OPERATING AND SERVICE MANUAL

MODEL 214A
PULSE GENERATOR

SERIALS PREFIXED: 722-

02056-6

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Table 1-1. Specifications

OUTPUT PULSE

Source Impedance: 50 ohms on the 50-volt and lower ranges: approximately 1500 ohms on the 100-volt range.

Pulse Shape
Rise and Fall Time: < 13 nsec on 20-volt and lower ranges and the -50 volt range, < 15 nsec on the +50 volt range. Typically < 10 nsec with vernier set for maximum attenuation. 100V range typically 15 nsec.

Pulse Amplitude: 100 volts into 50 ohms. An attenuator provides 0.2 to 100 volts in a 1,2, 5, 10 sequence (9 ranges). Vernier reduces output of 0.2v setting to 80 mv and provides continuous adjustment between ranges.

Polarity: Positive or negative.

Overshoot: < 5%, both leading and trailing edges.

Pulse Top Variations: < 4%.

Droop: < 6%.

Preshoot: < 2%.

Pulse Width: 50 nsec to 10 ms in 5 decade ranges. Continuously adjustable vernier.

Width Jitter: < .05% of pulse width + 1 nsec.

Pulse Position: 0 to 10 ms advance or delay, with respect to trigger output (5 decade ranges). Continuously adjustable vernier.

Position Jitter: < 0.05% of advance or delay setting +1 ns (between trigger pulse and output pulse).

REPETITION RATE AND TRIGGER

Internal
Repetition Rate: 10 cps to 1 Mc (5 ranges), continuously adjustable vernier.

Rate Jitter: < 0.5% of the period.

Manual: Push button single pulse, 2 cps maximum rate.

External
Repetition Rate: DC to 1 Mc
Sensitivity: < 0.5v pk
Slope: Positive or negative
Level: Adjustable from -40v to +40v.
Delay: Delay between input trigger and leading edge of pulse out is approximately 250 nsec in Pulse Advance mode (approx. 420 nsec minimum in Pulse Delay mode).

External Gating: +8 volt signal gates pulse generator on. Maximum signal, +40v peak.

Double Pulse
Minimum Spacing: 1 usec on the .05 to 1μsec pulse width range. On all other ranges 25% of upper limit of Width range.

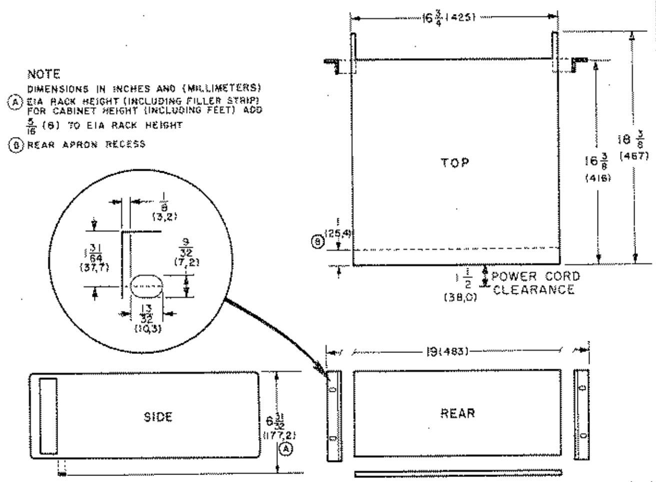
Trigger Output
Amplitude: > 10v open circuit.
Width: 0.05 μsec, nominal.
Polarity: Positive or negative.

GENERAL

Maximum Duty Cycle: 10% on 100 and 50 volt ranges; 25% on 20 volt range; 50% on 10 volt and lower ranges.

Power: 115 or 230v±10%, 50 to 60 cps, 325 watts.

Dimensions:



Weight: Net 35 lbs. (15,8 kg). Shipping 48 lbs. (19,6 kg).

SECTION I
GENERAL INFORMATION

1-1. INSTRUMENT DESCRIPTION.

1-2. The ⓗⓟ Model 214A Pulse Generator (Figure 1-1) is a versatile instrument providing variable repetition rate, variable width, variable amplitude, positive or negative, pulses with a rise and fall time of less than 15 nanoseconds. The complete specifications are given in Table 1-1. Pulse power of up to 200 watts is available when using a 50-ohm load. The Model 214A output impedance matches an external system of 50 ohms on all ranges of 50 volts amplitude and below, thus minimizing reflections. The maximum pulse amplitude is 100 volts (with a source impedance of 1500 ohms) and the amplitude may be set as low as 80 millivolts using the vernier and the lowest range. For pulse amplitudes of 10 volts and less, the duty cycle may be set as high as 50% (see Table 1-1 for duty cycle limits at other amplitudes), providing a square wave output.

1-3. Pulses may be obtained from the Model 214A at a rate of dc to 1 Mc using an external trigger source or from 10 cps to 1 Mc with an internal generator. For external triggers, positive or negative signals of 0.5 volt peak may be used and trigger slope and level may be selected to determine the triggering point on the waveform. A single pulse may be obtained from an internal circuit each time a manual button is pushed. Gating of pulses is done easily by applying an external signal and an output occurs only when the gating signal reaches a positive 8 volt level. Three modes of pulse operation allow: (1) setting of the output pulse to occur from 0 to 10 ms before (advance) the trigger output, (2) setting of the output pulse to occur from 0 to 10 ms after (delay) the trigger output, or (3) a double pulse output with variable spacing between the two pulses.

1-4. The Hewlett-Packard modular instrument enclosure system provides advantages in maintenance and operation. Easy removal of instrument covers allows access to all chassis and circuit components. As a bench type instrument the modular design provides mechanical stability even when several instruments are stacked together. The bench type instrument is readily converted for use in standard width

