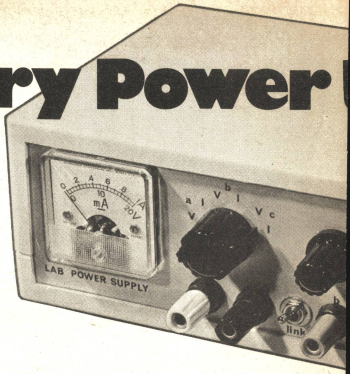
Laboratory Power



When building any electronic equipment, some form of power supply is required for testing and experimental purposes, even though the equipment power supply, in its final form, may be batteries or even a purpose-built mains powered unit.

The ability to vary the supply voltage, to simulate the effect of a failing battery for example, is a desirable feature when testing certain equipment. Many circuits require bipolar supplies (dual rail) while a fixed +5V for TTL is a definite asset. To anyone who has struggled to test a new circuit with partly discharged batteries or some hairy hook-up to give 5 volts for the logic, this Lab Power Supply will certainly take some of the exasperation out of experimentation.

J. THORNTON-LAWRENCE GW3JGA

Description

The Lab Power Supply provides three individual power supplies: +5V 0-400mA for TTL, 0 to +15V 0-100mA, 0 to −15V 0-100mA for op. amps and general transistor circuitry.

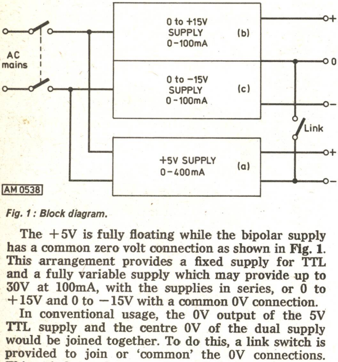


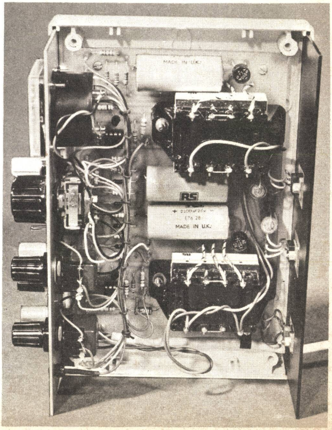
Fig. 1 : Block diagram.

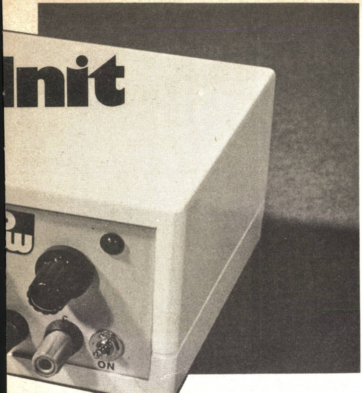
The +5V is fully floating while the bipolar supply has a common zero volt connection as shown in **Fig. 1**. This arrangement provides a fixed supply for TTL and a fully variable supply which may provide up to 30V at 100mA, with the supplies in series, or 0 to +15V and 0 to −15V with a common 0V connection.

In conventional usage, the 0V output of the 5V TTL supply and the centre 0V of the dual supply would be joined together. To do this, a link switch is provided to join or 'common' the 0V connections. This switch may be set to the un-linked position when full isolation of the supplies is required.

Circuit

The full circuit diagram is shown in **Fig. 2**. The 5V supply is shown in the lower part of Fig. 2 and comprises a mains transformer T2, full-wave bridge rectifier BR2, smoothing capacitor C5 and integrated circuit regulator IC3. Current and voltage metering is provided by R19-22 and R23 respectively. These are connected to the meter by S3. The rather unusual resistor arrangement for monitoring current avoids the difficulty of making up a low resistance shunt for the meter. The recommended resistors for R19-21 are 2% thick film types and for R22, 2% metal oxide, giving a worst case error of about 7%.





For voltage monitoring, the meter is switched in series with R23, giving 20V full scale deflection.

