

2400- OR 2600-CYCLE SINGLE-FREQUENCY SIGNALING SYSTEM

ENGINEERING INFORMATION

COMMON SYSTEMS

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1. GENERAL

1.01 The 2400- or 2600-cycle single-frequency (SF) signaling system conveys supervisory signals and dial pulsing over the line facilities of intertoll trunks by means of a single distinctive frequency in the voice band. Terminals of the system supplement trunk relay circuits and are joined to the latter for signaling by means of E and M leads. The system converts dc signals from the M lead into ac form for transmission over the line facility. Conversely, it converts ac signals from the line facility into dc form for transmission over the E lead. On 4-wire line facilities, 2600 cycles are transmitted in both directions; on 2-wire line facilities, 2600 cycles are transmitted in one direction and 2400 cycles in the other. Since signaling in each direction of transmission is conveyed by a single voice-band frequency, it is amplified as readily as speech and has comparable operational range.

1.02 This section is reissued to include a network for use with MF outpulsing on 2-wire lines. Since this is a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The system is used on intertoll trunks that are beyond the practical range of dc simplex or composite signaling. It is also employed on trunks with carrier line facilities, which do not have associated dc signaling paths.

1.04 In each direction of transmission, the basic idle and busy signals of the trunk are conveyed by the alternate presence and absence of the signal frequency. The use of two alternate signal conditions permits continuous supervision. The system is applicable to dial pulsing, multifrequency (MF) pulsing, and automatic trunks. On dial pulsing trunks, it is employed for both supervision and pulsing; on multifrequency pulsing and automatic trunks, for supervision only.

1.05 The system can satisfactorily transmit 8 to 12 pulses per second. This feature allows its use on trunks with subscriber dialing, the speed of which may reach 12 pps. Dial pulses are passed as successive alternations between the presence and absence of signal frequency. The dial pulse break interval corresponds to the presence of signal frequency; the make interval, to the absence of signal frequency. The requirements for minimum make and break intervals are more critical in SF than in dc signaling. The minimum intervals required are provided by input limits of 52 to 73 per cent break at 12 pps. Limits are specified at 12 pps because variations in per cent break become less critical as the speed of pulsing decreases. The SF receiver features a pulse-correcting circuit, which improves the characteristics of dial pulsing. For example, input variations of 52 to 73 per cent break at 12 pps are reduced to an output of 53 to 63 per cent break.

1.06 At zero transmission level, normal signal power is -20 dbm (that is, 20 db below the standard test tone of 1 milliwatt at 1000 cycles). Normal power is employed, except for the first 0.2 second that signal frequency is transmitted. This 0.2 second interval includes the tone-on period during dial pulsing. Signal power is 12 db higher than normal during this period (that is, 8 dbm at a zero transmission level). However, signal power is actually applied to the line, not at zero transmission level, but at -13 or -16 office transmission levels, which-

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ever is available in a particular office. Values of signal power at these levels are tabulated in Part 6.

1.07 The plan of operation and basic functions of the system are very similar to those of the older 1600- or 2000-cycle single-frequency signaling system. However, the 2400- or 2600-cycle system is simpler and less expensive mainly because design problems relating to protection against false signals are more easily solved with higher signal frequencies. MF pulsing can be employed in both directions on trunks where supervision is provided by the 2400- or 2600-cycle system. (MF pulsing cannot be used with the 1600- or 2000-cycle system on 2-wire line facilities in the direction of the 2000-cycle tone.) In view of these advantages, the 2400- or 2600-cycle system is for use in all new SF installations, except on those facilities that cannot transmit the higher frequencies. Modification of existing 1600- or 2000-cycle installations is discussed in Part 7.

1.08 The system consists of nine separate equipment units and two shop-wired relay rack bay frames.

1.09 The equipment units are grouped, in accordance with their functions, into three major divisions.

(1) *Frequency Supply*

- (a) An electron tube oscillator unit providing either 2400 or 2600 cycles.
- (b) A transfer and alarm unit serving two oscillator units of the same frequency.
- (c) Distributing resistances for the supply leads to signaling and maintenance units.

(2) *Signaling*

- (a) A signaling unit (transmitter-receiver) for each trunk terminal served.
- (b) A 2-wire line network unit for 2-wire line facilities.
- (c) A line network for MF outpulsing on 2-wire line facilities.

(3) *Maintenance*

- (a) A monitoring unit for in-service observations of the transmitter-receiver unit.
- (b) A testing unit for more complete out-of-service testing.

