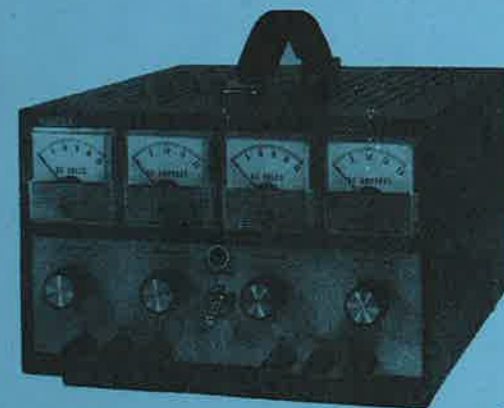
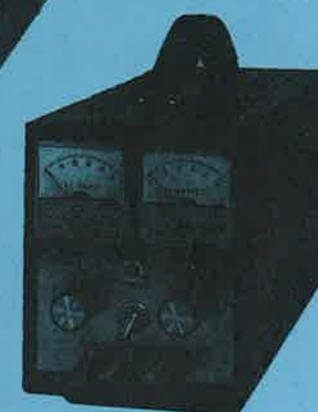
ANATEK

INSTRUCTION MANUAL



50-1D



50-1S

LABORATORY POWER SUPPLIES

POWER SUPPLIES
50-1S, 50-1D

CONTENTS

SPECIFICATIONS

Input .... 117 Vac ± 10%, 57-63 Hz, 0.8 A

Output .... 0 - 50 Vdc   cont. adjustable
0 - 1 Adc

Static Voltage Regulation

Line ...... 0.03%+ 1 mV **max for 10% change in** line voltage (load constant)
Load ...... 0.02% + 1 mV **max for** no load to full load change (line constant)

Static Current Regulation

Line ...... 0.2% + 1 mA for 10% change in line voltage (load constant)
Load ...... 1.0% + 1 mA for load change 10% to full (line constant)

Ripple and Noise..200 μV rms maximum
100 μV rms typical (280 μV p-p)

Transient Response: Output returns to within 10 mV of its previous value in 20 μsec or less (step change from half to full load)

Stability .... 0.02% over 8 hours after $\frac{1}{2}$ hr. warm-up period

Temp. Coefficient. 0.015%/^{o}C

Operating Temp. .. 0 - 35^{o}C
derate 12 mA/^{o}C above 35^{o}C up to 60^{o}C maximum temperature

All units are designed for convection cooling:

DO NOT BLOCK VENTILATION HOLES! (top & bottom)

Adjustments

Voltage ..... 10 - turn control, resolution 5 mV

Current ..... single turn control

Accuracy of meters. 2% of full scale deflection

Output connectors.. 5 - way binding posts

Dimensions (Hx W x D): Model 50-1S
5.75 x 4 x 10.25 inches
14.6 x 10.2 x 26 centimeters

Model 50-1D
5.75 x 8 x 10.25 inches
14.6 x 20.3 x 26 centimeters

Weight .... Model 50-1S 7 lbs (3.2 kg)
Model 50-1D 13 lbs (5.9 kg)

Anatek Electronics reserves the right to make changes or improvements in its products without incurring any obligation with respect to products previously manufactured.

INSTALLATION AND OPERATION

Unpack power supply and check for damage that might have occurred during shipment. Any claims for shipping damage should be made against the shipping company, NOT against Anatek Electronics Ltd.

BEFORE CONNECTING the unit to an AC outlet, make sure that the power switch is in "OFF" position and the Voltage & Current Controls are in the full counter clockwise position. The AC line voltage should be 117 V nominal (105-128 V).

Connect either the (+) or (-) terminal to the ground (GND) terminal depending upon the desired output voltage polarity. Use grounding barrier or short wire for this connection. If the output voltage is to be biased relative to ground, it is recommended that a 0.1 µF capacitor of sufficient voltage rating (200-1000V) be used in place of the shorting connection. The power supply output may be biased up to max. 500Vdc (positive or negative).

Plug line cord into GROUNDED AC outlet.
Switch power switch to "ON" position.
The pilot light located above the power switch will light, the meter readings will remain zero.

To use the power supply in the CONSTANT VOLTAGE MODE:
Turn the current control to the extreme clockwise position and set the voltage control to the desired voltage. The maximum current level (at any voltage setting) is approx. 1.2 A.
Note that voltage regulation specifications apply for a maximum current level of 1 A.

Operating the supply in the CONSTANT CURRENT MODE:
Turn voltage control to the extreme clockwise position and the current control fully counter clockwise. Connect shorting lead across out-

put terminals. Set desired maximum value of current by turning the current control slowly clockwise. Observe Ammeter; disregard reading on Voltmeter. Disconnect shorting lead across output terminals.

