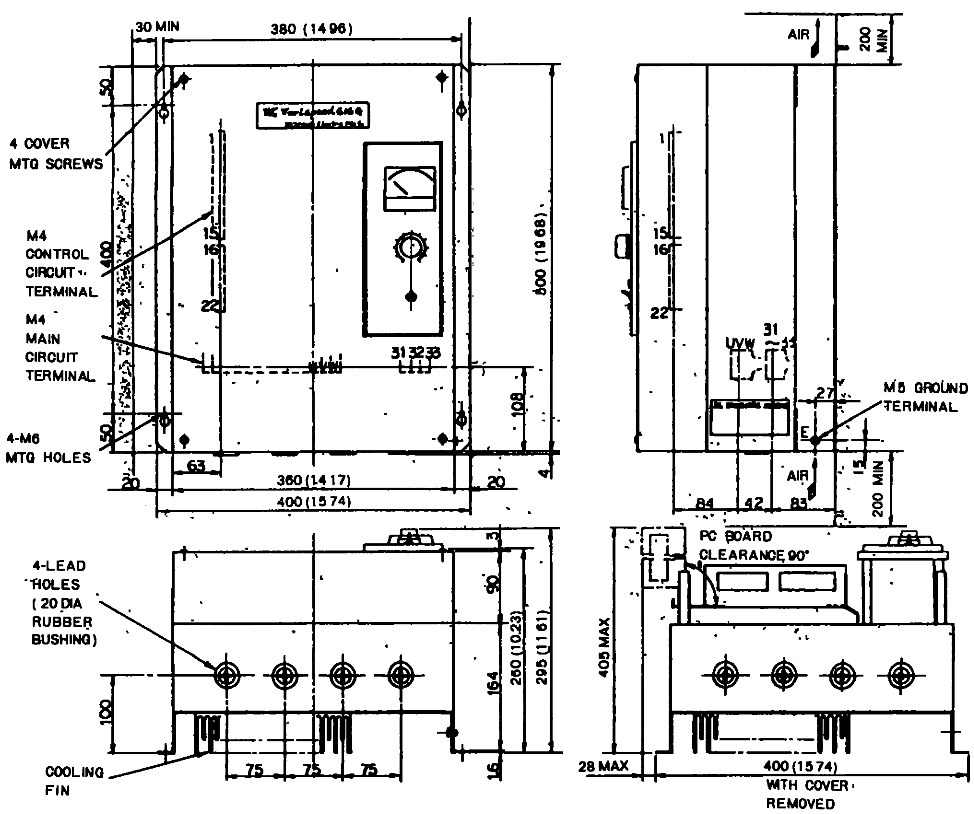


Fig. 18-6 Gasketed Wall-mounted Type CIMR-3.7G-22 APPROX WEIGHT: 22kg

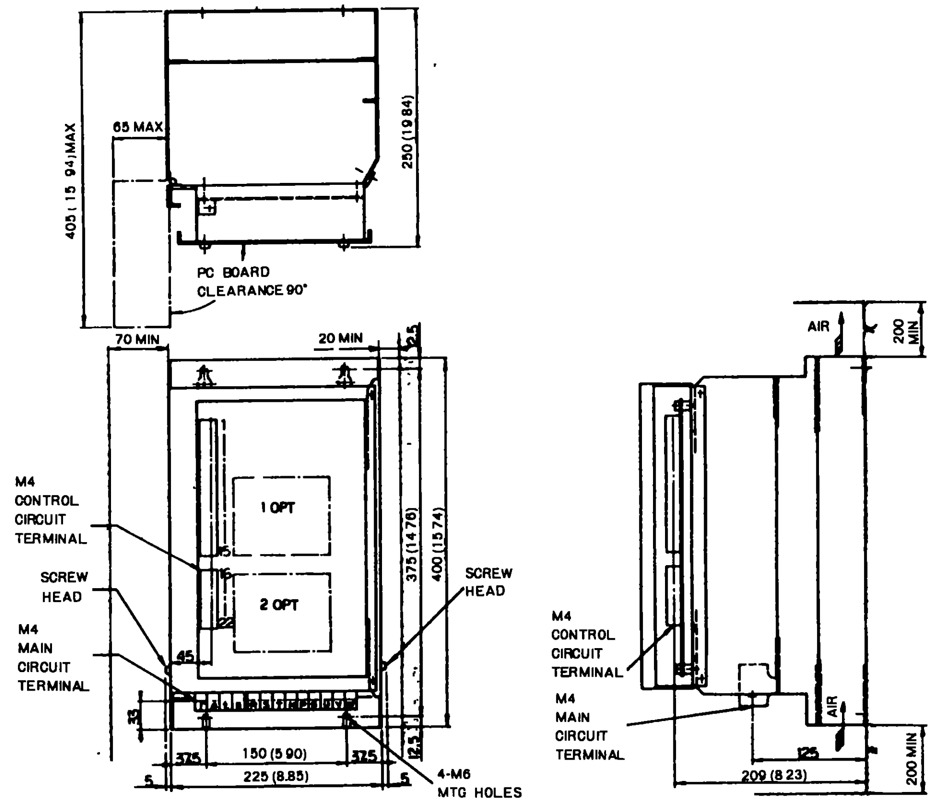


Fig. 18-7 Built-in Type CIMR-2.2H APPROX WEIGHT: 14kg

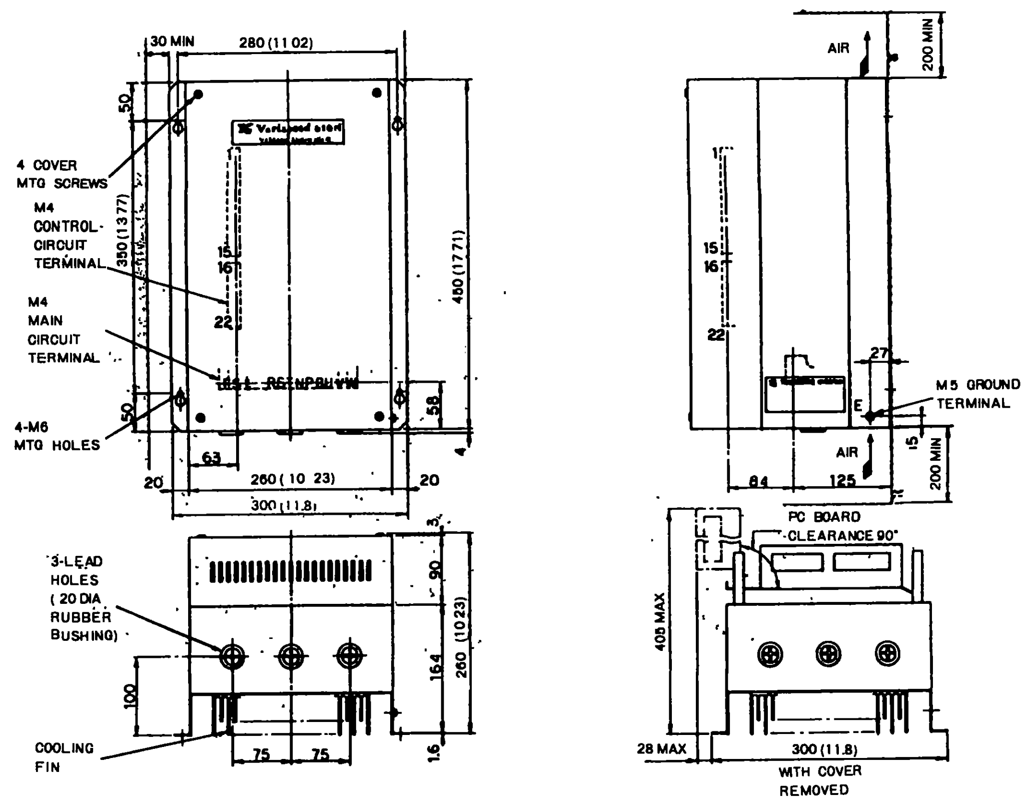


Fig. 18-8 Gasketed Wall-mounted Type CIMR-2.2H-11 APPROX WEIGHT: 17kg

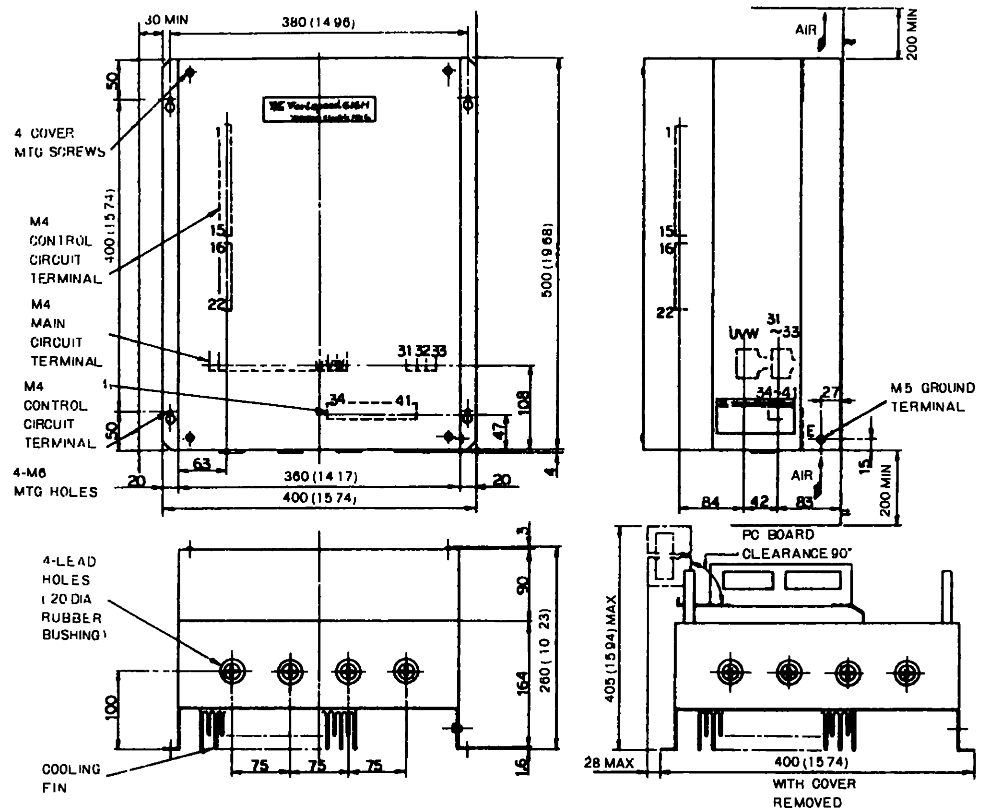


Fig. 18-9 Gasketed Wall-mounted Type CIMR-22H-23 APPROX WEIGHT 21kg

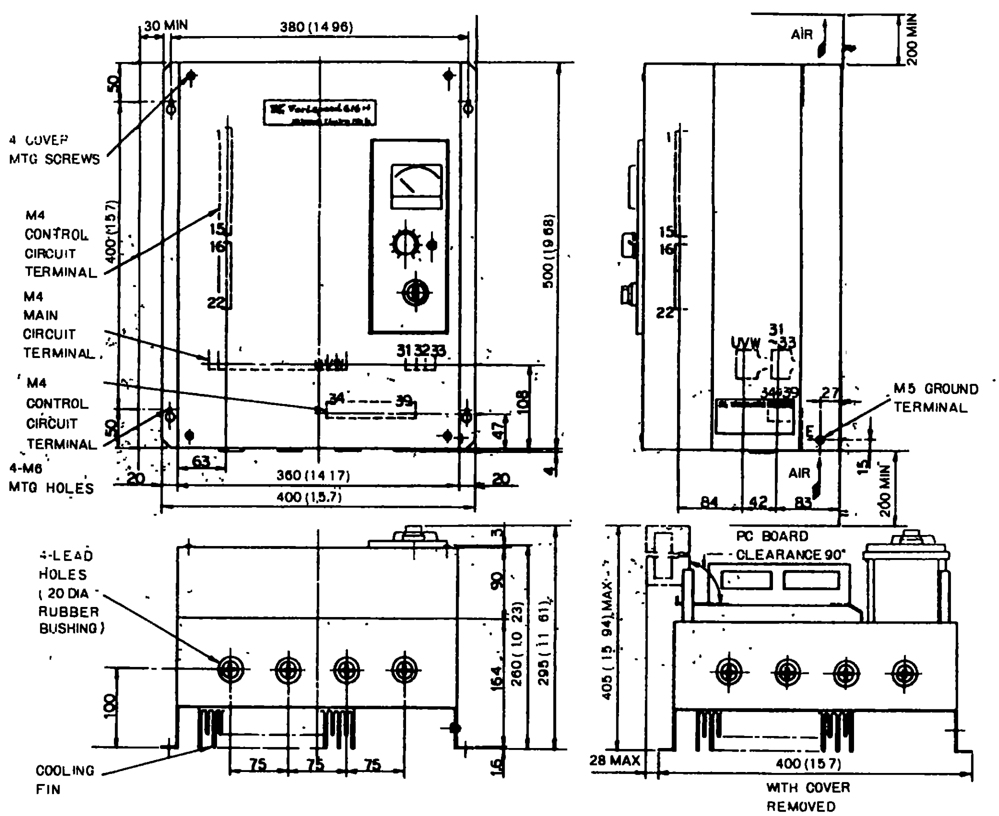


Fig. 18-10 Gasketed Wall-mounted Type CIMR-2.2H-24 APPROX WEIGHT 23kg

