Kim Frankcombe

GGT-25 Manual

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5.5.12 Duty cycle input - With The TRANSMITTER CONTROLLER (Zonge model XMT-12) connected to EXT control, set the TRANSMITTER CONTROLLER for a 256 Hz 50% duty cycle time domain signal.

The input to board 100 should be a 512 Hz square wave at DUTY on the lower left corner of the board on the GGT-25 and upper right corner of the board on the GGT-6. Switch to the 12-1/2% and 25% duty cycles. The waveform should change to match. Check the duty cycle output to the isoamp. This is a buffered output from board 100. It controls the sample and hold on the isoamp. Switch the TRANSMITTER CONTROLLER to 1 Hz and set the current set potentiometer to 5.00. On the GGT-25, this will be 2.0 volts at "Set". On the GGT-6 it will be 1.0 volt at "Set". Pin 1 of F6 (IH5042) should switch between 0.0 and 2.0 volts on the GGT-25 or 0.0 and 1.0 volt on the GGT-6. This checks the integrate and hold function for the pulse variable outputs. If there is no switching, check pin 16 of F6 for 0.0 volts and pin 4 for 2.0 volts or 1.0 volt. If pin 16 is not 0.0 but pin 3 of F7 is 0.0, this indicates a bad IH5042.

5.6 Power Supply

Refer to the power supply data sheet for test points and voltages. Remove the output connector before measuring the voltages. Check the input first to insure that the circuit breaker, control power switch, and generator are O.K.

If any voltages are out of tolerance return the supply to Zonge Engineering. They have no user serviceable parts and are covered by a four-year manufacturer's warranty.

6 APPENDIX

6.1 Checking Phase Sequence - Alternator

NOTE: This test should be made at the military plug on the end of the transmitter power cable that plugs into the transmitter (Figure A1). This insures that all the wiring is correct between the alternator and the input to the transmitter.

6.1.1 Use a DVM (Fluke) to check the absolute voltages on each phase. Set the Fluke to:

AC
200 volt range

6.1.2 Place the ground lead of the Fluke on the neutral lead of the plug, i.e. lead "D" (Figure A1). Place the positive Fluke lead on leads (phases) A, B, and C (Figure A1) in turn and record the voltages for each phase. The voltages should all be within 10% of each other.

6.1.3 NOTE: When you measure the 3-phase voltages as indicated above, if one of the phases measures the normal 110 to 120 volts and the other two phases measure approximately 200 volts, the lead "D" is not connected to "neutral" on the alternator. If you attempt to bring up the transmitter with the alternator in this configuration, serious damage will result.

6.1.4 Set a Tektronix 212 or similar oscilloscope as follows:

TRIGGER SOURCE	CH2
TRIGGER LEVEL	AUTO
SEC/DIV	.5m
VOLTS (BOTH Ch1 and Ch2)	50
INPUT COUPLING	AC

6.1.5 Connect the ground lead on the Ch2 probe on the oscilloscope to the neutral lead (Figure A1) on the military plug.

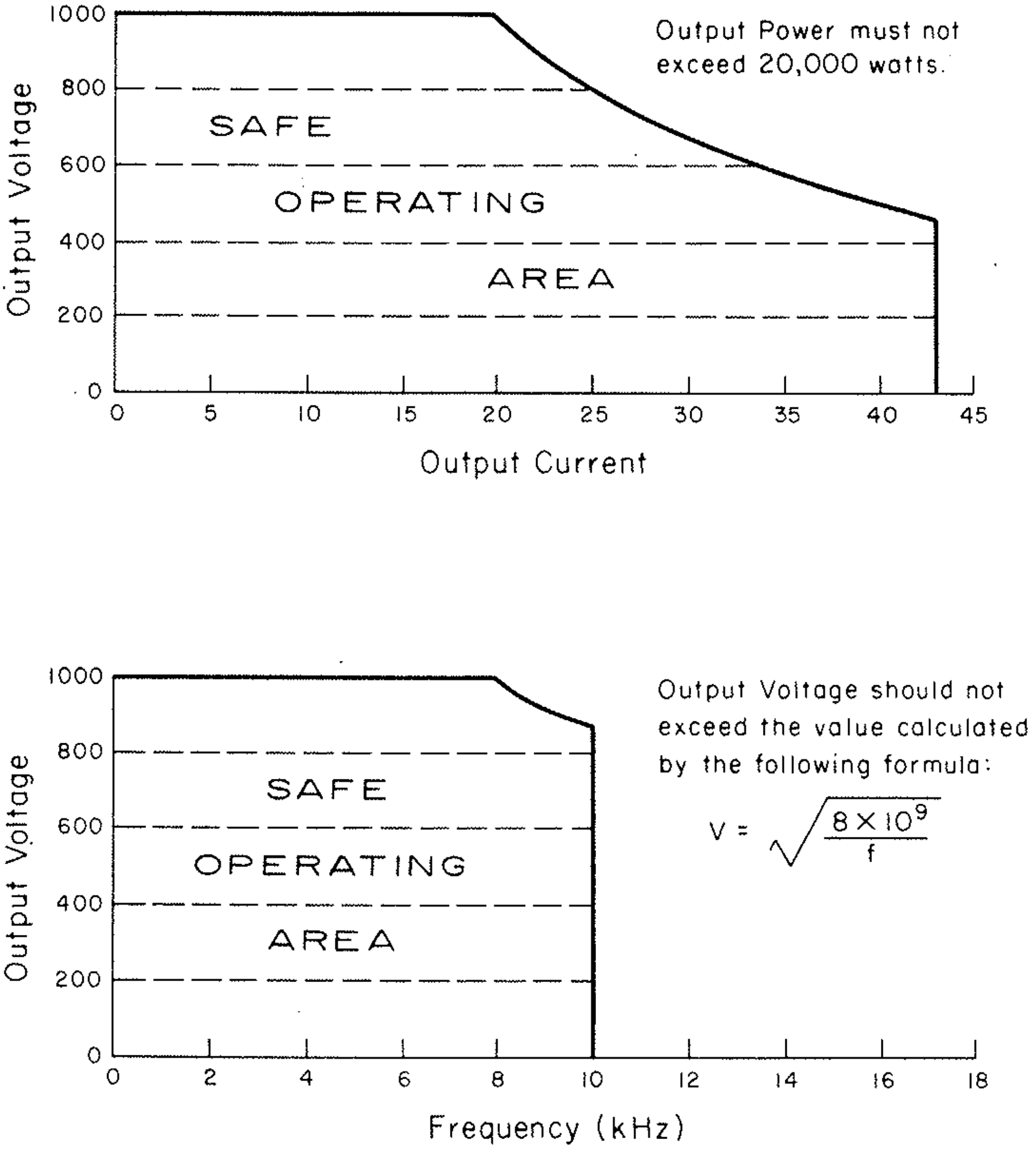
6.1.6 Bring up to 115 volts using the voltage regulator. WARNING: POTENTIALLY FATAL VOLTAGES ARE NOW PRESENT ON THE OUTPUT LEADS ON THE MILITARY PLUG.

6.1.7 Carefully place the Ch2 probe on pin A ("A" phase) on the military plug (Figure A1). Adjust the VOLTS/DIV VAR knob to achieve a peak-to-peak signal of four divisions. Adjust the HORIZ MAG knob to achieve a peak-to-peak signal of six divisions. Adjust the horizontal POS knob to adjust the waveform as shown in Figure A2.

6.1.8 The correct phase sequence is: B lags A and C lags B, both by 120 degrees. Keep the Ch2 probe on the A phase and place the Ch1 probe on the B phase (Figure A1). If you have the waveform on the oscilloscope such that the horizontal peak-to-peak signal is six divisions (Figure A2), then each division is equal to 60 degrees. Therefore, the B phase signal (Ch1) should be two divisions to the right of phase A (Figure A3). If the phase sequence is not correct, the B phase will lead the A phase by 60 degrees (Figure A4).

6.1.9 If the B phase leads the A phase (as shown in Figure A4), reverse any two of the transmitter power cable leads on the alternator and repeat section 6.1.

6.1.10 Keep the Ch2 probe on the A phase and place the Ch1 probe on the C phase. The C phase should lag the A phase by 240 degrees, i.e. the C phase should be four divisions to the right of the A phase (Figure A5).



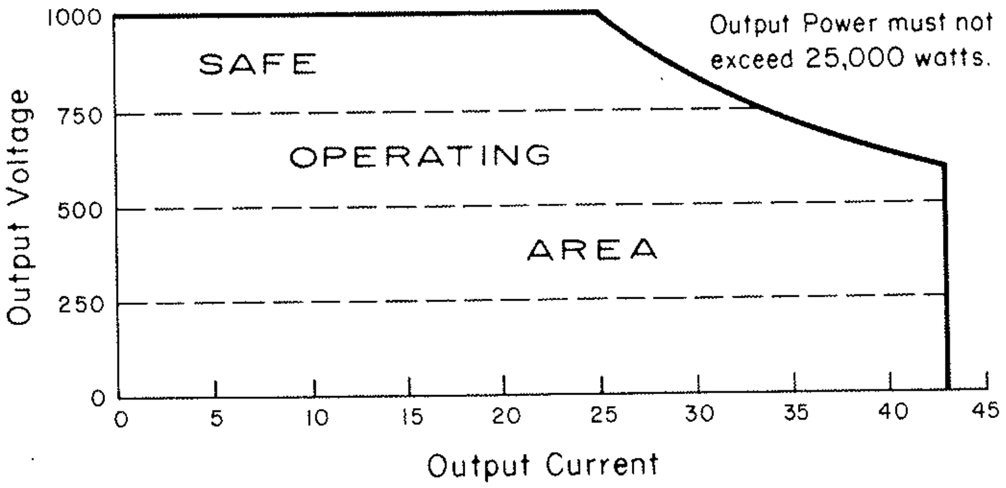
Output Power must not exceed 20,000 watts.

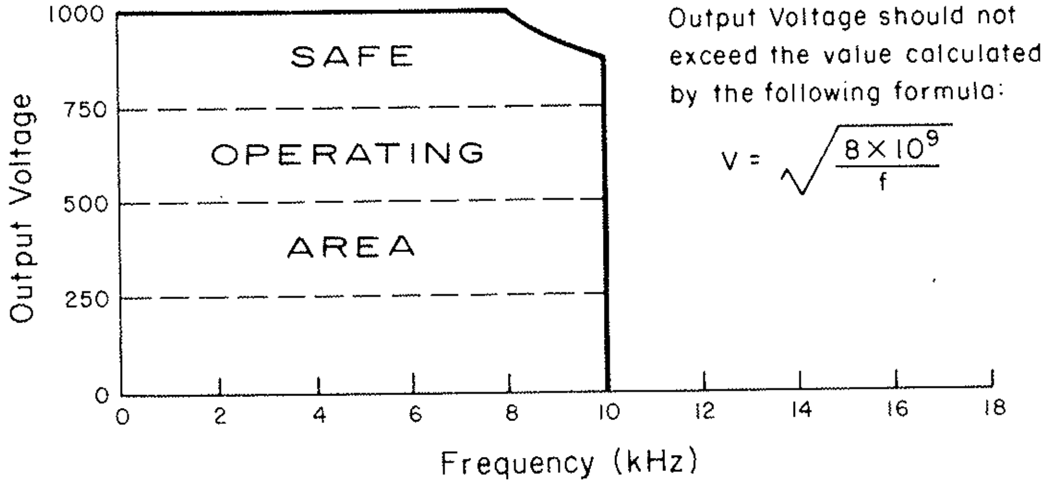
Output Voltage should not exceed the value calculated by the following formula:

$$V = \sqrt{\frac{8 \times 10^9}{f}}$$

Output voltage and current curves for safe operation of the GGT-20 transmitter.

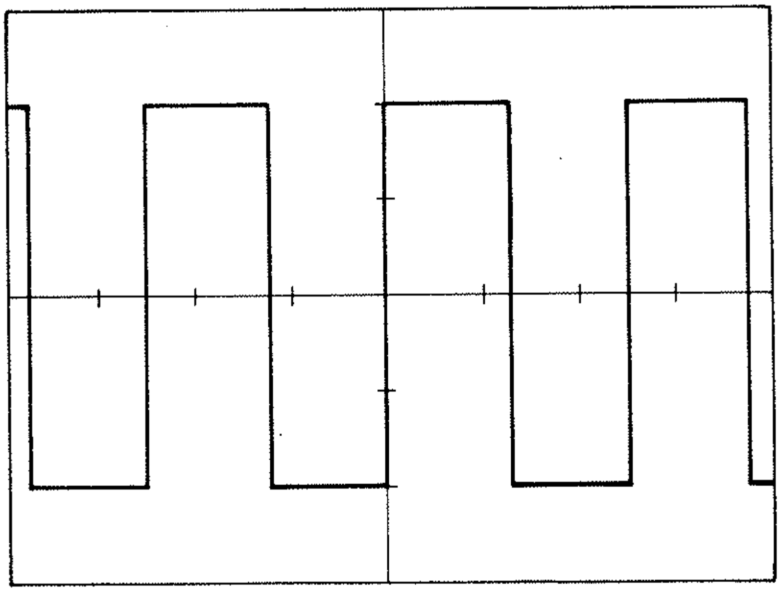
Figure 1.



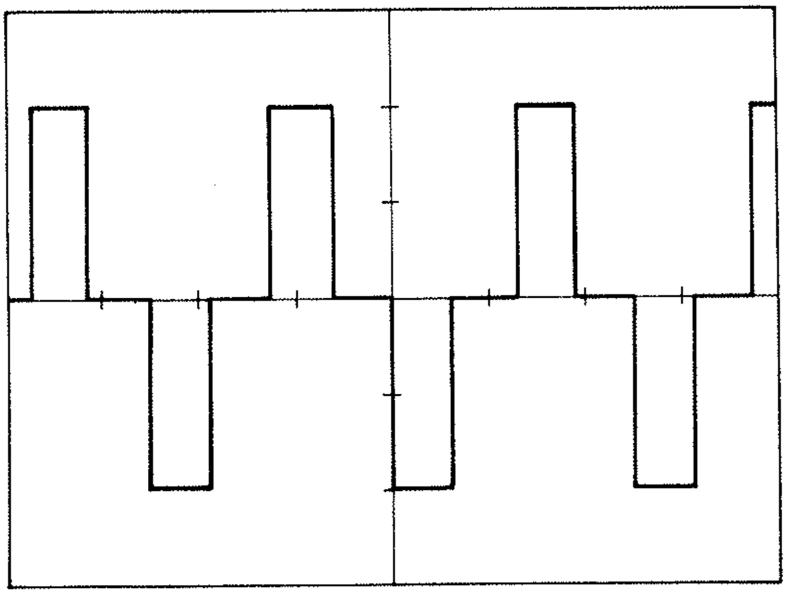


Output voltage and current curves for safe operation of the GGT-25 transmitter.

Figure 1.



