AMPLIFIER

Helpful Hints

1. Do not try to power lamps or other high power devices with the 6 volt source of the APS-101. The maximum power output available is ~0.1 watt.
2. Although warm-up time of the APS-101 is negligible, for very accurate measurements it is useful to leave the amplifier power supply on for 20 minutes prior to performing the experiment.
3. Any front panel binding post may be connected to any other front panel binding post without causing any damage, nor will the fuse blow.
4. Direct input to the amplifier is obtained by putting the "AC-DC" switch in the DC position. Use this position for amplification of DC or low frequency signals. Input voltages should never exceed 50 volts AC or DC.
5. Use 4A slow-blow fuses only.
6. Turn off the AC power switch before plugging or unplugging modules to the APS.

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LABORATORY GUIDE

THORNTON ASSOCIATES, INC.

APS-101 Amplifier Power Supply

Introduction

The APS-101 and associated plug-in or add-on modules operate together to form an electronic instrumentation system which can supplement any approach to the teaching of physics — from the traditional to the modern. The unit is compact and features plug-in printed circuit boards and is designed "student proof" so that no possible interconnection of the binding posts can harm the unit.

The system is flexible enough to be used at almost any academic level from introductory high school physics to under-graduate physics programs in colleges and universities.

There are two major internal systems in the APS-101, a regulated power supply and an amplifier. The amplifier has two parts, an integrated circuit operational amplifier and a power amplifier stage. This combination has a voltage gain of over 2000 without feedback, but strong negative feedback is used to reduce the gain from 0-100, resulting in exceptional stability.

As a power supply, the APS-101 services all the various plug-in and add-on modules. For experiments requiring a low current, low voltage supply, the APS-101 output can be varied from +6 volts to -6 volts and provide good regulation. A fixed -6 volt reference source is available on the front panel and other voltages are available at the first 10 pins of the side panel connector.

Operation

Power Supply-Front Panel Controls

A. Fixed 6 volt reference

A -6V reference voltage is available at the white binding post on the front panel of the power supply. This voltage is protected so that a continuous short circuit to ground (the black binding posts) will not harm the unit. Any attempt to draw in excess of 15-20 ma from this -6 volt supply will result in a voltage drop toward zero. Below the maximum load, the voltage at the -6 volt source is constant and is independent of load or the voltage variations.

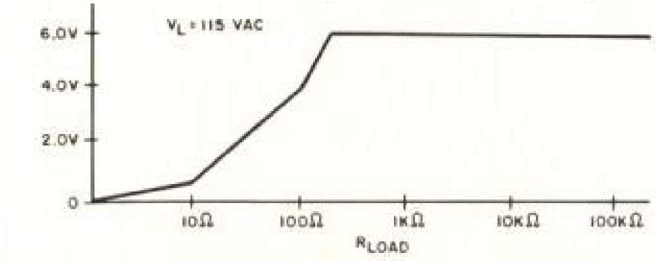


Figure 1

A typical power curve shown above illustrates that for any load from 400Ω to open circuit which is applied to the unit, a constant 6.04V DC is provided. When the line voltage is varied from 105 VAC to 125 VAC the voltage will remain constant.

In an experiment such as measuring temperature with a thermistor probe (TTP-100), this constant voltage is useful because the resistance of the thermistor varies, for example, from 102K ohms at 25° C to 53.8K ohms at 37.8° C. By applying this constant voltage to the thermistor you can generate a current which is dependent only on the thermistor resistance. When this current is amplified you can be assured that any changes in the current are a result of changes in temperature.

B. Variable voltage output

The red and black output binding posts of the amplifier-power supply may be used as a variable power supply. The gain setting should be at zero minimizing any effect of pick up which might be superimposed upon the output signal. The DC offset control will then vary the output voltage from -6 to +6 volts DC.

This voltage is also protected so that a continuous short circuit will not harm the unit.

A current up to 120ma is accessible delivering a maximum power output of 300Mw. The current output capability for a typical unit as a function of output voltage setting is shown in Figure 2.

