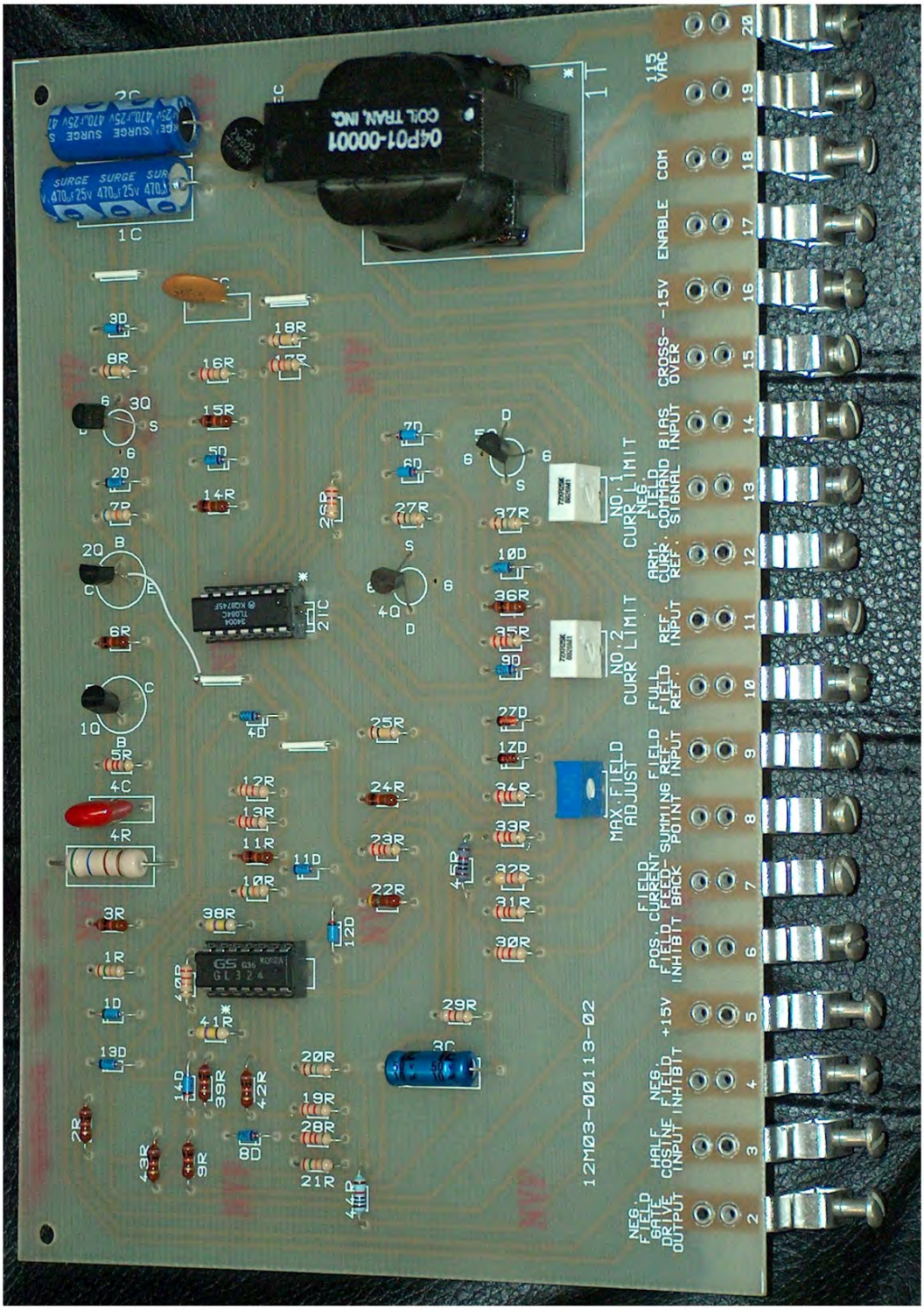
Trouble-Shooting Manual
MODEL 220 BI-DIRECTIONAL OUTPUT ADAPTOR
PART NUMBER 12M03-00113-01



