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# The *-hp-* 500-Volt, 200-MA Metered Power Supply

ONE of the workhorses of the electronics laboratory is the adjustable regulated power supply. Always valuable in terms of savings in engineering time, such supplies are essential for proper investigation of many laboratory problems.

The most recent of the *-hp-* regulated power supplies is the *-hp-* Model 712B. This supply provides continuously-variable d-c voltages from 0 to 500 volts at currents up to 200 milliamperes. It also provides an adjustable supply of up to −150 volts d-c, a fixed supply of −300 volts d-c, and a filament source of 6.3 volts a-c.

SEE ALSO:
How to Obtain Pulse Trains
*—back page*

A panel control adjusts the main output voltage in one continuous sweep. For any voltage setting the regulation of the main output is within 50 millivolts for a change from no current to full current. A panel voltmeter, accurate to within 2%, is provided to facilitate selection both of the main output and the adjustable bias voltage. Also provided is a panel milliammeter, accurate within 2%, for monitoring the main load current.

The voltage and current ranges of the main output from the supply are ample for all receiving tubes and for a number of small transmitting tubes. Further, all of the supply voltages are floating and can be grounded in any desired manner. This permits the main output and the −300 volt bias to be combined in several ways. For conventional operation, the negative terminal of the main output can be grounded to give a positive plate supply and two negative biases. When grounded in this way, the adjustable −150 volt bias is useful for ordinary grid bias applications, while the −300 volt bias is useful for applications requiring a large cathode bias such as in some types of differential amplifier work and for grid dropping networks in d-c amplifiers. For operating some small klystrons, the positive terminal of the main output can be grounded to give a negative beam supply and a more negative repeller supply. Finally, the negative terminal of the −300 volt bias can be grounded to give an 800-volt supply with a current rating of 50 ma.

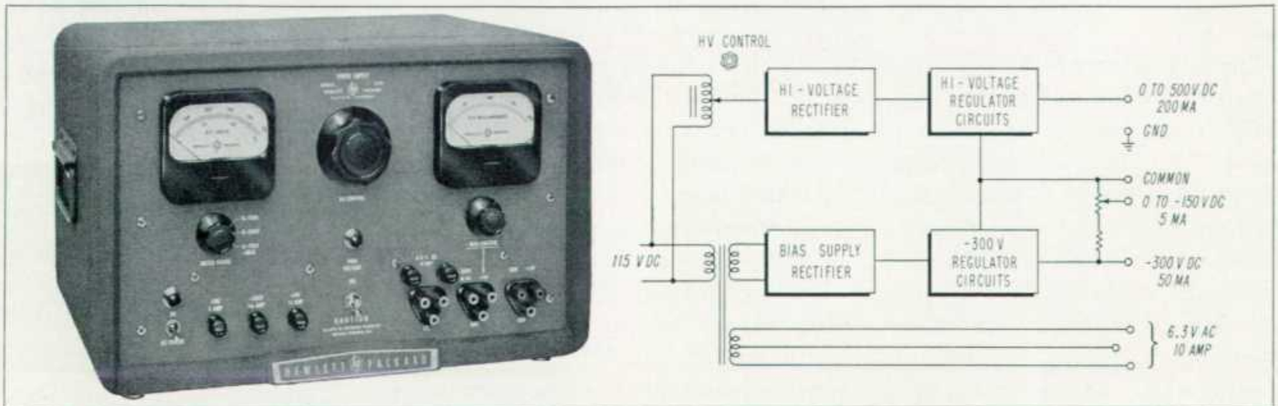


Fig. 1. *New -hp- Model 712B Regulated Power Supply provides up to 100 watts of plate power as well as bias and filament supplies. Diagram at right indicates terminal arrangement and ratings of various outputs.*