8 Hz Frequency Domain 100 Volts /div 50 msec /div



8 Hz Time Domain 100 Volts /div 50 msec /div

50% duty cycle

Figure 2

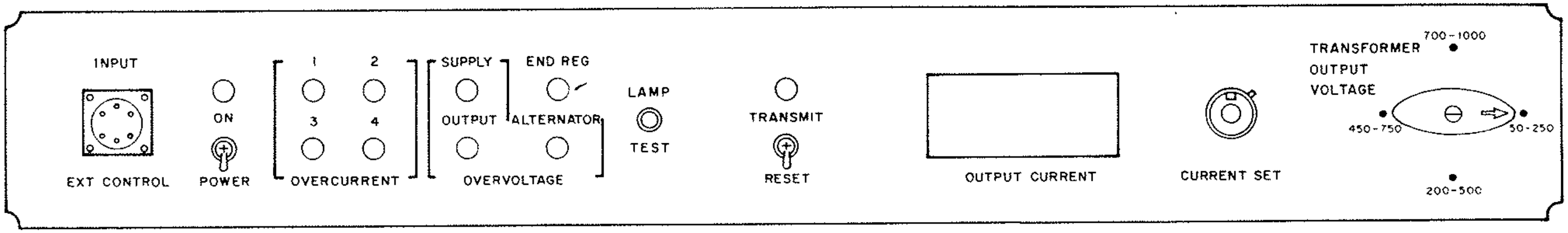


Figure 3.
GGT - 25 Front Panel

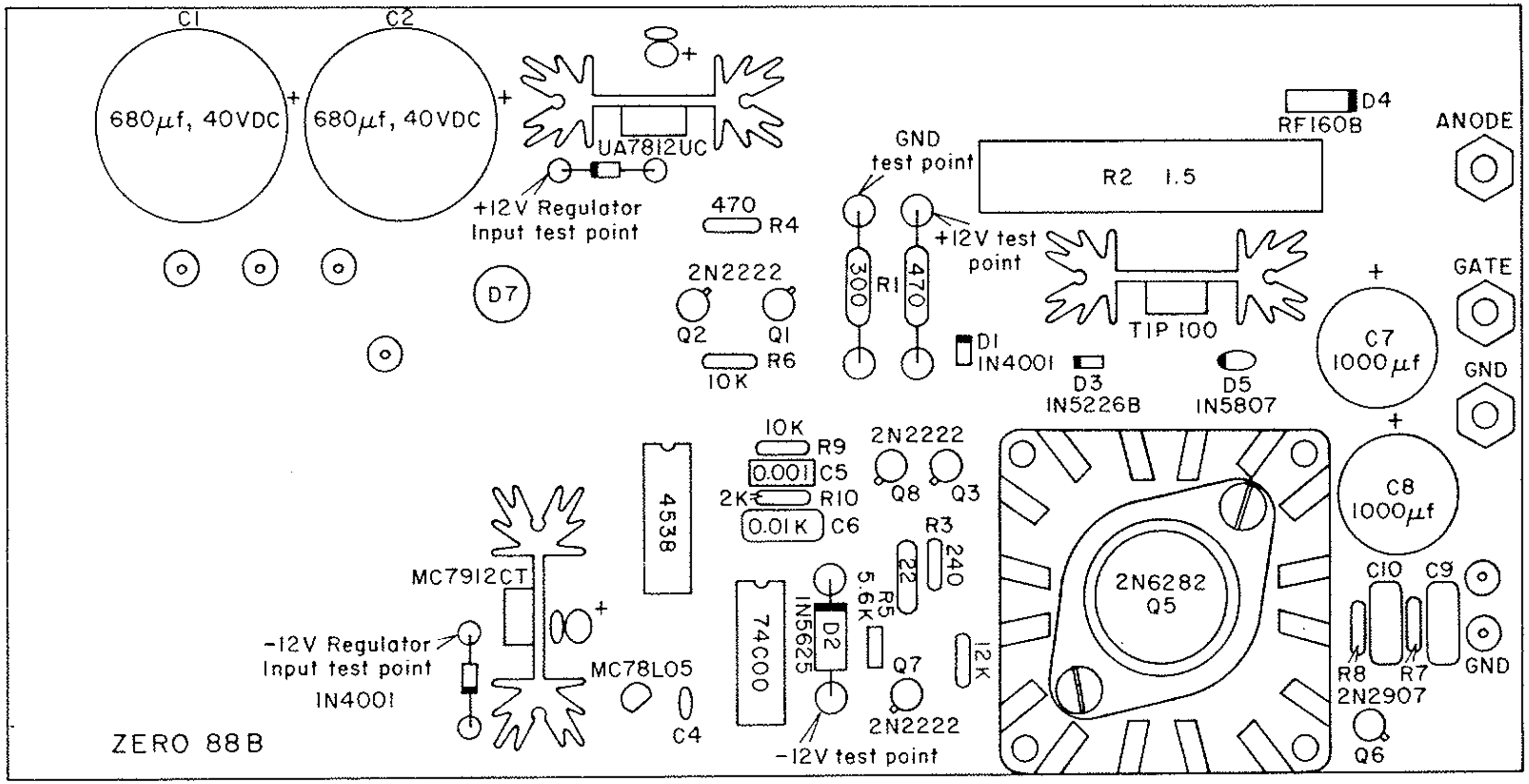
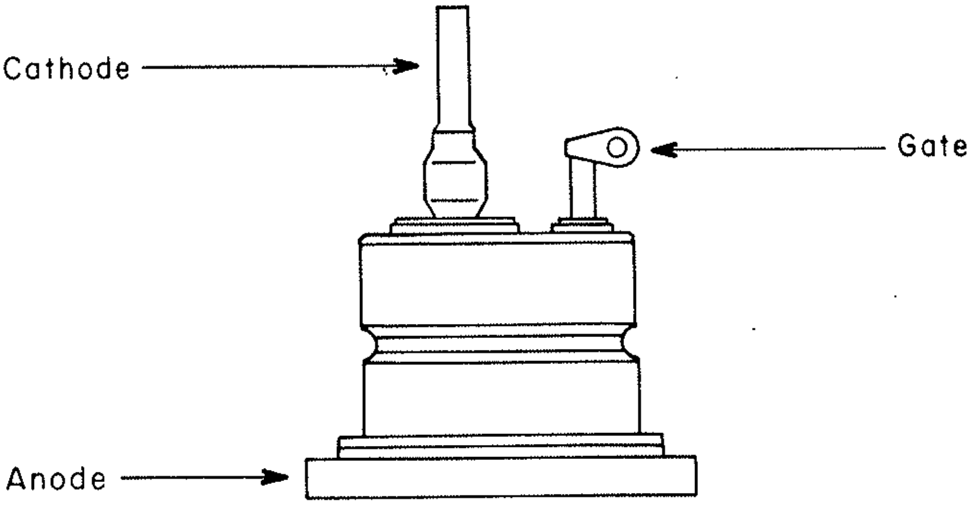
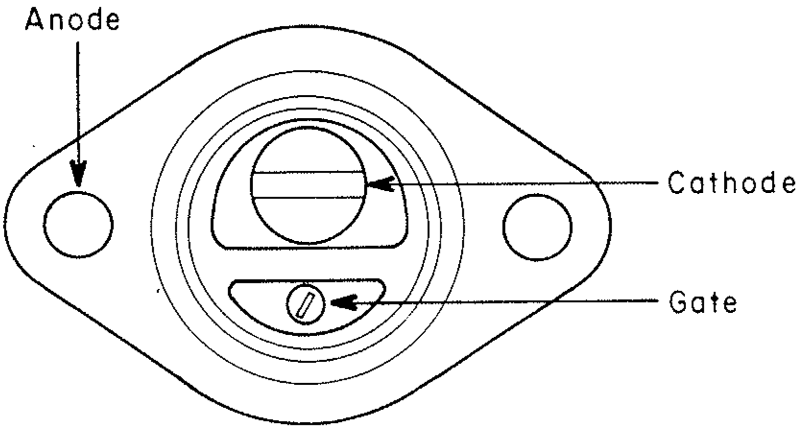


Figure 4.
Board 88



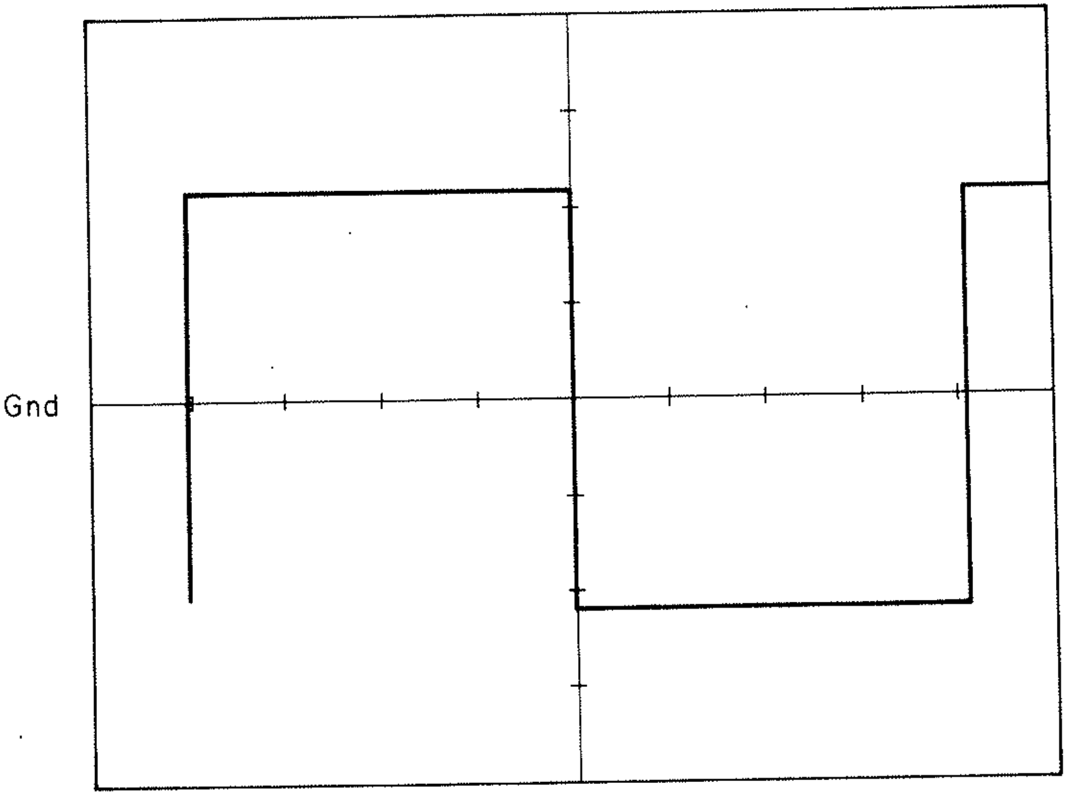
Side View



Top View

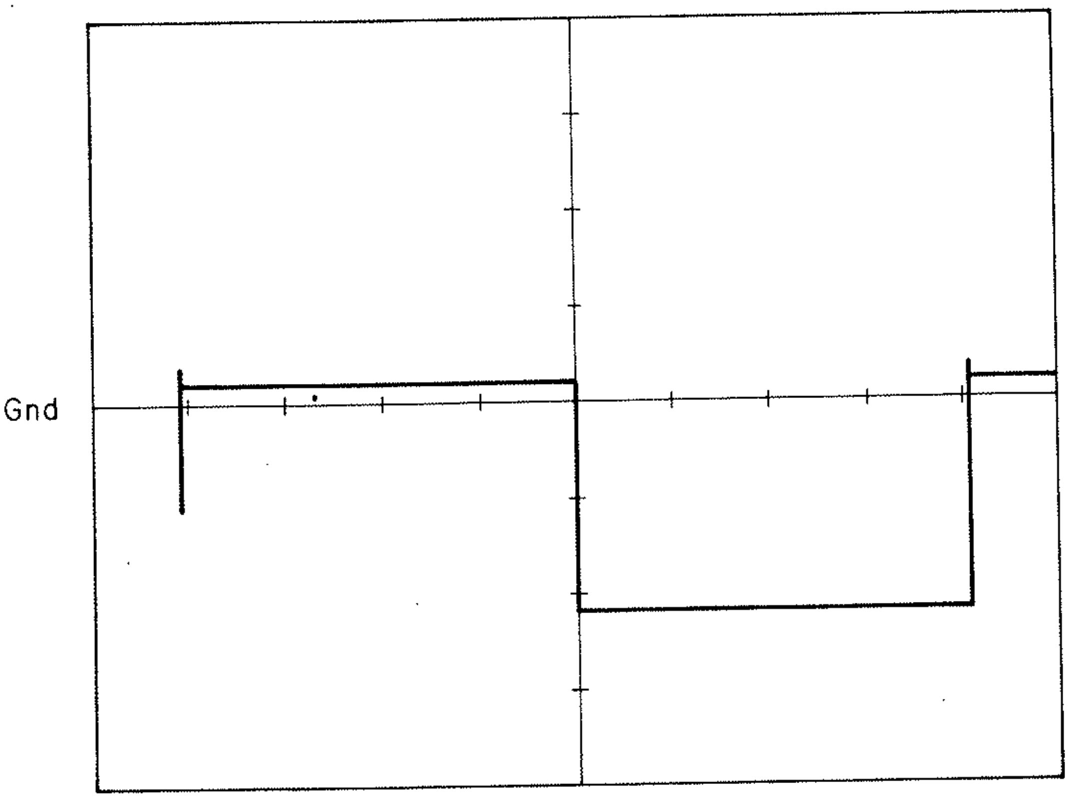
GTO GFF 90B12

Figure 5.



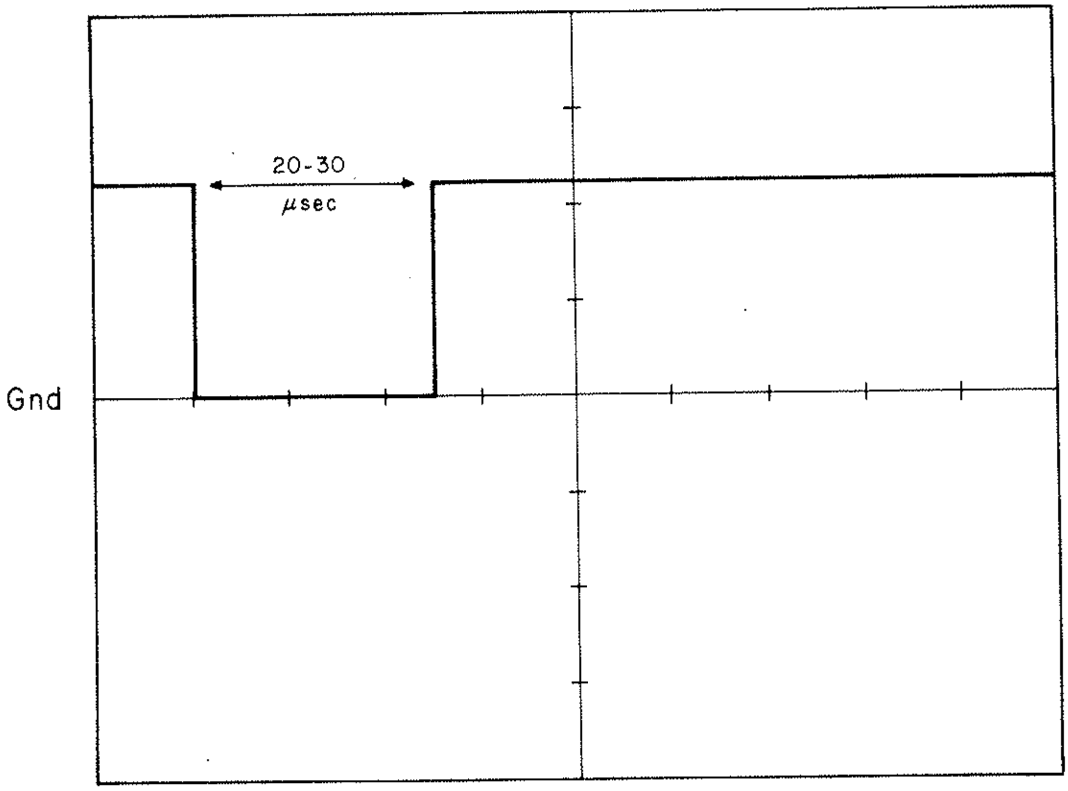
5 Volts / div 0.5 msec / div

Figure 6



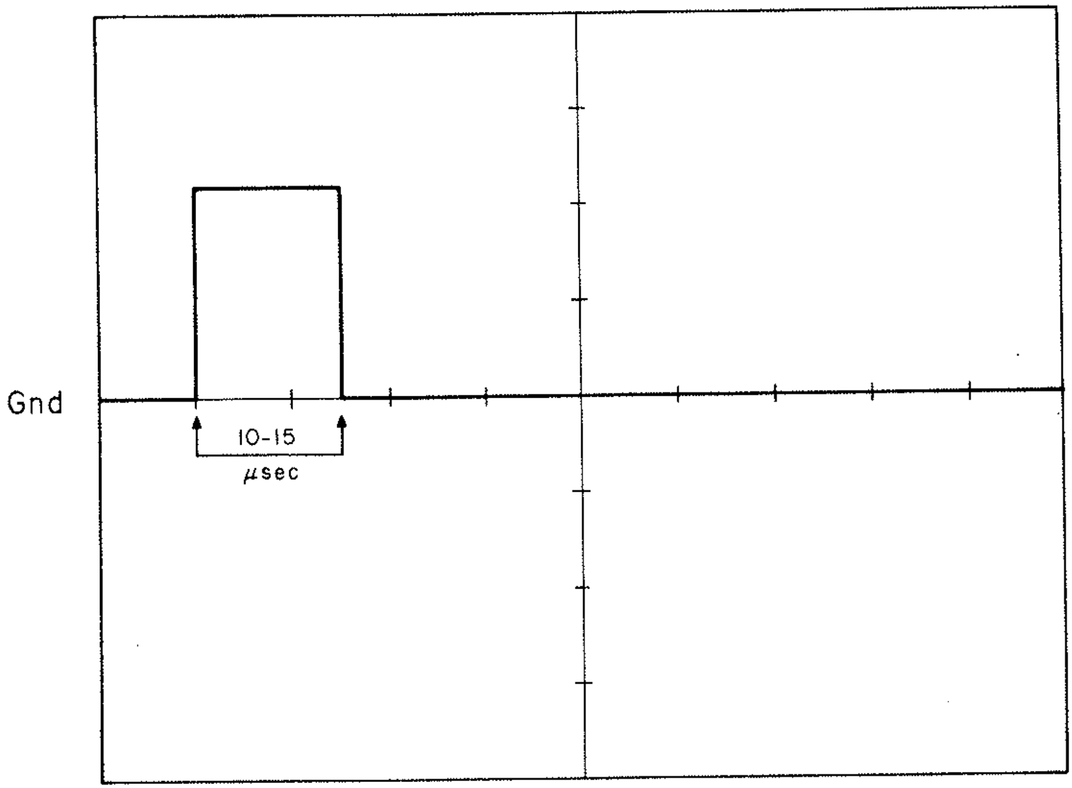
5 Volts / div 0.5 msec / div

Figure 7



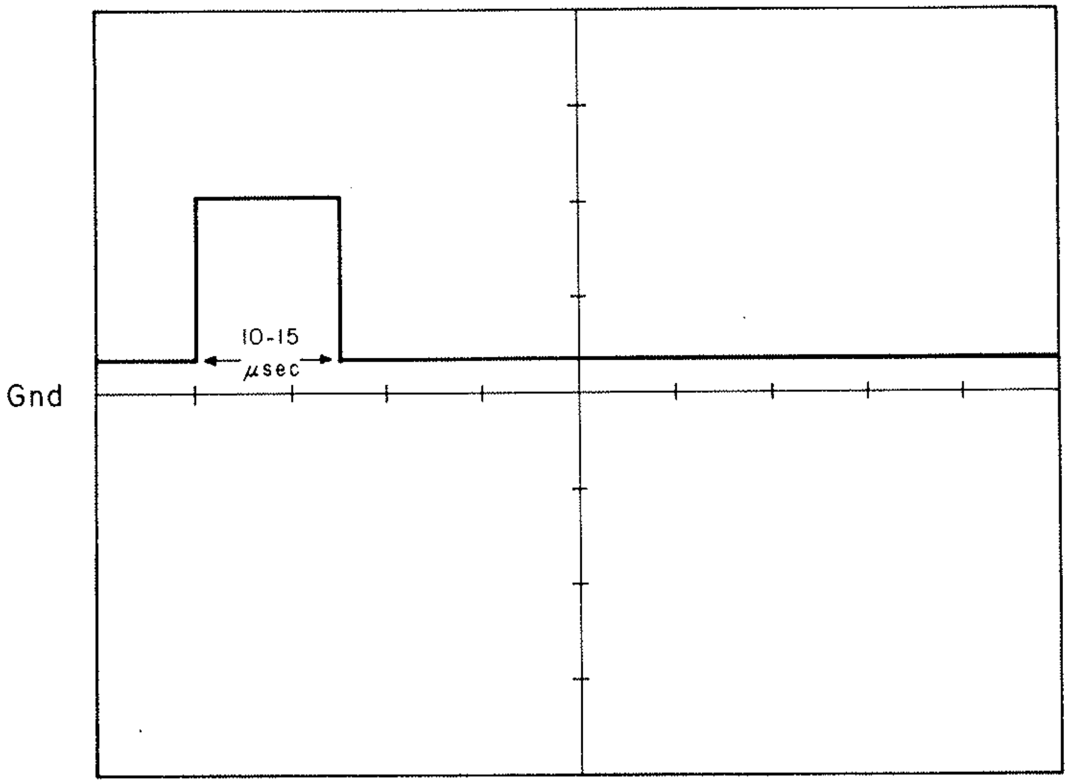
5 Volts / div 10 μsec / div

Figure 8a.



