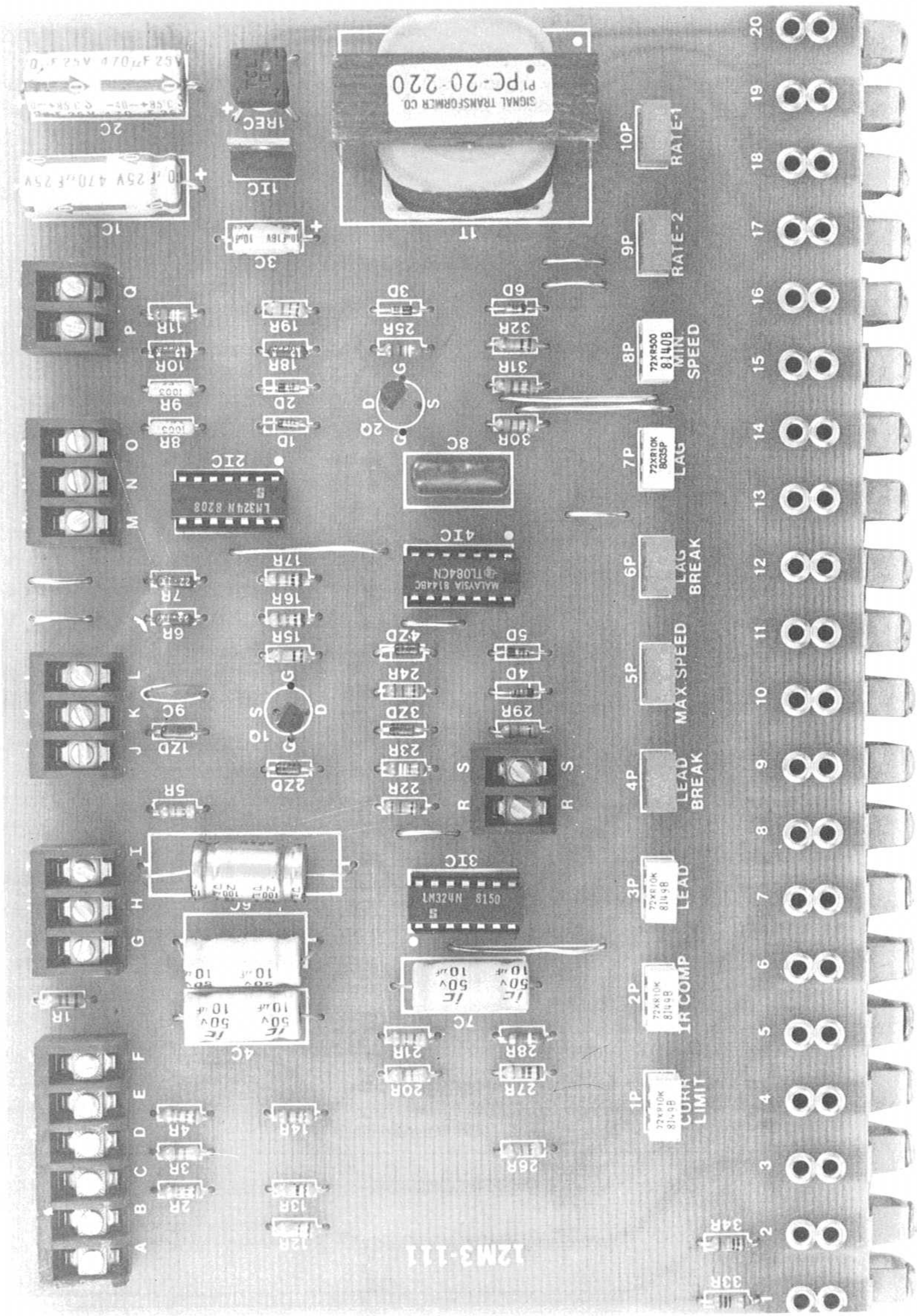
REFLEX®

Trouble-shooting Manual
MODEL 217 UNIVERSAL CLOSED-LOOP CONTROLLER
PART NUMBER 12M03-00111-01



