DLVP-50-120-1500
OPERATOR'S MANUAL

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1. INTRODUCTION

The Dynaload is a precision instrument which simulates electrical loads to test power supplies, generators, servo systems, batteries, and similar electrical power sources. It simulates, at the option of the user, resistive loads (amps/volt) or may be switched to a constant current load characteristic (current regulated at a pre-selected value) or a constant voltage type of load (similar to a battery or a zener diode). Provisions are also made for external programming in automated test set-ups. The external programming voltage is from 0-10V, with an input impedance of I0K minimum. Load current is directly proportional to programming voltage, and the sensitivity is adjustable with the front panel current adjustments.

In addition to the constant current external programming, the Dynaload may be programmed by an external resistance to function as a resistive load. The load resistance is inversely proportional to the programming resistance.

The pulse load may be varied in frequency and 10-100% duty cycle (pulse width). Frequency ranges are 20-200 Hz, 100-1000 Hz, and 500-5000 Hz.

Pulse amplitude is independently controlled and may be added to a preselected DC current by the combination of the front panel controls. The meter normally reads peak pulse current, so the DC current should be preset, and the pulse current is the difference between the peak reading and the previous DC reading. The output of the internal pulse generator is available at the rear panel (TB1-1). The pulse waveform may be modified by inserting wave shaping circuitry between TB1-1 and TB1-2, which are normally jumpered together by a clip on the terminal block.

The circuit breaker used to connect the source to the power devices in the load is electronically controlled and senses overcurrent, over-dissipation (volts x amps), and overvoltage. In the event of an overvoltage or over-temperature condition, protection circuits open the electronic circuit breaker. In the event of an overcurrent or over-power condition, circuitry is activated to limit the load current, and a front panel "power limit" LED is lit. If the current and power are increased further, protective circuitry will open the electronic circuit breaker. The power transistors are turned off prior to the circuit breaker opening.

2. SPECIFICATIONS

The following ratings apply:

Load voltage:	0-50V
Load current:	0-120A
Power dissipation:	0-1500W
Overload rating:	20%
Self-protection:	Overvoltage -less than 60V
	Overcurrent -less than 140A
	Over-power -less than 1750W

Mode Selector Switch Positions, from left to right:

<u>Position</u> 1: Constant resistance 0-5 A/V as determined by the front panel DC load adjust

<u>Position</u> 2: Constant resistance 0-30 A/V as determined by the front panel DC load adjust

<u>Position</u> 3: Constant current 0-30A as determined by the front panel DC load adjust

<u>Position</u> 4: Constant current 0-120A as determined by the front panel load adjust

<u>Positions 5 and 6</u>: A variable duty cycle pulse load with 0-30A and 0-120A ranges. The frequency ranges of 20-200, 100-1K, and 500-5K are selected by the three frequency range switches directly above the pulse load range switches.

<u>Position</u> 7: External modulation--will program from 0-120A with 0-I0V applied to the external modulation terminals (TB1-3 and TB2-5). Modulation sensitivity is directly adjustable by the front panel DC load adjust control.

<u>Position</u> 8: Constant voltage load. In this position, the load is similar to a battery being charged or a constant voltage zener diode; i.e.; no current is drawn until the source voltage reaches the regulating voltage. The voltage at which the Dynaload regulates is adjustable by the front panel volts control.

Front Panel Controls

S1: AC on-off switch and indicator lamp.

S2: DC load on-off switch and indicator lamp.

M1: Input voltage range as selected by front panel voltage range select switch: 0-6V, 0-18V, or 0-60V.

S3: Short circuit switch.

M2: Load current range as selected by front panel current range select switch: 0-12A, 0-36A, or 0-120A.

CAUTION: THE METER RANGE SELECTOR SWITCHES SHOULD ALWAYS BE MAINTAINED IN THE HIGHEST VOLTAGE OR HIGHEST CURRENT POSITION, EXCEPT WHEN READINGS ARE BEING TAKEN; I.E., ALTHOUGH THE METERS HAVE HIGH OVERLOAD CAPABILITY, THEY MAY BE DAMAGED BY OVERLOADS IN THE LOWER RANGE POSITIONS.

