GEMINI CONTROLS LLC

UNIVERSAL CLOSED LOOP CONTROLLER

PART NUMBER 12M03-00111

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 0.1 %, maximum - 0.5% of full speed

DRIFT

- Armature Voltage Feedback-Depends on motor heating, normally 5-10%
- Tachometer Feedback-Depends on tachometer generator drift, typically 0.5%.

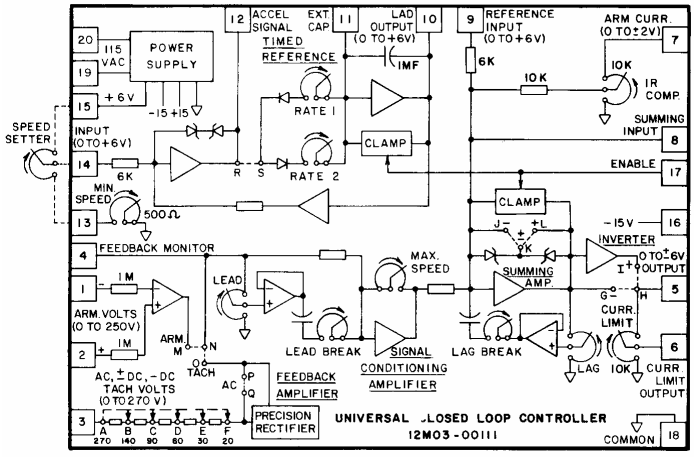

FIGURE 1. SIMPLIFIED SCHEMATIC

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RESPONSE

- Proportional, 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 1 mA 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.} linear extendable with external capacitor
- DECELERATION, 2-40 sec

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 proportional, 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 - 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. In steady state, 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, 31 R.

   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 21 R.

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 Gemini 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 1 TB 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 1 ZD 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.

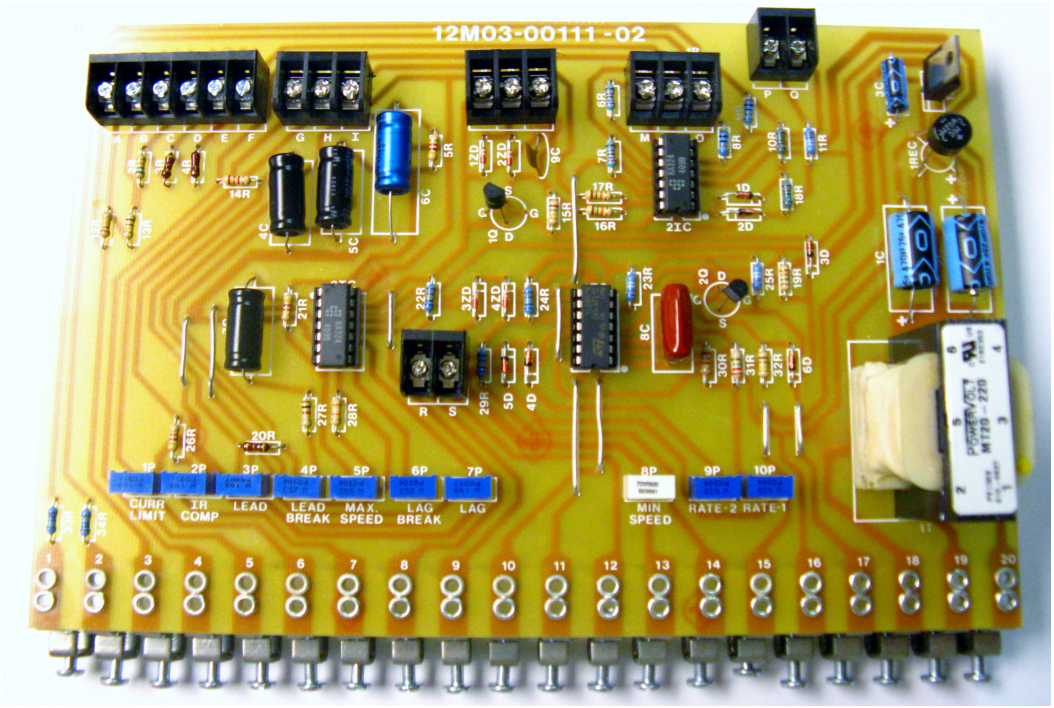
Since the output of the Summing Amplifier is limited by the zener diode clamps, the maximum voltage across 1P is also limited and is used as the reference to a minor loop regulator. Because the voltage to 1P is limited, the adjustment of 1P can be used to limit the current, voltage or other parameters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

