VOLTAGE REGULATOR
(PARALLEL CONTROL)

I. GENERAL DESCRIPTION

The parallel control voltage regulator module provides the reference shaping networks used with C-56 Basic regulators for motor armature thyristor power supplies as described in I.L. 16-800-126. Two variations are available, one for regenerative (DUAL CONVERTER) drives and the other for uni-directional (SINGLE CONVERTER) drive applications. Each provides tapered current limit, droop adjustment and IR compensation features.

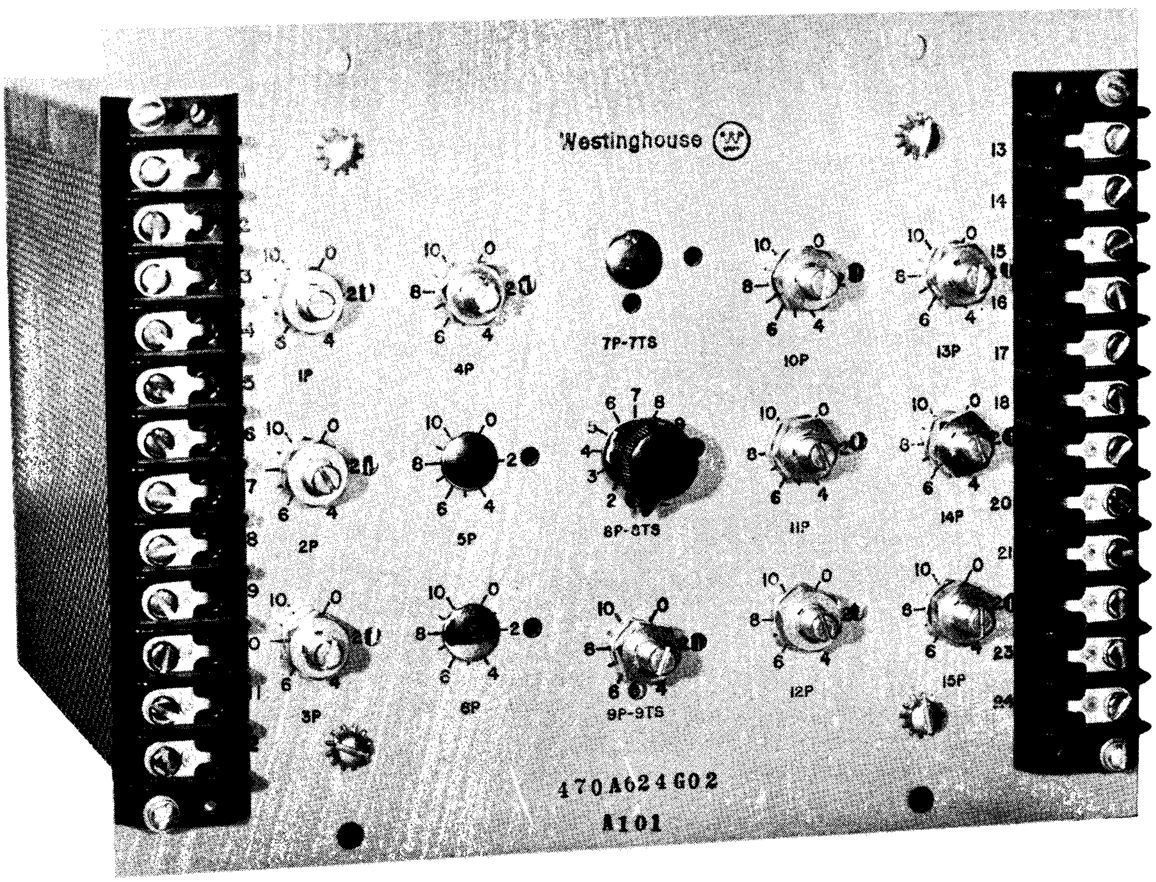


Figure 1

The module, shown in Figure 1, contains P101A operational amplifiers (I.L. 16-800-24), their associated function boards and sequencing relay boards arranged between parallel mounting bars extending from a 9" x 7" faceplate on which are mounted front accessible adjusting potentiometers, selector switches and screw type terminals to which all external connections are made. The mechanical arrangement of boards is shown in Figure 2.