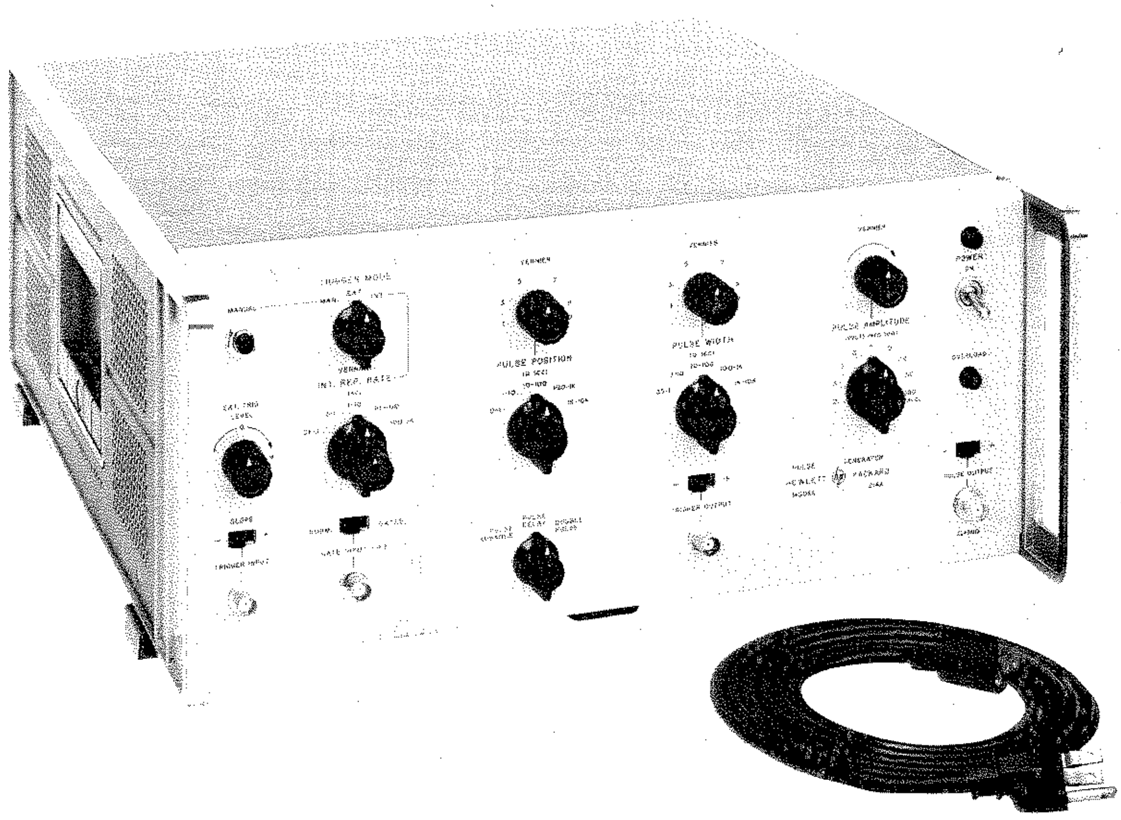


Figure 1-1. Model 214A Pulse Generator

rack using hardware shipped with the instrument. Paragraph 2-11 explains the details of converting to either the rack or bench version.

1-5. INSTRUMENT APPLICATIONS.

1-6. With its variable pulse characteristics the Model 214A is useful as a general purpose laboratory or production line test instrument. The high peak current output available, 2 amps, is useful for testing current driven devices such as magnetic memory cores, high power modulators, and power amplifiers. Fast rise and fall time combined with high power output pulses facilitate checking switching time of high power semiconductors. The positive or negative pulse output, with identical characteristics, provides an easy technique for checking either npn or pnp type transistors. By gating the Model 214A output, a burst of pulses may be obtained for making computer logic measurements. The double pulse feature may also be used for pulse resolution tests of amplifiers and memory cores.

1-7. EQUIPMENT AND ACCESSORIES AVAILABLE.

1-8. A complete line of electronic test equipment is available from the Hewlett-Packard Company for use in making test measurements with, or maintaining, the Model 214A. Also available are cables, connectors, adapters and other accessory items for use in various test or measurement applications. For information on specific items, consult the ⓗⓟ Catalog or your ⓗⓟ Field Engineer.

1-9. DIFFERENCES BETWEEN INSTRUMENTS.

1-10. The Hewlett-Packard Company uses a two-section, eight-digit serial number to identify instruments (e.g. 000-00000). The serial number is located on a plate attached to the instrument rear panel. The first three digits are a serial prefix number, also appearing on the first page of this manual, and the last five digits identify a specific instrument. If the serial prefix number of the instrument is higher than that on the first page, change sheets included with the manual will define differences between other instruments and the Model 214A described herein. If the change sheets are missing, your ⓗⓟ Field Engineer can supply the information. Refer to Appendix I at the back of this manual for changes required to adapt this manual to an instrument with a lower serial prefix.

SECTION II
PREPARATION FOR USE

2-1. INITIAL INSPECTION.

2-2. Upon receipt of the Model 214A, verify that the contents are intact and complete as ordered. Inspect the instrument for any physical damage such as a scratched panel surface, broken knob or connector, etc., incurred in shipping. To facilitate possible reshipment, keep the original packing material if reusable (see Paragraph 2-15), until a satisfactory operational check (Paragraph 5-3) is completed. If damage is found, file a claim with the freight carrier and refer to the warranty page in this manual. Section V outlines the recommended adjustment and troubleshooting procedures needed for normal maintenance or recalibration.

2-3. AC POWER CONSIDERATIONS.

2-4. POWER SOURCE REQUIREMENTS.

2-5. The Model 214A may be operated from an ac source of 115 or 230 volts (±10%), at 50 to 60 cps. With the instrument power cord disconnected, move the slide switch (located on the rear panel) until the desired voltage numbers (115 or 230) are visible. A narrow-blade screwdriver may be used to operate the switch. Fuse F1 (holder on rear panel) should be 3.2 amperes, slow-blow for 115v operation or 1.6 amperes, slow-blow for 230v operation.

2-6. THREE-CONDUCTOR POWER CABLE.

2-7. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument and cabinet be grounded. The Model 214A is supplied with a detachable three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument to the power line ground. The round pin on the power cable is the ground connection. To retain the protection feature when operating the instrument from a two-contact outlet, use a three-conductor to two-conductor adapter and connect the adapter wire to a suitable ground.

2-8. VENTILATION REQUIREMENTS.

2-9. GENERAL. The cooling fan and air filter are located on the rear panel of the Model 214A. Leave adequate clearance (at least 2 to 3 inches) behind and at both sides of the instrument for free movement of air. The path of air flow is through the filter and intake fan then out of the perforated side covers. It is important to keep the air intake area free of dust and small particles which could clog the filter. Section V provides maintenance information for fan and filter. In a rack installation be sure that recirculation of warm air within the rack cabinet does not produce an ambient temperature high enough to affect instrument operation.

2-10. COATING FILTER. Before placing the instrument in use, the air filter should be coated with a filter adhesive preparation. A recommended preparation is No. 3 Filter Coat, made by Research Products Company, and available in sprayer cans at heating-supply stores. This may also be obtained by contacting your hp Field Engineer (see maps at back of this manual) or by ordering directly from hp Customer Service. Hewlett-Packard stock number is 3150-0002.

2-11. RACK/BENCH CONVERSION.

2-12. The Model 214A is shipped as a bench-type instrument (even when ordered as a rack type) with plastic feet and tilt stand in place. The hp modular instrument enclosure system allows easy conversion to either bench or rack mode. Refer to the appropriate following procedure for conversion.

2-13. CONVERSION TO RACK MODEL.

a. Detach the tilt stand and all the plastic feet. Tilt stand removes by pressing away from the front feet. Remove feet by depressing metal release button and sliding feet free.

b. Using a thin-blade tool, loosen and remove the plastic trim strip (with adhesive back) from each side of the instrument (directly behind front handles). Removal of strip exposes threaded nuts pressed in the side casting.

c. Attach the rack-mounting flanges, with the screws provided, in the space where the trim strip was adhered. Each flange extends slightly below the front panel when attached correctly.

d. If the instrument is to be placed in a rack above or below another hp modular instrument, attach the filler strip between the front panels. Insert Model 214A in the rack and secure flanges to rack.

2-14. CONVERSION TO BENCH.

a. Remove instrument from rack, detach rack-mounting flanges and filler strip, if used between front panels.

b. Attach trim strip (in slots where rack flanges were located), plastic feet, and tilt stand. A fifth plastic foot at center-front of the instrument provides extra stability when the Model 214A is stacked atop another hp modular bench-type instrument.

