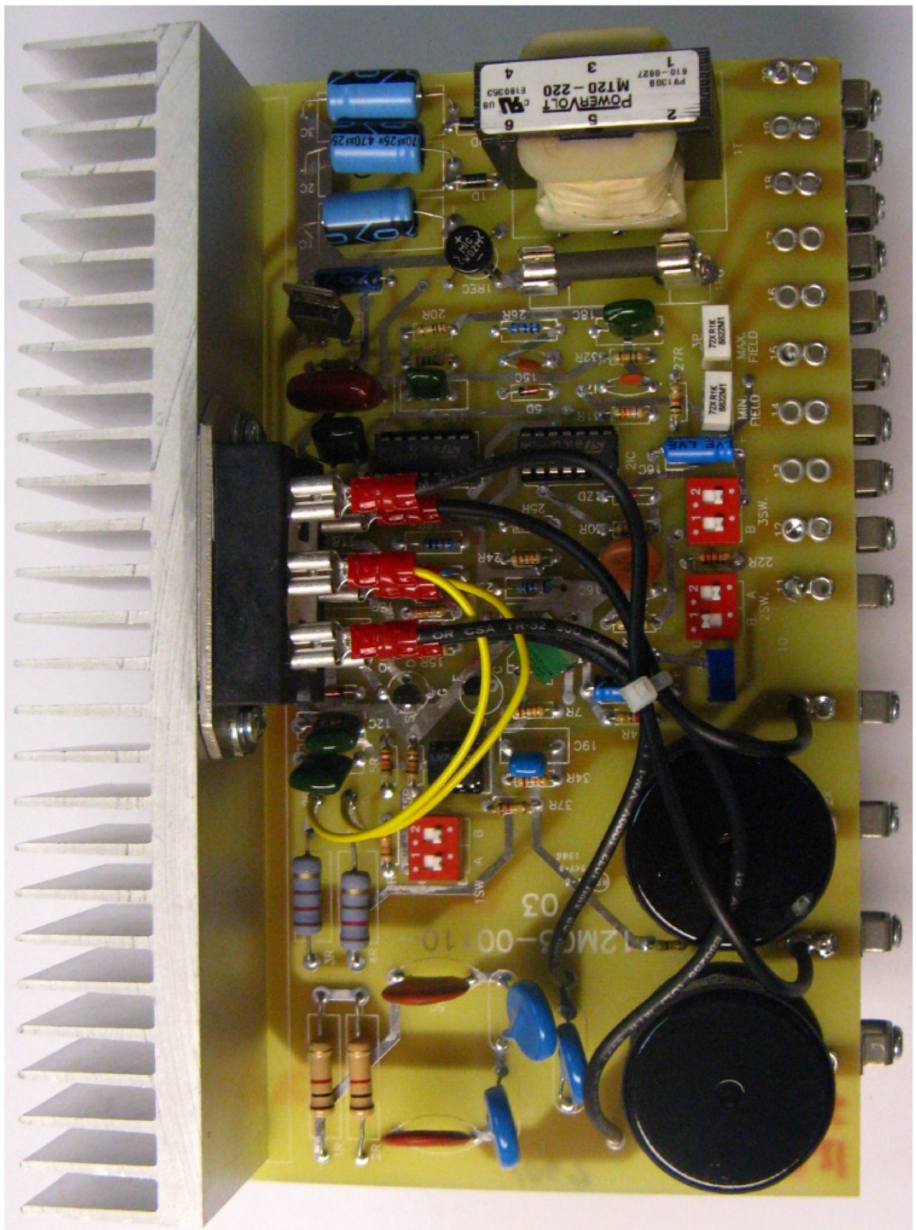
Trouble-shooting Manual

MODEL 216 SINGLE PHASE POWER CONVERTER

PART NUMBER 12M03-00110-03



GEMINI MODEL 216 SINGLE PHASE POWER CONVERTER

PART NUMBER 12M03-00110
SCHEMATIC DIAGRAM 12M03-00110-03

I. SPECIFICATIONS

SUPPLY:

- Single Phase, 50/60 Hz
- Control, 120 volts AC ± 10%
- Power, 120, 240, 480 volts AC (intermediate voltages with external calibration).