REFLEX® MODEL 217 UNIVERSAL CLOSED-LOOP CONTROLLER

PART NUMBER 12M03-00111
SCHEMATIC DIAGRAM 12M03-00111-01

I. SPECIFICATIONS

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

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

REGULATION
- Armature voltage feedback 2% (adjustable to 0% with IR Comp adjustment)
- Tachometer Feedback, typical – ¼% maximum – ½% of full speed

DRIFT
- Armature Voltage Feedback – Depends on motor heating, normally 5-10%
- Tachometer Feedback – Depends on tachometer generator drift, typically ½%.

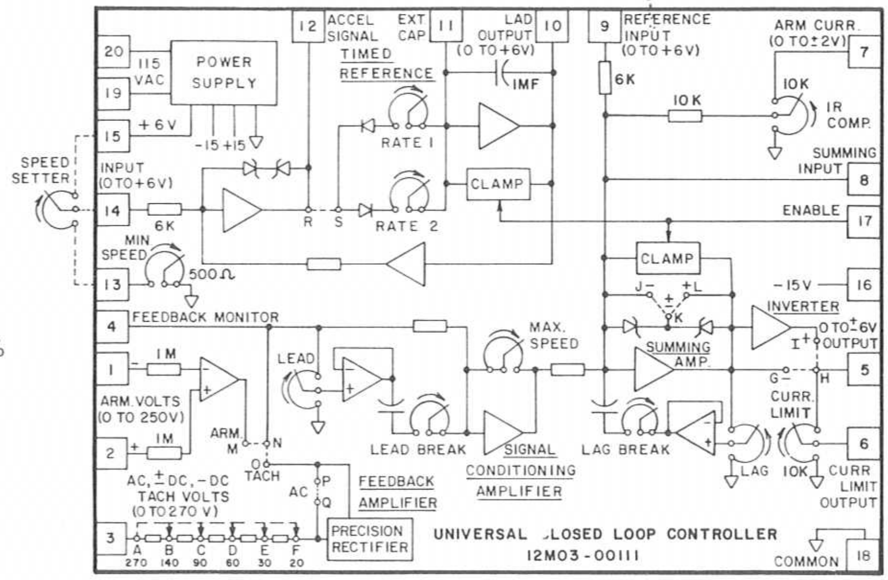


FIGURE 1. SIMPLIFIED SCHEMATIC DIAGRAM

RESPONSE
- Both Derivative and Integral Stability Adjustments are used to establish a gain versus frequency characteristic to satisfy most applications.

REFERENCE INPUT
- 0 to 6 volts DC at 0 to 1mA nominal

OUTPUT
- 0 to 6 volts at 0 to 5mA maximum

CURRENT LIMIT OUTPUT
- Adjustable from 0 to 6 volts nominal with internal 10K potentiometer

TIMING ADJUSTMENT RANGE
- ACCELERATION, 2-40 Sec.
- DECELERATION, 2-40 Sec.

} linear extendable with external capacitor

II. THEORY OF OPERATION

The Model 217 Universal Closed-Loop Controller is a versatile assembly for combining reference and feedback signals. It includes a ramp generator to convert step changes in reference input to a ramp output when needed. It also includes derivative and integral stability networks with a wide range of adjustment to establish a gain versus frequency characteristic to satisfy most applications.

It is normally used to drive a solid-state power converter either directly or in a minor feedback loop configuration. It can be used with armature voltage feedback from a three-phase thyristor power converter, reactor, DC generator or other power converter that provides easily filtered DC feedback. With the tachometer feedback option it can be used with DC, Eddy Current, AC adjustable frequency, AC adjustable voltage drives, or a Reduced Voltage Starter.

