NEW PULSE AMPLIFIER INCREASES UTILITY OF UNIT PULSER

Designed primarily as a companion instrument for the TYPE 1217-A [1] Unit Pulser, the TYPE 1219-A Unit Pulse Amplifier offers a specific solution to the problem of producing pulses with many different characteristics of duration, duty ratio, and impedance level at higher power levels. In combination, the Unit Pulser and Unit Pulse Amplifier constitute a pulse generator approaching the wide range of durations and repetition rates characteristic of the Unit Pulser, but with the power-output characteristics usually associated with more expensive and specialized pulse generators designed to fit limited fields of application. Through the economies of standardized unit design, this versatile combination is lower in price than many narrow range pulsers designed for medium power output.

When it is driven by any available source of either positive or negative pulses, the Unit Pulse Amplifier will produce pulses of current with magnitudes up to 600 ma. This pulse of current can drive internal loads to produce either positive or negative voltage pulses, or can be used to drive a load external to the instrument. The internal load resistors are chosen to terminate a wide variety of transmission lines in their characteristic impedances.

General Design Considerations

The main objective in the design of the TYPE 1219-A Unit Pulse Amplifier was to obtain a maximum value of current into the load while retaining as many of the desirable wide ranges of duration and repetition rates of the Unit Pulser as possible. It was obvious at the outset that some maximum duty-ratio limitations had to be imposed if the amplifier were to produce a usefully high output power at moderate cost. A current between ½ and 1 ampere, giving an adequate voltage for direct deflection of a cathode-ray tube with the lowest normally encountered transmission-line terminating impedance, was desirable. General considerations of power supply design, economical packaging, heat dissipation, and vacuum-tube availability led to the final choice

[1] Frank, R. W., "Pulses in a Small Package", *General Radio Experimenter*, Vol. XXVIII, No. 10, March 1954, pp. 1–7.

Figure 1. Panel view of the Type 1219-A Unit Pulse Amplifier.

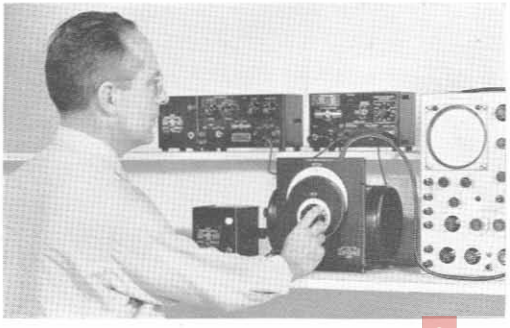
of peak current as 600 ma for very low duty ratios and 500 ma for duty ratios in the neighborhood of 0.1. The maximum duty ratio was set at 0.2 by plate dissipation in the output stage.

The auxiliary considerations of drive, bandwidth, and output circuit were chosen to make the unit as universally applicable as possible. Minimum output impedance was set at 50 ohms, and convenient values of output impedance, ranging up to 150 ohms for positive output pulses and 570 ohms for the negative pulses, were provided by internal switching. With pulses of long duration and low values of output impedance, a capacitive output coupling system would be bulky and would limit the output voltages. To overcome this problem, the output switching system was designed to permit both negative and positive output pulses to retain their d-c component relative to chassis ground.

For maximum flexibility, provision is made for both positive and negative driving pulses. A panel switch connects an amplifier-inverter stage into the circuit when positive drive is used. With this arrangement, it is possible to drive the amplifier from almost any pulse source.

To increase further the flexibility of the instrument, a switch has been provided which will reduce the output current by a factor of approximately 2.5,

Figure 2. The Unit Pulser and Unit Pulse Amplifier, as set up to pulse a Type 1218-A Unit Oscillator at 1400 megacycles.



so that it becomes possible to operate the instrument safely at duty ratios up to 0.5 with an output current of 200 ma. Two desirable features are gained by this mode of operation; it is possible to obtain a square-wave output, and the rise and decay times are improved.

As with any power amplifier where a maximum duty-ratio restriction is necessary to obtain the desired peak-power output, it is possible, by incorrect choice of the input time durations and repetition rates, to overload the output amplifier stage and therefore to damage it. The necessary protection for the output tubes and power supply is afforded by a 100-ma fuse mounted on the front panel. A neon panel lamp does double duty as pilot lamp and blown fuse indicator, since, in the event of a serious overload which will blow the fuse, the lamp is extinguished.

