OPERATING AND SERVICE MANUAL

MODEL 213A

SERIALS PREFIXED: 136-

PULSE GENERATOR

01129-1

Printed: SEPT 1961

Figure 1-1. Model 213A Pulse Generator

Table 1-1. Specifications

OUTPUT

Rise Time: Approximately 0.2 ns; always less than 0.5 ns

Top Droop: Less than 2% in first 100 ns following the rise

Width: Approximately 2 μs

Overshoot or Undershoot: Less than 5% as observed on 185A/187B Oscilloscope using 187B-76E 50-ohm T connector

Amplitude: At least 350 mv open circuit, either polarity

Output Resistance: Approximately 3 ohms. Designed to drive a 50-ohm system

Jitter: Less than 20 picoseconds when triggered with the 185A or 185B sync pulse

Repetition Rate: Free runs at a rate greater than 100 kc, or may be triggered

TRIGGER INPUT

Amplitude: 0.5 volts peak, either polarity

Rise Time: 20 ns or faster

Width: At least 2 ns

Maximum Current: 200 ma peak

Impedance: 200 ohms for signals less than 0.75 volt peak. Limiting lowers impedance to larger signals.

Repetition Rate: 0 to 100 kc

GENERAL

Power: 115 or 230 volts ±10%, 50 to 60 cps, approximately 1 watt

Dimensions: 1-1/2 in. high, 5-1/8 in. wide, 5 in. deep

Weight: Approximately 2 lbs net

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Model 213A is a fast pulse generator which can be used to check the dynamic response of wideband amplifiers and oscilloscopes. The pulse rise time is less than 0.5 nanoseconds. The pulse is approximately two microseconds wide and is useful as a flat topped step for 100 nanoseconds after the rise. The unit will free run at a rate between 100 and 200 kc or can be triggered by an external source from 0 to 100 kc.

1-3. This very fast rise time is useful in step testing amplifiers and oscilloscopes with bandwidths between 10 and 1000 mc, such as the hp Model 185A Sampling Oscilloscope.

1-4. DIFFERENCES BETWEEN INSTRUMENTS.

1-5. The Model 213A carries an eight-digit serial number. The first three digits (serial prefix) remain the same until a significant change occurs in the instrument. The prefix number also appears on the title page of the manual to indicate the instruments to which the manual directly applies. For instruments with a serial number prefix which differs from that on the title page, a supplement (or change sheets) is included with the manual describing the changes necessary to make the manual apply directly to the instrument.

1-6. POWER CABLE.

1-7. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when connected to an appropriate receptacle, grounds the instrument. The offset round pin on the three-prong power cable connector is the ground pin.

1-8. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

1-9. INSTRUMENT PROTECTION.

1-10. Excessive current should not be fed into the output connector. Steady state currents as high as 200 ma will not damage the tunnel diodes; however, short high transients, such as discharging capacitors, may destroy the tunnel diodes.

SECTION II
INSTALLATION

2-1. MECHANICAL INSPECTION.

2-2. Unpack the Model 213A on receipt and inspect it for signs of physical damage such as scratched panel surfaces, broken knobs, etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page of this manual.

2-3. INCOMING QUALITY CONTROL CHECK.

2-4. The instrument may be checked for proper operation by following the test procedure listed in section V of this manual.

2-5. REPACKAGING FOR SHIPMENT.

2-6. The following list is a general guide for repackaging an instrument for shipment. However, if you have any questions contact your authorized Hewlett-Packard sales representative.

a. If possible, use the original container designed for the instrument.

b. Wrap the instrument in heavy paper or plastic before placing it in the shipping container.

c. Use plenty of packing material around all sides of the instrument and protect the panel faces with cardboard strips.

d. Use a heavy cardboard carton or wooden box to house the unit, and strap with heavy tape or metal bands.

e. Mark packing box with "Fragile", "Delicate Instrument", etc. as appropriate.

Note

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. In any correspondence, be sure to identify the instrument by model number, and complete serial number.

