



INSTRUCTION MANUAL

EU-10053D

DRIVE CIRCUIT

DYNAPOWER INVENTORY NUMBER

EUD-7-100530000

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1. DESCRIPTION

1.1 DRIVE CIRCUIT DESCRIPTION

The function of the drive circuit 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.

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 shown in figure 2 operates as described above. The reference signal is applied to the summing amplifier (point A) and the amplifier output is applied to the base of a transistor amplifier. The voltage developed across "R" is the drive voltage connected to a firing circuit. A feedback voltage from the power supply is brought back to the summing amplifier (point B) through a "volt limit" control. The "volt limit" control sets the maximum output voltage of the power supply. Through the action of the summing amplifier the power supply output will follow the reference signal in a linear manner and keep the voltages at points A and B equal.

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 shown in figure 3. It is identical to the voltage summing amplifier except that it has current feedback brought into the amplifier through 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 outputs of the summing amplifiers are connected into a transistor output stage as shown in figure 3. The amplifier with the lower output, i.e.; where the reference and feedback are in balance, controls how much current flows through resistor "R" and thus is the amplifier "in control".

As power supply reference settings and feedback conditions change, the drive circuit 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 drive circuit 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 drive circuit 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 drive circuit 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 drive circuit is defined as the percentage deviation of the output from the set point. The linearity depends on the design of the drive circuit, 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 drive circuit controls the output of a power supply in response to reference signals (set points), feedback (limit) adjustments, and power supply load conditions .

2. DRIVE CIRCUIT FUNCTIONS

Besides regulating the output current and output voltage of power supplies, the drive circuit performs other functions as well.

2. REFERENCE VOLTAGE

The drive circuit 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 drive circuit, the reference voltage will ramp to its maximum value in about two seconds.

2.2 CURRENT FEEDBACK AMPLIFIERS

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.

There is a second shunt amplifier with an output of +3.3 volts when the input is at 50 milli-volts. This voltage is available at the terminal strip through a level control labeled CURR SIG. This voltage is used for other control functions. These amplifiers are normally referred to as the "positive" and "negative" shunt amplifiers. Each amplifier has a BIAS control to set the output to zero when there is not input to the amplifiers.

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 drive circuit 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 drive circuit terminal strip. This signal may be used as an inhibit logic signal to other circuits.

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

2.4 IMBALANCE DETECTOR

The output of a standard thyristor controlled power supply has a normal ripple frequency of 360 hertz. Certain problems with a power supply can result in an imbalanced output voltage which may result in imbalanced input currents which is an undesirable condition.

The imbalance detector or "line loss" circuit monitors the output waveshape. An imbalance condition normally results in a 120 Hz frequency component in the output. This frequency is detected by the line loss circuit.

When an imbalance is sensed, the circuit lowers the reference voltage, thus lowering the power supply output. This allows the power to operate at lower levels with imbalanced input currents. The sensitivity of the line loss circuit is adjusted with the LINE LOSS control. An LED indicator on the drive circuit is lit when the line loss circuit is active.

Also, a relay is energized when the line loss circuit is active. It's normally open contact is wired to the drive circuit terminal strip.

The line loss detector may be connected to look at either the current or voltage waveshape of the power supply output. The selection is made by a jumper connection on the circuit board. The line loss circuit looks at the voltage waveshape when the V- LL terminals are connected, and at the current waveshape when the I-LL are connected.

2.5 AUTOMATIC CURRENT DENSITY

Some plating processes require that the current density in a load be maintained constant when loads of different sizes are used on a power supply.

When operating in a constant voltage mode, the load current is determined by the resistance (load) that the power supply sees. Currents flowing through conductors and connections cause voltage losses that effectively cut down the voltage that reaches the load and thus cause less current to flow. These losses increase with current.

What is required is a system that will boost the power supply output voltage as larger loads are placed on the power supply. This is done by taking the current signal from the positive shunt amplifier (see 2.3 above) and connecting it to an external ACDC control. The signal from the ACDC control is added to the voltage reference through the ACDC input terminal on the drive circuit, thereby increasing the power supply output voltage.

2.6 DOUBLE CURRENT CHANNEL OPERATION

It is possible to operate the drive circuit as a two channel current control. This is accomplished by feeding a current feedback signal to the voltage channel by connecting the 2xACC terminals together. This makes the voltage channel a back-up current channel.

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.

2.7 DRIVE CIRCUIT INHIBIT

The drive circuit may be clamped to zero by connecting a 12 volt signal to the INHIBIT IN terminal of the drive circuit. 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.

2.8 REMOTE REFERENCE SIGNALS

Signals from external sources such as controllers may be used as reference signals to the drive circuit. 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.

2.8.1 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.

2.8.2 ISOLATION

It is always preferred that the remote reference signals be isolated. The drive circuit 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.

2.8.3 REFERENCE INHIBIT

Reference voltages should not be applied to the drive circuit when the drive circuit is clamped off by a signal on its inhibit terminal or when no power is applied to the drive circuit.

Remote reference signals should be at zero when the drive circuit is off or inhibited. Power surges resulting in fuse blowing could occur when the drive circuit is enabled with the references up.

2.9 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 drive circuit electronic common. It is then easy to connect the other bus, which is negative, to the voltage feedback terminal on the drive circuit.

2.9.1 VOLTAGE FEEDBACK RESISTOR

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.

