DYNAPOWER
CORPORATION

USER'S MANUAL

REGULATOR

Model EU-10053E, Rev. F

INVENTORY NUMBER: EUE-7-100530006

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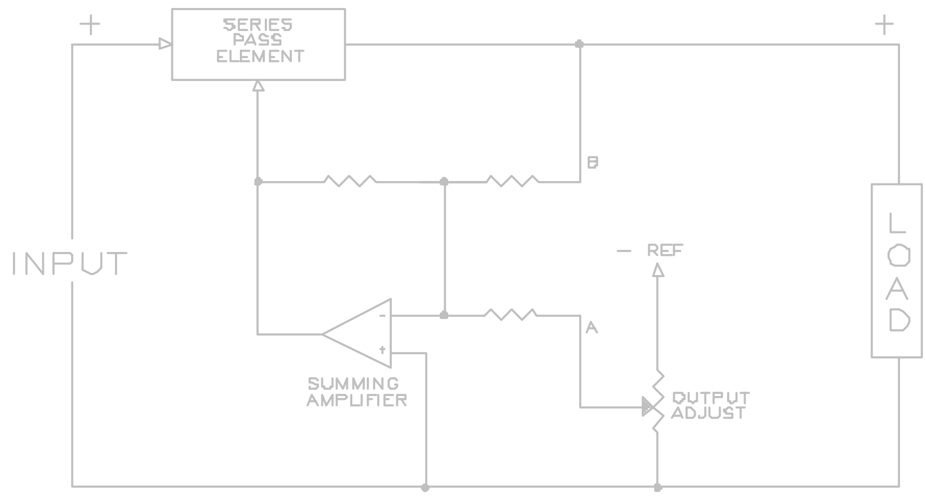
1. DESCRIPTION

1.1 REGULATOR DESCRIPTION

The function of the regulator is to derive, from reference and feedback signals, a control voltage to regulate the output of a power supply.

A basic example is a power supply with a series regulating element as shown in figure 1. A reference signal is connected to the input terminal (point A) of a control amplifier. Since the gain of the amplifier is large, any input signal will cause the output of the amplifier to go to maximum. The output of the amplifier is connected to the input terminal of a series pass element (power supply output) is directly proportional to the voltage at its input terminals. As the amplifier output voltage rises, the pass element opens and voltage is allowed to pass to the load.

A portion of the load voltage is also connected (fed back) to the amplifier input (point B). The polarity of this voltage must be so that it opposes the reference voltage. This is called negative feedback and causes the amplifier to lower its output. The amplifier is called a 'summing amplifier' since it sums the reference and the feedback voltages and gives an output voltage proportional to their difference



+
SERIES
PASS
ELEMENT
+
B
INPUT
– REF
L
O
A
D
A
SUMMING
AMPLIFIER
OUTPUT
ADJUST

FIGURE 1

The action of the summing amplifier keeps the feedback voltage at point B equal to the reference voltage at point A, thus regulating the output of the power supply.

1.2 VOLTAGE REGULATION

The voltage summing circuit operates as described above. The reference signal (AVC) is applied to the summing amplifier through a buffer. The feedback voltage from the power supply is brought back to the summing amplifier through a 'volt limit' control. The 'volt limit' control sets the maximum output voltage of the power supply.

If there is not enough feedback voltage available to match the reference voltage, the output of the summing amplifier will go to maximum and the amplifier is said to be "out of control".

1.3 CURRENT REGULATION

The current summing circuit is also as shown in Figure 1. The current reference (ACC) is connected to the current summing amplifier through a buffer. The current feedback is connected to a 'current limit' control that sets the maximum output current of the power supply. Through the action of the current summing amplifier, the output current will follow the current reference in a linear manner. Again, as in the voltage amplifier, if there is not enough current feedback to match the reference, the amplifier output will go maximum and is said to be 'out of control'.

1.4 AUTOMATIC CROSSOVER

The amplifier with the lower output, i.e., where the reference and feedback are in balance, controls how much voltage is fed to the firing circuit and is said to be the amplifier 'in control'.

As power supply reference settings and feedback conditions change, the regulator will automatically change its operating mode from constant current to constant voltage and vice versa. This is called automatic crossover.

For example, take a power supply with a rating of 12 volts, 5000 amperes with a current control (ACC) and a voltage control (AVC). Assume that the power supply is operating at 8 volts, 3000 amperes with the ACC control set for 5000 amperes and the AVC control set for 8 volts. The regulator therefore is operating in the voltage mode.

As load is added to the power supply, the current will rise. When the current reaches 5000 amperes, the current feedback signal will match the ACC signal and the current summing amplifier will "take over" and will not allow any further increase in output current. The regulator is now operating in the current mode. A further increase in load will result in less voltage while the current remains constant.

