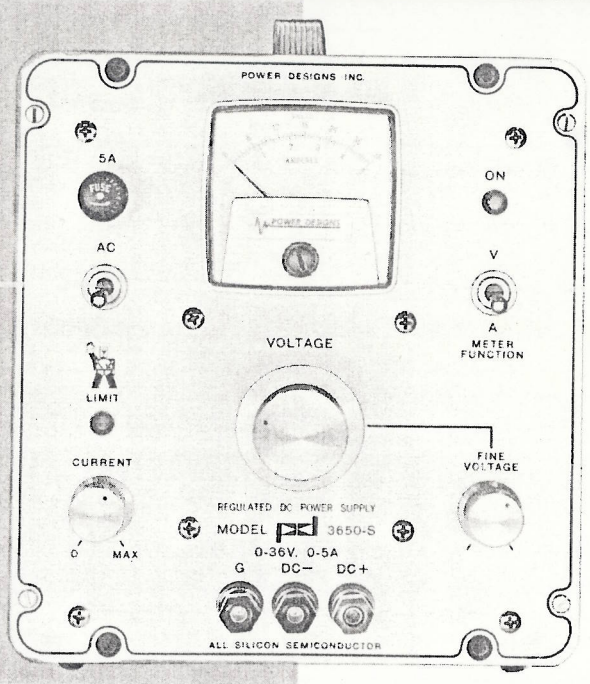
POWER DESIGNS

CONSTANT-VOLTAGE DC POWER SOURCE

TECHNICAL DATA

MODEL 3650S



0–36 VOLTS

0–5 AMPERES

The Model 3650S is a stable DC power source designed for laboratory, industrial, and electronic-system applications. Coarse and fine controls provide continuous adjustment over the entire output voltage range. A self-indicating current limiter permits output current control from zero to the maximum supply capability. Internal circuitry completely protects the instrument from overloads and short circuits. Rear terminals are provided for external voltage programming and remote sensing.

Design simplicity results in a portable instrument with high reliability under severe service conditions.

DESIGN FEATURES

- Continuously adjustable output voltage with coarse and fine controls; resolution of 10 MV.
- Continuously adjustable current limiting.
- Remote sensing.
- Remote programming.
- Automatic dissipation-limit control of internal power transistors.
- Series or parallel operation.
- Front and rear output terminals.
- All silicon semiconductors.
- Modular construction permits multiple-unit rack mounting. One or two supplies may be mounted in a standard 8¾" x 19" rack. (See catalog sheet RPA-62 for rack-panel adapters.)
- Processed under Power Designs' "Predictable-Reliability" program for a 5-year MTBF. The program features: avalanche-controlled silicon rectifiers, stress-tested transistors, pre-aged zener references with extrapolated stability criteria based on 1/f noise changes, computer-grade capacitors, tin-oxide-film resistors, and components operated at 50% of manufacturers' published ratings. Units pre-aged under full-load conditions for a minimum of 50 hours.

SERIAL NO:_____

SECTION 1
GENERAL DESCRIPTION

1-1. DESCRIPTION

The Model 3650S is a regulated DC power source suitable for use with laboratory and industrial instrumentation. The unit supplies from 0 to 36 volts at 5 amperes and automatically limits the load current if an overload should occur. The current limiting point is adjusted by a front panel control. Silicon semiconductors are used throughout for optimum temperature stability and reliability.

The power source is very easily adapted for remote sensing (compensation for lead losses) or remote programming of the output voltage by connections at the rear-panel terminal strip. A dissipation monitor* insures safe operation when remote programming is used.

The Model 3650S is designed for bench use. Panel adapters are available for mounting one or two units in a 19 inch rack.

1-2. ELECTRICAL SPECIFICATIONS

OUTPUT: 0 to 36 volts DC, 0 to 5 amperes, continuously adjustable.

INPUT: 105 to 125 volts, 55 to 440 Hz, single phase, 300 watts (at nominal line voltage).

REGULATION: Better than 0.01% +3 millivolts for line voltage variations of ±10% or 100% changes in rated load.