- (c) A battery supply unit for the 2B test set.

1.10 The two shop-wired relay rack bay frames are (1) a reference bay and (2) a signaling bay. The reference bay provides for frequency-supply and maintenance units in addition to signaling units and distributing resistances. The signaling bay provides for signaling units and distributing resistances only. Each group of four bays consists of one reference bay and three signaling bays and has capacity for 112 to 116 signaling units.

2. FREQUENCY SUPPLY UNITS

2.01 The oscillator unit is mounted on one 2- by 23-inch mounting plate. Each unit contains one oscillator circuit, either 2400 or 2600 cycles, as required. The circuit consists of a Wheatstone-Wien bridge with a 408-A electron tube arranged to function as a high-gain pentode. High stability of output level and frequency is a feature of this type of circuit. The output level is designed to hold within ± 0.25 db of normal with ordinary variations in tube characteristics, office temperature, supply voltage, and load. Output frequency varies normally no more than ± 3 cycles.

2.02 Frequency is set by adjustable capacitances in the Wheatstone-Wien bridge. At installations requiring both 2400- and 2600-cycle tones, separate supply units are provided for each frequency. Whenever possible, the 2600 tone is transmitted toward the larger office since this tends to reduce the need for both 2400 and 2600 oscillator units in smaller offices.

2.03 Taps on the output transformer of the oscillator provide either of two output levels as measured at the oscillator test jacks with a 600-ohm load. These are -9.6 dbm for signaling units with transmitting branches at -16 office transmission levels and -6.6 dbm for those with transmitting-branches at -13 levels. Unless otherwise specified, the oscillator is furnished with transformer taps connected for -6.6 dbm. In the event that both levels are required, the -6.6 option is used, and a tone level resistance provides 3-db attenuation in the distribution circuit of each signaling unit at -16 transmission level (see 2.08). Fine adjustments of output level are obtained by means of a potentiometer in the primary circuit of the output transformer.

2.04 The power requirements of an oscillator are about 0.008 ampere at +130 volts and 0.050 ampere at -48 volts. This results in heat dissipation of 3 to 4 watts per oscillator.

2.05 The supply load transfer and alarm unit uses one 2- by 23-inch mounting plate and one similar jack strip mounting. The unit is used with two oscillators of the same frequency (designated odd and even) which normally share the load equally. In the event of a failure in one oscillator, its load is transferred automatically to the other. In addition to making the transfer, the transfer and alarm unit sounds a minor alarm. If simultaneous failures occur in both oscillators, a major alarm is sounded. The unit requires a ground option for connection to the office alarm circuit in all offices except No. 5 crossbar. For No. 5 crossbar installations, battery option should be specified. The unit also includes one beat frequency checking circuit for comparison tests between the output of two oscillators. The circuit consists of tone-attenuating resistances and patch jacks for frequency input and a head receiver.

2.06 Two oscillator units, protected by a transfer unit, serve up to 116 signaling units, the maximum number mounted in a 4-bay group. Connected in this manner, each of the two oscillator units normally serves 58 signaling units and assumes the entire load of 116 signaling units in the event of a failure. Two oscillator units of the same frequency require an associated transfer unit unless the number of signaling units served is less than five. In very small installations, two oscillator units may be used without a transfer unit to serve three or four signaling units, and one oscillator unit to serve one to two signaling units. Testing and monitoring units may be included in the supply load in addition to signaling units. These figures do not indicate the actual load capacity of the oscillator circuit. They have been determined from the standpoint of protecting continuity of service by limiting the number of signaling units assigned to one oscillator. Normally, there is at least one oscillator for 58 trunks and a large trunk group is served by several separate oscillators. This tends to reduce signal crosstalk on the line facility since the different oscillators are in phase with each other for only a relatively brief period during each cycle.

2.07 The third unit in the supply group is a 2- by 23-inch mounting plate for distributing resistances. The resistances provide protective separation of the individual circuit supply leads and assist in the provision of correct power to the units which they serve. The mounting plate has capacity for thirty-two 18- or 19-type resistances, thirty-two 145-type resistances, two terminal strips, and a lamp resistance for a 2-wire automatic telephone circuit.

2.08 There are four SF resistance circuits, the functions of which are described below.

(a) The distributing resistance circuit for signaling units consists of 19-type resistances. One half of each resistance is connected in a supply lead so that a pair of resistances serves two signaling units as shown in Fig. 1. In order to distribute the load equally, the circuit associates all odd-numbered signaling units with the odd supply oscillator and all even units with the even oscillator.