The power supply will now automatically switch into current mode (current regulation) as soon as the set current level is reached and will not exceed this level (at any voltage setting) within the specification limits. (See Fig. 1)

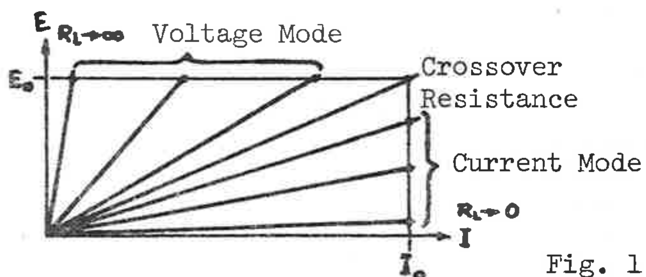


Fig. 1

A typical example:

With the output voltage set at 20 Vdc and the current level slightly over 0.5 A, the power supply will be in Constant Voltage mode when a load of 40 Ohms (orlarger) is connected. However, when a load of 20 Ohms is connected (the settings for voltage and current remaining the same), the power supply will be in the Constant Current mode with the voltage automatically decreased to a level of 10 Volts.
(Ohms Law: 20 Ohms x 0.5 Amps = 10 Volts)

Operation of DUAL SUPPLY.

This supply consists of 2 fully independent power supplies which have only the power switch and the pilot light in common. For independent operation of each supply the same procedure as outlined previously applies.

For PARALLEL OPERATION: Set both voltage controls to the same voltage before connecting the two (+) terminals and the two (-) terminals in parallel. Connect the load to either of each of the output terminals and adjust the voltage controls until both Ammeters show the same current. This indicates that both supplies share the load current equally. A total current of approx. 2.4 A is available. The maximum voltage remains 50 Vdc.

For SERIES OPERATION: Connect the (-) terminal of the left section of the supply to the (+) terminal of the right section. A total voltage of max. 100 Vdc is now available (CAUTION!) between the (+) terminal of the left section and the (-) terminal of the right section. (Add readings of both Volt meters). Connect the positive or the negative terminal to either of the (GND) terminals (depending on the desired output polarity).

If a "SPLIT" SUPPLY is desired connect either of the (GND) terminals to the (-) terminal of the left section or the (+) terminal of the right section (the connection between those two terminals remains!).
The left section ((+) terminal) then provides a positive voltage relative to ground and the right section ((-) terminal) a negative voltage. The current limits (current control) can be set independently. The max. current available in series or "split" operation remains approx. 1.2 A.

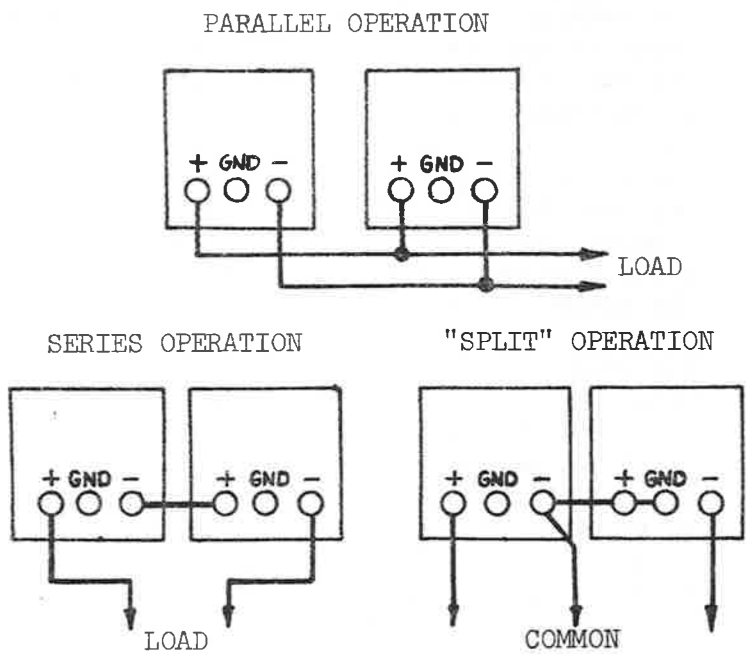


Fig. 2

THEORY OF OPERATION (see Fig. 3, 4, 5)

Single phase AC power is applied to the primary winding of transformer T1. The main secondary winding (terminals A,B,C) provides 56 Vac which is rectified by the rectifier bridge CR8 - CR11 and fed to filter capacitors C5 and C11, charging them to 40 Vdc (C5) and 78 Vdc (C11) respectively. This rectifier - filter combination provides the main DC Voltage source for the supply. Resistor R13 ("Bleeder") is connected parallel to filter capacitor C11 to remove any residual charge that might remain stored in this capacitor when the power supply is not in operation.

The auxiliary secondary winding (terminals D,E) provides 19 Vac which is rectified by CR7 and filtered by C4. The resulting 27 Vdc provides the auxiliary DC Voltage for the reference circuitry (in IC1) which is electrically isolated from the main voltage supply.

Capacitors C3 and C10 act to suppress any transients from the AC power line and protect the rectifiers (CR7 - CR11); they also attenuate transients originating in the power supply (step change no load to full load) from entering the AC power line.