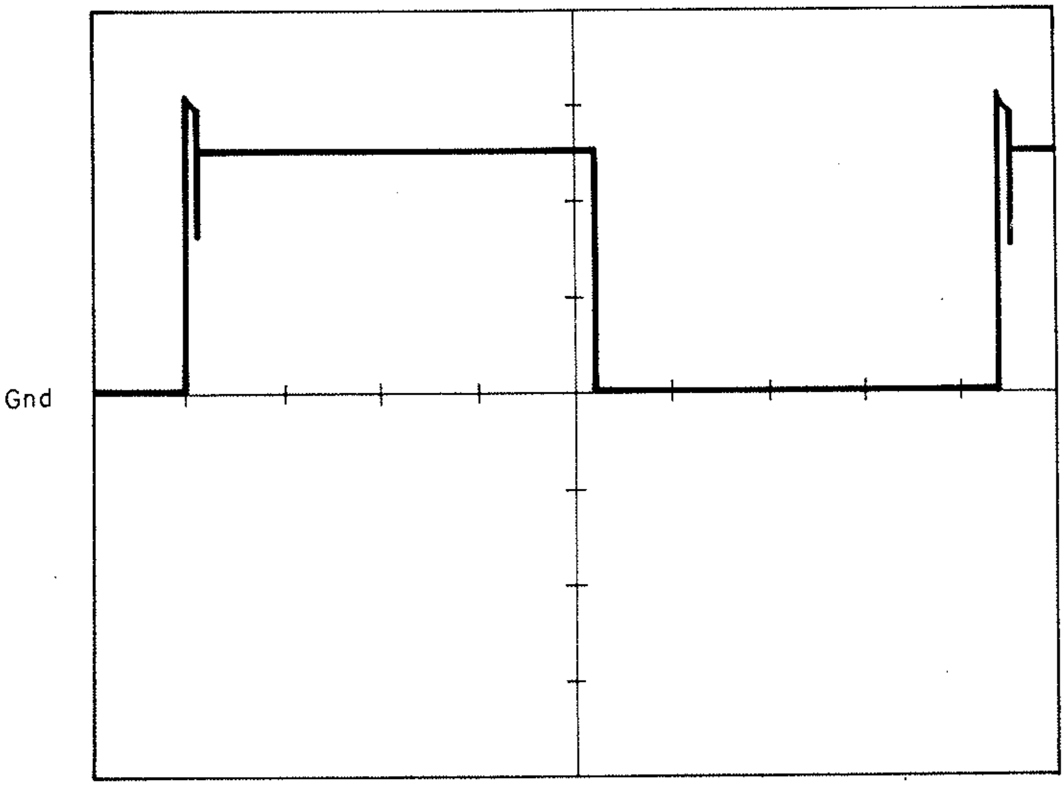
5 Volts / div 10 μsec / div

Figure 8b.



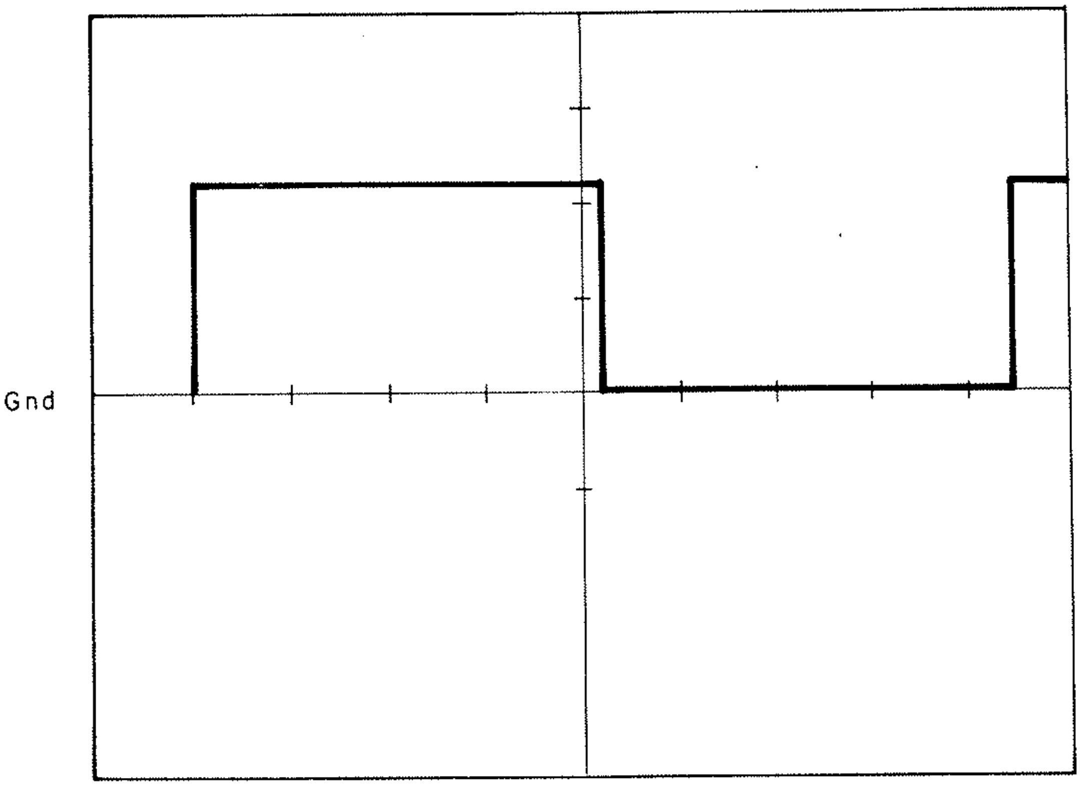
5 Volts / div 10 μsec/div

Figure 9a.



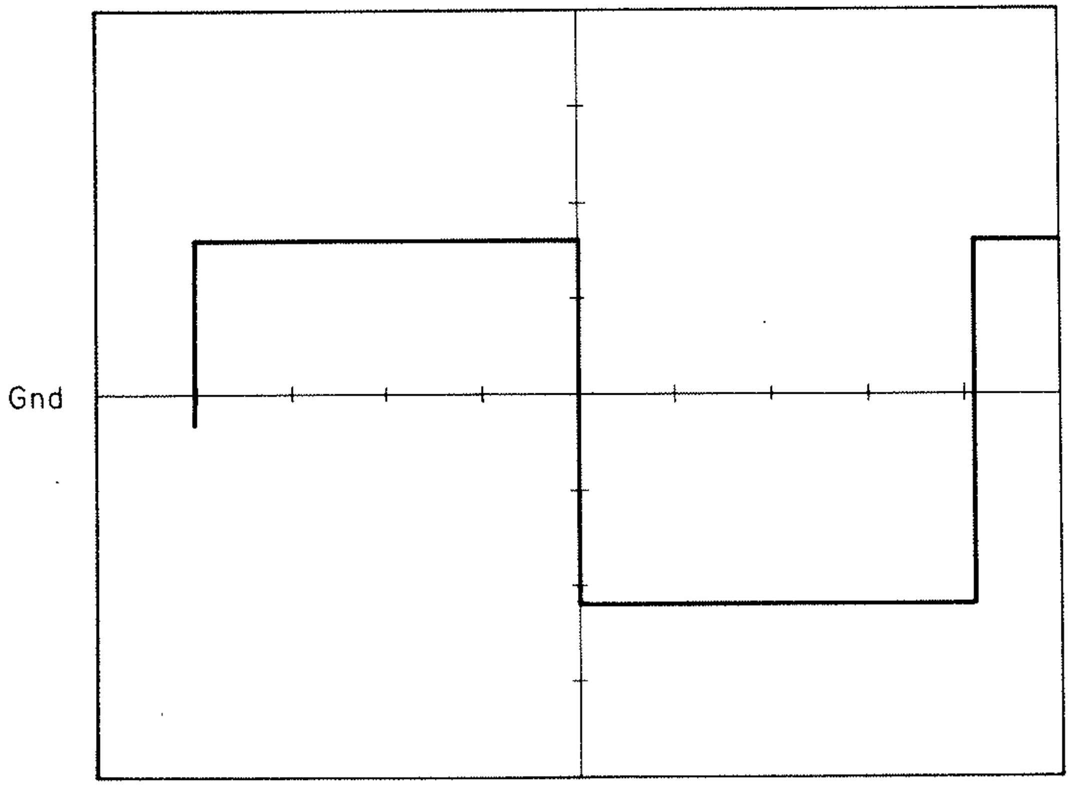
0.5 Volts / div 0.5 msec / div

Figure 9b.



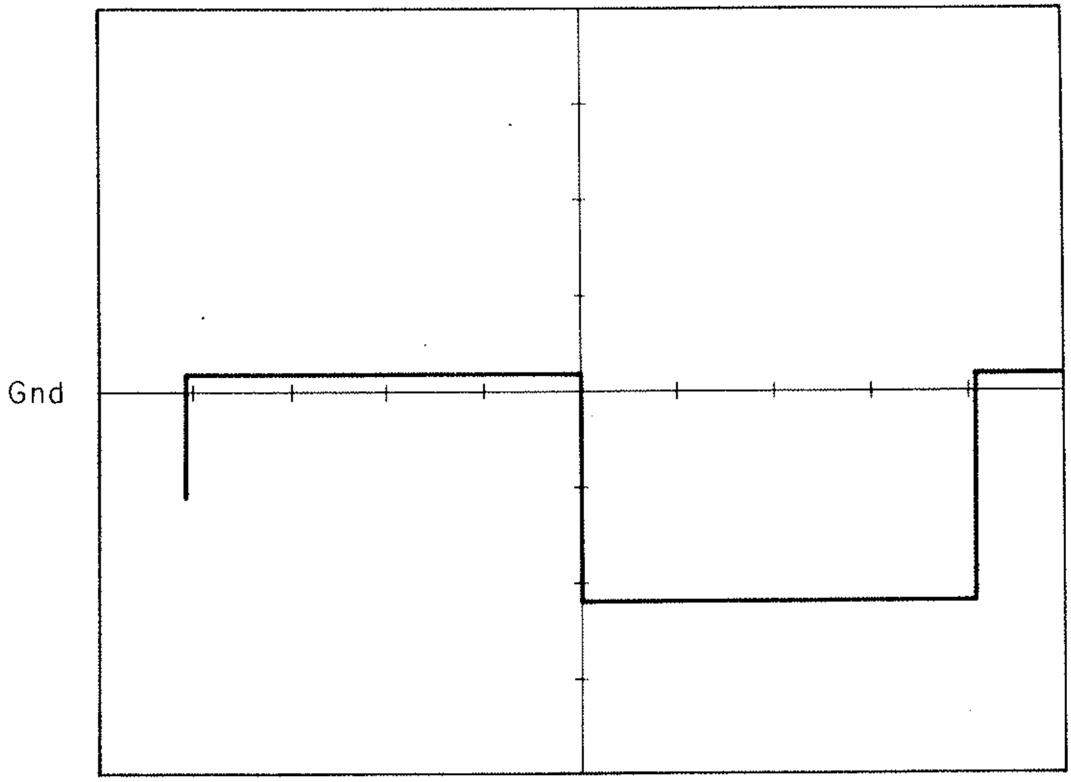
10 Volts /div 0.5 msec /div

Figure 10.



5 Volts / div 0.5 msec / div

Figure 11a.



5 Volts / div 0.5 msec / div

Figure 11b.