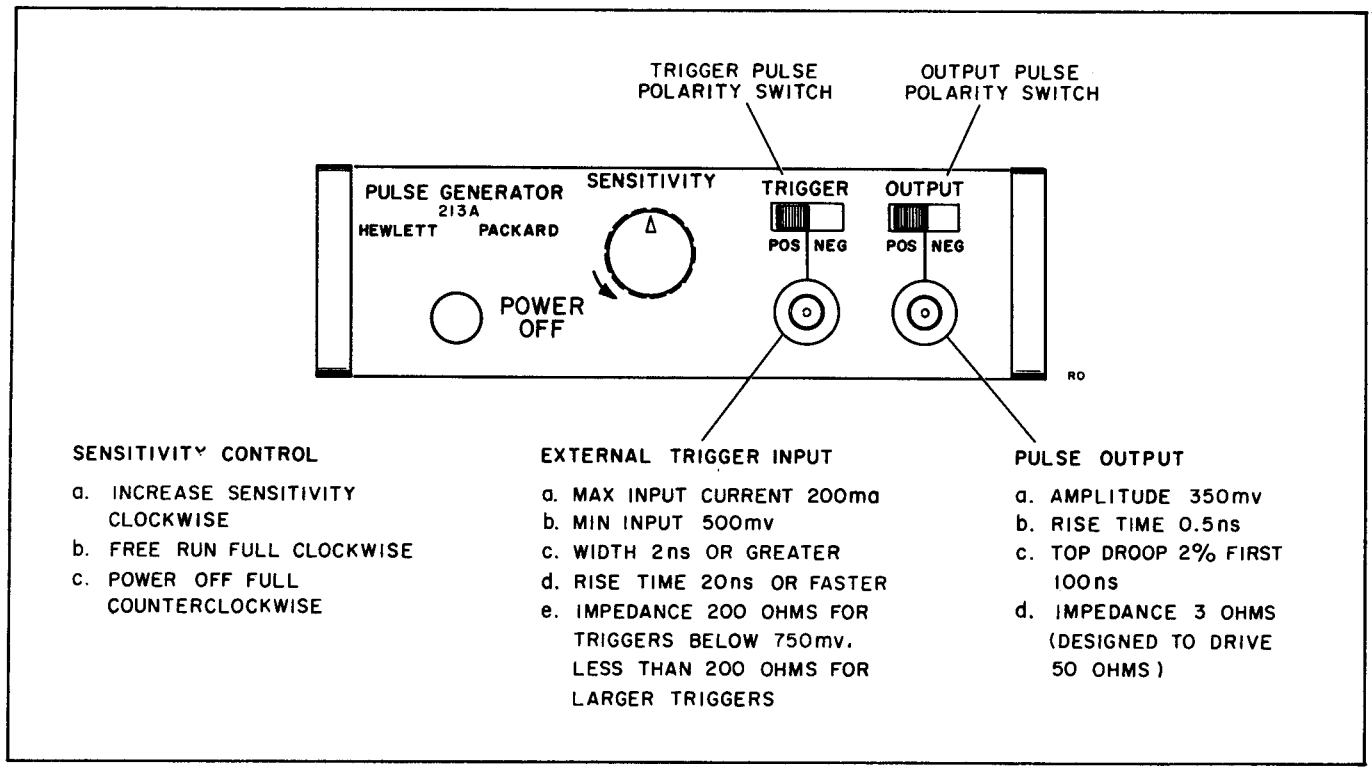


Figure 3-1. Model 213A Operating Controls

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The Model 213A is a pulse generator capable of producing pulses of either polarity with very fast rise times. The pulse generator will free-run or may be triggered from an external source, with either positive or negative pulses, at rates up to 100 kc. The output impedance is approximately 3 ohms, however the unit is designed to operate into 50 ohms. See figure 3-1.

3-3. OPERATING INSTRUCTIONS.

3-4. For external trigger operation connect the external trigger source to the TRIGGER connector and move the TRIGGER switch to the polarity of the input pulse. Connect the Model 213A OUTPUT to the device under test. Set the OUTPUT switch to the polarity desired. Adjust the SENSITIVITY control for stable operation.

3-5. For free-running operation turn SENSITIVITY control full clockwise. The rate of operation will be between 100 and 200 kc.

3-6. OPERATING PRECAUTIONS.

3-7. Although the Model 213A is designed to operate into a 50-ohm system it will drive systems as low as 20 ohms. Since the instrument is a low impedance source (approximately 3 ohms) it is very important to terminate the system under test with its characteristic impedance to eliminate reflections. Any reflections from the load will be re-reflected by the generator practically undiminished and may cause waveform distortion. The effects of secondary reflections can be minimized by installing an attenuator or sufficient length of cable, between the generator output and load.

