Instruction Book

IL 19-615

REGULATED INVERTER POWER SUPPLY

THREE PHASE

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Westinghouse Electric Corporation
Industrial Systems Division
Inverter Systems
Buffalo, New York

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WESTINGHOUSE REGULATED INVERTER POWER SUPPLY

1. GENERAL

The regulated Inverter Power Supply (IPS) is an automatically regulated silicon controlled rectifier type semiconverter rectifier, the function of which is to convert alternating current (AC) from the supply line into precisely regulated direct current (DC) for supplying the connected load and charging and maintaining charge on station battery of a given number of cells. The DC output voltage of the charger is held constant to ±1% from no load to full load with ±10% AC line voltage variations. The IPS is also current limiting to protect the charger as well as the battery from excessive charging current. It will deliver rated current continuously at a maximum ambient temperature of 40°C (104°F).

The power transformer is of the two-winding type and transforms the AC line voltage to a secondary voltage of suitable magnitude to provide the required DC output voltage. The transformer also isolates the DC system from the AC source.

The thyristors (SCR's) and silicon cells are protected from transient surge voltages and excessive dv/dt by capacitor-resistor surge suppression. On the larger chargers, Voltrap surge voltage suppressors may be supplied in addition. Consult main schematic diagrams for details.

On high current chargers where two or more semiconductors operate in parallel in each leg of the thyristor power module (TPM), current paralleling reactors are used to force division of current between parallel cells.

The IPS consists of the following components:

1 - AC circuit breaker
1 - Two-winding power transformer
1 - Thyristor power module (TPM) - semiconverter type
1 - Set of AC current limiting fuses
1 - DC circuit breaker
1 - Fully transistorized SCR gating controller/regulator
1 - Set of surge voltage suppressors
1 - DC filter reactor
1 - DC voltmeter
1 - DC ammeter
1 - Blower motor, fuse protected
1 - Set of control alarm and protection devices consisting of:

    1 - DC voltage adjusting potentiometer
    1 - Accel-decel board (if used)
    1 - AC input failure indicator
    1 - Blower failure indicator
    1 - TPM overtemperature indicator (if used)
    1 - Battery operation relay (if used)

CAUTION: IT IS RECOMMENDED THAT ALL SECTIONS OF THIS INSTRUCTION BOOK BE READ CAREFULLY SO THAT THE OPERATOR FULLY UNDERSTANDS ALL DETAILS OF THIS UNIT BEFORE POWER IS APPLIED.

1.1 Forced Cooling

The rectifier thyristors and silicon cells, power transformer and DC filter reactors are forced air cooled by an air exhaust system consisting of an airtight plenum chamber with an exhaust blower located in the top of the chamber. The chamber is formed by the side and rear cover panels of the cabinet. The control panels are located just inside the front door of the cabinet from the front wall of the chamber.

The heat sinks of the thyristors and silicon rectifier cells are mounted over cutouts in the front wall of the chamber. The power transformer is located in the bottom of the cabinet and the chamber is extended over and sealed around the coils. The filter reactor is mounted inside the chamber and is baffled when required to provide the required forced air cooling.

The exhaust blower located at the top of the chamber creates a differential pressure between the inside and outside of the chamber with the result that air is drawn in thru the semiconductor heat sinks and transformer coil air ducts only.

Access to chamber is obtained by removing either the side or back panels of cabinet.

CAUTION: AFTER SERVICING UNITS, ALWAYS MAKE CERTAIN THAT ALL COVERS AND PANELS THAT ENCLOSE CHAMBER ARE PROPERLY REPLACED BEFORE APPLYING LOAD TO THE UNIT. ALSO TAKE NECESSARY CAUTION NOT TO PUNCTURE OR CUT HOLES INTO CHAMBER. TO PROVIDE PROPER COOLING OF COMPONENTS, AIR IS DRAWN INTO CHAMBER THRU HEAT SINKS AND TRANSFORMER COIL AIR DUCTS ONLY. EXCESSIVE AIR LEAKAGE INTO CHAMBER WILL REDUCE THE DIFFERENTIAL PRESSURE. THUS THE AIR VELOCITY THRU COILS, AND HEAT SINKS IS REDUCED RESULTING IN EXCESSIVE TEMPERATURE RISE WHICH WILL BE DAMAGING TO THESE FORCED AIR COOLED COMPONENTS.

Air Flow Failure

Failure of the blower will energize time delay relay 3CR. After 2 seconds delay, 3CR operates and trips the AC breaker.

In a TPM overtemperature condition, the heat sink overtemperature switch HST opens, de-energizing relay 4CR causing the AC input breaker trip.

2. DESCRIPTION OF OPERATION

The main schematic and wiring diagram will show the arrangement of the power supply components.

AC power is brought into the AC circuit breaker and then to the primary of the power transformer. The transformer in addition to isolating the DC output from the line, also transforms the AC voltage magnitude to a value required to provide the correct DC output voltage.

The thyristor power controller (TPM) or rectifier is of the semiconverter type with thyristors in the three positive legs and diodes in the three negative legs of the module.

DC output smoothing reactor (1X) provides inductance to the circuit to prevent the power semiconductors from conducting on peaks thus keeping the form factor, or ratio of the RMS current to DC current within acceptable limits.

Diode 4D, connected across the DC output of the TPM, is called the freewheeling diode, and its use is necessary in all semiconverter circuits to insure continuous currents over the full range of gating angle, alpha (α).

The DC output of the TPM has a fundamental ripple frequency of 360 Hz (60 Hz base) until alpha (α) approaches 60 degrees. From 60 to 180 degrees, the ripple frequency is 180 Hz (60 Hz base).

Thyristor Gating Controller/Regulator

The thyristor gating angle (α) is controlled by a closed loop voltage regulator to hold the DC output constant within specified limits for variations in AC line voltage, and the inherent no load to full load voltage regulation. The regulator compares the DC output voltage of the power supply with a preset reference and then maintains the DC output voltage constant.

Current Limit

The DC output voltage holds constant until the DC output current approaches the setting of the current regulator, after which the current regulator overrides the voltage regulator to maintain constant DC current, by reducing the DC voltage to a value equal to the product of the DC current and load resistance.