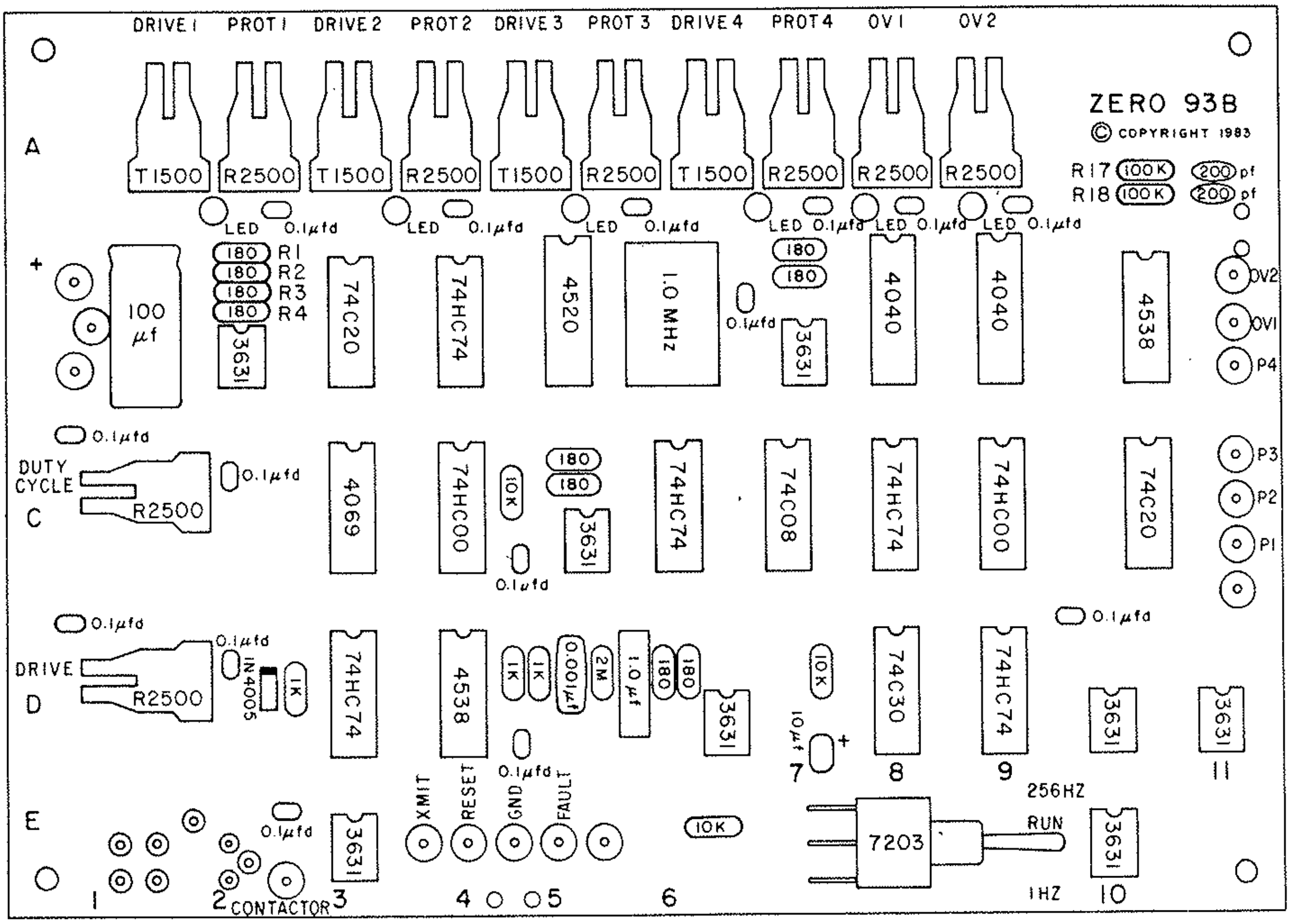
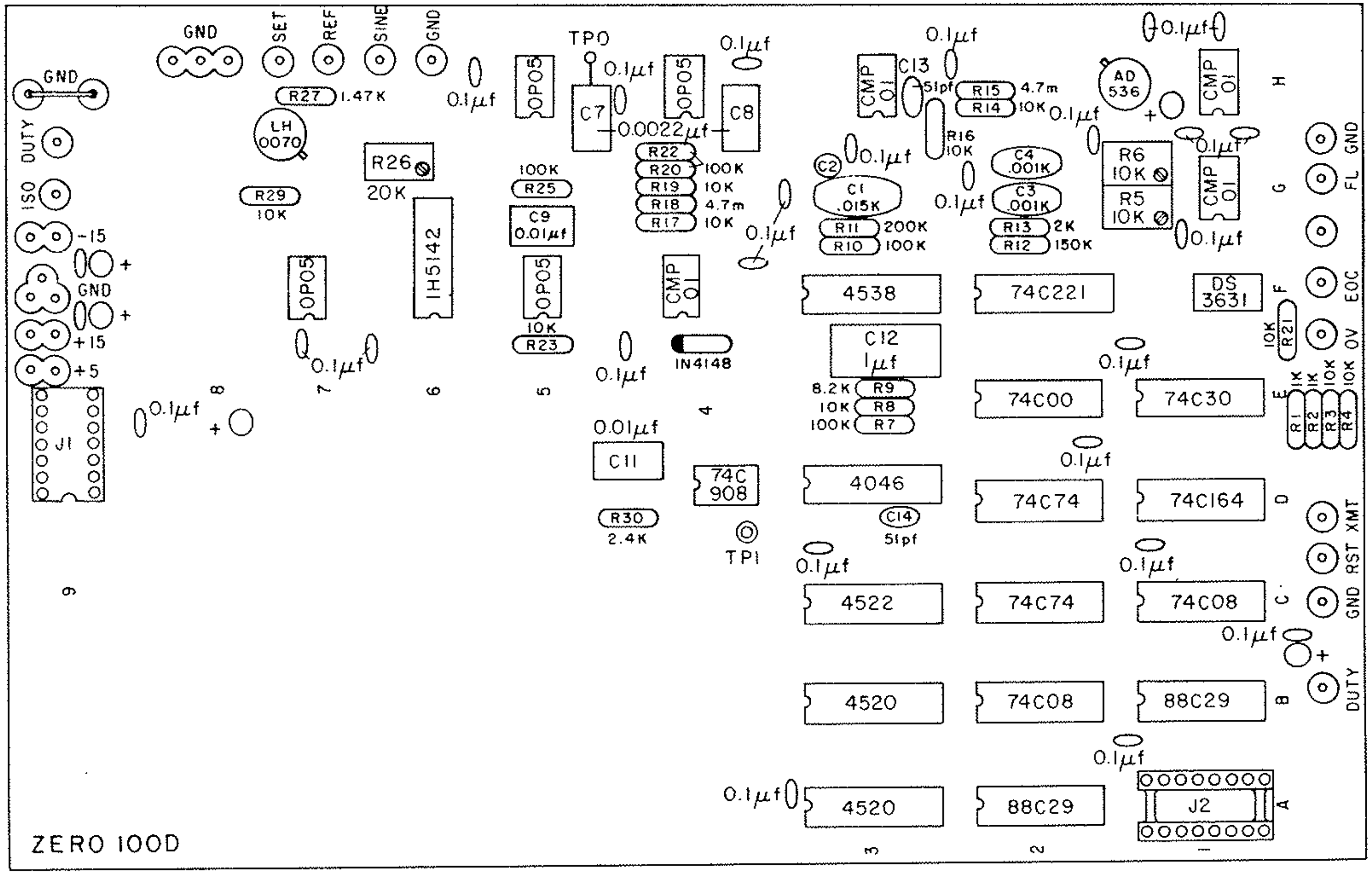
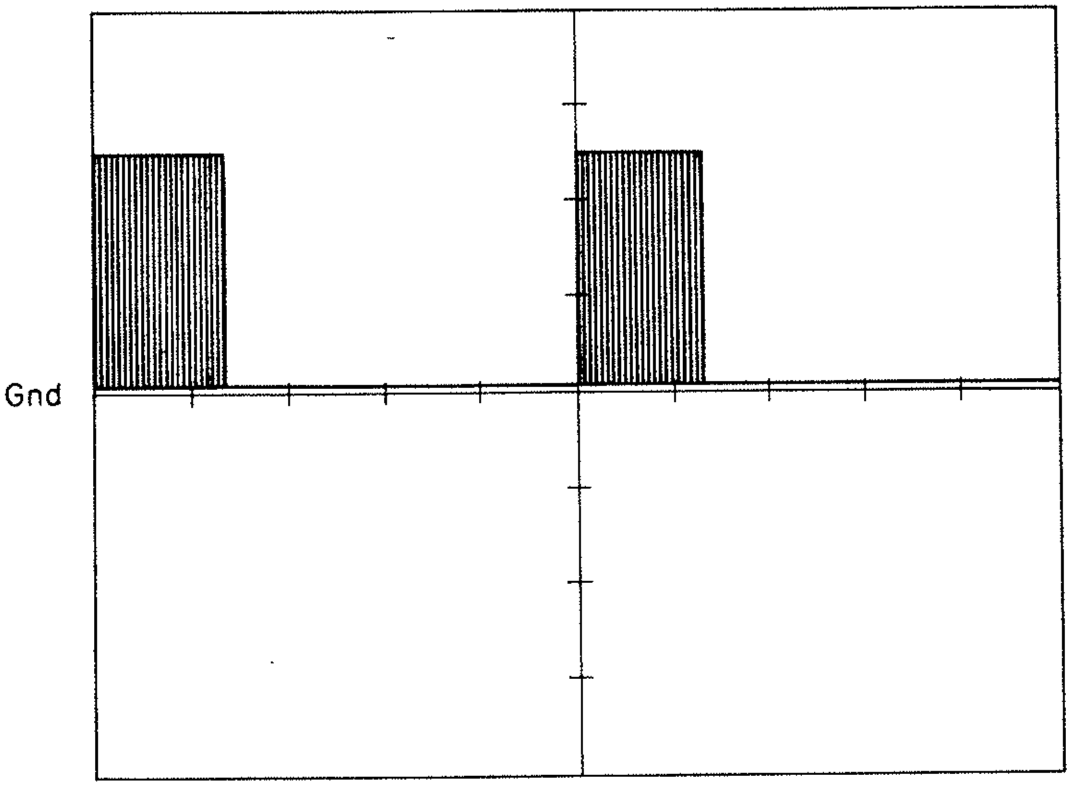

DRIVE 1
PROT 1
DRIVE 2
PROT 2
DRIVE 3
PROT 3
DRIVE 4
PROT 4
OV 1
OV 2
ZERO 93B
© COPYRIGHT 1983
A
T1500
R2500
T1500
R2500
T1500
R2500
T1500
R2500
R2500
R2500
R17 100K 200 pf
R18 100K 200 pf
LED 0.1μfd
LED 0.1μfd
LED 0.1μfd
LED 0.1μfd
LED 0.1μfd
LED 0.1μfd
+
100 μf
180 R1
180 R2
180 R3
180 R4
3631
74C20
74HC74
4520
1.0 MHZ
0.1μfd
180
180
3631
4040
4040
4538
OV2
OV1
P4
0.1μfd
DUTY CYCLE
C
R2500
0.1μfd
4069
74HC00
10K
0.1μfd
180
180
3631
74HC74
74C08
74HC74
74HC00
74C20
P3
P2
P1
0.1μfd
0.1μfd
DRIVE
D
R2500
0.1μfd
IN4005
1K
74HC74
4538
1K
1K
0.001μf
2M
1.0 μf
180
180
3631
10K
10μf
+
7
74C30
8
74HC74
9
3631
3631
11
0.1μfd
256HZ
RUN
1HZ
E
0.1μfd
3631
XMIT
RESET
GND
FAULT
10K
7203
3631
1
2
CONTACTOR
3
4
5
6
10

Figure 12.



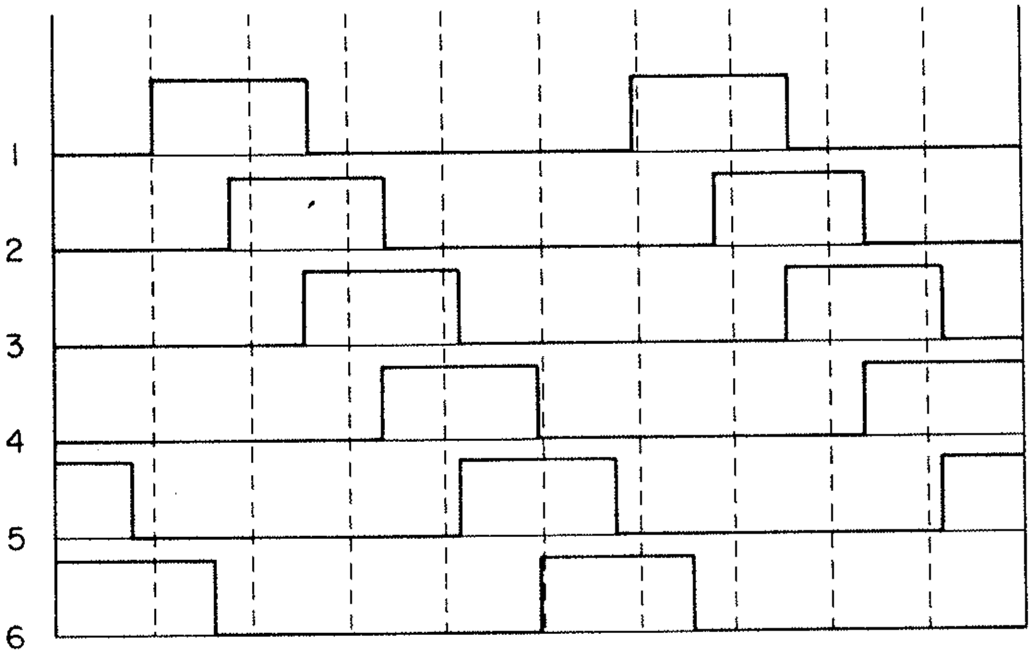
PHASE CONTROL
GGT-6, GGT-25

Figure 13.



2 Volts/div 0.5 msec/div
SCR Driver Waveform 38.4 KHz Burst

Figure 14.



0.5 msec/div
SCR Drive Waveform Sequence

Figure 15.

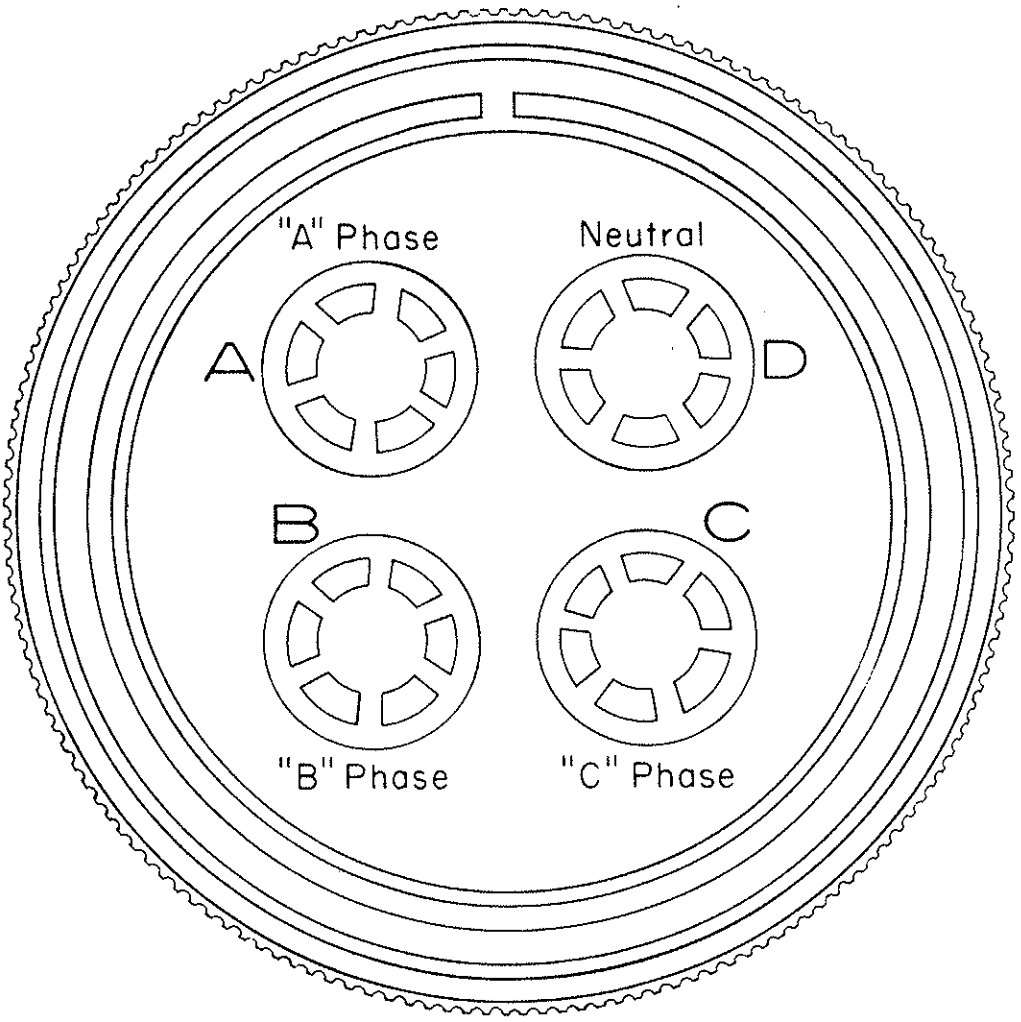


Figure A1. The military plug on the transmitter end of the power cable. Check phases here before plugging into transmitter.

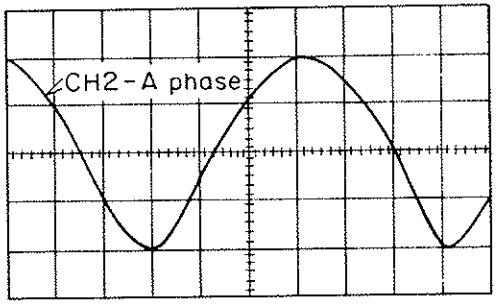


Figure A2. Adjust oscilloscope so that the A-phase waveform matches this diagram.

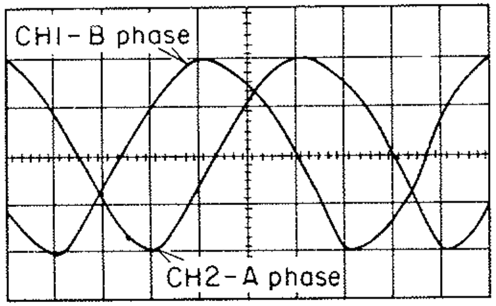


Figure A4. Incorrect phase relation for A and B phase.

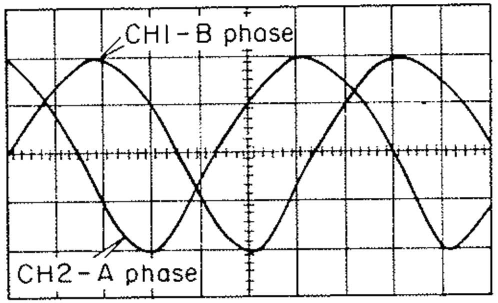


Figure A3. Correct phase relation for A and B phase.

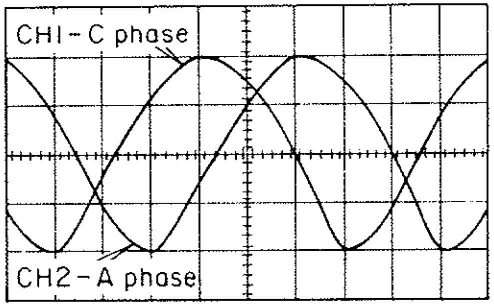


Figure A5. Correct phase relation for A and C phase.

Turn on with contactor disconnected.

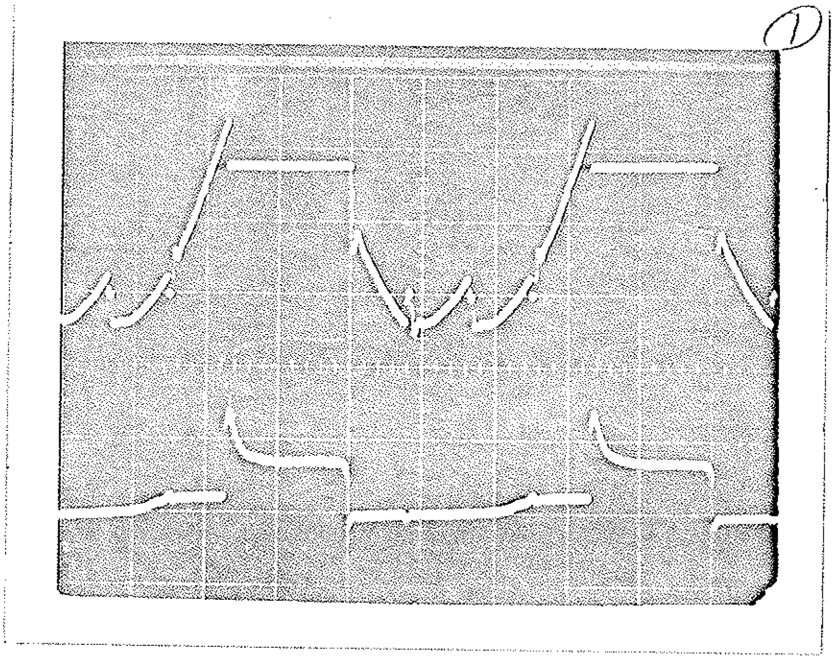


Figure 16: Voltage across SCR and Gate Drive.
Time: 0.5 ms/div; Scale: Top 20 V/div, Bottom 1 V/div
Ground hooked to A-phase on range switch
Top Trace: H.V. Probe on negative side of control bridge
Bottom Trace: Gate lead of SCR2 on Module A
Output: 400 V, 8 A