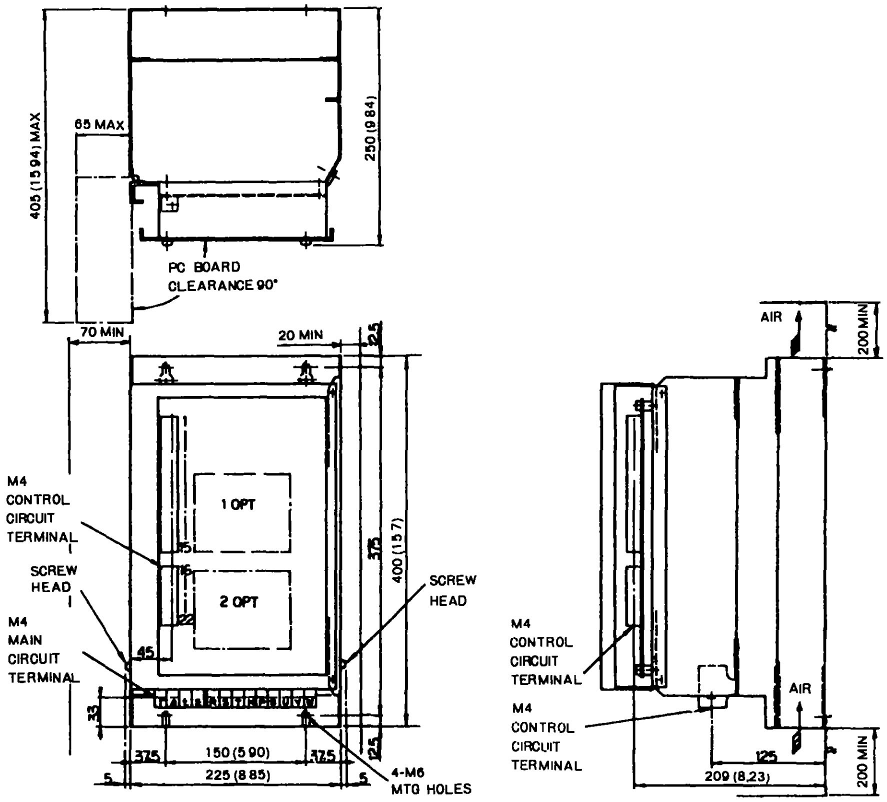


Fig. 18-11 Built-in Type, with Braking Function Type CIMR-2.2H1 APPROX WEIGHT 14kg

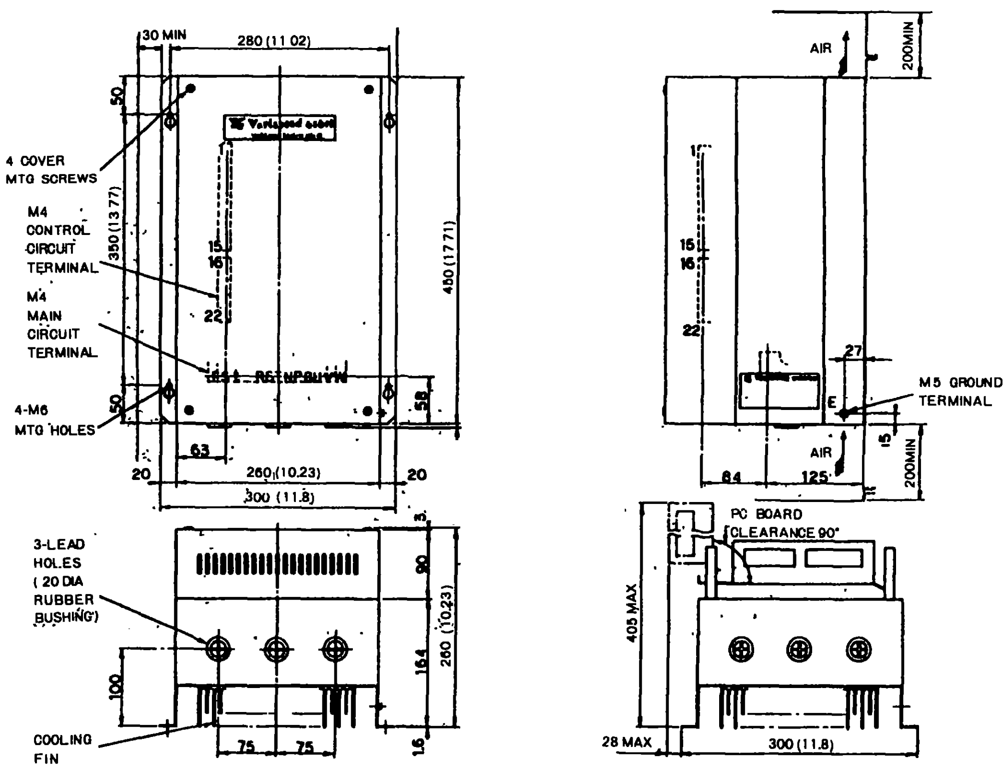


Fig. 18-12 Gasketed Wall-mounted, with Braking Function Type CIMR-2.2H1-11 APPROX WEIGHT . 17kg

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

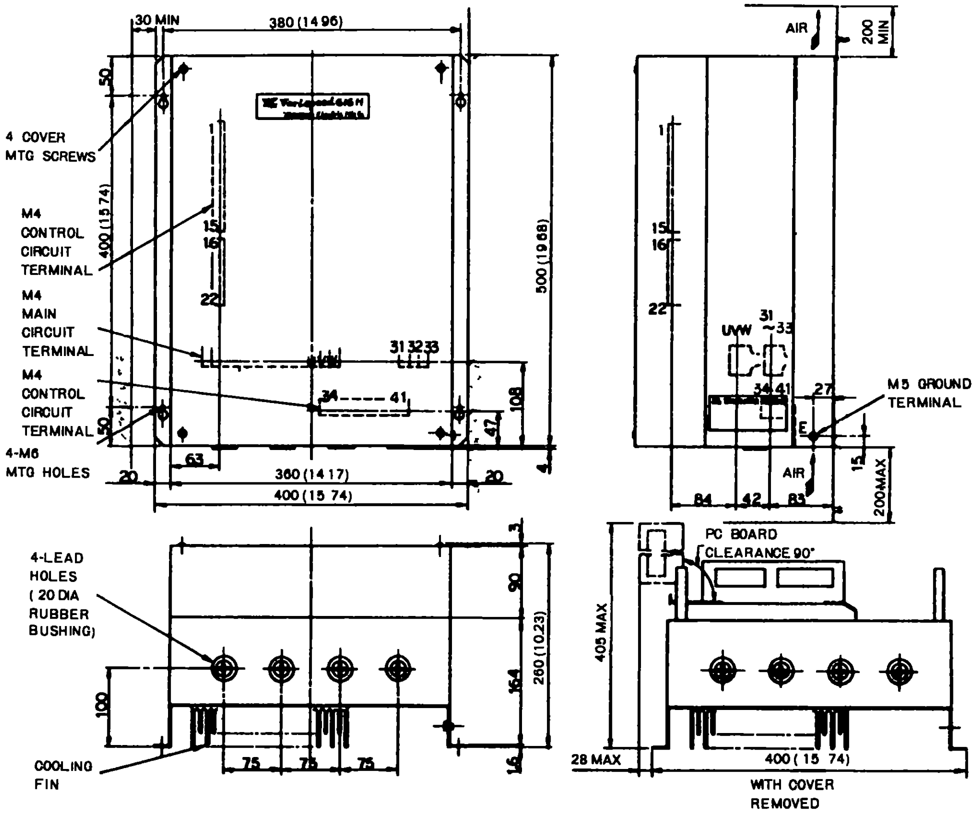


Fig. 18-13 Gasketed Wall-mounted Type CIMR-2.2H1-23 APPROX WEIGHT: 21kg

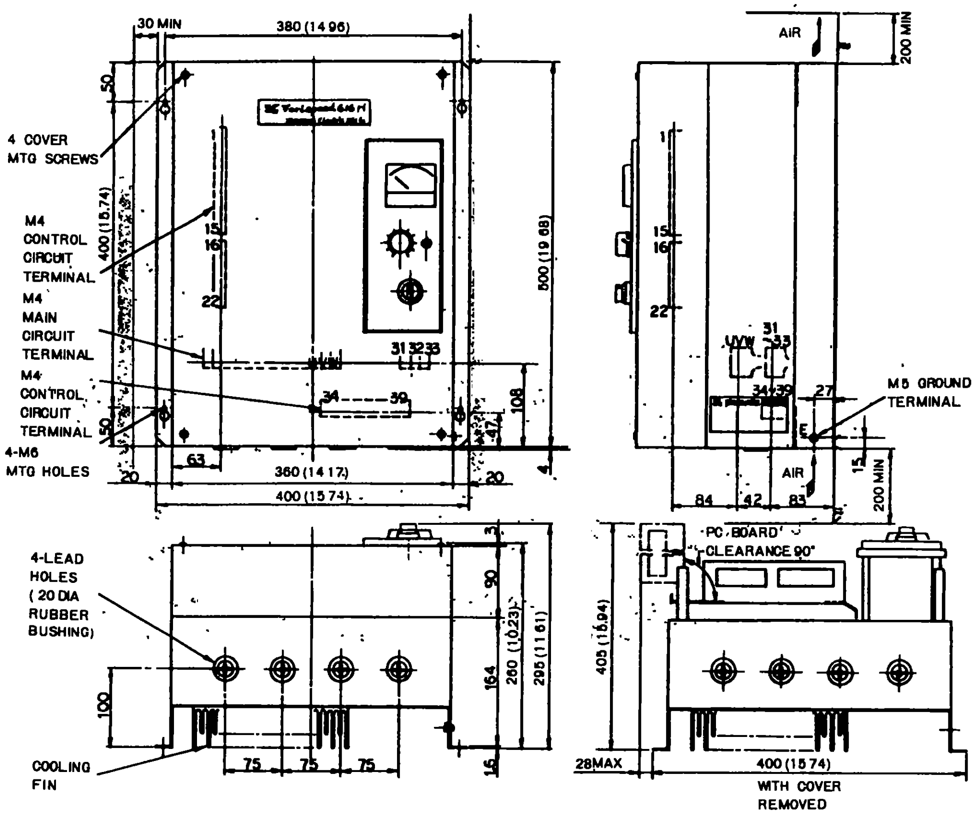


Fig. 18-14 Gasketed Wall-mounted, with Braking Function Type CIMR-2.2H1-24 APPROX WEIGHT: 23kg