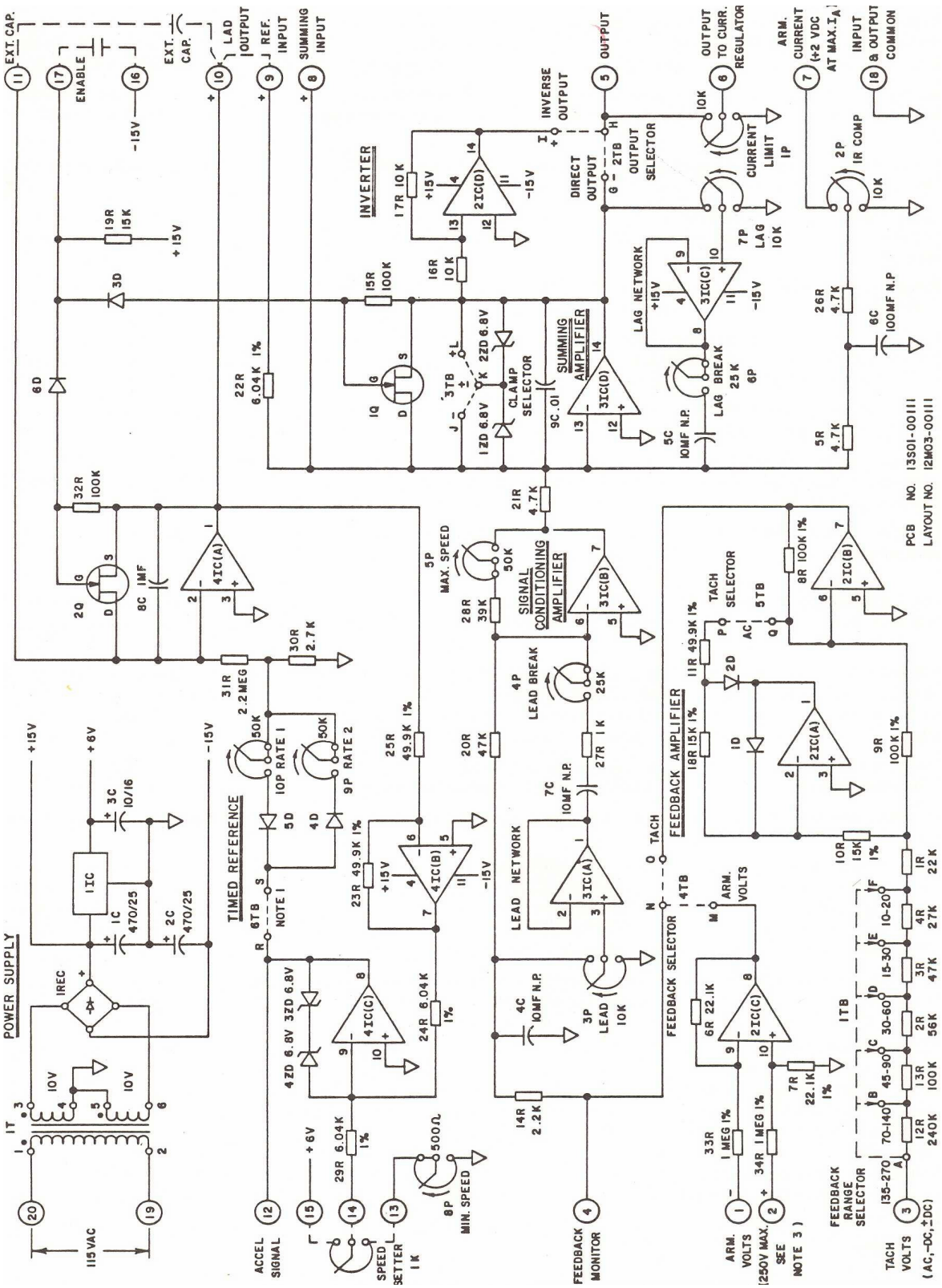
To allow operation of the Summing Amplifier, a negative 15 volts DC from any source with respect to circuit common must be applied to terminal 17. When this negative 15 volts is removed, field-effect switching transistor, 1Q, conducts, clamping the output of the Summing Amplifier to zero. This ensures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

b) *Lag Network* - Stability is achieved by reducing high frequency gain. Op-amp 3IC(C) provides a buffered rate-feedback (integration) for the Summing Amplifier 3IC(D). This network also reduces noise output from the assembly. The Lag adjustment represents the integral gain function of a conventional PID loop control. The lag break adjustment modifies the gain of Op-amp 3IC(C) at higher frequencies and is the proportional gain part of the PID loop control. The series connection of the integrating capacitor and the proportional gain resistor eliminates the objectionable “integral windup” that prevents rapid recovery of a control loop that is saturated. It means, however, that the two gains, integral and proportional, are not totally independently adjustable, and some trial and error may be required to arrive at the best combination.

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 21C(D).

6. *Options* - On the edge of the board opposite the input/output terminals are a number of barrier type terminal blocks. These are for the optional connections referred to in the text and on the schematic diagram. Short pieces of wire, stripped as necessary, are connected to these terminals to obtain the options indicated. The terminals are labeled with the letters shown on the schematic diagram. The terminal board containing option terminals R and S is located near the center of the board.




POWER SUPPLY
TIMED REFERENCE
INVERTER
SIGNAL CONDITIONING AMPLIFIER
SUMMING AMPLIFIER
FEEDBACK AMPLIFIER
LEAD NETWORK
LAG NETWORK
CLAMP SELECTOR
FEEDBACK SELECTOR
FEEDBACK RANGE SELECTOR
TACH SELECTOR
OUTPUT SELECTOR
CURRENT LIMIT
LAG BREAK
LEAD BREAK
MAX. SPEED
MIN. SPEED
SPEED SETTER
ACCEL SIGNAL
FEEDBACK MONITOR
ARM. VOLTS
TACH VOLTS
ARM. CURRENT
INPUT & OUTPUT COMMON
EXT. CAP.
ENABLE
LAD OUTPUT
REF. INPUT
SUMMING INPUT
INVERSE OUTPUT
OUTPUT
OUTPUT TO CURR. REGULATOR
IR COMP
115 VAC
PCB NO. 13501-00111
LAYOUT NO. 12M03-00111