2-15. REPACKAGING FOR SHIPMENT.

2-16. PACKAGING SUGGESTIONS.

2-17. To package an instrument for shipment, some types of original packing materials may be reused, or your hp Field Engineer will provide assistance in obtaining suitable packaging. The types of original packing materials which may be reused are: (1) foam enclosure pads, (2) cardboard layers separated by foam supports, and (3) laminated cardboard cut to desired packing shape. Original packing materials which are a cardboard "accordion-like" filler are not recommended for shipment since the useful cushioning qualities are usually gone after one use. If packing materials listed above are not available, first protect the instrument surfaces with heavy paper or sheets of cardboard flat against the instrument. Then place instrument in a durable carton, pad all sides with approximately 4 inches of new packaging material designed specifically for package cushioning, mark carton clearly for proper handling, and insure adequately before shipping.

2-18. RETURNING FOR SERVICE OR REPAIR.

2-19. Contact your Hewlett-Packard Company Field Office for shipping instructions. All correspondence should refer to an instrument by model number and the full (eight-digit) serial number.

SECTION III
OPERATING INSTRUCTIONS

3-1. GENERAL.

3-2. The Model 214A is self-protected and no combination of front panel control settings or connections to external circuits can damage the instrument, providing the overload relay circuitry is operating properly. An overload will be indicated if the limits on duty cycle specified in Table 1-1 are exceeded. The limits and combinations of settings which result in an overload indication are described in Paragraph 3-4. Other specific operating considerations are given in Paragraphs 3-7 and 3-9. Figure 3-3 illustrates and explains the function of all the front panel fixtures. The ac power connector, fuse, and line voltage switch are on the rear panel. Proper fuse size is: 3.2 amps slow-blow for 115v and 1.6 amps slow-blow for 230v operation. Setting line switch and other ac power information is given in Paragraph 2-3.

3-3. OPERATING CONSIDERATIONS.

3-4. DUTY CYCLE LIMITATION.

3-5. Duty cycle of operation is determined by front panel control settings. Duty cycle is defined as the ratio of duration of pulse (i.e. pulse width) to the total duration of one complete cycle. Figure 3-1 shows the relationship which determines the duty cycle. The time for one cycle is defined as the period, and the period is related to repetition rate by:

$$\text{Period} = \frac{1}{\text{Rep Rate}}$$

Thus the product of pulse width and frequency times 100 determines the percent duty cycle. For example if INT. REP. RATE is set to 1-10, VERNIER set to give a rate of 6 kc (or if the external trigger rate is 6 kc), and PULSE WIDTH and VERNIER are set to give a pulse 70 μsec wide, the percent duty cycle is:

$$(70 \times 10^{-6})\ (6 \times 10^{3}) \times 100 = 42\%$$

The same limits on duty cycle apply for external trigger operation or internal repetition rate. The limits are 50% for PULSE AMPLITUDE settings of 10 volts or less, 25% on 20 volts amplitude, and 10% on 50 to 100 volt amplitude. The maximum duty cycle will decrease slightly at repetition rates slower than 20 cps on the 50v and 100v PULSE AMPLITUDE ranges. At these slow repetition rates the overload relay reacts if there were a higher average voltage than that actually present.

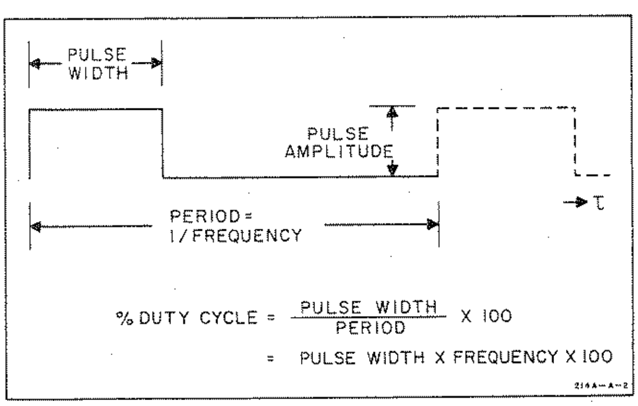


Figure 3-1. Defining Pulse Characteristics

3-6. If maximum duty cycle is exceeded for any pulse amplitude, the front panel light, OVERLOAD, will flash on and off and an internal relay will be heard as a clicking sound. No damage will occur to the instrument when this overload circuit is operating properly. When an overload is indicated it may be stopped by reducing either the frequency or the PULSE WIDTH setting. Usually this may be done easiest by turning the Width VERNIER counterclockwise, or by reducing the Width range setting. In DOUBLE PULSE operation the duty cycle limit is one half that for PULSE ADVANCE or PULSE DELAY. The expression for duty cycle using DOUBLE PULSE is given in Figure 3-2.