NOTE: WHEN TESTING LOW CURRENT SOURCES, IT MAY BE ADVISABLE TO USE AN EXTERNAL FUSE OR CIRCUIT BREAKER TO PROTECT THE SOURCE.

Provision is made to connect the load by front panel binding posts for load currents of less than 15A. When the load currents are greater than 15A, the studs on the rear of the unit should be used.

Current Sample: This is provided for measuring the combinations of steady state and pulse load current with an oscilloscope. The current sample output is calibrated for 1 amp per millivolt.

Sink Out: This is a pulse output, which is of the same frequency as the internal pulse generator and may be used to trigger an oscilloscope.

Peak Average Switch: This switch places the ammeter control circuitry in either a peak pulse current reading or an average current reading mode.

DC Load Current Adjust: Coarse and fine adjust controls with a 10 to 1 ratio for precisely setting the load current for the constant current and amps/volt ranges. This control is also functional in the pulse mode to adjust the DC load component.

Pulse Load Current Adjust: Coarse and fine adjust controls for the 0-30A and 0-120A pulse ranges.

Rate/Width Controls: The rate control continuously adjusts the frequency of the pulse load within the frequency range selected. The width control adjusts the duty cycle of the pulse from 10% to 100%.

Volts Control: This control sets the threshold voltage at which the Dynaload will regulate the voltage present at the input by drawing the load current required to bring the voltage down to the value set. The "knee" of the threshold is approximately 500 A/V.

Rear Panel Connections

E+: Plus load--connect to positive terminal of source to be tested.

E-: Minus load--connect to minus terminal of source to be tested.

TB1-1: Output of pulse generator.

TB1-2: Input to pulse load range switches. Terminals TBl-1 and TBl-2 are normally jumpered together.

TB1-3: External modulation input. Calibrated for 12A per 1-volt input.

TB1-4: 10V reference for use as programming voltage.

TB1-5: Resistance programming. Access pin to front panel DC load adjust potentiometer. Mode selector switches to the A/V ranges.

TB2-1: Status indication of electronic circuit breaker mode. With circuit breaker closed, a 5V signal will be present at this pin. With the circuit breaker open, no voltage will be present.

TB2-2: DC on. A short from this pin to circuit common will close the circuit breaker.

TB2-3: DC off. A short from this pin to circuit common will open the circuit breaker.

TB2-4: Short. The short circuit contactor can be energized by pulling this pin to circuit common. The short circuit will remain as long as the pin is kept low.

TB2-5: Circuit ground. This is the connection to the current regulators circuit common and is electrically connected to the E-stud.

> **NOTE:** THE CONTROL OF THE CIRCUIT BREAKER ONLY REQUIRES A MOMENTARY CONNECTION TO THE CIRCUIT COMMON TO CHANGE THE STATE OF THE BREAKER. THE PROTECTION CIRCUITRY IS NOT ALTERED BY THESE CONTROL PINS OR THE FRONT PANEL DC LOAD ON SWITCH. THE CIRCUIT BREAKER AND SHORT CIRCUIT CONTROL PINS REQUIRE LESS THAN 10MA TO CIRCUIT COMMON.

F1: AC line fuse 1A, SB.

3. OPERATING INSTRUCTIONS

The following procedure is recommended for connecting the Dynaload: The AC and DC Dynaload switches should be turned off so that the load is disconnected. The meter range switches should be set in their maximum voltage and current positions, and the load adjustment controls should be set in the counterclockwise position. The mode selector switch should be set to the appropriate mode to be used. The Dynaload should be plugged into standard 115V, 50-60 Hz power (optional input voltage ranges are available), and connections should be made from the source to be tested to the appropriate load terminals of the Dynaload. (E+ and E- on the rear of the unit. Two terminals are provided in parallel for each polarity for simplified connections.) If external modulation is to be used, the external programming voltage should also be connected.