RIPPLE AND NOISE: Less than 500 microvolts rms at 60 Hz line, less than 1 millivolt at 400 Hz line.

RECOVERY TIME: Less than 50 microseconds to return to within regulation limits after a step change (1 microsecond rise time) in rated load of 10 to 100% or 100 to 10%.

STABILITY: Better than 0.01% +5 millivolts per 8 hour period after warm-up at constant line, load and ambient temperature.

TEMPERATURE COEFFICIENT: 0.02% +2 millivolts per degree C.

PROGRAMMING CONSTANT: 200 ohms per volt nominal.

SOURCE IMPEDANCE: Less than 0.003 ohm at DC, 0.15 ohm at 100 KHz, 1.5 ohms at 1 MHz.

CURRENT LIMITING: 0 to 5 amperes, continuously adjustable.

OPERATING TEMPERATURE RANGE: 0 to 60°C.

OUTPUT POLARITY: Either output terminal may be connected to ground. The maximum potential between any terminal and ground must not exceed 500 volts.

*Patent applied for.

1-3. MECHANICAL SPECIFICATIONS

The Model 3650S is housed in a portable steel cabinet finished in blue vinyl enamel. The front panel is brushed, anodized aluminum with etched black lettering.

DIMENSIONS: 7-3/4 inches x 8-5/8 inches x 13-1/2 (depth behind front panel).

WEIGHT: 33 pounds.

SECTION 2
INSTALLATION AND OPERATION

2-1. GENERAL

No preliminary inspection or processing is required. The power supply is ready for operation as shipped from the factory.

2-2. INSTALLATION

a. Connect the line cord to a 105 to 125 volt, 55 to 440 Hz source.

b. Rotate the CURRENT control fully clockwise.

c. Set the METER FUNCTION switch to V and adjust the VOLTAGE and FINE VOLTAGE controls for the desired output voltage as shown on the panel meter.

d. Connect the load to either the front or rear panel DC+ and DC- terminals.

2-3. CURRENT LIMITING

Rotate the CURRENT control fully counterclockwise. Readjust the CURRENT control clockwise until the LIMIT lamp just goes out.

2-4. SENSING

The points to which the sensing leads are connected are the points at which optimum regulation is obtained. When the output voltage is sensed at the output terminals, the voltage across the load will be:

$$V_l = V_{out} - I_l \times R_{lw}$$

where V_{out} = supply output voltage
V_l = voltage across load
I_l = load current
R_{lw} = resistance of wires connecting power supply and load

The unit is connected for local sensing (i.e. the sensing terminals are connected to the output terminals) when it is shipped. However, if remote sensing is desired:

a. Disconnect the links between the S+ and DC+ and S- and DC- terminals at the rear of the supply. Connect the S+ terminal to the positive side of the load. Connect the S- terminal to the negative side of the load.

b. The wires between the sensing terminals and the load should be tightly twisted together. If more than 6 feet of wire is used, a 20 microfarad, 65 VDC capacitor should be connected across the sensing terminals.

2-5. REMOTE VOLTAGE PROGRAMMING

This feature allows the output voltage to be controlled remotely. However, because of the type of regulator used, the programming range

is limited by the power dissipation in the series pass transistors. The curve printed on the rear panel shows programmable ranges for the three settings of the VOLTAGE control. For example, if the VOLTAGE control is set for 36 VDC output, the supply may be programmed from 31 VDC to 38 VDC with a 5 ampere load, or from 15 VDC to 43 VDC with a 2.5 ampere load. The dissipation monitor will automatically limit the series pass dissipation if the unit is operated outside the safe area. The LIMIT light will go on when the monitor operates.