AMBIENT TEMPERATURE:

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

ALTITUDE:

- to 3300 feet above sea level (unless derated)

POWER OUTPUT:

- 10 amperes DC, inductive load
- 9 amperes DC, resistive load
- 7 amperes DC, armature load
- voltage to 88% of AC supply

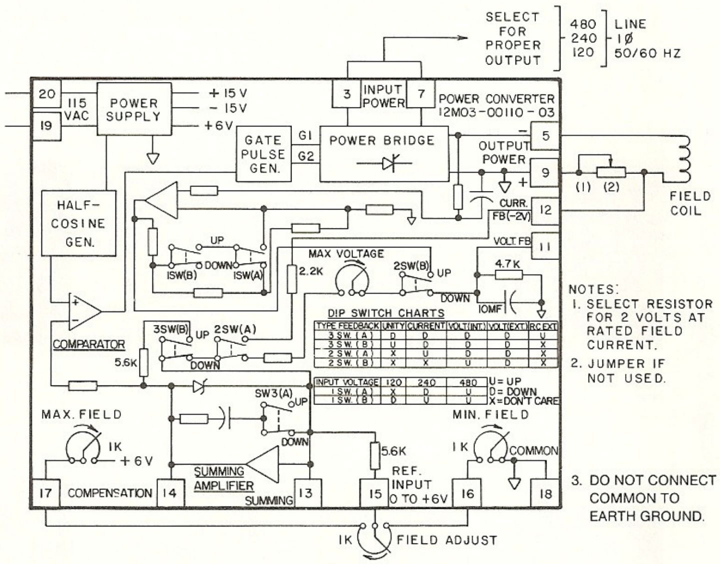


FIGURE 1. SIMPLIFIED SCHEMATIC

INPUTS:

A. Reference — 0 to +6 volts DC at terminal 15 or 0 to 1 mA nominal at terminal 13.

B. Firing Control — Operational Amplifier with Summing Junction and Output connected to external terminals for components as required to modify gain and feedback compensation. The amplifier is connected in an inverting configuration and causes firing of a thyristor power circuit when the input has a net positive value.

FEEDBACK:

Selectable: Open Loop or Closed Loop — Current or Voltage

NOTE: Switch SW3(A) is normally closed, but may be opened if an external R-C network is connected between terminals 13 and 14 for a different gain vs. frequency characteristic.

II. THEORY OF OPERATION

The Reflex® Single Phase Power Converter is a compact, rugged, adjustable voltage DC power supply for highly inductive fields or resistive loads and consists of several elements as shown in the simplified schematic diagram (Figure 1.)

1. Power Supplies
2. Half-Cosine Generator
3. Summing Amplifier
4. Comparator and Gate Drive
5. Power Bridge

1. **Power Supplies** — The power supply uses a transformer with two 10 volt secondary windings. One winding together with a bridge rectifier and a 470 MFD filter capacitor supplies a nominal +15 volts DC to the emitter of gate drive transistor 3Q.

   The other 10 volt winding together with half-wave diodes 1D and 2D and 470 MFD filter capacitors furnishes an unregulated +15 and −15 volts with respect to circuit common. Additionally a +6 volt regulated reference voltage is obtained from the +15 volt supply, using a positive voltage regulator 3IC and a 10 MFD filter capacitor.