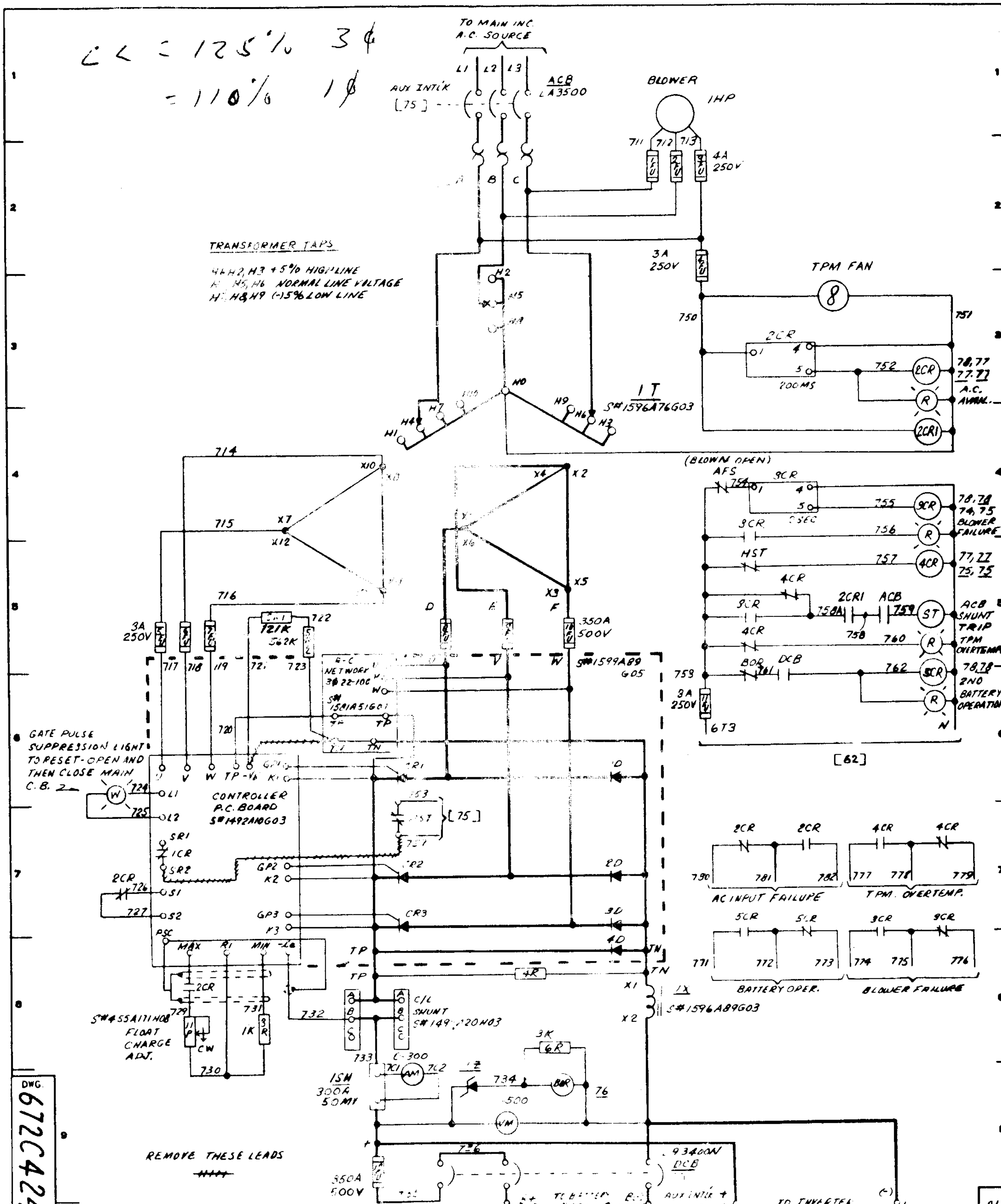
Refer to the gating controller/regulator instruction leaflet for complete details.

Ramp Function Generator (if used)

The Accel-Decel board mounted on the controller/regulator board allows the independent adjustment of the rise and decrease of output voltage. Pot 3P controls the voltage rise and pot 2P controls the voltage decrease. The ramp can be adjusted from 2 to 30 seconds.

Gate Pulse Suppression

On short circuits and severe overloads exceeding the capability of current limit, the gating controller will go into gate pulse suppression (GPS). GPS is indicated by an indicating light located on the IPS door. Opening and then reclosing the AC breaker resets the gate pulse suppression circuit.



WESTINGHOUSE ELECTRIC CORPORATION

INDUSTRY SYSTEMS BUFFALO NEW YORK

75KW INVERTER POWER SUPPLY

SUB 1Ø3	DWG 672C424	SHEET 7
CONT'D ON 8		

DWG. 672C424 SHEET 7

3. INSTALLATION

A. Preliminary

1. Mechanical Inspection - The roughest mechanical abuse which the equipment is subjected to has already occurred, namely, that during loading, shipping, unloading and installation. Inspect the cubicle thoroughly for evidence of mechanical strain or damage, and spot-check the tightness of bolts, cables, and wiring. Remove any packing items such as blocking wedges from relays, contactors (if used), shipping braces, etc. If any component or subassembly requires repair or replacement, notify the carrier immediately so that he can make restitution.

2. Check that AC input voltage and frequency agree with rating nameplate.

3. Install unit in location where cooling air will not be restricted and the ambient air temperature will not exceed the value specified on the rating data sheet or rating nameplate.

B. Electrical Connections

1. Make all connections with power turned off by an external switch.

2. Refer to wiring diagram. Connect the three AC incoming cables to line terminals marked L1, L2 and L3. Reference section 4 "Startup Instructions" and SCR gating controller/regulator instruction leaflet for special phase sequencing that may be required.

3. Connect the DC outgoing load cable to DC terminals marked (+) and (-) observing polarity carefully.

   NOTE: The size of the IPS DC cables should be selected to carry approximately twice the charger ampere current rating or provide less than 0.5 volts total drop in the loop or leads between the IPS and battery terminals.

4. Make control connections using diagrams as an aid.

   CAUTION:

   1. ON FORCED AIR COOLED UNITS, DO NOT CUT HOLES INTO PLENUM CHAMBER TO RUN CABLES. SINGLE PROPER COOLING OF SEMICONDUCTORS, TRANSFORMERS, AND DC FILTER REACTOR IS ONLY OBTAINED WHEN THE TOTAL AIR ENTERING THE PLENUM CHAMBER PASSES THROUGH THE SEMICONDUCTOR HEAT SINKS AND TRANSFORMER AND REACTOR AIR DUCTS.