It consists of the following elements as shown in the Simplified Schematic Diagram (Figure 1):

1. Power Supply
2. Timed Reference
3. Feedback and Signal Conditioning Amplifiers
   a) Armature Voltage with IR Compensation
   b) Tachometer Voltage
   c) Lead Network
4. Summing Amplifier
   a) Amplifier
   b) Lag Network
5. Inverter

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 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 plus 6 volts is obtained from the positive 15 volt supply using regulator 1IC with a 10 MF filter capacitor.

2. **Timed Reference** – The Timed Reference section is basically a closed-loop feedback circuit in which the rate of change of output is controlled by internal adjustments. Normally the output and input voltages are equal. A change of the input reference causes an error on the input stage until the output, delayed with respect to time, is again equal to the input.

   When the input voltage at terminal 14 is changed, an error signal at the summing junction formed by reference scaling resistor 29R and feedback scaling resistor 24R exists at pin 9 of 4IC(C). 4IC(C) saturates in a direction determined by the polarity of the difference with its output voltage limited by diode clamps 3ZD and 4ZD.

   A signal that changes linearly with time is generated by the action of the op-amp 4IC(A) which charges or discharges capacitor 8C at a constant rate proportional to the magnitude of the current into or out of the summing junction at pin 2 of 4IC(A).

   Separately adjustable rates of Acceleration and Deceleration are selected by diodes 5D and 4D, respectively. Normally "Rate 1" is "Acceleration" and "Rate 2" is "Deceleration"

   With a net positive signal applied to pin 9 of 4IC(C), its output swings negative establishing a voltage which is in turn divided by Potentiometer, 10P, and resistor 30R. The voltage across 30R is applied to pin 2 of 4IC(A) through a 2.2 megohm resistor, 31R.

   As the voltage across 30R is decreased by clockwise adjustment of 10P, the charging rate of capacitor 8C is decreased, increasing the time for output voltage to reach the desired level.

   The output at terminal 10 is inverted by one op-amp 4IC(B) and applied to the input (pin 9) of 4IC(C) as negative feedback. When the input and output signals are essentially equal, the output of 4IC(C) drops to a value just sufficient to regulate the output equal to the input within specified limits regardless of external variations.

   When the input reference potentiometer is turned to reduce the signal at pin 9 of 4IC(C), all polarities reverse and capacitor 8C is discharged at a rate governed by the setting of potentiometer 9P.

   To allow operation of the Timed Reference, a negative 15 volts DC from any source with respect to circuit common must be applied to terminal 17. When this negative 15 volts is removed, field-effect switching transistor 2Q discharges capacitor 8C, allowing the output to be reset to zero at a rapid rate.

   The output of the Timed Reference at terminal 10 is normally connected to the Reference Input, terminal 9, of the Summing Amplifier.

3. **Feedback and Signal Conditioning Amplifier** – Two modes of operation are available: Armature or Tachometer Voltage Feedback. Any other appropriate isolated feedback may also be applied at the Tachometer Voltage Feedback terminals.

   The type of feedback desired is selected by a jumper on 4TB, filtered by 14R and 4C and applied directly through 20R to pin 6 of the Signal Conditioning Amplifier 3IC(B). Additionally, the output of the Feedback Amplifier is conditioned by the Lead Network described below and also fed to the Signal Conditioning Amplifier. The output of the Signal Conditioning Amplifier is applied to the input of the Summing Amplifier through 21R.

a) *Armature Voltage Feedback* – Armature voltage is applied to terminals 1 and 2. The high value (1 megohm) resistors 33R and 34R into differential amplifier 2IC(C), provide impedance isolation from the armature power loop.

   To maintain electrical clearance requirements dictated by national codes, the input voltage on terminals 1 and 2 must be limited to 250 volts.