(b) The tone level resistance circuit consists of one 145-type resistance. When required (see 2.03), the resistance is connected as shown in Fig. 1.

(c) The distributing resistance circuit for testing and monitoring units consists of two 19-type resistances. One half of each resistance is connected in a supply lead so that a pair of resistances serves one testing unit and one monitoring unit. This circuit differs from the distributing resistance circuit for signaling units only in the value of resistances.

(d) In installations with 2-wire line networks (see 3.08), a circuit is provided for testing the attenuation of the network. The circuit consists simply of two 18-type resistances, one in each supply lead.

3. SIGNALING UNITS

3.01 The principal component of the system is the signaling unit (transmitter-receiver), one of which is required at each trunk terminal or end of signaling section served. Two units, mounted side by side, occupy the space of four 2- by 23-inch mounting plates. Each unit is 8 inches high, 11 inches wide, and 7 inches deep. The signaling unit is arranged for plug and socket mounting and is secured to the mounting bars with screw fasteners to facilitate its removal for maintenance.

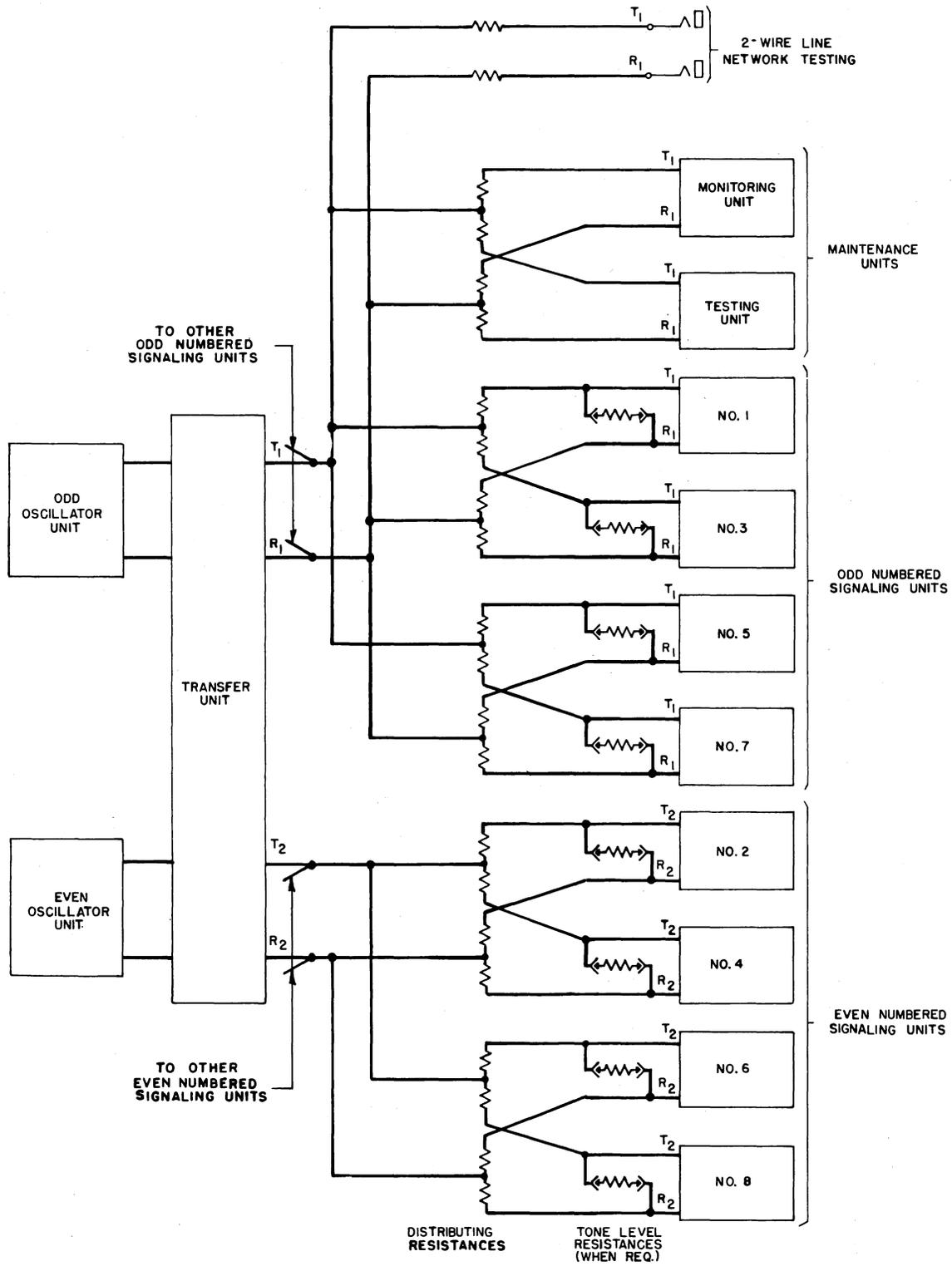


Fig. 1 - Distribution Arrangement

3.02 The transmitter applies and removes signal frequency to the line facility in response to dc signals from the M lead. It is connected to the line facility at transmission levels of either -16 or -13, depending upon the levels available in the office.

3.03 The receiver accepts SF signals from the line facility and transmits corresponding dc signals over the E lead to the trunk relay circuit. It is connected to the line facility at transmission levels of either +7 or +4.

3.04 Odd-numbered transmitter-receiver units are connected through their distributing resistances to the odd oscillator, even-numbered units, to the even oscillator. This arrangement assures equitable distribution of the load between the two oscillator units in a supply. Eight leads are required to insert the transmitter-receiver in the line facility, four going to the line side and four to the equipment side of a unit. Each group of four leads consists of a transmitting branch (T and R) and a receiving branch (T1 and R1).

3.05 The power requirements of the unit are 0.316 ampere at -48 volts and 0.016 ampere at +130 volts. This results in heat dissipation of about 18 watts per unit.

3.06 The signaling unit has only one option, either to receive 2400-cycle or 2600-cycle tone; it will transmit whichever frequency is furnished by the supply without modification.