   2. REFER TO SECTION 4 "STARTUP INSTRUCTIONS" AND THE SCR GATING CONTROLLER/REGULATOR INSTRUCTION LEAFLET.

$\frac{300KW}{350V}$ = 857 A D.C.

572 A A.C. (300 = 0.46 I x 1.14)

4. INITIAL STARTUP INSTRUCTIONS

4.1 Before applying power to the unit, FIRST read all sections of this instruction leaflet including the instruction leaflets for the SCR gating controller/regulator. Also consult the equipment data sheet in front of this I.L. for special instructions that may apply to this specific type of equipment.

4.2 Preliminary Checks

4.2.1 Check equipment as outlined in Section 3 "Installation."

4.2.2 Check AC input voltages to insure that all three phases are available and that voltage and frequency is in agreement with the nameplate rating and the equipment data sheet.

4.3 Phase Sequencing of Incoming AC Voltage

The SCR gating controller/regulator is phase sensitive. For proper operation, the three incoming AC power cables must be connected to line terminals in sequence L1, L2 and L3.

With unit at no load or DC breaker open, and DC filter capacitors (when supplied) disconnected, apply AC power. Should the phase sequence of incoming line voltage be incorrect, the gating pulses to the thyristors will be suppressed and the thyristors will not turn on. Gate pulse suppression is indicated by a light on the IPS door.

Improper phase sequencing can be corrected by isolating charger by the external AC feeder disconnect and interchanging any two of the three AC power cables on the line or load side of the charger AC breaker. Reconnect DC filter capacitors observing polarity carefully.

CAUTION: DO NOT INTERCHANGE LEADS AT ANY OTHER PLACE IN THE CHARGER.

4.4 Fan Cooled Units

When cooling blowers are provided, the blower motors are three phase and phase sensitive. Correct phase sequencing of incoming AC voltage will also insure that the blowers rotate in the proper direction to provide the correct direction of air flow and proper cooling of the power supply.

The TPM module may be fan cooled. If fan cooled, a single phase fan is used.

4.5 Initial Startup

After preliminary checks, including phase sequencing, have been made, it is recommended that the following procedures be followed before unit is placed into operation.

4.5.1 If desired, place oscilloscope probes across the plus and minus DC bus on the rectifier side of the DC smoothing reactor.

WARNING: When using an oscilloscope, it is recommended that the following safety precautions be taken.

a. Use insulating transformer between power source and scope AC input.

b. Do not ground the oscilloscope case.

c. Provide a rubber mat for the operator to stand on, to insulate him from ground.

4.5.2 At no load or with the DC disconnect open, energize power supply and observe on scope three phased back waveforms per cycle with approximately equal peaks which phase forward smoothly without loss of any of the three waveforms at any time. The waveforms should be steady with no oscillations. Refer to sketch #1, Figures 1 and 2.

The DC output voltage as read by the DC voltmeter should agree with the float charge voltage for the number of battery cells. Refer to the equipment data sheet.

4.5.3 Check all control circuits for proper operation including air flow circuitry, when supplied, to insure that it will shut down power supply upon fan failure. Failure can be simulated by shorting out the air flow relay contacts.

On units where air flow switch operates into the shunt trip circuit of the AC circuit breaker, there will be a two-second time delay before the breaker trips.

NOTE: Some units are equipped with overtemperature switches which shut the IPS down on overtemperature rather than air flow failure. The main schematic diagram will indicate which system is used.

4.5.4 Before placing power supply into operation, read Section 5 "To Put Into Operation" and also consult the equipment data sheet for special startup sequences that may apply.

5. TO PUT INTO OPERATION

5.1 Refer to installation instructions - Section 3 of instruction book.

5.2 Observe that the incoming AC power cables are connected to terminals L1, L2, and L3 in the correct phase sequence as outlined in Section 4 of this instruction book.

5.3 Observe that the positive terminal of the battery is connected to the positive (+) terminal of the IPS and the negative terminal of the battery is connected to the negative (-) terminal of the IPS.

5.4 See "Operator's Instructions" for IPS operating procedures.

6. MAINTENANCE

To insure a high reliability and a minimum of shutdown time, it is recommended that a preventative maintenance program be set up whereby the equipment is inspected periodically and repairs made before a major breakdown occurs.

Since the power unit, other than relays, switches and fan motors have no moving parts, maintenance is quite simple. Periodic cleaning of thyristor and rectifier assemblies is recommended to maintain maximum heat transfer and insulation resistance. Components may be freed of an accumulation of dust by a slight blast of air from an air hose and brushing with a soft brush.

To insure that unit is receiving a proper amount of cooling air on those units equipped with air filters, periodically inspect air filters, and replace when the accumulation of dirt is such as to impair the flow of air.

Blower motors are properly lubricated for years of service. Should bearings ever require relubricating, it is recommended that they be replaced.

Current limiting fuses are selected to provide short circuit protection to thyristors and silicon cells, and they should always be replaced with exact duplicates in type and rating.

When installing thyristors and silicon rectifier cells to their respective heat sinks, always use a torque wrench and follow the instructions given in the attached AD 54-050.

7. TROUBLE SHOOTING

Although it is not possible to anticipate specific troubles, the following general outline may be useful in isolating the cause of the malfunction. Once the trouble has been located, the remedy is usually self-evident.

7.1 Check AC input voltages to insure that all three phases are available and that voltages and frequency are in agreement with the nameplate ratings.

7.2 Check control circuits and fuses where trouble is suspected and correct when found necessary.

7.3 Three phase semiconductor power controllers are phase sensitive. Incorrect phasing of incoming AC voltage will shut the unit down. Refer to the gating controller instruction leaflet or Section 4 of this book for phasing instructions.

7.4 Sudden Loss of Charging Voltage

Observe gate pulse suppression light on door of charger. If light is on, gate pulses are in suppression. After preliminary check indicates that output is not short circuited and no fuses have blown, charger can be re-started by opening and then closing, after approximately two seconds delay, the AC breaker.

7.5 Current Limiting Fuses

Check with an ohmmeter.