II. SCOPE OF APPLICATION

The parallel control voltage regulator can be used on all drive applications requiring thyristor power supplies with C-56 basic regulators as motor armature supplies.

The reference voltage representing rated output voltage of the C-56 basic regulator must be 10 volts or higher.

III. ELECTRICAL SPECIFICATIONS

POWER REQUIREMENTS:

VOLTAGE: + 24/0/-24 VDC

REGULATION: ± 1%

CURRENT: 170 mA for SINGLE CONVERTER

230 mA for DUAL CONVERTER

RESPONSE

The response of the voltage control is determined by the response of the inner voltage loop and the time delay of the voltage regulator. The time delay is adjustable from 15 to 80 msec.

The IR compensation feedback is delayed by a filter time constant of approximately 600 msec.

IV. DESCRIPTION OF OPERATION

The following description covers all the features available in the parallel control voltage regulator module, it is recommended that the reader check the Regulator Systems Diagram and Regulator Signal Distribution Diagram of the customer's schematic for the features required for his application. The schematic diagram for regenerative (dual converter) applications is shown in Figure 3; the schematic for uni-directional (single converter) applications is shown in Figure 4.

The parallel control voltage regulator module consists of one voltage controller together with one or two current controllers (the number of current controllers depends on whether a single converter or dual converter thyristor power modulator [TPM] is used). The outputs of the controllers feed into the diode switching circuit which in turn feeds into the inner voltage loop.

When the voltage controller is used as a reference shaper, terminal #6 is connected to terminal #9. The voltage controller then consists of a proportional delayed amplifier with four inputs. Three inputs (terminals #1, #2, #4) have a small filter associated with them. The remaining input at terminal #3 (and #5) is available for the application of droop or IR compensation. Input #7 is available for testing the amplifier.

Dynamic adjustment is afforded by potentiometers 4P and 2P. Pot 4P adjusts the droop or IR compensation, and pot 2P changes the effective time constant or response of the voltage loop. For special purpose voltage regulator where a second closed voltage loop is necessary, the jumper connection, terminal #6 and #9 should be removed transforming the voltage controller from an adjustable delay to an integral controller. The adjustment of pot 2P then determines the response of the voltage loop.

The current controller(s) for the single and dual converters consists of two integral amplifiers with common inputs #13, #14 and #15. With relays 2CR and 3CR in their energized position, the controllers are operative. The references to these two controllers are supplied from pots 11P and 14P. Current feedback is connected to terminal #13. This signal is applied through a lead of approximately 30 msec. In order to obtain a tapered current limit, voltage feedback can be connected to terminals #14 and #15. The dynamic adjustment available on the integral current controllers is that of the integrating time constant. This is adjusted by means of potentiometer 9P and switch 8TS.

In order to control for zero current, relays 2CR and 3CR are both de-energized. This removes the current reference from both controllers and under these conditions both current controllers will control for zero current. The action of de-energizing these two relays also eliminates the voltage feedback to the current controller which is used to provide tapered current limit.

For the case when only uni-directional current is applied, one of the current controllers is completely removed along with its associated input and feedback circuits. Otherwise the operation of the two controllers is exactly the same as mentioned above.

V. START-UP PROCEDURE

The following assumes the basic regulator is working.

1.0 Balance of Amplifier

1.1 Check AC power indicating light on.

1.2 Check PSN & PSP indicating light on.

1.3 Energize relays 1CR, 2CR, and 3CR.

1.4 Connect terminals #1 thru #5 inclusive to module PSC.

1.5 Balance the voltage amplifier by turning pot 1P until the output terminal #10 has zero volts. If amplifier does not balance, see Step 2.2.

1.6 Check voltages terminal #19 and #20, these should be approximately -12 and +12 volts respectively. (For single converters, terminal #20 will be zero volts).

1.7 Adjust pots 2P, 3P, 4P, 11P, 12P, 14P, 15P full CCW.

1.8 Turn switch 8TS full CCW, and pots 10P and 13P to 50% each.

2.0 Check Basic Regulator

2.1 Disconnect current feedback signal feeding terminal #13.

2.2 Add <u>temporary</u> jumper between terminals #6 and #9 if a permanent connection is not already in place.

<u>Remove temporary</u> jumper before starting Dynamic Adjustment of Voltage loop step 8.0.