NOTE: The programming terminals are sensitive to noise and hum pick-up. A shielded, twisted pair of wires should be used to connect the programming resistor to the terminals. The shield must be connected to the chassis of the unit. Locate the resistor away from fields caused by solenoids, radio transmitters, etc.

a. Adjust the VOLTAGE control until the panel meter indicates the output voltage closest to that at which the supply will be programmed. Set the AC switch off.

b. Disconnect the jumper between the RV1 and RV2 terminals. Connect the programming resistance between the RV1 and S- terminals. The value of this resistance is given by:

$R_p = V_o \times 200$ where R_p = programming resistance in ohms
V_o^p = desired output voltage change in volts

c. Connect the load and set the AC switch on. The series pass transistors will be protected from excessive dissipation by the dissipation monitoring circuit. The LIMIT lamp will light if an overload should occur.

CAUTION

DO NOT MAKE CHANGES IN THE PROGRAMMING CONNECTIONS WITH LINE VOLTAGE APPLIED TO THE UNIT.

SECTION 3
PRINCIPLES OF OPERATION

3-1. GENERAL

The Model 3650S uses a conventional series regulator to control output from a variable voltage full-wave rectifier. Series pass transistors Q1 through Q4 act as the control elements. The voltage drop across these transistors is adjusted by a high gain, DC amplifier to maintain the output voltage at some preset level. The dissipation limiting circuit continuously monitors the series pass power dissipation and limits it if an overload should occur. Operating voltages from the DC amplifier and power monitoring circuits are derived from an auxiliary regulator.

3-2. UNREGULATED SOURCE

The output from transformers T3 and T1 is rectified by diodes CR1 and CR2 and smoothed by capacitor C3.

3-3. SERIES PASS ELEMENT

Series pass transistors Q1 through Q4 are connected in parallel. Base drive is provided by Q5 connected as a Darlington amplifier.

3-4. CONTROL AMPLIFIER

Transistor Q10 compares the DC output voltage with the voltage across reference zener CR14. An increase in the output voltage will cause Q10 collector current to fall, reducing the collector current of Q9. This in turn will reduce the collector currents of Q5 and the series pass network and the output voltage will fall. Compensation for load current changes is provided by R18 and R27. CR6 compensates for temperature effects.

3-5. DISSIPATION MONITOR

Q7 monitors the voltage across the series pass transistors. Q8 monitors the voltage across load current sensing resistor R19. Should either of these voltages rise above the level set by the potentiometer, R14 or R24 and R16, Q7 and Q8 will start to conduct, preventing the load current from rising further.

3-6. AUXILIARY REGULATOR

Zener diode CR12 provides regulated 20 vdc for the semiconductors in the control amplifier and dissipation monitor. Zener diode CR14 provides the reference voltage for the control amplifier and any change in the reference will be reflected in the output voltage. To minimize these changes, Q11 and CR13 maintain a constant current through CR14 and are compensated against line voltage and temperature changes.

3-7. LIMIT INDICATOR

When the unit is in the current or dissipation limiting mode, Q10 will be in saturation and Q12 will be cut off as a result. This will allow lamp I2 to light. As soon as Q10 comes out of saturation, Q12 will start to conduct and the lamp will no longer have the voltage needed to sustain ionization.

2-6. PHASE SHIFT NETWORKS

Each transistor and its associated circuitry will introduce some phase shift. Networks such as R23 and C6 correct the gain and phase shift of the DC amplifier and prevent oscillation.

SECTION 4
MAINTENANCE

4-1. MAINTENANCE

Under normal conditions, no special maintenance of the Model 3650S is required. However, the characteristics of semiconductor components do change with age and the following adjustments and calibration should be made at six-monthly intervals:

4-2. MAXIMUM VOLTAGE ADJUSTMENT

a. Rotate the VOLTAGE and CURRENT controls fully clockwise. Rotate the FINE VOLTAGE control fully counterclockwise.

b. Connect the line cord to a 115 VAC supply. Set the AC switch to ON. Set the METER FUNCTION switch to V.

c. Adjust trimmer potentiometer R30 until the panel voltmeter reads 36 volts.