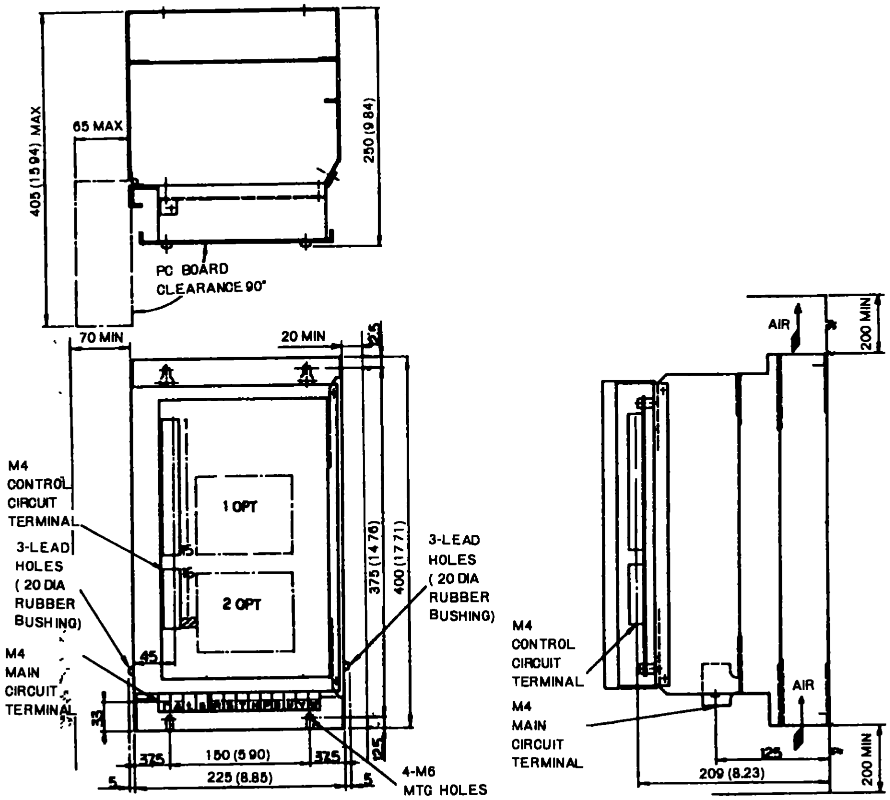


Fig. 18-15 Built-in Type CIMR-3.7H APPROX WEIGHT: 14kg

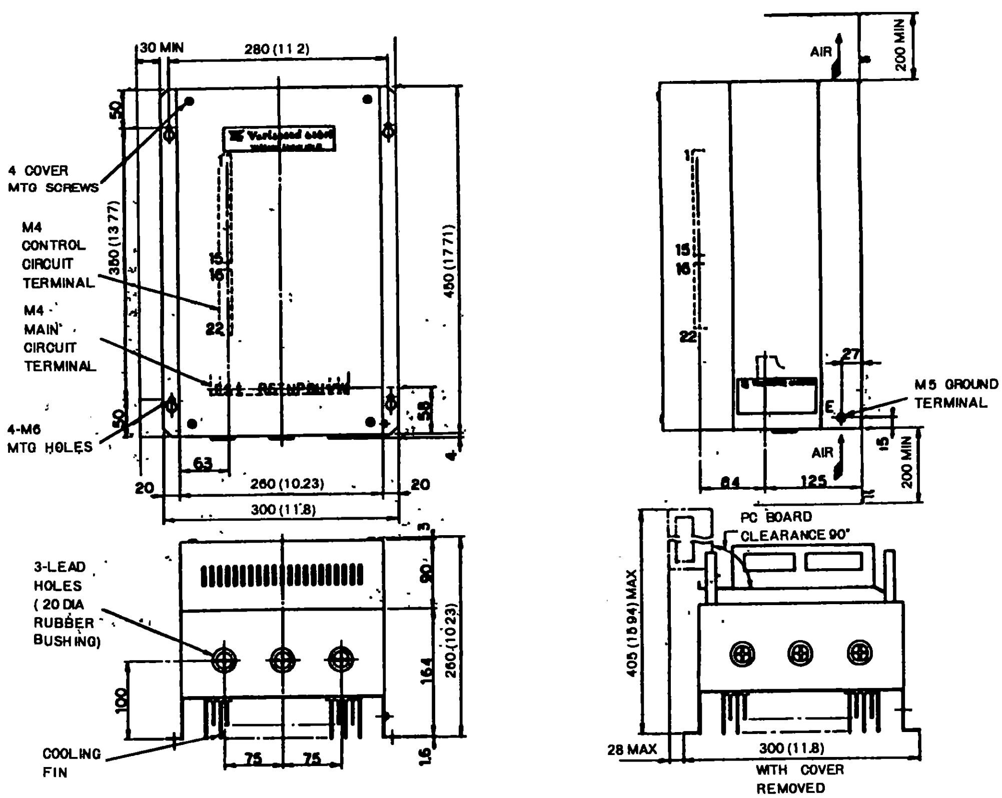


Fig. 18-16 Gasketed Wall-mounted Type CIMR-3.7H-11 APPROX WEIGHT: 17kg

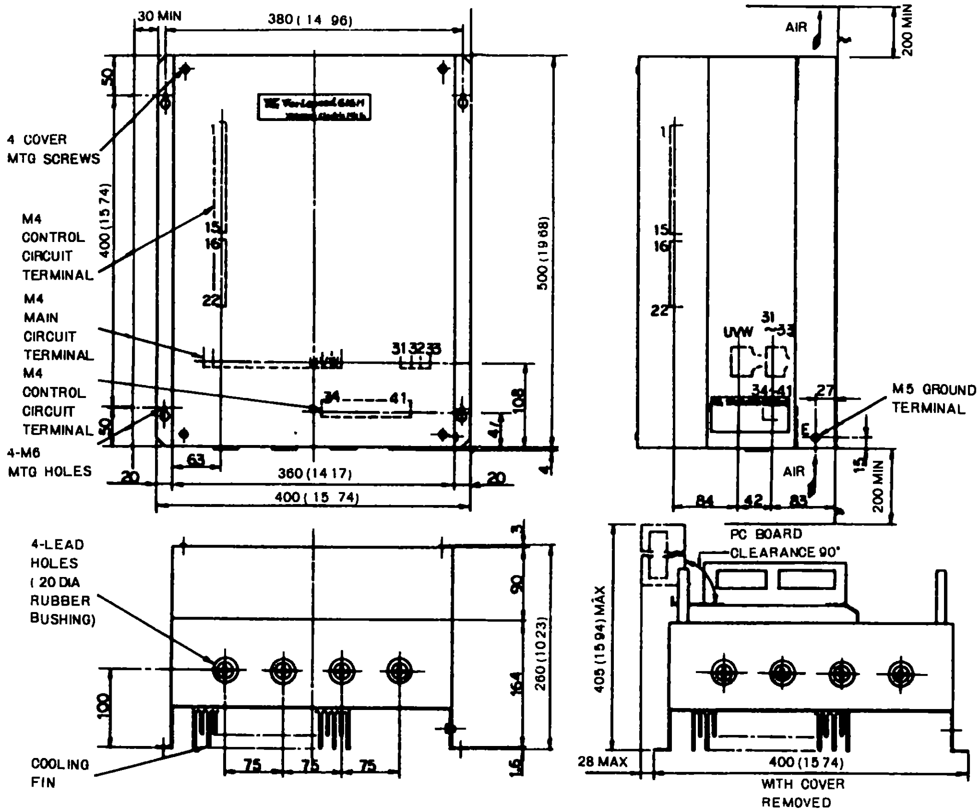


Fig. 18-17 Gasketed Wall-mounted Type CIMR-3.7H-23 APPROX WEIGHT: 21kg

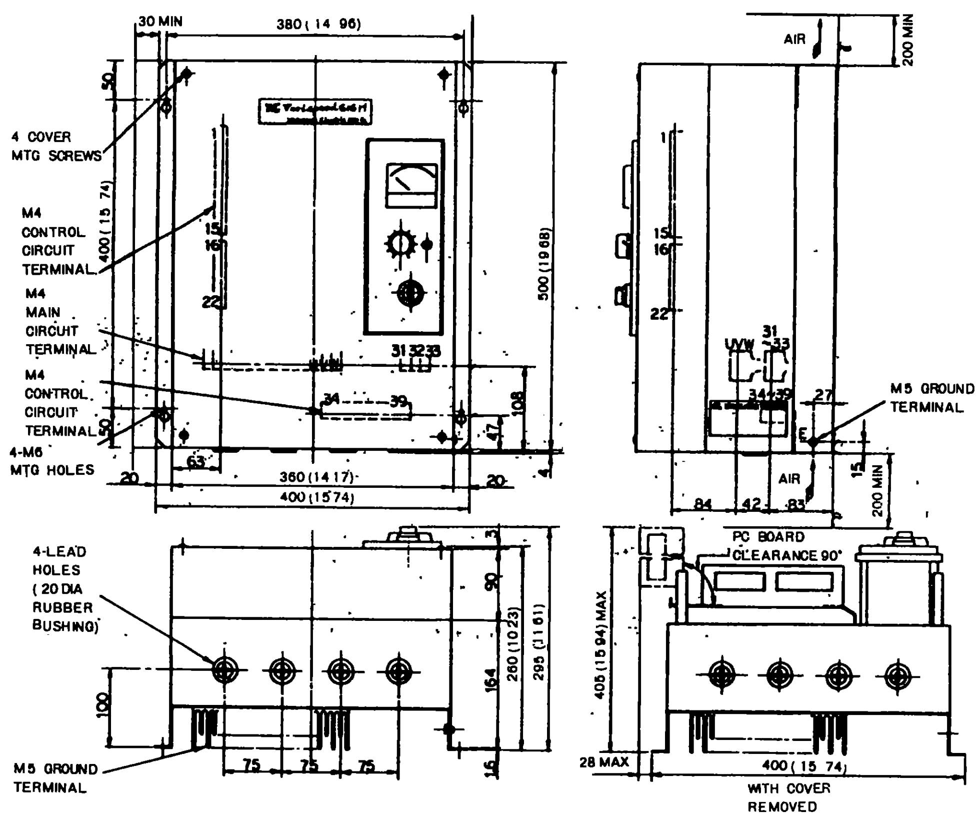


Fig. 18-18 Gasketed Wall-mounted Type CIMR-3.7H-24 APPROX WEIGHT: 23kg

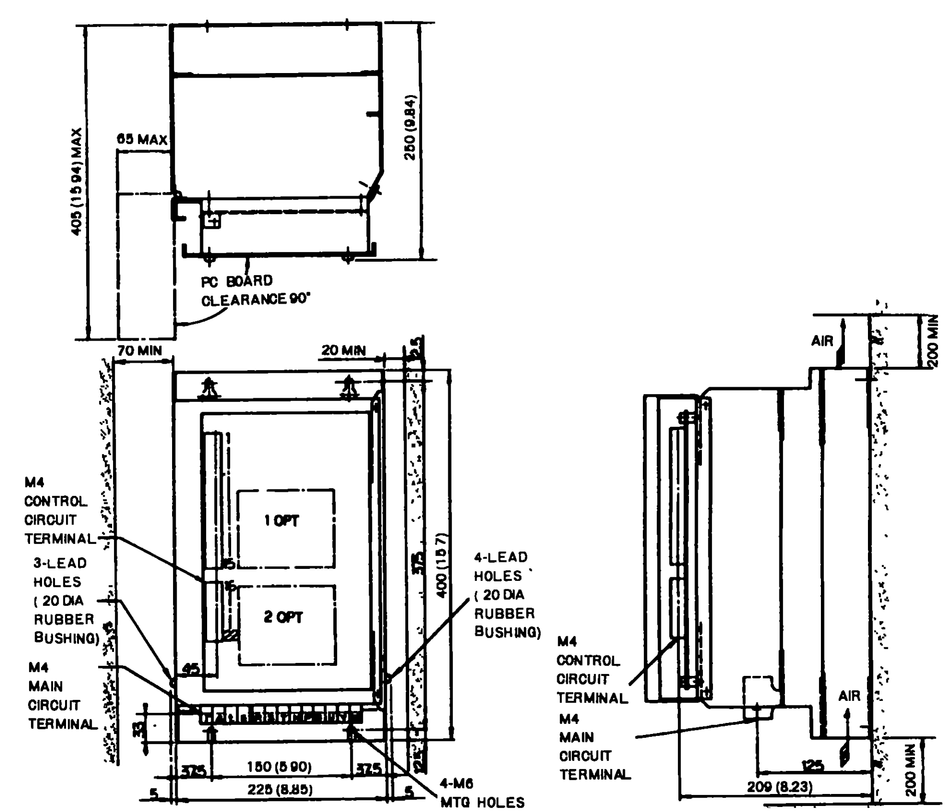