2.3 Remove voltage feedback signals from terminals #14 and #15.

2.4 Energize relays 2CR and 3CR.

2.5 Apply (+)ive reference to terminal #2.

2.6 Turn 3P slowly CW until motor turns over to check basic regulator, then turn 3P slowly CW until 10% voltage is reached.

2.7 Connect one terminal of Simpson multimeter to PSC and check the polarity of the signal feeding into terminal #2 and the lead disconnected from terminal #13. These must be of opposite polarity.

2.8 Turn 3P full CCW.

2.9 De-energize thyristor power supply.

2.10 Reconnect current feedback signal to terminal #13.

2.11 Disconnect motor field.

2.12 Energize thyristor power supply.

CAUTION: The following tests are carried out without field on the motor. Take care to continually monitor the speed of the drive to prevent it from taking off. Also do not linger while passing armature current through stalled motor. Return armature current to zero and allow adequate cooling time, if required.

3.0 Adjustment for Current Control Zero

For drives where accurate control for zero current is required.

3.1 De-energize relay 2CR and apply (+)ive reference signal to terminal #2.

3.2 Turn 3P CW, the current should remain approximately zero with zero voltage.

3.3 Adjust pot 10P to give zero current.

3.4 Turn 3P to full CCW.

3.5 Remove reference signal and energize relay 2CR.

For Dual Converters

3.6 De-energize relay 3CR and apply (-)ive reference signal to terminal #2.

3.7 Slowly turn 3P CW, the current should remain approximately zero with zero voltage.

3.8 Adjust pot 13P to give zero current.

3.9 Turn 3P full CCW, remove reference signal and energize relay 3CR.

4.0 Dynamic Adjustment of Current Loop

4.1 Apply (+)ive reference voltage (+10 volts) to terminal #2 and slowly turn 3P CW. Armature current will increase for a while, but will be limited to 30% I_R.

4.2 Turn 3P full CW, adjust 11P CW till rated current is reached.

For single converters continue with Step 4.7.

4.3 Turn 3P full CCW.

4.4 Reverse polarity of reference connected to terminal #2.

4.5 Slowly turn 3P CW, current should be limited to 30% I_R.

4.6 Turn 3P full CW, then turn 14P CW till rated current is reached.

4.7 Apply ± 10 volt step reference to terminal #2 and record current response.

4.8 Turn switch 8TS and pot 9P in CW direction until current starts to oscillate.

4.9 Turn switch 8TS CCW 1 position. This is the correct current loop gain.

5.0 Adjustment of Gate Pulse Suppression

For gate pulse suppression adjustment, do not circulate armature current for more than 25 seconds, allowing at least two minutes for cooling after current is reduced to zero.

5.1 On current sensor (CS) board of basic regulator turn gate pulse suppression pots 4P, 5P full CW.

5.2 Apply +10 volts into terminal #2 and increase pot 11P CW until 115% current limit is reached.

5.3 On current sensor (CS) board of basic regulator turn gate pulse suppression pot 4P (forward converter) slowly CCW until GPG suppresses pulses.

5.4 Turn 11P full CCW.

For dual converter drives.

5.5 Apply (-) 10 volt signal to terminal # and increase pot 14P CW to 115% current limit.

5.6 On current sensor (CS) board of basic egulator turn gate pulse suppression pot 5P (reverse converter) slowly CCW until G G suppresses pulses.

5.7 Turn 14P full CCW.

6.0 Current Limit Adjustment

6.1 Apply (+) 10 volts signal to terminal #2 and turn pot 11P CW until current limit is reached.

For dual converter drives

6.2 Apply (-) 10 volts signal to terminal #2 and turn pot 14P CW until current limit is reached.

6.3 Remove reference from terminal #2.

7.0 Tapered Current Limit, Droop and IR Compensation

7.1 Tapered Current Limit

7.1.1 With motor field disconnected, and armature loop closed, remove voltage feedback from terminal #14.

7.1.2 Apply (-) 10 volt between terminal #14 and PSC.

7.1.3 Apply positive reference (10 volts) to terminal #2 to obtain current limit.

7.1.4 Turn 12P CW to reduce armature current to its current limit value at rated voltage V_R.

For dual converter drives.