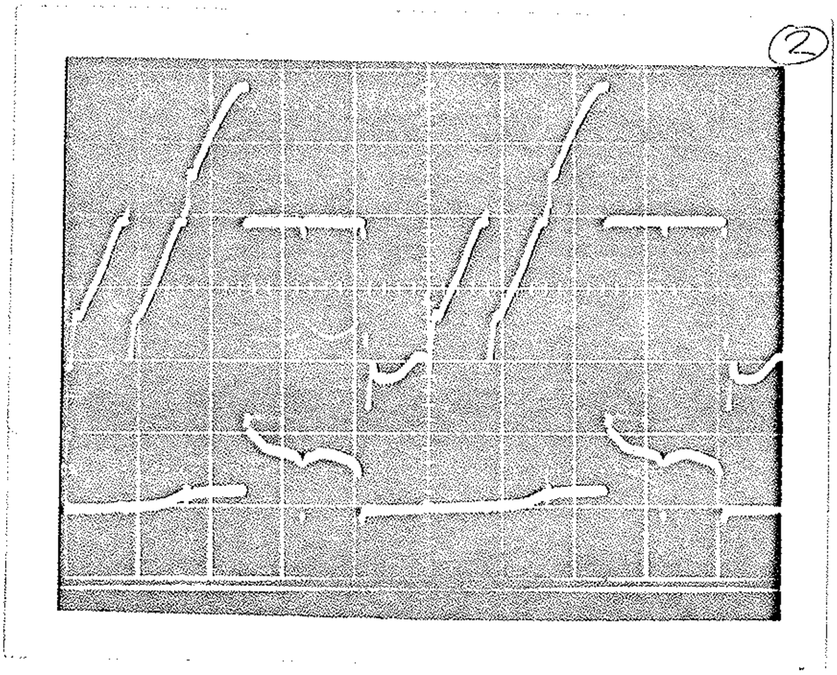


Figure 17: Same as Figure 1, except output = 150V, 2.7 A

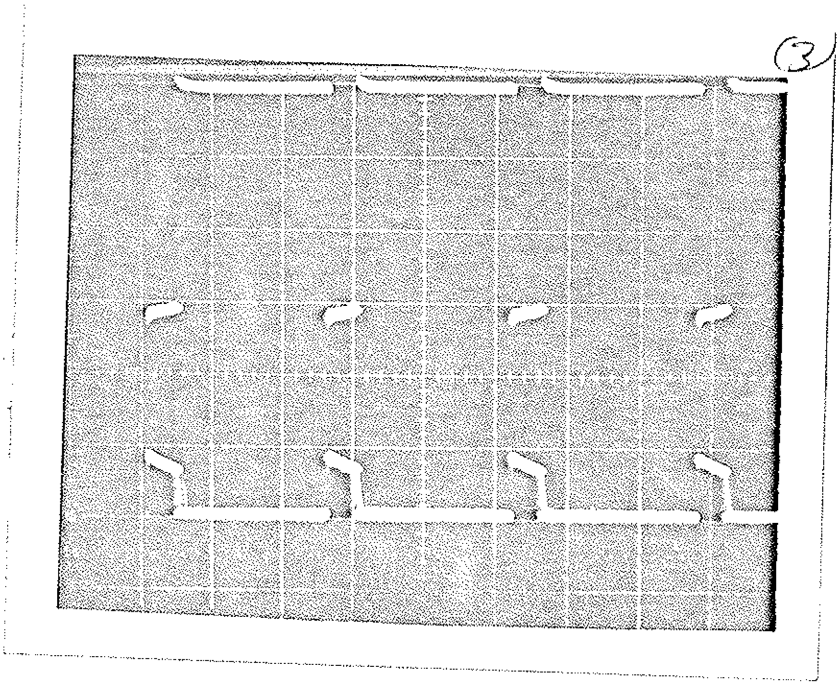


Figure 18: Normal Gate Drive Pulse for Semikron
Top: Input voltage across pulse transformer 5 V/div, 10 μs/div.
Bottom: Output voltage across pulse transformer 5 V/div, 10 μs/div.

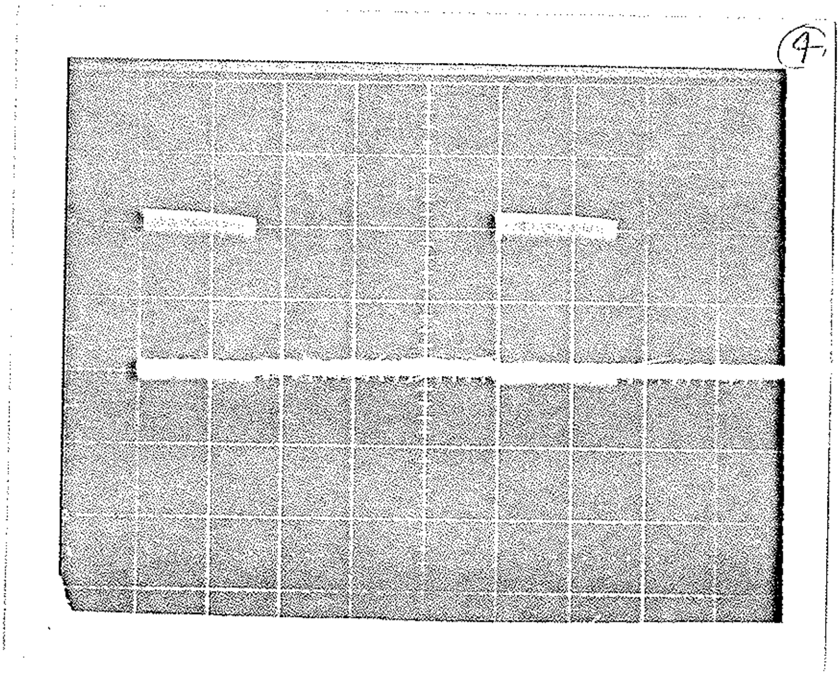


Figure 19: Gate current - across 10 ohm resistor
Scale: 2 V/div, 0.5 ms.

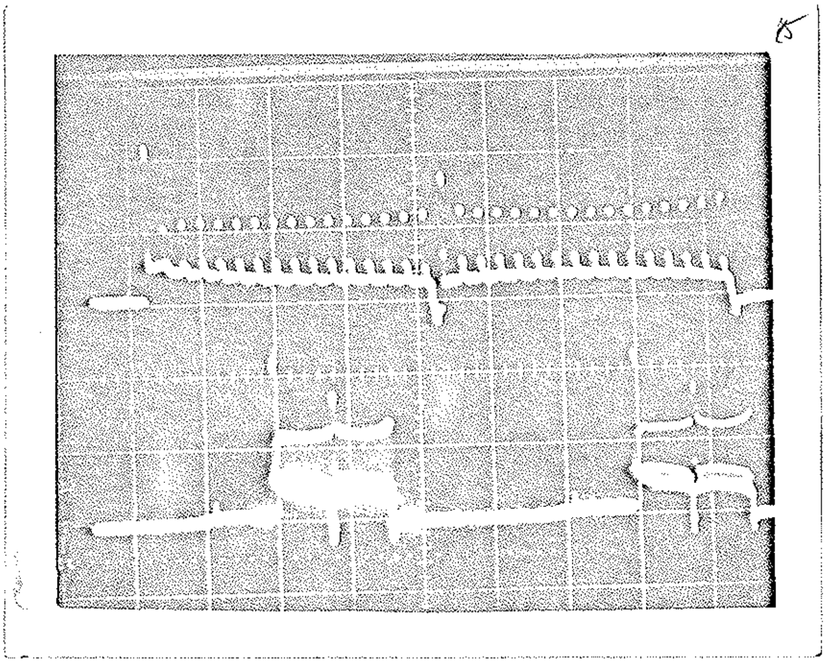
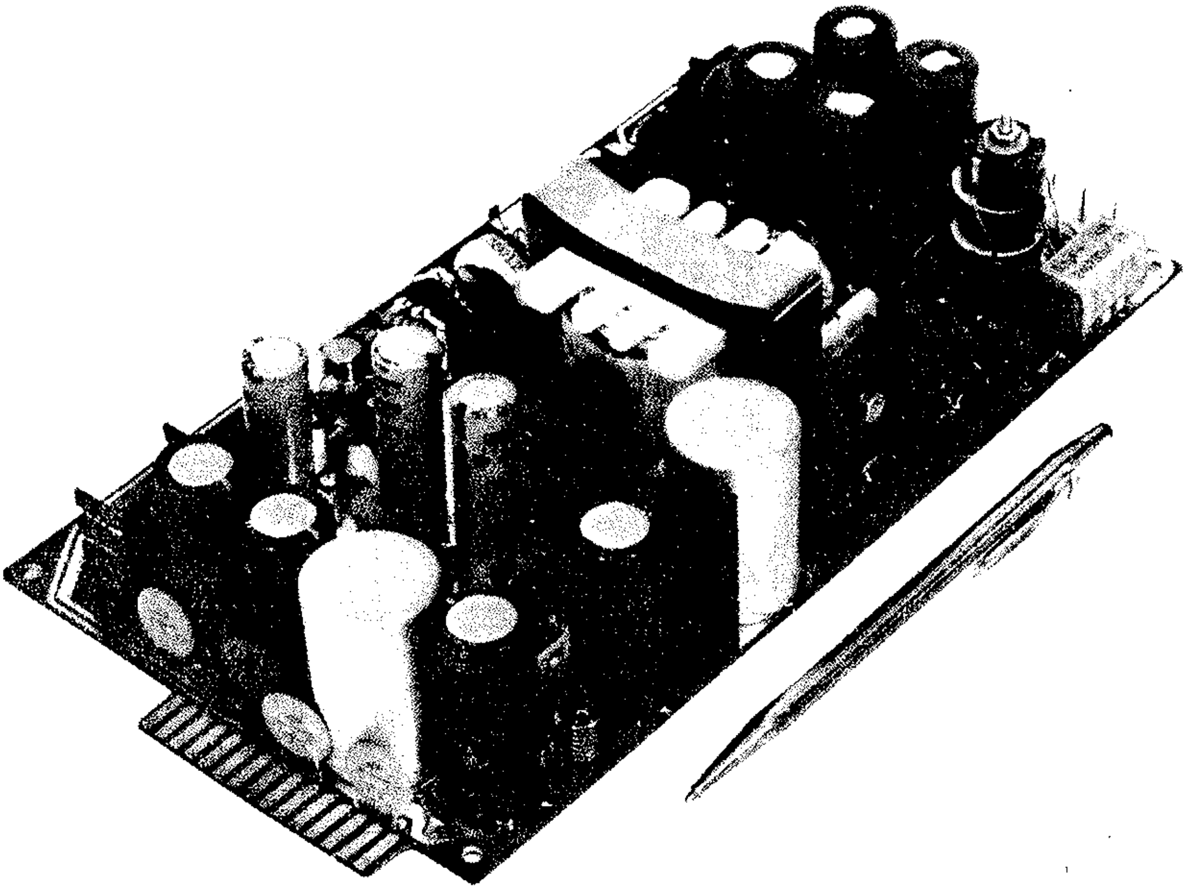


Figure 20: Gate Drive

Top: Expanded view, 0.1 ms/div
Bottom: Gate voltage under load, 0.5 ms/div
Scale: 2 V/div

20

MODEL AC-65
Five Output—65 Watt
Switch-Mode Power Supply



The Conver Model AC-65 power supply has output voltage of ± 5 V, ± 12 V (or ± 15 V) and + 24 V and a maximum continuous power rating of 65 Watts. The input voltage is user selectable from 80 to 140 VAC to 160-264 VAC. The unit is designed to meet UL478, CSA22.2 #154 and VDE 0804 and 0730. It is mechanically interchangeable with and meets or exceeds all specifications of the Boschert, Inc. OL-65.

CONVER Corporation

10631 Bandley Drive • Cupertino, CA 95014 • (408) 255-0151

FEATURES OF AC-65 SERIES

Accepts all worldwide operating voltages +10% -20%
All outputs short-circuit protected (Note 12)
Input-Output isolation
  4000 VAC RMS
  10 meg ohms
Input Transient Protection
  5 joules at up to 5000 V and 250 A
Input Leakage Current - 0.3 mA worst case
Meets VDE N-12 conducted noise limit
Overvoltage Protection (Note 13)

OUTPUT VOLTAGES AND MAXIMUM RATED LOADS (Note 9)

Model AC 65-3020	Model AC 65-3032
+5.0 V — 6.0 A	+5.0 V — 6.0 A
−5.0 V — 0.5 A	−5.0 V — 0.5 A
+12 V — 2.5* A	+15 V — 2.5* A
−12 V — 1.5 A	−15 V — 1.5 A
+24 V — 1.5 A	+24 V — 1.5 A

Maximum Continuous Output Power — 65 W
Note 10

ELECTRICAL CHARACTERISTICS

Parameter	Conditions	Limits
Centering (Initial Setting) Note 1	**+5 V output (adjustable)** All outputs at 50% max. rated load	4.5 V min. To OVP Trip Point
	Any other output All outputs at 50% max. rated load, +5 V adjusted to 5.00 V	±5% max.
Load Regulation Note 2	**+5 V output** 60% ± 40% max. rated load change	±1% max
	R_{out} ohms	.002 typ
	−5 V output 60% ± 40% max. rated load change	±1% max.
	R_{out} ohms	0.1 typ.
	±12 V (or ±15 V) outputs 60% ± 40% max. rated load change	±3% max.
	R_{out} ohms	0.7 typ.
Cross Regulation Note 3	**+5 V output** Change any output from 75% ±25% max. rated load	±0.5% max.
	Any other output Change +5 V output from 75% ±25% max. rated load	±2.5% max.
	Change some other (not +5 V) output from 75% ±25% max. rated load	±0.5% max.
Input Line Regulation Note 4	**All outputs** 80 VAC $\leq V_{in} \leq$ 140 VAC	±0.2% max.
	160 VAC $\leq V_{in} \leq$ 264 VAC	±0.2% max.
Noise and Ripple (P.A.R.D.)	**Any output** Peak to Peak	2% max.
	RMS	40 mV max.
Input Voltage		80 VAC to 140 VAC 160 VAC to 264 VAC User Selectable
Input Surge Current Note 5	Cold start, peak current	10 A
Input Frequency Range		47 Hz to 440 Hz
Efficiency Note 6	At maximum continous output power, nominal line input	65% typ.

*All specifications apply for a max. +12 V (or +15 V) current of 1.5 A. At 2.5 A max. current, the load reg. goes to ±4% max.

ELECTRICAL CHARACTERISTICS (Continued)

Parameter	Conditions	Limits
Hold-up Time Note 7	Nominal input voltage, max. output power	32 mS min.
Overvoltage Protection Threshold Note 8	**+5 V output**	6.25 V ± 0.75 V

GENERAL SPECIFICATIONS

Parameter	Conditions	Limits
Shock and Vibration	The power supply will withstand without degradation any reasonable shock and vibration found in the normal course of storage and operation, when properly packaged, handled, and installed. This includes transportation by a commercial carrier and operation in a non-mobile mainframe.	
Ambient Temperature Range	Operating (derate 2.5%/°C above 50°C) Storage	0°C to +70°C −20°C to +85°C
Temperature Coefficients of Outputs	+5 V output Any other output	0.02%/°C typ. 0.05%/°C typ
Relative Humidity Range	Non-condensing	5% to 80%
Altitude	Operating (Note 11) Non Operating	10,000 ft. max. 30,000 ft. max.
Weight		1.7 lbs (0.77 kg)

Notes:

1. Centering is measured with 50% max. rated load on each output, and nominal line input voltage and the +5 V adjusted to 5.00 V. The +5 V output can be adjusted from 4.5 V to the point where the overvoltage protection trips (6.25 V ± 0.75 V) by means of a potentiometer on the board. All other outputs will rise and fall proportionally as the +5 V output is adjusted.
2. Load regulation is measured by varying the load only on the output being considered, from 60% by ±40% max. rated load. An effective first order approximation to the output change with load is a Thevenin equivalent voltage source. Using a know R_{out} voltage change will be:

   $V_{out}(\text{final}) = V_{out}(\text{initial}) - I_{out} \times R_{out}$
3. Cross regulation is determined by setting the measured output at 20% max. rated load and varying another output from 75% max. rated load through a ±25% load change. All other outputs set at 20% max. rated load. The effects of load and cross regulation are not generally cumulative, but may act to cancel each other.
4. Line regulation is measured at full rated output power, varying the input voltage over its full range and measuring the effect on any output.
5. Double these figures for 240 V operation.