Fig. 18-19 Gasketed Wall-mounted, with Braking Function Type CIMR-3.7H1-23 APPROX WEIGHT: 14kg

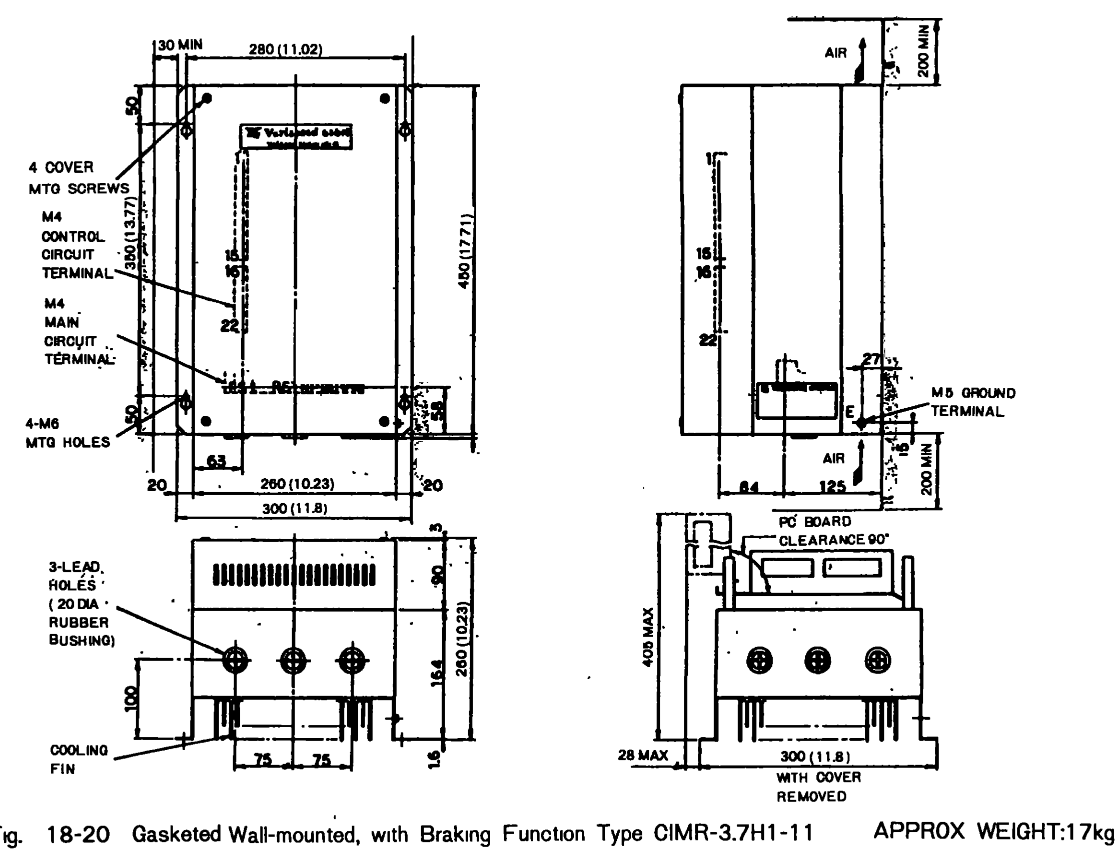


Fig. 18-20 Gasketed Wall-mounted, with Braking Function Type CIMR-3.7H1-11 APPROX WEIGHT: 17kg

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

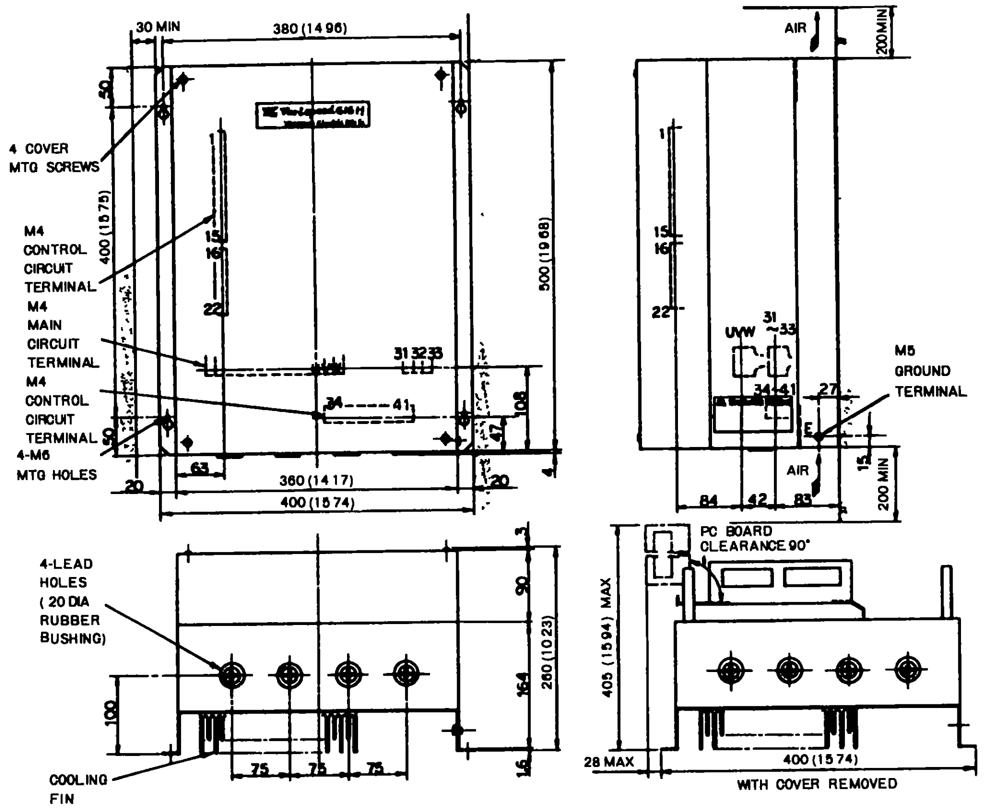


Fig. 18-21 Gasketed Wall-mounted, with Braking Function Type CIMR-3.7H1-23 APPROX WEIGHT: 21kg

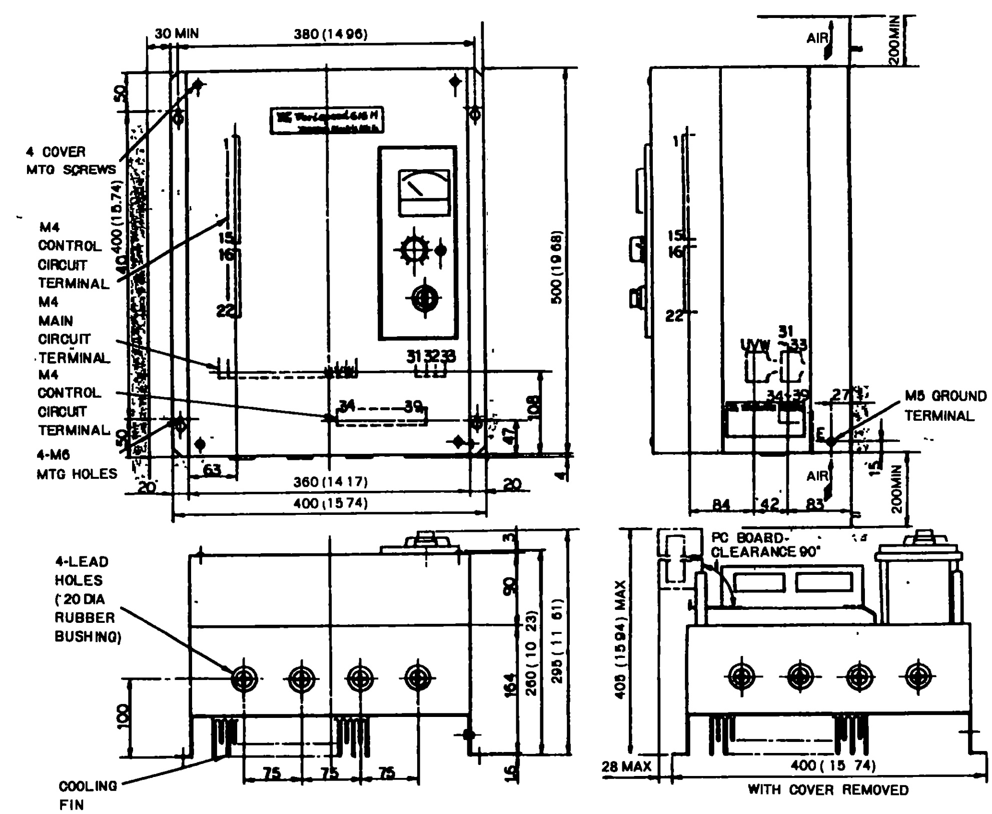


Fig. 18-22 Gasketed Wall-mounted, with Braking Function Type CIMR-3.7H1-24 APPROX WEIGHT: 23kg