7.1.5 Reverse polarity of signals feeding into terminal #2 and terminal #14.

7.1.6 Turn 15P CW to reduce armature current to its current limit at rated voltage.

7.2 Droop Adjustment

7.2.1 With motor field disconnected and armature loop closed, pot 3P full CCW.

7.2.2 Apply (+)ive reference to terminal #2 and slowly turn pot 3P CW until armature current is at its rated value.

7.2.3 Measure bus voltage V_{BM} and turn 3P full CCW.

7.2.4 Calculate $D = \frac{V_{BM}}{V_R}$

7.2.5 Calculate $I_X = \frac{D}{(PI_R/\%)} I_R$

where: D = % natural droop

PI_R = % droop desired as percentage of top speed at rated load

7.2.6 Slowly turn pot 3P CW until rated current is obtained then turn pot 4P CW to reduce armature current I_X.

7.3 <u>IR Compensation</u>

7.3.1 Reverse polarity of signal feeding into terminal #3. Disconnect lead into terminal #5.

7.3.2 Apply (+)ive reference to terminal #2 and slowly turn 3P CW until rated current is obtained.

7.3.3 Turn pot 4P CW until armature current is reduced to 50% for 100% IR compensation. Take correspondingly less pot setting for lower percentage of IR compensation.

7.3.4 Reverse polarity of signal feeding into terminal #3.

7.3.5 Reconnect lead into terminal #5.

8.0 <u>Dynamic Adjustment of Voltage Loop</u>

8.1 Remove power to the thyristors, remove temporary jumper that may have been added in Step 2.2, reconnect motor field and start up drive again.

8.2 Apply +10V to terminal #2 and increase 3P CW till 5% voltage is obtained.

8.3 Apply reference in steps, check response at terminal #9.

8.4 Adjust pot 2P CW to give faster response. Make sure current limit is <u>not</u> reached during this adjustment.

9.0 <u>Reference Calibration</u>

9.1 With full reference on terminal #2 turn 3P CW until 10 volts output is measured at terminal #10.

9.2 Adjust potentiometer 1P on voltage sensor (VS) card in basic regulator to set thyristor power supply output at rated voltage as indicated by armature voltmeter on cabinet door.

THE DRIVE IS NOW BASICALLY ADJUSTED.

VI. SERVICE

Using the procedure outlined in Section V, any problem can be isolated to either a component on a function board or a faulty A101A transistorized operational amplifier. Our component board designs, utilizing stand-off terminals, facilitate the replacement of components using the proper sized (wattage) soldering iron. However, proper servicing of the A101A TOA requires instruments and techniques particular to transistorized, low-noise level circuits. Customers without the proper facilities are advised to return the defective unit to:

Westinghouse Electric Corporation
Industrial Systems Division
P. O. Box 225
Buffalo, New York 14240