3-8. Since the unit is dc coupled for both trigger input and pulse output, steady state bias voltages applied to either connector may impair operation.

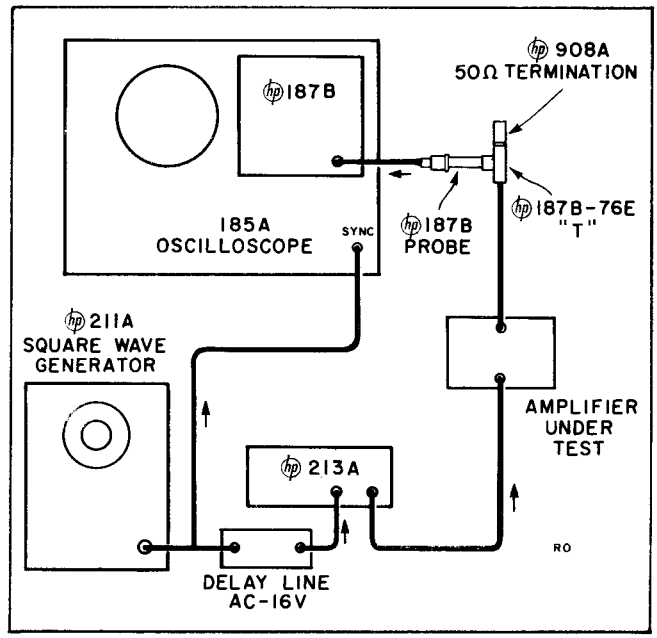


Figure 3-2. Typical Model 213A Application, Amplifier Rise-Time Measurements

3-9. APPLICATION INFORMATION.

3-10. RISE TIME MEASUREMENTS.

3-11. The Model 213A may be used to establish the rise time of oscilloscopes and amplifiers capable of operation in the 10 mc to 1000 mc region. Typical applications are shown in figures 3-2 and 5-1.

3-12. TRANSMISSION-LINE MEASUREMENTS.

3-13. With the advent of the High Frequency Sampling Oscilloscope, Model 185A, a new method for making microwave transmission-line measurements has been developed. The Model 213A makes an ideal source for these measurements. These measurements are described in Application Note 53 titled "Transmission Line Testing using the Sampling Oscilloscope". Copies of this application note are available from either the Hewlett-Packard Company or your local sales representative.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 213A consists of a low impedance power supply, sync input circuits including pulse inverting transformers, and a tunnel diode pulse generator. The simplified circuit is shown in figure 4-1.

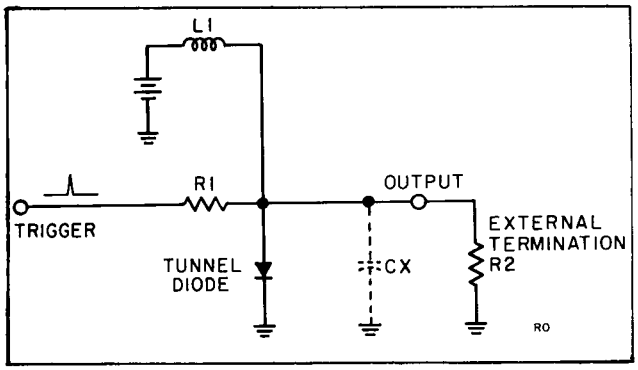


Figure 4-1. Simplified Circuit

4-3. CIRCUIT DESCRIPTION.

4-4. TUNNEL DIODE.

4-5. A typical tunnel diode characteristic curve is shown in figure 4-2. A negative resistance region of operation, in which current decreases as the voltage increases, exists between points B and D. In this region the diode is very unstable and rapid voltage changes will occur.