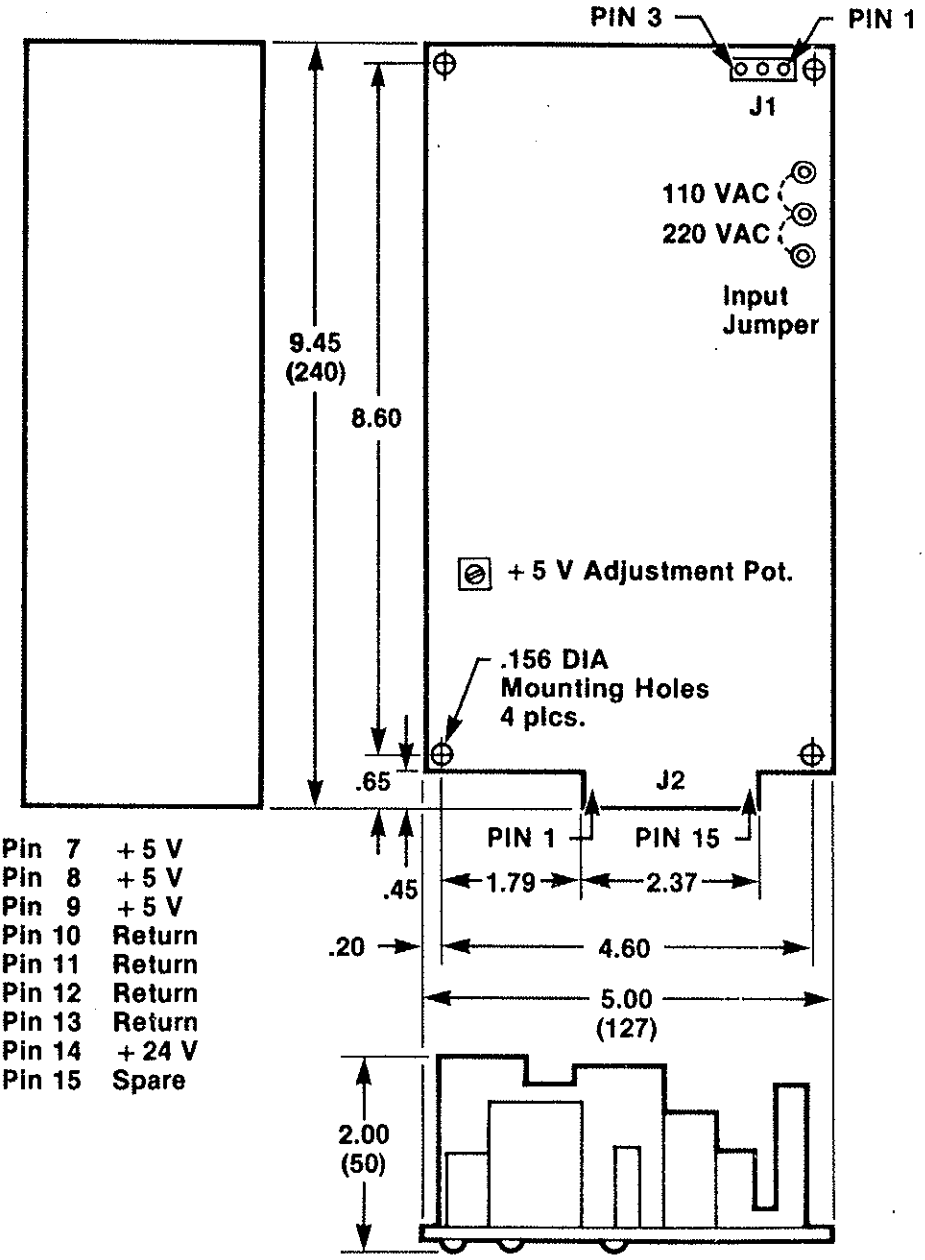
6 ±5% depending on which outputs are loaded.

7. Some supplies can be modified for longer hold-up time. For this custom option, consult the factory.
8. Overvoltage protection is standard on all +5 V outputs.
9. All outputs have a common return. Separate returns available on a custom basis.
10. Maximum current cannot be drawn from all outputs simultaneously. At no time should the average power (excluding transients) exceed the maximum continuous output power rating. Above this point, the short-circuit protection feature will begin to reduce output voltages and currents on all outputs.
11. Derate the free convection max. ambient operating temperature linearly from 50°C at sea level to 35°C at 10.000 ft.
12. Short-circuit protection, except for the -5.0 V output, is accomplished by shutting down the regulator when the total delivered power exceeds 75 W. The supply will try to restart approximately every one-half second until the overload condition is removed The average input power during this overload condition is a safe 5.0 W. Each output, except -5.0 V, can handle the full overload power without damage.

    The -5.0 V output is regulated with a three terminal IC regulator which has thermal overload protection. This results in a current limit of approximately l.4 A at 40°C.
13. The +5.0 V output has a overvoltage protection (OVP) circuit which fires an SCR across the output. This causes the supply to go into current limit mode and shuts down all outputs (see Note 12). The unit will automatically recover from the OVP condition upon removal of the cause. The only time where any of the output voltages can go significantly above design value is in the unlikely event of a failure of the OVP circuit and the regulator loop. This affords an unusual level of protection from a power supply failure.

Note! The +5 V adjustment can put the supply into the OVP condition.

Model AC-65
Physical Specifications



J1

Pin 1	AC Input
Pin 2	Chassis
Pin 3	AC Input

J2

Pin 1	Spare
Pin 2	− 5 V
Pin 3	Spare
Pin 4	− 12 V (− 15 V)
Pin 5	+ 12 V (+ 15 V)
Pin 6	+ 5 V
Pin 7	+ 5 V
Pin 8	+ 5 V
Pin 9	+ 5 V
Pin 10	Return
Pin 11	Return
Pin 12	Return
Pin 13	Return
Pin 14	+ 24 V
Pin 15	Spare

Connector

J1	J2 (Mating)
Amp, Inc.	Amp, Inc.
Part No. 2-87025-3 (Housing)	Part No. 1-640136-5 (Housing)
Part No. 87027-1 (Pins)	Part No. 350011-3 (Pins)

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1 INTRODUCTION

This manual is intended to provide the information necessary to operate the GGT-25 and keep it in proper operating condition. It also provides the information necessary to repair the most common transmitter problems.

Section 2 deals with the specifications for the GGT-25 and presents curves for safe areas of operation. These curves should be observed at all times since operation outside these areas causes immediate component damage.

Section 3 deals with the instructions and procedures needed to operate the GGT-25 in the field.

Section 4 covers the theory of operation of the GGT-25 and contains valuable information should troubleshooting become necessary.

Section 5 covers information necessary to troubleshoot the GGT-25 properly in the field. The troubleshooting and repair steps given cover those which are possible in the field. The intent of this guide is to provide the operator with a set of explicit instructions for testing the major features of each board so that the operator can determine if repair in the field is possible, if specific boards or modules must be replaced, or if the GGT-25 must be returned to our service center.

2 GGT-25 SPECIFICATIONS

2.1 Electrical

Input: 120/208V 3-phase 400-cycle

All input power goes through a 3-phase contactor for power shut down,

Standby Power: 100VA

Power connector: MIL SPEC Screw type

Output Table

SN 2001 to 2014 except 2013 Control Range	SN 2013, 2015 and on Control Range	GGT-25 Current Settings
700-1000V	650-1000V	.2-25 amp
500- 800V	400- 750V	.2-33 amp
300- 600V	150- 500V	.2-43 amp
100- 400V	50- 250V	.2-43 amp

For DC to 10 KHz output frequency, using time or frequency domain and pulse EM wave form. Refer to Figure 1 for safe range operating curves.

2.2 Mechanical

GGT-25

Weight: 265 lbs. (120 kg)

Case: L30xW18xH17-1/2 inches (76.2x45.7x44.5 cm)

Case Construction: All aluminum, with four side panels and a lid panel, removable for easy troubleshooting and component replacement. All high voltage components are physically isolated from the low voltage components and wiring. All heat sinks are remountable and replaceable as modules.

2.3 Electronics

Solid state electronics are incorporated for control and protection circuits. There are separate gate drive cards for each output device with protection sensing. All drive modules for the output switch are interchangeable.

Overcurrent sense and shut down is present at each output device. All connections between the high voltage section and control section are isolated by fiber optic links, isolation transformers, and industrial grade isolation amplifiers.

2.4 Front Panel Controls

Meters: Digital LCD and Analog

Input Voltage Meters (Analog):	0 to 150 volts
Output Voltage (Analog):	0 to 1000 volts
Output Current (Digital):	0 to 199.9 amps

2.5 Controls

Power on/off, transmit/reset. The main AC contactor will open for fault conditions, isolating the equipment in case of an emergency. When going to transmit, the contactor closes, and power will ramp up to preset level; automatic shut down will occur if various limits are exceeded.

Voltage taps: 1000, 750, 500, and 250. These are chosen for best efficiency for ground loading; output current is adjustable from .2 to 100 percent of full scale. See output table, section 2.1

Current range is adjusted with a 10-turn potentiometer, and compensated for temperature drift.

2.6 External Control

Frequency and duty cycle are controlled by an external controller. A simple 20 ma current loop is used to control the logic. It is isolated from the rest of the system by a fiber optic link connecting the input plug to the control board.

The controller manufactured by Zonge Engineering is capable of time or frequency domain operation. In time domain, duty cycles of 12.5%, 25%, and 50% may be selected; in frequency domain, any 16 consecutive, binary-interval frequencies in the range of 1/1024 Hz to 10 KHz may be selected. The controller is isolated from the transmitter by an optical coupler link. Custom controller units, which will match the transmitter to most other well-known geophysical systems, can be supplied with the transmitter.

3 OPERATING INSTRUCTIONS

3.1 First Time Operation

3.1.1 Inspection

Inspect the transmitter on arrival for any damage that may have occurred during shipment. Remove the two long side panels and inspect the printed circuit cards for damage. Also check for connectors and cables that may have come loose during shipment. If any damage has occurred, it should be reported to the shipper and to Zonge Engineering immediately and corrected before operation is attempted.

3.1.2 Preparatory Set-up

Set the controls as follows:

CONTROL POWER	OFF
OUTPUT VOLTAGE	400 volts
CURRENT SET	0

Connect a 100 ohm resistive load (dummy load - Zonge Engineering Model #LB2500) to the red and black output jacks on the transmitter. To install wire in the output plugs which are provided, unscrew the plastic backshell and run the wire through the backshell. Strip back the insulation on the wire and install it in the brass plug and tighten the hex-headed set-screw so that the wire cannot be pulled out. Then reinstall the plastic backshell.

Connect a 3-phase power source (120/208 V-400 Hz) to the transmitter power input. (See section 3.2 for operation of the ZMG-series motor generators.) The pins on this connector are labeled A, B, C, and D. D is the neutral input. Pins A, B, and C are the A-phase, B-phase, and

C-phase respectively. C lags B by 120 degrees, and B lags A by 120 degrees. This is important for proper operation of the GGT-25. If in doubt, refer to the APPENDIX, Checking Phase Sequence - Alternator.

Connect a battery powered or line isolated oscilloscope to the CAL output jacks on the transmitter. CAUTION: FAILURE TO USE AN ISOLATED OSCILLOSCOPE CAN CAUSE A SHOCK HAZARD AND MAY DAMAGE THE OSCILLOSCOPE. Set up the oscilloscope as follows:

0.5m Sec/division
0.5 volt/division

Connect a transmitter controller (XMT-12 or GDP-12) and set the frequency to 8 Hz and frequency domain.

Hook up the ZMG-10 or ZMG-20 to the GGT-25 and turn the 120 VAC generator voltage on. Fans should be running on the ZMG alternator and GGT-25. (If uncertain as to exact procedure, see next section, "Recommended Motor-Generator Hook-up Procedure").

Turn on CONTROL POWER. The green power indicator should be on.

Toggle the TRANSMIT/RESET switch to RESET. All fault indicator lights should be off except for "END REG". If not, the transmitter has been damaged in shipment and the failure should be reported to Zonge Engineering for corrective action. To test for burned out or damaged lights, press LAMP TEST; this will cause all lamps to turn on. Replace any burned-out bulbs by unscrewing the lens and placing a new bulb in the socket. All lamps are 5 volt bulbs except for the TRANSMIT lamp, which is a 24 volt bulb.

Toggle the TRANSMIT/RESET switch to RESET and then immediately to TRANSMIT. Do not hold TRANSMIT in the TRANSMIT position. Release the switch immediately after going to TRANSMIT. Adjust the current control knob for 2 amps output current. The FREQUENCY/TIME DOMAIN switch on the transmitter controller can be toggled between either position and the oscilloscope trace should look like Figure 2.

3.1.3 If the transmitter fails to operate properly contact Zonge Engineering for possible corrective action.

3.2 Motor-Generator Hook-up Procedure (ZMG-Series)

Disconnect the MG trailer from the towing vehicle and level the unit as much as possible to permit normal oil circulation in the motor. Skid-mounted MG sets must be on level ground.

Remove the motor tarp and generator cover.

Check the oil level with the dipstick. Add oil if necessary.

Check the belt tension (belts should deflect at least 1 to 2 inches [2 to 5 cm] at the center of the belt but should not deflect over 4 inches [10 cm]).

Check all nuts, bolts and wires visually. Tighten any loose ones.

Place the voltage regulator (VR) on the ground on the generator cover. (For electrical isolation and protection of the VR.) Connect the VR to the alternator using the proper cable. Place the VR out of the way and in the shade if possible. Under the trailer is a good place; it can't be tripped over, is in the shade and will be convenient to operate. Make sure the VR is turned off.

Connect the power cable between the MG and the transmitter. Route the cable on the ground, out of standing water, and out of the way. It is not recommended procedure to leave the cable where it can be tripped over. When tightening the military-style connectors, screw the threaded sleeve until it is tight, then push and wiggle the connector to confirm the sleeve is as tight as possible. Do this with the connector on the GGT-25 as well as the connector on the MG.

Once the MG has been checked out it may be started. If the motor is cold, pull the choke out from the control panel. Turn the throttle handle 1/2 turn to the left (counter clockwise), releasing it from the nylon lock ring, and pull it out from the control panel about 1 to 2 inches (2 to 5 cm).

Turn the ON-START switch to START. The electric starter should crank the motor and it should start within 30 seconds. If it doesn't, refer to the appropriate manufacturer's literature. Once the motor has started, allow it to idle for about 5 minutes. The choke should only be needed for a few seconds unless the weather is very cold or damp.

Once the ZMG is warmed up, the engine speed can be increased to approximately 3600 RPM, and the alternator may be put into use. Refer to the VR MANUAL for complete instructions and troubleshooting procedures.

Turn the voltage regulator on and depress the START button on the voltage regulator holding it down MOMENTARILY until the alternator is working. Holding the button down too long can damage the alternator, the alternator cooling fans, the GGT cooling fans, or VR circuitry.

Confirm that the cooling fan on the alternator is running. Operation under heavy load without the cooling fan <u>will</u> damage the alternator rapidly by overheating it.

Adjust the engine speed to produce an AC frequency between 400 and 425 Hz. Adjust the VOLTAGE ADJUST for 120 v. See the VR manual for complete instructions.

3.3 <u>Description of Controls</u>

Refer to Figure 3 for the following description of controls.

3.3.1 <u>RESET/TRANSMIT</u> switch.

The RESET/TRANSMIT switch resets all of the internal circuitry in the GGT-25. The GGT-25 cannot be made to transmit until a valid RESET is given. After RESET is activated the operator has a 2 second time-out period during which a valid TRANSMIT can be given. If TRANSMIT is not activated during this 2 second period another RESET must be given. This insures proper sequencing of the internal circuitry.

3.3.2 <u>TRANSMIT</u> light.

The TRANSMIT light being on indicates that the GGT-25 is transmitting and that high voltage is present on the output. It is connected across the safety power contactor and will go off when a fault or reset occurs which opens the contactor.

3.3.3 SUPPLY OVERVOLTAGE light.

The SUPPLY OVERVOLTAGE light being on indicates that the voltage level on the supply to the output switch has exceeded the safe operating level of 1000 volts. This can be caused by driving a large capacitive load or by running with an input voltage from the alternator of more than 120 volts, while using the 1000 volt tap on the TRANSFORMER OUTPUT VOLTAGE switch.

3.3.4 OUTPUT OVERVOLTAGE light.

The OUTPUT OVERVOLTAGE light being on indicates that the voltage level on the output has exceeded 1000 volts.

3.3.5 ALTERNATOR OVERVOLTAGE light.

The ALTERNATOR OVERVOLTAGE light being on indicates that the voltage level from the alternator exceeded 130 volts or was less than 95 volts and must be adjusted into the proper range, preferably 120 volts.

3.3.6 OVERCURRENT lights.

The four OVERCURRENT lights allow the operator to determine which module detected an overcurrent situation. The detection level is 43 amps and is set at the factory. It is not adjustable. The operator should always note which module light is on when an OVERCURRENT situation occurs because this can speed troubleshooting, should it become necessary.

3.3.7 END REG. light.

The END REG. light being on indicates that the transmitter is not able to supply the amount of current desired. Either the current must be lowered or the TRANSFORMER OUTPUT VOLTAGE tap switch must be set to a higher voltage.

3.3.8 LAMP TEST switch.

The LAMP TEST switch causes all indicator lamps on the lower panel to turn on. Lamps that are burned out can be replaced by unscrewing the lens cap and installing a new lamp in the cap. All lamps are 5 volt except for the transmit lamp which is 24 volts.

3.3.9 TRANSFORMER OUTPUT VOLTAGE tap switch.

The TRANSFORMER OUTPUT VOLTAGE tap switch selects the output voltage range of the transformer and sets operation over the range described in the Output Table in section 2.1.

3.3.10 LOGIC SUPPLY circuit breaker.

The LOGIC SUPPLY circuit breaker is a push to reset circuit breaker for the logic power supply (+5, +15, -15, +24). If the button is held down during an overcurrent situation, the breaker will still open. This is a safety feature.

3.3.11 DRIVE SUPPLY circuit breaker.

The DRIVE SUPPLY circuit breaker is a push to reset circuit breaker for the four drive power supplies for the GTO drive modules.

4 THEORY OF OPERATION

4.1 Board 88

Board 88 accepts drive control signals from board 93 and uses these to control the turn-on and turn-off of the GTOs. Each board has its own transformer and power supply. This is because the ground on board 88 is connected to the cathode of the GTO and needs to be isolated during operation since the cathode, when the GTO is on, will be approximately 3 volts below the voltage being transmitted into the ground. When the GTO is off, the cathode will drop to ground potential.

Overcurrent detection is accomplished on these boards by sensing the voltage across a sense resistor. If the current exceeds an acceptable level, the fiber optic transmitter which is normally on, will turn off, causing board 93 to latch an overcurrent situation and remove drive to all GTOs.

The current which a GTO can turn off has an upper limit which is a function of peripheral circuitry, gate current, etc. It is very desirable to prevent GTO current from exceeding its limit which could occur, for example, from spurious signals which cause both GTOs to turn on simultaneously (board 93 failure), output short circuits, or overloads. Once the overcurrent level is detected, a minimum period of approximately 20 microseconds must elapse before initiating turn-off after a GTO has been turned on. This minimum delay from turn-on insures that the snubber circuit capacitors have discharged to a safe level and are able to prevent a high rate of voltage change (dv/dt) at turn-off. Also the anode current rate-of-rise must be controlled. This is accomplished by the current-limit inductor.