Circuits

The basic circuitry of the Unit Pulse Amplifier is conventional, as shown by the elementary schematic of Figure 3 and consists of a power stage using two paralleled 5763 power pentodes (V-3, V-4), a driver employing a TYPE 12AU7 (V-2), and, for positive input pulses, an amplifier-inverter stage (V-1). Two internal power supplies of 300 volts and 260 volts for the output tubes and drivers, respectively, are provided.

A single 12-position output switch, S-4, controls the internally available output impedances and output pulse polarity. Four positions of this switch select output pulses that are positive with respect to chassis ground at impedance levels of 50, 75, 100, and 150 ohms. In this class of operation the two

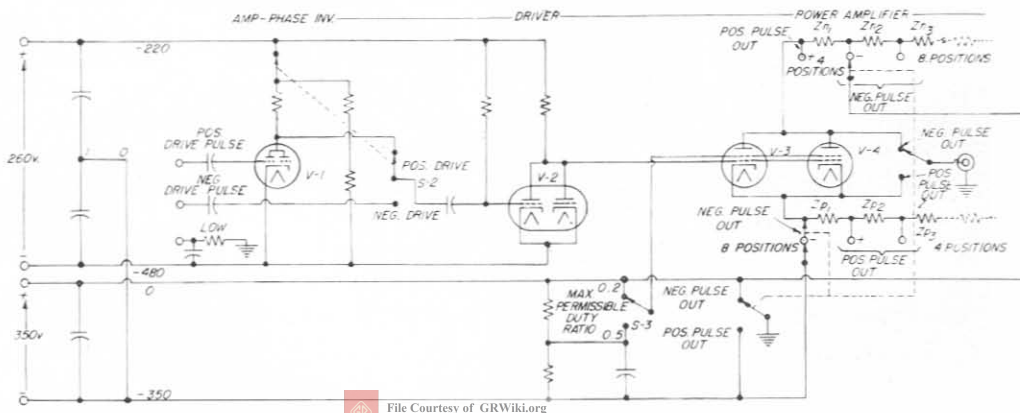
output tubes are used as cathode followers, and their 300-volt power supply has its negative side on chassis ground. For pulses with negative polarity the remaining eight switch positions are used to provide internal loads with impedances ranging from 50 to approximately 570 ohms. The loads in this case are placed in the plate circuit of the 5763's, and the positive side of the 300-volt power supply is grounded to chassis. The output stage for negative pulses thus approaches a current source, and the output impedance is linear and independent of tube characteristics.

For negative pulse input, the input polarity switch connects the input terminals directly to the driver stage. In this use, the power amplifier is a two-stage unit and provides an output pulse of excellent shape (see Figure 4) in which the input pulse duration is faithfully reproduced. For a large-amplitude negative pulse, ultimate rise and decay times for the output stage are .050 and .030 μsec respectively. Pulses as brief as .050 μsec at the half-amplitude points have been faithfully reproduced. When the duty ratio switch is in the 0.5 position, the rise and decay times are improved to .030 and .020 μsec respectively (see Figure 7a).

The amplifier-inverter stage is connected to the input terminals and supplied with plate voltage when the input polarity switch is in the *Positive Input* position. This stage then provides a negative pulse to turn off the driver upon the application of a positive driving pulse. Some care must be exercised to preserve the good shape characteristics inherent in the driver-power amplifier system. An excessive positive driving amplitude will cause the output pulse to be stretched by up to 0.4 μsec and will cause a small hump of the order of 3% of the pulse amplitude to appear before the late transition (see Figure 7c).

Since the output system is direct-coupled, the input signals at the grid of the driver and amplifier must be applied through coupling capacitors. These signals must appear negative or positive with respect to the cathode potentials of either the driver or amplifier. If the input were applied relative to chassis ground rather than referenced to the negative supply, any noise or hum on this supply would add to the signal. This would unnecessarily complicate the design of the driver-power supply. Note that, in Figure 4, the input signals are referenced to the *driver supply* negative rather than to chassis ground by virtue of an insulated low input terminal. Best performance will always be obtained by floating the ground of the input system on this post. This does not preclude obtaining synchronizing

Figure 3. Elementary schematic circuit diagram of the Unit Pulse Amplifier.