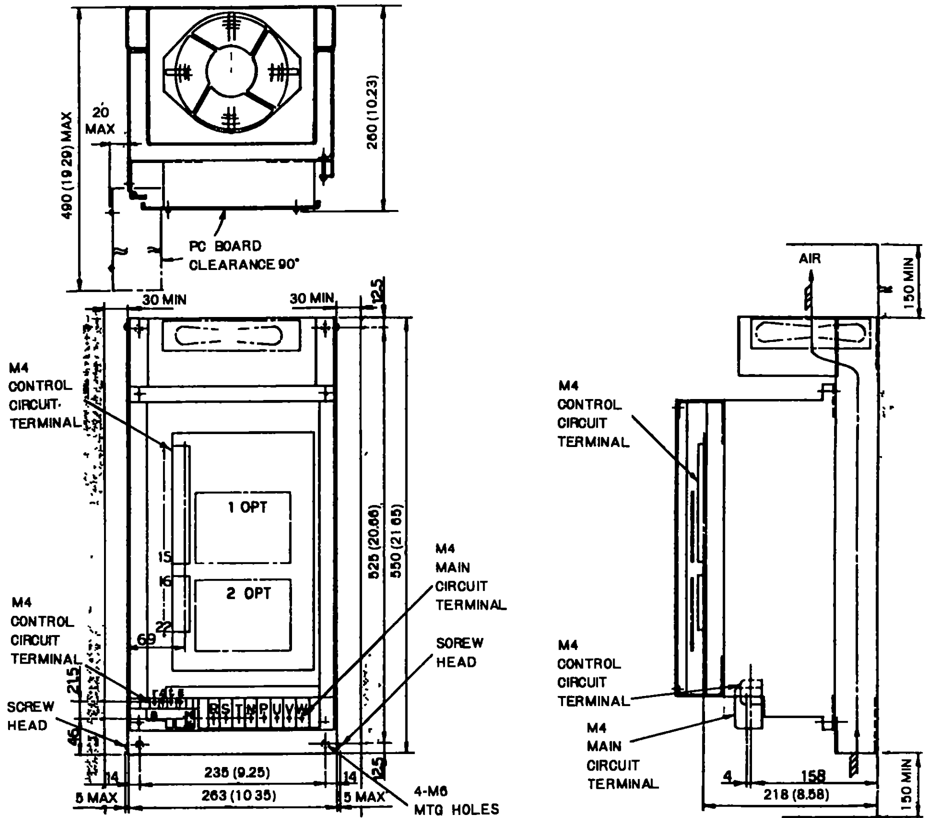


Fig. 18-23 Built-in Type CIMR-7.5H APPROX WEIGHT:25kg

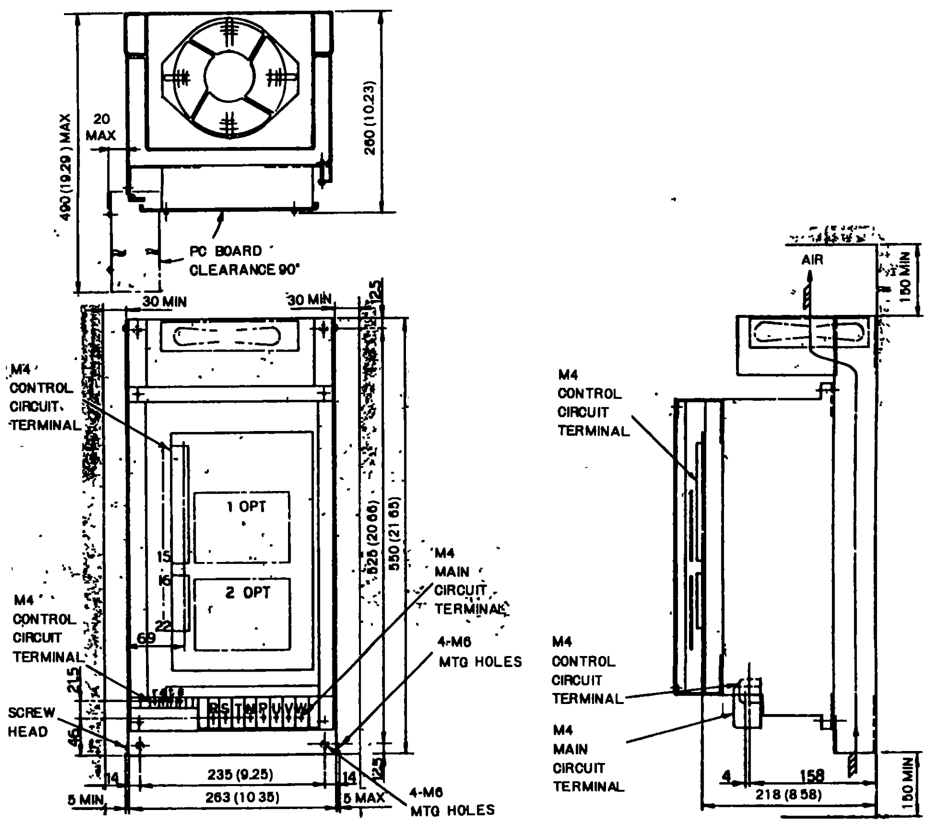


Fig. 18-24 Built-in, with Braking Function Type CIMR-7.5H1 APPROX WEIGHT:25kg

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

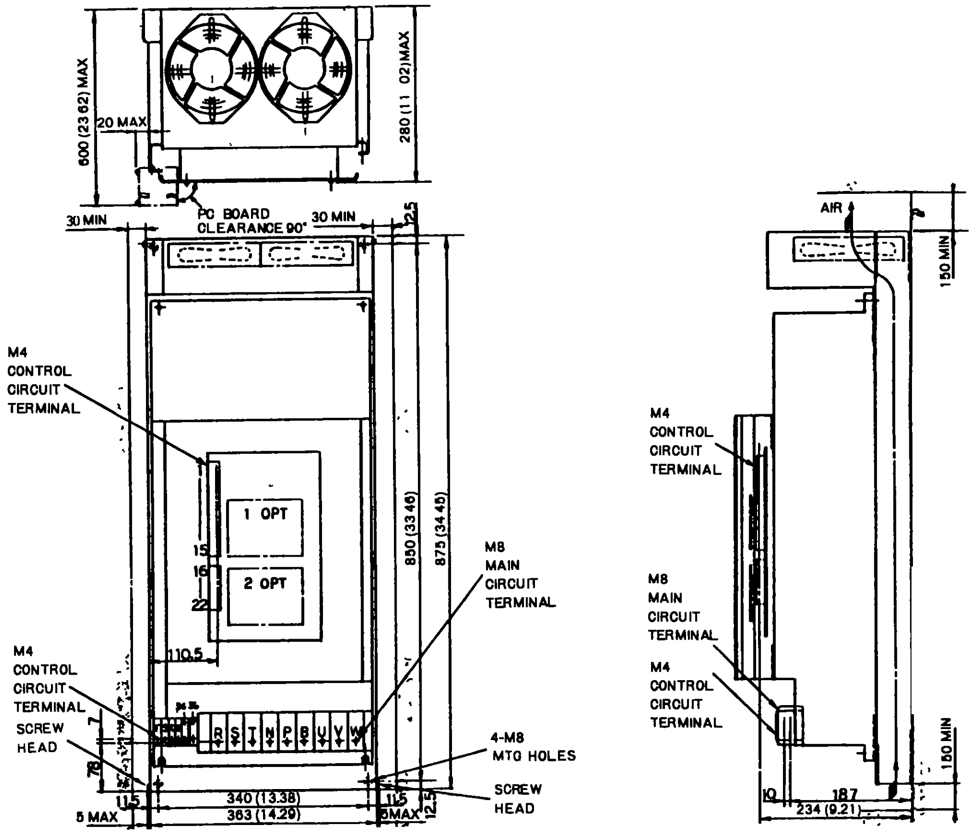


Fig. 18-25 Built-in Type CIMR-15H APPROX WEIGHT: 50kg

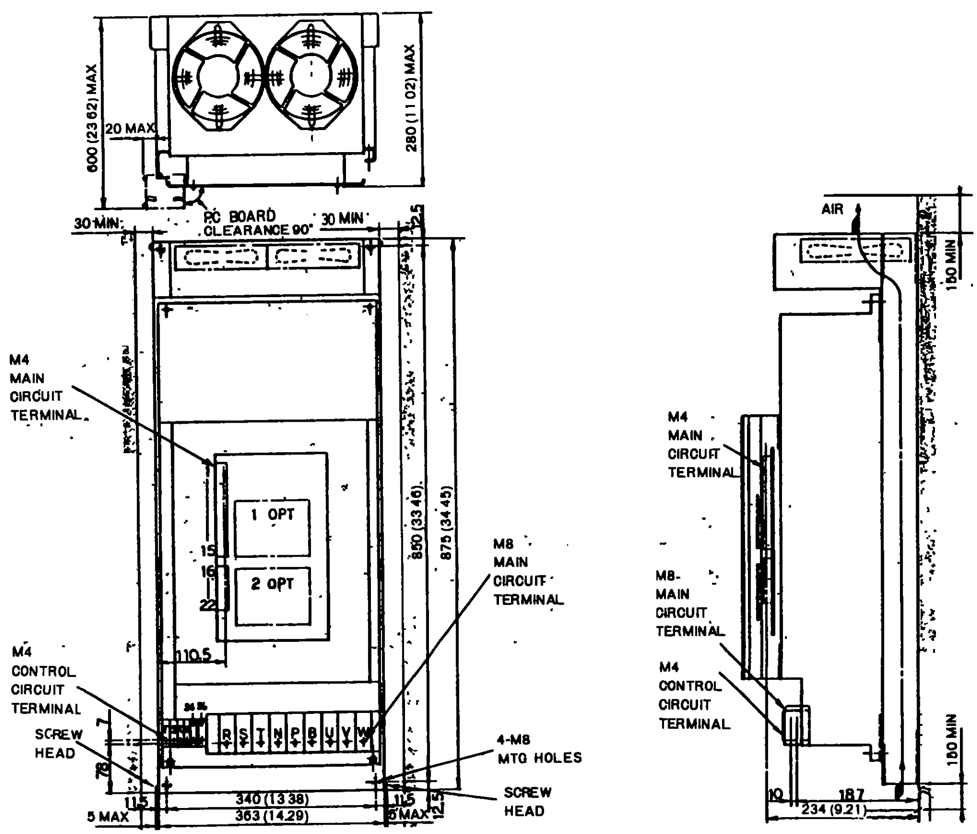


Fig. 18-26 Built-in, with Braking Function Type CIMR-15H1 APPROX WEIGHT: 50kg

