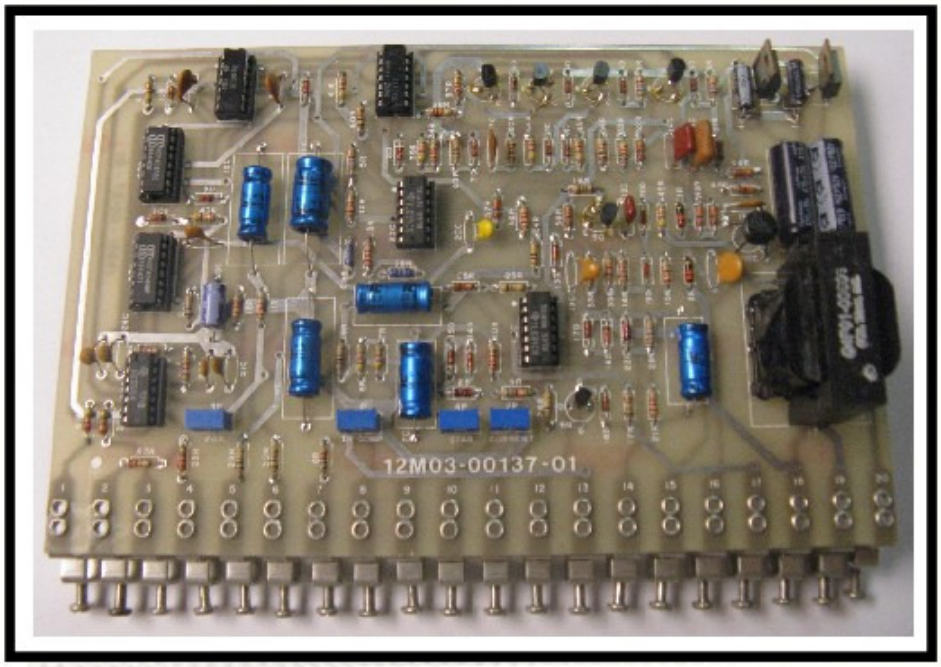
Trouble-shooting Manual
MODEL 247 TWO QUADRANT FIRING CIRCUIT
PART NUMBER 12M03-00137-01



BENCH TEST

TEST MATERIAL REQUIRED:

1 – Dual Trace Oscilloscope (Tektronix 2213 or equal)
1 – DVM (Beckman HD-110 or equal)
1 – 5K Potentiometer
1 – 47K Resistor
1 – 22K Resistor
1 – 10K Resistor
1 – 6.8K Resistor
1 – 115V AC Line Cord with spade lugs one end
1 – 100-300V DC Power Supply
8 – Clip Leads

1. Connect a jumper between terminals 9 and 10. Connect the CW end of 5K potentiometer to terminal 14, CCW end to terminal 18 and wiper to terminal 7. Connect 6.8K resistor between terminals 11 and 12. Connect a 10K resistor between terminals 13 and 18. Connect a 22K resistor to terminal 13 and leave the other end open. Connect a 47K resistor between terminals 8 and 9.
2. Turn the 5K potentiometer full CW and on the printed circuit board. Turn the Max Speed and Current Limit potentiometer full CW. Turn IR Comp and Stability full CCW.
3. Apply 115V AC to terminals 19 and 20.
4. Jumper the open end of the 22K resistor to terminal 14. Observe pulses on terminals 1-4, with terminal 1 and 2 or 3 and 4 180º out of phase and pulses 16.4 milliseconds apart. Terminals 1 and 3 or 2 and 4 will be identical.
5. Connect the oscilloscope to terminals 1 and 2. Remove the jumper on the 22K resistor to terminal 14 and pulses should disappear.
6. Jumper terminals 16 and 17. Two pulse trains will appear 180º out of phase. The pulse trains will have 4 pulses 2 milliseconds apart with an off period of 10 milliseconds between pulse trains. Each pulse will last 6.5 milliseconds. Note: All times are nominal values and may vary slightly.
7. Turn the 5K potentiometer CCW. The number of pulses should decrease to zero. Return to full CW.
8. Turn Current Limit potentiometer CCW. The number of pulses should decrease to zero. Return potentiometer to full CW position.
9. Connect the DC power supply to terminals 5 and 6 with positive on terminal 6. Set the output for 200V DC. Turn the Max Speed potentiometer CCW until the number of pulses decreases to zero. Return the potentiometer to full CW position.
10. With 200V DC still on terminals 5 and 6, jumper the open end of the 22K resistor to terminal 14 and turn the 5K potentiometer CCW until the last adjustable pulse lines up with the stationary pulse. Turn IR Comp potentiometer full CW and the adjustable pulse should advance 2.5 milliseconds nominally from the fixed pulse.
11. Remove the 200V DC from terminal 6. Wait 1 second then reapply the voltage to terminal 6 while watching the pulses on terminals 1 and 2. The number of pulses should decrease to 2, then return to the original number. Turn Stability full CW and repeat the procedure. This time the pulses will decrease at a faster rate and will decrease to only 1 before returning to normal.