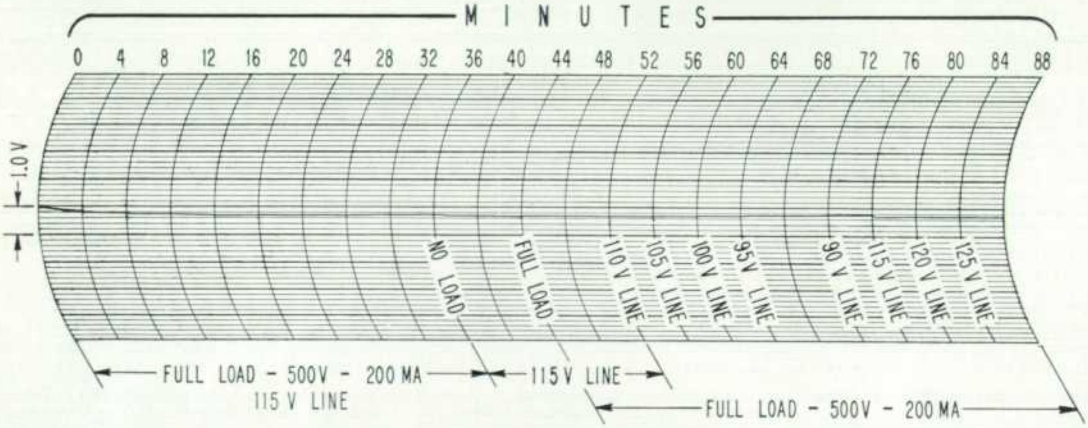


Fig. 2. *Record made of main output voltage while 712B was subjected to wide changes in line voltage and output current.*

The 712B is designed along conventional lines, but care has been taken to refine to a high degree all of its operating characteristics. For example, two important characteristics often overlooked in the design of supplies have been carefully controlled in the 712B. These are the transient response and the a-c impedance of the supply. In the 712B the maximum recovery time of the main output under extreme switching transients has been held to less than 500 microseconds, while the a-c impedance has a very low value of 0.1 ohm in series with 25 microhenries when current is drawn.

Other characteristics that contribute to the overall quality of the supply include a low d-c resistance of approximately $\frac{1}{4}$-ohm for the main supply, a low ripple of less than 500 microvolts for all outputs, overload protection, and general conservativeness of design.

#### LOAD DATA

The performance of the 712B with regard to load variations and variations in line voltage is shown in Fig. 2. This illustration is a reproduction of a recorder chart which has been marked to show the various operations made on the supply during the course of the recording. The first 36 minutes of the chart show the variations in output occurring while the supply was operated at full load of 200 milliamperes at 500 volts. Prior to "0" on the chart, the 712B was operated for less than a minute, just sufficient to make the necessary adjustments on the supply and the recorder.

During the first 36 minutes, the total variation in the output voltage was 0.4 volt or 0.08%. This includes the drift occurring while the supply warmed up. After about a 15-minute warm-up, the variation was less than 0.1 volt (interval from 15 to 36 minutes).

The first portion of the chart is essentially an indication of the stability of the supply which, in turn, is an indication of the stability of the type 5651 reference tube and the voltage divider circuits in the supply. Typically, after warm-up, the main output voltage of the supply will remain within approximately 0.25 volt for a 24-hour period.

At 36 minutes on the chart, the current output was reduced from 200 milliamperes to zero, while the line voltage was held at 115 volts. A slight change in output voltage of less than 0.05 volt accompanied this current reduction.

At 44 minutes the current was increased from zero to a full 200 milliamperes. No discernible change in output voltage occurred.

In the interval from 52 to 76 minutes, the supply was operated at full load, while the line voltage was lowered in 5-volt steps down to 90 volts. At a line voltage of 95 volts, a change of about +0.1 volt occurred in the supply voltage.

In the interval from 76 to 88 minutes, the line voltage was increased in steps to 125 volts. At 76 minutes, when the line voltage was increased from 90 to 115 volts, a −0.1 volt change occurred, compensating for the earlier change when the line voltage was dropped to 95 volts.

#### TRANSIENT RESPONSE AND A-C IMPEDANCE

High stability with load and line voltage changes is not the only criterion of the performance of a power supply. For many applications, the transient response is important. In addition, the a-c impedance, usually much larger than the d-c resistance, is often neglected.