With the AC power switch on, the AC-on indicator lamp should light. The DC-on circuit breaker should now be actuated by pressing the momentary contact "DC LOAD-ON" switch. The indicator lamp in the "DC LOAD-ON" switch should light, and the front panel Dynaload voltmeter should indicate the source voltage. (If the circuit breaker does not close, or if there is no indication of source voltage, check all the external connections for voltage and polarity.) The load may now be increased by turning the load adjust controls slowly clockwise until the appropriate load is obtained. The meter range switches may be switched to the lower scale positions if greater accuracy is required, and external instrumentation may be used to obtain further accuracy and eliminate the effects of line voltage drops at high currents.

3.1 Constant Resistance Mode (Amps/Volt)

Two scales are provided: i.e., 0-5 A/V and 0-30 A/V. Minimum resistance on the 0-5 A/V is 0.2 ohm, and minimum resistance on the 0-30 A/V is 0.03 ohm. For example, to test a 12V battery with a two ohm resistive load, the mode selector should be set to the 5 A/V position, and the coarse and fine load adjust controls adjusted to obtain the 6A load. The two ohm load is now set, and this resistance value will remain constant for the full range of input voltage.

The resistive load characteristics of the Dynaload simulate a pure resistance down to approximately 1 to 2V input; i.e., for a given resistance setting, the current is directly proportional to the voltage over wide dynamic ranges. In the very low voltages, the power transistors will saturate.

3.2 Constant Current Mode

Some power sources, such as variable power supplies, are rated at a fixed maximum load current and adjustable over a predetermined voltage range: i.e., 5-30V @ 20A. If the resistive load characteristic were used for this type of test, it would be necessary to reset the load each time the power supply voltage was changed, in order to maintain the full load current. However, if the load is set to the 0-30A range, and a load of 20A is applied, then the power supply can be adjusted from 5-30V, and the load current will remain constant.

It should be noted that many power supplies are designed for short circuit protection by internal current limiting and bendback, and therefore, may not start up into a constant current type of load. Accordingly, the constant resistance characteristic should be used as a load when simulating short circuit protection and recovery of most power supplies, unless otherwise specified by the manufacturer.

3.3 External Modulation

In the external modulation mode, the Dynaload acts as a constant current load with the constant current proportional to the external voltage applied to TB1-3 and TB2-5.

The Dynaload will program from 0-120A if the DC load adjustments are set in the maximum clockwise position. The programming sensitivity may be reduced proportionately by the front panel DC load adjust controls; i.e., turning the load adjust counterclockwise reduces the programming sensitivity. The input impedance of the external modulation terminals is approximately 10K ohms. The linearity of the external program is set to be within 2% above 1A. The transient response of the Dynaload is determined by the feedback loop characteristics of the constant current regulator to achieve precision programming.

3.4 Pulse Mode

The pulse load may be varied from 0-30A or from 0-120A peak current by the pulse amplitude control on the front panel. The frequency may be varied from approximately 20-5000 Hz by the pulse frequency control and range switches on the front panel. This pulse load may be superimposed on top of a constant DC load, which may be selected by the DC load control on the front panel.

If the pulse is to be used down to a no-load state, the DC load controls should be turned fully counterclockwise. The maximum total of the pulse and DC load will be limited around 125A by the internal current limit protection.

The rise time of the load current pulse is approximately 50 μs for 0-120A. If this is too fast for the application, the waveform may be altered by inserting a network between TB1-1 and TB1-2.

The DC and pulse load may be mixed in any combination through the use of the separate DC load coarse and fine and the pulse load coarse and fine controls. When the 0-30A pulse mode is used, the DC load control is calibrated to a 30A maximum range and the pulse load control also has a 0-30A range. The 120A range functions similarly.

3.5 Constant Volts Mode

In the constant volts mode, the Dynaload acts as an adjustable power zener diode. The regulating voltage is programmable from approximately 2-50V by the front panel volts adjust control. The constant volts position is used to simulate a battery to a battery charger, or the Dynaload may also be used as a shunt regulator for special applications.

3.6 Power Rating

The model DLVP 50-120-1500 will dissipate 1500W continuously. In order to assure that overheating does not occur, the rear and sides of the Dynaload should be clear for the air intake and the air exhaust; i.e., the cooling air enters from the sides and leaves from the rear. The Dynaload should periodically be checked for dust accumulation. If the power devices should exceed 125 ° C, a thermal cutout will trip the circuit breaker.