2. **Half-Cosine Generator** — If the relationship between firing angle and DC output of a single phase controlled rectifier bridge is analyzed, it is found that:

   $$V_{dc} = .45\ E_{ac}\ (1 + \cos a) \qquad \text{EQ. 1}$$

   Where "V_{dc}" is the average DC value for a given half cycle of the AC wave, "E_{ac}" is the RMS value of the AC waveform, and "a" is the firing angle. Therefore, when a cosine relationship between input firing signal and firing angle is established, the DC output will be a linear function of the input signal. This feature allows accurate open loop control of output voltage, simplifies closed loop analysis and improves performance.

   The integrator 1IC(A) receives a nominal 10 volts AC from the power supply transformer and using a 220K ohm resistor and .047 MF capacitor for scaling, produces a nominal 2.5 volt cosine wave for 60 Hz and 3.0 volts for 50 Hz.

Because of the full-wave nature of the power bridge, a half-cosine wave is needed for each of the half cycles of the AC line. This requirement is accomplished by 1IC(D), an op-amp with a gain of one that can be switched between non-inverting and inverting by field-effect switching transistor, 1Q. The switching is performed at the zero crossing of the AC line.

To maintain purity of the half-cosines, the switching from inverting to non-inverting must not be affected by line noise spikes. For this reason, op-amp 1IC(B) performs a second integration on the cosine wave to produce a –sine wave, almost perfectly pure because of the double integration. 1IC(C) acts as a comparator to determine the zero crossings and to operate the FET switch accordingly.

To add the "1" to the cosine wave to obtain the (1+cos) function, a peak detector, 2IC(B), determines the negative peak of the half-cosine waves, and adds it to the waves. The DC "1" is stored in a 1 MF capacitor, which is allowed to discharge slowly to allow the circuit to follow line voltage or frequency variations. The final resulting waveform is connected to one input of the Comparator 2IC(C).

3. **Summing Amplifier** — The firing command signal is generated by summing op-amp 2IC(D) in response to a number of options selected by a DIP switch on the printed circuit board as shown by the chart on the schematic diagram. In any case, a reference signal is selected by the Field Adjust potentiometer from the regulated +6 volts, or other positive external reference. This signal is fed to the op-amp, and the result is determined by the nature of the feedback. Control is of three types:

   a) **Unity** — in this mode, the op-amp is programmed to have a nominal gain of one, and the system acts basically open loop. Because the magnitude of the cosine wave is inversely dependent on frequency, the magnitude of reference for a given output is 20% greater for 50 Hz than for 60 Hz. This difference can be compensated for by the Max Field potentiometer, 3P.

   b) **Field Current Feedback** — When field current feedback is selected, a resistor in series with the field is used to develop 2 volts at rated field current, and this signal acts as feedback. In this mode, line frequency does not affect field current, nor does heating of the field windings. This type of feedback is not recommended for resistive loads, since the filtering action of the inductive field is not present, and the ripple content of the feedback signal may overload the op-amp. Since a resistive load does not normally change appreciably with temperature, the field voltage feedback option is recommended.

   c) **Field Voltage Feedback** — Voltage feedback for line voltages of 120, 240 and 480 can be selected by the feedback selector. In this mode, DC output voltage is controlled in response to the input reference. Output is unaffected by supply voltage or frequency or changes in load, but field current will diminish as the field winding temperature increases.

4. **Comparator and Gate Drive** — The firing command signal from 2IC(D) is compared to the (1+cos) wave by op-amp 2IC(C), acting as a voltage comparator. Its output drives a pair of transistors 2Q and 3Q, to produce gate drive to the thyristors in the power bridge, 2REC. If the command signal is positive, no gate drive appears. As it moves negative, gate signals occur earlier and earlier in the half cycle until full conduction occurs when the command signal is more negative than the negative peaks of the (1+cos) wave.

5. **Power Bridge** — The power circuitry uses a conventional bridge rectifier with two controlled legs, and a free wheeling diode. Line reactors, a MOV surge suppressor, and RC networks protect the bridge from line voltage transients.