The transient response is a measure of how quickly the regulator circuits operate after a change in load current. The response of the 712B is indicated by the oscillogram in Fig. 3. In this oscillogram, the current from the main output of the supply was switched from full current (200 ma) to zero just following the start of the sweep. This caused a transient voltage rise of only 0.06 volt and 170 microseconds duration. By comparison, the specified decay time for this transient is less than 0.5 millisecond. At the middle of the sweep, the current was then turned fully on, causing a voltage drop of 0.2 volt. This transient decayed in about 25 microseconds.

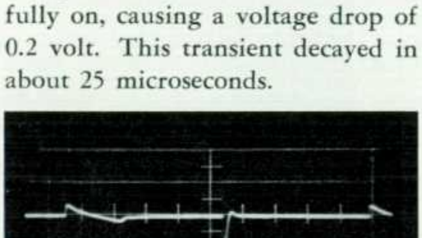

Fig. 3. *Transient response of main output. First transient corresponds to change from full current to no current. Notch at center corresponds to change from no current to full current. Amplitude of large notch is only 0.2 volt and dies out in 25 microseconds.*

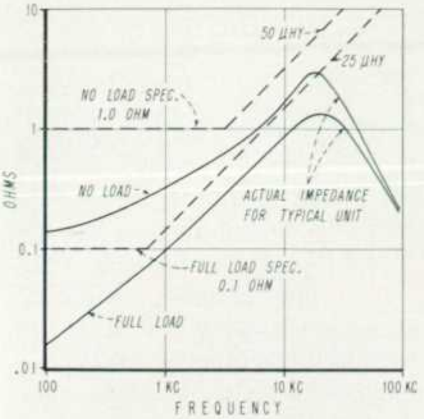


Fig. 4. *Impedance characteristics of main output of typical 712B power supply under load and no-load conditions. Rated impedance is shown in dashed lines.*

The longer decay time when current is cut off occurs because a 4-microfarad capacitor at the output of the supply must discharge through higher resistance paths than when some current is drawn.

The internal impedance of the 712B's main output is rated under two conditions: full current load and no load. While the impedance is very small in either condition, it is different in the two conditions because the operating conditions for the regulator circuits are different. Under no-load conditions, the series regulator tubes are operating in the cutoff region.

The impedance characteristics of the main output are shown in Fig. 4. Under full current load, the supply is rated as having an internal impedance equivalent to 0.1 ohm in series with 25 microhenries. Typically, the impedance will be less than this limit, as shown in the figure. The maximum impedance occurs in the vicinity of 20 kc. Above this frequency the impedance falls, owing to the influence of the 4-microfarad capacitor at the output of the supply.

Under a no-load condition, the main output is rated as having an impedance of 1 ohm in series with 50 microhenries. This limit is also plotted in Fig. 4 together with the impedance of a typical supply under no-load conditions.

At frequencies above 100 kc, the internal impedance of the supply will again show an increase, principally because the gain of the regulator circuits falls off as a result of stray capacities. This factor is not of prime importance, however, because the inductance of necessary lengths of hook-up wire begins to have an effect of the same magnitude as the internal impedance of the supply. Because of lead inductance, it is good practice at frequencies of 100 kc and above to by-pass the supply leads locally. To emphasize this point, it should be noted that the reactance of two feet of hook-up wire can easily amount to 10 ohms at 1 megacycle.

### BIAS SUPPLY IMPEDANCE

The −300 volt bias is regulated and, typically, has a low internal impedance of approximately 0.5 ohm in series with 0.8 millihenry. The d-c resistance is such that a change from no current to full current (50 milliamperes) causes less than 50 millivolts change in bias voltage.

The adjustable −150 volt bias is derived from the −300 volt bias by means of a resistive network, as shown in Fig. 1. This supply is rated to provide a maximum of 5 milliamperes. The internal impedance of the supply approaches 10,000 ohms at the higher bias voltages.

### BIAS PROTECTIVE CIRCUIT

The −300 volt supply is fused for overload protection. To protect external tubes from loss of bias and self-destruction if the bias fuse is blown, the 712B is arranged with a protective circuit.