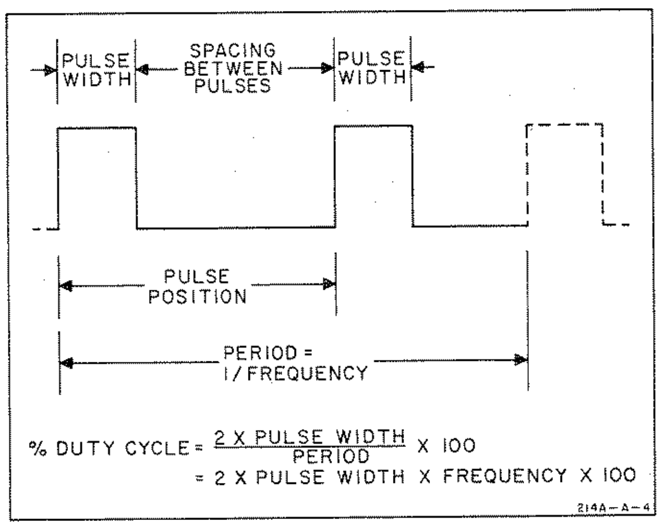


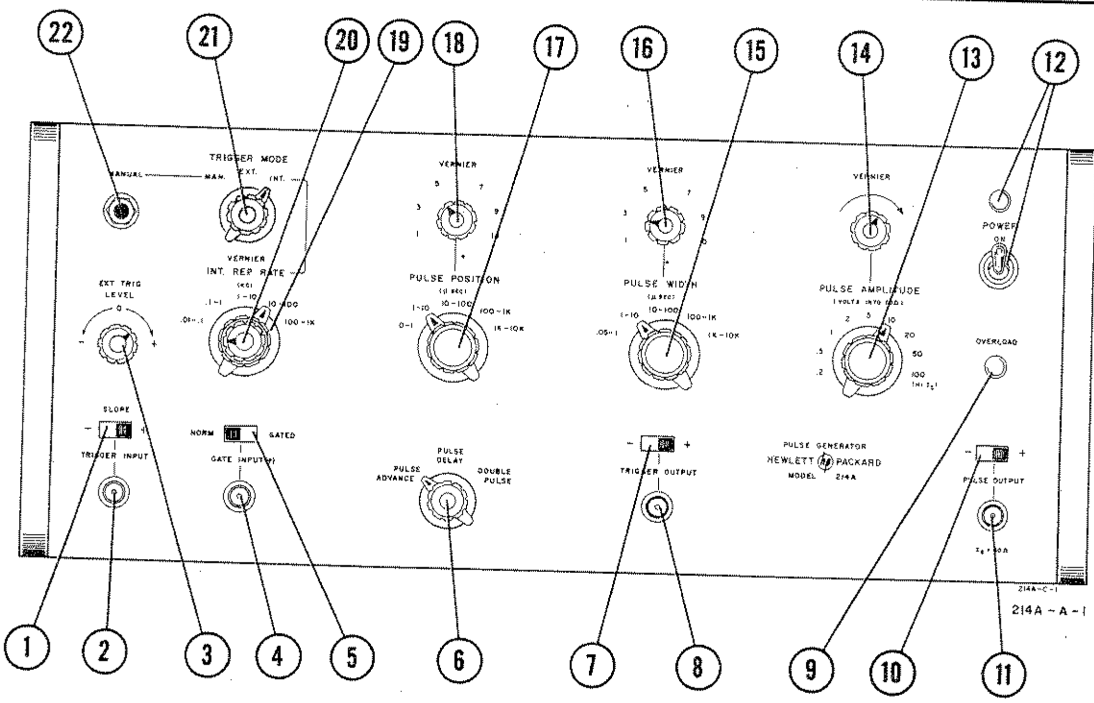
Figure 3-2. DOUBLE PULSE Operation

3-7. PULSE POSITION VS. RATE.

3-8. In either PULSE ADVANCE or PULSE DELAY operation, the PULSE POSITION setting should always be less than the period (i.e. 1 divided by the frequency). For example if the repetition rate is 25 kc, the period is:

$$\text{Period} = \frac{1}{25\text{ kc}} = 40\ \mu\text{sec}$$

and the PULSE POSITION range combined with VERNIER setting should not exceed 40 μsec. For DOUBLE



1. SLOPE. Allows setting for triggering to occur on either negative-going or positive-going slope of external trigger-source waveform.

2. TRIGGER INPUT. Connector for external triggering signals.

3. EXT. TRIG. LEVEL. Sets voltage level on external trigger-source waveform at which triggering occurs.

4. GATE INPUT (+). Connector for gating voltage which then allows pulse outputs only when input is at +8 volts or more; 40V maximum.

5. NORM./GATED. Set to GATED when the duration of pulse output is to be controlled by a gating voltage.

6. PULSE ADVANCE/PULSEDELAY/DOUBLE PULSE. Set to PULSE ADVANCE for pulse output before trigger output. Set to PULSE DELAY for pulse output after trigger output. DOUBLE PULSE gives two pulses at output.

7. TRIGGER OUTPUT polarity. Determines polarity of trigger output pulse.

8. TRIGGER OUTPUT connector. Provides 10 volt synchronizing pulses across 1000 ohms.

9. OVERLOAD. Indicator lights when duty cycle limit is exceeded.

10. PULSE OUTPUT polarity. Determines polarity of main pulse output.

11. PULSE OUTPUT connector. Provides output pulse with characteristics set by front panel controls (see Table 1-1 for specifications).

12. POWER switch and indicator. Switch controls ac power to instrument; indicator lights in ON position. 115-230 volt switch on rear panel.

13. PULSE AMPLITUDE. Controls amplitude range of pulse output.

14. VERNIER. Provides continuous overlapping adjustment between setting of PULSE AMPLITUDE and next lower range.

15. PULSE WIDTH. Changes limits of VERNIER control over output pulse width.

16. VERNIER. Provides continuous, semi-calibrated, adjustment between limits set by PULSE WIDTH switch.

17. PULSE POSITION. Changes limits of VERNIER control over output pulse position with respect to the trigger output pulse.

18. VERNIER. Provides continuous, semi-calibrated, adjustment between limits set by PULSE POSITION switch.

19. INT. REP. RATE. Changes limits of VERNIER control over internal repetition rate circuit.

20. VERNIER. Provides continuous adjustment between limits set by INT. REP. RATE switch.

21. TRIGGER MODE. Selects mode of generating pulses. MANual push button, EXTernal trigger source, or INTernal repetition rate.

22. MANUAL. Push button provides single pulse output when TRIGGER MODE is set to MAN.

Figure 3-3. Model 214A Front Panel Description

PULSE operation, the minimum allowable PULSE POSITION setting depends on the PULSE WIDTH used; this is explained in Paragraph 3-9.

3-9. MINIMUM SPACING WITH DOUBLE PULSES.

3-10. In DOUBLE PULSE operation, the PULSE POSITION control sets the spacing between the start of the first pulse and the start of the second pulse. For proper operation without affecting pulse shape, there are minimum spacing limits between the two pulses, and these limits depend on the PULSE WIDTH setting. For a 0.05-1 setting the minimum spacing between pulses is 1 μsec. For other PULSE WIDTH settings, the minimum spacing is 25% of the upper limit of range selected. For example, if PULSE WIDTH is set to 100-1K, the minimum spacing between pulses is 25% of 1K microseconds, or 250 microseconds. Figure 3-2 shows the output pulse characteristics as set by the Model 214A controls in DOUBLE PULSE mode. Note from Figure 3-2 that the setting of PULSE POSITION and PULSE WIDTH controls the actual spacing between pulses. The spacing between pulses is then the PULSE POSITION setting minus the PULSE WIDTH setting.

3-11. GATING OF PULSES.

3-12. By applying a positive signal voltage to the GATE INPUT (+) connector and sliding the switch to GATED, pulses will occur at the output only when the gating signal is at +8 volts or greater. The maximum gating signal amplitude is +40 volts. To ensure that output pulses occur when the gate signal just reaches +8v, a fast rise time input should be used. If a gating sine wave signal is used, a larger amplitude (but less than 40 volts peak) will generally provide better results. For synchronized pulse trains, the gating signal and repetition rate must be locked together. Figure 3-4 illustrates the result of gating the pulse output.

3-13. OPERATING PROCEDURES.

3-14. MANUAL TRIGGER MODE.

3-15. When TRIGGER MODE is set to MAN. and the MANUAL button is pushed, a single pulse output will occur. Other front panel controls are set to obtain the desired pulse characteristics. The same operating considerations apply as explained in Paragraphs 3-4, 3-7, and 3-9. The maximum rate for pushbutton pulses is 2 cps.

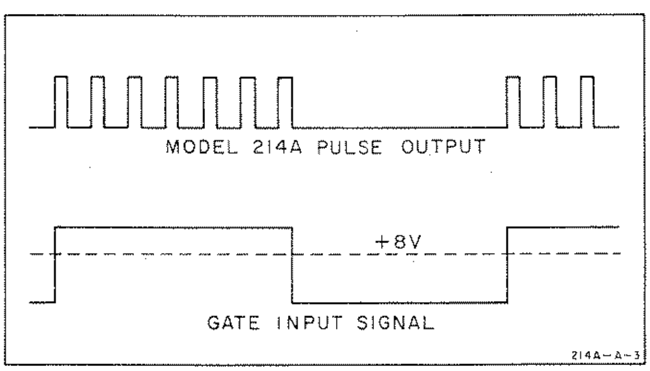


Figure 3-4. Gating Pulse Output

3-16. EXTERNAL TRIGGER MODE.