GEMINI MODEL 247 TWO QUADRANT FIRING CIRCUIT

PART NUMBER 12M03-00137-01

SCHEMATIC DIAGRAM 12M03-00137-01

I. SPECIFICATIONS

SUPPLY:

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

AMBIENT TEMPERATURE:

- 0º to 40ºC (32º to 104ºF)
- 50ºC in cabinet

INPUTS:

- To Current Regulator:
  Reference: 0 to negative 6 volts DC into a Current Limit Potentiometer at terminal 10 or negative 1mA into an op-amp summing junction at terminal 12.

  Current Feedback: 0 to positive 2 volts DC into terminal 13 at the desired maximum current.
- To Speed (Voltage) Regulator:
  Reference: 0 to positive 6 volts DC at terminal 7 or 0 to +1mA into op-amp summing junction at terminal 8.

  Voltage Feedback (Optional): 0 to 180 volts DC nominal at terminals 5 and 6.

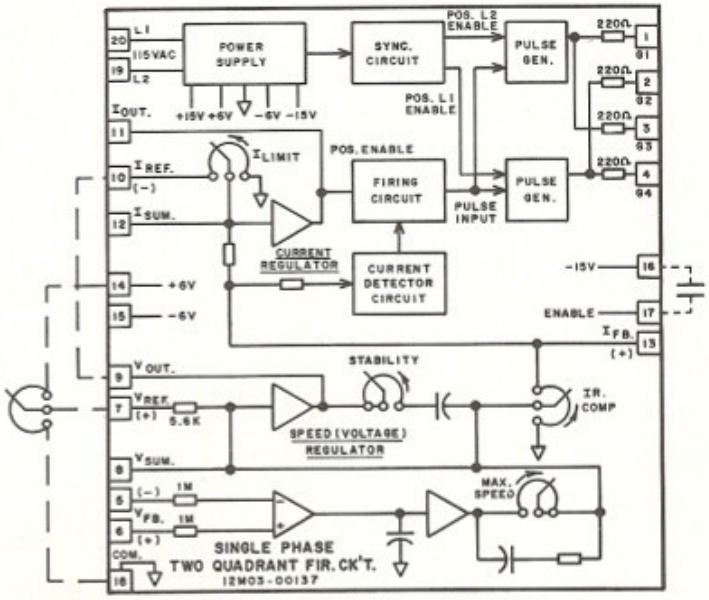


FIGURE 1. SIMPLIFIED SCHEMATIC

OUTPUTS:

- Voltage Regulator Output: 0 to negative 7 volts nominal at terminal 9, usually connected to terminal 10 as the Current Regulator Reference.
- Four pulse outputs, one for firing each thyristor in a four thyristor bridge or two thyristors when used with a center-tapped transformer. Outputs cannot be connected directly to the thyristors, but must be isolated and amplified as required.
- Pulse output is 0 to 12 volts open circuit nominal with a 220 ohm output resistance.
- Positive and negative regulated 6 volts are available at terminals 14 and 15 respectively as reference signals.