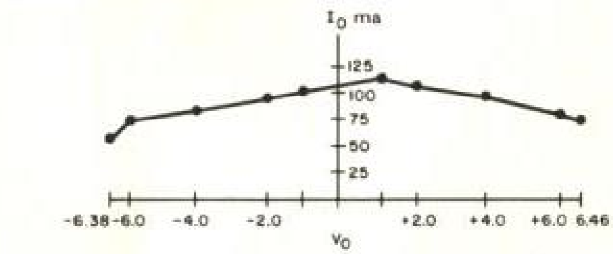


Figure 2

When set at 1.5V DC, the unit will deliver a constant VDC to any load from 0-105ma and when the line voltage is varied from 105-125 VAC the output voltage remains constant. Another variable voltage is available between the -6 volt reference (white binding post) and the red output binding post. When the DC offset control is varied the voltage will vary from -.3 to +12.5V providing 15-20ma of current.

Power Supply — Plug-In Connections

The minus 6 volt reference and the output voltages are also accessible on the plug-in strip. A regulated +12 volts is also provided with capabilities similar to the -6 volt source. It is also protected for continuous short circuit regulated and provides 10-15 ma output. When used in series with the -6 volts it provides a regulated 18 volts DC at 15 ma.

For higher power outputs up to 15 watts, the plug-in strip provides + and - 18V DC or in series 36V DC at no load. When loaded, the voltage will drop to + and - 15V DC or 30V at 500ma. These supplies are rectified and filtered, not regulated. The voltage will vary as a function of line voltage, for example, the V_{out} of a typical unit varies from 17 volts to 20.5 volts as the line voltage varies from 105-125 VAC.

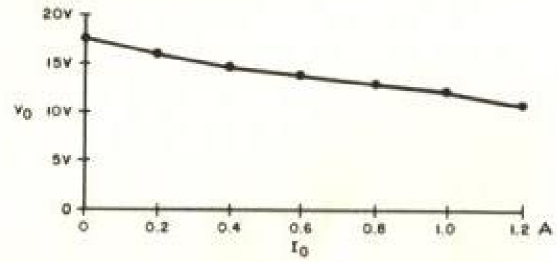


Figure 3

Two AC voltages are available on the plug-in strip, 25 VAC with grounded center tap and 150 VAC floating. By connecting these in series adding or series subtracting you can have 175 VAC or 125 VAC. These voltages are fused for protection. A short circuit of the 25.2 volts will immediately blow the fuse. A short circuit of 150 VAC will take 10 sec before the fuse goes. Be sure to replace the fuse with a 0.4 amp slow blow unit. (IMPORTANT)

Nominal Voltage	Max. Current	Connections
+18V DC	500mA	6 and 8
-18V DC	500mA	8 and 5
+12V DC	10mA	9 and 10
-6V. DC	15mA	10 and 7
18V DC	10mA	9 and 7
36V DC	500mA	6 and 5
25.2 VAC	1 amp	1 and 2
12.6 VAC	500mA	1 and 8 or 2 and 8
150 VAC	20mA	3 and 4
125 VAC	20mA	1 and 3 with 2 shorted to 4
175 VAC	20mA	1 and 4 with 2 shorted to 3

Amplifier — Front Panel Controls

The input binding posts, red and black, serve as the main access to the amplifier portion of the unit. An input voltage there will appear at the output binding posts multiplied from 0-100 times (depending upon the gain setting) plus or minus 6 volts (depending upon the offset setting) subject to these limits.

V_o must be between -6 and +8 volts
I_o must be less than 120ma

To amplify a DC voltage, set the offset voltage to zero, set theAC/DC switch to DC, connect the voltage to the input, and dial in the desired gain. The output voltage will be (V_{in} x gain). A typical unit will deliver V_o as shown in Figure 4. By adjusting the DC offset control to +2 volts the dotted curve is given,similar to what would happen if you put a 2 volt battery in series with the output.