III. BENCH TEST — Refer to Simplified Schematic Diagram (Figure 1)

1. Connect "Feedback Selector" to Field Voltage (INT) position.
2. Connect "Input Voltage" selector to the 120 volt position.
3. Connect jumpers between terminals 3 and 19 and between terminals 7 and 20.
4. Connect a 1K "Field Adjust" potentiometer as shown to terminals 15, 16 and 17.
5. Turn "Max Field" potentiometer full CW, and "Min Field" potentiometer full CCW.
6. Connect 115 volts AC (nominal) to terminals 3 and 7.
7. Measure 0 to 105 volts DC between terminals 9(+) and 5(–) as the Field Adjust potentiometer is turned CCW to CW.
8. If the result is not as described in step 7, go on to the VOM and Oscilloscope checks described elsewhere in this manual.

Symbol	Part #	Description (Acceptable Substitute) *
1T	04P01-00001	Transformer - 120V AC PRI, two 10V AC SEC @ 220mA (Signal-PC20-220)
1X, 2X	04P06-00010	Reactor - 100 UH, 14A (Renco-RL-1256-4-100)
1-3SU	05P07-00002	MOV - 780 volt breakover (GE-V480LA20A)
1REC	05P01-00003	Rectifier Bridge - 50V, 1A (EDI-PF50)
2REC	05P06-00009	Thyristor Bridge - 1200V, 25A Gentron T514F-2)
1D, 2D	05P01-00001	Diode - Medium Power, 1A, 400 PIV (1N4004)
3D, 4D, 5D	05P02-00001	Diode - Signal, 50 mA, 200 PIV (1N4148)
1ZD	05P03-00005	Zener Diode - 6.8V, 500mW 10% (1N5235B)
1Q	05P05-00001	Transistor - N Channel JFET (2N4093)
2Q	05P04-00002	Transistor - NPN, Small Signal (2N3392)
3Q	05P04-00009	Transistor - PNP, Darlington (GE-D41K1)
1IC, 2IC	05P08-00002	Quad Op-Amp (TI-TL084)
3IC	05P08-00006	+6 Volt Regulator (7806)
4IC	05P08-00011	Op-Amp (LM741)
1P	02P04-10301-00	Potentiometer - 10K, ½W (Beckman-72XR10K)
2P, 3P	02P04-10201-00	Potentiometer - 1K, ½W (Beckman-72XR1K)
1F	08P99-00025	Fuse - ½A, 250V (Littlefuse 102071)
1C, 2C, 3C	03P01-47102-01	Capacitor - 470MF, 25V, Electrolytic
4C, 5C	03P06-20399-00	Capacitor - 0.2MF, 1000V, Ceramic
6, 9, 10C	03P01-10001-00	Capacitor - 10MF, 16V, Electrolytic
7C	03P07-10510-00	Capacitor - 1.0MF, 100V, Film

