MULTIFREQUENCY PULSING SYSTEM

ENGINEERING INFORMATION

COMMON SYSTEMS

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1. GENERAL

A. Introduction

1.01 The multifrequency pulsing system consists of components used for supplying, transmitting, and receiving ac signals for the transfer of numerical information over telephone line facilities. It can be used for pulsing, that is, passing called numbers over trunks, or for any similar requirement. The system works with short signal pulses, each one a combination of two single voice frequencies. Each pulse represents one digit in any number or the beginning or end of these pulsing signals. MF pulsing is used as an alternative to other types of pulsing because it enables numbers to be transferred more rapidly and because it can travel the same distances as speech. Its initial use is on trunks to crossbar-type offices. General descriptive information on the multifrequency pulsing system is presented in Section 953.001.01.

1.02 This specification is reissued to incorporate previous appendix changes.

1.03 The MF system transmits only number information and does not provide for supervision of trunk connections. The latter requires additional means; for example, loop, composite, or single-frequency signaling. Once a connection is established, the MF equipment is disconnected and used to set up other connections. On the other hand, the means for supervision must be provided individually in each trunk for continuous indication of the service condition.

1.04 In the following table, the digits and signals transmitted by MF pulsing are shown in terms of the frequency combinations used:

FREQUENCIES	900	1100	1300	1500	1700
700	1	2	4	7	—
900		3	5	8	—
1100			6	9	KP
1300				0	—
1500					ST

B. Applications

1.05 MF pulsing is transmitted by operators using keysets and by dial system senders. Operators with keysets transmit on the average about 2 digits per second; dial system MF senders, about 7 digits per second. The pulses go directly over trunks to MF receiver units, one of which is associated with each register or incoming sender in the distant office.

1.06 Since MF pulses go rapidly and directly over trunks, the holding time required of incoming senders and registers in crossbar-type offices is reduced. This is an important economic consideration, particularly where the calling rate is high and the number of trunks in a group is sizeable. In most cases, the saving realized

through the more efficient use of crossbar switching units outweighs the added cost of MF pulsing equipment. For this reason, the chief application of MF pulsing is on trunks to crossbar-type offices.

1.07 Although DC keypulsing permits the same operator keying speed as MF pulsing, it is limited in range to intraoffice use. Switchboard senders are provided in the originating office to accept DC keypulsing and transmit either dial or revertive pulsing over outgoing trunks. Since time is required for translation in these senders, receiving equipment does not receive the complete number until some time after keying has ceased. On the other hand, since MF pulsing is transmitted directly over trunks, no switchboard sender is required and receiving equipment receives digits as rapidly as they are keyed.

C. Combined MF-DC Pulsing Arrangement

1.08 Positions equipped only with MF keysets are limited in the use of pulsing to offices equipped with MF receivers, unless additional arrangements are provided. One such arrangement makes use of switchboard senders arranged to receive MF pulsing from keysets and transmit dial or revertive pulses to step-by-step or panel offices. Another arrangement provides for combined MF-DC keysets at switchboard positions. Using these keysets, operators can transmit either MF or DC keypulsing as required.

D. MF Pulsing With SF Signaling

1.09 MF pulsing may be used to transmit called number information where supervision is provided by the 2400- or 2600-cycle single-frequency signaling system. It may also be employed with the 1600- or 2000-cycle SF signaling system in the direction of the 1600-cycle tone. However, it ***cannot*** be used in the same direction as the 2000-cycle tone on 2-wire line facilities because of the presence of a 1600-cycle blocking network in the receiving path. This network would prevent 1500- and 1700-cycle MF tones from reaching the MF receiver with sufficient strength for proper operation.

2. CURRENT SUPPLY

A. General

2.01 The MF current supply provides six distinctive single frequencies in the voice range for MF pulsing from keysets and senders. An MF supply bay contains two oscillator groups, a transfer and alarm unit, distribution jacks, distributing resistances, and test equipment. Capacitance neutralizing networks may also be included, as required. All of this equipment is mounted on one standard 11-foot 6-inch angle-type relay rack arranged for 23-inch mounting plates.

B. Oscillators

2.02 Each of the two oscillator groups in a supply bay contains six separate vacuum tube, bridge-type oscillators, stabilized within ± 1 per cent for frequency and ± 1 db for output voltage. Both groups operate continuously and normally share the supply load equally. In the event of a failure in one group, the transfer and alarm unit gives an alarm and automatically switches the load of the group in trouble, placing the entire load on the other group. The transfer unit also prevents transmission of pulses by senders while the load is being switched. Oscillator groups are furnished with filament circuits wired to use either 48- or 24-volt battery, as required.

C. Distribution

2.03 A 6-wire distribution arrangement, one lead for each frequency, connects the distributing resistances in the supply bay to each keyset or sender. In wiring an installation, two important considerations are induction from the supply leads into other leads and capacitance between supply leads.

