227C AND 227D AMPLIFIERS

DESCRIPTION

CONTENTS PAGE

1. GENERAL

1.01 The 227C and D amplifiers are plug-in, one-way, 2-transistor, voice-frequency amplifiers with adjustable gain. They are suited for use in toll, exchange, telegraph, manual, and PBX systems.

1.02 The 227C and D amplifiers were designed primarily for use in V4 telephone repeater applications but may be used in other applications where one-way audio gain or isolation is required. The 227C amplifier was developed for use in high-speed, low-error rate data circuits requiring reduced low-frequency delay distortion. In all other respects the 227C amplifier is similar to the 227B amplifier. The 227D amplifier is similar to the 227C amplifier produced with date codes prior to April, 1966 but with reduced sensitivity to impulse-type noise and the elimination of the T,R turnover in the transmission through the amplifier. The 227C amplifiers produced beginning in April, 1966 differed from the earlier models in some of the transmission characteristics. These differences are explained in Part 4. Both the 227C and 227D amplifiers include diodes for protection against excessive line voltages. The 227C amplifier is now rated MFR DISC.

1.03 The 227C and D amplifiers provide 0- to 36-dB adjustable gain and can operate at a maximum output power level of +17 dBm. The gain-frequency characteristic is substantially flat from 100 to 10,000 Hz. These amplifiers are designed to operate from a supply voltage of -20 to -26 volts. They may be operated from a supply voltage of -40 to -52 volts if a 1400-ohm series dropping resistor is used. The ambient temperature may range from 40° to 140°F for operation and -40° to +150°F for shipping and storage.

1.04 The input and output transformers of the amplifier are designed primarily to provide either 600- or 1200-ohm line impedance with a balanced center-tap connection for simplex signaling. Additional input and output impedances of 150 and 300 ohms can be obtained for special applications through use of the center tap as one side of the transmission circuit. However, this precludes use of the center tap for signaling. The input and output transformers meet a 60-dB minimum longitudinal balance requirement.

2. EQUIPMENT DESCRIPTION

2.01 The 227C amplifier (see Fig. 1) is a plug-in unit terminated in a 15-pin connector plug; it is designed to be mounted on a shelf per J98615 on 1-3/4 inch centers. Overall dimensions are approximately 1-3/4 inches square by 7-1/2 inches long. The 227D amplifier is identical in appearance to the 227C except for the code marking.

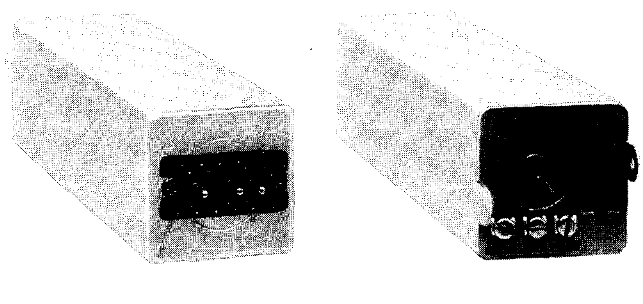


Fig. 1—227C Amplifier

2.02 The 227C or D amplifier consists of circuit components mounted on a printed wiring board and assembled in an extruded aluminum can. The circuit is connected to the 15-pin connector plug on the rear of the can for use in plug-in mounting in the associated shelf. A gray faceplate on the front of the unit completes the assembly. Two lugs are provided on the front of the can to facilitate removal of the amplifier from its mounting shelf socket with a 602C or a 602D tool.

2.03 A gain control potentiometer, three gain-control screw-type switches, and two pin jacks for monitoring the amplifier output are mounted on the faceplate. The gain-control potentiometer provides a gain adjustment range of about 15 dB and is recessed in the faceplate to prevent accidental movement. Two screw-type switches control an 11-dB pad and a third screw-type switch controls an 11-dB feedback step. With the screw-type switches designated 21—36 and 10—24 closed (turned in) and screw-type switch designated 0—13 opened (turned out), a gain range of approximately 21 to 36 dB may be obtained, depending upon the setting of the potentiometer. With only the 10—24 screw-type switch closed (turned in), the gain range is 10 to 24 dB; with only the 0—13 screw-type switch closed (turned in), the range is from 0 to 13 dB. Refer to Fig. 2 for circuit connections associated with these switching operations and for faceplate arrangement.

3. CIRCUIT DESCRIPTION

3.01 Figure 2 is a schematic of the 227C or D amplifier. The circuit consists of two transistors, input and output transformers, gain control potentiometer, resistors, capacitors, diodes, and three screw-type switches.

3.02 The input and output transformers are designed primarily to present either 600-ohm or 1200-ohm impedances to the line circuits. Highly balanced center-tap connections on the transformers provide for simplex signaling or supervisory arrangements. By using a center tap for connection to one side of the line, additional input and output impedances of 150 and 300 ohms can be obtained for special applications. The simplex must be sacrificed in order to do this.