ADJUSTMENTS:

- Stability
- Maximum Speed
- Current Limit
- IR Compensation

GENERAL SPECIFICATION:

The Reflex® Two Quadrant Firing Circuit is designed to control the outputs of single phase thyristor circuits such as the Reflex® Model 254 that are capable of two quadrant operation. The basic circuit is a current regulator, with optional features of voltage feedback with IR drop compensation for use as a simple speed controlled DC Motor Drive. Additional input terminals are provided for use in more complex systems, or for control of other variables such as Torque or Position.

II. THEORY OF OPERATION

Any two quadrant single phase thyristor controller requires certain basic elements to function properly without damage to itself or the connected load. These are:

1. The circuit must be able to differentiate between the two half cycles of the AC line waveform. This is similar to phase sequence in a three phase system.
2. During circuit operation in a regenerative mode with continuous conduction, it becomes necessary to transfer or commutate the load current from one pair of thyristors to another pair. If this is not accomplished, a condition known as "Inversion Fault" or "Commutation Failure" occurs. Under these circumstances excessive voltage is applied to the load with corresponding excessive load current. While this excessive current may not be destructive, it does interfere with normal operation.

   Prevention of such faults is generally accomplished by including an "End Stop" firing signal near the end of each half cycle. Operation at discontinuous conduction where the armature current goes to zero during each half cycle, as occurs with light loading at high speeds, is not compatible with such as End Stop Pulse. Correct design procedures therefore require that the End Stop signal appears only during continuous conduction.

The REFLEX® firing circuitry contains the necessary elements to avoid the problems discussed above. The control consists of the following elements as shown on the Schematic Diagram and Figure 1.

1. Power Supply
2. Synchronizing Circuit
3. Current Regulator
4. Current Detector
5. Firing Circuits
6. Pulse Generators
7. Speed (Voltage) Regulator

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 470MF filter capacitors to provide a nominal positive and negative unregulated 15 volts DC with respect to the transformer center-tap which is connected to circuit common.

   Additionally, a regulated positive and negative 6 volts is obtained from the positive and negative 15 volt supplies using regulators 1VR and 2VR each with a 10 MF filter capacitor.

2. **Synchronizing Circuit** — The synchronizing circuit uses AC voltage from the secondary of the Power Supply transformer to generate a variety of logic signals, timed with specific relationship to the AC line. Refer to the Logic Diagram, Figure 2, for the timing details.

   Transistors 1Q and 2Q receive signals from the secondary windings through resistors 46, 47, 51 and 52R and act as switches that turn on and off at the zero crossing of the AC waveform. Resistors 3R and 4R, modify the timing so that the switching action occurs slightly before and slightly after the zero crossing. Figure 2 shows these logic signals as "A" and "B."

   Diodes 3D and 4D act as an "AND" gate to provide logic signal "C" also shown in figure 2. The positive transition of logic signal "C" is detected by capacitor 17C, resistors 63R, and diode 70D. After passing through comparator 2IC(D) it becomes logic signal "C" which is a well-defined pulse occurring just prior to the end of each half cycle. This pulse will be used as the "End Stop" signal when such signal is required.

   Transistors 3Q and 4Q form a switching circuit identical to 1Q and 2Q but the input to these two transistors is phase-retarded by 30 to 40 degrees because of capacitor 14C. Logic signals "D" and "E" result from the switching action.

   Logic Signals "A" and "B" in combination with logic signals "D" and "E" are used to determine firing intervals for pairs of thyristors corresponding to alternate half-cycles of the AC waveform. Signals "A" and "D" are combined through "NAND" gate 3IC(A) to provide Logic Signal "G." Logic Signal "G" provides a measure of the entire range of permissible firing times for the thyristor(s) that can conduct during the time when line L2 is positive with respect to L1. This "G" signal is applied to the enable input (pin 4) of one of the Pulse Generators.