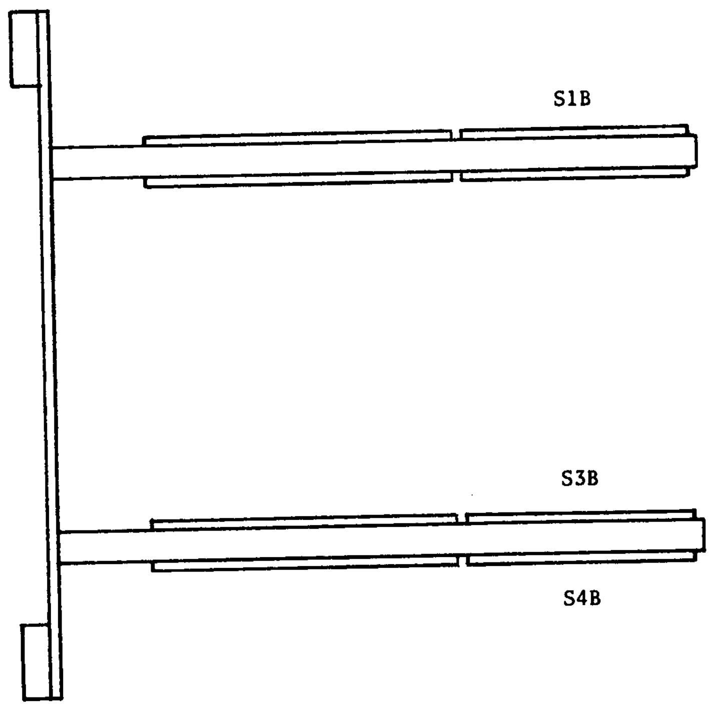
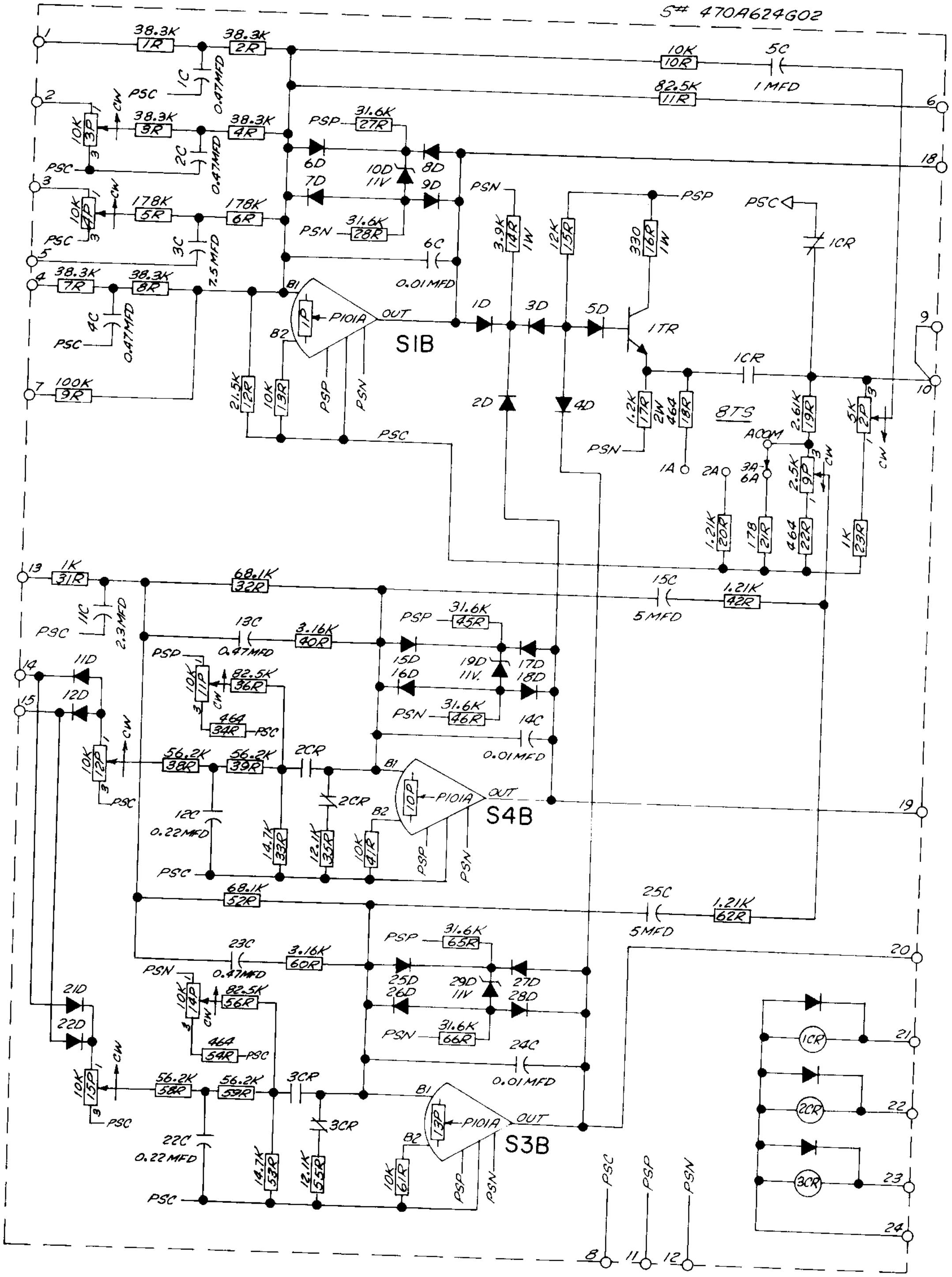


Figure 2

PARALLEL CONTROL VOLTAGE REGULATOR MODULE

WITH COVER REMOVED

(TOP VIEW)