Symbol	Part #	Description (Acceptable Substitute) *
8C	03P03-10503-00	Capacitor - 1.0MF, 35V, Tantalum
11, 12, 13, 18C	03P07-10410-00	Capacitor - 0.1MF, 100V, Film
14C	03P07-47310-00	Capacitor - 0.047MF, 100V, Film
15C, 17C	03P06-10205-00	Capacitor - 0.001MF, 50V, Ceramic
16C	03P06-50305-00	Capacitor - 0.05MF, 50V, Ceramic
19C	03P07-22410-00	Capacitor - 0.22MF, 100V, Film
1R, 2R	01P01-10203-02	Resistor - 1K, 2W, 5%
3R, 4R	01P01-12103-02	Resistor - 120 OHM, 2W, 5%
5R	01P01-22300-02	Resistor - 22K, ¼W, 5%
6R	01P01-39300-02	Resistor - 39K, 1W, 5%
8R, 32R	01P01-10400-02	Resistor - 100K, ¼W, 5%
9, 10, 17, 18, 26R	01P02-10031-01	Resistor - 100K, ½W, 1%
11, 21, 22R	01P01-22200-02	Resistor - 2.2K, ¼W, 5%
12R	01P01-27300-02	Resistor - 27K, ¼W, 5%
13R	01P01-22400-02	Resistor - 220K, ¼W, 5%
14R	01P01-47200-02	Resistor - 4.7K, ¼W, 5%
15R	01P01-15200-02	Resistor - 1.5K, ¼W, 5%
16R	01P01-33100-02	Resistor - 330, ¼W, 5%
19R	01P01-22500-02	Resistor - 2.2M, ¼W, 5%
20R	01P01-10500-02	Resistor - 1.0M, ¼W, 5%
23R	01P02-20031-01	Resistor - 200K, ½W, 1%
24R	01P01-15300-01	Resistor - 15K, ¼W, 5%
25, 31R	01P01-68300-02	Resistor - 68K, ¼W, 5%
27R	01P01-10200-02	Resistor - 1K, ¼W, 5%
28R, 29R	01P01-56200-02	Resistor - 5.6K, ¼W, 5%
7, 30, 33, 34R	01P01-10300-02	Resistor - 10K, ¼W, 5%
35, 36R	01P01-47400-02	Resistor - 470K, ¼W, 5%
37R	01P01-12400-02	Resistor - 120K, ¼W, 5%

* OR EQUAL

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VOM and OSCILLOSCOPE CHECKS

This information pertains to the printed circuit board 12M03-00110 (Single Phase Power Converter), and Schematic Diagram 12M03-00110-03.

The Schematic, Voltage Checks, Waveforms, Theory of Operation and Component List will aid in trouble shooting the circuits.

ONLY QUALIFIED PERSONNEL ACQUAINTED WITH ELECTRICAL SAFETY PROCEDURES SHOULD SERVICE THE CONTROLLER.

When checking voltages, a good quality 20,000 ohm/volt meter is required. When checking waveforms, use a good quality DC scope capable of at least 2 megahertz bandwidth. All measurements are referenced to circuit common (Terminal 18).

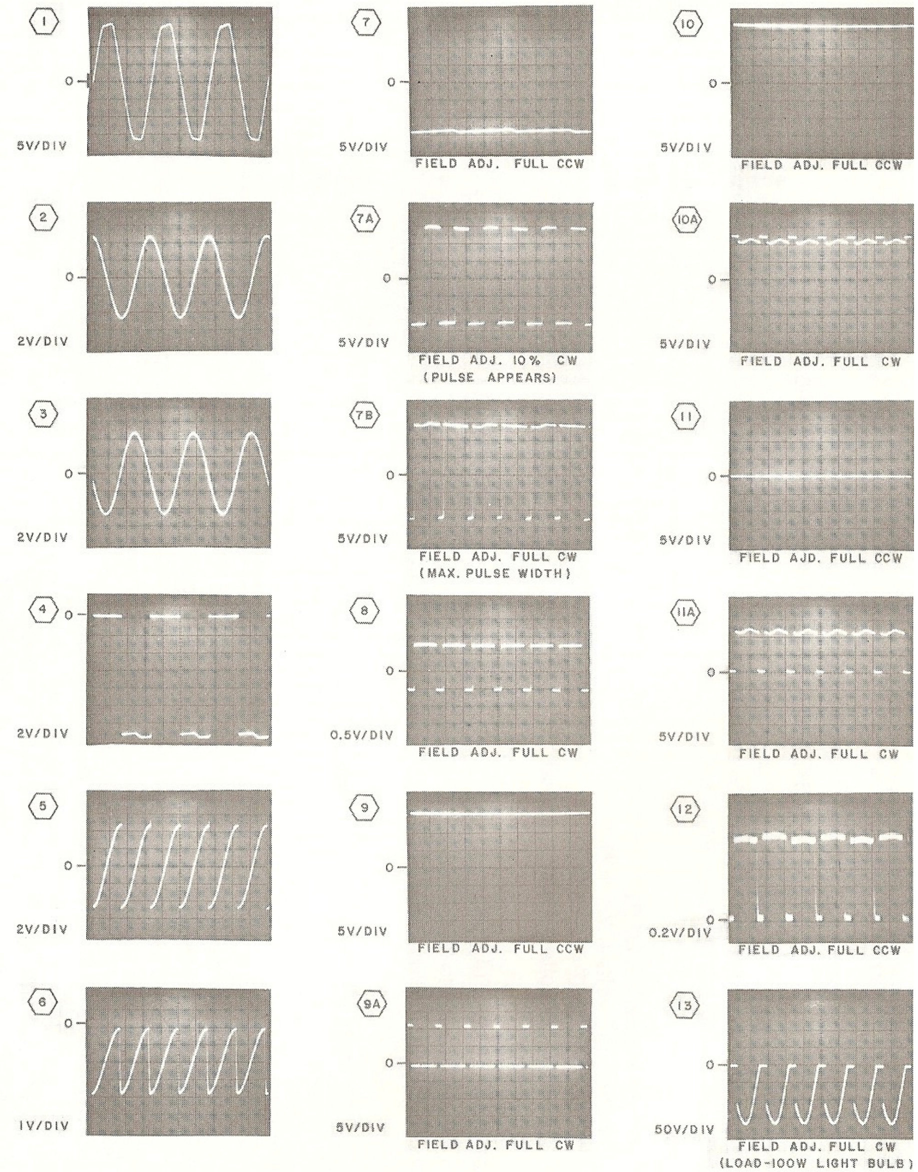
Caution should be observed when checking the integrated circuits and transistors. To avoid damage to the components, do not short out adjacent pins with the probe.