3-17. With TRIGGER MODE set to EXT., an external triggering signal from dc to 1 Mc with 0.5 volts peak amplitude is required to generate pulses in the Model 214A. Refer to Paragraphs 3-4, 3-7, and 3-9 and proceed as follows:

a. Set TRIGGER MODE to EXT. and connect signal to TRIGGER INPUT.

b. Select + or - SLOPE setting.

c. Set EXT. TRIG. LEVEL to obtain desired triggering level on input waveform. Polarity of EXT. TRIG. LEVEL must agree with SLOPE setting.

d. Set GATED/NORM. switch to NORM. unless using an external gating signal.

e. Select setting for PULSE ADVANCE/PULSE DELAY/DOUBLE PULSE. PULSE ADVANCE or PULSE DELAY means the output pulse will occur advanced or delayed in time, with respect to the trigger output pulse. DOUBLE PULSE provides two pulses out at a rate determined by the TRIGGER MODE circuits.

f. Select polarity of TRIGGER OUTPUT and connect coaxial cable to external circuit being triggered.

g. Select PULSE AMPLITUDE range. Note that these amplitudes are volts into a 50 ohm load at the PULSE OUTPUT connector. The 100 v range will not produce a pulse without the 50 ohm termination.

h. Select PULSE WIDTH range and adjust VERNIER. Observe duty cycle limit for amplitude range.

i. Select polarity of PULSE OUTPUT and connect coaxial cable to external test circuit.

j. Select PULSE POSITION range and adjust VERNIER as desired. With PULSE ADVANCE or PULSE DELAY operation, PULSE POSITION setting is the spacing between the pulse output and the trigger output pulse. With DOUBLE PULSE, PULSE POSITION sets the spacing between the two pulses.

k. Adjust VERNIERS if necessary to obtain exact position, width, and amplitude characteristics.

3-18. INTERNAL TRIGGER MODE.

3-19. With TRIGGER MODE set to INT., the Model 214A will generate pulses at a rate set by the INT. REP. RATE range and VERNIER. This repetition rate is adjustable from 10 cps to 1 Mc. Refer to Paragraphs 3-4, 3-7, and 3-9 and proceed as follows:

a. Turn instrument POWER switch to ON and allow several minutes for warmup.

b. Set TRIGGER MODE to INT.

c. Set INT. REP. RATE range and VERNIER to approximate position for frequency desired (maximum frequency is fully clockwise).

d. Complete steps d through k of Paragraph 3-16.

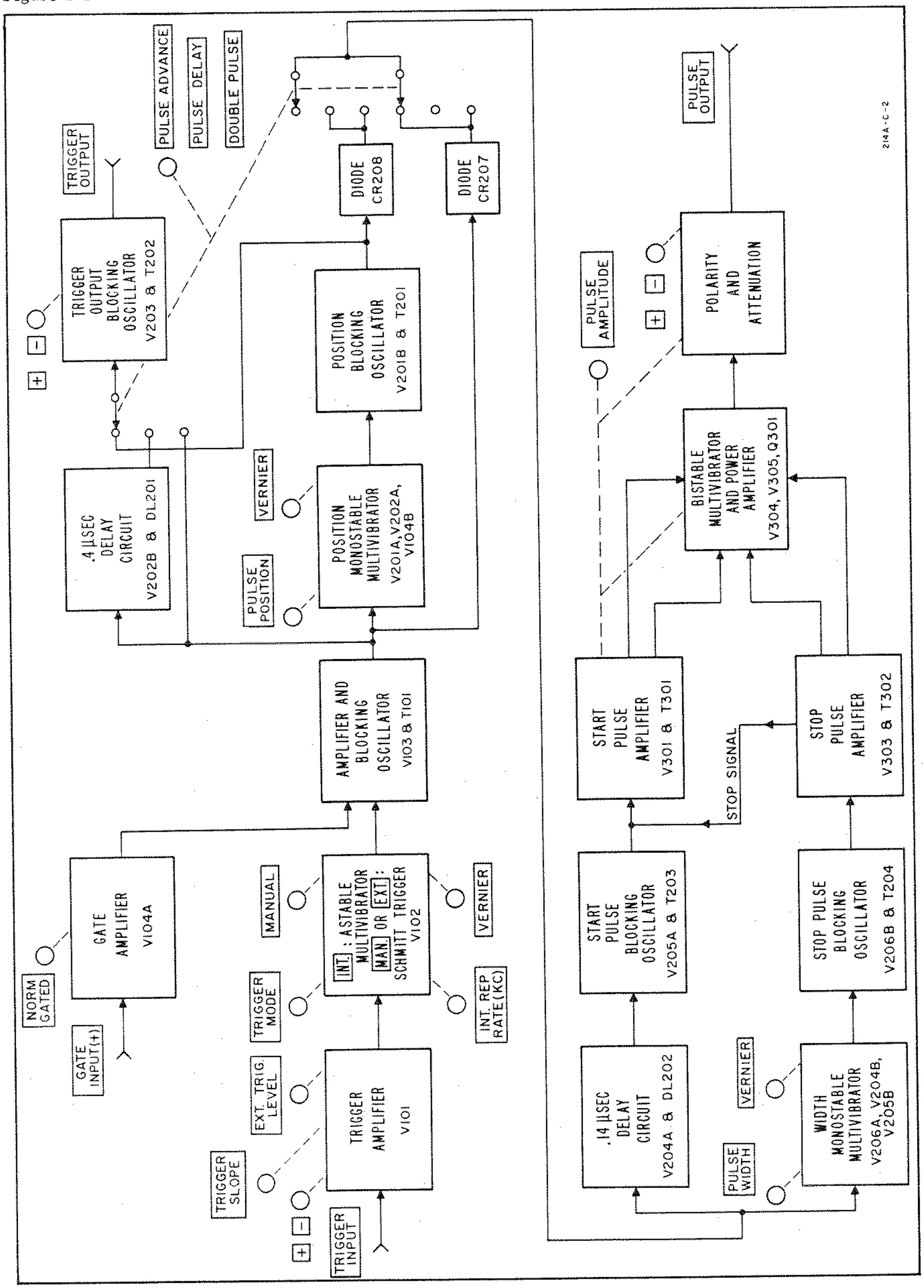


Figure 4-1. Model 214A Block Diagram

SECTION IV
PRINCIPLES OF OPERATION

4-1. GENERAL.

4-2. The complete circuit operation is shown in Figure 4-1. The output pulse is formed by the following general sequence: a trigger pulse from the rate circuit (V102), functioning either as a Schmitt trigger or an astable multivibrator, is applied to blocking oscillator V103, which triggers both the Position Multivibrator (V201A, V202A, V104B) and blocking oscillator V203 for the trigger output pulse. The position Multivibrator triggers Position Blocking Oscillator V201B which in turn triggers both start and stop pulse circuits. The start and stop pulses are used to switch a bistable multivibrator-power amplifier combination (V304, V305, Q301) which forms the output pulse. The details of each block are contained in the schematics, and the following circuit description explains the operation of each circuit, both as to basic type and to the part it plays in the sequence of forming the output pulse.