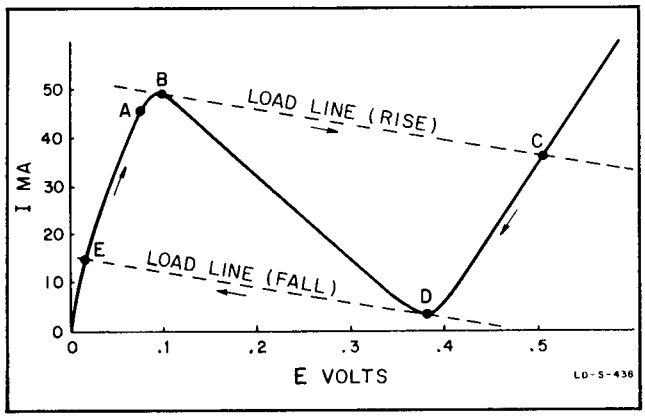


Figure 4-2. Typical Current/Voltage Characteristic Curves, Tunnel Diode

4-6. The diode is originally biased at point A on the curve. Inductor L1 serves as constant current source to the diode and load. A small trigger is applied through R1 raising the current slightly above point B. The diode operating point then jumps to point C passing through the negative resistance area of the diode. The rapid decrease in diode current, due to the negative resistance portion of the characteristic curve, serves to charge the diode and stray capacities C_x producing the voltage step across the load R2.

4-7. Inductor L1 maintains essentially a constant current to the diode and load for approximately 100 nanoseconds. As the current supplied by L1 decreases, the diode operating point follows the curve to point D and again finds an unstable condition, due to the negative resistance area. The diode operating point switches rapidly to E on the curve and follows the curve to its steady state bias condition at point A.

4-8. The resulting voltage waveform, across R2, is represented by figure 4-3. The letters on the waveform correspond in time to the switching points on the characteristic curve. The pulse output is on a 100 to 200 millivolt bias which is positive when the output polarity is positive and negative when the output polarity is negative.

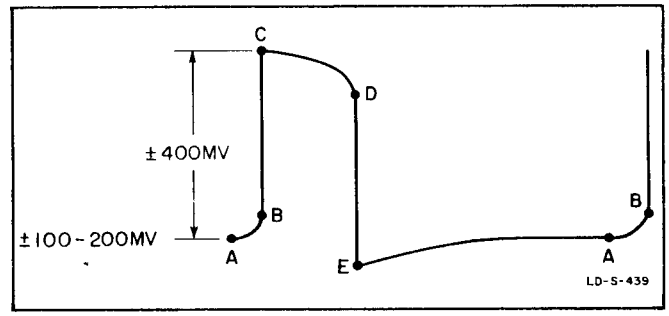


Figure 4-3. Typical Output Waveform

4-9. Both positive and negative output pulses are obtained by placing two diodes back-to-back, see schematic diagram (figure 5-5), and inverting the trigger pulse (with S2 and T3) and bias (with S3) for the tunnel diodes. The tunnel diode conductance is so high in the reverse direction that the characteristic of a back-to-back pair is only slightly different from the forward characteristic of a single diode.

4-10. POWER SUPPLY, PROTECTION CIRCUITS.

4-11. The emitter follower Q1 provides the low impedance source required by the tunnel diode. CR3 through CR6 provide source regulation to the emitter follower utilizing the constant voltage drop characteristic of a forward biased diode.

4-12. Diodes CR9 and CR10 limit trigger currents to approximately 5 ma to prevent larger triggers from influencing the step waveform. Current triggers up to 200 ma will not damage the limiting diodes.

4-13. CR7 and CR8 are protective clamps to reduce the possibility of damage to the tunnel diodes by applying excessively high currents.

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Recommended Instrument
Oscilloscope	Rise Time: Less than 0.4 ns Sensitivity: 20 mv/cm	hp Model 185A/187B
Oscilloscope	Pass Band: 10 mc Sensitivity: 100 mv/cm	hp Model 150A/152B hp Model 160B/162A hp Model 170A/162A
Square Wave Generator	Frequency Range: To 100 kc Output Voltage: 0.3 to 1 volt rms	hp Model 211A
Probe T Connector	Impedance: 50 ohms Coaxial with type N connectors	hp 187B-76E
Termination	Impedance: 50 ohms Type N connector	hp Model 908A
Cable	Impedance: 50 ohms Type N connector on one end and BNC connector on other	hp AC-16W