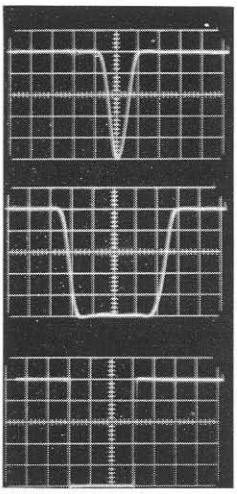
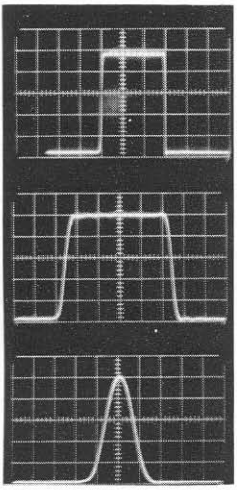


Figure 4
Negative output pulse

0.1μsec/cm P.R.F. = 10kc
50Ω 28 volts T_p = 0.1μsec

0.1μsec/cm P.R.F. = 10kc
50Ω 28 volts T_p = 0.5μsec

1μsec/cm P.R.F. =10kc
50Ω 28 volts T_p = 3μsec

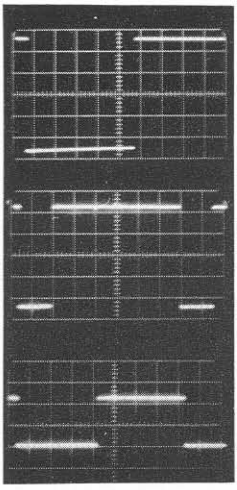


Positive output pulse

1μsec/cm P.R.F. = 10kc
50Ω 30 volts T_p = 3μsec

0.1μsec/cm P.R.F. = 10kc
50Ω 30 volts T_p = 0.5μsec

0.1μsec/cm P.R.F. = 10kc
50Ω 30 volts T_p = 0.12μsec



Negative output pulse

200μsec/cm P.R.F. = 200c
50Ω 25 volts T_p = 1000μsec
(Note slope of bottom)

133μsec/cm P.R.F. = 1kc
570Ω 270 volts T_p = 200μsec

1kc square wave
50Ω 10 volts

pulses, etc., from the driving source, since these signals are generally obtained through coupling circuits whose low-frequency impedance is negligible.

The two internal power supplies are of the full-wave-doubler variety, which make most efficient use of the power transformer copper and to which selenium rectifiers lend themselves so well. Large rectifier de-rating figures have been used to insure long life. Adequate filtering is provided by two-section R-C units for both driver and output supplies. The hum on the output pulse is less than 1%.

Some Notes on Operating Characteristics

In any specific use, careful consideration must be given to two important effects that are encountered with (1) pulses of high duty ratio and (2) pulses of long time duration. The characteristics of the TYPE 1219-A under these conditions are given in Figures 5 and 6 below.

Figure 5 shows the effect of high duty ratios on output current. This information is tabulated on the panel. The effect is due to power supply regulation, and it is an advantageous one because it permits a more economical use of the output tubes for the low duty ratios most commonly encountered. Without the protection of decreasing power supply voltage at higher duty ratios, either the range of duty ratios or the peak current at the lower ratios would have to be decreased.

Figure 6 shows the characteristics of the output pulse with regard to maximum permissible pulse durations for negative drive. Here the criterion selected was a droop of 10% in the "tube on" portion of the pulse. The ramp-off may be due to any one or a combination of three effects: (1) discharge of the internal power supply, (2) insufficient

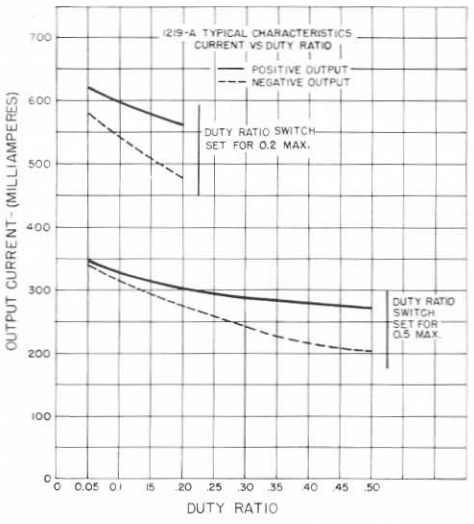


Figure 5. Effect of duty ratio on output current.