4-3. LOAD REGULATION

a. Repeat steps a and b in paragraph 4-2.

b. Connect a differential or digital voltmeter between the S+ and S- terminals.

c. Connect the line cord to a 115 VAC supply and set the AC switch to ON. Note the voltmeter reading.

d. Connect a 7.2 ohm, 200 watt load between the rear panel DC+ and DC- terminals. Adjust potentiometer R18 until the voltmeter reading is the same as that noted in step c.

4-4. METER CALIBRATION

a. Energize the power supply. Set the METER FUNCTION switch to A.

b. Connect a 0 to 10 A ammeter in series with a 7.2 ohm, 200 watt load between the DC+ and DC- terminals.

c. Adjust the VOLTAGE and CURRENT controls until the ammeter indicates 5 amperes.

d. Adjust potentiometer R34 until panel meter indicates 5 amperes.

4-5. DISSIPATION LIMITER ADJUSTMENT

a. Energize the power supply. Set the METER FUNCTION switch to A. Rotate the CURRENT control fully clockwise.

b. Connect a 0-50 VDC meter between the collector and emitter of Q1. Short circuit the DC+ and DC- terminals.

c. Adjust the VOLTAGE control until the panel meter reads 1.5 A.

d. Adjust R14 until the voltmeter reads 50 volts.

e. Repeat steps c and d until no further adjustments are necessary

4-6. CURRENT LIMITER ADJUSTMENT

a. Energize the power supply. Rotate the VOLTAGE and CURRENT controls fully clockwise.

b. Connect a 0 to 10 A meter in series with a 6 ohm, 250 watt load between the DC+ and DC- terminals.

c. Adjust R24 until the ammeter indicates 5.5 A.

APPENDIX

1. INTRODUCTION

This Appendix contains an Electrical Parts List, Schematic Diagram, Parts Location Diagram and equipment Warranty.

2. ELECTRICAL PARTS LIST

All electrical and electronic parts are listed in the sequence of their circuit numbers as shown on the Schematic Diagram. A brief description of each part is given, followed by the code number of the manufacturer and his part number. All manufacturers' code numbers are taken from Cataloging Handbooks H4-1 and H4-2, Federal Supply Code for Manufacturers. These handbooks can be obtained from Federal Agencies or ordered directly from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

We recommend that all parts with the code number 98095 be ordered directly from Power Designs, Inc. The commercial equivalents of these parts may have wide parameter tolerances or require special factory inspection or modification before they can be used in the power supply.

All components used in the power supply or supplied as replacements are carefully inspected at the factory. Inspections are performed on a 100% basis or at AQL levels to Military Specification MIL-Q-9858 under which Power Designs, Inc. has been qualified.

All semiconductors are inspected on a 100% basis, not only for operating parameters, but also for critical characteristics related to reliability and predictable life expectancy. Some of these characteristics are observed when the device is taken beyond its normal operating regions. These test techniques have been developed under a "predictable reliability" program in operation at Power Designs, Inc. for the past twelve years. Under this program, quality control procedures are constantly revaluated and updated as advances are made in solid state technology and experience is gained from field history.

Semiconductor manufacturers are continually modifying their products. Complete lines are discontinued to be replaced by devices having improved gain, operating voltage levels and frequency responses. The high gain, closed loop DC amplifiers used in regulator circuits are particularly sensitive to slight changes in these parameters. Commercial or military "equivalent" transistors may affect the performance of the power supply. We can assure compliance with the original specifications if replacement semiconductors are ordered from the Factory.

All replacement semiconductors are processed and stocked at the factory to insure complete interchangeability with the devices in the original equipment. These devices are coded with a Power Designs, Inc. part number. For example:

MS	1028	A
Semiconductor Manufacturer's Code	Power Designs, Inc. Type	Suffix Identifying Special Parameters

When ordering replacements, please identify the device as thoroughly as possible, giving the model and serial number if available.

The replacement part you receive may not have the same part number as that shown on the Electrical Parts List. This can be due to several factors:

a. A different prefix indicates that Power Designs, Inc. is using another vendor source. The operating characteristics of the devices are identical.

b. A completely different part number indicates:

1. The original vendor has discontinued manufacture of the item or can no longer manufacture it to the original specifications.