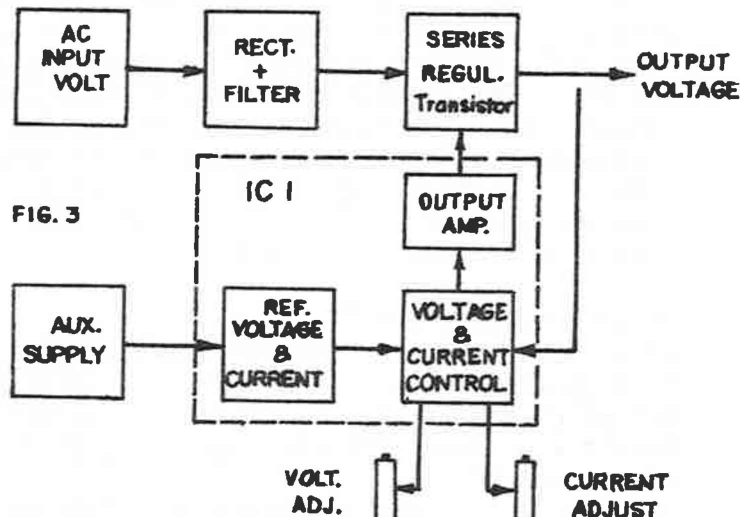


FIG. 3

Fig. 4 shows the internal circuitry of the integrated circuit IC1 broken down into functional segments.

INTERNAL VOLTAGE REGULATOR.

The auxiliary voltage (27 Vdc) is applied to pin 14 (+) and pin 7 (-). Zener diodes D1 and D5 (@7.25 V) with their associated forward biased diodes D2 - D4 and D6 - D8 form a stable reference needed to balance the differential amplifier Q1/Q2 ($V_{B1} = V_{B2}$). At balance, the output voltage (between pins 12 and 7) is at a value twice the drop across either of the two diode strings (18 V typical). Other voltages, temperature compensated or otherwise, are also derived from these diode strings for use in other parts of the circuit.

The VOLTAGE CONTROLLED CURRENT SOURCE is a PNP-NPN composite (Q3/Q4), which, due to the high NPN Beta, yields a good working PNP from a lateral device working at a collector current of only a few microamperes. Its base voltage (V_{B2}) is derived from a temperature compensated portion of the diode string and consequently the overall current (Iref) is dependent on the value of the (external) emitter resistor R1 (between pins 2 and 12). The circuit reference voltage (desired output voltage) is derived from the product of Iref and R2, the voltage adjustment control. With R1 = 7.86 k , the reference current is 1 mA and the output voltage in Volts is equivalent to the value of R2 in k Ohms.

VOLTAGE CONTROL AMPLIFIER.
Loop amplification in the constant voltage mode is supplied by the voltage control amplifier, a high gain differential amplifier (Q5/Q6). The inputs are diode protected against differential over-voltages.
An emitter-degeneration resistor (38 Ω) has been added to Q5; for an emitter current in both Q5 and Q6 of 0.5 mA there will exist a pre-set offset voltage of 15 mV at this differential amplifier to ensure that the output voltage will be zero when the reference voltage is zero.

THE CURRENT CONTROL AMPLIFIER circuit is nearly identical to the voltage control amplifier. The gain of this stage ensures a rapid crossover from the constant voltage to the constant current mode and provides a convenient point to control the output current level of the power supply.

In use, a reference voltage derived from the internal voltage regulator (pin 12) and a voltage divider consisting of R4 and R3 (current control), is applied to the base of Q8 (via pin 10) while the output current is sampled across R15 (into base of Q7 via pin 11). When the voltage across R15 is 50 mV above the reference voltage, the voltage on the collector of Q8 begins to rapidly rise, eventually gaining complete control of Q9 and limiting the output current to a value derived by R15. The voltage pin 9 - 10 is adjustable by R3, controlling the current limit over the full range of the power supply (0-1A).

Since the constant voltage to constant current change-over requires only a few millivolts, the voltage regulation maintains its quality to the point of current limit. Note that the regulator can switch back into the constant voltage mode if the voltage reaches a value greater than the voltage set by R2. Operation through zero milliamperes is guaranteed by the inclusion of an offsetting resistor to the emitter of Q8 (30 Ω).

OUTPUT AMPLIFIER.
Transistor Q9 and 5 diodes comprise the essential parts of the output stage. The diodes perform an "OR" function which allows only one mode of operation at a time; constant current or constant voltage. The function of Q9 is to invert the logic and make it compatible with the driving requirements of the Series - Regulator transistor (external) as well as providing additional gain. A 2 mA collector current source (Q10/Q11) sets the maximum output current of the output amplifier.

The schematic diagram of the power supply (Fig. 5) shows 7 diodes added for protective purposes.

CR2 and CR3 protect the input of the voltage control amplifier during short circuit or transient conditions.
CR4 protects the integrated circuit IC1 in the event of a short of Series-Regulator transistor Q4.
CR6 discharges capacitor C1 during a short circuit at the power supply output.
CR12 and CR13 are for protection against external voltages which may accidentally be applied to the output terminals.
CR14 acts as a blocking diode when, at high output voltage settings, the base-collector junction of transistor Q2 (Series-Regulator) is forward biased.

C1 provides additional noise filtering.
C2 and the RC network R5/C6 between pins 5 and 6 provide frequency compensation for the integrated circuit.
C12 prevents high frequency oscillation in the Series-Regulator circuit.