Voltage Required (use the Schematic Diagram for reference purposes, complete the Bench Test listed on the reverse side before proceeding).

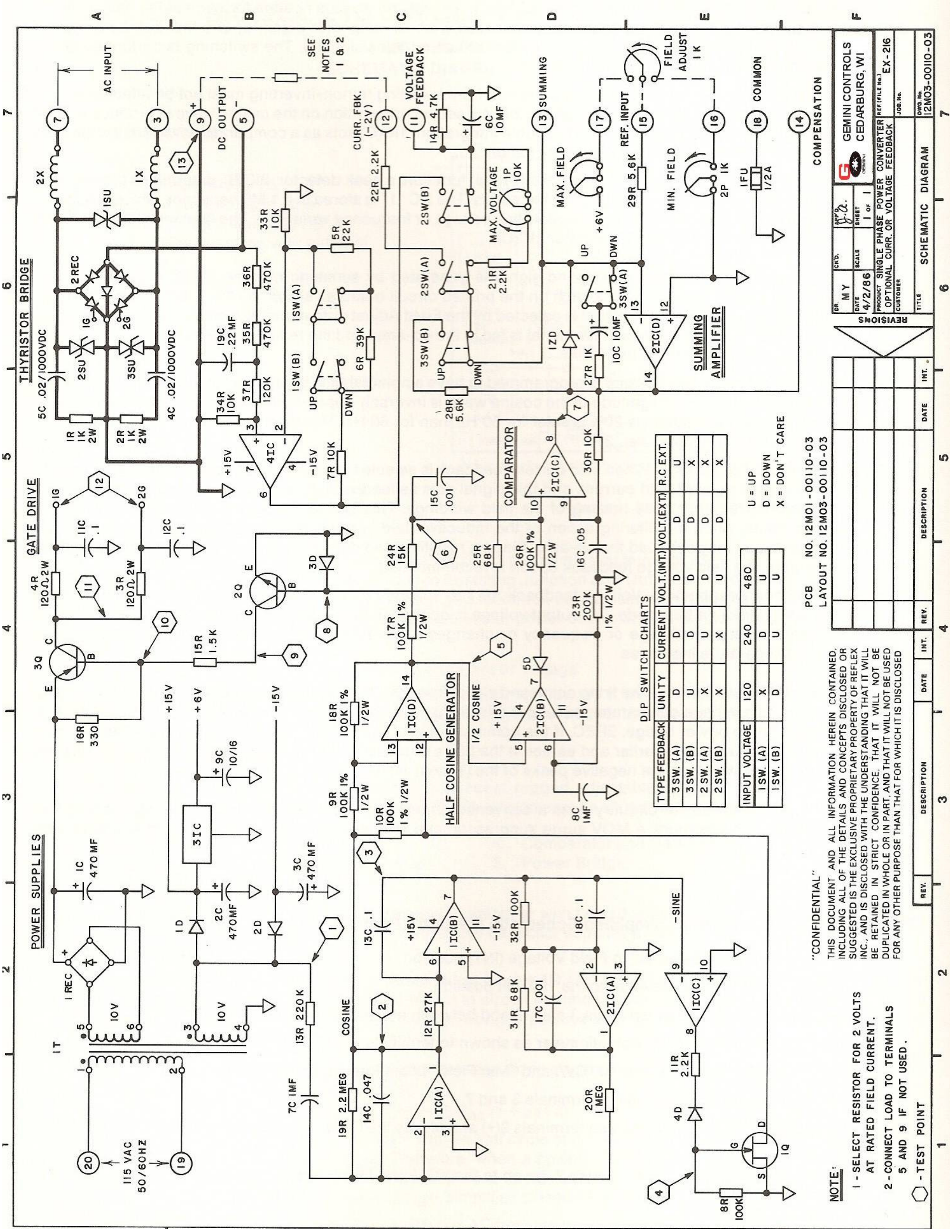
1. Determine if supply voltage (Terminals 3 and 7) is proper. If voltage is not present, check all fuses and disconnect devices.
2. The primary voltage of 1T (Terminals 19 and 20) should be 115V AC (and connected to the same AC phase as Terminals 3 and 7).
3. The secondary voltage of 1T (leads #5 and 6) should be 10V AC. Readings can be taken at the AC input to 1 REC.