Table 5-2. Trouble Localization

External Indication	Circuit Indication	Possible Fault
No Output (either polarity)	Low 5 volt supply Average operating voltage 0.8 across CR3 Average operating voltage 0.8 volt across diode CR4, CR5, CR6	Weak CR1, CR2 Shorted CR3 Shorted Q1 Shorted CR4, CR5, CR6 Shorted CR7, CR8
No Output (one polarity)	Average resistance of pair is 2.5 to 3.5 ohms	Shorted CR12, CR13
Low Pulse Out		Weak CR12, CR13
Pulse Jitter	Typical ripple (SENSITIVITY control full counterclockwise) 5-volt supply, 80 mv ripple Collector Q1, 4 mv ripple At output connector, 0.5 mv ripple	Ripple on power supply due to weak CR1, CR2; unstable CR3, CR4, CR5, CR6; leaky C3, C4.
Low Trigger Sensitivity		Weak CR1 through CR6, Q1 Shorted CR9, CR10
Will Not Free Run		Low 5-volt supply Weak Q1
Pulse Sag (exceeding 2% in first 100 ns of pulse)		Partially shorted L3 or L4

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section gives the maintenance and servicing information for the Model 213A. Included in the section is information on recommended test equipment, troubleshooting, repair and calibration. There is no routine maintenance on the Model 213A.

5-3. TEST EQUIPMENT.

5-4. Test equipment for use in testing and servicing the Model 213A is listed in table 5-1.

5-5. TROUBLESHOOTING.

5-6. Table 5-2 is a troubleshooting aid designed to help you locate malfunctions within the instrument.

5-7. PERFORMANCE CHECK PROCEDURE.

5-8. PULSE CHARACTERISTICS.

5-9. EQUIPMENT SETUP. See figure 5-1.

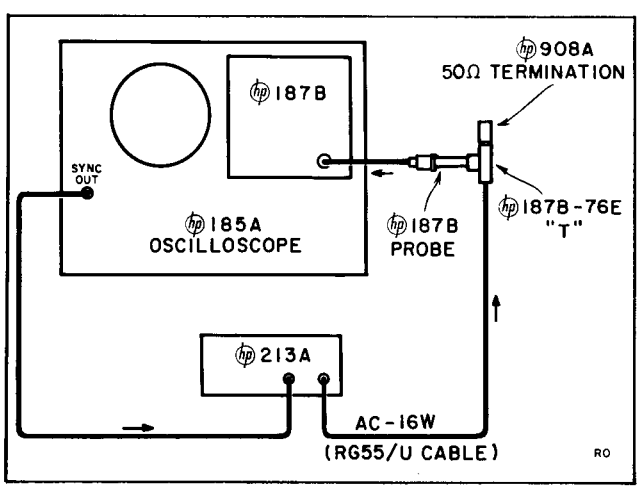


Figure 5-1. Calibration Setup for Output Pulse Characteristic Measurements

5-10. PROCEDURE.

a. Set the 185A SYNC PULSE to ON, SCANNING to FINE, TIME SCALE MAGNIFIER to X1, TIME SCALE to 10 ns/cm, MODE to FREE RUN, SENSITIVITY to 100 mv/cm, and RESPONSE to NORMAL.

b. Set the 213A TRIGGER and OUTPUT switches to POS, and adjust the SENSITIVITY for a stable pattern.

(1) Pulse Amplitude should be at least 350 mv.

c. Switch the MAGNIFIER on the 185A to X20 and adjust DELAY to present pulse rise time on the oscilloscope.

(1) Rise Time of the generator should be 0.5 ns between the 10% and 90% (amplitude) points on the waveform.

Note: The rise time measured on the oscilloscope may be as long as 0.64 ns and still be within specifications since the viewed rise time is a combination of the pulse generator rise time and the oscilloscope rise time. This combination of rise times can be expressed as

$$T_m = \sqrt{T_1^2 + T_2^2}$$

where T_m = measured rise time on oscilloscope

T_1 = oscilloscope rise time

T_2 = pulse generator rise time

Example: If T_m = 0.64 ns, T_1 = 0.4 ns

then $T_2 = \sqrt{T_m^2 - T_1^2} = 0.25 = 0.5$ ns

(2) Overshoot and Undershoot must be 5% or less of the pulse amplitude.

(3) Top Droop, after overshoot and undershoot, must be 2% or less, of the pulse amplitude, for the first 100 ns of pulse length.

(4) Typical pulse characteristics are shown in fig. 5-2.