2.04 In all cases, cables containing paired leads are used to neutralize the effect of induction. A pair takes the output of each oscillator as near as is practicable to the terminals of two separate keysets or senders. ***In extending individual leads to terminals, the maximum permissible length of unpaired wires is 20 feet.*** Either 6- or 12-pair cable may be used. A 6-pair cable can serve two keysets or senders; a 12-pair cable, four keysets or senders.

2.05 Where capacitance between the paired leads from oscillator outputs exceeds 0.4 mf, neutralizing inductances are required to prevent excessive loss. The inductances are provided as a capacitance neutralizing network in which various combinations can be connected to provide from 2 to 69.7 mh for each of the six oscillators in a group. Each inductance required is shunted across an oscillator output to form, with the lead capacitance, a parallel resonant circuit having high impedance to the oscillator frequency.

2.06 The capacitance between paired leads is about 25 mmf per foot. Thus, 16,000 feet of paired leads will present 0.4 mf of capacitance to an oscillator output. Since each pair carries signaling current to two positions or senders, this figure is equivalent to 200 keysets or senders, each requiring a 160-foot run of distribution lead.

D. Capacity

2.07 One MF supply has ample capacity for the load of an ordinary central office, either local or toll. In fact, one supply may be used for two or more ***local*** offices of moderate size which are located in the ***same building.*** However, a minimum of one supply is provided at each ***toll*** office to assure continuity of service. In No. 4-type toll offices, two supplies are furnished in separate locations as an additional precaution against the interruption of toll service.

2.08 The load per MF current supply bay with two oscillator groups is dependent upon:

(a) The number of circuits (N) per supply.

(b) The number of MF call attempts (A) per circuit in the busy hour.

(c) The number of control and digit pulses (KP, D, C) per call attempt for each circuit.

The above items vary with office conditions; the items which follow are based upon measurements and study.

(d) The average time in seconds (T) of each MF pulse.

(e) The probability of using the same one frequency (F) in each pulse.

Combining these factors, the average number of simultaneous uses (U) during the busy hour is given by the general formula:

$$U = NA \quad \frac{KPTF + DTF + CTF}{3600 \text{ seconds per hour}}$$

2.09 Calculation of all uses is aided by the provision of a formula for each type of circuit supplied. The load of test circuits is disregarded on the basis that this will be negligible for the busy hour. The other circuits are given subscripts to identify factors in the uses formula as follows:

(a) Switchboard position keysets (k) KP and digit pulses each = 0.1 second

$$U_k = N_k A_k \quad \frac{0.1 + 0.4\ (0.1)\ D_k}{3600}$$

(b) Senders (s)

KP pulse = 0.13 second, digit pulses = 0.07 second

$$U_s = N_s A_s \quad \frac{0.13 + 0.4\ (0.07)\ D_s}{3600}$$

(c) CAMA position keysets (c)

No KP pulse, digit pulses = 0.1 second

$$U_c = N_c A_c \quad \frac{0.4\ (0.1)\ D_c}{3600}$$

(d) Service observing DP to MF converters (o)

KP pulse = 0.08, digit pulses = 0.1 second

$$U_o = N_o A_o \quad \frac{0.08 + 0.4\ (0.1)\ D_o}{3600}$$

(e) Recording-completing and toll switching 1F-2F trunk circuits (t)

Ringing (700 cycles) = 2.0 seconds
Coin return (1100 cycles) = 1.0 second
Coin collect (700 + 1100 cycles) = 1.0 second
Ringing assumed on 25 per cent of calls
Control signals per call = 1.1

$$U_t = N_t A_t \frac{2\,(0.25) + 1(1.1)}{3600} = 0.00044\ N_t A_t$$

The total load is limited to that resulting in a 0.5-db drop in any oscillator output voltage. This allows a maximum of 14 simultaneous uses for all except recording-completing and toll switching trunks, and with a probability of 0.001, an average of 5.2 simultaneous uses. In the case of recording-completing and toll switching trunk circuits the 0.5-db drop limitation allows a maximum of 7 simultaneous uses, and with a probability of 0.001, an average of 1.5 simultaneous uses. Defining full rated load for an MF supply with two oscillator groups as 5.2 simultaneous uses (1.5 for recording-completing toll switching trunks), the fore-going equations are converted to express the percentage of full rated load (P) as follows:

(f) General formula

$$P = \frac{\text{Average number of uses}}{5.2}\ 100$$

(g) Switchboard position keysets

$$P_k = 0.0001\ N_k A_k\ (6 + 2D_k)$$

(h) Senders

$$P_s = 0.0001\ N_s A_s\ (7 + 1.5\ D_s)$$

(i) CAMA position keysets

$$P_c = 0.000214\ N_c A_c D_c$$

(j) Service observing converter circuits

$$P_o = 0.0001\ N_k A_k\ (5 + 2D_o)$$

(k) Recording-completing and toll switching trunk circuits

$$P_t = 0.03\ N_t A_t$$

2.10 In engineering an MF pulsing system, the sum of the P's of all the circuits associated with one current supply bay must not exceed 100 per cent. In general, an MF current supply bay will adequately serve either 500 switchboard position keysets, 150 senders, 130 CAMA position keysets, 7500 service observing converter circuits, or 270 recording-completing or toll switching trunk circuits. Combinations of these that fit within the limits of the following formula may be supplied without further engineering:

Number of switchboard position keysets $+3.33$ (number of senders) $+$ 1.85 (number of recording-completing or toll switching trunks) $+$ 3.85 (number of CAMA position keysets) $+$ 0.066 (number of service observing converter circuits) < 500. If the combination ***approaches*** 500 the more exact formulas should be applied.

3. TRANSMITTERS

3.01 A keyset is required at each switchboard position where MF pulsing is desired. The keyset consists of two rows of keys and a row of three lamps. There are ten keys for digits, one or two KP keys as required, and one ST key. The keyset is connected to a front or rear cord circuit by the operation of the front or rear KP key.

3.02 MF outpulsing equipment is required in each dial office sender arranged for this service. Usually this consists of five relays for each digit, two delays for KP and ST, and other relays to control the progression of pulsing.

4. RECEIVER

A. General

4.01 One MF receiver unit is provided for each sender or register required to receive MF calls. The unit receives MF pulses and translates them into dc form for acceptance by the associated sender or register.

4.02 A receiver unit occupies the space of five 2- by 23-inch mounting plates. Units may be segregated on separate bays or mounted directly with senders or registers. When segregated, 12 receivers are mounted on a standard 11-foot 6-inch relay rack bay.

B. Filament Supply

4.03 The vacuum tube filaments of each MF receiver are supplied with 6.3 volts ac by a filament transformer which operates on 115-volt ac power. The 115 volts ac is provided by a filament supply unit which contains fuses

and receptacles for supplying six receivers. Two supply units, each occupying the space of one 2-inch mounting plate, are located in the center of a receiver bay.

C. Emergency Operation

4.04 In the event of commercial ac power failure, filaments are supplied with dc power from an emergency filament supply utilizing 48-volt central office battery. The transfer to dc power is made automatically by a transfer control unit whenever the ac voltage drops below 90 per cent of its rated value. Normal ac operation is resumed automatically when the voltage returns to 95 per cent of its rated value.

4.05 For emergency operation, the control unit connects the filament circuits of 36 receivers in a series parallel arrangement consisting of six parallel chains of six receivers each. Three of the six chains may be arranged to accommodate a seventh receiver, usually one assigned for test or monitoring purposes.

4.06 These units are located on a miscellaneous relay rack arranged for 23-inch mounting plates. The emergency supply unit occupies the space of five 2-inch plates; the control unit, the space of two 2-inch plates. One supply unit and one control unit are required for each group of 36 to 39 MF receivers. Voltage drop in the leads to receiver filaments limits the distance of the emergency supply unit from the receiver bay.

D. Maintenance

4.07 A pad circuit is provided for adjusting the volume-limiting action and operate sensitivity of MF receivers. The circuit obtains test frequencies from a multifrequency current supply and attenuates them to the levels required for proper adjustment. The attenuating circuit is located on the MF supply bay, occupying the space of two 1-3/4-inch mounting plates. It includes jacks for patching to interbay trunks which terminate at test tone supply jacks on MF receiver bays. The supply jacks are mounted on one 2-inch mounting plate directly below the receiver ac filament supply units. A patching cord is used to connect from the jacks to any receiver in a bay. In offices having MF receivers associated with registers or incoming senders, but not requiring the regular MF current supply, a single oscillator group with a pad circuit is provided for testing receivers.

4.08 In any office where keysets or senders are used for multifrequency pulsing, MF receivers are required to monitor outpulsing from keysets and to test senders.

5. RANGE OF MF PULSING

5.01 The normal power output of MF transmitters in toll, combined toll and DSA switchboards, testboards, test frames, and senders is −3 dbm per frequency at zero transmission level. The normal sending power from MF keysets in local manual switchboards is −6 dbm per frequency because the MF tones in this instance are heard by the calling subscriber. The engineering limit for operate sensitivity of the receiver is −22 dbm per frequency. These values permit the use of MF pulsing on trunks having maximum losses of 19 db (15 ±4 db) when connected to toll and DSA switchboards, testboards, and senders or 16 db when connected to local manual switchboards. Little interference from crosstalk, noise, and echoes is encountered on lines satisfactory for voice transmission.

6. REFERENCES

6.01 The following is a list of related equipment engineering practices:

J98609 — 801-620-151 — MF Current Supply
J95102 — 801-620-150 — MF Receiver
J25150 — 819-055-150 — MF Current Supply and Receiver — No. 5 Crossbar Offices