3.07 The amount of resistance in the M lead affects the operation of the signaling unit. A limit of 25 ohms is standard where the M lead conveys dial pulsing. A limit of 50 ohms is satisfactory for supervision only. The resistance in the E lead is limited by the particular trunk relay circuit associated with the signaling unit. However, the limits for the M lead are, in general, also satisfactory for the E lead.

3.08 A 2-wire line network is associated with the receiving branch of the signaling unit only when the latter is connected to 2-wire line facilities. It is required to prevent echoes of signal frequency, applied to the line facility by the transmitter, from interfering with the receiver in the same signaling unit. The network is automatically inserted in, or removed from the line side of the receiver by a relay, which is included in the network circuit and which is controlled by the transmitter-receiver. The circuit is furnished in a separate equipment unit

which is 2 inches high by 23 inches wide. Each unit has provision for three network circuits, which include either 2400- or 2600-cycle blocking networks. The frequency option selected should correspond to whichever frequency is transmitted by the signaling unit associated with the network.

3.09 A second network is required to suppress MF echoes on trunks having 2-wire line facilities and which use sender MF outpulsing. MF outpulsing cannot take place until the incoming end provides the necessary stop-start control signals. The outgoing end SF receiver's guard channel is disabled about 0.2 second after the start pulse is received, but this delay proves incompatible with senders in No. 4M, No. 5, and crossbar tandem offices. These senders commence outpulsing so quickly after receipt of a start-pulse indication that the SF receiver (which is still in a guard condition) is forced to release by MF echoes from the 2-wire line. False release of the receiver results in failure of the attempted call. This network prevents the aforementioned by inserting a filter which passes only received SF tone and protects the receiver until its guard channel is disabled. The filter is then automatically switched out. Dial pulsing may be used on the same trunk and SF signaling circuits in the opposite direction and requires the 0.2 second delay making it impractical to remove the delay from the SF receiver itself.

3.10 Two networks mounted on a 2- by 23-inch mounting plate comprise one equipment unit. Location of the equipment unit on a miscellaneous relay rack bay is recommended since its application is variable. Each network consists of a bandpass filter for either 2400- or 2600-cycles and three relays. The relays, which are under control of an associated SF transmitter-receiver unit, insert or remove the filter as required. Circuitwise, this network appears in the receive leg of the SF receiver on the line side of the 2-wire network discussed in 3.08.