4.2 Board 93

There is a test switch located on this board for ease of troubleshooting. This switch must be in the RUN position for normal operation. When in a test position, this switch provides either a 1 Hz or 256 Hz drive signal.

When RESET is activated one of the 4538 ICs generates a two microsecond reset pulse which goes to all the protection latches. RESET also goes to a second 4538 which is used as a two second timer. The purpose of this circuitry is to insure that the transmitter cannot be made to transmit before a valid RESET is generated. After RESET is activated the operator has two seconds to activate TRANSMIT. If TRANSMIT is not activated within two seconds another RESET will have to be given to initiate transmitting.

When TRANSMIT is activated during the two second time-out, one half of a 74C74 latches the contactor relay driver (DS3631). A fault condition will reset the contactor latch and remove power from the transformer and drive to the GTO's.

The deadtime circuitry is set for an eight microsecond deadtime which is used to gate out overcurrent detection during switching. It is generated by a 4520, 74C74, and a 1MHz oscillator. One half of the 4520 is held in a reset state while the other half is counting. When reset on the 4520 is removed it counts eight oscillator cycles before triggering one half of the 74C74, and causes a drive signal to be generated. Loss of the oscillator prevents the drive signal from being generated.

Overcurrent is latched on this board. The fiber optic signal for overcurrent is active-low or off. This insures that the loss of a cable will protect the drive cards and prevent drive signals from being generated. Four latched indicators are included on board to help determine the exact source of the overcurrent situation. These correspond to the OVERCURRENT fault lights on the front panel.

Overvoltage is latched on this board and the signal is active-high or on.

4.3 Board 100

The purpose of board 100 is to regulate the output current of the transmitter. This board provides the drive to the controlled bridge rectifier, feedback control of the bridge, plus inhibit and protection functions during faults. Its main function is to maintain a constant current at the output of the transmitter for varying loads.

Due to the harmonic noise generated by the phase control of the output voltage, the primary waveform from the alternator is distorted from a pure sine wave. In order to minimize the noise on the reference signal, an active filter is used to remove the higher harmonics. The active filter is set for a phase shift of 60 degrees at 400 Hz. This is compensated for in the control circuitry. The filter provides the reference waveform for all of the control circuits. The output of the filter is sent to the absolute value circuits and the phase lock loop.

The phase lock loop circuit (4046) is used to multiply the 400 Hz signal to a higher value which is then divided by two divider chains, one which divides by 768 and the other which divides by 128. These give outputs of 400 Hz and 2400 Hz respectively from a master frequency of 307.2 KHz. The 2400 Hz signal is used by the ring counter to clock the data which comes from the main comparator. This provides the equidistant pulses used to fire the controlled bridge SCRs. The 400 Hz output of the other divider chain is fed back to the 4046 phase locked loop. It is this phase reference which is compared with the input waveform. This keeps the multiplied signal phase locked to the input frequency. Due to the large capture ratio of the system, the phase locked loop can remain in lock over a large range of frequencies. After power up on the system, it may take a second or so for the phase locked loop to lock in. After it locks in, it should remain so for all conditions except a complete loss of power.

The main comparator provides updated information on the output current to the firing circuits. It provides the reset pulses for the ring counter. The switching point provides the timing for the firing angle of the SCRs. Maximum firing angle is reached when the control voltage is equal to the peak of the reference sine wave while the converse is true when the control voltage is at zero. During normal regulation, the control voltage will increase and decrease as needed to maintain a constant output current.

4.3.1 Current Regulation

This is composed of the following sections: Current setpoint, slow turn-on, isolated current sensing, and integration of the current setpoint with current feedback.

4.3.1.1 Current Setpoint

Current control is accomplished by sensing a control voltage which is buffered by an amplifier controlling the offset of the integrator's negative input. This voltage sets the point at which the integrator output is equal to the voltage required to maintain a steady state current in the feedback loop.

4.3.1.2 Current Feedback

The transmitted current is sensed across a 0.05 ohm resistor and then sent through a true root mean square (RMS) device (AD536), a sample-hold device and an isolation amplifer. This provides a DC representation of the output with noise and ripple being averaged out. The output of the isolation amplifier is sent to both the integrator and the digital voltage meter through gain adjusting amplifiers. These provide corrections for amplifier mismatch.

4.3.1.3 Transmit, Slow Turn-on

Two other devices tie onto the positive integrator summing junction. These are used in transmitter turn-on and fault control. Soft turn-on is provided by the 74C908. It does this by controlling the rate at which the voltage can rise on the input to the integrator. Also, the 74C908 forces the positive input of the integrator to be high in a fault or reset condition.

4.3.1.4 Fault Detection

The board can sense various out of range levels and act accordingly. There are provisions for alternator undervoltage, overvoltage, and end of regulation.

Alternator under/overvoltage is sensed by the true RMS converter and scaled to be proportional to the input voltage. If it exceeds the preset value, the alternator overvoltage lamp will light and the board will shut down.

End of regulation also uses the alternator voltage and senses when there is not enough voltage to maintain regulation by comparing the alternator voltage to the control voltage. A lamp will light for this condition but no shutdown takes place.

4.3.1.5 Output Pulse Amplifiers

Board 99 contains the pulse amplifiers and transformers. As long as inhibit is high, the gate drive will output to the drive amplifiers with the modulation signal impressed on it. This signal drives the 2N5335 transistors which drive the pulse transformers. The pulse transformers drive the SCRs and provide isolation between the SCRs and the control board. By using high frequency modulation, an efficient transformer can be used and a lower average current in the pulse transistors is maintained.

5 TROUBLE-SHOOTING PROCEDURES

5.1 High Voltage Areas

Dangerous voltages are present throughout the transmitter. The following is a list of most but not all of the areas where caution should be exercised.

3-phase 120VAC input at contactor, line fuses, power supply, board 100, high-voltage transformer and GTO drive transformers.

All heat sinks, which can vary from ground potential to 1000 volts.

All boards numbered 88. These float along with the transmitter output and can have 1000 volts at whatever frequency is being transmitted.

The voltage-tap switch, phase-control SCRs, filter choke, supply capacitor, protection choke, and protection diode.

The metal chassis is connected to the AC generator neutral line and should not under normal operating conditions carry high voltage. However, for safety, it is normal to ground the transmitter chassis to a stake well away from any transmitter electrodes.

All four output terminals are naturally dangerous at all times. When the transmitter is turned off, it takes approximately five seconds for the bleeder resistor to discharge the capacitor completely. It is good practice to touch only one output terminal at a time while keeping your other hand in your back pocket, even when the transmitter is turned off.

5.2 Disassembly

The top panel can be removed by removing the 16 screws which hold it in place. The panel must be removed to gain access to the heat sinks on which the GTO thyristors are mounted. The unit should always be kept upright when this panel is removed because the panel holds the heat sinks in place. By removing the wiring at the terminal blocks on any heat sink, and on its accompanying board 88, that entire heat sink can then be lifted out for replacement.

5.3 Board 88 - GTO Thyristor Drive

Board 88 can be tested by connecting a 120VAC-400Hz motor generator or an isolated 117VAC 60Hz line to the transmitter input military connector. To use 117VAC 60Hz, first disconnect the power leads to the two cooling fans. These leads are on a terminal block between the two fans. Then connect the AC line to pins A and D on the power input connector on the transmitter. CAUTION: FAILURE TO USE AN ISOLATION TRANSFORMER CAN CAUSE FATAL SHOCK. Pin A is the A-phase input and provides power for the internal power supplies for board 88. Pin D is the transmitter neutral. Disconnect the external drive source as the internal timing is used for most of the tests on this board. Disconnect the contactor relay by disconnecting the molex plug near the contactor. NOTE: IT IS VERY IMPORTANT THAT THE CONTACTOR BE DISCONNECTED SO THAT HIGH VOLTAGE WILL NOT BE PRESENT ON THE GTO MODULES DURING TESTING. Follow the procedure below to determine if the fault lies with this board or with some other part in the transmitter. NOTE: ALL RESISTANCE MEASUREMENTS SHOULD BE MADE WITH THE TRANSMITTER TURNED OFF.

5.3.1 Verify first that board 93 is working since its proper operation is essential to proper operation of these GTO drive boards. See section 5.4.

5.3.2 A fault light that cannot be RESET is a good indication of a GTO or board 88 failure. Disconnect the gate and anode lead to the GTO heatsink module suspected to be failing and then follow the procedure below using a Fluke or similar digital voltmeter. The "from" point uses the ground lead on the Fluke and the "to" point uses the positive lead of the Fluke. All resistance measurements are made with the transmitter turned off.

5.3.3 Measure the resistance from anode to cathode of the GTO. The test points are on the board. See Figures 4 and 5. The gate test point is the disconnected gate lead. The anode test point is the disconnected anode lead. This reading should be approximately 500 ohms, ± 100 ohms. If not, go to section 5.3.9.

5.3.4 Measure the resistance from cathode to anode. This reading should be infinite. If not, go to section 5.3.9.

5.3.5 Measure the resistance from gate to anode and from gate to cathode. These readings should be infinite. If not, go to section 5.3.9.

5.3.6 Measure the resistance from anode to gate. This reading should be approximately 550 ohms. If this reading indicates a short or infinite, go to section 5.3.9.

5.3.7 Measure the resistance from cathode to gate. This reading should be approximately 700 ohms. If this reading indicates a short or infinite, go to section 5.3.9.

5.3.8 If GTO has tested O.K., go to section 5.3.11 to test board 88.

5.3.9 Replace the GTO. Disconnect the gate lead at board 88 by removing the nut. Remove the nut and bolt holding all of the wires on the cathode lug. See Figures 4 and 5. Be careful when removing or installing wires on the cathode lug to prevent damaging the GTO. Remove the two screws in the base of the GTO and remove it from the heatsink. Reverse this process to install the replacement GTO. Stir well and apply a thin coat of the conductive silver heatsink compound. Do not use the standard (high dielectric) heatsink compound. Avoid excessive torque on the two screws in the base of the GTO to prevent stripping these holes. If they are stripped, the heatsink will need to be replaced.

5.3.10 Whenever a GTO fails it is possible that another one has also failed. Check the other GTOs using the previous procedure. Next, it is essential that the quenching diode on the red heatsink around the protection inductor be tested. If this diode has shorted, then the overcurrent protection will not work and more GTOs will be lost if another short occurs. If this diode has opened, then the output will be unstable and will cause either OVERVOLTAGE indications or GTO failure. Test this diode by removing its cathode lead at the inductor and measuring it with a Fluke or similar digital volt meter on the lowest diode range (2k). Anode to cathode resistance should be infinite. Cathode to anode should be in the range of 500-800 ohms. If the diode is bad replace it.

5.3.11 Turn on the transmitter. Check for 117VAC at each module and if 117VAC is present, go to 5.3.13 and proceed with those tests. If 117VAC is not present, follow the steps below.

5.3.12 Check the circuit breaker and if it has tripped, reset it and recheck for 117VAC input at each module. If 117VAC is still not present check for wiring problems or problems with the power source. Correct the problem and go to 5.3.13. If the modules continue to trip the circuit breaker, determine the module which is responsible and replace it.

5.3.13 Check the +12 volt supply. See Figure 4 for test points. This should be within 1/2 volt of 12 volts. If this supply is within this limit, go to 5.3.16.

5.3.14 Check the input to the positive regulator. This should be approximately +17 volts but will vary according to the input source voltage. If the input is not +17 volts, check D7, C1 and the output of the transformer. Correct the problem and go to 5.3.13.

5.3.15 If the input to the regulator is correct but the output is not, then remove transistor Q5 and recheck the output from the regulator. If the problem is eliminated then replace Q5. If this does not correct the problem, check diode D1 for a shorted condition. Also check transistor Q4 for a short between emitter and collector. Correct the problem and go to 5.3.13.

5.3.16 Check the -12 volt supply. This should be within 1/2 volt of 12 volts. If this supply is within this limit, go to 5.3.19.

5.3.17 Check the input to the negative regulator. This should be approximately -17 volts but will vary according to the input source voltage. If the input is not -17 volts, check D7, C2 and the output of the transformer. Correct the problem and go to 5.3.16.

5.3.18 If the input to the regulator is correct but the output is not, then check the regulator, D9, D5, D2, C8, and the two IC's for a failure. Correct the problem and go to 5.3.16.

5.3.19 Check the 5 volt regulator (78L05). Use -12 for ground reference because the logic is referenced to -12 volts. If the regulator is putting out 5 volts +/- .2 volt go to 5.3.20. If the regulator is failing, replace it and recheck the output. If it still appears to be failing, then the optical receiver that it is supplying is bad and must be replaced. Correct the problem and continue on.

5.3.20 Plug in all of the cables to the GTO drive modules and set the test switch on board 93 for a 256 Hz test signal. See Figure 15. Then activate the RESET switch on the transmitter after applying power to the unit. All of the fault lights should be out. If not, go to 5.3.39 before proceeding any further. The fault light will indicate a failing module but others may also be failing and can be checked by performing this same procedure starting at 5.3.2.

5.3.21 Disconnect the gate and anode lead on all the GTO modules. Attach a scope to the cathode (ground) lead of board 88 and the gate output. The output observed on the scope should be a 256 Hz square wave of approximately +/- 11 volts. See Figure 6. This should be observed on all four boards. When the square wave is not present or of only one polarity, the board is not driving properly. Go to 5.3.23 in this case. When the proper square wave is observed, connect a 100 ohm 2 watt resistor between gate and cathode (ground). The square wave will diminish in amplitude but should still be present. If the square wave becomes unipolar when the resistor is added, go to 5.3.23.

5.3.22 Reconnect the leads between Board 88 and the GTO heat sink modules. The output should look like Figure 7 on all modules. If not, recheck step 5.3.21 and if the problem is still present go back to 5.3.2 and recheck the GTO. If the output agrees with Figure 7, Boare 88 is working properly. Turn the transmitter off and check diode D4 using a Fluke meter on the diode range. Replace the diode if it is open or shorted. Testing D4 in this manner is recommended because testing it while transmitting without the proper high voltage probe can be hazardous to the operator and can cause excessive dissipation in Q4 causing it to fail.

5.3.23 Recheck the power supplies (+12, -12, 5 volts) using steps 5.3.13 to 5.3.19, and correct any power supply problems. Set the test switch on Board 93 to 256 Hz.

5.3.24 Connect the scope ground lead to the -12 volt supply. Connect the scope probe to the base of transistor Q2. A 256 Hz signal between 0.25 - 0.35 and 0.65 - 0.75 should be visible. If present, go to 5.3.26. If this is not present, check the fiber optic drive cable from board 93 by looking at the end of the cable. It should glow red. Move the test switch on board 93 to the 1 Hz position. Now the drive signal should alternate on and off at a 1 Hz rate. If there is no drive signal and no fault lights are on, repair board 93. Board 93 will not produce drive signals when faults are indicated. If fault lights are on and RESET does not clear the fault, go to Board 93's troubleshooting procedure. If the fiber optic drive is working and the signal at the base of Q5 is incorrect as tested above, continue on.

5.3.25 Lift the base of Q2 and check for a 0.3 to 4.7 volt 256 Hz square wave on pins 5 and 8 of the fiber optic receiver (HFBR-2500). If this is not present replace the fiber optic receiver and recheck for the square wave. If it is not present, go back to 5.3.23 because something has been missed. If it is present reconnect the base of transistor Q2 and check the base for a 256 Hz signal between 0.25 - 0.35 and 0.65 - 0.75 volt. If this is not present, replace Q2 and go to 5.3.24. Otherwise, continue on.

5.3.26 Check the signal at the collector of Q2. This should be a 256 Hz square wave between 0.3 and approximately 11 volts. If this signal is present, go to 5.3.27. If not, check R6 which should be 10K ± 5%. Replace Q2 if R6 measures properly and recheck for the proper square wave. If present, continue on. If a square wave is not present replace the 74C00 IC; Q2 was working. Check for the square wave and continue on if it is present.

5.3.27 Check pin 11 of the 74C00 IC. This should be a 256 Hz square wave. If this signal is present, go to 5.3.28. If pin 12 is at ground potential, there will be no output at pin 11. A fault light will be on on the front panel. Clear it with RESET. If it can't be cleared and pin 12 is still at ground potential, go to 5.3.39. The square wave should be present in which case, go to 5.3.28. If it is not present, either the 74C00 or the 4538 is bad. Replace the 74C00 as a first guess and then the 4538 if necessary to obtain a 256 Hz square wave on pin 11, then continue on.

5.3.28 Check pin 9 of the 4538 IC for the waveform shown in Figure 8a. If this waveform is present, go to 5.3.29. If it is not present, check R10 (2K ohms). If this is not the problem, replace the 4538 and continue on.

5.3.29 Check pin 3 of the 74C00 IC for the 256 Hz square wave. If it is present, go to 5.3.30. If it is not, replace the 74C00 IC, recheck the signal and continue on.

5.3.30 Check pin 6 of the 4538 IC for the waveform shown in Figure 8b. If it is present, go to 5.3.31. If it is not, replace the 4538 IC and recheck for the waveform. If replacing the IC doesn't fix the problem, check R9 which should be 10K. If R9 tests bad, replace it. Also check the input at pin 5 of the 4538 IC which should be a 256 Hz square wave coming from pin 3 of the 74C00 IC tested in 5.3.29. A final source of trouble could be caused by a failure in transistor Q8. To check for this problem disconnect the base of Q8 and check for the proper waveform at pin 6 of the 4538 IC. If it is present now but is not present with the base of Q8 connected, replace Q8 and recheck signal at pin 6. Replacing Q8 may not correct the problem if R6 (22 ohm) has failed in a shorted condition. Replace R6 if necessary and go back to the beginning of this paragraph.