   The "IR COMP" circuit is most commonly used on a DC motor drive with Armature Voltage Feedback. A signal of plus 2 volts at maximum rated current with respect to circuit common is applied to terminal 7. The "IR COMP" potentiometer is adjusted so that speed remains constant with the application of load. An isolated signal is preferred, but it can be direct-connected. When used with REFLEX Control and Power Modules, this signal is normally obtained from the same source as the 2 volt feedback signal for the inner current loop of the power converter.

b) *Tachometer Voltage Feedback* – A tachometer (or other isolated feedback) voltage is applied between terminal 3 and circuit common, terminal 18. Position of the jumper on 1TB selects the required scaling of full speed voltages from 10 to 270 volts AC or DC depending on the tachometer voltage available.

   When an AC tachometer generator (or DC tachometer generator where polarity is not significant) is used, the signal is conditioned by an absolute value amplifier consisting of 2IC(A) and 2IC(B) and associated passive components so that the output at pin 7 is always positive with respect to circuit common. This signal in turn is inverted by Signal Conditioning Amplifier 3IC(B) to provide a negative signal to the Summing Amplifier. Under these conditions it must always be used with a positive reference signal. If the application requires a distinction between forward and reverse speed as indicated by tachometer generator polarity, the absolute value amplifier is disabled by removing the jumper on 5TB, and the voltage is applied through unity gain op-amp 2IC(B) to pin 6 of Signal Conditioning Amplifier, 3IC(B). Under these circumstances either polarity reference may be appropriate (negative feedback with negative reference).

c) *Lead Network* – The lead signal prevents overshoot by providing an additional feedback proportional to the rate-of-change of feedback. It may not be required with Armature Voltage Feedback.

4. **Summing Amplifier**

a) *Amplifier* – Reference and feedback signals are summed at the input (pin 13) of 3IC(D). A small difference between reference and feedback signals causes the output of this amplifier to rise to a value limited by the zener diode clamps 1ZD and 2ZD.

The output polarity is selected by a jumper on 3TB for positive, negative or bi-directional output. Clamping the output prevents the amplifier from swinging in the wrong direction, with possible delays in response.

Since the output of the Summing Amplifier is limited by the zener diode clamps, the maximum voltage across 1P is also limited and is used as the reference to a minor loop regulator. The adjustment of 1P can be used to limit the current, voltage or other parameters controlled by the minor regulating loop.

To allow operation of the Summing Amplifier, a negative 15 volts DC from any source with respect to circuit common must be applied to terminal 17. When this negative 15 volts is removed, field-effect switching transistor, 1Q, conducts clamping the output of the Summing Amplifier to zero. This ensures that the output is zero prior to turning the drive on.

b) *Lag Network* – Stability is achieved by reducing high frequency gain. Op-amp 3IC(C) provides a buffered rate-feed-back (integration) for the Summing Amplifier 3IC(D). This network also reduces noise output from the assembly.

5. **Inverter** – The output at terminal 5 is normally negative with respect to circuit common. If a positive output is required, a jumper on 2TB will utilize the Inverting Amplifier 2IC(D).

COMPONENT LIST - ASSEMBLY #12M03-00111

Symbol	Part #	Description (Acceptable Substitute)*
1T	04P01-00001	Transformer – 120V AC PRI, two 10V AC SEC @ 220 mA (Signal-PC20-220)
1REC	05P01-00003	Rectifier Bridge – 50V, 1A (EDI–PF50)
1-4ZD	05P03-00005	Zener Diode – 6.8V, 500 mW 10%
1-6D	05P02-00001	Diode – Signal, 50 mA, 200 PIV (1N4148)
1Q, 2Q	05P05-00001	Transistor – N channel JFET (2N4093)
1IC	05P08-00006	+6 Volt Regulator (7806)
2, 3IC	05P08-00001	Quad Op-Amp (National–LM324)
4IC	05P08-00002	Quad Op-Amp (TI–TL084CN)
1, 2, 3, 7P	02P04-10301-00	Potentiometer – 10K, ½W (Beckman–72XR10K)
4, 6P	02P04-25301-00	Potentiometer – 25K, ½W (Beckman–72XR25K)
5, 9, 10P	02P04-50301-00	Potentiometer – 50K, ½W (Beckman–72XR50K)
8P	02P04-50101-00	Potentiometer – 500, ½W (Beckman–72XR500)
1, 2C	03P01-47102-01	Capacitor – 470MF, 25V, Electrolytic
3C	03P01-10001-00	Capacitor – 10MF, 16V, Electrolytic
4, 5, 7C	03P02-10002-00	Capacitor – 10MF N.P., 25V, Electrolytic
6C	03P02-10101-00	Capacitor – 100MF N.P., 16V, Electrolytic
8C	03P07-10510-00	Capacitor – 1.0MF, 100V, Film
9C	03P06-10305-00	Capacitor – 0.01MF, 50V. Ceramic