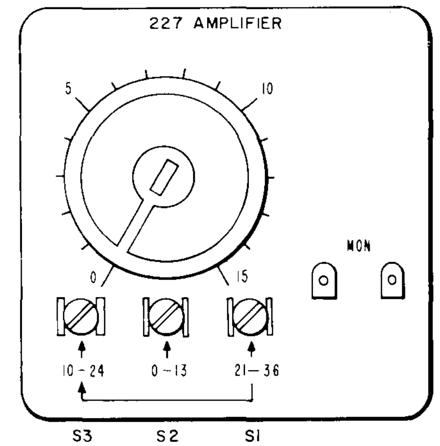
3.03 The input circuit consists of transformer T2, an input pad, and signal voltage divider circuit C1, R1, R6, and R3. The line winding of the input transformer is center-tapped for a simplex connection or balanced-to-ground operation. An electrostatic shield is provided. The secondary winding is tapped and the amplifier may be connected to present a 600-ohm or 1200-ohm port to the line. The secondary winding is brought out to terminals. This arrangement permits an equalizer to be connected into the amplifier for equalization of loss-frequency characteristics of cable facilities.

3.04 Screw-type switches S2 and S3 control the connection of the input pad into the circuit. With S2 open and S3 closed, the pad is omitted and maximum signal is applied to the amplifier. Resistor R9 provides a termination for the pad or for the input transformer. Capacitor C1 couples the signal voltage to gain potentiometer R1 and blocks dc voltages. Gain potentiometer R1 is adjusted to obtain the desired overall amplifier gain in the range selected by the screw-type switches. Resistor R3 is in the emitter circuit of transistor Q2 and the voltage drop across it, due to current flow through Q2, acts as feedback to stabilize the overall amplifier gain.

3.05 The amplifying components, transistors Q1 and Q2, are used in the common emitter configuration. Signal voltage developed across R3, R6, and the portion of R1 in the circuit, is applied through R7 to the base of Q1. Varistor RV2 provides temperature compensation for Q1. The collector of Q1 is directly connected to the base of Q2. Collector current of Q2 through transformer T1 provides the output signal.

3.06 The output circuit consists of a 2-winding, multitapped transformer T1 and a feedback network. The line winding of the output transformer is center-tapped for balanced operation, and taps are provided to give output impedances of 600 ohms between terminals 4 and 8 or 1200 ohms between terminals 2 and 10. The primary winding is tapped for 10:1 impedance division for connection to the feedback circuit. The output impedance is generated by feedback action, thus avoiding the power loss in a terminating resistance. Resistor R12 and capacitors C4 and C7 serve to control the feedback loop cutoff characteristic. Resistors R2 and R5 and capacitors C5 and C6 form the feedback network. Pin jacks mounted on the front panel

GAIN RANGE IN DB	SCREW-TYPE SWITCH POSITIONS		
	S1	S2	S3
21–36	CLOSED	OPEN	CLOSED
10–24	OPEN	OPEN	CLOSED
0–13	OPEN	CLOSED	OPEN



FACEPLATE OF AMPLIFIER

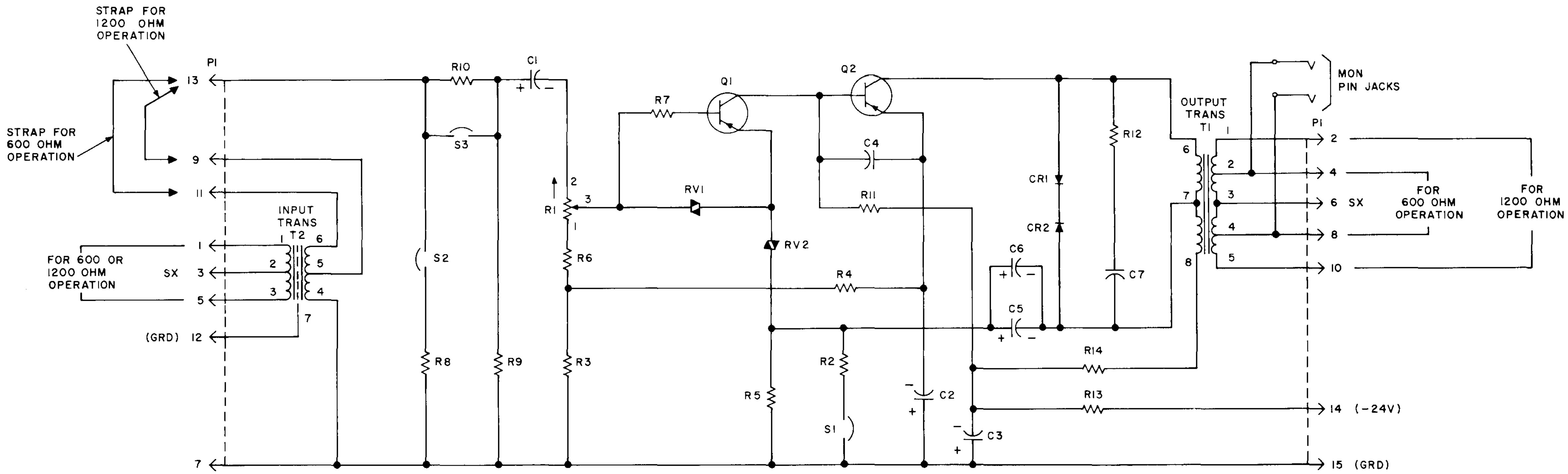


Fig. 2—227C or D Amplifier—Schematic and Faceplate Arrangement

are bridged across the 600-ohm terminals of the output transformer and are provided for monitoring with a high-impedance receiver.