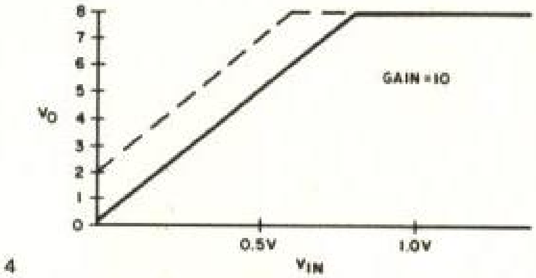


Figure 4

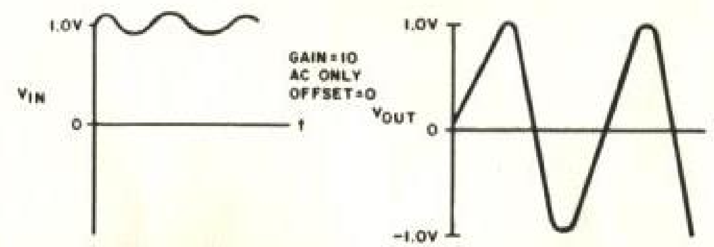
Clearly, input voltages larger than .08 volts when amplified by 100 will result in overdriving the amplifier with 0 offset. With -6V offset, voltages up to .14V may be amplified x 100.

The input impedance of the amplifier is 20KΩ so that when you are amplifying a current input

V_{out}=(I_{in} x 20K) x (Gain Setting)

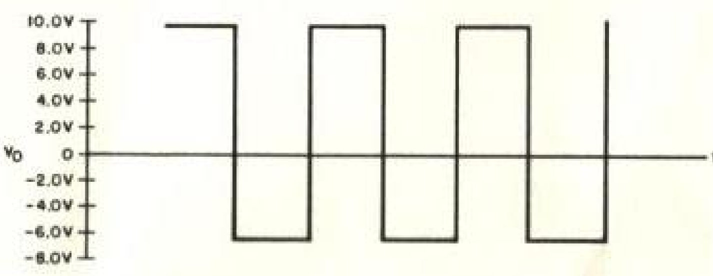
A typical experiment where full gain is used for a DC signal is the thermocouple experiment where a pair of chromel-alumel couples are connected in opposition to the input of the amplifier. When both are at the same temperature, no voltage appears, but with a 100° C temperature difference between couples, a voltage of 5 MV is generated. With the DC offset at zero and gain at 100 the output voltage will be 0.5 volts, easy to read on any meter.

To amplify low frequency AC signal keep the AC/DC switch at DC unless you want to block low frequencies and DC. All the switch does is insert a .1μf capacitor in series with the input. For example, if you have a 1KHz signal of 0.1V rms. with no DC component, it makes little difference which position you use. But if there is 1.0V DC in the signal then use the AC position to block the DC.



Although in most cases the DC position on the switch is used, there are some instances where AC is required. For example, when modulating the microwave signal with the FGR-100 — APS-101 combination the AC position is utilized. Also in the ultrasonic experiment the AC is used and the signal rectified into a DC μa meter.

In some instances it is convenient to overdrive the amplifier. By amplifying a 0.1 VAC signal by 100 times, a "square wave" is provided. The amplifier will limit and the wave form will look as shown below with a peak to peak voltage of 16 volts.



The amplifier will act as a square wave generator when a capacitor is connected between the red input and red output terminals. For any capacitance the frequency can be adjusted somewhat by varying the gain control. The unit will not oscillate for all gain settings and the symmetry of the wave form depends upon the offset setting.

Capacitance	Gain	Approximate Frequency (Hz)
1µf	10 20 50	10 8 6
0.2µf	10 20 50	48 39 32
0.12µf	10 20 50	80 65 53
.05µf	10 20 50	193 157 128

Amplifier — Plug-In Connector

Signals applied to the variable input pin appear across the 10K gain pot and will appear at the output, amplified from 0-200 times depending upon the gain setting. If the gain is to remain at 0-100 an external 10K resistor must be placed between the input signal and the variable input pin. If a fixed gain of 200 is desired, use the non-inverting input pin.

A small positive signal applied to the inverting input pin appears on the output as a large negative signal. This connection point should not be used unless you have sufficient experience to understand how this point is used to control the feedback and DC bias.

Note that any input at the "in" binding posts will be mixed with the inputs occurring at the plug-in strip.