2.9.2 VOLTAGE FEEDBACK FROM POSITIVE BUS

Sometimes it is necessary to connect the shunt into the negative bus. The voltage feedback is then taken from the positive bus. As this feedback is of the wrong polarity, it must be inverted.

This is done by connecting the positive bus, through a dropping resistor, to the INV terminal on the drive circuit.

3. DRIVE CIRCUIT ADJUSTMENTS

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

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

NEG CURR AMP BIAS sets the bias voltage of the negative shunt amplifier. Clockwise adjustment increases negative bias.

POS CURR AMP BIAS sets the bias voltage of the positive shunt amplifier. Clockwise adjustment increases negative bias.

LINE LOSS sets the sensitivity of the line loss current. Clockwise adjustment increases sensitivity.

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

INV BIAS sets the bias voltage of the inverter amplifier. Clockwise adjustment increases negative bias.

CURR SIG sets the positive current signal at the current signal out terminal. Clockwise adjustment increases the signal.

4. TERMINAL FUNCTIONS

<u>No.</u>	<u>Label</u>	<u>Function</u>
1	115 VAC	Input Power
2	115 VAC	Input Power
3	LLR	Line loss relay contact
4	LLR	Line loss relay contact
5	NEG BUS	Volt feedback from neg. bus
6	ACDC	ACDC signal input
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	Volt feedback from pos. bus
14	CURR SIG OUT	Output of pos shunt amp
15	INHIBIT IN	Circuit clamp input signal
16	INHIBIT OUT	Trip circuit output signal
17	FC +	Circuit output positive

5. POWER SUPPLY OUTPUT ADJUSTMENT

5.1 Power Supplies with AVC

- a. Set output control to zero.
- b. Measure output of negative shunt amplifier to test point -SA. Should be between zero and -.05 volts.

Adjust with NEG CURR AMP BIAS if necessary.

- c. Light load in tank.

Bring AVC control to 100%

Adjust power supply output voltage to rating with VOLT LIMIT

- d. Heavy load in tank.

Slowly bring up AVC control and observe current. If current wants to exceed supply rating, adjust CURR LIMIT.

5.2 Power Supplies with ACC

- a. Set output control to zero.
- b. Measure output of negative shunt amplifier at test point -SA. Should be between zero and -.05 volts.

Adjust with NEG CURR AMP BIAS if necessary.

- c. Light load in tank.

Slowly bring AVC control to 100%.

Adjust power supply output voltage to rating with VOLT LIMIT

- d. Heavy load in tank

Slowly bring ACC control to 50%.

Output current should be approximately 50% of rating

Adjust CURR LIMIT if necessary.

- e. Slowly bring ACC control to 100%.

Adjust current to power supply rating with CURR LIMIT

5.3 Power Supplies with AVC and ACC

- a. Set output controls to zero.

- b. Measure output of negative shunt amplifier at TP -SA.

Should be between zero and -.05 volts.

Adjust with NEG CURR AMP BIAS if necessary.

- c. Light load in tank.

Set ACC control to 100%.

Adjust power supply output voltage to rating with VOLT LIMIT

- d. Set ACC control to zero, AVC control to 100%.

Heavy load in tank.

Slowly bring ACC control to 50%.

Output current should be approximately 50% of rating

Adjust CURR LIMIT if necessary.

- e. Slowly bring ACC control to 100%.

Adjust current to power supply rating with CURR LIMIT

5.4 Power Supplies with ACDC

- a. Have available the smallest and largest load to be used.

- b. Set current control to 100%.

Set CURR SIG control on drive circuit to about 50% rotation.

Set the ACDC control to about 30%.

- c. Set small load into tank.
Adjust AVC control to obtain correct current for this load.
- d. Set larger load into tank.
Adjust the ACDC control to obtain a current about 10% higher than the correct current for this load.
- e. Set small load into tank.
Adjust the ACDC control to obtain the correct current for this load.
- f. Set large load into tank.
Adjust the ACDC control to obtain the correct current for this load.
- g. Repeat steps e and f until the two proper current values are obtained when switching between the two loads.

6. DRIVE CIRCUIT 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 BIAS adjustments.

- a. Apply 115 VAC to terminals 1 and 2.
Connect a 1 k-ohm resistor between terminals 17 and 18.
- b. Measure + 12 volt power supply at test points.
Should be within .5 volts of nominal.
- c. Measure voltage at test point -SA.
Should be between zero and -.05 volts.
Adjust with NEG CURR AMP BIAS if necessary.
- d. Measure voltage at test point +SA.
Should be between zero and +.05 volts.
Adjust with POS CURR AMP BIAS if necessary.
- e. Measure voltage at test point IA.
Adjust to \approx zero volts with INV BIAS.
- f. Measure voltage at test point CS.
Should be between zero and -1 volt.
- g. Measure voltage at TP VS.
Should be between +.5 volts and -.5 volts.

- h. Measure voltage at terminal 18.
Should be +12 volts.
- i. Short together terminals 7,8 and 9.
Leave on for remainder of test.
Measure voltage at terminal 9.
Should be +2.5 volts, + .25.
- j. Measure voltage at test point CS.
Should be between +6 and +8 volts.
- k. Measure voltage at test point VS.
Should be between +6 and +8 volts.
- l. Measure voltage at terminal 18.
Should be approximately +2 volts.