Symbol	Part #	Description (Acceptable Substitute)*
1R	01P01-22300-02	Resistor – 22K, ¼W, 5%
2R	01P01-56300-02	Resistor – 56K, ¼W, 5%
3, 20R	01P01-47300-02	Resistor – 47K, ¼W, 5%
4R	01P01-27300-02	Resistor – 27K, ¼W, 5%
5, 21, 26R	01P01-47200-02	Resistor – 4.7K, ¼W, 5%
6, 7R	01P02-22121-01	Resistor – 22.1K, ½W, 1%
8, 9R	01P02-10031-01	Resistor – 100K, ½W, 1%
10, 18R	01P02-15021-01	Resistor – 15.0K, ½W, 1%
11, 23, 25R	01P02-49921-01	Resistor – 49.9K, ½W, 1%
12R	01P01-22400-02	Resistor – 240K, ¼W, 5%
13, 15, 32R	01P01-10400-02	Resistor – 100K, ¼W, 5%
14R	01P01-22200-02	Resistor – 2.2K, ¼W, 5%
16, 17R	01P01-10300-02	Resistor – 10K, ¼W, 5%
19R	01P01-15300-02	Resistor – 15K, ¼W, 5%
22, 24, 29R	01P02-60411-01	Resistor – 6.04K, ½W, 1%
27R	01P01-10200-02	Resistor – 1K, ¼W, 5%
28R	01P01-39300-02	Resistor – 39K, ¼W, 5%
30R	01P01-27200-02	Resistor – 2.7K, ¼W, 5%
31R	01P01-22500-02	Resistor – 2.2M, ¼W, 5%
33, 34R	01P02-10041-01	Resistor – 1.0M, ½W, 1%

*OR EQUAL

III. BENCH TEST

The Schematic Diagram, Voltage Checks, 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.