ALL POTS = 2W
ALL RESISTORS = 0.5W UNLESS OTHERWISE SPECIFIED

Figure 3 Parallel Control Voltage Regulator (DUAL CONVERTER)

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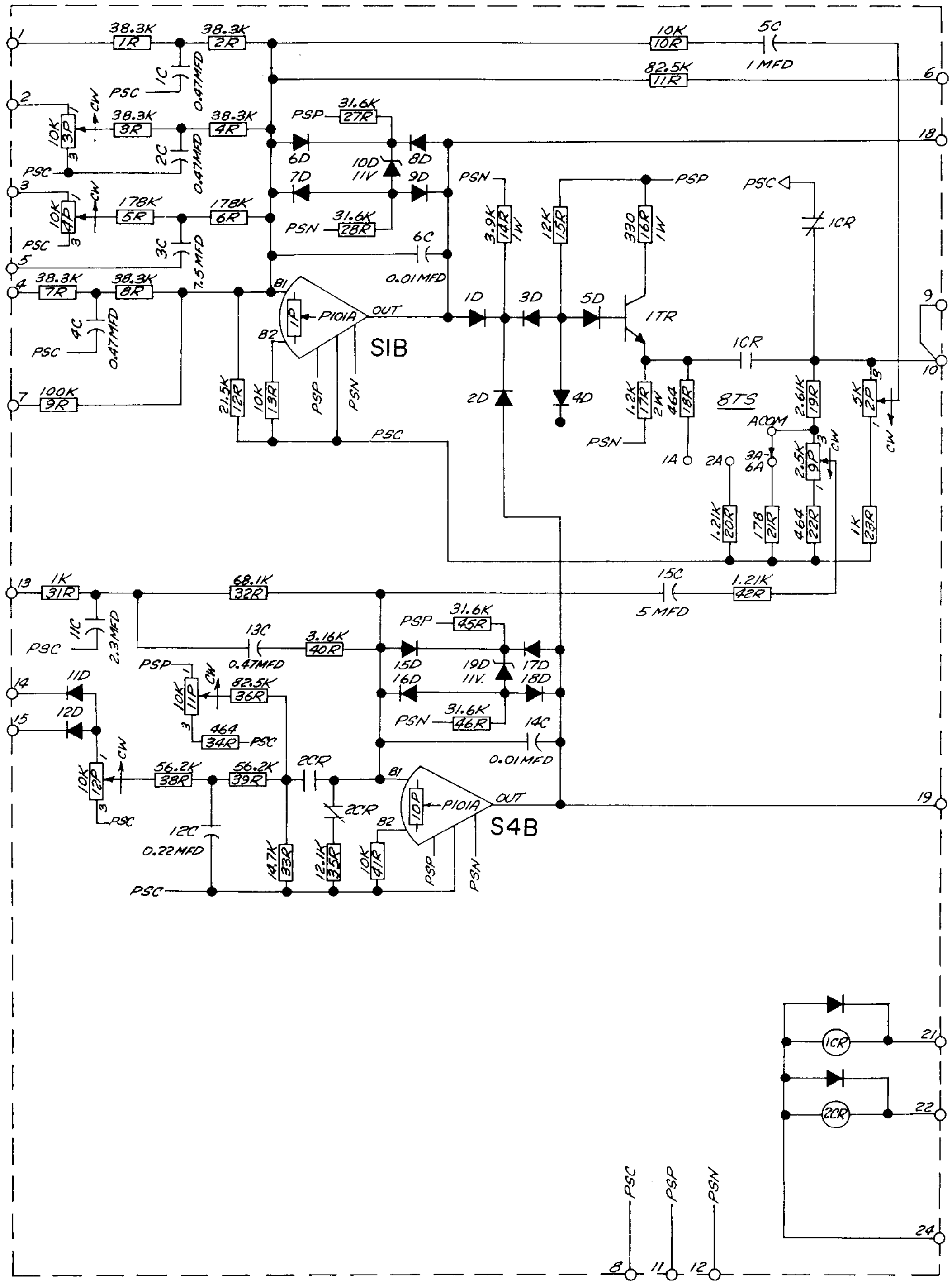

ALL POTS = 2W
ALL RESISTORS = 0.5W UNLESS OTHERWISE SPECIFIED.

Figure 4 Parallel Control Voltage Regulator (SINGLE CONVERTER)