CAUTION: BEFORE REPLACING A BLOWN FUSE, ALWAYS CHECK THYRISTORS (SCR) AND/OR SILICON RECTIFIER CELL IN FUSE CIRCUIT AND REPLACE IF FOUND DEFECTIVE, OBSERVING MOUNTING TORQUE REQUIREMENTS OUTLINED IN THE MAINTENANCE SECTION OF THIS INSTRUCTION BOOK.

On units equipped with trigger fuses, be sure to replace trigger fuse when replacing main fuse.

7.6 Check SCR's and Silicon Cells

A silicon rectifier cell has a low resistance in the forward direction and high resistance in the reverse direction. An SCR has a high resistance in both forward and reverse direction with no gate voltage applied.

SCR's and silicon cells properly protected by current limiting fuses usually fail by shorting. The shorted silicon cell will be indicated by little or no resistance in either direction, and a damaged SCR may be indicated by little or no resistance in forward direction and either a high resistance or little or no resistance in the reverse direction, with no gate voltage applied.

To properly test an SCR or silicon cell, the device should be isolated from the rectifier by removing the shunt connection or removing the unit from the rectifier assembly.

In lieu of more precise test equipment, the general condition of the semiconductor can be determined by an ohmmeter. However, since the cell resistance varies with changes in temperature and current, it is difficult to define values of resistance to be measured.

A second method of testing silicon cells and SCR's is the flashlight method. Connect two leads on a flashlight so that the silicon device can be connected in series with the series combination of batteries and lamp to complete the flashlight circuit. A good silicon cell will be indicated when the lamp lights for one position of polarity. When the polarity is reversed across the cell, the lamp will not light. A shorted silicon cell will be indicated by the lamp lighting for both positions of polarity. The lamp failing to light in either position of polarity will indicate that the cell is open-circuited, or will indicate that an SCR is probably good.

7.7 Check by continuity for open circuits. Use wiring diagram as an aid.

7.8 Should trouble originate in the SCR gating control module, determine that each SCR is receiving a gating pulse with the aid of an oscilloscope. Check out control module using aids given in the control module section of this instruction book.

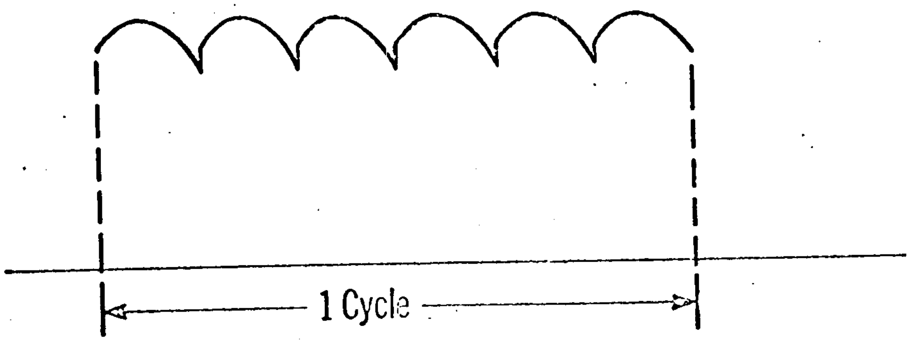


Fig. #1
DC OUTPUT
Power SCR's Phased
Full on Fund.
Ripple Freq. 360 C.P.S.

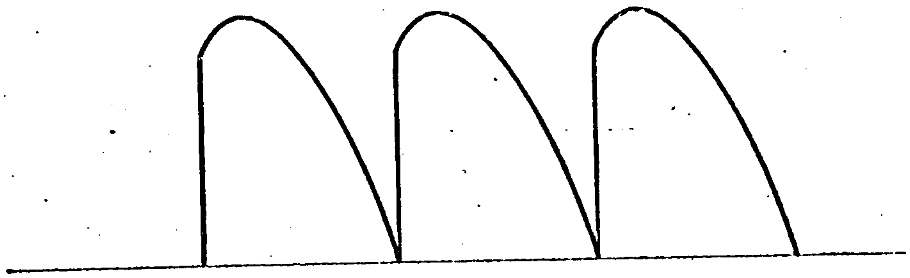


Fig. #2
DC OUTPUT
3 SCR Controller
60° Phase Back
Position Ripple
Freq. 180 C.P.S.
(No Filter)

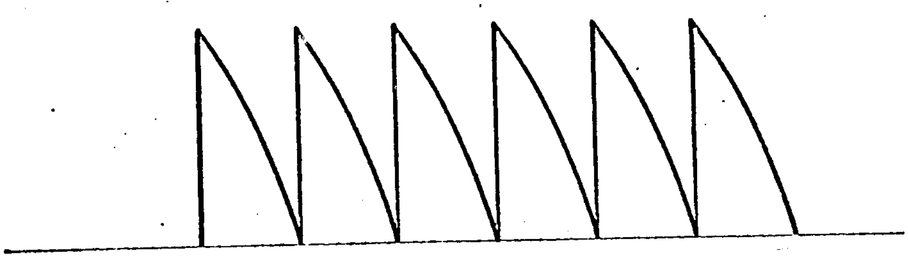


Fig. #3
DC OUTPUT
6 SCR Controller
60° Phase Back
Position Ripple
Freq. 360° C.P.S.
(No Filter)

Sketch #1

APPROXIMATE DC OUTPUT VOLTAGE, WAVE FORMS
60 HZ Input Power

THREE PHASE SCR GATING CONTROLLER BOARD

STYLE 1492A10G

FOR

DC VOLTAGE AND/OR DC CURRENT REGULATED POWER SUPPLY

Main Schematic Diagram	1492A10 Sh. 5 & 6
Printed Circuit Board	661C233

INDEX

I. DESCRIPTION OF OPERATION

The controller printed circuit board provides all the dynamic control functions necessary to regulate the Thyristor Power Module (TPM). The controller provides filtered ±24 VDC power and zener regulated DC power for all controller and gating functions.

In discussing the controller, it is best to start with the intermost functional block in the control loop, namely, the Gate Pulse Generator (GPG). The GPG is really a "subcircuit" of the controller board, but a very important one. In Figure 1, it is convenient to show the GPG terminals as well as the 24 volt power supply. The points marked "PSP" refer to +24 volts, those marked "PSC" refers to "system ground" NOT EARTH GROUND, and "PSN" refers to -24 volts.