   The secondary voltage of 1T (leads #3 and 4) should also be 10V AC. Readings can be taken from the cathode of diode 2D to circuit common (Terminal 18).
4. +15V DC between the positive end of capacitor 1C and Terminal 18(–).
5. –15V DC between the negative end of capacitor 3C and Terminal 18(+).
6. +6V DC between Terminal 17 and Terminal 18(–).
7. 0 to +6V DC between Terminal 15 and Terminal 18(–) as Field Adjust pot is turned clockwise (leave Max Field adjust fully CW, Min Field CCW).
8. Measure 0 to 88% of AC supply voltage between Terminals 9(+) and 5(–) as the Field Adjust potentiometer is turned CCW to CW.
9. Perform scope test in the order indicated (see Figure 2). If a dual trace scope is used, leave channel one on Test Point 1, and perform subsequent tests with channel two to compare phase relationships. Set trigger on channel one.

FIGURE 2 - OSCILLOSCOPE WAVEFORMS



NOTES: 1 - TIME BASE - 5.0MS/DIV, DC COUPLED
2 - ⬡ - TEST POINT



DIP SWITCH CHARTS

TYPE FEEDBACK	UNITY	CURRENT	VOLT.(INT.)	VOLT.(EXT.)	R.C EXT.
3 SW. (A)	D	D	D	D	U
3 SW. (B)	U	D	D	D	X
2 SW. (A)	X	U	D	D	X
2 SW. (B)	X	X	U	D	X

INPUT VOLTAGE	120	240	480
1 SW. (A)	X	D	U
1 SW. (B)	D	U	U

NOTE:
1 - SELECT RESISTOR FOR 2 VOLTS AT RATED FIELD CURRENT.
2 - CONNECT LOAD TO TERMINALS 5 AND 9 IF NOT USED.
⬡ - TEST POINT