5.3.31 Check pin 6 of the 74C00 IC. This should be a 256 Hz square wave. If it is present, go to 5.3.32. If it is not present, recheck pin 3 as in 5.3.29 and if the 256 Hz square wave is present on pin 3 and not on pin 6, pull the base of transistor Q3 and recheck pin 6 for the 256 Hz square wave. If pulling the base of transistor Q3 does not result in a 256 Hz square wave, replace the 74C00 IC and reinstall the base of transistor Q3. Recheck signals and go to 5.3.32. If pulling the base of transistor Q3 does result in a 256 Hz square wave being present at pin 6 of the 74C00 IC, replace Q3 and recheck signals. Replacing Q3 will not help if R3 has failed and is less than 240 ohms. Check R3 with a Fluke or similar digital volt meter and if necessary replace R3. Go back to the beginning of this paragraph and recheck the signals.

5.3.32 Check the emitter of transistor Q3 for a 256 Hz square wave. If it is present, go to 5.3.33. If it is not present, Q3 is bad and must be replaced. Replacing Q3 may not help if R3 has failed and is less than 240 ohms. Check R3 with a Fluke DVM and if necessary replace R3. Then go back to the beginning of this paragraph to recheck signals.

5.3.33 Check the emitter of transistor Q8 for the waveform shown in Figure 9a. If it is present, go to 5.3.34. If it is not, recheck the signal on pin 6 of the 4538 IC as described in 5.3.30. If it passes the tests in 5.3.30, replace Q8 after checking R6 (22 ohm) for failure. R6 may have shorted and can be checked with a Fluke or similar digital volt meter. If R6 is shorted both it and Q8 should be replaced. Then go back to the beginning of this paragraph and repeat the tests.

5.3.34 Check the base of Q5 for the waveform shown in Figure 9b. If the waveform is present, go to 5.3.35. If it is not, check R3 (240 ohms), R5 (10K ohms), and R6 (22 ohms). Replace Q7 if resistors are correct. Then, recheck the base of Q5 for the proper waveform. If the problem still exists, go back to 5.3.29 and recheck the signals.

5.3.35 Check the collector of transistor Q5 for the waveform shown in Figure 10. If it is present, go to 5.3.36. If it is not, check the gate and anode leads to the GTO; they should be disconnected. If this eliminates the problem go to 5.3.36. If the output is always less than 12 volts, then either R1 (470 ohms) has failed open or D3 has failed open. R1 can be checked with a Fluke DVM. Replace it if necessary. Otherwise, replace D3. If the output is always around ground potential, Q5 probably has an emitter-collector short. Replace Q5 and repeat this step.

5.3.36 Whenever Q5 has failed, D5 has probably failed as well. In any case, check D5 with a Fluke DVM in both directions. If it is shorted or open, replace it. When D5 is shorted, the GTO cannot be turned on. When D5 is open, the GTO cannot be turned off.

5.3.37 Now attach the ground lead from the scope to the ground (cathode lead) of board 88. Check the waveform at the emitter of transistor Q4. This should look similar to Figure 11a. If the proper waveform is present go to 5.3.38. If it is not, replace Q4 and go back to 5.3.35.

5.3.38 Using a jumper cable, connect the anode output from board 88 to the ground (cathode lead) output. The waveform should now look like Figure 11b. If it still goes positive, replace D4 and repeat this step. If it is correct, board 88 is working properly.

5.3.39 Disconnect the overcurrent sense line on board 88 and connect a jumper between ground (cathode) and the ground for current sense. See Figure 4. Attach the scope ground lead to -12 volts. Attach the scope lead to the collector of transistor Q6 which should be at ground potential. If it is, go to 5.3.40. If it is not, replace transistor Q6. Check resistors R7 and R8 which both should be 1K ohm. Replace them if necessary and repeat this step.

5.3.40 Using a jumper, connect the overcurrent sense line to -12 volts on board 88. The collector of transistor Q5 should now be approximately 11 - 12 volts. If it is, go to 5.3.41. If it is not, check R7 and R8 which both should be 1K ohm. Replace Q6 if the resistors are not at fault and repeat this step.

5.3.41 Attach the scope lead to pin 8 of the 74C00 IC and observe the levels as the jumper on the current sense input (not current sense ground) is connected and disconnected from -12 volts. When the current sense input is connected to -12 volts, pin 8 should be approximately at ground potential and when the current sense input is disconnected pin 8 should be approximately 11 - 12 volts. If this is occurring, go to 5.3.42. If this is not occurring, recheck steps 5.3.39 and 5.3.40 and if problem persists, replace the 74C00 IC and go to the beginning of this step.

5.3.42 Attach the scope lead to the emitter of transistor Q1, and again connect and disconnect the current sense input. When connected the emitter should be low and when disconnected, it should be high. If it is, go to 5.3.43. If it is not, replace Q1 and go to the beginning of this paragraph. If problem persists recheck steps 5.3.39 to 5.3.41.

5.3.43 Observe the light output of the gray optical-transmitter. When the current sense input is connected to -12 volts, it should be off, and when disconnected, it should be on. If it does this, the current sense circuitry is working properly. Go to 5.3.20 and recheck. If it is not, recheck 5.3.42 and if it passes, check resistor R4 which should be 470 ohms. If R4 is correct, replace the gray optical-transmitter and repeat this step.

5.4 Board 93 - Output Switch Control

This board can be tested by connecting the transmitter to a motor generator or to an isolated 117VAC 60 Hz line. CAUTION: FAILURE TO USE AN ISOLATION TRANSFORMER CAN CAUSE FATAL SHOCK. To use 117VAC 60 Hz, disconnect the power leads to the two cooling fans, then connect the AC line to pins A and D on the power input connector on the transmitter. Pin A is the A-phase input and provides power for the internal power supplies for this board and the GTO driver modules. Pin D is the transmitter neutral and is connected internally to the transmitter chassis. Therefore, an isolation transformer is needed on the oscilloscope. Disconnect the external drive source as the internal timing is used for most of the tests on this board. Disconnect the contactor relay by disconnecting the molex plug by the contactor. NOTE: IT IS VERY IMPORTANT THAT THE CONTACTOR BE DISCONNECTED SO THAT HIGH VOLTAGE WILL NOT BE PRESENT ON THE OUTPUT DURING

TESTING. Follow the procedure below to determine if the fault lies with this board or with some other part in the transmitter. NOTE: ALL RESISTANCE MEASUREMENTS SHOULD BE MADE WITH THE TRANSMITTER TURNED OFF.

5.4.1 Push "RESET".

5.4.2 If the OVERVOLTAGE lights are still on, go to 5.4.15.

5.4.3 If the OVERCURRENT lights are still on, go to 5.4.17.

5.4.4 Set the test switch on this board to the 1 Hz position and pull all of the fiber-optic cables labeled DRIVE. See Figure 12. These connectors are gray. Observe the lights (LEDs) in the four optical drivers. DRIVE1 and DRIVE2 should be alternating with DRIVE3 and DRIVE4 at 1 Hz. If this is not occurring, go to 5.4.8.

5.4.5 Set the test switch to the RUN position and attach the external controller. Set the frequency to 1 Hz and again observe the output from the four optical drivers. If they do not alternate, go to 5.4.7.

5.4.6 Reinstall the four drive cables. This board has tested O.K.

5.4.7 Check the fiber optic cables from the drive input board 91 to board 93 to insure that all cables are installed properly. If this does not correct the problem, pull the TRANSMITTER DRIVE cable from board 93 and observe the output from the cable. The light should be alternating on and off. If it is not, the external controller may be off or malfunctioning or the input optical driver may be bad. If the output of the cable is alternating on and off, then either the optical receiver is bad or IC C3 is bad. Correct the problem and go to 5.4.5.

5.4.8 Using an oscilloscope check for a 1 MHz square wave at pin 1 of IC B5. If there is no signal here, check the 5 volt supply to this board and be sure the power is on. If the power is on and 5 volts is absent, check the power supply and replace it if necessary. If 5 volts is present, replace the oscillator and go to 5.4.4.

5.4.9 Check for a 1 Hz drive signal on pins 7 and 15 of IC B5 (4520). If this is not present, make sure that the test switch is in the 1 Hz position. If the 1 Hz drive signal is not present, IC C3 or C4 is bad. Replace the faulty IC, check the drive signal, and go to 5.4.4.

5.4.10 Set the test switch to 256 Hz. A 256 Hz square wave should be present at pins 3 and 11 of IC B4. If this square wave is not present, IC B5 is bad and must be replaced. Replace IC B5, check the square wave again, and go to 5.4.4.

5.4.11 Check for 256 Hz square wave at pins 5 and 9 of IC B3. If this is not present, replace IC B4 and go to 5.4.4.

5.4.12 Check for 256 Hz square wave at output of IC B3. If this is not present, look at the levels on the following pins. Pins 1, 2, 4, 10, 12, and 13 should all be at 5 volts. If they are not, check for fault lights being on, 5 volt power supply failure, IC C3 failure or Duty Cycle optical receiver failure. Correct the failure and go to 5.4.4.

5.4.13 Check for 256 Hz square wave at pins 3 and 5 of IC B2. If this is not present, either B2 is bad or the optical drivers are bad. Determine which is failing and replace.

5.4.14 Check for an active drive signal light at the output of the optical drivers. If present, go to 5.4.5. If not, go back to 5.4.8 and recheck the signals.

5.4.15 Pull all four of the OVERCURRENT cables from the blue optical receivers labelled PROT1, PROT2, PROT3, and PROT4. This should cause the OVERCURRENT fault lights to come on. Now reinstall the four OVERCURRENT cables and push the RESET switch and observe the fault lights. If the OVERCURRENT fault lights reset, then IC D9 or the OVERVOLTAGE optical receiver is bad; correct this problem and go to 5.4.1. If the OVERCURRENT fault lights stay on, go to 5.4.16.

5.4.16 The tests indicate that either IC D4 or the RESET switch or wiring is bad. Correct the problem with the RESET circuitry and go to 5.4.1.

5.4.17 Pull the OVERCURRENT fault cable associated with the fault light which cannot be reset. If the end of the cable glows red go to 5.4.19.

5.4.18 The GTO module (board 88) associated with the unlit cable is failing or has its cable unplugged. Repair the module or plug in the cable and go to 5.4.1.

5.4.19 Pull the other OVERCURRENT cables. The OVERCURRENT fault lights should come on. Reinstall the cables and activate the RESET switch. If the OVERCURRENT lights associated with the cables that were pulled do not go out, go to 5.4.16.

5.4.20 Check the ICs associated with the fault light that cannot be reset which will be either C7, D7, C6, C8 and C9 and the optical receiver associated with the fault light. Repair the problem and go to 5.4.1.

5.5 Board 100 - Current Feedback and SCR Drive Signals

This board can be tested by connecting the transmitter to a 115/200 VAC-400 Hz motor generator. Pin A is the A-phase input and provides power for this board. Pin D is the transmitter neutral. Disconnect the external drive source as the internal timing is used for most of the tests on this board. Disconnect the contactor relay by disconnecting the molex plug at board 93. NOTE: IT IS VERY IMPORTANT THAT THE CONTACTOR BE DISCONNECTED SO THAT HIGH VOLTAGE WILL NOT BE PRESENT ON THE GTO MODULE DURING TESTING. Follow the procedure below to determine if the fault lies with this board or with some other part in the transmitter. NOTE: ALL RESISTANCE MEASUREMENTS SHOULD BE MADE WITH THE TRANSMITTER TURNED OFF.

5.5.1 Verify first that the supply voltages +5 and ±15 are present (see the test points on Board 100, Figure 13). If they are not within ±5% unplug board 100 and recheck the power supply. If the power supply is still not working, notify Zonge Engineeirng as there are no user serviceable parts on the power supply.

5.5.2 Setup a Tektronix model 212 oscilloscope or similar battery operated or line isolated oscilloscope as follows:

DC coupled
5.0 volt Range
1 msec/div
Channel 2 trigger
Ground lead on ground wire

5.5.3 Setup procedure for the active filter output - This adjustment must be made before any other setup or checkout procedure can be made. With the scope probe tip on the output of pin 6 of H-4 (OP-5) (see TP-0 on Figure 13) adjust pot R26 for a 20VPP (± 1 volt) signal at pin 6 H-4.

5.5.4 Phase lock loop - The phase lock loop (D3) is used to multiply the 400 Hz signal to get a resultant frequency of 307,200 Hz. (See theory of operation.) Pin 1 on D3 is the in lock indicator. When the system is in lock the output of pin 1 of D3 is a 5 volt level signal with a pulse 5.0 microseconds wide going to ground at 2.5 milliseconds intervals. Pin 4 should have a 307,200 Hz square wave with a period of 3.3 microseconds and pin 3 should have a 400 Hz square wave synchronized with pin 14. The output of pin 4 is divided by A3. This results in a 2.4 kHz square wave and a 38.4 kHz signal for gate drive to the SCR drivers. The 307,200 Hz signal is also divided by C3 (4522) and B3 (4520) to 400 Hz which is the feedback to the phase lock loop for phase comparison with the incoming signal. There will be no output from A3 if reset is high. Reset is generated by the positive-going pulse each time the comparator F4 (CMP01) switches.

5.5.5 Current set point reference - To check the output current set point reference G7 (LH0070) use a digital voltmeter set for DC input on the 20 volt range. Check the REF output to the current setpoint potentiometer; for a GGT-25 it should be 4.04 volts ±10 mv and for a GGT-6 it should be 2.02 volts ±10mv. Put the probe tip on the Set input from the current setpoint potentiometer and adjust the current set potentiometer from 0.0 to 10.0 divisions. The voltage should vary according to transmitter type from 0-4 volts or 0-2 volts. Check the output of H5 (OP5), the current set buffer, for tracking over the same range.

5.5.6 TRANSMIT/RESET Switch - To check the TRANSMIT/RESET switch, put the scope probe on pin 8 B2 (74C74). The signal will be low for RESET and high for TRANSMIT.

Pin 9 of F3 (4038) should give a two second low pulse each time the TRANSMIT/RESET switch is toggled to TRANSMIT. This is the inhibit time for the contactor to pull in. This reduces the transient pulse which occurs when an unloaded transformer is energized.

5.5.7 Fault inhibit - Pin 8 of R1 (74C30) should be low after two seconds when the TRANSMIT/RESET switch is toggled toward TRANSMIT and goes high when the switch is toggled toward RESET. Pin 6 of E2 (74C00) is the inverse. This signal controls the soft start gate and the output gate drive to the SCR bridge. If pin 6 of the E2 does not go high, check the alternator over/under voltage and pin 9 of 74C221 (F3). This should be high for the output of E1 (pin 9) to go low.

5.5.8 Alternator High-Low shut down - This signal also controls the inhibit function. It is generated by the level of the AC voltage from the active filter which feeds H2 (AD536, a true RMS converter). The output should be 10 volts for a 20 volt PP-AC signal. This is the reference for the transmitter alternator shut down comparators. G1 and H1 should be high if they are in tolerance for correct alternator input voltage (see setup procedure for correct voltages on shut down), i.e. 90 volt for low shut down and 130 volt for high shut down.

If the outputs to E1 are both high but pin 6 of E2 is still low, check the FL-EXT.FAULT input at the lower edge of board 100. This is the fault input from board 93. It will also inhibit board 100.

5.5.9 Soft start - This is an open collector pull-up to inhibit the feedback integrator. By pulling up pin 3 of F5 through R 30, the intergrator shuts down. Put the scope probe on pin 6 of F5 and toggle the TRANSMIT/RESET switch. The output should remain high in RESET and drift negative on TRANSMIT.

5.5.10 Current feedback - The output of F5 is compared to the reference waveform from the active filter by comparator F4 (CMP-01). As long as pin 6 of F5 is greater than 10 volts, there is no output from F4. As pin 6 goes more negative the output of F4 switches from 0.0 to 5.0 volts as the sinewave crosses the level of the pin 3 input. Normally the output of the isoamp drives this input which regulates the output current. In the test mode the output of the integrator will swing from +10V to -10V. As it swings, the output of the comparator (pin 7 of F4) will sweep from zero volts to a 400 Hz square wave after the two second delay. This happens each time the TRANSMIT/RESET switch is toggled.

The output of compartor F4 (pin 7) goes to pin 2 of F2. This is a one shot multi-vibrator (74C221). Pin 13 is the Q output which resets A3 (see the phase locked loop section). QNOT (pin 4) also triggers pin 10 of F2 which provides a low inhibit pulse of 1.6 microseconds to keep the A half of F2 (74C221) from retriggering at the 180 degree point of the reference waveform.

Pins 4 and 8 of F2 (74C221) provide the reset pulses to the main counter A3 and the shift register D2, C2 and D1. This shifts the firing angle information through the SCR drive gates B2 and C1.

Pin 13 of F2 is compared with the 400 Hz square wave from the comparator H3 (CMP01). If the phase position of pin 13 of F2 as compared to the 400 Hz input is greater than 90 degrees, then the end of regulation light is turned on. In test mode with the current set point at zero, the end of regulation light should extinguish momentarily two seconds after going to transmit and then come on again. Toggle the transmitter RESET switch on and off to insure that this is happening.

5.5.11 SCR driver wave forms - Look at pin 9 of A2 (88C29). As the TRANSMIT/RESET switch is toggled to transmit, a waveform as shown in Figure 14 of 38.4 kHz and 0.8 milliseconds wide should be found on pins 5 and 9 of A2 and on pins 5, 6, 8, and 9 of B1. These are the SCR drive waveforms. Each waveform is shifted in time from the previous one by 0.4 milliseconds from 1 to 6 in the SCR outputs. This is the firing sequence for the SCR controlled bridge. See Figure 15.