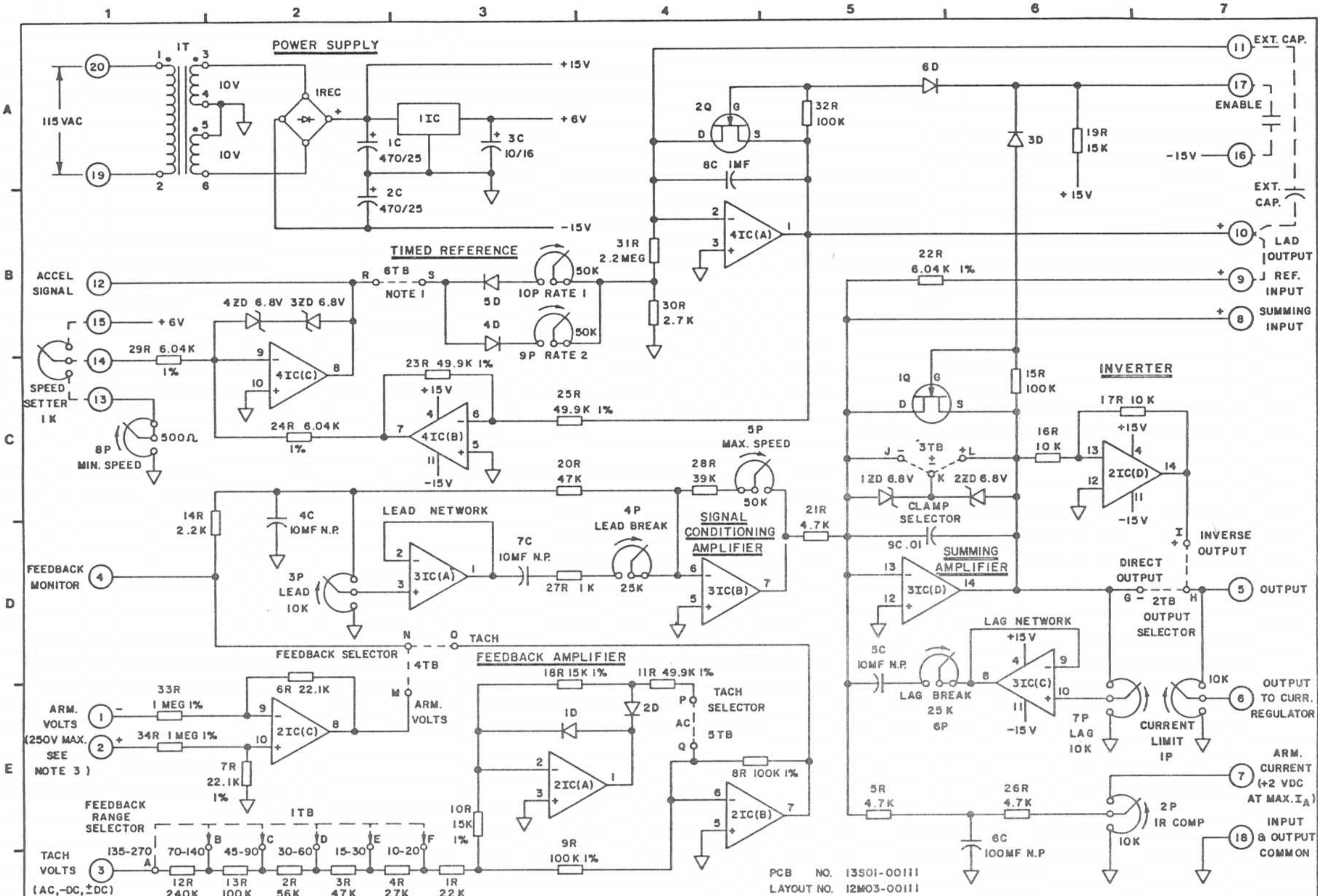
1. With the power off, jumpers removed, and terminal 3 disconnected, measure the following resistances ± 5%: A to B - 240K, B to C - 100K, C to D - 56K, D to E - 47K, E to F - 27K.
2. Measure 0 to 500 ohms between terminals 13 and 18 as "Min. Speed" potentiometer is turned CCW to CW.
3. Jumper R to S on 6TB and terminal 16 to 17. Turn "Rate 1" and "Rate 2" full CCW.
4. Connect an oscilloscope with the vertical input set for DC at 1V per division between terminal 10(+) and terminal 18(-).
5. Apply 115V AC between terminals 19 and 20.
6. Note the voltage on terminal 10 increases to +6 volts nominal in 2 to 3 seconds when terminal 14 is jumpered to terminal 15. Remove the 14-15 jumper and note that the voltage on terminal 10 drops to zero at approximately the same time (2-3 seconds).
7. Advance both "Rate" potentiometers to the 50% position and repeat step 6. The rise and fall times should be approximately 20 seconds.
8. Jumper 14 to 15 again, and after the output reaches 50% or more, remove the jumper from terminals 16 to 17. The output should immediately drop to zero.
9. Reconnect 16 to 17, and remove the jumpers R to S and 14 to 15.
10. Remove the 115V AC on terminals 19 and 20.
11. Move the scope from terminal 10 to terminal "O" on 4TB. Set the vertical input for 2V per division.
12. Jumper 18 to 19 and 3 to 20 and reapply 115V AC to terminals 19 and 20.
13. Read a sine wave of approximately 10 volts peak to peak at terminal "O" on 4TB.
14. Jumper "P" to "Q" on 5TB. The scope should show a 5V peak full-wave positive rectified waveform at terminal "O".
15. Remove the 115V AC power from terminals 19 and 20 and move the jumpers from 18-19 to 2-19 and 3-20 to 1-20.
16. Reapply the 115V AC power. Measure approximately 8 volts AC peak to peak from terminal 18 (common) to terminal "M" on 4TB.
17. Remove the 115V AC power and disconnect the jumpers from 2-19 and 1-20.
18. With an Ohmmeter read zero ohms from terminal 4 to "N" and 6.0K ± 1% from terminal 8 to 9.
19. Jumper "G" to "H" on 2TB. Turn all pots CCW except "Max. Speed", which should be CW. Leave jumper on terminals 16 to 17 and "P" to "Q". Connect a 4.7K resistor between terminals 5 and 8.
20. Reapply 115V AC to terminals 19 and 20.
21. Connect a digital meter capable of reading millivolts AC to terminals 6 and 18. Apply 0.5V AC RMS 60 Hz to terminals 4 and 18. Adjust "Current Limit" CW, and note a smooth rise of 0 to between 45 and 55 millivolts RMS.
22. Measure the voltage between terminals 5 and 18. The reading should be the same as in step 21. Return the meter to terminal 6. Connect the scope to common (terminal 18) and terminal 6.
23. Adjust and read as follows:

"Lead" full CW	1.7 to 2.3V RMS
"Lead Break" full CW	120 to 130 millivolts RMS
"Max. Speed" full CCW	275 to 285 millivolts RMS
"Lag Break" half CW	no change
"Lag" full CW	190 to 200 millivolts RMS
"Lead Break" CCW	3.9 to 4.1V RMS

24. Jumper "K" to "J" on 3TB. The top half of the sine wave should go to zero. Jumper "K" to "L". The bottom half of the sine wave should go to zero. Remove jumper.
25. Remove jumper from terminal 16 to 17. The sine wave should go to zero. Reconnect the jumper.
26. Jumper 16 to 7 and turn "IR Comp" CW. The sine wave on the oscilloscope should rise and its tops should clip at approximately +7V DC. Return "IR Comp" to the CCW position.
27. Disconnect the 4.7K resistor from terminals 5 and 8 (step 19). The oscilloscope should show a square wave of approximately 14 volts peak to peak.

IV. VOLTAGE CHECKS

1. The primary voltage of 1T, leads 1 and 2 (terminals 20 and 19), should be 115V 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 1 REC (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 circuit common (terminal 18) and the positive end of capacitor 1C.
4. -15V DC nominal between circuit common (terminal 18) and terminal 16.
5. +6V DC nominal (6.4 to 7.2 volts) between circuit common (terminal 18) and terminal 15.



NOTES:

1 - REMOVE JUMPER FOR EXTERNAL TIME ADJUSTMENT (DUPLICATE INTERNAL CIRCUIT BETWEEN TERMINALS 11 AND 12.)
2 - POLARITIES SHOWN CORRESPOND TO POSITIVE REFERENCE INPUT.
3 - SEE APPLICATION NOTES.

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REV.	DESCRIPTION	DATE	INT.

REVISIONS

DR. MY	CKD.	APP'D. [signature]	REFLEX INC. CEDARBURG, WI
DATE 12-30-81	SCALE	SHEET 1 OF 1	
PRODUCT UNIV. CLOSED LOOP CONTROLLER			REF. FILE No. EX-217
CUSTOMER			JOB No.
TITLE SCHEMATIC DIAGRAM			DWG. No. 12M03-00111-01