3.07 The feedback arrangement consists of three parts.

(a) Capacitor C4 couples the emitter of transistor Q2 to the base and decreases the gain of the amplifier at high frequencies for feedback stabilization.

(b) Signal voltage between terminals 7 and 8 of the output transformer primary winding is coupled through C5 and C6 to R5, which is in the emitter circuit of Q1. When screw-type switch S1 is closed, R2 and R5 are in parallel and the feedback voltage developed across R5 is decreased. This increases the amplifier gain by 11 dB.

(c) Resistor R3 is common to the base circuit of Q1 and the emitter circuit of Q2. Increased signal current through Q2 results in more voltage drop across R3 and reduces signal voltage applied to the base of Q1. Thus the overall amplifier gain is stabilized.

3.08 The power supply circuit consists of resistor R13 and capacitor C3, which serve to decouple the amplifier from the battery supply. The amplifier requires an input of -20 to -26 volts with respect to positive ground and draws a nominal current of 18 mA. This voltage may be obtained from a 24- or 48-volt battery. When operated from a 48-volt battery supply, an external 1400-ohm series voltage-dropping resistor must be provided.

4. TRANSMISSION CHARACTERISTICS

4.01 The transmission characteristics given in the following paragraphs apply to both 227C and D amplifiers.

A. Impedance

4.02 The 227C and D amplifiers present a nominal input and output impedance of either 600 or 1200 ohms. Thus the amplifier may present 600 ohms to the office equipment and 1200 ohms to H88-loaded exchange cable pairs. Figure 3 shows the input impedance of the amplifier with the input and output transformers arranged for the 600-ohm condition and with the amplifier set for maximum and minimum gain on the high-gain range. Likewise, Fig. 4 shows the input impedance of the amplifier for the maximum gain condition on the medium-gain range. This impedance is not sensitive to potentiometer setting on this range. On the lowest gain range the input is closer to a 600-ohm resistive impedance since an 11-dB pad is added to the input circuit. Figure 5 shows the output impedance of the amplifier for the 600-ohm condition with the potentiometer set for maximum and minimum gain on the high-gain range. Figure 6 shows the output impedance with the feedback increased by closing screw-type switch S1, with the potentiometer set at maximum.

B. Gain Frequency

4.03 The gain-frequency characteristics of the typical 227C and D amplifiers are shown in Fig. 7. The two lower gain ranges (0—13 dB and 10—24 dB) are shown as a single curve labeled 10,20 DB for gains of 10 and 20 dB at 1000 Hz. Since the gain shape is relatively insensitive to the setting of the gain potentiometer, this curve is typical for any 1000-Hz gain setting between 0 and 25 dB. The solid curve labeled 30 DB is for the 227D amplifier or for the 227C amplifier with a date code of 3/66 or earlier, with the potentiometer set to give 30-dB gain at 1000 Hz on the high-gain range. A similar curve for the 227C amplifier with a date code of 4/66 or later is shown by a dotted line in Fig. 7. On the high-gain range the gain shape below 150 Hz is sensitive to the setting of the potentiometer with the flattest gain curve being obtained for the maximum gain setting of the potentiometer. The high-frequency portions of the curves are insensitive to the potentiometer setting.

C. Harmonic Distortion

4.04 The second- and third-order harmonic distortion versus the output power of the fundamental is shown in Fig. 8 and 9. Harmonic distortion increases with increased output load but is typically 25 dB minimum below the fundamental at an output power of +17 dBm. These curves are for the amplifier on the high-gain range. For the other ranges, feedback reduces the harmonics by 11 dB. Figure 8 gives typical curves for the 227D amplifier and for 227C amplifiers produced 3/66 or earlier and Fig. 9 shows curves for the 227C amplifiers produced 4/66 or later.