4. MAINTENANCE UNITS

4.01 The monitoring unit is contained in two 2- by 23-inch mounting plates. It provides means for making in-service monitoring observations on the signaling units. The unit consists essentially of a socket for a V3-type amplifier with associated input-output jacks and a calibration circuit for bridging measurements. The amplifier is not provided as part of the monitor-

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ing equipment unit and must be ordered separately. The monitoring panel also contains jack appearances for transmission measuring trunks to the toll testboard or the transmission measuring bay.

4.02 Battery supply jacks furnish -48-volt battery for a 2B test set and a 35-type test set. The 2B test set is used at this position only to monitor on the E lead and measure plate current in the final output tube of the signaling unit. For these functions, it requires only -48-volt battery, which is provided from the A jack on the monitoring panel. The B jack, ordinarily required to furnish the test set with +130 and -24 volts, is provided only for mechanically holding the B power cord and is not electrically connected.

4.03 The monitoring unit has two options, which are required only at locations without a supply transfer unit. One provides a patch cord and jacks for manually transferring the load on one oscillator to the other. The second option furnishes a beat frequency checking circuit, which is ordinarily provided in the transfer unit.

4.04 One monitoring unit is required in each group of four relay rack bays. The lengths of the patching cords used in monitoring will not permit patching to signaling units in more than three adjacent bays.

4.05 The testing unit, which is 8 inches high by 11 inches wide, provides means for making out-of-service adjustments and tests on signaling units. The unit to be tested is plugged into a test position adjacent to the testing unit. Testing conditions can then be set up by means of two rotary-type switches on the testing unit. The 13A or equivalent transmission measuring set, the 35F relay test set, and the 2A or 2B signaling test set are used in conjunction with this unit for measuring and testing.

4.06 In offices with both 2400- and 2600-cycle supplies, both frequencies are connected to the testing unit. Choice of frequency for testing is permitted by a key on the unit. In offices with two output levels of signal frequency, the higher level is connected to the testing unit.

4.07 A jack strip, associated with each testing unit, is 1-3/8 inches high by 23 inches wide. It provides jacks for battery supply for the test sets, transmission measuring trunks, and

a 1000-cycle tone for testing. Although associated with the testing unit, the jack strip is ordered as part of the reference bay equipment.

4.08 Ordinarily, only one testing unit is required per office. However, where different floors or large numbers of signaling units are involved, it is desirable to have one testing unit for each floor or for every 500 to 600 signaling units.

4.09 A battery supply unit, occupying the space of one 2- by 23-inch mounting plate, is required to provide the 2B test set with filtered -24 volts dc. This voltage is obtained from the -48-volt supply through a potentiometer and a filter network, consisting of retard coils and capacitors. The output of the battery supply unit is connected to the testing unit jack strip, which also provides the +130 and -48 volts required by the 2B test set. However, 2B test sets with "V" option (now rated "Mfr Disc.") should not be connected to the battery supply units, since the "V" option units use -24 volts for their filament circuits. Separate power supply jacks are provided on the jack strip to connect these sets directly to -24-volt office battery. One battery supply unit is required for each testing unit jack strip in the office. As explained in 4.02, a battery supply unit is *not* needed for the test set battery supply jacks associated with the monitoring unit.

5. BAY ARRANGEMENTS

5.01 A typical bay arrangement of the equipment units is shown in Fig. 2. Both the reference and signaling bays are 11 feet 6 inches high and spaced for 23-inch mounting plates. Both have the same bulb-angle-type framework and are factory wired for the units which they mount. No bay terminal strips are provided, all connections to other equipment being direct from apparatus terminals or unit terminal strips. The bay arrangement shown provides for all the equipment units of the system, except the 2-wire line network and the battery supply unit. Since the need for 2-wire line networks is variable, they are mounted on nearby miscellaneous relay rack. The battery supply unit should be mounted as near as possible to the testing unit jack strip in order to reduce inductive interference in the -24-volt supply for the 2B test set.

5.02 The signaling bay provides for a maximum of 30 signaling units. The reference bay has capacity for 22 to 26 units, depending upon the number of supply and maintenance units required. Some possible equipment arrangements in the reference bay are shown in the following table.

TABLE A — REFERENCE BAY EQUIPMENT ARRANGEMENTS

SUPPLY AND MAINTENANCE UNITS	MAXIMUM NUMBER OF SIGNALING UNITS
1 — 2600-cycle frequency supply	26
1 — Monitoring unit	
1 — 2600-cycle frequency supply	24
1 — Monitoring unit	
1 — Testing unit	
1 — 2600-cycle frequency supply	24
1 — 2400-cycle frequency supply	
1 — Monitoring unit	
1 — 2600-cycle frequency supply	22
1 — 2400-cycle frequency supply*	
1 — Testing unit	
1 — Monitoring unit	

* Where 2400 cycles are required only for testing receivers, a single 2400-cycle oscillator is adequate. The maximum number of signaling units in the reference bay is not affected by this change.