4-3. INPUT AND RATE GENERATOR.

4-4. EXTERNAL TRIGGER OPERATION.

4-5. With TRIGGER MODE set to EXT. position, a signal of at least 0.5 volts peak will cause Differential Amplifier V101 to amplify the difference between the levels at the control grids, pins 2 and 7. TRIGGER SLOPE switch S101 routes the trigger input to one grid of V101 and also transfers the external trigger level circuit of R105 to the other grid. Resistor R105 sets the grid bias which must be overcome by the trigger input at the other grid to obtain an output at the plate, pin 6 of V101. The output from V101 is coupled through S103A, through a low-impedance network (DS101, R116, and C107), and S103B to R125 and the grid of V102.

4-6. In external trigger operation, V102 functions as a cathode-coupled binary, or Schmitt Trigger, circuit. The plate to grid coupling network is from pin 1 through S103B and the parallel RC combination, R129-C110, to the grid, pin 7. The left half of V102 is normally off and the right half conducting so the output at pin 6 is at a positive level (about 125 volts), less than the +150 supply. As the signal at pin 2 becomes positive enough (upper hysteresis limit), the left half of V102 conducts and regenerative action cuts the right half off. When the input at pin 2 decreases enough (lower hysteresis limit), the left half of V102 is cut off and the circuit returns to the original state. The output at pin 6 then is a positive pulse each time the signal at pin 2 causes the left half to conduct, and the rate at which this occurs is exactly that of the external trigger signal (1 Mc limit on input frequency). The output pulse from pin 6 is coupled through C122 to pin 2 of Blocking Oscillator V103.

4-7. MANUAL TRIGGER OPERATION.

4-8. With TRIGGER MODE set to MAN. position, V102 again functions as a Schmitt Trigger circuit as in external operation, with the parallel RC network R129-C110 coupling between plate and grid. When MANUAL switch S102 is energized, the side of capacitor C106 toward the switch charges toward +150 volts through R120. This positive-going, slow rising exponential voltage is coupled to the grid (pin 2) of V102 and the left half of the tube conducts. The right half of V102 now cuts off and a positive pulse to +150V is the output coupled to the grid of V103.

4-9. INTERNAL TRIGGER OPERATION.

4-10. With TRIGGER MODE set to INT. position, V102 functions as an astable multivibrator. The free-running rate of this circuit is controlled by range capacitors, C113 through C117, coupling between plate (pin 1) and grid (pin 7), and by VERNIER, R137. Breakdown diode CR101 sets the bias at the grid of the left half of V102. This circuit has no stable state and is always changing between two states: (1) left-half cutoff, right-half conducting or (2) left-half conducting, right-half cutoff. The rate at which this changing of states occurs is primarily a function of the capacitors between plate and grid since this determines the exponential rise and decay time of the grid (pin 7). When the grid (pin 7) voltage rises exponentially enough to cause the right half to conduct, the output at pin 6 is about +125 volts. Then as the voltage at pin 7 decays exponentially, the right half cuts off and the output at pin 6 is at the supply voltage, +150v. A regenerative action occurs as the right half of V102 just starts to conduct and the left half starts to cutoff: the increase in voltage at the plate (pin 1) is coupled through the range capacitor to speed turn on of the right half. Symmetry Adjust, R133, changes the grid bias of pin 7 to nearly equal the bias at pin 2 making the two halves of the waveform equal in width.

4-11. TRIGGER BLOCKING OSCILLATOR.

4-12. Tube V103 and transformer T101 function as an amplifier-blocking oscillator, when the output of V102 is not being gated by the circuit of V104A (see Paragraph 4-13). Normal operation of the blocking oscillator is as a monostable circuit being triggered by an amplified signal. The left half of V103 amplifies the positive pulse at its grid and the resulting plate pulse is coupled through transformer T101, reversed in phase, to the grid of the right half. This puts the right half of V103 in conduction and a regenerative action drives the plate (pin 6) voltage down abruptly and the grid voltage (pin 7) abruptly positive. Next the action reverses and as the plate voltage becomes more positive, the grid goes negative and regeneration turns the tube off agian. The output is taken from the cathode (pin 8) and the pulse drives other circuits depending on which pulse mode (advance, delay, or double) is used (see Paragraph 4-15).

4-13. GATE INPUT CIRCUIT.

4-14. When switch S105 is in the NORM. position, Gate Cathode Follower V104A is conducting enough so CR103 is biased off, and the pulse at pin 2 of V103 is unaffected in operation. However, when S105 is moved to GATED, V104A is cut off, biasing the cathode of CR103 more negative than its anode and CR103 conducts, changing V103 input impedance so the rate pulse does not develop enough signal to trigger the blocking oscillator. By applying a positive signal of at least 8 volts (but less than 40) V104A will again conduct, cutting off CR103 and the pulse at V103 triggers the blocking oscillator (explained in Paragraph 4-11).

4-15. ADVANCE, DELAY, DOUBLE PULSE MODES.

4-16. Three modes of pulse operation are obtained by switching the timing pulse from the Trigger Blocking Oscillator V103 through combinations of circuits. These circuits are described below first in terms of general operation (Paragraphs 4-17 through 4-26) and second, as each is used in either PULSE ADVANCE, PULSE DELAY, or DOUBLE PULSE (Paragraphs 4-27 through 4-32).

4-17. PULSE POSITION CIRCUIT.

4-18. POSITION MULTIVIBRATOR. The circuits of tubes V201A and V202A form a monostable multivibrator which controls the position relationship between the output pulses and trigger output or between both output pulses in DOUBLE PULSE operation. This multivibrator substitutes cathode-coupling with a common cathode resistor for the usual coupling between plate of V202A and grid of V201A, but still is a monostable circuit. The width of the multivibrator pulse is controlled by range capacitors, C201 through C205, and the VERNIER control R207. By controlling the time V202A is cut off, with the range capacitor and VERNIER, the delay before triggering the position blocking oscillator V201B is also controlled (V201B is triggered as V202A starts conducting; see Paragraphs 4-19). Tube V104B acts as a screen biasing supply for V202A. The output at pin 9 of V202A is a variable width positive pulse which is coupled through C209 to pin 6 of V201B.

4-19. POSITION BLOCKING OSCILLATOR. The signal from V202A triggers Position Blocking Oscillator V201B at the plate. This signal is coupled through T201 to the grid (pin 7) and the circuit functions in the same way as V103 right half, described in Paragraph 4-11. The output is taken from the cathode as a positive pulse about 30 volts in amplitude.

4-20. PULSE WIDTH MULTIVIBRATOR.

4-21. The circuits of tubes V206A and V204B form a monostable, cathode-coupled multivibrator, and the circuit functions the same as that described in Paragraph 4-18. The time for which V204B remains cutoff is determined by range capacitors C225 through C229 and VERNIER, R257. The output at pin 9 of V204B is used to drive the stop pulse blocking oscillator V206B (see Paragraph 4-26). The time delay obtained from the width multivibrator thus determines how long since the output pulse started before the stop pulse blocking oscillator returns the pulse to zero (this time is the pulse width).