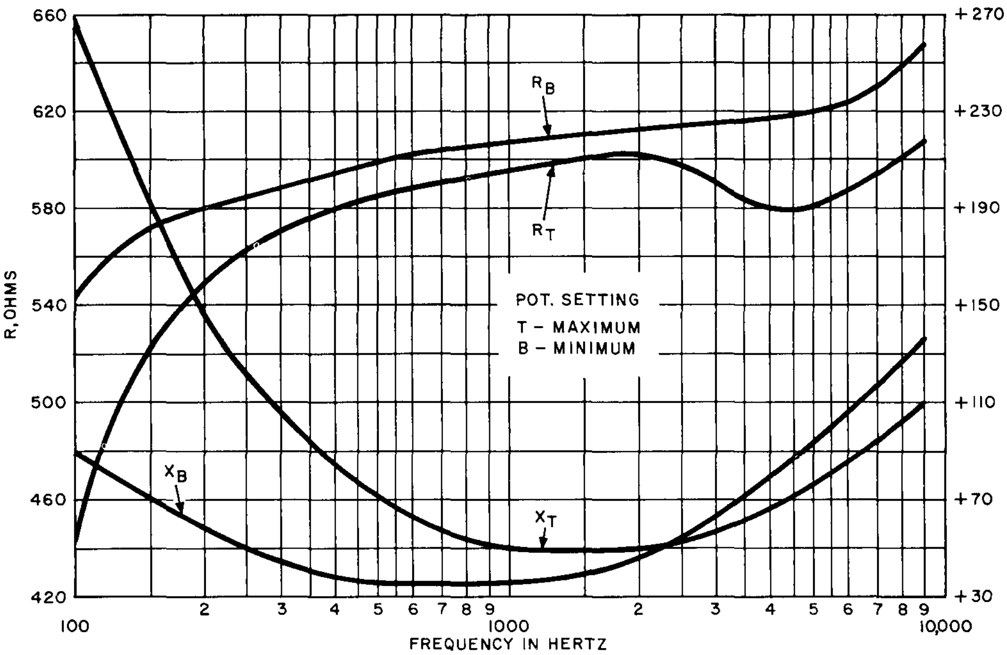


Fig. 3—227C or D Amplifier—Input Impedance—600-Ohm Termination —High-Gain Range—Typical Amplifier

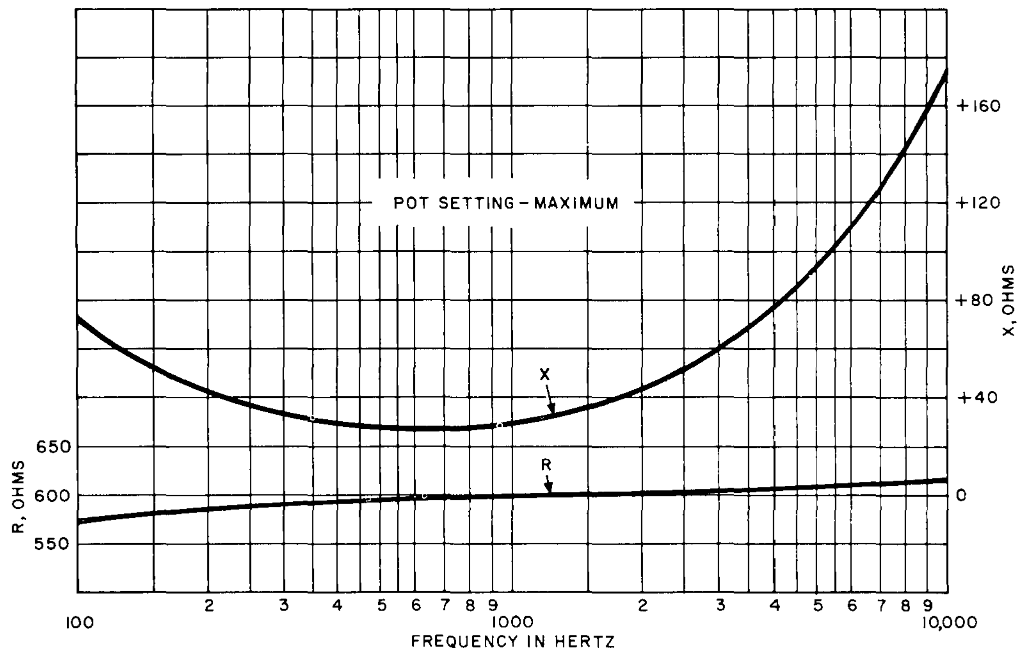


Fig. 4—227C or D Amplifier—Input Impedance—600-Ohm Termination —Medium-Gain Range—Typical Amplifier