This will make sense if Ohm's Law is remembered. Ohm's Law states that the current flowing in an electrical circuit is the result of the voltage applied to the circuit divided by the resistance (load) connected to the circuit. Thus, as the resistance becomes smaller (more load), less voltage is required to maintain a current.

As load is removed, the output voltage will rise until it reaches the set-point. The voltage summing amplifier will 'take over' and will not allow a further increase in voltage. A further decrease in load will result in less current while the voltage remains constant.

1.5 LIMIT ADJUSTMENTS

The limit adjustments on the regulator determine the transfer curve of the power supply, i.e., the relationship between reference voltage and power supply output.

Again, the action of the summing amplifier keeps the voltage at its inputs equal. The limit control acts as a voltage divider, a portion of the feedback voltage appearing across may be passed on to the summing amplifier. Therefore, the setting of the limit control determines how much signal (power supply output) must appear across it so that the inputs to the summing amplifier are equal. Thus, adjusting the limit control changes the power supply output and determines the power supply output limit with 100% reference voltage.

1.6 LINEARITY

The linearity of the regulator is defined as the percentage deviation of the output from the set point. The linearity depends on the design of the regulator, mainly its gain. Once the system has been adjusted and a transfer curve established, normally only changes in feedback conditions will cause set point deviations.

1.7 SUMMARY

The regulator controls the output of a power supply in response to reference signals (set points), feedback (limit) adjustments, and power supply load conditions.

2. REGULATOR FUNCTIONS

In addition to regulating the output current and output voltage of power supplies, the regulator performs other functions as well.

2.1 REFERENCE VOLTAGE

The regulator generates a reference voltage that is used with the power supply output controls. The reference voltage is a nominal +2.5 volts dc and is available on the circuit terminal strip. When power is applied to the regulator, the reference voltage will ramp to its maximum value in about two seconds.

2.2 CURRENT FEEDBACK AMPLIFIER

Dynapower power supplies normally use a 50 milli-volt shunt to measure the output current of a power supply. This signal is too small in comparison to the reference voltage, therefore it must be amplified to a usable level. The "shunt amplifier" raises the current feedback signal to about -3.3 volts when the input is at 50 milli-volts. This voltage is connected to the current limit control.

The amplifier has a BIAS control to set the output to zero when there is not input to the amplifier.

2.3 OVER-CURRENT PROTECTION

A "trip circuit" monitors the output of the negative shunt amplifier. The circuit will "trip" when the shunt amplifier output voltage (proportional to output current) exceeds a preset peak level. The trip level is set by a control labeled TRIP LEVEL.

When the circuit is tripped, the output of the regulator is shut down immediately by clamping the reference voltage to zero. After approximately a 3 second delay the trip circuit resets itself and the reference voltage is again ramped up and power supply output is re-established. If the condition that caused the trip has cleared, the power supply will resume normal operation. If the fault is still present, the circuit will continue to trip until the fault is cleared.

The trip circuit has been designed to give fast response to current overloads, normally the power supply is shut down within 10 milli-seconds of a sensed overload.

A logic signal, indicating that the circuit is in a tripped mode, is available at the regulator terminal strip. This signal may be used as an inhibit logic signal to other circuits.

The circuit will always trip when the regulator is energized. There will always be the trip delay before output is established when power is applied to the regulator.

2.4 DOUBLE CURRENT CHANNEL OPERATION

It is possible to operate the regulator as a two channel current control. This is accomplished by feeding a current feedback signal from terminal 6 into terminal 5.

This mode of operation is chosen when a remote current reference is used to control the power supply current and voltage control or voltage limiting is not needed. The internal reference is used as the reference signal for the back-up current channel. The back-up channel is adjusted to limit the power supply output current to its rating. Then, if the remote current signal tries to drive the current too high, the circuit crosses over into the back-up channel and limits the current to power supply rating.

Voltage feedback may not be used when this connection is made and voltage control or voltage limiting is not possible.

2.5 REGULATOR INHIBIT

The regulator may be clamped to zero by connecting a 15 volt signal to the INHIBIT IN terminal of the regulator. The inhibit command clamps the internal reference voltage to zero. When the inhibit signal is removed, the reference voltage will ramp to its normal level.

2.6 REMOTE REFERENCE SIGNALS

Signals from external sources such as controllers may be used as reference signals to the regulator. However, certain precautions should be taken.

Remote reference voltages should not exceed the internal reference voltage and, if possible, should match the internal reference as close as possible. This is helpful when switching between remote and internal references since a difference in reference voltage results in different power supply output levels.