4-22. TRIGGER OUTPUT BLOCKING OSCILLATOR.

4-23. Tube V203 and transformer T202 function as an amplifier-blocking oscillator in a nearly identical circuit as described in Paragraph 4-11 for the circuit of V103. A signal at pin 2 of V203 is amplified and coupled from the plate through T202 to the grid of the right half. For a positive trigger output, S203 routes the cathode signal to J201 and for a negative trigger out, S203 routes the signal from pin 1 of T202 to J201.

4-24. START-STOP PULSE BLOCKING OSCILLATORS.

4-25. START PULSE BLOCKING OSCILLATOR. The circuit of V205A and T203 is another blocking oscillator working the same way as described in Paragraph 4-11. The signal which triggers V205A plate has been amplified by V204A and delayed by 0.14 microseconds by DL202. The output from the cathode of V205A is a positive pulse of about 35 volts which drives the input to V301.

4-26. STOP PULSE BLOCKING OSCILLATOR. The blocking oscillator of V206B and T204 also is of the same type already described in Paragraph 4-11. The signal to trigger V206B comes from the width multivibrator circuit when V204B starts conducting. The output from the cathode of V206B is a positive pulse of about 35 volts and it drives the input to V303, the Stop Pulse Spiker.

4-27. PULSE ADVANCE TIMING LOGIC.

4-28. Figure 4-2 shows the timing logic for PULSE ADVANCE mode of operation. The timing pulse from V103 goes directly through diode CR207 to the start-stop pulse circuits (through V204A to V205A, and through the width multivibrator to V206B). The timing pulse also goes through CR201 to the grid of V201A to operate the position multivibrator. The resulting waveform from the position blocking oscillator is coupled through C216 to pin 2 of V203. Now the position multivibrator is used to effectively delay the trigger output, i.e. the main pulse output occurs in advance of the trigger. The pulse width multivibrator and start-stop pulse blocking oscillators function the same as described previously.

4-29. PULSE DELAY TIMING LOGIC.

4-30. Figure 4-3 shows the timing logic for PULSE DELAY mode of operation. The V103 timing pulse goes directly to Cathode Follower V202B and is taken, delayed by 0.4 microseconds by DL201, through S202B to the trigger output blocking oscillator, to cause a trigger output pulse. The timing pulse has also triggered the position multivibrator circuit through CR201. The output from V201B goes through CR208 and S202B to the width multivibrator and start-stop blocking oscillators. This time the position multivibrator has been used to effectively delay the start of the pulse output with respect to the trigger output.

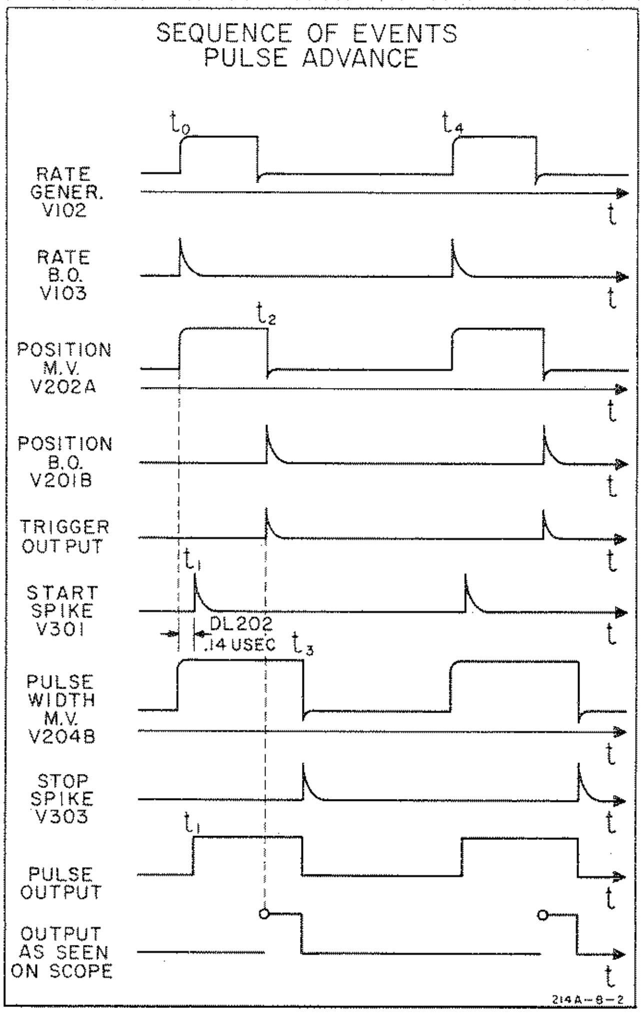


Figure 4-2. PULSE ADVANCE Timing Sequence

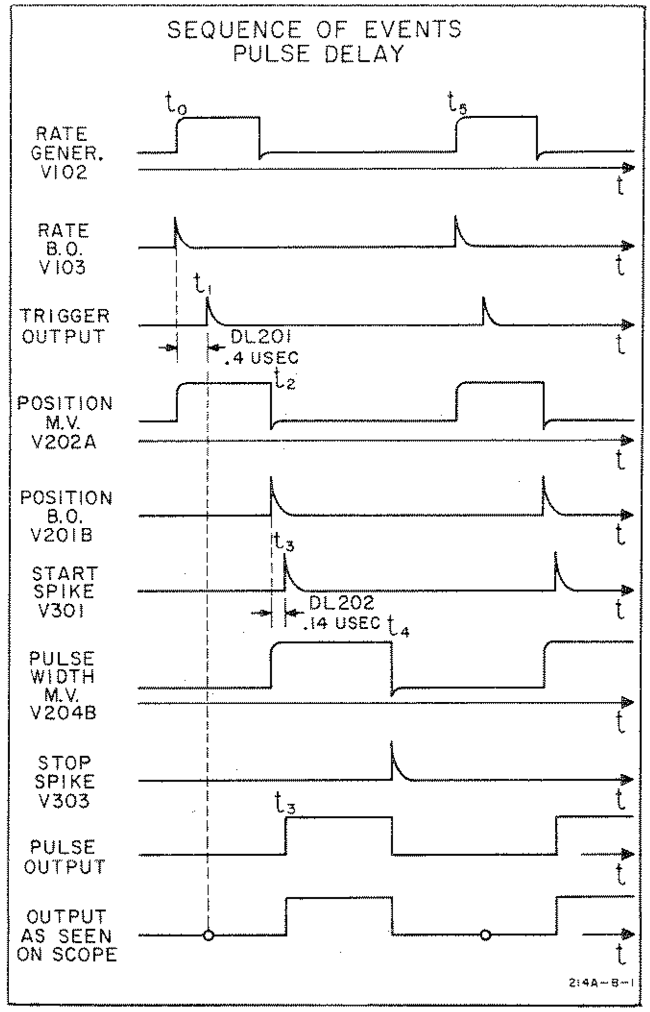


Figure 4-3. PULSE DELAY Timing Sequence

4-31. DOUBLE PULSE TIMING LOGIC.