   Similarly, Logic Signal "I" is derived from Logic Signals "B" and "E" to determine firing intervals when line L1 is positive with respect to L2.

3. **Current Regulator** — The current regulating amplifier 1IC(C) compares a reference signal from either the Current Limit Potentiometer, or a signal fed direct to the summing junction, to a feedback signal of nominally 2 volts at terminal 13. The amplified error between these two signals appears at pin 8 and becomes the input to the voltage controlled oscillator of the firing circuit.

   To allow operation of the Current Regulator, a negative 15 volts from any source with respect to circuit common must be applied to terminal 17. When this voltage is removed, field-effect switching transistor 6Q conducts, clamping the output of the current regulator to zero.

4. **Current Detector** — The same signal used as current feedback is also used to detect when the thyristor converter is conducting. The filter consisting of 19R and 6C eliminates any high frequency noise signals and also provides a slight delay to the current signal which "fools" the Current Detector into believing that the current is still flowing for a slight period after it is stopped.

   After filtering, the signal is amplified by a factor of 10 to 1 and provided to comparator 1IC(D). The output of this comparator provides a logic signal which indicates bridge output current. The use of this logic signal will be described below.

5. **Firing Circuits** — Each firing circuit utilizes two parts — a Voltage Controlled Oscillator and a Digital Counter. Each firing circuit is designed to work with one half cycle of the AC waveform. Because the range of possible firing angles extends for more than one-half cycle of the AC Waveform, it is necessary to have a separate pulse-generating circuit for each half-cycle. The Digital Counters perform this function. The Voltage Controlled Oscillator delivers pulses to both Counters simultaneously.

   "NOR" Gates 4IC(C) and (D) work to provide pulses from either of the Counters described above, or from the "End Stop" pulse generator with its output signal "C." In the absence of load currents the End Stop Pulse does not pass through to the Pulse Generator for either half of the bridge. If current is flowing in a given half of the bridge at the time the End Stop Pulse appears, then the End Stop Pulse is passed through to the pulse generators for that half of the bridge to insure commutation from one half of the bridge to the other. This avoids the "Inversion Fault" and still allows operation past 180° when current is not flowing.

6. **Pulse Generator** — The Pulse Generator consists of a dual timing circuit connected as a one-shot multivibrator.

   Synchronizing signals "G" and "I," as described in the synchronizing discussion, are used to enable either section of the dual timer (pins 4 and 10).

7. **Speed (Voltage) Regulator** — The Speed Regulator is a conventional regulating circuit that compares ε .ero to positive 6 volt reference input at terminal 7 to an armature voltage feedback signal developed by amplifiers 2IC(A) and (B). Amplifier 2IC(B) is a differential isolation amplifier that allows measurement of armature voltage with high common-mode rejection at an impedance level of one megohm.

   IR Compensation is provided to increase the armature terminal voltage under load while motoring and to reduce it while regenerating in order to maintain relatively constant speed.