MODEL 220 BI-DIRECTIONAL OUTPUT ADAPTOR

PART NUMBER 12M03-00113-01
SCHEMATIC DIAGRAM 12M03-00113-01

I. SPECIFICATIONS

SUPPLY
- 120 Volts AC ± 10%
- 50/60 Hz, single phase

TEMPERATURE
- 0° to 40°C (32° to 104°F)
- 50°C in cabinet

INPUTS AND OUTPUTS
- Must be connected to the Model 201 Field Firing Assembly and optional Model 223 Crossover Assembly

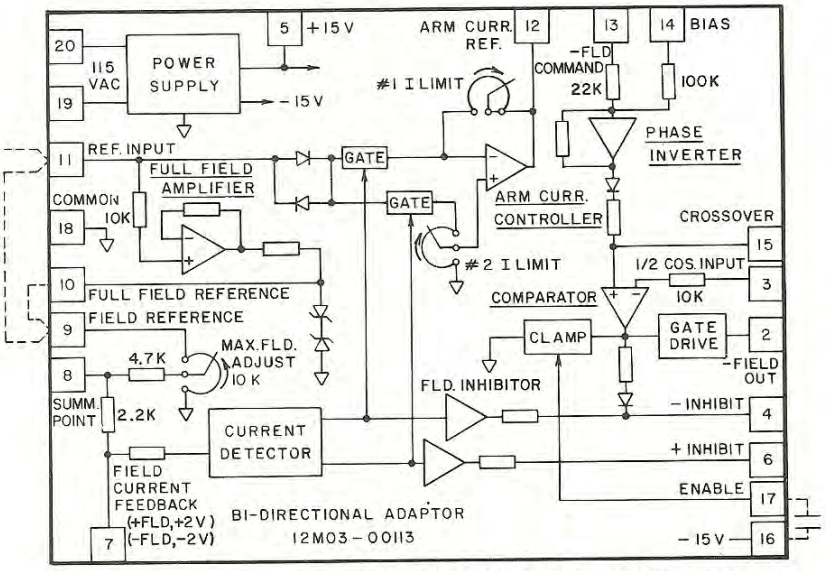


FIGURE 1. SIMPLIFIED SCHEMATIC DIAGRAM

II. THEORY OF OPERATION*

The REFLEX MODEL 220 Bi-directional Output Adaptor Assembly is designed for use with the Model 201 Field Firing Assembly to provide bi-directional field current for applications such as a DC Reversing Generator or a Field Reversing Regenerative DC Motor Drive, and for alternate excitation of two fields such as an Eddy Current Clutch and Brake.

When used with a Field Reversing Regenerative DC Drive it provides either Proportional Field Control or Full Field Control. With Proportional Field Control, field excitation is held to a minimum value necessary to furnish the torque required by the load, and allows the most rapid reversal of torque. It is slower in response to changes in load. With Full Field Control, full field excitation is applied to the motor except when reversal of speed or torque are required, providing the fastest response to changes in load. It is slower in response to reversals in torque.

The change from Proportional to Full Field Control is made by changing a single jumper. If rapid reversal of very high torques is required for special applications, other Field Regenerative controls are available. Since the standard control will handle torques up to 150% of full load, and can establish regenerative torque in as little as .08 seconds and full torque reversal in as little as 0.4 seconds, the standard control provides a very high level of performance for most applications.

Refer to the "Theory of Operation for the Model 201 Field Exciter" and "Theory of Operation for Field Reversing Regenerative Operation of a DC Motor" for a complete understanding of this assembly.

The Model 220 Bi-directional Output Adaptor consists of the following elements shown in the Simplified Schematic Diagram (Figure 1).

1. Power Supply
2. Full Field Amplifier
3. Phase Inverter
4. Comparator and Gate Drive
5. Current Detector
   a) Field Inhibitor
   b) Armature Inhibitor
6. Armature Current Controller

1. **Power Supply** — The power supply uses a center-tapped transformer with 10 volts on each side of center together with a bridge rectifier and two 470 MF filter capacitors to provide a nominal plus and minus unregulated 15 volts DC with respect to the transformer center-tap which is connected to circuit common.

2. **Full Field Amplifier** — A bi-directional 6 volt maximum Reference Input signal from a potentiometer or from the Model 217 or similar speed amplifier is applied to the Reference Input terminal 11 which is connected through a 10K resistor to the input, pin 12, of op-amp 2IC(D), a non-inverting amplifier with a gain of 10. This amplifier saturates with very small input signals and acts as a switch whose output polarity is determined by the polarity of the input. The output of this amplifier, terminal 10, is jumpered to terminal 9 to provide a Full Field Reference voltage for the "Max Field Adjust" potentiometer.