Ground Connections

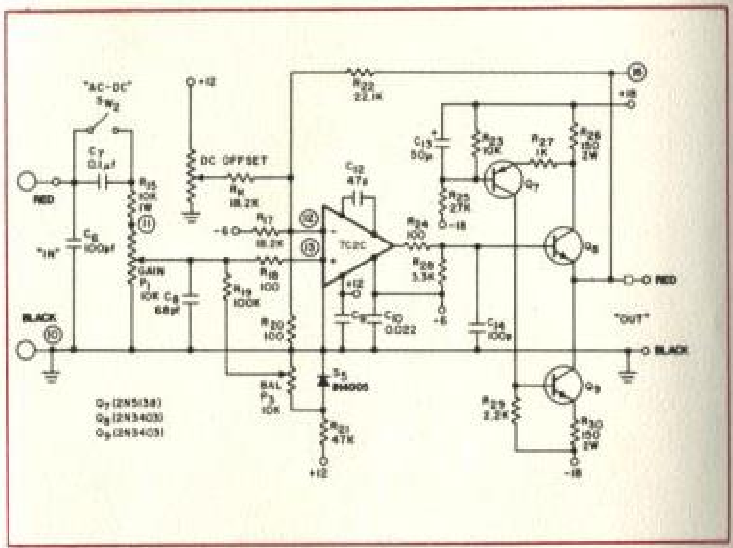
The APS-101 has three connections for ground. There are some very practical reasons for this. Most circuit diagrams are drawn with only one common ground, on the assumption that all points can be considered to be at the same potential if they are connected together. This is only true if there are no voltage drops (IR) in these connections.

Consider what happens when connection points 6 and 8 are used to supply a current of 500ma. Suppose that there are 4 inches of circuit board copper in the point 8 ground lead with a resistance of .03 ohms per foot. This lead has a resistance of 0.010 ohms and an IR drop of 5 millivolts due to a 500ma load current. One would like to avoid imposing this drop on the input signal to the amplifier. This is accomplished by tying the signal ground to the center tap of the transformer in such a way that any changes in the current do not alter the DC level of the signal ground.

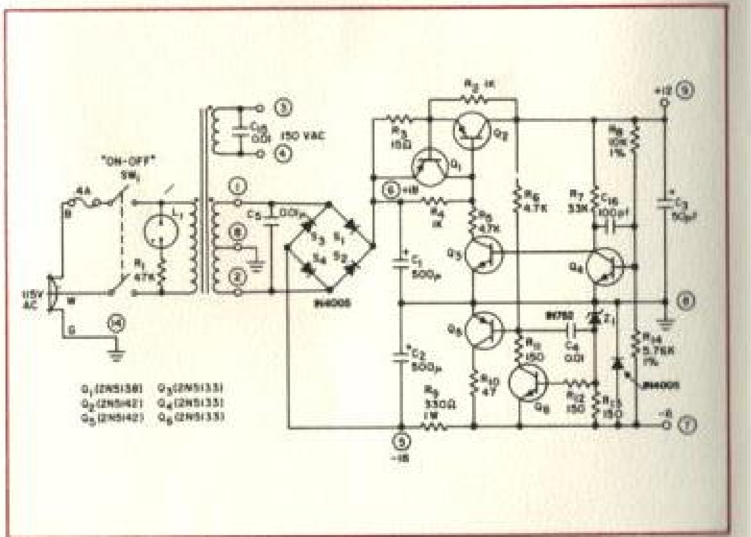
The third ground is the chassis, or case. To conform to modern safety practices, not only the case of the APS-101, but also of the individual plug-ins, must be attached to the building ground through the green wire in the line cord. The chassis ground is tied to the amplifier circuitry at one point only, thus avoiding ground loops. The extrusion ground (pin 14) ties the modules to ground through the plug-in strip.

In general, draw large current from connection point 8 (power supply grd.) and use point 10 (signal grd.) for the well regulated low current voltages at points 7 and 9.