4-32. Figure 4-4 shows the timing logic for DOUBLE PULSE mode of operation. The V103 timing pulse goes directly through CR201 to the position multivibrator and directly through CR207 to the start pulse and stop pulse circuitry (i.e. through V204A and also through the width multivibrator). This causes one pulse output. Then the delayed timing pulse from the position multivibrator and blocking oscillator comes through CR208 to trigger the start-pulse circuitry a second time and another pulse output is formed. The delayed timing pulse from V201B determines the position in time at which the second pulse occurs (i.e. the time between leading edge of pulses). The pulses have the same variable width since both are controlled by the width multivibrator.

4-33. FORMING AND CONTROLLING OUTPUT PULSE.

4-34. The fast rise and fall time of the output pulse is achieved by rapid charging of the input capacitance represented by the grid of tubes V304 and V305, then rapidly discharging this capacitance to end the pulse. A large current spike waveform is used and the output tubes are held on during the pulse by a bistable type multivibrator circuit. The amplitude of the output pulse is controlled by varying the output tube screen supply, by changing the bias levels of the output circuits, and some attenuation at the output.

4-35. START PULSE SPIKER.

4-36. The positive pulse from V205A is coupled through L301, C301, and CR301 to the control grid of V301. The input circuit of V301 changes the dc level of the start pulse and smoothes the transition from triggered on state to the steady state during the output pulse. Diode CR301 discharges the input circuit after the start spike occurs and C302 discharges through R301 to increase the fall time of the spike. The rise time of the spike is sharpened by clipping diode CR303. Tube V302A is a screen supply for V301. The output of V301 is a current spike which is increased to about 0.5 amp by current step-up transformer T301 and coupled to the input circuit of V304/5 to charge up the input capacitance.

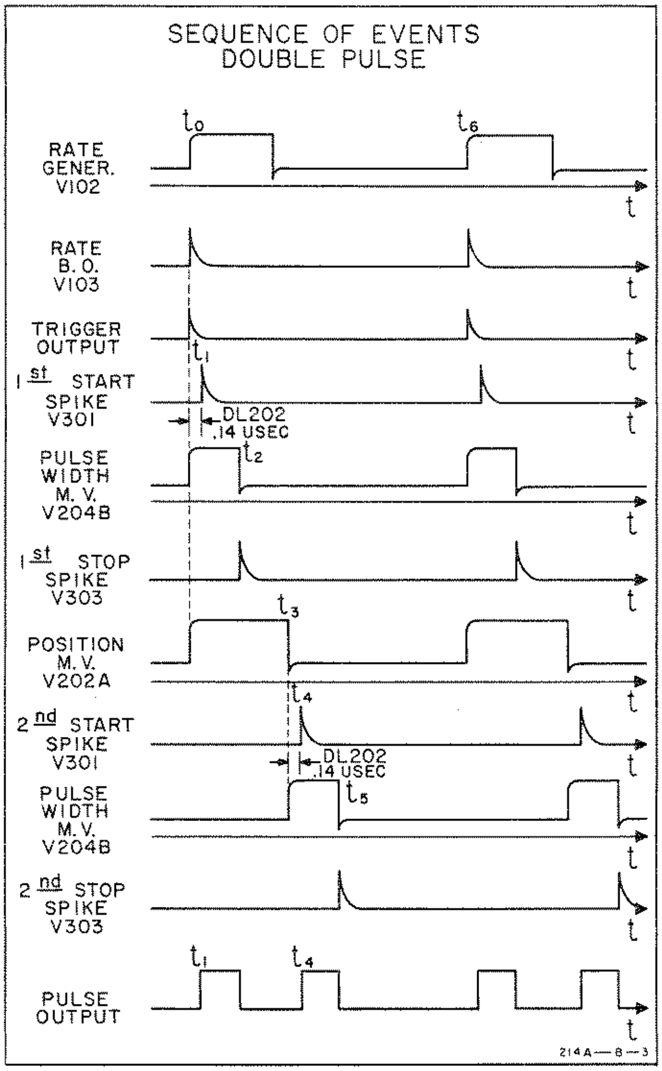


Figure 4-4. DOUBLE PULSE Timing Sequence

4-37. STOP PULSE SPIKER.

4-38. The positive pulse from V206B is coupled through L303, and CR308 to the control grid of V303. The input circuit of V303 is nearly identical to that of V301 and the same result is obtained in a negative current spike at the plate. The output of V303 is coupled by current step-up transformer T302, but reversed in phase to that from T301 which initiated the pulse, to the input circuit of V304/5 to discharge the input capacitance.

4-39. PULSE OUTPUT CIRCUIT.

4-40. Parallel output tubes V304/5 are turned on by the current spike from the top winding (pins 3 and 4) of T301 and then held on by a type of bistable multivibrator circuit which includes the output tubes. Diodes CR324 and CR325 sharpen the rise time of the spike input. The steady state cutoff bias of V304/5 is set by a voltage divider network including breakdown diode CR326. To keep the output tube conducting after the start pulse, CR326 is taken out of the breakdown area by transistor Q301. Transistor Q301 is triggered on by the other winding of T301 (pins 1 and 2) and held on by bias developed across CR327 and CR328. This clamps the collector voltage of Q301 to the emitter, reducing CR326 voltage to less than breakdown. With Q301 conducting, V302B now supplies a steady 11 ma current to keep diodes CR324/5 conducting, holding V304/5 on. Then to turn V304/5 off and end the output pulse, the negative spike from T302 through the top winding (pins 1 and 2) discharges the input capacitance rapidly and the other transformer winding (pins 3 and 4) turns Q301 off. This restores the bias on CR326 and the circuit returns to its original state, ready for the next start spike from V301. The output pulse is taken across a 50 ohm resistance in the plate circuit of V304/5 for all ranges except 100v. This 50 ohm source impedance, consisting of R405 through R408 in parallel, absorbs reflections from an external system mismatch.

4-41. PULSE OUTPUT AMPLITUDE CONTROLS.

4-42. The circuits changed by switch S401 control the output pulse amplitude in various ways. S401C switches different breakdown diodes (CR320-322) into the control grid circuit of the output tubes. S401D changes the bias on screen supply tube V302A in the start pulse spiker circuit. S401A and S401B are in the screen supply for the output tubes and this circuit also affects the pulse amplitude. Increasing the Amplitude VERNIER R360, charges C325 from the cathode of V307 for a quick response to an increase in control voltage. To get a quick response for a decrease in control voltage, V308 discharges C325. Other sections of S401, at the output, switch in attenuator resistors on lower pulse amplitudes.

4-43. REVERSING PULSE POLARITY.

4-44. Either positive or negative output pulses are obtained merely by reversing the connections between center conductor and shield of the coaxial cable carrying the pulse. Switch S402 reverses these connections. This method of reversing polarity is possible because a floating power supply is used allowing the ground reference to be established at any level. Inductors L308, L401, and L402 isolate the voltage supply and prevent the supply from bypassing the pulse. Negative pulse outputs occur when the plates of the output tubes drive the center conductor of the coaxial cable and the shield is tied to the 0V, isolated supply reference. Positive pulses occur by reversing these connections and placing the center conductor at the 0V isolated reference voltage.