3.7 Protective Circuits

The Dynaload has internal current limiting at approximately 125A maximum, at which point the power limit lamp is lit, and if the load current exceeds aproximately 130A, the circuit breaker will trip. The Dynaload also incorporates reverse voltage protection by reverse diode; i.e., if the input is hooked up backwards, the source will be shorted. In the event that an overvoltage is applied to the Dynaload, an internal overvoltage circuit will open the circuit breaker, thereby protecting all internal circuits.

The voltage current product is also monitored to prevent an overpower condition from happening. Accordingly, the current limit characteristic is set to approximately 125A, which is maintained to approximately 12V. At this point, the current limit characteristic is reduced as the input voltage is increased, thereby limiting the maximum power which may be programmed into the Dynaload. When the load exceeds 125A or 1500W, the power limit indicator will be lit.

3.8 Special Applications

The Dynaload may be used for AC load testing, within its ratings, by the use of an external bridge rectifier, so that the Dynaload sees pulsating DC, but the AC source sees an AC load. The effect of the rectifier is to slightly distort the Dynaload characteristics at low voltages and currents. The Dynaload is not normally recommended for testing AC sources above 1000 cycles due to its limited speed of response, unless the user specifically recognizes the load characteristics at higher frequencies.

The Dynaload may also be used as a current or voltage regulator rather than a load for special applications as illustrated in Sections 3.2 and 3.5.

3.9 Effects of Cable Inductance on Pulse Loading

When the Dynaload is used for high current pulse loading, the effects of cable inductance must be considered. The critical parameters are the 50-microsecond rise time and the 3V minimum compliance specifications. If the inductance of the cables from the voltage source to the Dynaload is great enough to cause the voltage at the Dynaload to go below 3V, then excessive current waveform distortion will occur. This is because the power devices are driven into saturation in an attempt to reach the programmed current which cannot occur because of the low collector voltage. Once in a saturated state, the response time is much slower. The result is a significant overshoot on the rising edge of the pulse. The peak reading ammeter will measure this peak and give deceiving results.

In order to prevent this from occurring, it should be noted that:

1. 1 microhenry = 2.4 feet of wire (total).
2. 50A @ 50 microseconds rise time = 1 volt drop with 1 microhenry
3. The inductive drop cannot exceed the difference between the source voltage and the 3V compliance.

For example: To test a 10V source with a 100A pulse, the maximum cable length would be:

E Max drop = 7V

$$E = L \frac{di}{dt} \qquad 7V = L \frac{100A}{50\mu s}$$

L = 3.5 microhenries maximum

Maximum cable length = 8.4 feet total or
4.2 feet from source to Dynaload.

If the distance from the load to the source must be greater than this, there are several methods to increase the maximum distance. One way is to use several insulated conductors. This cuts the inductance in half if 4 are used instead of 2, or by one-third if 6 are used. This doubles or triples the maximum length, respectively. Another method is to slow down the rise time of the pulse generator before applying it to the regulation loop. This can be done by removing the jumper on TB1 and inserting an R-C network between the pulseout and pulse-in terminals. Increasing this rise time to 50 microseconds will double the maximum cable length. The third method is to use a large electrolytic capacitor at the Dynaload studs that can supply the current necessary to counteract the inductive drop of the cable. If the previous example required 15 feet of total cable length or 6.25 microhenries, which would be 12.5V of inductive drop, then the capacitor would have to supply 5.5V @ 100A for 50 microseconds. By the formula:

$$E \qquad \frac{I \quad T}{C}$$

The capacitor required would be 900 microfarads.

4. CALIBRATION PROCEDURES

4.1 Voltmeter Calibrate

No Load Current, Circuit Breaker Closed

6V range; set 3V. (2.94-3.06V) R37

18V range; set 9V. (8.82-9.18V) R38

60V range; set 30V. (29.4-30.6V) R39

4.2 Ammeter Calibrate

PEAK-AVG. Switch in AVG. Position

12A range; set 10A. (9.8-10.2A) R40

* Check @ 2A reading. (1.96-2.04A)

36A range; set 30A. (29.4-30.6A) R41

120A range; set 100A. (93-102A) R42

* Adjust R77 if necessary.