If the bias fuse blows, the voltage from the main supply drops to a relatively low value to reduce the plate voltage on the tube being supplied. If the main supply is set for full output of 500 volts, failure of the bias fuse will reduce the main supply to not more than 150 volts unloaded or less if current is being drawn. This is adequate for protection of most tubes. For lower settings of the main output, the voltage will be reduced to a proportionately lower voltage.

Additional fuses have been placed in three other circuits in the 712B. The line circuit, the main output, and both sides of the 6.3 volt filament supply are all fused in addition to the bias supply.

*—Don Broderick*

**SPECIFICATIONS**

**-hp-**

**MODEL 712B POWER SUPPLY**

*OUTPUT VOLTAGES:*
DC Regulated High Voltage: 0 to +500 volts (without switching); maximum load, 200 ma.
DC Regulated Fixed Bias: −300 volts; maximum load, 50 ma.
DC Variable Bias: 0 to −150 volts; maximum load, 5 ma.
AC Unregulated: 6.3 volts CT; maximum load, 10 amps.

*REGULATION:* (for line voltage 115 volts ±10%)
DC Regulated High Voltage: Less than 50 millivolts change no-load to full-load at any output voltage.
DC Regulated Fixed Bias: Less than 50 millivolts change no-load to full-load.
DC Variable Bias: Regulated against line voltage changes. Internal impedance 0 to 10,000 ohms depending on bias control setting.

*RIPPLE:* Less than 500 microvolts.

*INTERNAL IMPEDANCE:*
DC Regulated High Voltage: (For frequencies above 20 cps.) Full-load: 0.1 ohm in series with 25 microhenries maximum. No-load: 1 ohm in series with 50 microhenries maximum.

*RECOVERY TIME:* Upon application of full-load: 0.1 millisecond maximum.
Upon decrease from full-load to:
(a) 0 ma, 0.5 millisecond maximum.
(b) 25 ma, 0.1 millisecond maximum.
Maximum transient voltage, 1 volt.

*METERING:*
Current Meter: 0 to 200 ma (high voltage only).
Voltmeter: Three ranges, 0 to +500 volts, 0 to +150 volts and 0 to −150 volts. Panel switch connects meter to DC regulated high voltage or DC variable bias and selects range.

*TERMINALS:* Either positive or negative DC regulated high voltage terminal may be grounded. Positive terminals of both bias supplies and negative terminal of DC regulated high voltage are common.

*OVERLOAD PROTECTION:* AC line, DC regulated high voltage, DC regulated fixed bias and filament supply are separately fused. DC regulated high voltage drops to a safe value if bias fuse blows.

*POWER SUPPLY:* 115 volts ±10%, 50 to 1000 cps. Approximately 120 to 450 watts depending on load and line voltage.

*DIMENSIONS:* Cabinet Mount: 12½" high, 20¾" wide, 14½" deep. Rack Mount: Panel 10½" high, 19" wide, 14½" deep.

*WEIGHT:* Cabinet Mount: 72 lbs., shipping weight approximately 110 lbs. Rack Mount: 62 lbs., shipping weight approximately 100 lbs.

*ACCESSORIES:* For rack mounted unit: Detachable end frames with handles for bench use, $7.50 pair (specify -hp- #17 End Frames).

*PRICE:*
-hp- Model 712B Power Supply, Cabinet Mount, $365.00.
-hp- Model 712BR Power Supply, Rack Mount, $350.00.

Prices f.o.b. Palo Alto, California.

*Data subject to change without notice.*

# A Convenient Source of Multiple Pulses

Pulse-coding work and similar applications require a flexible generator of multiple pulses or pulse trains. Sometimes it is desirable to have a source capable of generating six or more pulses in a train in which the characteristics of each pulse can be separately adjusted and selected.

Quality pulse trains having a high degree of flexibility can be readily obtained by using a combination of *-hp-* 212A general-purpose pulse generators. The pulses generated by the 212A are continuously variable in length from at least 0.07 to 10 microseconds, have a maximum amplitude of at least 50 volts into 50 ohms, and have rise and decay times of less than 0.02 microsecond. Their repetition frequency is adjustable from 50 to 5,000 pps. The pulses are available at either positive or negative polarity.