Operation of the SERIES-REGULATOR.
The operation of the emitter follower configuration of Q2 and Q4 depends on the output voltage level. Up to approx. 30 V the circuit operates as a true emitter follower. The output amplifier of the integrated circuit provides the drive current of max. 2 mA for Q4. This transistor (a high gain Darlington device) in turn provides the drive current for Q2 which operates as the main Series-Regulator, supplying the full output current of the power supply.
At output voltage levels over 30 V the collector current of Q2 drops to zero, due to the low collector voltage of approx. 40 V supplied by the main voltage source. Transistor Q4 with its higher collector voltage now takes over the function of the main Series-Regulator, delivering the full output current through the base-emitter junction of Q2. R17 provides for a smooth transition between the conduction

stages of Q2 and Q4.
Resistor R11 serves as a "bleeder resistor" for output capacitors C8 and C9.
This circuit configuration maximizes efficiency and minimizes thermal stress on transistors Q2 and Q4.

The function of Q1 together with CR1, R6 and R7 is to protect the voltage control R2 when the positive output voltage becomes more positive than the setting on the voltage control. This can occur when operating 2 power supplies with different output voltages in parallel (see "Operation of Dual Supply").

stages of Q2 and Q4.
Resistor R11 serves as a "bleeder resistor" for output capacitors C8 and C9.
This circuit configuration maximizes efficiency and minimizes thermal stress on transistors Q2 and Q4.

The function of Q1 together with CR1, R6 and R7 is to protect the voltage control R2 when the positive output voltage becomes more positive than the setting on the voltage control. This can occur when operating 2 power supplies with different output voltages in parallel (see "Operation of Dual Supply").

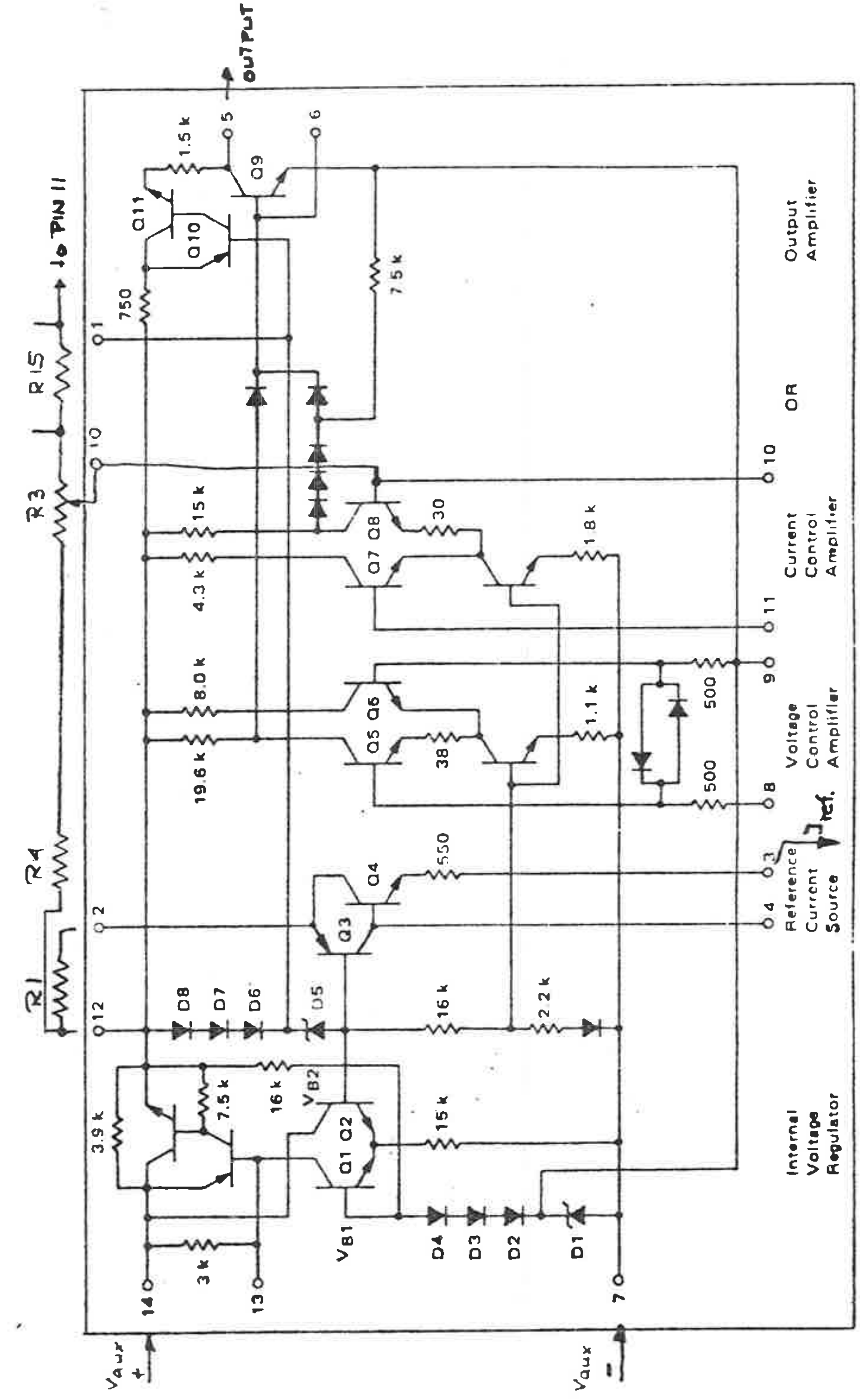
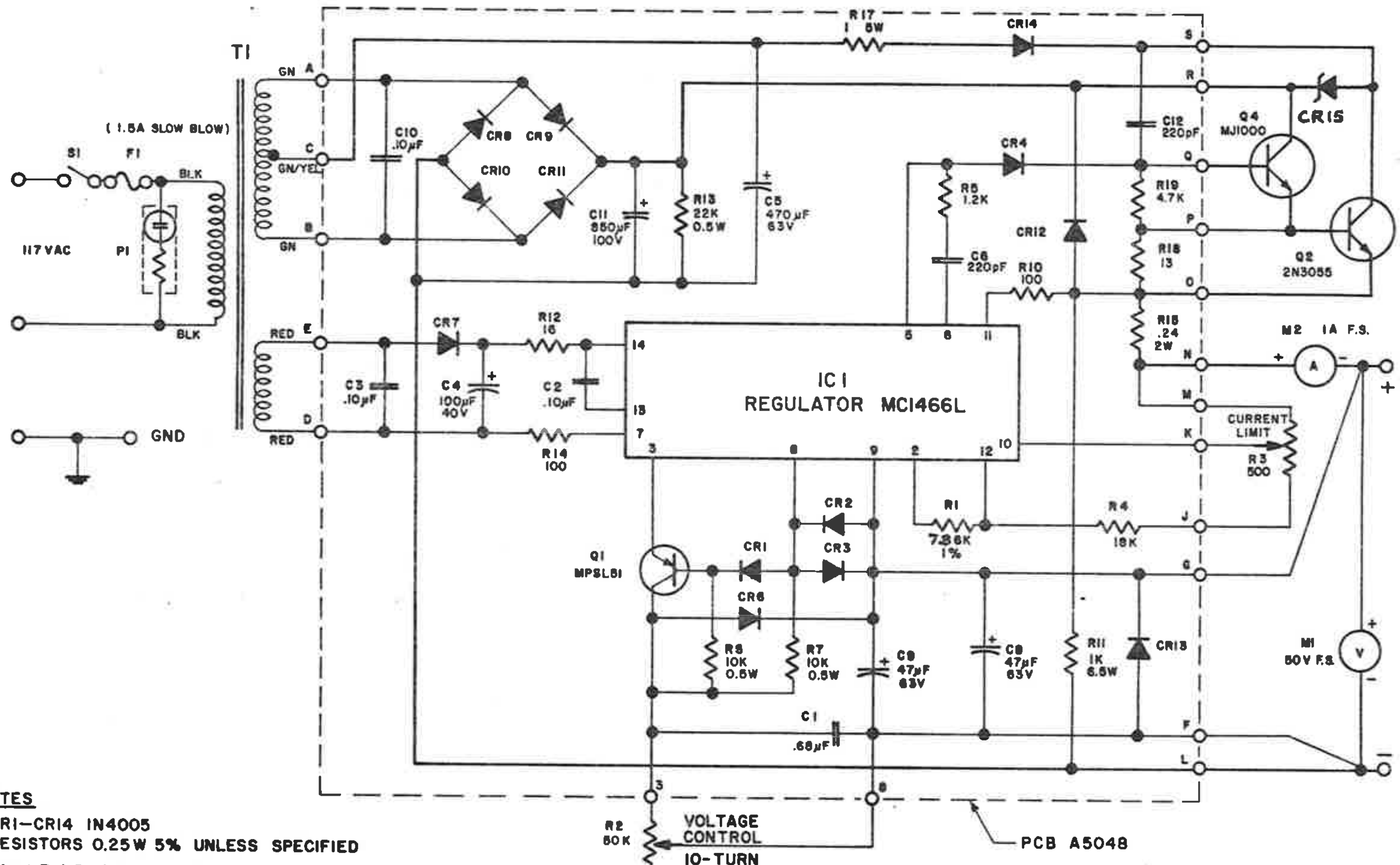