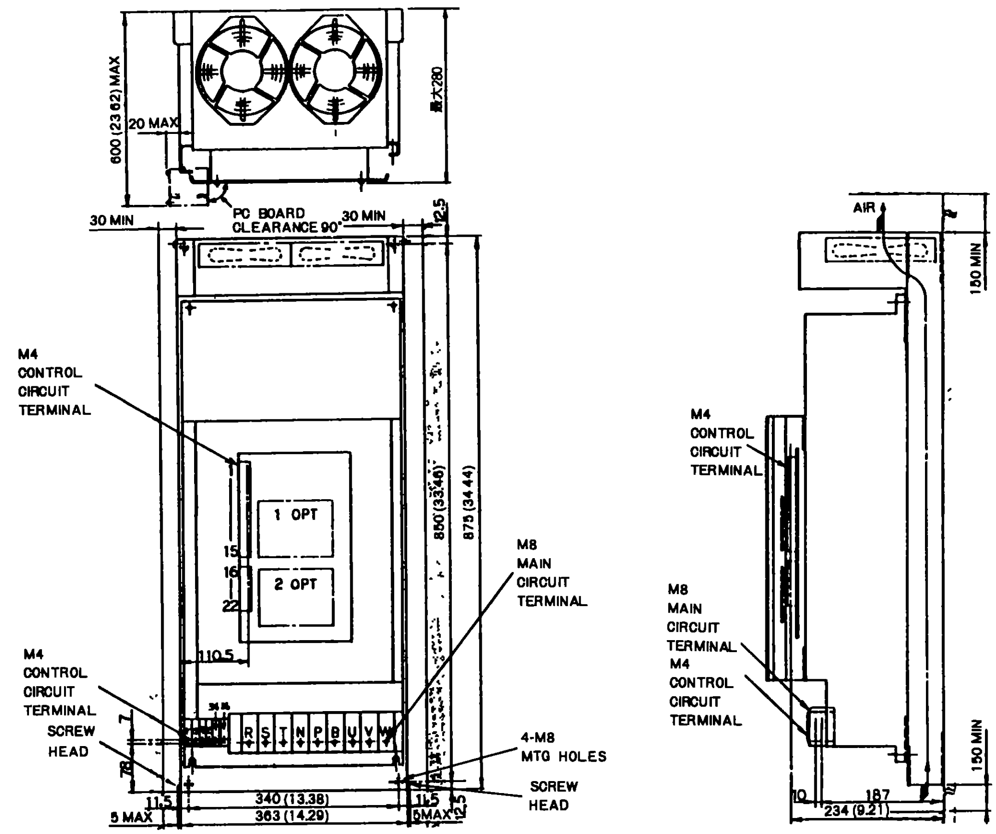


Fig. 18-27 Built-in Type CIMR-22H APPROX WEIGHT: 50kg

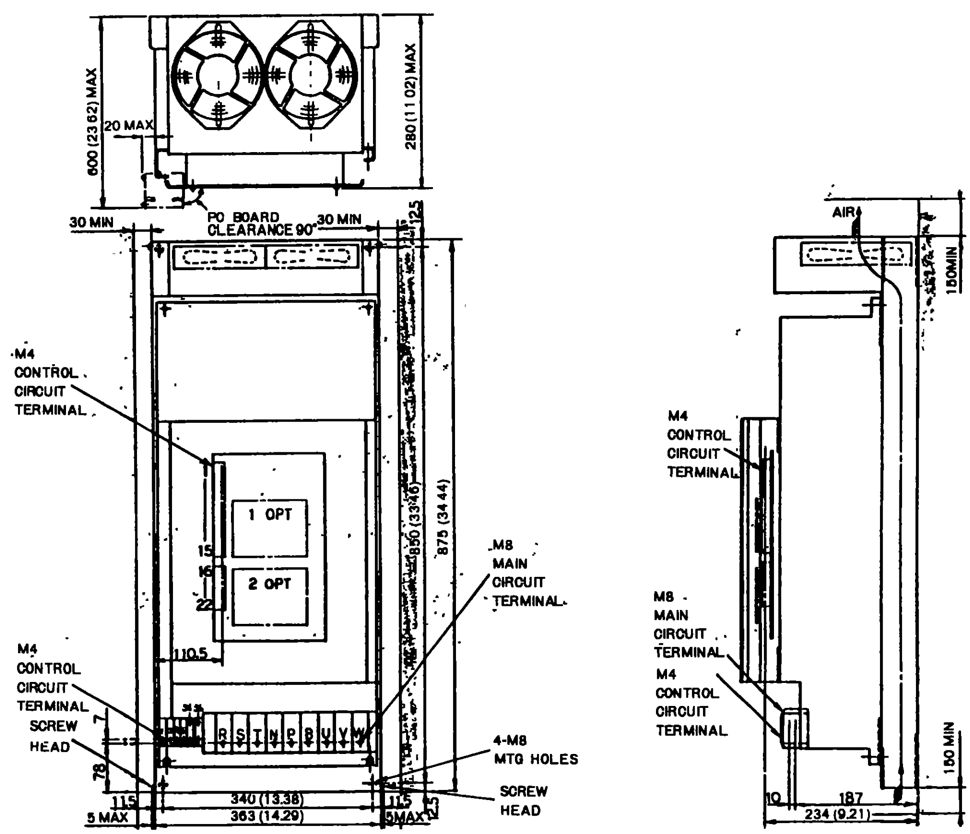


Fig. 18-28 Built-in, with Braking Function Type CIMR-22H1 APPROX WEIGHT: 50kg

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

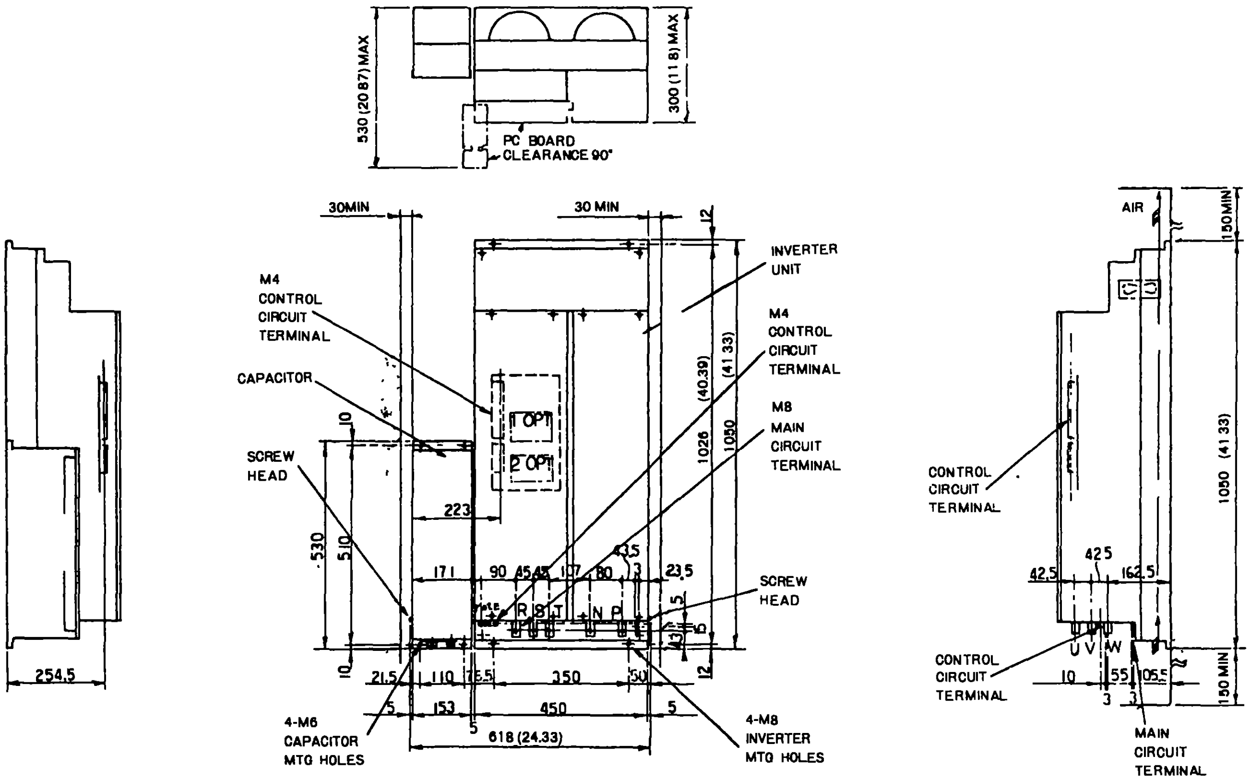


Fig. 18-29 Built-in Type CIMR-30H

APPROX WEIGHT:88kg

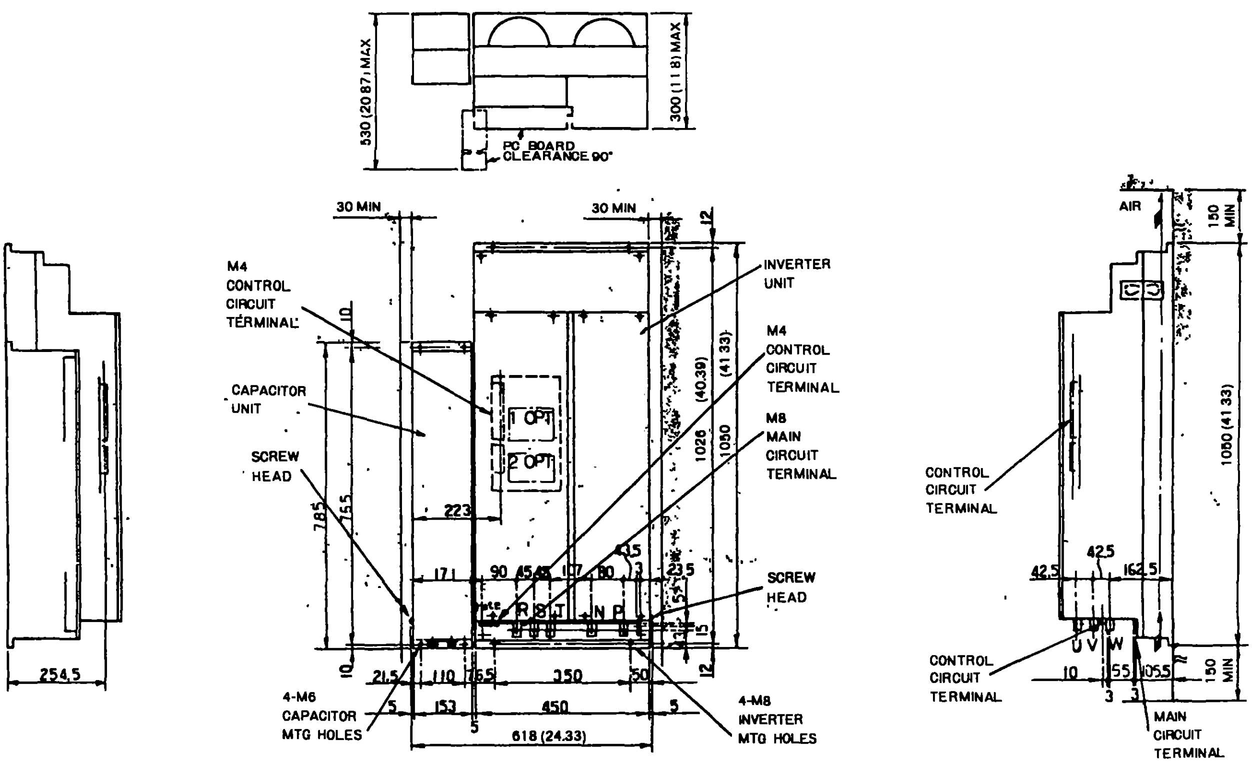


Fig. 18-30 Built-in Type CIMR-45H

APPROX WEIGHT:95kg

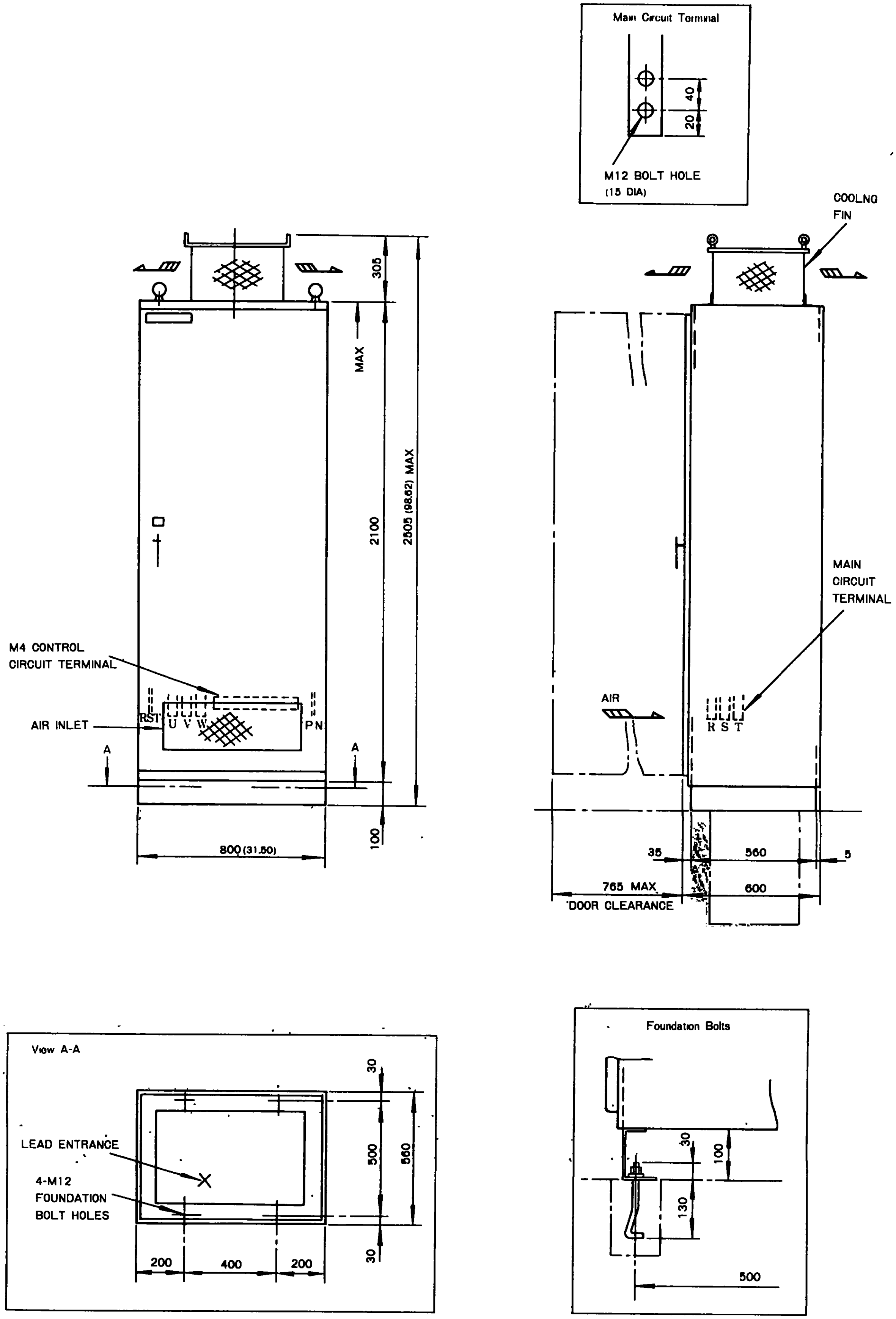