**Terminal designations in parenthesis refer to terminals on the Model 201 Field Firing Assembly.*

NOTE: For purposes of polarity determinations and discussion, a "negative field" current results when the two thyristors with a common cathode are conducting. A "positive field" current results when the two thyristors with a common anode are conducting. These are arbitrary polarity designations and have been established to insure proper connections.

A feedback signal, proportional to field current of 2 volts at maximum field current is connected to terminal 7. This signal must be positive with respect to circuit common when the current feedback from the thyristor power bridge is positive (positive field). The current output of the "Field Adjust Potentiometer" and the field current feedback signal are summed through resistors 32R and 31R respectively at terminal 8 which is connected to the Summing Junction (terminal 15) of the Model 201 Field Firing Assembly.

A very small Reference Input Signal on terminal 11 drives Full Field op-amp 2IC(D) to full output. The resulting signal is limited to a nominal plus and minus 6 volts by action of zener diodes 1ZD and 2ZD. If the Reference Input signal is negative, the Model 201 Field Firing Assembly drives the thyristor power bridge to full negative output (negative field).

When Proportional Field control is required, the "Field Reference Input" to the Max. Field Adjust potentiometer, terminal 9, is connected directly to the Reference Input terminal 11, instead of to the output of the Full Field Reference, terminal 10, and the field varies in magnitude and direction in proportion to the magnitude and direction of the Reference Input signal.

The output of the Model 201 Summing Amplifier (terminal 14) is connected to the Phase Inverter of the Model 220 Bi-directional Output Adaptor, terminal 13.

3. **Phase Inverter** — When the output of the Model 201 Summing Amplifier is positive, resulting in full positive output of the thyristor bridge, the input to the Phase Inverter, 2IC(B) pin 6 is also positive. Consequently its output is negative, back-biasing diode, 5D, so no signal is applied to the Comparator, 2IC(C).

   When the Reference Input signal is changed from negative to positive, the output of the Full Field Amplifier swings positive, reversing the voltage on the "Max Field Adjust" potentiometer, and consequently reversing the input reference to the Model 201 Summing amplifier.

   The output of the Model 201 Summing Amplifier swings negative stopping the gate drive signal to the positive half of the thyristor power bridge. However, this same negative voltage is applied to the input of the Model 220 Bi-directional Output Adaptor, terminal 13, causing the output of the Phase Inverter to swing positive. This positive output is applied to the Comparator as described below.

   Additionally, a positive or negative bias voltage can be connected to the input of the Phase Inverter, terminal 14, to provide overlapping or separation of the two thyristor bridges when controlling two fields.

4. **Comparator and Gate Drive** — The positive output of the Phase Inverter is compared to a Half-cosine signal from the Model 201 Field Firing Assembly (terminal 12), which is connected to terminal 3 of this assembly. Op-amp 2IC(C) acts as a voltage comparator. Its output drives a pair of transistors, 2Q and 1Q to produce gate signals to the thyristors in the negative leg of the power bridge.

   When the output of the Phase Inverter is negative, no gate signals appear. As it moves positive, gate signals occur earlier and earlier in the half cycle until full conduction occurs when the output of the Phase Inverter is more positive than the positive peaks of the (1+cos).

   The Gate Drive is disabled by FET switch 3Q until a minus 15 volt signal is applied to the "Enable" terminal to avoid indiscriminate firing on powering up. It is also disabled by action of the Current Detector or a minus 15 volt DC signal through a 4.7K resistor to the "Inhibit" terminal 4 if required.

   The output of the Darlington power transistor 1Q is connected to terminal 2. This terminal is connected to the Model 201 Field Firing Assembly (terminal 4), to furnish firing signals to the input diode of opto-coupler 2IC. The output of 2IC drives a Darlington power transistor which furnishes gate drive for the two thyristors in the negative half of the power bridge.

   In this configuration the cathode of the input diode of 1IC in the Model 201 Field Firing Assembly (terminal 3) is jumpered directly to the minus 15 volt supply (terminal 16).