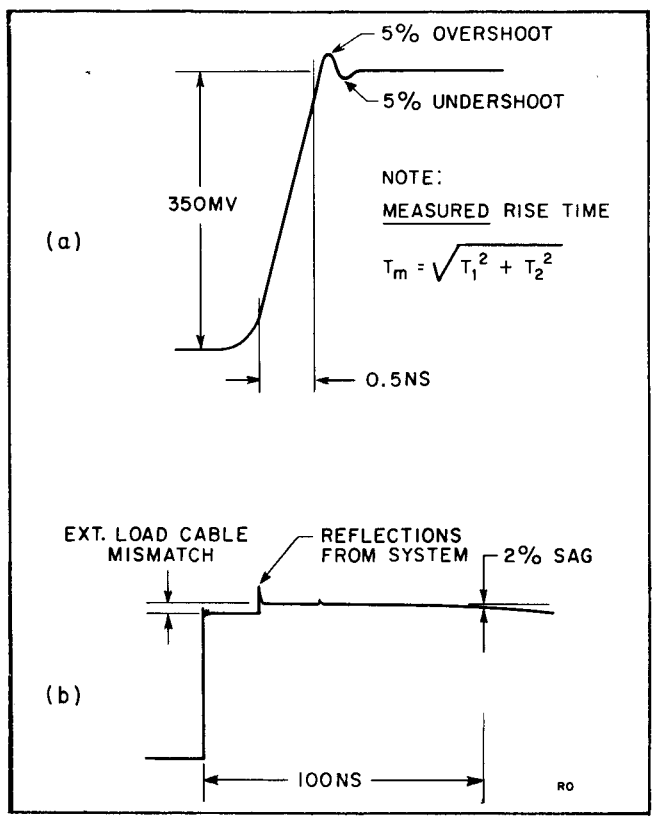


Figure 5-2. Typical Pulse Characteristics
(a) Rise Time, (b) Pulse Flatness

5-11. TRIGGER SENSITIVITY, FREE RUN.

5-12. EQUIPMENT SETUP. See figure 5-3.

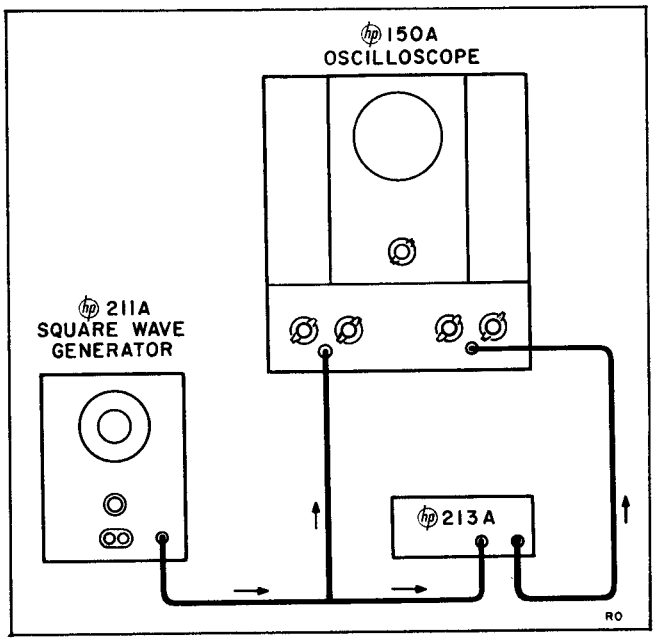


Figure 5-3. Calibration Setup for Trigger and Free Run Measurements

5-13. PROCEDURE.

a. Set the square-wave generator output voltage to 0.5 volt peak and adjust the 213A SENSITIVITY for a stable output.

(1) Trigger Sensitivity should be 0.5 volt peak or less at all frequencies up to 100 kc.