COMPONENT LIST — ASSEMBLY #12M03-00137-01

Symbol	Part #	Description (Acceptable Substitute) *
1T	04P01-00001	Transformer - 120V AC PRI, two 10V SEC @ 220mA (Signal-PC20-220)
1REC	05P01-00003	Rectifier Bridge - 50V, 1A (EDI-PF50)
1,2ZD	05P03-00005	Zener Diode - 6.8V, 500mW
1-20D	05P02-00001	Diode, Signal - 50mA, 200PIV (1N4148)
1VR	05P08-00006	Positive 6 Volt Regulator (7806)
2VR	05P08-00007	Negative 6 Volt Regulator (7906)
1-4Q	05P04-00002	Transistor, NPN, Small Signal (2N3392)
5Q	05P04-00001	Transistor, PNP, Small Signal (2N3638A)
6Q	05P05-00001	Transistor, N Channel JFET (2N4093)
1-2IC	05P08-00002	Quad Op-amp, BIFET (TI-TL084)
3IC	05P09-00011	Quad NAND Gate (4011)
4IC	05P09-00001	Quad NOR Gate (4001)
5IC	05P08-00008	Dual Timer (National LM556)
6,7IC	05P09-00004	Binary Counter, 12 Bit (4040)
1-3P	02P04-10301-00	Potentiometer, 10K, ½W (Beckman-72XR10K)
4P	02P04-50301-00	Potentiometer, 50K, ½W (Beckman-72XR50K)
1,2C	03P01-47102-01	Capacitor, 470MF, 25V, Electrolytic
3,4C	03P01-10001-00	Capacitor - 10MF, 16V, Electrolytic
5C	03P01-25001-00	Capacitor - 25MF, 16V, Electrolytic
6-8C	03P02-10002-00	Capacitor - 10MF, 25V, NP, Electrolytic
9,10C	03P02-50001-00	Capacitor - 47MF, 16V, NP, Electrolytic
11C	03P02-10101-00	Capacitor - 100MF, 16V, NP, Electrolytic
12C	03P07-33210-00	Capacitor - 0.0033MF, 100V, Film
13C	03P07-10310-00	Capacitor - 0.01MF, 100V, Film
14C	03P07-22410-00	Capacitor - 0.22MF, 100V, Film
15,16C	03P06-50305-00	Capacitor - 0.047MF, 50V, Ceramic
17C	03P06-47105-00	Capacitor - 470PF, 50V, Ceramic
18,19C	03P06-10105-00	Capacitor - 100PF, 50V, Ceramic
20C	03P06-10005-00	Capacitor - 10PF, 50V, Ceramic
21-24C	03P06-10305-00	Capacitor - .01MF, 50V, Ceramic
25,26C	03P06-10205-00	Capacitor - .001MF, 50V, Ceramic
1,2R	01P01-33000-02	Resistor - 33 Ohm, ¼W, 5%
3-5R	01P01-68200-02	Resistor - 6.8K, ¼W, 5%
6,7R	01P01-47200-02	Resistor - 4.7K, ¼W, 5%
8,9R	01P01-56200-02	Resistor - 5.6K, ¼W, 5%
10-13R	01P01-22000-02	Resistor - 2.2K, ¼W, 5%
14R	01P01-27200-02	Resistor - 2.7K, ¼W, 5%
15R	01P01-33100-02	Resistor - 330 Ohm, ¼W, 5%
16R	01P01-68300-02	Resistor - 68K, ¼W, 5%
17R	01P01-15300-02	Resistor - 15K, ¼W, 5%
18R	01P01-33200-02	Resistor - 3.3K, ¼W, 5%
19,20R	01P01-10100-02	Resistor - 100 Ohm, ¼W, 5%
21-23, 61,62R	01P01-22100-02	Resistor - 220 Ohm, ¼W, 5%
24-27R, 63R	01P01-10400-02	Resistor - 100K, ¼W, 5%
28-30R	01P01-10500-02	Resistor - 1M, ¼W, 5%
31,32R	01P01-12300-02	Resistor - 1K, ¼W, 5%
33R	01P01-47100-02	Resistor - 470 Ohm, ¼W, 5%
34-38R	01P01-22300-02	Resistor - 22K, ¼W, 5%
39-45R	01P01-47300-02	Resistor - 47K, ¼W, 5%
46-57, 60R	01P01-10300-02	Resistor - 10K, ¼W, 5%
58,59R	01P02-22120-01	Resistor - 22.1K, ½W, 1%