5. **Current Detector** — This circuit detects the magnitude and direction of the field current and has two functions: (a) it inhibits the pulse generator for the opposite half of the thyristor power bridge above 10% field current and (b) it opens the gate controlling armature current so armature current does not flow when the field current is less than 10%. Its output is applied directly to the armature current gates for use with Field Reversing Regenerative DC Drives and is inverted for the "Field Inhibitor."

   Op-amp 1IC(B) and 1IC(C) act as voltage comparators to sense a 10% level of field current. Diodes 8D and 4D are biased with a forward voltage of 0.7 volts. A divider network across these diodes furnishes a negative or positive 0.2 volt reference to the comparators (pin 5 or pin 9 respectively). A signal proportional to field current of 2 volts at rated field current is applied through an RC filter network to the inputs, pin 6 and 10 of 1IC(B) and 1IC(C) respectively.

   With no field current signal, the positive 0.2 volt bias on pin 9 of 1IC(C) causes its output to swing negative. As the field current signal at terminal 7 swings positive (positive half of the thyristor bridge conducting), the voltage at pin 10 of 1IC(C) exceeds the 0.2 volt bias on pin 9 and its output swings positive.

   When field current flows in the opposite direction (negative half of the thyristor bridge conducting) polarity of the current feedback signal reverses and the output of op-amp 1IC(B) swings from positive to negative as its 0.2 volt negative bias is exceeded.

   a) *Field Inhibitor* — The Field Inhibitor circuit blocks the gate drive to the half of the thyristor bridge that is not conducting. This prevents the End Stop pulse from firing the non-conducting half of the bridge, which would limit maximum output and cause excessive circulating currents.

   When the positive half of the thyristor bridge conducts, field current greater than 10% of rated causes the output of 1IC(C) to swing positive. This positive signal is inverted by 1IC(D) and applies a minus 15 volt signal through a 10K resistor 2R to the cathode of diode 1D, terminal 4. The diode conducts taking the base of transistor 2Q to minus 0.7 volts, thus blocking gate signals to the negative half of the thyristor bridge. "Negative Field Inhibit," terminal 4, is not used for the applications described.

When the negative half of the thyristor bridge conducts, field current greater than 10% of rated causes the output of 1IC(B) to swing positive. This positive signal is inverted by 1IC(A) and applies a minus 15 volt signal through a 10K resistor 9R, to the "Positive Field Inhibit" terminal 6. This terminal is connected to the "Inhibit" (terminal 11) of the Model 201 Field Firing Assembly, pulling the base of transistor 7Q in the Model 201 Field Firing Assembly, to minus 0.7 volts, thus blocking gate signals to the positive half of the thyristor bridge.

b) *Armature Inhibitor* — The Armature Inhibitor conditions the signal to the armature current loop when operating in a regenerative mode. To avoid motor commutation problems at extremely weak field as the field current swings from one direction through zero to the reverse direction, the reference signal to the armature inner current loop is removed, momentarily interrupting armature current.

Whenever the positive field current signal on the input to 1IC(B) is less than 0.2 volts (10% of rated field current) the output of 1IC(B) is negative, pulling the gate of 4Q to minus 15 volts, opening the gate to the input (pin 2) of the Armature Current Controller 2IC(A).

Whenever the negative field current signal on the input of 1IC(C) is less than 0.2 volts, its output is negative, pulling the gate of 5Q to minus 15 volts opening the gate to the input (pin 3) of the Armature Current Controller 2IC(A).

6. **Armature Current Controller** (Used only with a Field Reversing Regenerative DC Drive.) — Amplifier 2IC(A) conditions the Reference Input signal depending on the polarity of the motor field current. The polarity of the Reference Input at terminal 11 determines the field polarity. The field current polarity controls the Armature Inhibitors 4Q and 5Q and selectively applies the Input Reference voltage to either the inverting or non-inverting input of the Armature Current Controller 2IC(A) so that its steady-state output is always of a negative polarity to the Armature Inner Current Loop. Independent adjustments of gain are provided for inverting and non-inverting modes to allow separate adjustment of motoring or regenerating torque (No. 1 and No. 2 Current Limit) as described in section 5b above.

The motor field must be at 10% of rated output before either Armature Inhibit gate is closed. Diodes 6D and 7D in the Reference Input block the first 10% of the input signal to the Armature Current Controller 2IC(A). This allows field current to build to 10% to control one of the gates to the Armature Current Controller before armature current is allowed to flow.