Fig. 4



NOTES

CR1–CR14 1N4005
RESISTORS 0.25W 5% UNLESS SPECIFIED

Highest Ref. Designation used

R19 (R8,9,16, not used)
C12 (C7 not used)
CR14 (CR5 not used)
Q4 (Q3 not used)
F1
IC1
M2
P1
S1
T1

COMPONENT LIST A6147
DRAWING LIST A6072

Fig. 5

ITEM NO.	QTY.	DESCRIPTION	MATERIAL	PART NO.
		ANATEK ELECTRONICS LTD. VANCOUVER B.C. CANADA	Standard Products	

REDRAWN 5/76
TOLERANCES UNLESS OTHERWISE SPECIFIED
SCALE N.T.S.
DATE 5/6/76
DRAWN M.F.
CHECKED
TITLE: 50-1S SCHEMATIC
DRAWING NO. A2017

PERFORMANCE TESTING

The performance of a regulated power supply is determined primarily by the internal (source) impedance of the supply (which the load "sees" in series with it). The lower the source impedance, the better the regulation. This power supply has a source impedance of only a few milliohms and the connections at the output terminals should be made with care to take full advantage of the regulation capabilities of the supply. The contact resistance of alligator clips or similar terminations is unpredictable and could be several times larger than the internal impedance of the supply (e.g. with a contact resistance of 20 milliohms per alligator-clip-connection and an output current of 1 A, the total voltage drop across the (+) and (-) connection will be 2 x 20 (mΩ) x 1 (A) = 40 mV, degrading the load regulation at 20 V output to 0.21%!). Obviously, alligator clips are not acceptable for high performance operation.