The popularity of the 212A has been such that many laboratories have several of these instruments. When the need arises for a source of multiple pulses, the outputs from these 212A's can be combined to permit each pulse of the train to have all of the flexibility that the 212A provides.

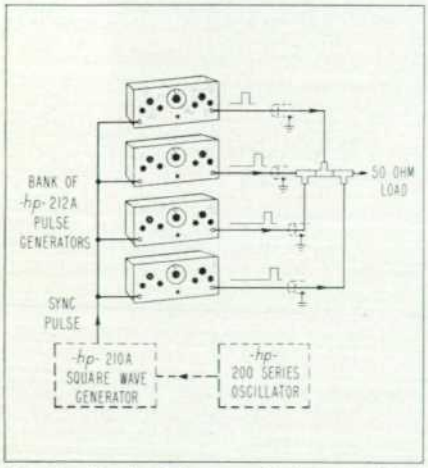


Fig. 1. *Method for combining bank of -hp- 212A Pulse Generators to obtain high output pulse trains. Up to 10 generators can be used to provide peak pulse voltages of 30 volts.*

Either of two arrangements can be used for connecting the 212A's to the load. One arrangement gives higher pulse voltage but increases the rise time of the pulses by a factor of two or three, depending upon the number of generators used and cable lengths. The second arrangement causes little increase in rise time but gives less pulse voltage than the first method.

Fig. 1 illustrates the first method. The 212A's are connected through coaxial cables to a bank of coaxial type Tee's, which in turn connect to the load. Cable lengths should be kept short to minimize the increase in pulse rise time. Where no synchronizing pulse is available, an oscillator and square wave generator can be used as illustrated to provide such a pulse.

Fig. 2 shows a series of oscillograms of pulse trains illustrating how the set-up permits individual pulses to be varied. Through suitable setting of the appropriate controls on the 212A's, the length and spacing of the individual pulses in the trains can be adjusted to meet special requirements. The polarity of each pulse can also be selected by the 212A's polarity switch, so that a combination of positive and negative pulses can be obtained where desired.

In the oscillograms shown, the peak value is about 35 volts. Up to ten 212A outputs can be combined and a maximum output of approximately 30 volts peak will still be obtained.

The second method for combining the generators is shown in Fig. 3. The output of each generator is connected through cables of any practical length to a split pad. To provide for connecting to the load, this pad should include one connector more than there are generators. The resistance R in series with each connector is calculated from the equation shown. A 50-ohm load and cables are assumed.

The voltage obtained at the load is inversely proportional to the number of generators used, i.e., if five generators are used, about one-fifth of the voltage from an individual generator will be impressed across the load.

Fig. 2(a). *Train of five 0.5-microsecond pulses obtained by combining output of five pulse generators.*

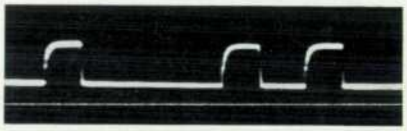

Fig. 2(b). *Controls on individual generator can be used to vary individual pulses in train. Second and fifth pulses have been reduced to zero amplitude.*

Fig. 2(c). *Single 0.5-microsecond pulse of train expanded to show pulse detail.*

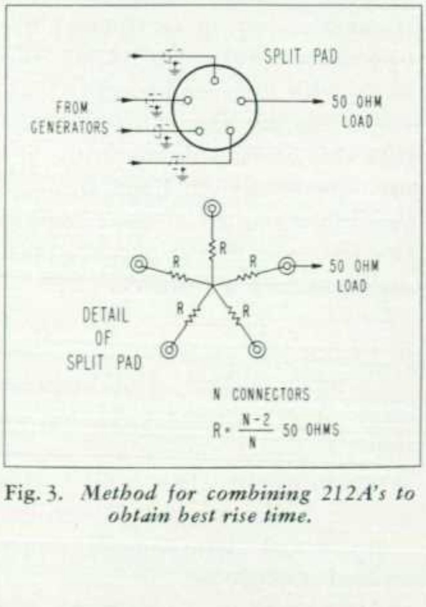


Fig. 3. *Method for combining 212A's to obtain best rise time.*