A positive Reference Input is applied thru diode 7D, and FET gate 4Q to the inverting input of the Armature Current Controller 2IC(A), an op-amp with a gain adjustable from 0 to 1 depending on the setting of No. 1 Current Limit potentiometer 3P.

When the Reference Input reverses polarity the signal is applied to the non-inverting input of the Armature Current Controller through diode 6D, FET gate 5Q, and No. 2 Current Limit potentiometer, 2P.

COMPONENT LIST - ASSEMBLY #12M03-00113-01

Symbol	Part #	Description (Acceptable Substitute)*
1T	04P01-00001	Transformer–120V AC PRI, two 10V SEC @ 220 mA (Signal-PC20-220)
1REC	05P01-00003	Rectifier Bridge–50V, 1A (EDI-PF50)
1-10D	05P02-00001	Diode–Signal, 50mA, 200 PIV (1N4148)
1,2ZD	05P03-00005	Zener Diode–6.8V, 500mW, 10% (1N5235B)
1Q	05P04-00001	Transistor–PNP Small Signal (2N3638A)
2Q	05P04-00002	Transistor–NPN Small Signal (2N3392)
3-5Q	05P05-00001	Transistor–N Channel JFET (2N4093)
1IC	05P08-00001	Quad Op-Amp- (National-LM324)
2IC	05P08-00002	Quad Op-Amp- (TI-TL084)
1P	02P04-10301-00	Potentiometer–10K, ½W, (Beckman-72XR10K)
2,3P	02P04-25301-00	Potentiometer–25K, ½W, (Beckman-72XR25K)
1,2C	03P01-47102-01	Capacitor–470MF, 25V, Electrolytic
3C	03P02-10002-00	Capacitor–10MF, 16V, Electrolytic
4C	03P07-10410-00	Capacitor–0.1MF, 100V, Film
5C	03P06-50305-00	Capacitor–0.05MF, 50V, Ceramic
1,21R	01P01-15300-02	Resistor–15K, ¼W, 5%
2,3,6,9, 10,11,14, 15,24,36R	01P01-10300-02	Resistor–10K, ¼W, 5%
4R	01P01-56103-03	Resistor–560, 2W, 10%
5,13,23,28, 31,33,34,35R	01P01-22200-02	Resistor–2.2K, ¼W, 5%
7R	01P01-68300-02	Resistor–68K, ¼W, 5%
8,18,25R	01P01-10400-02	Resistor–100K, ¼W, 5%
12,19,30R	01P01-12200-02	Resistor–1.2K, ¼W, 5%
16,17R	01P01-22300-02	Resistor–22K, ¼W, 5%
20,27,37R	01P01-10500-02	Resistor–1MEG, ¼W, 5%
22R	01P01-47500-02	Resistor–4.7MEG, ¼W, 5%
26R	01P01-27300-02	Resistor–27K, ¼W, 5%
29R	01P01-82100-02	Resistor–820, ¼W, 5%
32R	01P01-47200-02	Resistor–4.7K, ¼W, 5%

*OR EQUAL

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III. BENCH TEST

TEST MATERIAL REQUIRED

1 - 120V AC Line Cord
1 - 5K, 2 Watt Potentiometer
2 - 10K, ¼ Watt Resistors
8 - Clip Leads
1 - Digital Voltmeter (Beckman HD-110 or equal)
1 - Oscilloscope (Tektronix 2213 or equal)

1. Connect a 5K potentiometer to a ± 6 volt power supply as follows:

   CW end of potentiometer to +6V
   CCW end of potentiometer to -6V
   Power supply zero to terminal **18** on the PCB
   Center of potentiometer to terminal **11** on the PCB

2. Connect a voltage divider consisting of two 10K resistors in series between +6V and power supply common. Connect the center of the divider to terminal **3** on the PCB. Connect a 560 Ohm resistor from terminal **7** to **18**, jumper terminals **12** to **13** and **16** to **17** and connect a 1K resistor from terminal **2** to **18**.

3. Connect a 10V DC Meter between terminals **12** and **18**. Adjust Max Field to full CCW and both Current Limits to full CW.