The power is received through points "U", "V" and "W" which is applied to the primary windings of transformers 1T, 2T, and 3T, which are connected in delta-star. The secondaries of the transformers are fed to a 3 phase bridge rectifier made up of diodes 34D through 39D. These very same secondaries supply reference timing waves to the input of the gate pulse generator circuit (upper half of Figure 1).

Gate Pulse Generator (Subcircuit)

A glance at Figure 1 will show 3 identical circuits comprising the GPG. Only one will be described since the other two function identically. The timing reference from X2 of transformer 2T is fed to a 30° delay filter comprising resistors 75R, 72R and capacitor 25C. Since it is necessary to have close tracking of the 3 pulses, this capacitor has a tolerance of ±1% (the corresponding capacitors 27C and 29C are also ±1%).

Since it is necessary to understand the power commutation process before one can understand gating requirements, a discussion of power commutation process follows. Figure 3 shows the sequence of the excitation voltage (U, V, W) and the corresponding sequence of pulses. Inside the rectangular boxes are the devices which are in conduction at each moment.

Though the thyristor conduction periods are shown at overlap, in practice this is not the case. Only 120 degrees conduction is possible. The overlapping was necessary to show the range of possibilities of conduction. For example, 1TH can be gated anytime that the wave U-W is positive. The third of a cycle later (120 degrees) 2TH is gated and any current remaining in 1TH is now commutated to 2TH. It is quite possible for the thyristors and diodes to conduct less than 120 degrees, because free-wheeling diode commutates the current from 3D rather than allowing 1D to do the job.

NOTE: The gating controller requires a standard 230 volt or 460 volt AC power for proper operation. Since many power supplies require non-standard AC voltages feeding the TPM to obtain the required DC output voltage, the power to the gate controller is usually taken from a separate source. However, in either case, the power source to the gating controller (U-V-W) are always in phase with each other.

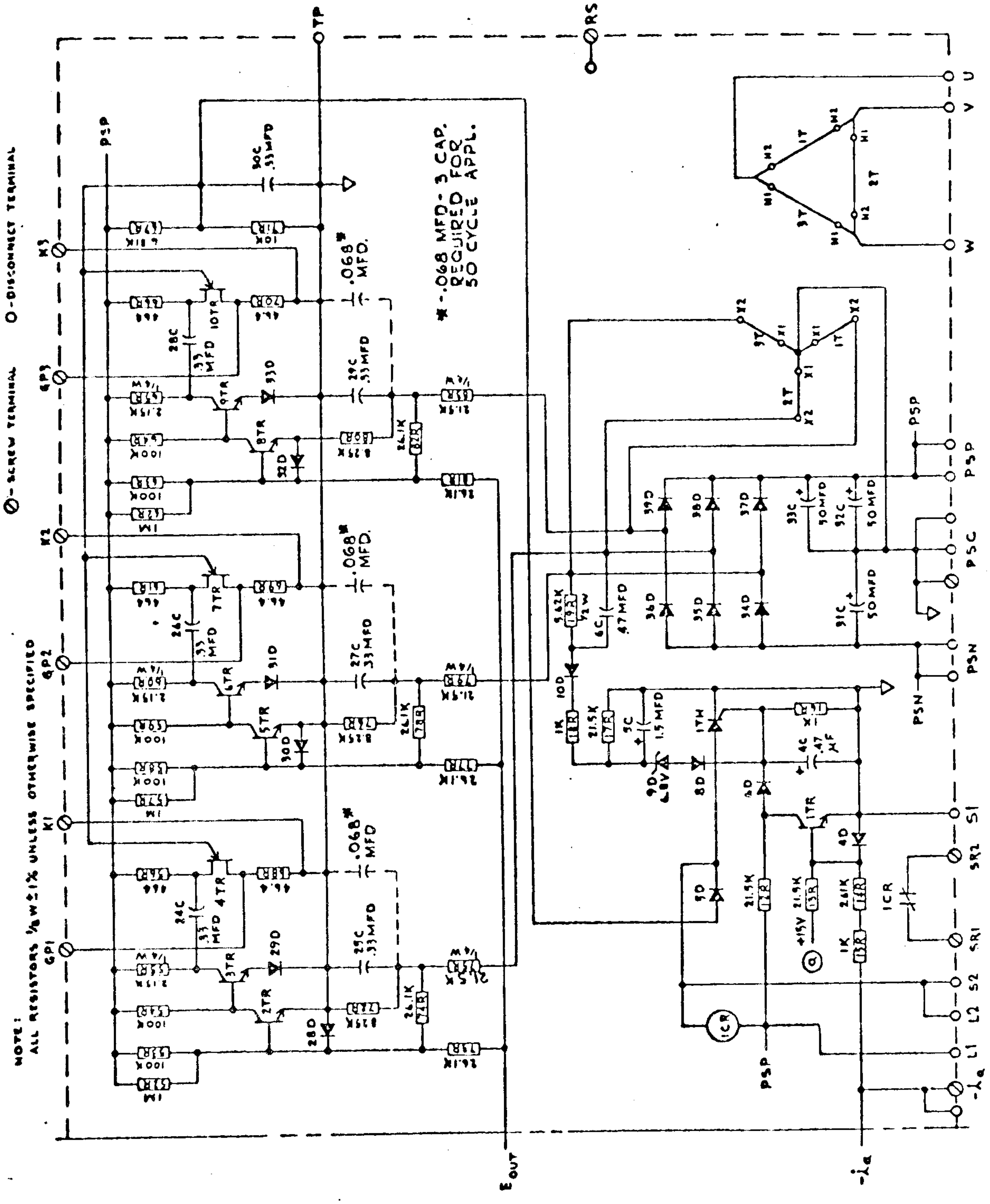

NOTE: ALL RESISTORS 1/8W ±1% UNLESS OTHERWISE SPECIFIED
⊘-SCREW TERMINAL O-DISCONNECT TERMINAL
*-.068 MFD-3 CAP. REQUIRED FOR 50 CYCLE APPL.
TP
RS
PSP
PSC
PSN
E_{OUT}