4.3 Current Calibrate Sample

Set @ 100mV with 100A load. (R64)

4.4 Amps Per Volt Calibrate

Apply 4V to unit; measure voltage with digital at TP1 and TP2.

With coarse load, adjust full clockwise.

0-5 A/V range, set 20A. (19.8-20.2A) R35

0-30 A/V range, set 120A. (119-121A) R36

4.5 Constant Current Calibrate

With coarse load**,** adjust full clockwise, 10V applied to unit.

0-30A range (29.75-30,25A) R33

0-120A range (119-121A) R34

4.6 Current Limit Calibrate

Set C. L. at 10V. (120-130A) R85

4.7 Power Limit Calibrate

Set P. L. (34-39A) at 45V. R94

Set P. L. (43-50A) at 35V. R94

Set P. L. (60-70A) at 25V. R94

Check power limit indicator.

4.8 Linearity Calibrate

A 0-10V power supply with high resolution of adjustment will be required to accurately set the program voltage. The program voltage is applied to the external modulation pin at TB1-3. The calibration should be done with a 10V source voltage.

Program Voltage	Load Current
0.5V	________(5.88A-6.12A)
1.0V	________(11.76A-12.24A)
4.0V	________(47.04A-48.96A)
7.0V	________(82.32A-85.68A)
0.0V	________(117.6A-122.4A)

NOTE: R67 IS USED TO ADJUST LOW CURRENT SET, AND R32 IS USED TO ADJUST HIGH CURRENT.

5. THEORY OF OPERATION

5.1 Current Regulator Loop

Operation amplifiers U3 and U4 process a voltage that is derived from either the reference for constant current or from the source voltage in the amps per volt mode. Operational amplifier U5 is used as an error amplifier that compares the processed voltage from U3, U4 and the voltage drop generated on SH101 from the load current. The output of U5 is sent through a current gain stage (Q2) and then directly to the power transistors to control the load current. The power transistor section consists of 3 drivers and 32 main transistors. Each main transistor has an emitter resistor that allows equal current sharing. The emitter resistors are of the fusible type such that the failure of any one transistor will cause the resistor to open and that transistor will be isolated from the bank by the individual base steering diodes.

A voltage is applied through R17 and/or R31 to pin 2 (inverting input) of U3 that is determined by the front panel load adjust controls. If the DC load adjust is adjusted for 120A, then +0.6V will be present on D4 and R17. Pin 2 of U3 is a virtual null and should not be measured. The output of U3 will be -0.9V and is sent through R46 to U4, pin 2. The output of U4 will be +0.2V and is applied to pin 3 (non-inverting input) of U5. This is now the reference voltage for comparison with the shunt voltage. The shunt voltage is applied to pin 2 of U5 through R65. Error amplifier U5 will control the loop to maintain equal voltages on pins 2 and 3.

If the processed reference voltage on pin 3 of U5 is greater than the shunt voltage, then the output on pin 6 will drive Q2 harder, which will in turn increase the drive current to the power transistor configuration. This will increase the load current from the source until the shunt voltage reaches the reference voltage, at which point the error amplifier will reduce the drive, and the loop will equalize in regulatory fashion.

The RC networks around U5 determine the speed of response of U5 and are made to be slower than the sum of the other components in the loop to assure that U5 is the controlling factor. The response time of the loop is approximately 50us for a 0-120A step.

Potentiometer R67 is used to balance the input section of U5 and to compensate for ground potential differences from shunt to the PCB. This control is used to calibrate the linearity in the external program mode.

Transistor Q3 is used to actively shut down the power section if the shunt voltage should exceed that programmed, and therefore, improves the fall time during high current pulse loading.

5.2 Peak Reading Ammeter

The basic principal involved in the peak reading ammeter circuit is to charge a capacitor to a value proportional to the peak voltage developed across the shunt. The voltage must not decay more than 2% between successive pulses. This is accomplished by operational amplifiers U6 and U7.

NOTE: The voltage gain of an operational amplifier is directly proportional to the ratio of input current to feedback current. Three configurations are used in this unit.