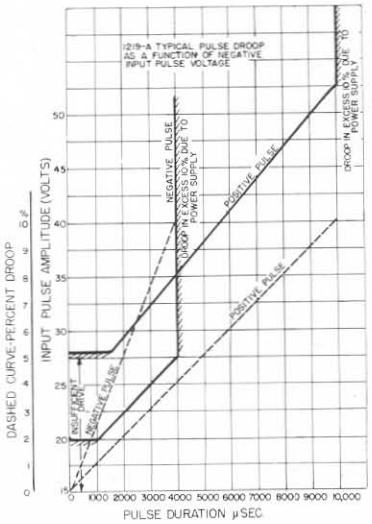


Figure 6. Output pulse characteristics as function of maximum permissible pulse duration.

driving amplitude which will cause the driver tube to come back on prematurely, or (3) a combination of low driving voltage with an external blocking capacitor in the driving pulse generator. Figure 6 shows that, with a driving voltage in excess of 27.5 volts, the first effect will predominate, and a ramp-off of 10% will be reached with an output pulse of 4000 μsec. The rate of ramp-off is very nearly linear so a 1000-μsec pulse will have a droop of 2.5% due to this effect, etc. (dotted curve). Interaction between the driver and main power supplies holds the droop for positive pulse outputs down, so that, with input amplitudes in excess of 55 volts, positive output pulses up to 10,000 μsec may be obtained. As the driving voltage is lowered below its maximum value, the effect due to discharge of the driver coupling circuit predominates, and the 10% ramp-off figure is reached sooner. For example, with only 25 volts available, the output pulse droops by 10% at 3000 μsec.

With positive input pulses, the driver stage supplies an adequate voltage to permit the maximum durations shown in Figure 6 to be reached.

Figure 7 illustrates two additional minor characteristics of the Pulse Amplifier which are of interest when the unit is used to produce brief pulses. The effects are time delay and a tendency for the input pulse to be stretched when the inverter-amplifier stage is overdriven by a positive input pulse. Figures 7, a and b, illustrate the time

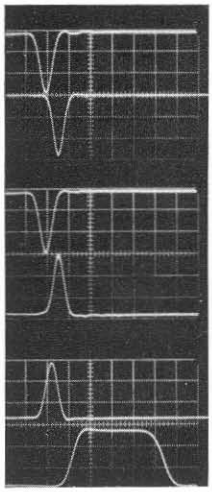


Figure 7
Time delay and overdrive effects

Input Neg. 50v 0.05μsec
Output Neg. 25v 50Ω 0.05μsec

Input Neg. 50v 0.05μsec
Output Pos. 20v 50Ω 0.05μsec

Input Pos. 50v 0.05μsec
Output Pos. 30v 50Ω 0.4μsec
(Note stretching caused by overdrive)

delay effect for both negative and positive outputs with a brief negative input pulse; the time delay through the Pulse Amplifier is of the order of 0.05 μsec. In Figure 7c, a high-amplitude positive pulse is used to overdrive the pulse input stage, and the output pulse is "stretched" by approximately 0.35 μsec. The stretching effect is reduced by reducing input amplitude.

— R. W. FRANK

SPECIFICATIONS

Output Pulse: The open-circuit output pulse voltage is between 10 and 250 volts and is the product of the combination of impedance and available current listed below.

(1) Impedance:
- a. Positive pulse: 50, 75, 100, 150 ohms, all ±10%
- b. Negative pulse: 50, 75, 100, 150, 200, 250, 300 ohms, all ±10%; 570 ohms ±20% designed to permit *maximum* output voltage.

(2) Output Current: This quantity depends upon the position of the duty-ratio selector switch and upon the duty ratio.

DUTY RATIO	OUTPUT CURRENT (ma)			
	POSITIVE PULSE		NEGATIVE PULSE	
	DR Sw 0.2	DR Sw 0.5	DR Sw 0.2	DR Sw 0.5
0.05	620 ±10%	350 ±15%	575 ±10%	330 ±15%
0.1	580 ±10%	325 ±15%	550 ±10%	300 ±15%
0.2	550 ±10%	300 ±15%	475 ±10%	275 ±15%
0.5	—	250 ±15%	—	225 ±15%

(3) Transition Times: The transition times depend on the transition times, magnitude, and polarity of the input pulse, as well as on the settings of the output impedance, polarity, and duty-ratio switches. These characteristics are summarized in the table below.

(4) Maximum Pulse Duration: The maximum duration of the pulse depends only on the tolerable ramp-off during the "on" period. If 10% is chosen, then the maximum "on" period for positive pulses is 10 mμsec and for negative pulses 4 mμsec; with the Type 1217-A, the maximum for negative pulses is 1 mμsec, for positive pulses, 10 mμsec.

(5) Pulse Shape: Overshoot less than 5% of amplitude on any output switch position.