In the variable supplies, the mains transformer T1, bridge rectifier BR1, and smoothing capacitors C1 and C2 generate a dual 20V supply line. From these rails, regulated lines of +10V, +5V, −5V and −10V are provided by corresponding Zener diodes D1, D2, D3 and D4. These voltages are fed to various parts of the circuit.

Variable regulator circuit

The basic regulator circuit is shown in **Fig. 3**. It consists of a 741 operational amplifier used as a summing amplifier and a power transistor, Tr1, connected as an emitter follower. The output from the emitter follower is fed back to the inverting input of the 741 and so provides negative feedback. This causes the output of the emitter follower to maintain the voltage at the inverting input equal to the non-inverting input, i.e. at zero volts.

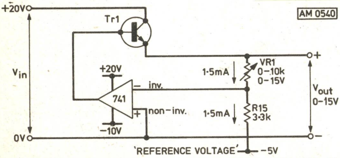


Fig. 3: The basic schematic of the variable voltage section. Fig. 2, the complete circuit diagram, is shown on page 589.

A negative current of 1·5mA is set up through R15 by connecting the bottom end to −5V. An equal but opposite polarity current comes from TR1 emitter (the output terminal) through VR1 to cancel out this

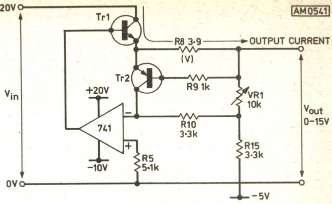


Fig. 4: The current limiting circuitry.

negative current thus maintaining the 'summing junction' at 0V. With VR1 set at zero resistance, +1·5mA will be provided with the output terminal virtually at 0V; with VR1 set to maximum (10kΩ), Tr1 emitter and the output will now move to +15V to maintain +1·5mA through VR1. Therefore, at any setting of VR1 the output voltage will be equal to the voltage drop across VR1 produced by 1·5mA through it.

★ components

Resistors

R1 680Ω ¼W
R2 680Ω ¼W
R3 330Ω
R4 680Ω
R5 5·1kΩ
R6 5·1kΩ
R7 330Ω 2%
R8 3·9Ω 2% ½W thick film
R9 1kΩ
R10 3·3kΩ
R11 3·3kΩ
R12 1kΩ
R13 330Ω 2%
R14 3·9Ω 2% ½W thick film
R15 3·3kΩ
R16 3·3kΩ
R17 20kΩ 2%
R18 20kΩ 2%
R19 3·9Ω 2% ½W thick film
R20 3·9Ω 2% ½W thick film
R21 3·9Ω 2% ½W thick film
R22 1·2kΩ 2%
R23 20kΩ 2%

All ¼W 5% carbon film, except where stated.

VR1 10kΩ 1W wire wound
VR2 10kΩ 1W wire wound

Capacitors

C1 2200μF 25V
C2 2200μF 25V
C3 10μF 25V
C4 10μF 25V
C5 2200μF 25V
C6 220nF
C7 470nF

Semiconductors

Tr1 TIP31
Tr2 BC214
Tr3 BC184
Tr4 TIP32
IC1 741
IC2 741
IC3 7805
BR1 1A type
BR2 1A type