4. Apply 115V AC to terminals **19** and **20**.

5. Connect terminal **9** to +6 volts. As the 5K potentiometer is moved through its range, the output at terminal **12** should remain at zero. Turn the 5K potentiometer fully CCW. Now adjust the Max Field in a CW direction. Somewhere between half and full rotation, the output at terminal **12** should abruptly drop to -6 volts. As the 5K potentiometer is moved through its range, the output should follow, with the same polarity. Adjust for -6 volts output. Now, adjust "Curr. Limit #2" in a CCW direction. The -6 volt output should smoothly go to zero. Return "Curr. Limit #2" to CW position. Adjustment of "Curr. Limit #1" should have no effect.

6. Observe the output at terminal **4** with the input to **9** at +6 volts. It should be -0.5 to -1.0 volts. Remove the voltage to terminal **9**. Terminal **4** should go to +12 to +15 volts.

7. Connect terminal **9** to -6 volts, and return the "Max Field" to the CCW end. Again, movement of the 5K potentiometer should not change the output at **12** from zero. Move the 5K potentiometer to the CW extreme. Now advance the "Max Field" CW, and somewhere between half and full rotation, the output at **12** should abruptly drop to -6 volts. Movement of the 5K potentiometer should be followed by output voltage changes, but with opposite polarity. Adjust for -6 volts output. Now, the position of "Curr. Limit #2" should not have any effect, while moving "Curr. Limit #1" CCW should cause the output to smoothly go to zero. Restore "Curr. Limit #1" to full CW position.

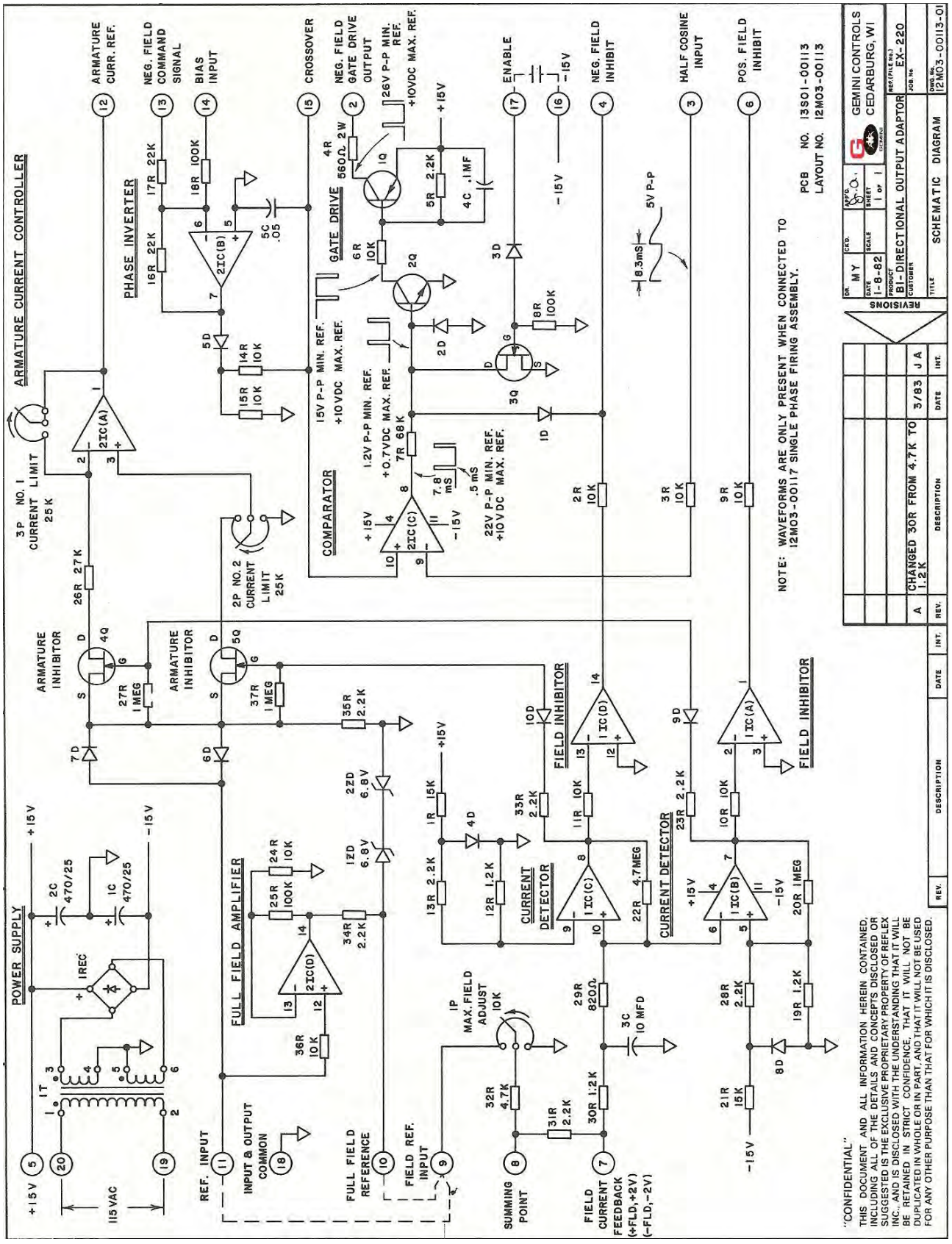
8. Observe the output at terminal **6** with the input at **9** at -6 volts. It should be at -12 to -16 volts. Remove the voltage at **9** and terminal **6** should go to +12 to +16 volts.