For reliable performance testing use the instruments listed below and the test set-ups shown.

Recommended test equipment:

Variable autotransformer 0 - 140 Vac, 1.5 A min. (Variac, Powerstat etc.)

Oscilloscope with 10 MHz bandwidth (min.) and 1 mV/cm (or better) sensitivity. (Tektronix 453, HP 180A or equivalent)

Digital voltmeter with 0.001% resolution (Fluke 8300) or Differential voltmeter with 1 mV full scale null sensitivity. (Fluke 891A)

True RMS differential voltmeter (Fluke 931B)

V.O.M. with current measuring capability of 1.5 A. (Simpson).

Non-inductive variable load resistor 0-50 Ohms, 75 Watts minimum.

Precision resistor 1Ω, 1%, 3W min.

Set-up for all performance tests except Constant-Current mode and transient response tests:

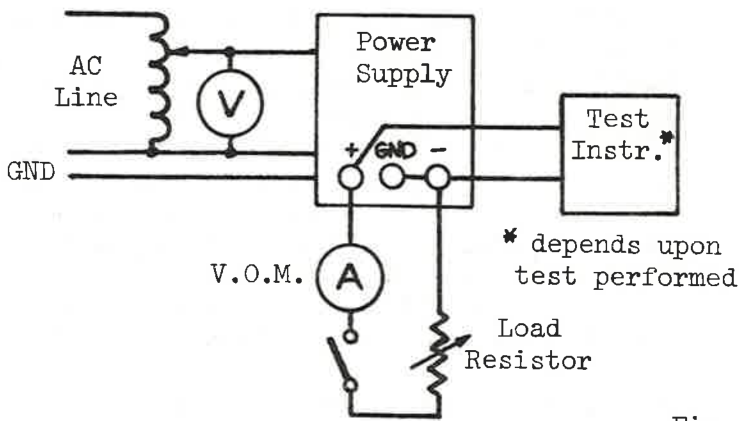


Fig. 6

Connect the AC line cord to an autotransformer with provision for exactly measuring its output voltage. Make sure that "GROUND" is provided to the line cord ground pin of the supply.
Connect (-) terminal to (GND) terminal (short wire). Connect one side of both the load resistor and the instrument to be used (see individual tests) directly to the (-) terminal of the supply.
Connect the other side of the instrument and one side of the V.O.M. (range 0 - 1.5 A) directly to the (+) terminal of the supply. A twisted pair of wires or a shielded cable should be used

for connecting the test instrument to avoid coupling and pick-up problems.
Make sure that the connections are clean and tight.
Connect the other side of the V.O.M. to the load resistor (via a switch if preferred).

A) CONSTANT VOLTAGE LINE REGULATION
Connect the differential voltmeter (or the digital voltmeter) as "test instrument".
Set the autotransformer output voltage to 117 Vac.
Set the output voltage of the supply to a convenient level (50 Vdc max.) and the current control fully clockwise.
Using a differential voltmeter: Dial appropriate voltage setting and null the meter (in differential mode).
Vary the output voltage of the autotransformer form 117 Vac to 105 Vac and/or from 117 Vac to 129 Vac. The supply output voltage change in either case should not exceed 0.03% + 1 mV.
(For 50 Vdc output $50 \times 3.10^{-4} + 1 = 16$ mV)
This test can be performed with any load current between 0 and 1A. If connecting the load, be sure not to vary the load (current) during this test.

B) CONSTANT VOLTAGE LOAD REGULATION
The connections and the instruments used are the same as in test "A". The current control must be in the extreme clockwise position. (Voltage setting as in test "A" saves readjusting of differential voltmeter).
Connect the load resistor and adjust it to draw a current of 1A (observe V.O.M.).
Read level on the differential voltmeter (or DVM), disconnect load and note differential voltage full load-no load and vice versa.
It should not exceed 0.02% + 1 mV in either case.
(For 50 Vdc setting 0-1 A:11 mV)

C) RMS RIPPLE and NOISE

Connect the True RMS differential voltmeter as "test instrument". Due to the very low voltage levels to be measured (50 - 100 μV approx.), the use of a shielded cable is recommended.
Turn current control fully clockwise.
Adjust output current (load) and voltage to maximum (50V/1A)or slightly below. The settings are not critical as long as they don't exceed the specified maxima. Be sure that unit is not in current mode. Vary input voltage over the full range (105 - 129 Vac).
The total RMS voltage at any setting should be 100 μV or lower typical, 200 μV maximum.

D) PEAK to PEAK RIPPLE and NOISE

The only difference between this test and test "C" is the use of an oscilloscope as test instrument instead of the RMS meter.
Set sensitivity of the oscilloscope to 1 mV/cm or better.
Observe magnitude and waveform.
Maximum excursion should be about 280 μV or lower.