FIG. 1

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

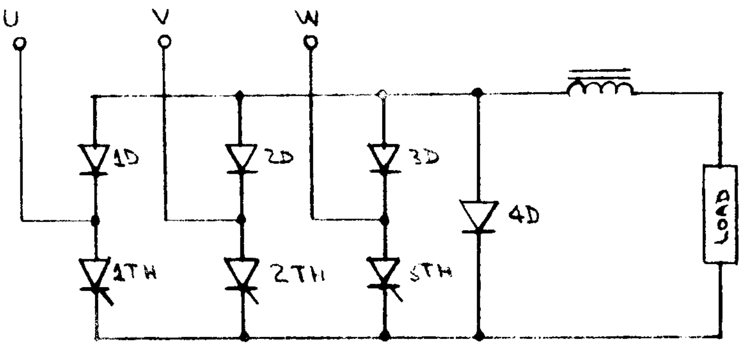


FIG 2

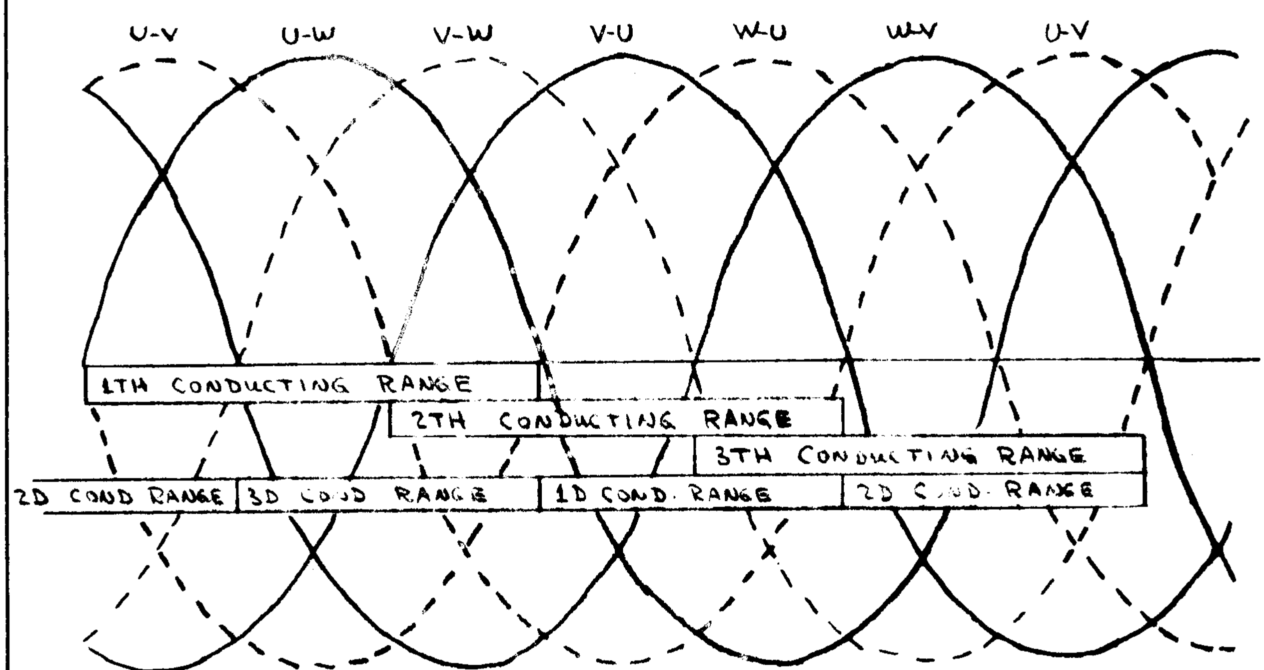


FIG 3

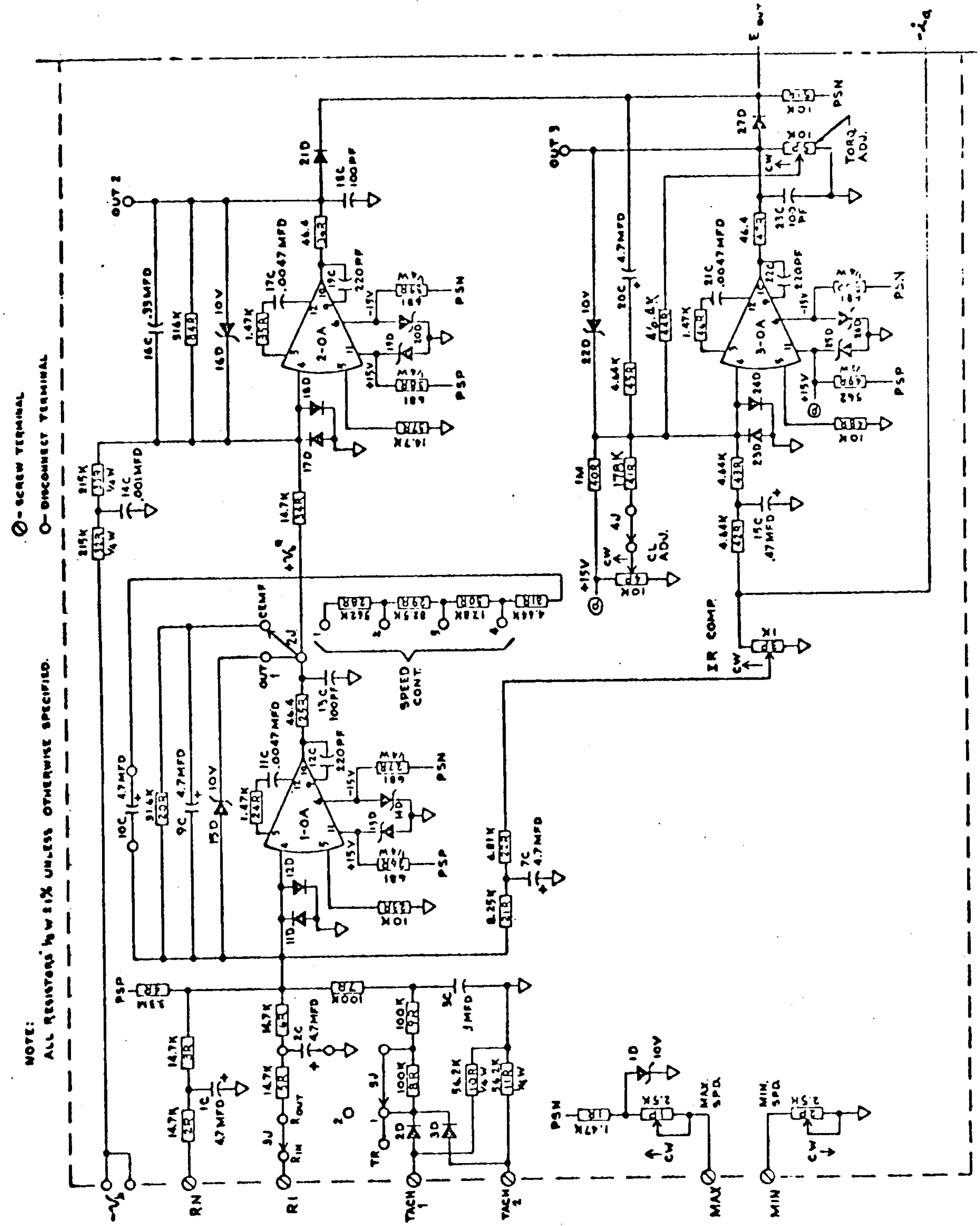


FIG. 4

Since 1TH can be fired only during the time that the voltage (U-W) is positive, we want to use the voltage (U-W) as a reference wave to time pulse #1 (GP1) from the GPG. Likewise, wave (V-U) becomes a reference wave for GP2, and wave (W-V) is the reference wave for GP3.

Ideally, a linear relationship is desired between the input to the GPG (i.e., E_{out} from the operational amplifier circuit) and the output of the thyristor rectifier. To generate this relationship, a Cosine wave must be generated. The gate pulse is timed by shifting the level of the cosine wave with respect to PSC. When the cosine wave crosses zero volts (PSC) in the negative going direction, a pulse is released to the proper thyristor. Figure 11 shows the reference (excitation voltage) voltage (U-W) and the cosine wave biased to gate at α = 180 degrees.

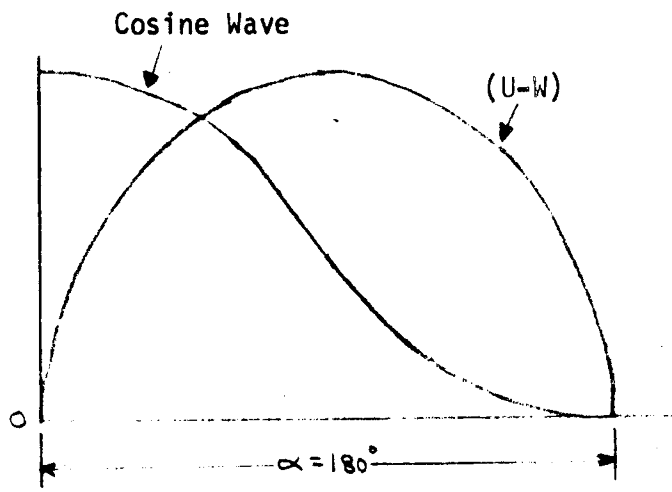


FIGURE 5

The cosine wave, generated by the transformer, 2T, and the input filter on the GPG must be shifted as shown in Figure 5 when no voltage is present at E_{out}. The parallel combination of 52R and 53R performs this function. The voltage, E_{out} has the limits: -10 volt $\leq E_{out} \leq$ 0 volts. When E_{out} is zero, Figure 5 results. When E_{out} is -10 volts, it is desirable to approach a gating angle (α) of 0 degrees. This means that the peak-to-peak voltage of the cosine wave should be approximately 10 volts (i.e., equal to the maximum range of E_{out}. The same filter used to shift the 120 degrees signal from 2T back 30 degrees also was used to attenuate the 50 volt peak-to-peak signal to 10 volts peak-to-peak.

The base of transistor, 2TR, sums this "timing wave" through 74R with the signal E_{out} through resistor 73R and the cosine shifting bias through resistors 52R and 53R as mentioned above. When the base of 2TR goes negative, its collector jumps to +24 volts, which saturates transistor 3TR, changing its collector to about 0.7 volt. Capacitor, 24C, couples this signal to the base-2 of unijunction transistor 4TR. The time constant of 24C, 55R and 56R causes a negative-going spike to be seen on the unijunction's base -2 which causes it to fire. The energy to gate the thyristors comes from each of the three unijunctions 4TR, 7TR, 10TR via the charging capacitor, 30C.