Switches

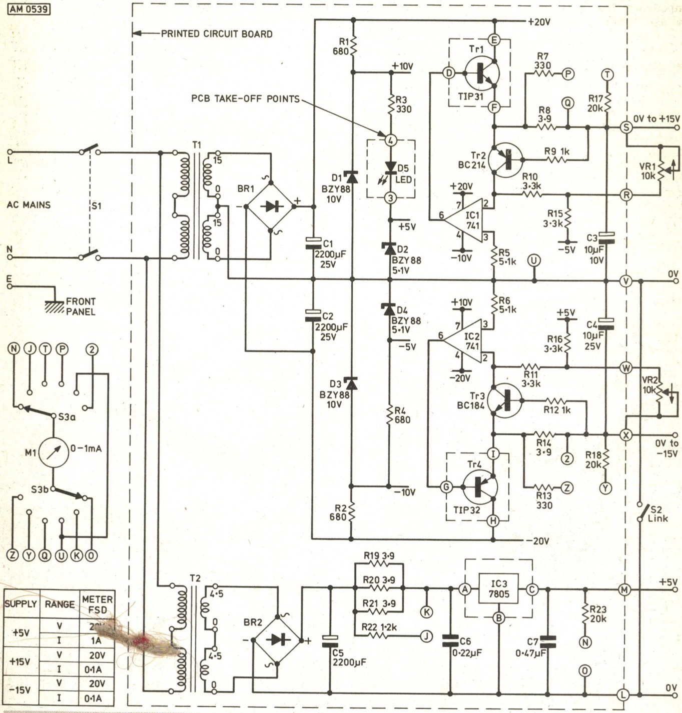
S1 DPDT
S2 SPST
S3 2 pole 6 way

Transformers

T1 Primary 240V, secondary two windings each of 15V 0·2A
T2 Primary 240V, secondary two windings each of 4·5V 0·6A

Miscellaneous

PC (from Readers PCB service, if required), Meter 0-1 mA, terminals, knobs, mains lead, hardware, cabinet (21 × 8 × 14cms).



SUPPLY	RANGE	METER FSD
+5V	V	[illegible]
	I	1A
+15V	V	20V
	I	0·1A
−15V	V	20V
	I	0·1A

Fig. 2: The complete schematic. The mains transformer primaries are not connected to the printed circuit board. As such, they are not indicated by reference letters which correspond with Fig. 6, the PCB overlay.

Rotation of VR1 produces a linearly variable output voltage of 0-15V.

When a current is drawn from the output terminal, this tends to reduce the output voltage slightly and this negative change is at once apparent at the 'summing junction' and so produces a positive change at the output and restores the output voltage to the correct value again, or almost so. This amplified correction gives the characteristically low output impedance that can be obtained from electronic voltage regulator circuits.

Regulator with current limiting

The circuit with the additional components is shown in **Fig. 4**. A current sampling resistor, R8, monitors the load current. This resistor is between the emitter and base of Tr2 and when the load current produces a sufficient voltage drop across R8, Tr2 turns on causing positive current to flow from the collector of Tr2 to the 'summing junction'. This results in a negative polarity change in the output, ensuring that the output current does not rise to a dangerously high value. Tr2 will turn on when the emitter-base voltage (V) reaches about 0·55V:

$$I_{max} = \frac{0\cdot55V}{3\cdot9\Omega} = 140\text{mA approx.}$$

The resistor R8 performs a dual purpose in that with R7 (see Fig. 2) it provides a meter shunt for monitoring output current, giving a full scale deflection of the panel meter for 100mA. The shunting arrangement is similar to the +5V supply circuit previously described.

R9 is included in the base circuit of Tr2 to limit the base current to a safe value and R5 is included in the non-inverting input of the 741 to balance the small voltage off-sets produced by the input currents of the device. C3 is fitted across the output terminals to provide a low output impedance at medium and high frequencies. The negative supply is a mirror image of the positive supply.

The panel meter has a basic sensitivity of 1mA full scale deflection and is switched to various parts of the circuit for output voltage and current measurements.

Construction

The prototype was housed in a Verobox. The printed circuit board carrying all the components was fixed to tapped pillars provided in the base of the Verobox. The front and rear panels fit into slots in the base and cover.

The printed circuit board layout is given in **Fig. 5**. The overlay, **Fig. 6**, shows numbered interconnection points where the wiring from the front and rear panels is connected. These points are also identified on the circuit diagram shown in Fig. 2. The only connections not identified in this way, are those to the mains transformer primaries, as they do not connect with the PCB. The primaries of the transformers are fed from S1, the double-pole on/off switch.