(6) Noise: Hum on the output pulse less than 1% of pulse amplitude.

(7) Input Pulse: The maximum duration of the output pulse is to some extent determined by the input pulse voltage, and tolerable droop.

Input	MAXIMUM DURATION TO 10% DROOP	
	Positive Output	Negative Output
Negative 30 v	2000 μsec	4000 μsec
Negative 55 v	10,000	4000
Positive 10 v	10,000	6000

The droop is approximately linear, hence the

INPUT PULSE			OUTPUT CHARACTERISTIC				
			DUTY RATIO Sw 0.2		DUTY RATIO Sw 0.5		
Polarity	Amplitude	Rise and Decay Time	Rise Time	Decay Time	Rise Time	Decay Time	OUTPUT Switch
Negative	30 v	2 mμsec	50 mμsec	30 mμsec	40 mμsec	20 mμsec	Negative, 50 Ω
			50	50	60	50	Negative, 50 Ω
Negative	30 v	50 mμsec	100	100	30	90	Negative, 570 Ω
			80	80	60	70	Positive, 50 Ω
			180	110	110	80	Positive, 150 Ω
			60	90	40	80	Negative, 50 Ω
Negative	50 v	1217-A	100	120	90	110	Negative, 570 Ω
		Pulser	90	120	70	100	Positive, 50 Ω
			180	160	120	130	Positive, 150 Ω
			60	240	40	160	Negative, 50 Ω
Positive	2.5 v	1217-A	110	240	80	160	Negative, 570 Ω
		Pulser	90	180	90	120	Positive, 50 Ω
(Minimum necessary drive)			180	240	130	160	Positive, 150 Ω
			50	80	40	60	Negative, 50 Ω
Positive	25 v	1217-A	90	110	100	100	Negative, 570 Ω
		Pulser	90	110	60	80	Positive, 50 Ω
(Pulse stretching 0.3 μsec)			180	150	110	110	Positive, 150 Ω

maximum durations for 5% droop are ½ the above figures.
Input Impedance: Approximately 50 kilohms shunted by 30 μμf.

Power Supply: 105–125 volts, 50–60 cycles.
Input Power: 75 watts, full load, 115-volt line.
Dimensions: (Width) 10½ × (height) 5⅜ × (depth) 6¼ inches over-all. **Net Weight:** 8½ lbs.

Type		*Code Word*	*Price*
1219-A	**Unit Pulse Amplifier**	ACRID	**$175.00**

U. S. Patent 2,548,457

A REGULATED POWER SUPPLY FOR UNIT INSTRUMENTS

To provide the ultimate in performance from General Radio Unit Instruments, a voltage-regulated power unit, the TYPE 1201-A Unit Regulated Power Supply, is now available.

Although the TYPE 1203-A Unit Power Supply is adequate for all normal uses of Unit Instruments, there are applications where maximum stability of oscillator output amplitude and frequency is required, where amplifier hum level or pulse jitter must be minimized, or where local line voltage fluctuates so badly that regulation is a necessity. For these and other critical applications, the new regulated power unit is well suited.

The TYPE 1201-A Unit Regulated Power Supply is identical in size and external construction to the TYPE 1203-A Unit Power Supply, so that the two are completely interchangeable mechanically for the operation of Unit Instruments. The regulated unit, however, is capable of furnishing higher output current with greatly reduced ripple and noise.

The circuit, shown in Figure 2, is that of a conventional series regulator, using a 5651-type voltage reference tube and a high-gain cascode amplifier.

For critical applications, the use of the TYPE 1201-A Unit Regulated Power Supply will result in improved performance from GR Unit Instruments.

SPECIFICATIONS

High-Voltage Output:
Magnitude, 300 volts dc, ± 1%
Regulation, ± 0.5%
Current, 70 ma, max.
120-Cycle Ripple, 10 millivolts at full load
Heater Output: 6.3 volts, ac; 4 amp., max.; unregulated.
Input: 105 to 125 volts, 50 to 60 cycles, 100 watts.
Tubes: 1 — 12AX7 1 — 6AV5GT 1 — 5651
Dimensions: (Width) 5 × (height) 5¾ × (depth) 6¼ inches, over-all, not including power cord. **Net Weight:** 5 pounds.

Type		*Code Word*	*Price*
1201-A	**Unit Regulated Power Supply**	ASSET	**$80.00**

Figure 1 (right). Panel view of the Unit Regulated Power Supply. Figure 2 (below). Elementary schematic.