Both the rate of charging and the final value of the voltage on 30C is governed by resistors 67R and 71R. The charging rate must not be so slow that the voltage doesn't reach its final value before the next pulse is to be released. The fixed potential of the capacitor must not be too large or the unijunction transistors will fire needlessly or at improper times. If the capacitor potential isn't high enough, the power used to gate the thyristors is substantially reduced. The voltage divider 67R and 71R also serves to compensate for line voltage changes. In that event, the divider keeps the capacitor potential at a level which never exceeds the intrinsic standoff ratio of the unijunction.

Gate Pulse Suppression

Gate Pulse Suppression is also a subcircuit of the controller board. Its operation is based on the tripping of a thyristor (1TH) which discharges the charging capacitor (30C) in the gate pulse generator subcircuit. The thyristor is tripped (or made conductive) only when the instantaneous load current becomes greater than 400 percent of rated current. Coupled to the gate-pulse-suppression subcircuit is a phase-sequence protection and detection circuit. The voltages on the secondary terminals (X2) of transformers 2T and 3T are fed to an RC network made up of capacitor 6C and resistor 19R which is sensitive to phase rotation. If phase rotation is correct, the voltage built up across capacitor 5C and zener diode 9D is less than the zener's breakdown voltage and no signal is seen at the gate of thyristor 1TH. If phase rotation is incorrect, or if one of the phases is missing, the voltage will be high enough to break down the zener diode (9D) and gate the thyristor 1TH. Whenever the thyristor is gated (i.e., when gate pulse suppression is activated), the voltage across the coil of relay 1CR and the gate pulse suppression lamp becomes equal to 24 volts, which lights the lamp and picks up the relay.

After the cause of gate pulse suppression has been found and corrected, the control can be reset by opening the AC circuit breaker for two seconds and then closing it. If unit also includes an AC contactor, the contactor must be closed after the AC breaker is closed.