5.03 Since each signaling bay has capacity for 30 transmitter-receiver units, a 4-bay group, consisting of one reference bay and three signaling bays, has capacity for 112 to 116 units depending upon the reference bay arrangement.

5.04 The resistance mounting plate on each bay is equipped with two terminal strips, one for odd and one for even transmitter-receiver units. By means of strapping at these terminals, the units may be associated with either the 2400- or 2600-cycle supply.

5.05 The space between relay rack guardrails may be from 30 to 42 inches for the apparatus side and 20 to 30 inches for the wiring side of the bays. The smaller aisles result in a space saving of about 20 per cent, but cause greater heat dissipation per square foot. Heat dissipation per bay of 30 transmitter-receiver units averages 90 watts per square foot of used floor space with narrow aisle spacing and 67 watts per square foot for the wider arrange-

ment. While these figures are reduced when other terminal room floor space is included, the amount of heat produced needs consideration in provisions for conditioning and changes of the air.

6. TRANSMISSION LEVELS

6.01 The office transmission levels available for the transmitter are either -16 or -13; for the receiver, +7 or +4. These are the same transmission levels which are available at the 4-wire voice frequency patchboard. Nominal gain in the line facility for signaling is determined by these levels. Values of nominal gain are shown in Table B for the four possible combinations of transmitter and receiver levels.

TABLE B

TRANSMISSION LEVELS		NOMINAL GAIN IN LINE FACILITY
TRANSMITTER	RECEIVER	
-16	+7	23 db
-16	+4	20 db
-13	+7	20 db
-13	+4	17 db

6.02 Normal signal power (in dbm) is transmitted at 20 db below the office transmission level of the transmitter. High signal power is 12 db greater than normal or 8 db below the office level. Table C tabulates values of signal power at transmitter, receiver, and zero transmission levels.

TABLE C — SIGNAL POWER AT OFFICE TRANSMISSION LEVELS

OFFICE TRANSMISSION LEVEL	NORMAL SIGNAL POWER	HIGH SIGNAL POWER
Zero Level Point		
0	-20 dbm	-8 dbm
Transmitter		
-16	-36 dbm	-24 dbm
-13	-33 dbm	-21 dbm
Receiver		
+7	-13 dbm	-1 dbm
+4	-16 dbm	-4 dbm

6.03 For 4-wire line facilities, the over-all loss allowance for variations in signal power between terminals is 9 db. This includes 3 db for variations within the signaling equipment and 6 db for variations in gain within the line facility.

6.04 For 2-wire line facilities, 3 db more is allowed to compensate for less favorable line conditions and for a blocking network associated with the receiver. The over-all loss allowance is 12 db.

6.05 The operate sensitivity of the receiver is thus either 9 db or 12 db below the nominal values of normal signal power. Values of operate sensitivity are tabulated in Table D in terms of the type of line facility and the office transmission level.

TABLE D — OPERATE SENSITIVITY OF SF RECEIVERS

OFFICE TL	TYPE LINE FACILITY	
	4 WIRE	2 WIRE
+7	-22 dbm	-25 dbm
+4	-25 dbm	-28 dbm

7. MODIFICATION OF 1600- OR 2000-CYCLE SIGNALING UNITS

7.01 About two-thirds of the 1600- or 2000-cycle signaling circuits now in service are the later model, single-circuit type. A modification is now available for these units which per-

mits their operation with the 2400- or 2600-cycle system. The principal features of this modification involve only change in signal frequency and replacement of networks in receivers. A few other minor changes are made to insure satisfactory operation at the higher frequencies of the 2400- or 2600-cycle system.

7.02 The 1600- or 2000-cycle signaling system is still required on narrow-band facilities such as EB channels, early C carrier, and H-172 loaded cable. The number of older, 2-circuit, 1600- or 2000-cycle units now in service appears sufficient for all of these narrow-band facilities.

8. REFERENCES

8.01 The following is a list of related sections on the 2400- or 2600-cycle SF signaling system:

- 953.002.01 - General Descriptive Information
- J68602(AA262.001) - Equipment Units
- J68655(Mfr Disc.) - Signaling Bays