Fig. 18-31 Free-Standing Type CIMR-55H, -75H

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

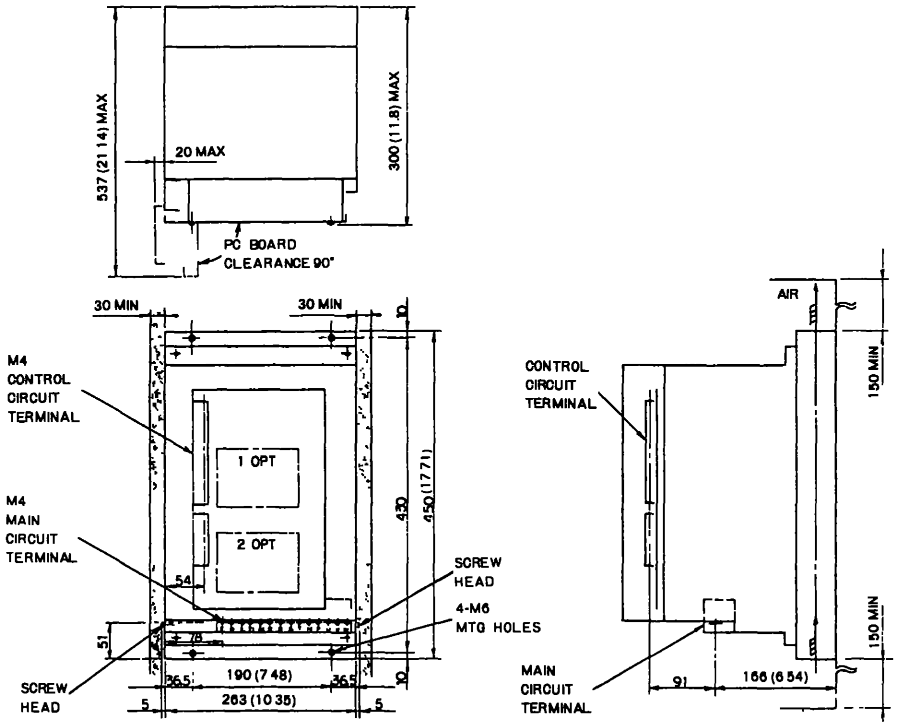


Fig. 18-32 Built-in Type CIMR-H3.7H, -H7.5H APPROX WEIGHT: 22kg

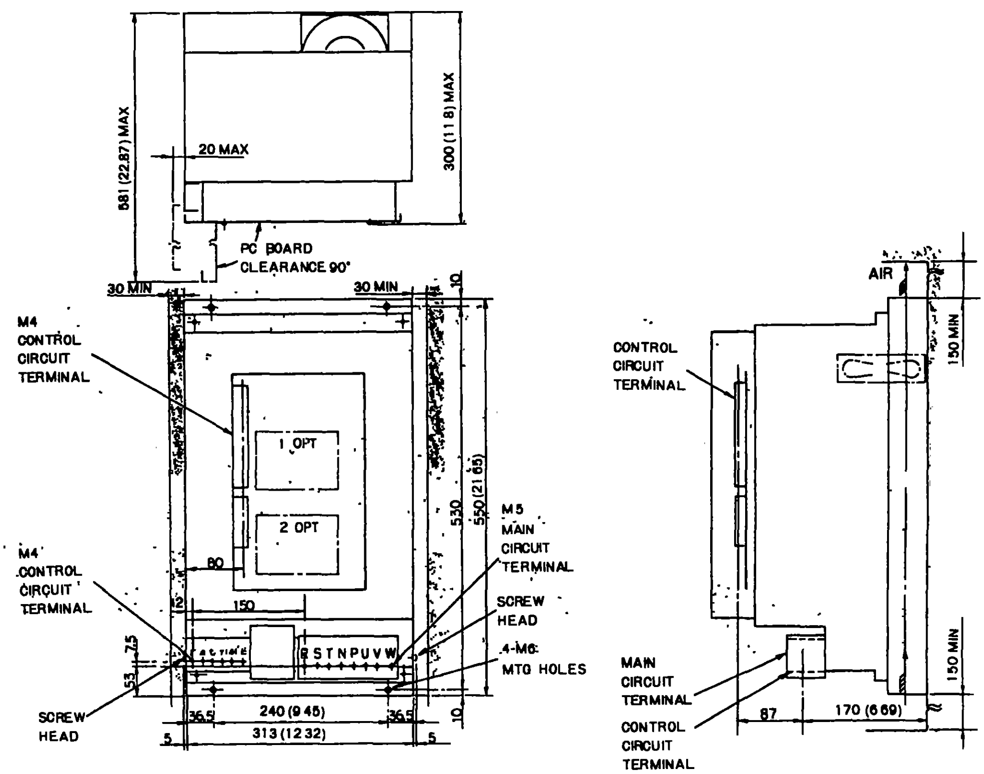


Fig. 18-33 Built-in Type CIMR-H15H APPROX WEIGHT: 33kg

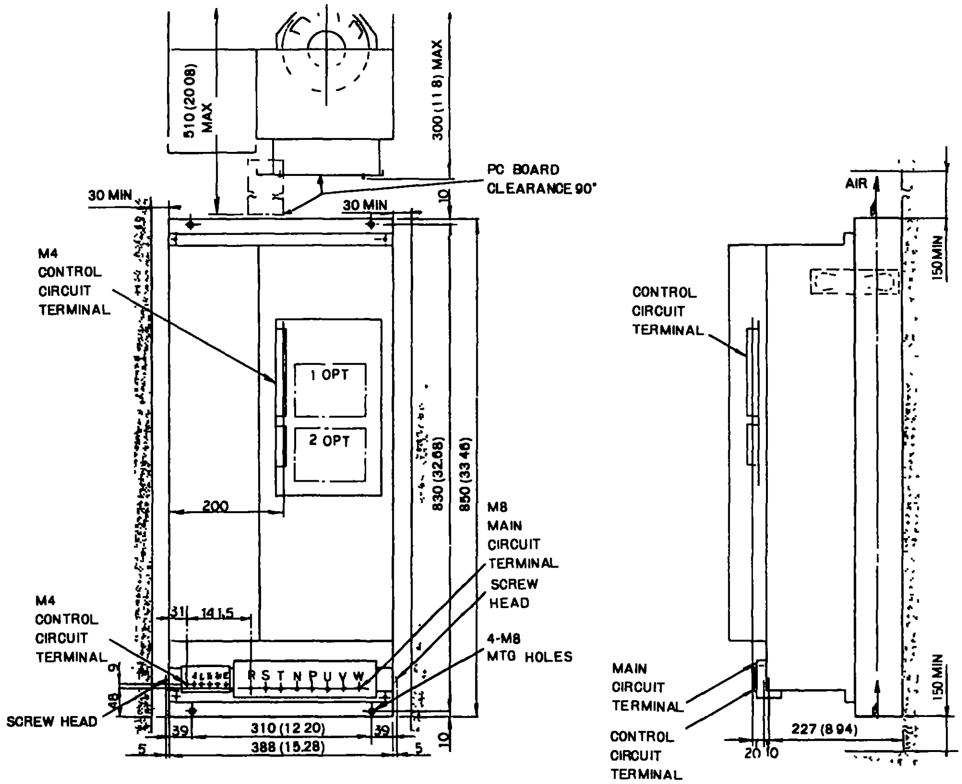


Fig. 18-34 Built-in Type CIMR-H30H APPROX WEIGHT:62kg

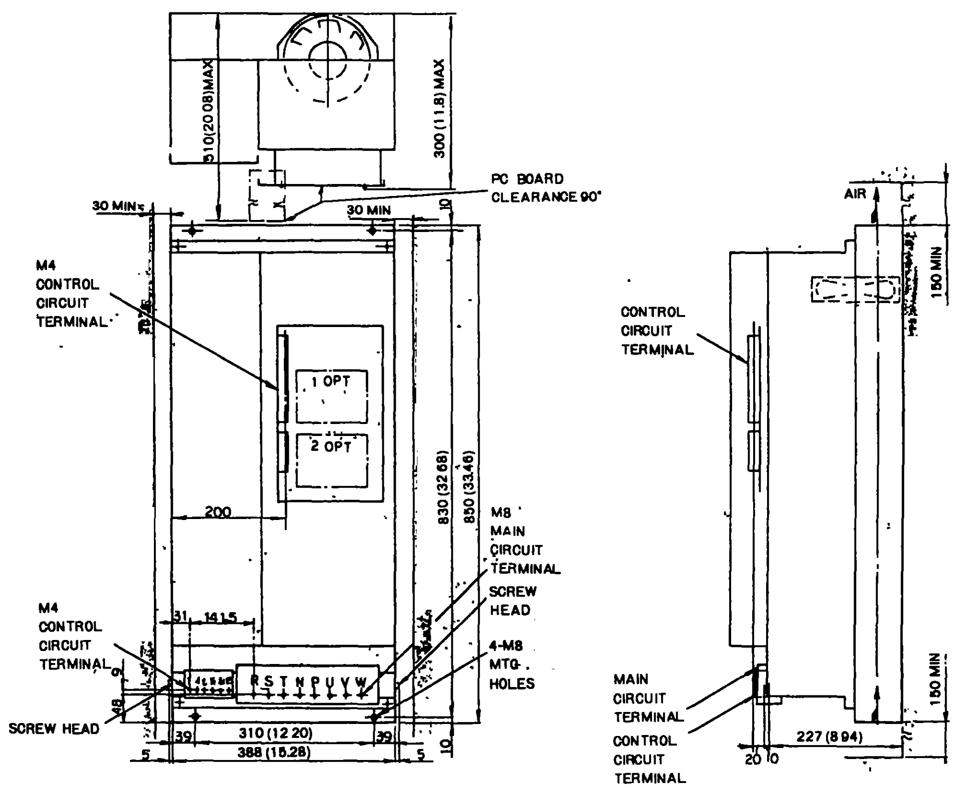


Fig. 18-35 Built-in Type CIMR-H45H APPROX WEIGHT:66kg