2. A better device for use in a particular circuit has been substituted.

3. Tighter controls for interchangeability have provided greater assurance of reliability with the replacement.

ELECTRICAL PARTS LIST

NOTE: Before replacing semiconductors, see paragraph 2 of this Appendix.

Circuit Number	Description	Mfr Code Number	Part Number
C1,C2	Capacitor,plastic film,0.1 uf,200 vdc	98095	CP-17-2
C3	Capacitor,electrolytic,8000 uf,60 vdc	98095	CE-76-.6
C4	Capacitor,plastic film,0.001 uf,200 vdc	98095	CP-24-2
C5	Capacitor,plastic film,0.01 uf,200 vdc	98095	CP-16-2
C6	Capacitor,plastic film,0.001 uf,200 vdc	98095	CP-24-2
C7	Capacitor,plastic film,0.01 uf,200 vdc	98095	CP-16-2
C8	Capacitor,electrolytic,20 uf,100 vdc	98095	CE-103-1
C9	Capacitor,ceramic disc,1 uf,3 vdc	98095	CC-100M3AD
C10	Capacitor,electrolytic,350 uf,85 vdc	98095	CE-47-.85LT
C11	Capacitor,ceramic disc,1 uf,3 vdc	98095	CC-100M3AD
C12	Capacitor,electrolytic,100 uf,80 vdc	98095	CE-91-.8
C13	Capacitor,plastic film,0.1 uf,200 vdc	98095	CP-17-2
*C14	Capacitor,electrolytic,35 uf,25 vdc	98095	CE-16-.25
C15	Capacitor,ceramic disc,0.05 uf,600 vdc	98095	CC-34-6
C16	Capacitor,electrolytic,51 uf,50 vdc	98095	CEX-51-50
CR1,CR2	Diode, silicon	98095	ST241
CR3	Diode, silicon	98095	GI44,TS44
CR4	Diode, silicon, zener	98095	SI-250A
CR5 thru CR7	Diode, silicon	98095	GI44,TS44
CR8	Diode, silicon	98095	ST241
CR9 thru CR11	Diode, silicon	98095	GI44,TS44
CR12	Diode, silicon, zener	98095	MS587
CR13,CR14	Diode, silicon, zener	98095	AC359B1-D SV359B1-D
F1	Fuse, Slo-Blo, 5 amperes	71400	MDX5
F2	Fuse, Fast-Blo, 7½ amperes	71400	AGC7½
I1	Lamp assembly, neon	98095	PLA-7
I2	Lamp assembly, neon	98095	PLA-18
M1	Meter, dual scale, 0-36V/0-5 amperes	98095	MVA-100
Q1 thru Q5	Transistor, silicon, NPN	98095	ST1700A
Q6	Transistor, silicon, NPN	98095	2N2243A
Q7,Q8	Transistor, silicon, NPN	98095	TI-2270/U
Q9	Transistor, silicon, PNP	98095	MS1028A
Q10	Transistor, silicon, NPN	98095	TI-2270/U
Q11	Transistor, silicon, PNP	98095	MS1028A
Q12	Transistor, silicon, PNP	98095	2N4888
R1 thru R4	Resistor,wirewound,1 ohm,5%,5 w	98095	RW-010-3RA
R5	Resistor,composition,10 k ohms,10%,½ w	01121	EB1031
R6	Resistor,composition,56 ohms,10%,½ w	01121	EB5601
R7	Resistor,composition,270 ohms,10%,½ w	01121	EB2711
R9	Resistor,composition,5.6 k ohms,10%,2 w	01121	HB5621
R10	Resistor,composition,100 k ohms,10%,½ w	01121	EB1041
R11	Resistor,composition,330 ohms,10%,½ w	01121	EB3311
R12	Resistor,composition,180 ohms,10%,½ w	01121	EB1811
R13	Resistor, prec.,metal film,681 ohms,1%,½W	98095	RD-6810-1QA