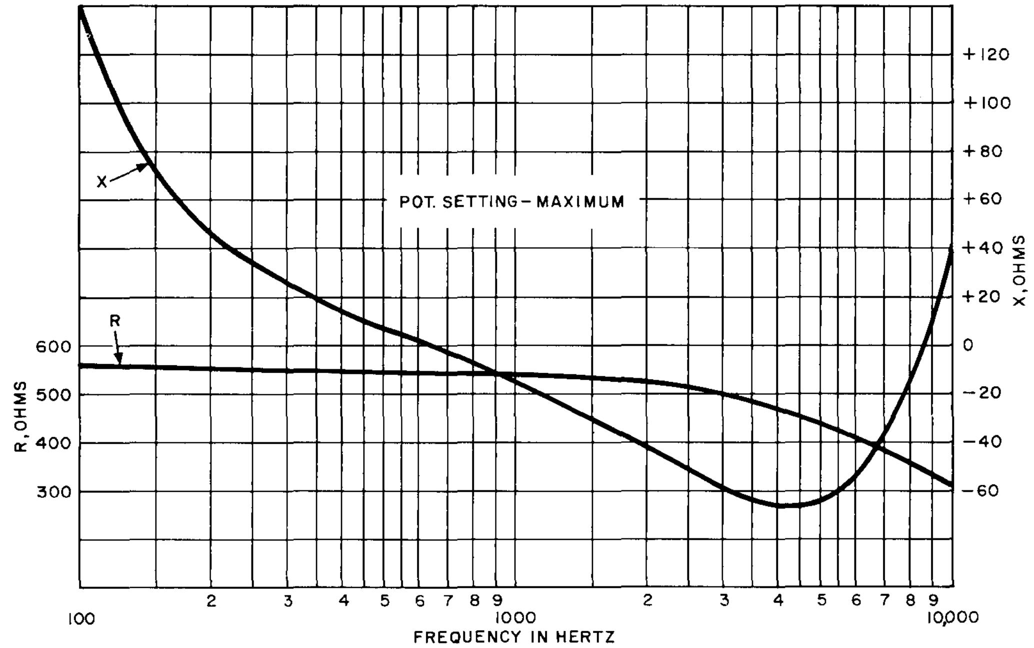


Fig. 5—227C or D Amplifier—Output Impedance—600-Ohm Termination —High-Gain Range—Typical Amplifier

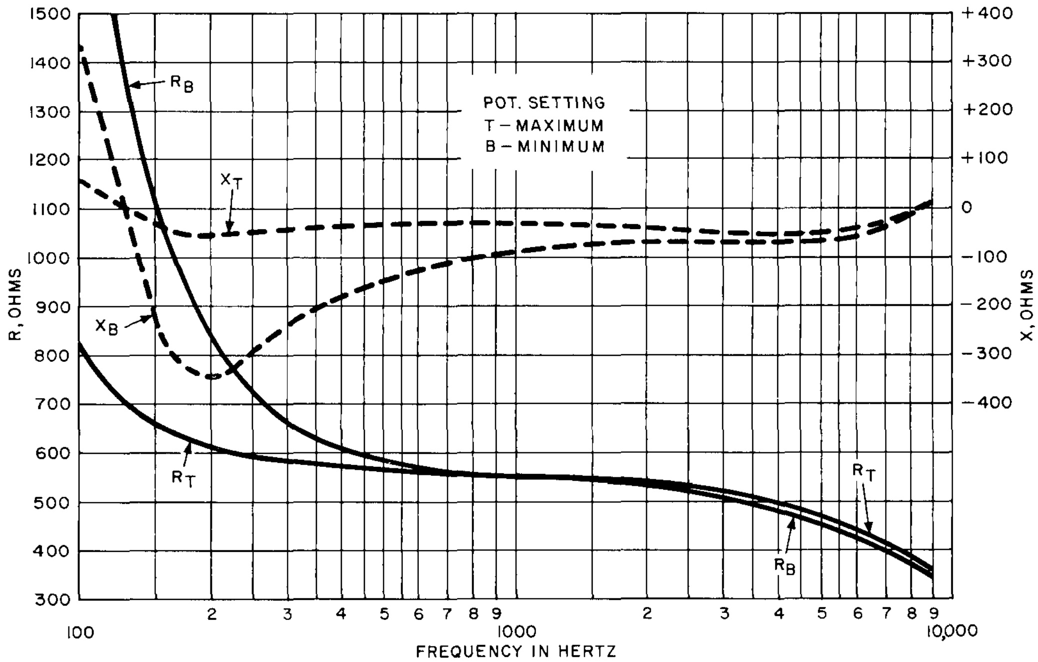


Fig. 6—227C or D Amplifier—Output Impedance—600-Ohm Termination —Medium-Gain Range—Typical Amplifier