Schematic APS-101 Amplifier



Schematic APS-101 Power Supply



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varying the gain control. The unit will
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Approximate Frequency (Hz)
10
8
6
48
39
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80
65
53
193
157
128

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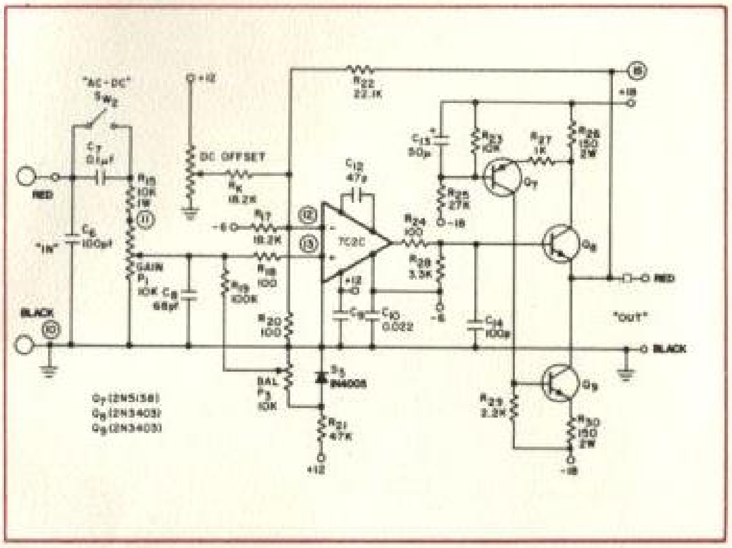

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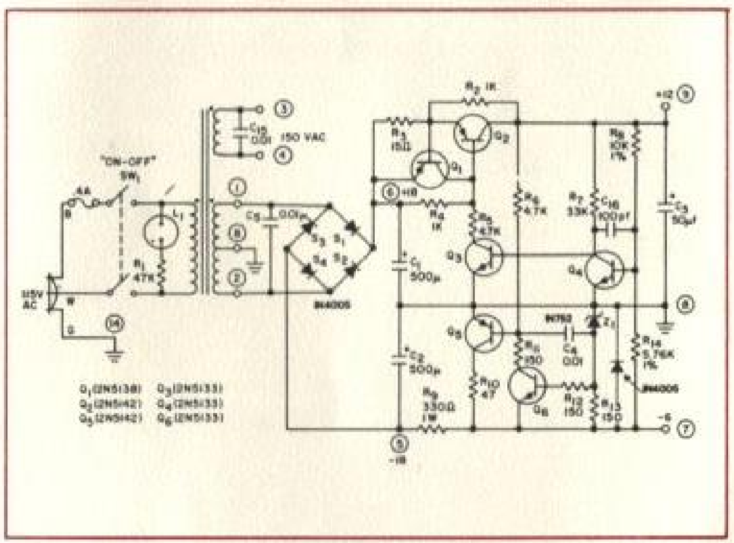