9. Connect -6 volts to terminal 9. Observe the output at terminal 2. With the 5K potentiometer at the CCW end, terminal 2 should show zero volts. As the 5K potentiometer is turned CW, at approximately 75% rotation the output at terminal 2 should jump to +10 volts (nominal). Remove the jumper from **16** to **17** and the voltage should drop to zero.

10. Observe the voltage at terminal **10**. As the 5K potentiometer is moved through its range, the voltage at **10** should go from +7 volts to -7 volts (nominal) with the full output range concentrated in the center 10 to 20% of the 5K potentiometer rotation.

IV. VOLTAGE CHECKS

1. The primary voltage of 1T, leads 1 and 2 (terminals 20 and 19), should be 120V AC.
2. The secondary voltage of 1T, leads 3 to 4 and leads 5 to 6, should be 10V AC. These can be measured between circuit common, terminal 8 (leads 4 and 5), and each AC input to the bridge rectifier 1REC (leads 3 and 6). Voltage at the AC input to the bridge rectifier 1REC (leads 3 to 6) should be 20V AC.
3. +15V DC nominal between the positive end of capacitor 2C and terminal 8.
4. -15V DC nominal between the negative end of capacitor 1C and terminal 8.
5. Use an oscilloscope to verify that waveforms are as shown on the schematic diagram.


ARMATURE CURRENT CONTROLLER
POWER SUPPLY
PHASE INVERTER
COMPARATOR
GATE DRIVE
FULL FIELD AMPLIFIER
CURRENT DETECTOR
FIELD INHIBITOR
ARMATURE CURR. REF.
NEG. FIELD COMMAND SIGNAL
BIAS INPUT
CROSSOVER
NEG. FIELD GATE DRIVE OUTPUT
ENABLE
NEG. FIELD INHIBIT
HALF COSINE INPUT
POS. FIELD INHIBIT
3P NO. 1 CURRENT LIMIT 25K
2P NO. 2 CURRENT LIMIT 25K
ARMATURE INHIBITOR
REF. INPUT
INPUT & OUTPUT COMMON
FULL FIELD REFERENCE
FIELD REF. INPUT
SUMMING POINT
FIELD CURRENT FEEDBACK (+FLD,+2V) (-FLD,-2V)
IP MAX. FIELD ADJUST 10K
3C 10 MFD
115 VAC
NOTE: WAVEFORMS ARE ONLY PRESENT WHEN CONNECTED TO 12M03-00117 SINGLE PHASE FIRING ASSEMBLY.
PCB NO. 13S01-00113
LAYOUT NO. 12M03-00113
REVISIONS
A CHANGED 30R FROM 4.7K TO 1.2K 3/83 J A
DR M Y DATE 1-8-82 CK'D. APP'D. SCALE SHEET 1 OF 1
GEMINI CONTROLS CEDARBURG, WI
PRODUCT BI-DIRECTIONAL OUTPUT ADAPTOR REF(FILE NO.) EX-220
CUSTOMER JOB No.
TITLE SCHEMATIC DIAGRAM DWG. No. 12M03-00113-01
"CONFIDENTIAL"
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