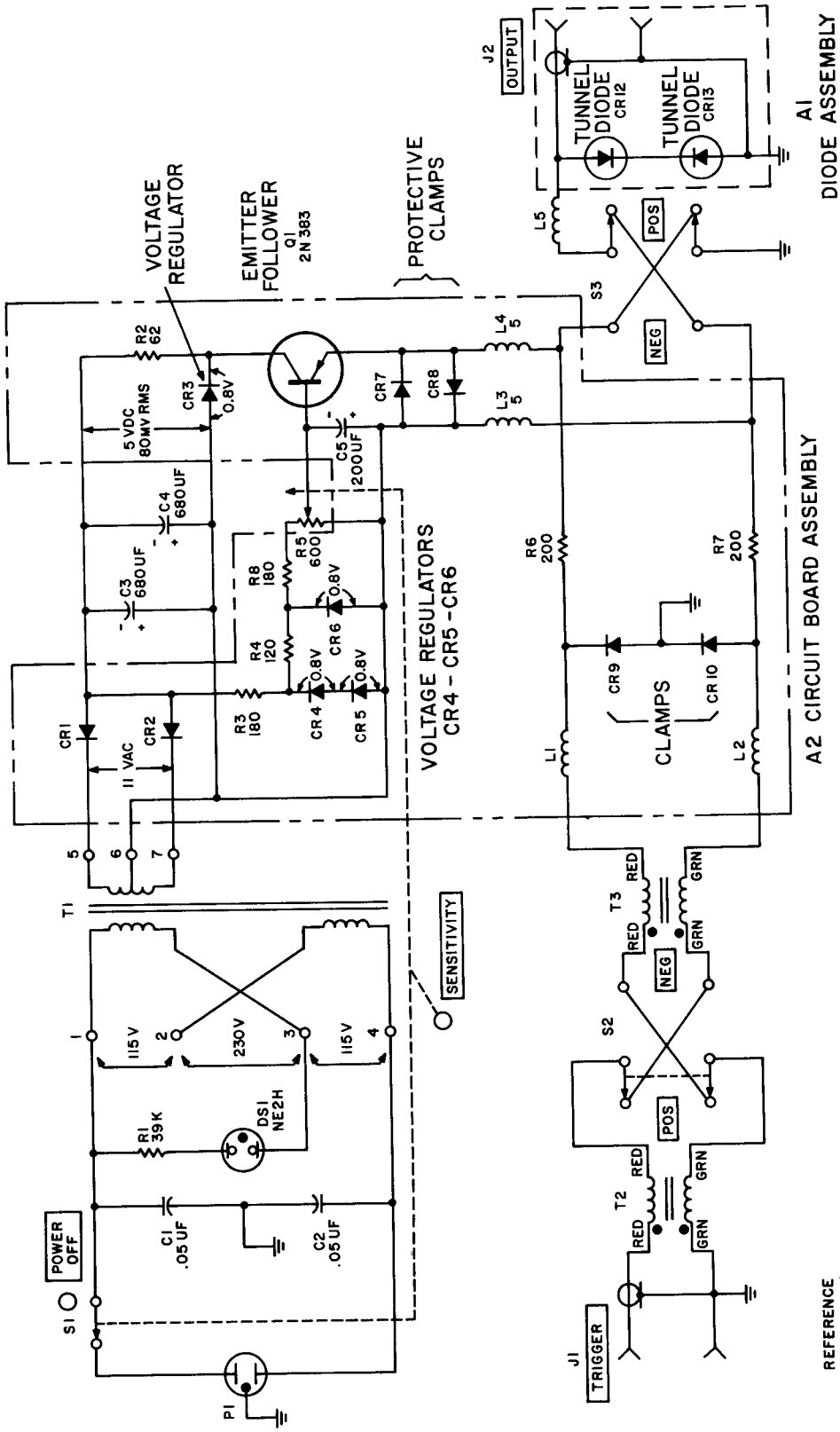
b. Remove the TRIGGER input signal from the 213A and turn the SENSITIVITY control full clockwise.

(1) Free Run rate of operation between 100 kc and 200 kc should be obtained.

5-14. REPAIR.

5-15. The Model 213A utilizes etched circuit boards. See figure 5-4 for etched board service information.

5-16. The two tunnel diodes are mounted within the output connector. Should the diodes require replacement, the complete output connector assembly should be installed.



NOTES

1. HEAVY BOX INDICATES FRONT PANEL ENGRAVING
2. ARROWS SHOW CLOCKWISE ROTATION OF CONTROLS
3. RESISTANCE VALUES IN OHMS, INDUCTANCE IN MICROHENRIES
4. ALL VOLTAGES MEASURED WITH SENSITIVITY AT MINIMUM
5. DC VOLTAGES MEASURED WITH -*hp*- MODEL 412A VTVM
6. AC VOLTAGES MEASURED WITH -*hp*- MODEL 400D VTVM

UNASSIGNED:
CR11

DELETED:
NONE

REFERENCE DESIGNATORS	
C1 - 5	
CR1 - 13	
DS1	
J1 - 2	
L1 - 5	
P1	
Q1	
R1 - 8	
S1 - 3	
T1 - 3	

Figure 5-5. Pulse Generator, Schematic Diagram

SECTION VI
REPLACEABLE PARTS

6-1. INFORMATION.