Specifications

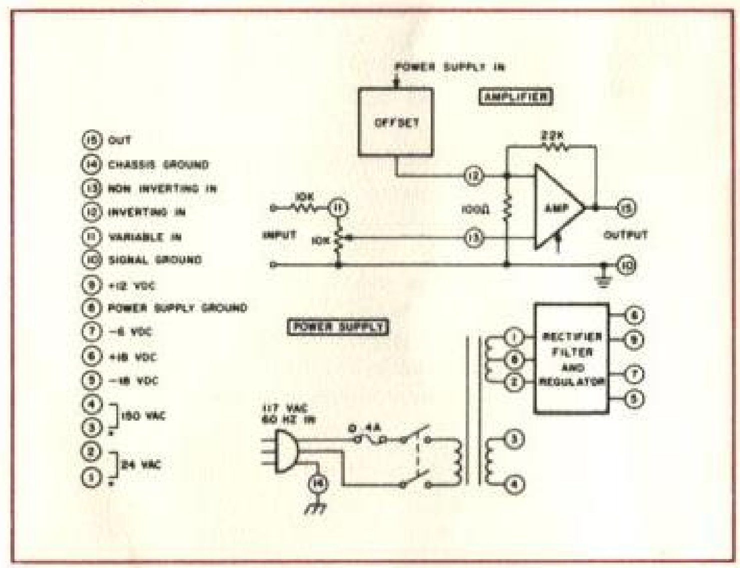
Amplifier

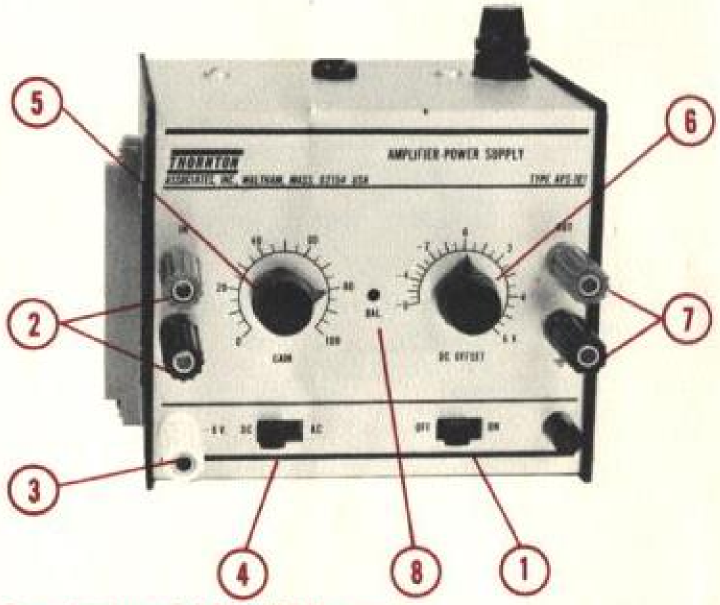
Voltage gain	0-100 (on front panel); 0-200 (at connector)
Bandwidth	DC-500KHZ (to 1MHZ at lower gain)
Power output	300mW DC or 150mWAC into 100Ω load
Input Impedance	20K ohms in parallel with 100pF
Output impedance	< 1ohm
DC offset	+6V to -6V DC, Variable

Power Supply

-6 Volt supply	
Voltage	-6V ±5%
Current	15mA
Regulation	2mV (.03%) (1mV p-p ripple)
12 Volt supply	
Voltage	12V ±5%
Current	10mA
Regulation	4mV (.03%) (1mV p-p ripple)
18 Volt supply	
Voltage	18V, Nominal
Current	500mA at 15 volts
Regulation	none
-18 Volt supply	
Voltage	18V, Nominal
Current	500mA at -15 volts
Regulation	none
25.2 VAC supply (grounded center tap)	
Voltage	25.2 VAC, Nominal
Current	1 amp. max.
150 VAC supply	
Voltage	150 VAC, Nominal
Current	20 mA, max.

Block Diagram APS-101





Description of APS-101 Controls

1. "ON-OFF" switch at the lower right. An "ON" indicator lamp to the right of this switch will light when power is applied to the unit and the switch is on. The lamp will not be on if the power fuse is blown.
2. "INPUT" terminals, red and black are at the left, for amplifier input.
3. "-6V" terminal, white, is at the lower left. The second terminal to complete the circuit may be either of two black ground terminals, or in some cases the red amplifier input terminal.
4. "DC-AC" switch for blocking DC from the amplifier input.
5. "GAIN" potentiometer, (left knob) to set the amplifier gain from 0 to 100 for inputs to the INPUT terminals.
6. "DC OFFSET" potentiometer, (right knob) for bucking the DC component of amplified AC signals up to ± 6 volts DC, or in the absence of an input signal, to set the DC voltage at the output.
7. "OUTPUT" terminals, red and black, are at the right and deliver the amplified signal or a regulated, variable DC voltage.
8. "BAL" (Balance) control, halfway between the GAIN and OFFSET controls is a small hole in the front panel for a screwdriver access to the amplifier balance. To adjust, short the input terminals and set the gain knob to 0. Attach a meter to the output terminals of the amplifier. Adjust the metered output voltage to 0 with the DC OFFSET knob. Turn the gain pot up to 100 and adjust the BAL control until the output voltage is 0. The output voltage will now remain constant regardless of the gain settings for 0 input voltage.

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