*or 51 uf, 25 vdc, part number CEX-51-25

Circuit Number	Description	Mfr Code Number	Part Number
R14	Resistor, variable, wirewound, 200 ohms, 10%, 1½ w	98095	RWTP-201-C4
R15	Resistor, composition, 220 ohms, 10%, ½ w	01121	EB2211
R16	Resistor, variable, wirewound, 200 ohms, 10%, 2 w	98095	RWV201C4.87
R17	Resistor, prec., metal film, 64.9 ohms, 1%, ¼ w	98095	RD-64P9-10A
R18	Resistor, variable, wirewound, 200 ohms, 10%, 1¼ w	98095	RWTP-201-C4
R19	Resistor, wirewound, 0.3 ohms, 5%, 20 w	98095	RW-003-3F
R20, R21	Resistor, composition, 15 k ohms, 10%, ½ w	01121	EB1531
R22	Resistor, composition, 1.5 k ohms, 10%, ½ w	01121	EB1521
R23	Resistor, variable, wirewound, 5 k ohms, 10%, 1½ w	98095	RWTP-502-C4
R24	Resistor, variable, wirewound, 10 ohms, 10%, 1½ w	98095	RWTP-100-C4
R25	Resistor, composition, 680 ohms, 10%, ½ w	01121	EB6811
R26	Resistor, composition, 4.7 k ohms, 10%, ½ w	01121	EB4721
R27	Resistor, composition, 220 k ohms, 10%, ½ w	01121	EB2241
R28	Resistor, composition, 6.8 k ohms, 5%, ½ w	01121	EB6825
R29	Resistor, precision, metal film, 1210 ohms, 1%, ½ w	98095	RD-1211-10A
R30	Resistor, variable, wirewound, 200 ohms, 10%, 1½ w	98095	RWTP-201-C4
R31	Resistor, variable, wirewound, 10 k ohms, 10%, 4 w	98095	RWV103M4-5.06
R32	Resistor, variable, wirewound, 200 ohms, 10%, 2 w	98095	RWV201C4.87
R33	Resistor, wirewound, 0.2 ohms, 10%	98095	RWF00020
R34	Resistor, variable, wirewound, 50 ohms, 10%, 1¼ w	98095	RWT-500-C4
R35	Resistor, prec., metal film, 35.9k ohms, 0.5%, ½ w	98095	RD-3592-60A
R36	Resistor, composition, 15 k ohms, 10%, 2 w	01121	HB1531
R37	Resistor, composition, 10 ohms, 10%, ½ w	01121	EB1001
R38	Resistor, wirewound, 700 ohms, 5%, 5 w	98095	RW-701-3RA
R39	Resistor, prec., metal film, 249 ohms, 1%, ½ w	98095	RD-2490-10A
R40	Resistor, composition, 1.5 k ohms, 5%, ½ w	01121	EB1525
R41	Resistor, composition, 12 k ohms, 5%, ½ w	01121	EB1235
R44	Resistor, composition, 22 k ohms, 10%, ½ w	01121	EB2231
R45	Resistor, composition, 47 k ohms, 10%, ½ w	01121	EB4731
R46, R47	Resistor, composition, 100 ohms, 10%, ½ w	01121	EB1011
R48	Resistor, composition, 330 ohms, 10%, ½ w	01121	EB3311
R51	Resistor, composition, 4.7 k ohms, 10%, ½ w	01121	EB4721
S1	Switch, toggle, SPST	98095	ST-5
S2	Switch, toggle, DPDT	98095	ST-16
S3	Switch, thermal	98095	STH-2
T1	Transformer, power	98095	TTM-66
T2	Transformer, auxiliary	98095	TTH-27
T3	Transformer, variable	98095	TTV-3
	Transformer assembly - T3 and R31	98095	TTV-3B-3

CODE LIST OF MANUFACTURERS

01121	Allen-Bradley Company	Milwaukee, Wisconsin
71400	Bussman Manufacturing Division	St. Louis, Missouri
98095	Power Designs Inc.	Westbury, New York