6-2. This section contains information for ordering replacement parts for the Model 213A Pulse Generator.

6-3. Table 6-1 lists parts in alpha-numerical order of their reference designations and indicates the Hewlett-Packard stock number in each case. Table 6-2 lists parts in alpha-numerical order of their Hewlett-Packard stock number and provides the following information on each part:

a. Description of the part.

b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Total quantity used in the instrument (TQ col).

d. Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

6-4. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-5. ORDERING INFORMATION.

6-6. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland

6-7. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designation.

d. Description.

6-8. To order a part not listed, give a complete description of the part and include its function and location in the instrument.

Table 6-1. Reference Designation Index

Circuit Ref.	℗ Stock No.	Note	Circuit Ref.	℗ Stock No.	Note
A1	213A-76A		J2		a
A2	213A-65A		L1	9170-0016	
C1	0150-0052		L2	9170-0016	
C2	0150-0052		L3	213A-60C	
C3	0180-0121		L4	213A-60C	
C4	0180-0121		L5	9170-0016	
C5	0180-0060		P1	8120-0037	
CR1	1901-0025		Q1	1850-0040	
CR2	1901-0025		R1	0687-3931	
CR3	1901-0025		R2	0761-0003	
CR4	G-29A-80		R3	0687-1811	
CR5	G-29A-80		R4	0687-1211	
CR6	G-29A-80		R5	2100-0286	
CR7	1911-0001		R6	0683-2015	
CR8	1911-0001		R7	0683-2015	
CR9	G-29L-76		R8	0687-1811	
CR10	G-29L-76		S1		b
CR11	Not assigned		S2	3101-0040	
CR12		a	S3	3101-0040	
CR13		a	T1	9100-0145	
DS1	1450-0039		T2	213A-60A	
J1	1250-0118		T3	213A-60B	

Notes:

a. Part of A1; component not separately replaceable.

b. Part of R5; component not separately replaceable.

Table 6-2. Replaceable Parts

Stock No.	Description	Mfr.*	TQ*	RS*		
G-29A-80	Diode, silicon	28480	3	3		
G-29L-76	Diode, silicon	28480	2	2		
213A-60A	Transformer, trigger	28480	1	1		
213A-60B	Transformer, pulse	28480	1	1		
213A-60C	Inductor, bias: 5 mh	28480	2	1		
213A-65A	Assembly, etched circuit, includes C5, CR1 thru CR10, L1 thru L4, Q1, R2 thru R4, R6 thru R8	28480	1	0		
213A-76A	Assembly, diode: includes CR12, CR13, J2	28480	1	0		
0150-0052	Capacitor: fixed, ceramic, 0.05 μf ±20%, 400 vdcw	0000R	2	1		
0180-0060	Capacitor: fixed, electrolytic, 200 μf -10% + 100%, 3 vdcw	56289	1	1		
0180-0121	Capacitor: fixed, electrolytic, 680 μf -10% + 100%, 10 vdcw	56289	2	1		
0683-2015	Resistor: fixed, composition, 200 ohms ±5%, 1/4 W	01121	2	1		
0687-1211	Resistor: fixed, composition, 120 ohms ±10%, 1/2 W	01121	1	1		
0687-1811	Resistor: fixed, composition, 180 ohms ±10%, 1/2 W	01121	2	1		
0687-3931	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W	01121	1	1		
0761-0003	Resistor: fixed, metal film, 62 ohms ±5%, 1 W	07115	1	1		
1250-0118	Connector, female: BNC, type UG-1094A/U	91737	1	1		
1450-0039	Lamp, neon: NE2H	08717	1	1		
1850-0040	Transistor: 2N383	94154	1	1		
1901-0025	Diode, silicon	73293	3	3		
1911-0001	Diode, germanium: 1N91	03508	2	2		
2100-0286	Resistor: variable, composition, linear taper, 600 ohms ±30%, 1/2 W; w/SPST switch S1	71450	1	1		
3101-0040	Switch, slide: DPDT	42190	2	1		
8120-0037	Cord, power	70903	1	1		
9100-0145	Transformer, power	98734	1	1		
9170-0016	Bead, shielding	02114	3	1		

* See introduction to this section