E) STABILITY and TEMPERATURE COEFFICIENT

Connections and instruments are the same as used in test "A".
For the stability test: The line voltage, load (current) and ambient temperature have to be held constant over the full $8\frac{1}{2}$ hour test period.
Note: A reliable measurement of the stability (output voltage change of 10 mV max. for 50 Vdc output over an 8 hour period) can only be made using a differential or digital voltmeter with a stability specification of at least 10 times better than the supply under test.
To test temperature coefficient: The line voltage and load (current) have to be held constant.
Change ambient temperature of the power

supply (i.e. in suitable oven) within the specified range.
Allow the temperature to stabilize properly at each setting.
The maximum output voltage change at maximum settings (50 V/1A) should not exceed 7.5 mV for each ^{o}C change in temperature.

Set-up for constant current mode tests:

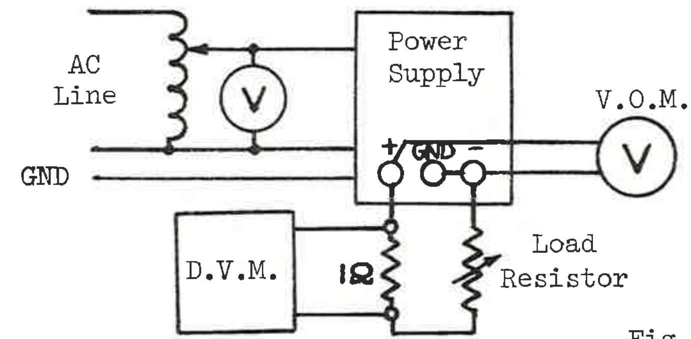


Fig. 7

F) CONSTANT CURRENT LINE REGULATION

Turn voltage control and current control fully clockwise.
Adjust load resistor to draw a current of slightly over 1 A (reading on digital voltmeter approx. 1.020 V).
Adjust current control until the DVM reads exactly 1.000V. This assures that the power supply is operating in the constant current mode. DO NOT adjust voltage control.
Vary the output voltage of the autotransformer from 117 Vac to 105 Vac and/or from 117 Vac to 129 Vac.
The voltage change across the 1Ω precision resistor should not exceed 3 mV in either case. This translates (Ohm's Law) into a current change of maximum 0.2% + 1 mA = 3 mA.

G) CONSTANT CURRENT LOAD REGULATION

In this test the load resistance is varied instead of the line voltage (test "F")
Set AC voltage to 117 V and make sure that the voltage control is in the extreme clockwise position.
With load resistor and current control adjusted as in previous test (DVM reading 1.000V), the output voltage of the supply should be 50 V approx. (read V.O.M.)
Decrease load resistance until the output voltage has decreased to 10% of its former value (approx. 5 V).
As illustrated in Fig. 1 (and example), the total load resistance at the supply terminals (load + 1Ω resistor) is now 10% of its former value. For this full to 10% load change (and vice versa) the voltage change across the 1Ω resistor should not exceed 11 mV.
$([\ 1\% + 1\ \text{mA}\ ] \times 1\Omega = 11\ \text{mV})$

H) TRANSIENT RESPONSE

Good transient response (dynamic regulation) is important when the load current is switched with transistor loads or digital circuitry.
Some additional equipment is required for accurately measuring transient response:

1) Pulse (or square wave) generator with a rise time of better than 1 μ sec

2) Anatek Electronic load

The electronic load can be substituted by the circuit shown in Fig. 8 (the two 25 W load resistors should be non-inductive).
When using this simplified circuitry, use the shortest connections possible between the components to prevent oscillation (or "ringing") during the test. Mount transistor MJ1000 on a suitable heatsink.

Connect the leads from the oscilloscope directly to the power supply terminals. Shielded cable is recommended for this connection and the pulse generator connection.

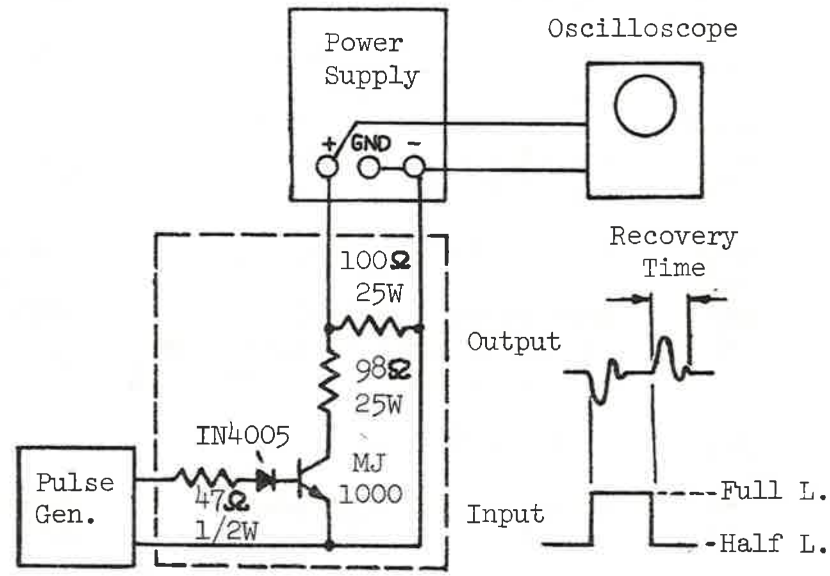


Fig. 8

Adjust voltage control for 50 V output.
Turn current control fully clockwise.
Set pulse generator to approximately 500 Hz.
Set horizontal sweep of oscilloscope to 5 μ sec/cm.