The inverting amplifier, where the input is to pin 2, has a voltage gain equal to the feedback resistor from pin 6, divided by the input resistor to pin 2. In this configuration, the quiescent output voltage is equal to the voltage on pin 3.

The voltage follower, where the input is to pin 3, has unity gain if pin 2 is connected to the output only.

The comparator or error amplifier configuration will compare the voltages present on pin 2 and 3, and the output will be high if pin 3 is greater, or low if pin 2 is greater.

The input amplifier of the peak reading ammeter is U7. The circuit consists of an inverting amplifier (U7), a storage capacitor (C9). and a high impedance voltage follower (U6). The gain of the circuit is determined by the input resistor selected by the ammeter range switches and an overall feedback resistor R56.

As a voltage pulse is impressed on the shunt by a current pulse, U7 amplifies and inverts the signal to -5V peak for a full-scale reading. Transistors Q4 and Q5 supply the current required to instantaneously pull capacitor C9 to this -5V potential. Capacitor C9 is now charged to a voltage proportional to the peak of the load current waveform. Voltage follower U6 transfers this voltage to the ammeter through R74 without loading down C9. Potentiometer R77 is used to zero the ammeter. The peak average switch S4 is out of the circuit for peak reading and shorts out CR9 for average reading. Shorting CR9 causes R71 to load down C9, and therefore, the pulse current is not stored. The ammeter sees the pulse current wave formand will give a mechanically averaged reading.

5.3 Current Limit/Power Limit

Operational amplifier U8 performs the function of current limit and power limit by comparing a reference set by R85 to a combination of the shunt voltage and input source voltage. If the source voltage is below 13V, then the comparison is just reference to shunt voltage. When the shunt voltage exceeds the value set by R85,, the output of U8 will go negative and shut down the drive to the power transistors through the power limit indicator and R62. When the product of source voltage and shunt voltage exceeds 1500W, the drive will similarly be limited. This is accomplished by zener diodes VR7 and VR10. A portion of the source voltage is added to the shunt voltage by VR7 and VR10, such that, as the source voltage increases, the current limit point is reduced. The power limit curve is a dual slope approximation.

5.4 Electronic Circuit Breaker

A J-K flip-flop (U9) is used to energize a power contactor through Q8. The front panel DC load on switch is a momentary contact type that grounds pin 12 of U9 to change the state of the flip-flop. The set input (pin 13), reset (pin 2), and output (pins 8, 9) are brought out to TB2-1 for remote control and status. The current limit section (U8) is directly connected to the reset input and will override any other control in the event of an overcurrent, overvoltage, or over-power condition.

5.5 Overvoltage Protection

Operational amplifier U8 also provides overvoltage protection through the use of R89, VR8, and VR9. If the source voltage exceeds 50V, these zener diodes will cause the voltage on pin 2 to rise rapidly and put the loop into power limit. The circuit breaker will trip because of the connection from U8 to the reset input of U9.

5.6 Pulse Generator

Integrated circuit U1 (A3) is a variable pulse width oscillator whose frequency is determined by the value of capacitance from pin 7 to ground. The pulse width is determined by the DC reference voltage present at pin 2. Pin 10 is a 5V reference. The output of the oscillator (pins 12, 13) is inverted by Q2 (A3) and sent to the pulse load adjust controls. Transistor Q1 on A3 is used to generate a spike from the pulse generators output for triggering an oscilloscope.

5.7 Short Circuit

Power contactor K1 is provided for testing the short circuit current of a power supply. The contactor is energized by Q6 and Q7. A current path of less than 10mA from TB2-4 to circuit ground is needed to energize the contactor.

5.8 Power Supply Circuitry

Power is applied through F1 and S1 to the two fans and the primary of T101. The two primaries of T101 may be connected in parallel for 115 VAC, or in series for 230V operation. Secondary 8, 9, 10 is rectified and filtered both positive and negative. Three pin regulators U1 and U2 regulate the raw DC to ±12V for all of the operational amplifiers and mode indicator lamps. Secondary 5, 6, 7 is rectified and filtered to 28V for the short circuit and circuit breaker contactors.