Operational Amplifier Subcircuit

In addition to the gate pulse-generator, power supply and gate pulse suppression subcircuits, there are three operational amplifier subcircuits of the controller board (see Figure 4). Amplifier (1-OA) is associated with the input reference circuit, which is made up of resistors 5R, 6R and 1R; potentiometers 1P and 2P; and capacitor 2C. The potentiometers 1P and 2P are for adjusting maximum and minimum DC output voltage set points. Jumper 2J is connected to "CEMF" on the controller board. In this position, resistor 20R is connected across the feedback of (1-OA) giving the amplifier a gain of unity with respect to the reference input. "IR COMP." potentiometer 3P is adjusted to provide the best DC output voltage regulation of the power supply over the no load to full load range of the power supply. The current feedback signal comes from an expanded metal shunt, which feeds back approximately -0.5 volt for 100% rated load current. This signal (-ia) adds to the reference signal applied to the input of 1-OA, and is considered positive feedback.

The output of amplifier (1-OA) is proportional to the bus voltage and becomes the reference (+vb*) for the voltage controller, amplifier (2-OA). The bus voltage reference (+vb*) is summed with the bus voltage feedback (-vb) in amplifier (2-OA) whose output (E_{out}) is fed to the gate pulse generator subcircuit. It is this signal (E_{out}) which directly controls the gating of the thyristors and hence, the bus voltage. Maximum limits are set on the outputs of each amplifier by the feedback diodes 15D, 16D, and 22D.

The limits of the gate control voltage, E_{out} are between zero and -10 volts. The voltage can be generated by either the current controller 3-OA, or the voltage controller, 2-OA, depending on which output is least negative. Switching diodes, 21D and 27D, switch the least negative output to the gate pulse generator input (E_{out}). The more negative of the two switches into a negative limit of -10 volts. While a controller output is in negative limit, it is said to be "out of control", and has no effect upon the bus voltage in any way. When two amplifiers are connected as above, they are said to be connected in parallel and are referred to as parallel regulators. Such systems can be adjusted to give faster response than multiloop systems. Because switching between two or more regulators is possible with a parallel regulator system, two different modes of operation are possible. In the 22-100, 3 phase system, the two modes of operation are voltage and current.

Regulator Adjustments

Potentiometers 1P and 2P, briefly mentioned before, are used to set maximum and minimum DC voltage points. The range of adjustment of the voltage adjust potentiometer external to control board and connecting to terminals "MAX", "MIN" and "RI" can be adjusted with pots 1P and 2P.

DC voltage feedback is taken at the rectifier and the resistance drop or regulation (no load to full load) between the rectifier and the output terminals of the power supply is compensated by "IR COMP" which is adjusted by pot 3P.

NOTE: The majority of DC power supplies are only IR compensated to the DC output terminals of the power supply. Only in special cases and only when specifically specified is IR compensation provided to the load since the power transformer feeding the TPM must have extra voltage to provide proper operation.

An adjustment for limiting the DC output current is available called the "Current Limit Adjust" potentiometer 4P in Figure 4. Adjustment of DC current is available over an approximate range of 20 to 150% of rated current. On application where the current adjustment potentiometer is remote from the control board, jumper 4J is removed and a potentiometer is connected between the slider or pot 4P and PSC with slider connected to resistor 41R. Pot 4P then operates as an end stop adjustment for the remote current adjustment potentiometer.

The "Slop Adjust" potentiometer 5P adjust the amount of negative feedback applied to the current controller. The effect is to reduce the amount of current-limit reference current entering the summing junction of 3-OA, which is to say the current limit is lowered as the output of 3-OA increases. The result is a sloped current-limit characteristic.

CAUTION: ON MOST DC POWER SUPPLY APPLICATIONS, POTENTIOMETER 5P IS ADJUSTED TO PROVIDE A ZERO SLOPE AND A SHARP CURRENT LIMIT CHARACTERISTIC.

II. SPECIFICATIONS AND RATINGS

Input Voltage (U, V, W)

Controller S#1492A10G03 - 230 volts, 3 phase, 60 Hz

Controller S#1492A10G04 - 460 volts, 3 phase, 60 Hz

NOTE: Modification kit S#1527A50 is required for 50 Hz operation.

Board Voltages

PSP	-	+25 volts nominal
PSN	-	-25 volts nominal
E_{out}	-	OTO - 10 volts
Out 1	-	-0.5 to +10 volts
Out 2	-	+0.5 to -10 volts
Out 3	-	+0.5 to -10 volts
(-ia)	-	0 to -1 volt (no load to full load)
(-vb)	-	0 to -10 volts

Inverter DC Power Supply Adjustment Guide

The Inverter DC Power Supply for use with Westinghouse AccurCon Inverters and Westinghouse single-phase inverters make use of the standard 22-1000 type S-300 control board. Adjustment of this board is, therefore, relatively straight-forward and well understood by many.

If only a simple adjustment of output voltage level is required, this may be accomplished by adjusting the external voltage adjustment pot mounted on the power supply panel or by adjusting pot 1P on the controller board.

In the event complete readjustment of the controller is required, for example, after installation of a new board, the steps outlined below should be followed.

1. Initial pot adjustments.

   a. Turn pot 1P on controller full counter-clockwise. (MAX. SPD.)

   b. Turn pot 2P on controller full clockwise. (MIN. SPD.)

   c. Turn torque adjust pot 5P full counter-clockwise.

   d. Turn current limit pot 4P and IR compensation pot 3P to the same relative physical orientation as found on the board being replaced. Or, if the existing board is not being replaced, do not readjust these pots. These adjustments are approximations and can only be made exact under load conditions.

2. Close the AC input circuit breaker, starting the power supply and adjust the voltage adjust pot mounted on the panel to give rated output volts.

3. Open AC input breaker and close the DC output breaker, or battery disconnect, connecting the DC bus to the power supply output.

4. Reclose the AC input breaker noting that the power supply is not loaded above full load; check the output DC volts and adjust to rated if necessary.

5. In the event that a dummy load equal to at least 125% of rated load is available, the IR compensation pot and the current limit pot may be adjusted by following the steps outlined below.

   a. After adjusting the output DC voltage per the above steps, apply full rated load to the power supply and adjust the IR compensation pot 3P to give rated output volts.

   b. Apply 125%-130% rated load and adjust the current limit pot 4P to limit the current to 125%.