2.6.1 REMOTE CURRENT LOOPS

The current from a current loop must flow through a resistor to develop a reference voltage. If the current loop is a 4-20 ma loop, a 120 ohm resistor will normally suffice to develop the reference voltage. However, it is not possible to get a reference voltage of zero since the minimum loop current is 4 ma. This means that the power supply cannot be brought to zero output with the current loop signal.

If the loop current controls the current channel, the reference offset may be compensated for with the negative shunt amplifier bias. If the loop controls the voltage channel, nothing can be done about the offset. It is therefore preferred to use a 0-20 ma current.

2.6.2 ISOLATION

It is always preferred that the remote reference signals be isolated. The regulator should not be connected to other equipment through the controller as ground loops may be established that could cause poor operation of the system. Worse yet, damage may result if circuits with different potentials are tied together.

2.6.3 REFERENCE INHIBIT

Reference voltages should not be applied to the regulator when the regulator is clamped off by a signal on its inhibit terminal or when no power is applied to the regulator.
Remote reference signals should be at zero when the regulator is off or inhibited. Power surges resulting in fuse blowing could occur when the regulator is enabled with the references up.

2.7 VOLTAGE FEEDBACK

In Dynapower power supplies the current measuring shunt is normally connected into the positive bus. The positive signal terminal of the shunt is connected to the regulator electronic common. It is then easy to connect the other bus, which is negative, to the voltage feedback terminal on the drive circuit.

Some applications require that the shunt be connected into the negative bus. The feedback is then taken from the positive bus which is connected to the INV terminal of the regulator.

To obtain better resolution with the voltage limit control, the voltage across it is reduced. This is done with an external voltage dropping resistor that is connected between the bus and the voltage feedback input terminal. The value of this resistor, in k-ohms, is approximately 2.5 times the voltage rating of the power supply.

3. REGULATOR ADJUSTMENTS

VOLT LIMIT sets the maximum output voltage of the power supply. Clockwise adjustment lowers output.

V BIAS sets the bias voltage of the voltage summing amplifier.

CURRENT LIMIT sets the maximum output current of the power supply. Clockwise adjustment lowers output

I BIAS sets the bias voltage of the shunt amplifier. Clockwise adjustment increases negative bias.

TRIP LEVEL sets the over-current trip level. Clockwise adjustment raises the TRIP level.

EXT REF ADJ sets the external reference voltage to the level of the internal reference.

4. TERMINAL FUNCTIONS

Terminal		
No.	Label	Function
1	115 VAC	Input Power
2	115 VAC	Input Power
3	EXT IN	External input
4	EXT OUT	Adjusted external reference
5	NEG BUS	Volt feedback from neg. bus
6	IB	Current feedback signal
7	AVC	Voltage reference input
8	ACC	Current reference input
9	+ REF	Reference output
10	REF GRD	Reference common
11	SHUNT +	Shunt positive input
12	SHUNT -	Shunt negative input
13	INV	Voltage Feedback from pos. bus
14	"0" Current	Zero Current logic signal
15	INHIBIT IN	Circuit clamp input signal
16	INHIBIT OUT	Trip circuit output signal
17	FC +	Circuit output positive
18	FC -	Circuit output negative

5. POWER SUPPLY OUTPUT ADJUSTMENT

The power supply adjustment procedure outlined in the power supply User's Manual should be followed.

6. REGULATOR BENCH TEST

NOTE: All measurements are dc and are referenced to terminal 10. This test will not reveal any problems related to output stability.

The voltages stated in the following are not critical; however care should be taken when making a BIAS adjustment.

a. Apply 115 VAC to terminals 1 and 2.

   Connect a 1 k-ohm resistor between terminals 17 and 18.

   Short terminal 7 to 8 to 10.

   Short terminal 17 to 15

b. Measure ⌖ 15 volt power supply at test points.

   Should be within .5 volts of nominal.

c. Measure voltage at terminal 6.

   Should be between zero and +.05 volts.

   Adjust with CUR BIAS (P6) if necessary.

d. Measure voltage at pin 14 of U1.

   Should be between zero volts.

e. Measure voltage at pin 1 of U4.

   Set to ⌖ .005 with VOLTAGE BIAS (P3).

f. Measure voltage at terminal 18.

   Should be +15 volts.

g. Measure voltage at terminal 9.

   Should be +2.5 volts, ⌖ .1.

H. Remove short on terminal 17 and 15.

Remove short on terminal 7, 8, and 10.

Connect terminal 7 to 8 to 9.

Measure voltage at pin 14 of U1.

Should be +10 volts.

i. Measure voltage at pin 7 of U4.

Should be between +10 volts.

j. Measure voltage at terminal 18.

Should be approximately +2 volts.