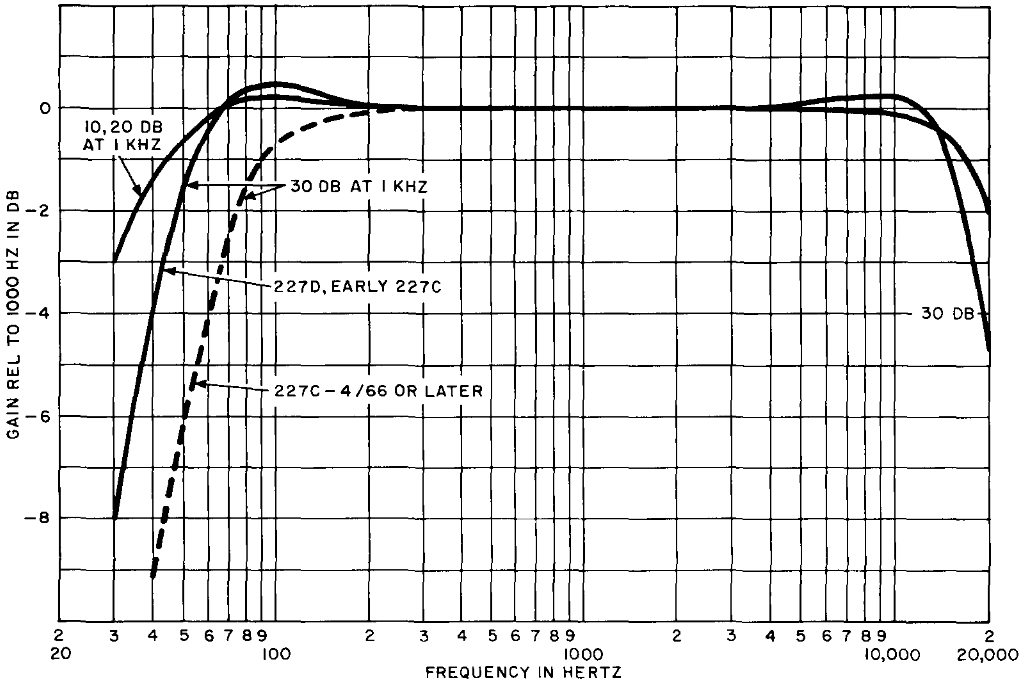


Fig. 7—227C and D Amplifiers—Gain-Frequency Characteristics

D. Envelope Delay

4.05 The envelope delay of the typical 227C or D amplifier in the three gain-range conditions is given in Table A. The two lowest gain ranges have the least delay distortion and the delay distortion is not sensitive to the setting of the gain control potentiometer. The delay distortion is greatest on the high-gain range with some sensitivity of the delay to the setting of the potentiometer. On this high-gain range, the lowest delay distortion is obtained when the gain is highest while the highest delay distortion is obtained at the minimum gain setting.

TABLE A

227C AND D AMPLIFIERS — ENVELOPE DELAY, MICROSECONDS, FOR VARIOUS 1-KHZ GAINS

FREQUENCY (HZ)	227D OR EARLY 227C				227C DATED 4/66 OR LATER			
	LOW- AND MEDIUM-GAIN RANGES	HIGH-GAIN RANGE			LOW- AND MEDIUM-GAIN RANGES	HIGH-GAIN RANGE		
	10, 20 DB	30 DB	MAX	MIN	10, 20 DB	30 DB	MAX	MIN
300	75	125	80	150	100	210	120	250
400	50	75	50	90	60	120	75	140
500	40	55	45	60	45	85	55	95
800	25	35	30	40	30	45	35	50
1000	25	30	30	30	25	35	30	40
2000	20	25	25	25	20	25	25	25
3000	20	25	25	20	20	20	20	20

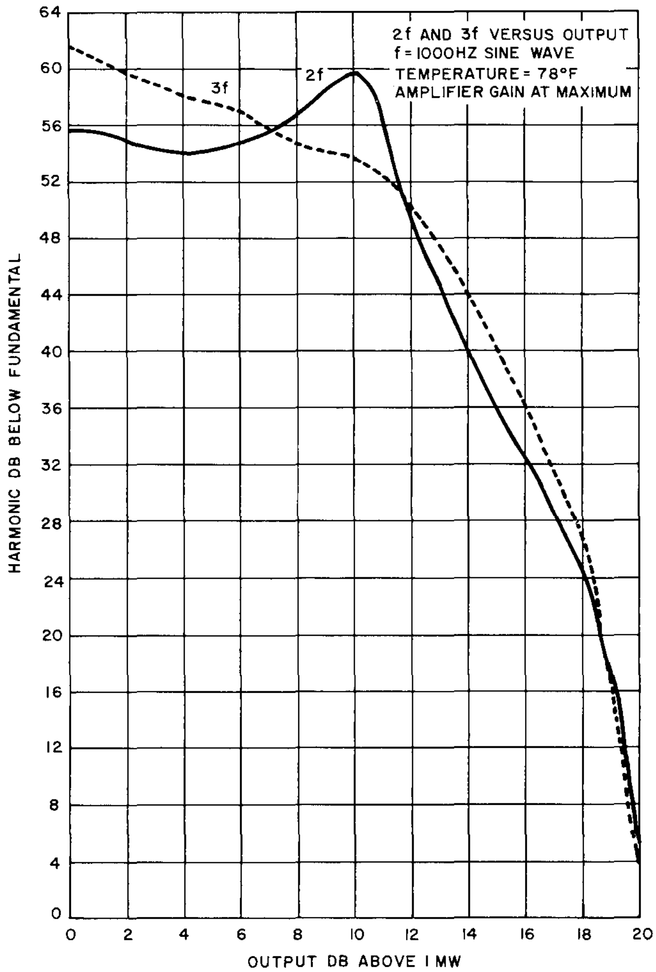


Fig. 8—Harmonic Content of 227C Amplifier (3/66 or Earlier Production) and 227D Amplifier