* OR EQUAL

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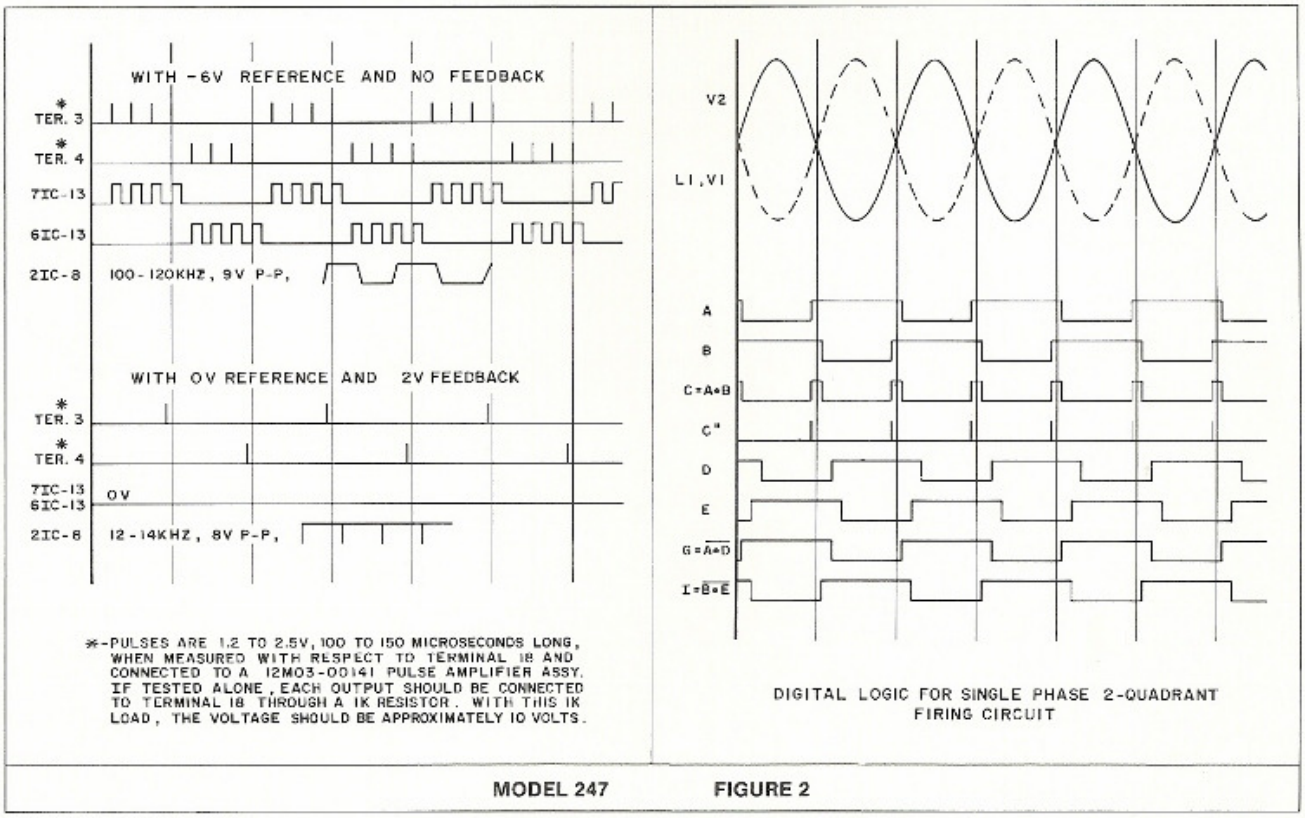
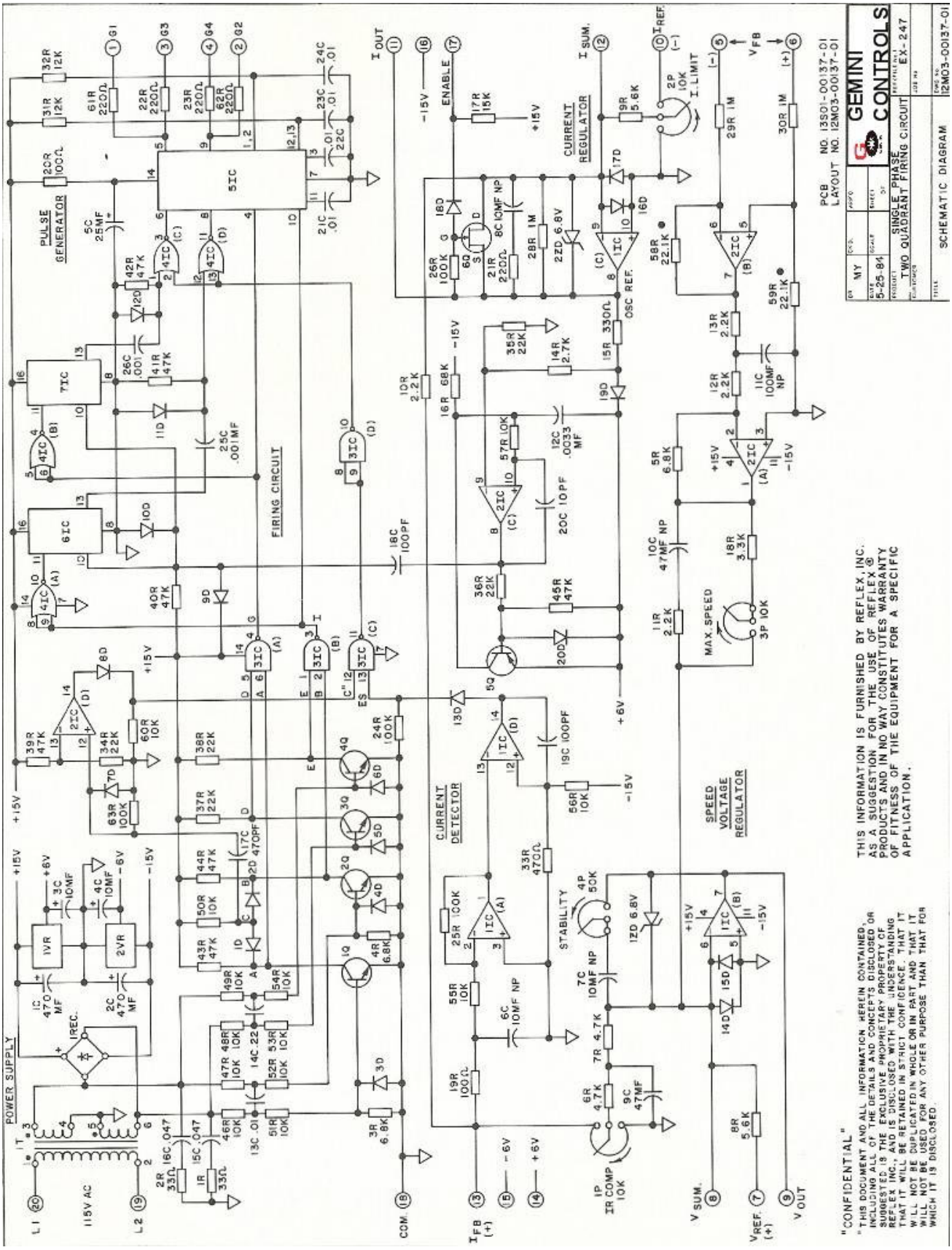
VOLTAGE CHECK

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 18 (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 should be 20V AC.
3. +15V DC nominal between the positive end of capacitor 1C and terminal 18 (common).
4. –15V DC nominal between terminal 16 and 18 (common).
5. +6V DC nominal (5.5 to 6.5V) between terminal 14 and 18 (common).
6. –6V DC nominal (5.5 to 6.5V) between terminal 15 and 18 (common).
7. Use an oscilloscope to verify that the digital logic signals appear as in Figure 2.



MODEL 247 FIGURE 2


GEMINI CONTROLS
SINGLE PHASE TWO QUADRANT FIRING CIRCUIT
SCHEMATIC DIAGRAM
EX-247
12M03-00137-01
PCB NO. 13501-00137-01
LAYOUT NO. 12M03-00137-01
5-25-84
MY
FIRING CIRCUIT
PULSE GENERATOR
POWER SUPPLY
CURRENT DETECTOR
SPEED VOLTAGE REGULATOR
CURRENT REGULATOR
I LIMIT
MAX. SPEED
STABILITY
ENABLE
OSC REF.
I OUT
I SUM.
I REF.
V FB
V SUM.
V REF.
V OUT
I FB
COM.
L1
L2
115V AC
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