18. VS-616 DIMENSIONS in mm (inches) (Cont'd)

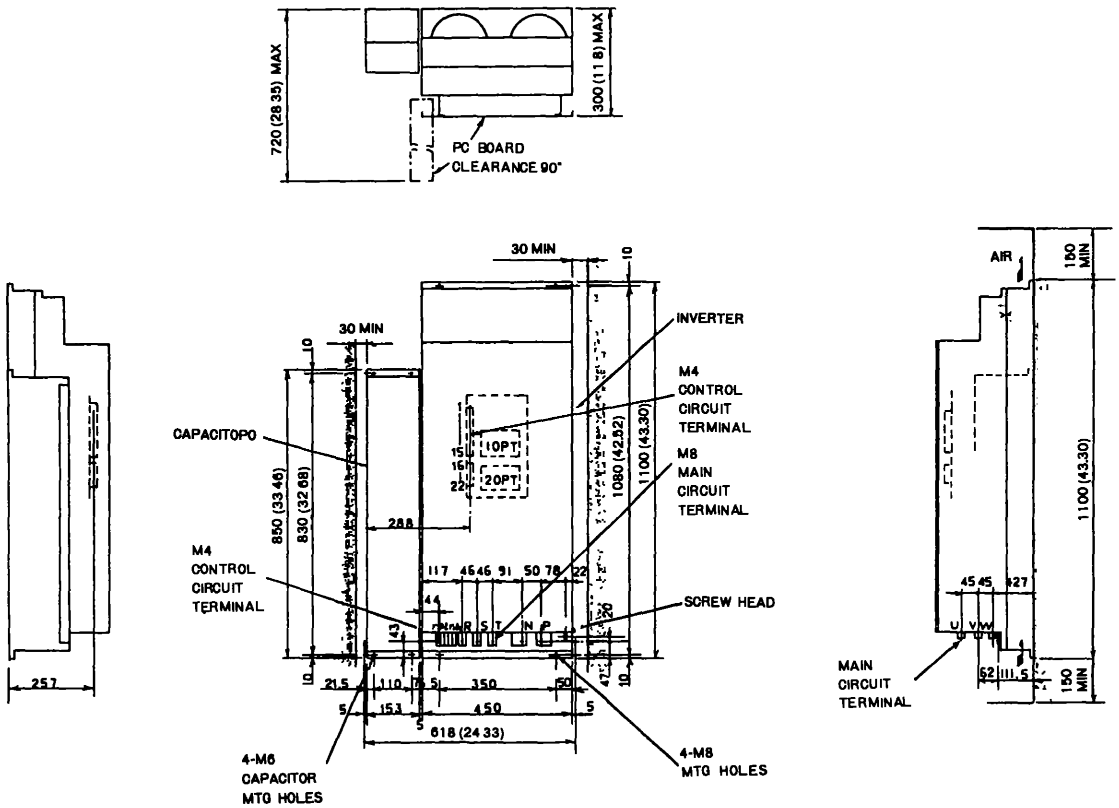


Fig. 18-36 Built-in Type CIMR-H55H APPROX WEIGHT: 120kg

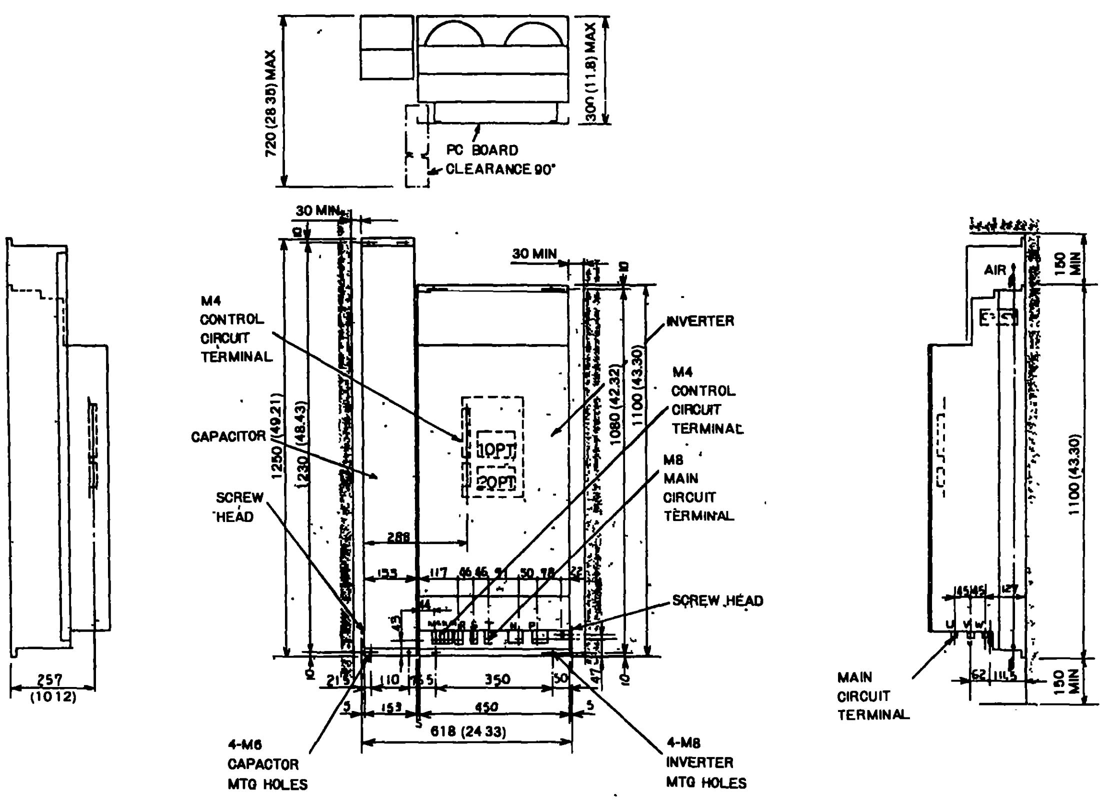


Fig. 18-37 Built-in Type CIMR-H75H APPROX WEIGHT: 130kg

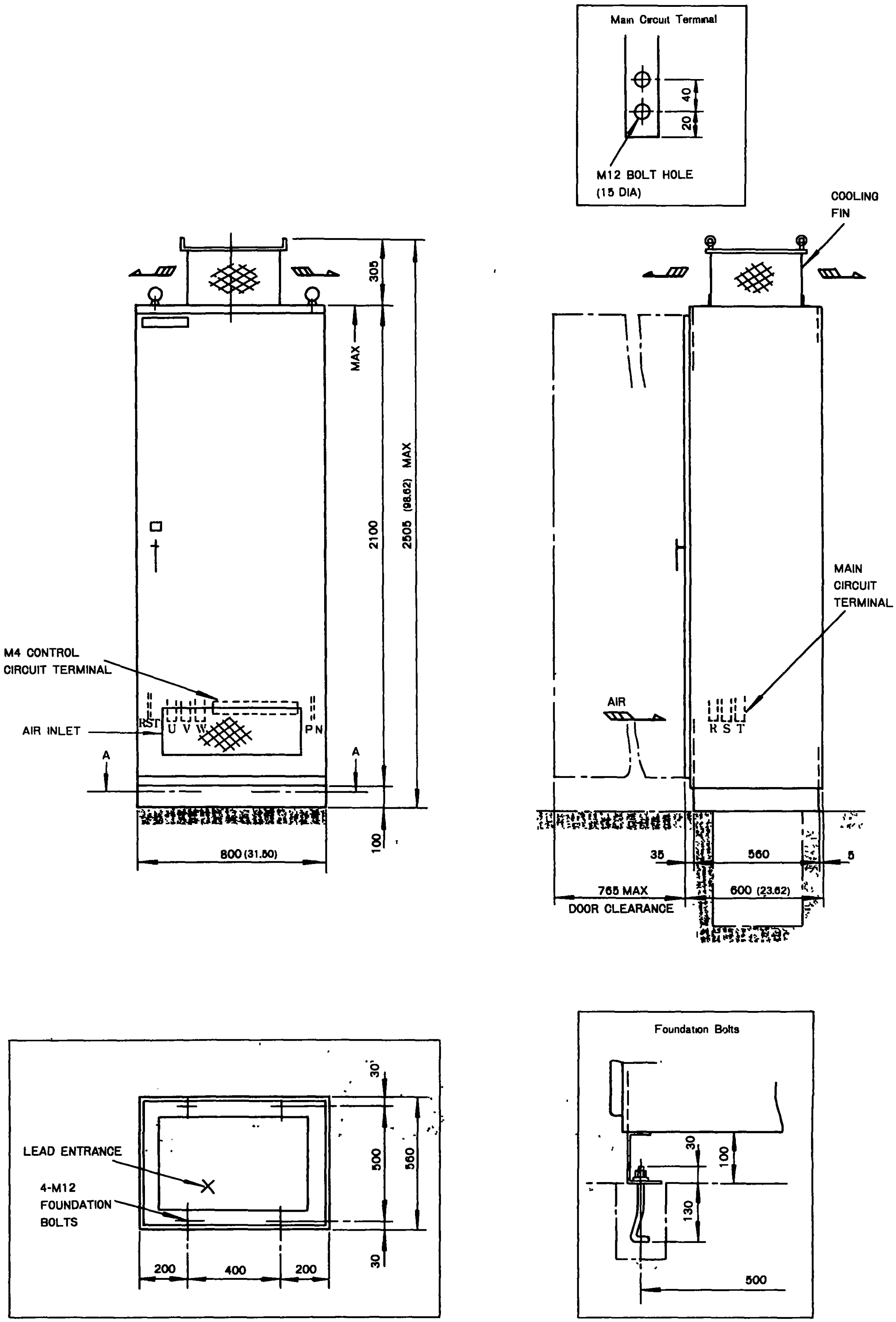


Fig. 18-38 Free-Standing Type CIMR-H110H, -H160H

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GENERAL PURPOSE TRANSISTOR INVERTER

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