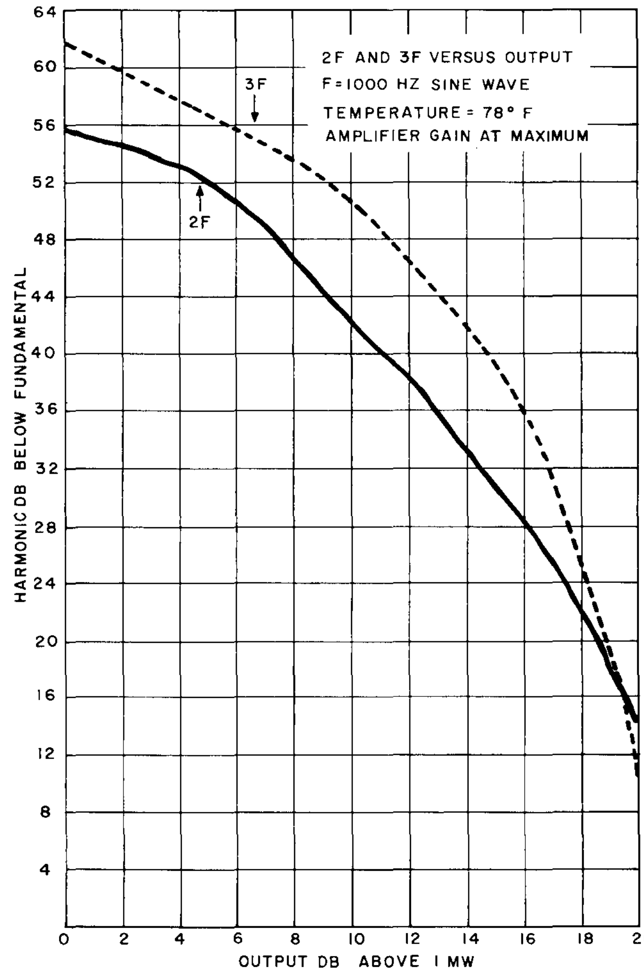


Fig. 9—Harmonic Content of 227C Amplifier (4/66 or Later Production)

E. Noise

4.06 The input or output longitudinal balance of the 227C or D amplifier is 60 dB minimum over the 100- to 4000-Hz frequency range.

4.07 The susceptibility of the amplifier to noise on the 24- or 48-volt battery is given in Table B as a function of frequency. Susceptibility in this instance is defined as the dB loss ratio of the noise voltage across the battery output to that across the 600-ohm output line, terminals 4 and 8. The 3A noise measuring set for bridging measurement and flat-weighting is used to make both measurements. In the case of the 48-volt battery, filtering is accomplished by the 1400-ohm resistor in series with the battery lead in combination with resistor R13 and capacitor C3 in the amplifier. In the 24-volt battery case, additional filtering for large offices is accomplished by a decentralized filter, and for small offices by an inductor and capacitor suitable for use with 1 to 12 amplifiers (see Note 1).

> *Note 1:* With these added filtering arrangements, the noise on the output of the amplifier, set for maximum gain, is not expected to exceed 29 dBrnc, as measured on the 3A noise measuring set.

> *Note 2:* For 227C amplifiers dated 4/66 or later, R13 was increased from 33 to 100 ohms. This gives an average noise reduction of 8 dB on the 24-volt battery and negligible reduction on the 48-volt battery.

TABLE B

RATIO OF BATTERY NOISE TO 600-OHM AMPLIFIER OUTPUT NOISE

FREQUENCY (HZ)	24-VOLT BATTERY		48-VOLT BATTERY WITH 1400-OHM RESISTOR (DB)
	227C AMPLIFIER DATED 3/66 OR EARLIER (DB)	227C AMPLIFIER DATED 4/66 OR LATER (SEE NOTE 2) AND 227D AMPLIFIER (DB)	
60	−8	−2	20
100	−8	0	25
200	−3	+6	30
300	0	+9	34
500	+5	+14	37
1000	+10	+19	42
2000	+15	+24	47
3000	+16	+25	48

4.08 In some applications of the 227C amplifier on private line services, it is found that the amplifier is susceptible to impulse-type noise generated by arcing relay contacts on circuits connected to the same battery ground. Component and circuit changes have been incorporated in amplifiers produced after 3/66 which reduce this impulse-type noise susceptibility by approximately 40 dB. the improved amplifier should be used in cases where impulse-type noise is a problem. An additional 40-dB improvement is realized in the 227D amplifier by using a new design of transistor Q1 (12P replaces 12B). This amplifier should be used whenever excessive impulse noise is expected.