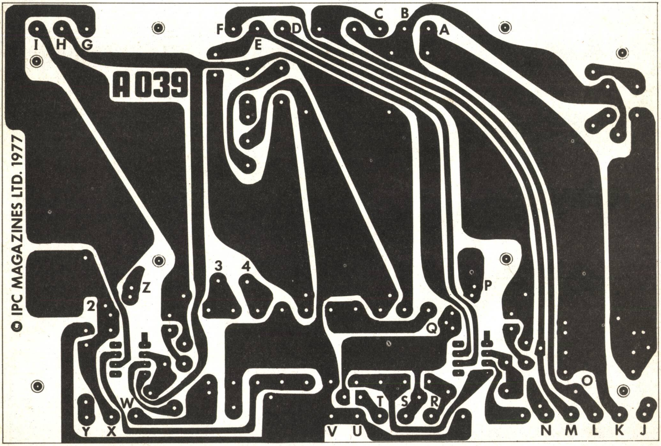
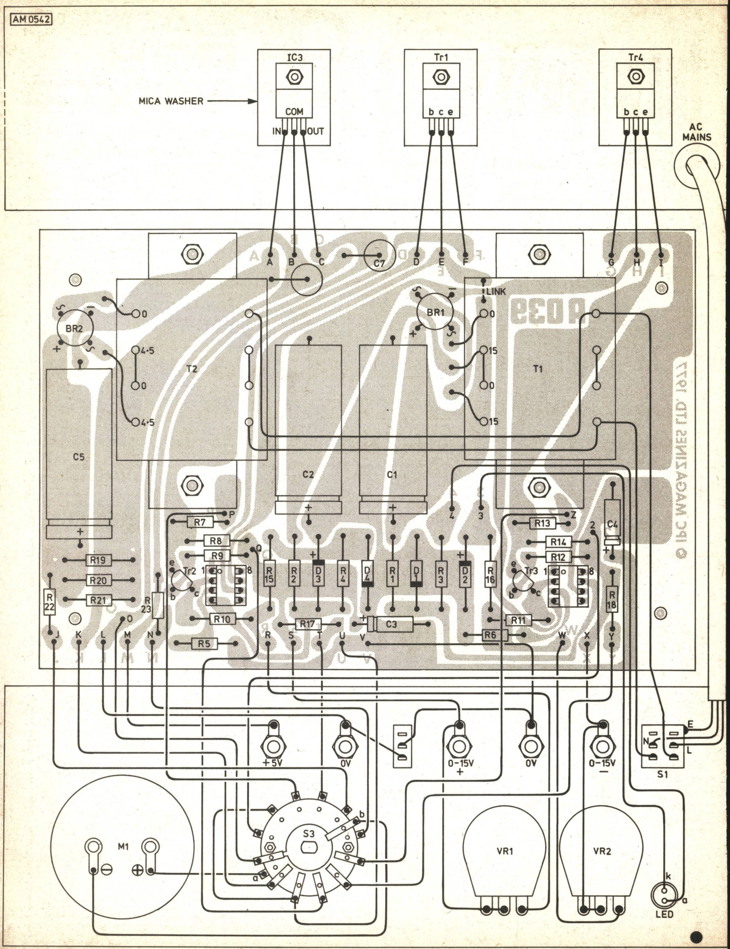


Fig. 5: The PCB shown copper side. The scale factor is one; ready made boards may be obtained from the PW Readers' PCB service. Details page 593.
Fig. 6: Component overlay. This drawing is shown on page 591 (overleaf). The reference letters refer to the circuit diagram.


AM 0542
IC3
MICA WASHER
COM
IN
OUT
Tr1
b c e
Tr4
b c e
AC MAINS
A B C
C7
D E F
G H I
LINK
BR1
BR2
T2
T1
0
4·5
0
4·5
0
15
0
15
C5
C2
C1
P
Q
Z
4
3
2
C4
R7
R8
R9
R19
R20
R21
R22
R23
Tr2
Tr3
R10
R5
R15
R2
D3
R4
D4
R1
D1
R3
D2
R16
R13
R14
R12
R18
R17
C3
R11
R6
J K L M N O
R S T U V
W X Y
+5V
0V
0–15V +
0V
0–15V −
E
N
L
S1
S3
a
b
M1
VR1
VR2
k
a
LED