The recovery time (observe wave form on scope) should be less than 20 μ sec for either switching half load to full load or vice versa.

PARTS LIST

REF DESIG	DESCRIPTION	ANATEK PART NUMBER
C1	Cap. foil o.68 µF/100V	1511-1500
C2,C3 C10	Cap. foil 0.1 µF/250V	1515-5000
C4	Cap. elect. 100 µF/40V	1502-0650
C5	Cap. elect. 470 µF/63V	1502-1500
C6,C12	Cap. ceramic 220 pF/100V	1501-3000
C8,C9	Cap. elect. 47 µF/63V	1502-0480
C11	Cap. elect. 850 µF/100V	1502-1690
CR1-CR14	Diode 1N4005 (1A/600V)	4802-2001
CR15	**Zener Diode 1N5369**	**4809-1200**
F1	Fuse 1.5 A slo blo (50-1S only)	5101-7250
	Fuse 2.5 A slo blo (50-1D only)	5101-7300
IC1	Regulator MC 1466 L	3144-8000
M1	Voltmeter 50V full scale	2901-8130
M2	Ammeter 1A full scale	2901-8100
P1	Neon pilot light	3902-2000
Q1	Transistor PNP MPS L51	4818-3500
Q2	Transistor NPN 2 N 3055	4811-1010
Q4	Tranisitor Darlington MJ1000 sel.	4811-0100
R1	Resistor 7.86 k ¼W 1%	4705-2978
R2	Pot. 10turn 50 k 5W 5%	4702-6000
R3	Pot. 1 turn 500Ω 2W 10%	4701-2005
R4	Resistor 18 k ¼W 5%	4703-3350
R5	Resistor 1.2 k ¼W 5%	4703-2000
R6,R7	Resistor 10 k ½W 5%	4703-6900
R10 R14	Resistor 100Ω ¼W 5%	4703-0850
R11	Resistor W.W. 1 k 6.5W 5%	4706-2900
R12	Resistor 16Ω ¼W 5%	4703-0200

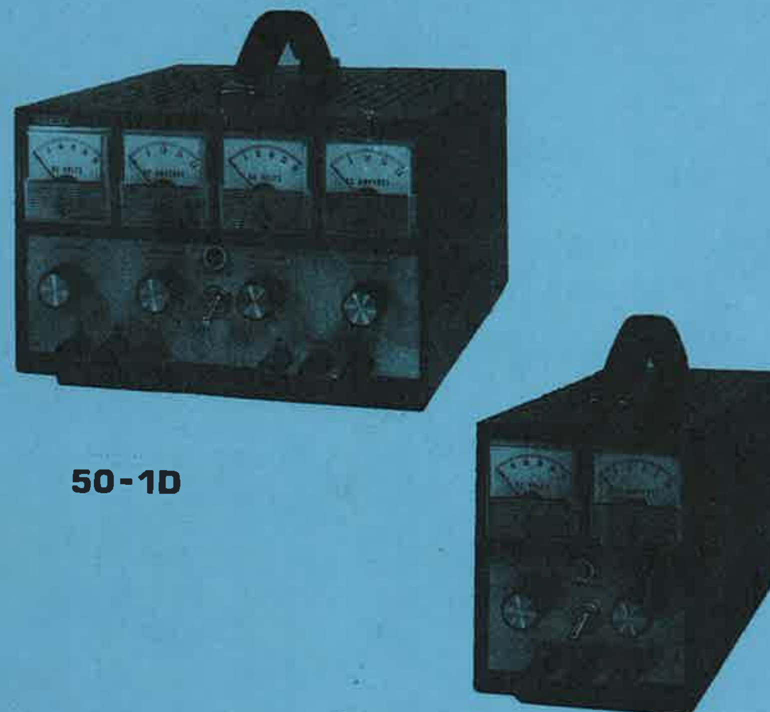
REF DESIG	DESCRIPTION	ANATEK PART NUMBER
R13	Resistor 22 k ½W 5%	4703-7100
R15	Res. W.W. 0.25Ω 2W 5%	4706-0105
R17	Res. W.W. 1Ω 5W 10%	4706-2375
R18	Resistor 13Ω ¼W 5%	4703-0150
R19	Resistor 4.7 k ¼W 5%	4703-2650
S1	Switch SPST	5106-4000
T1	Transformer	5602-0750
	Printed Circuit Board (loaded)	1701-1010
	Cabinet single supply	1402-3000
	Cabinet dual supply	1402-4000
	Front panel single supply	1406-1300
	Front panel dual supply	1406-1200
	Carrying handle	2404-6000
	Rubber feet	2819-5000
	Control knob	2405-3000
	Binding post BLACK	2101-0300
	GREEN	2101-6000
	RED	2101-9000
	Line cord	6005-3000
	Strain relief for line cord	2806-4100
	Fuse holder	2102-1500

The reference designation refers to the schematic diagram Fig. 5.

When ordering replacement parts be sure to provide the Anatek Part Number together with the description.

ANATEK

INSTRUCTION MANUAL



50-1D

50-1S

LABORATORY POWER SUPPLIES