F. Output Load Carrying Capacity

4.09 The curve of Fig. 10 shows the output load carrying capacity of the 227C or D amplifier for a battery voltage of 24 volts.

G. Crosstalk

4.10 The equal level crosstalk coupling loss at 1000 Hz between amplifiers is expected to exceed 75 dB.

H. Reverse Transmission Loss

4.11 The curves of Fig. 11 show the typical 600-ohm insertion loss when transmitting through the 227C or D amplifier in the reverse direction. The amplifier is connected for 600-ohm input and output impedances. The same loss is obtained for 1200-ohm amplifier impedances measured between 1200-ohm terminations.

I. Phase Shift

4.12 For the standard amplifier connection used in V4 applications with input T,R connected to terminals 1,5 and output T,R connected to terminals 4,8, respectively, the phase shift at 1000 Hz is about 180° for the 227C amplifier. This T,R turnover is not suitable for Di-pulsing applications or other applications where a T,R reversal cannot be tolerated. This T,R turnover has been eliminated in the 227D amplifier.

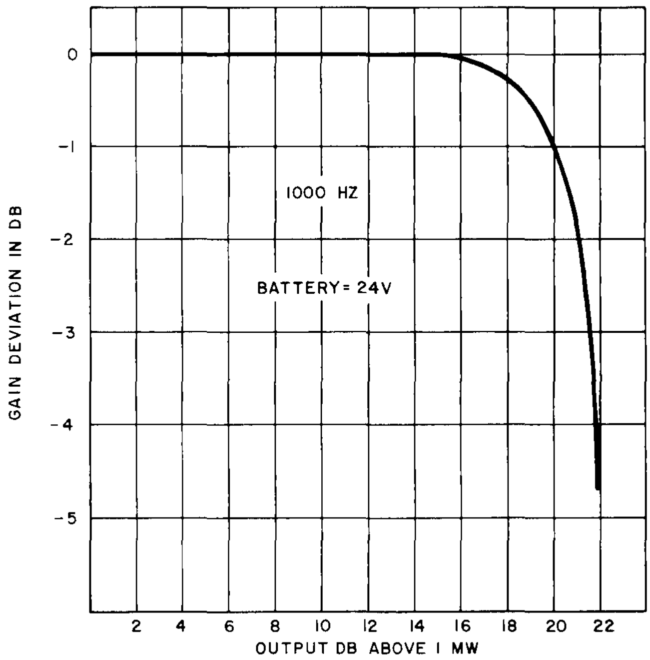


Fig. 10—227C or D Amplifier—Typical Output Load Carrying Capacity

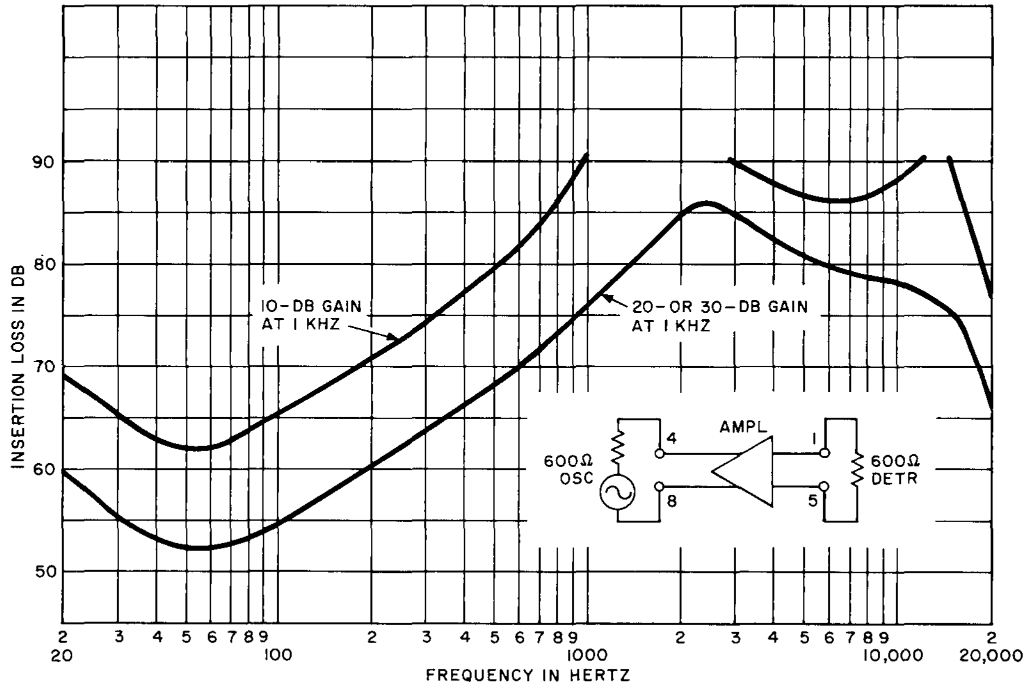


Fig. 11—227C or D Amplifier—Reverse Transmission Loss