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SUPPRESSION OF RADIO INTERFERENCE CREATED BY TELEGRAPH COMMUNICATIONS EQUIPMENT

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A discussion of the sources of radio-interference in telegraph equipments, their means of propagation, and methods of suppression. Examples of interference suppression in telegraph equipment are given.

Telegraph equipment and devices causing sudden changes of current and voltage in electrical circuits interfere with radio reception. In the space surrounding the equipment high-frequency electromagnetic fields are created, and at the terminals as well as between the terminals and the housings of equipment there occur high-frequency interference voltages with a continuous spectrum, embracing almost the entire range of frequencies used for radio broadcasting and television. The intensity and degree of the interference depends on a whole series of causes in which the design of the source of interference and the number of current or voltage changes per second are of considerable importance.

In most cases the sources of interference in telegraph equipments are commutator drives and contact devices (motors, keys, cam distributors, sounders, etc) changing (switching) the value and direction of current 100 or more times per second.

The sparking accompanying the switching process scorches the contacts, resulting in unreliable conduction across the latter. In order to reduce this harmful effect in many telegraph systems a spark quencher (the circuit consisting of R and C in Figure 1) is connected in parallel with the contacts. The spark-quenching circuit not only facilitates contact operation but also provides a parallel path for transient current and reduces the intensity of interference with radio reception.

The radio interference created by telegraph equipment is propagated by direct radiation into space and along the conductors connected with this equipment. Over especially long distances (several kilometers) radio interference is propagated along power and telegraph wires and along lighting, telephone, and signalling circuits close to these wires. Extensive branching of interference-carrying circuits complicates the task of combatting radio interference along the paths of its propagation.

In most cases the adoption of anti-interference measures at the receiving site does not afford sufficient reduction of interference with radio and television reception. Interference penetrates a radio receiver chiefly through capacitive coupling between the receiving antenna and the interference-carrying circuit. The most thorough method of combatting industrial interference is its suppression directly at the source, though minimum precautions must always be observed at the receiving site and along the paths of interference propagation (by correct orientation of the receiving antenna, isolation of interference-carrying circuits by blocking capacitors, etc).

The permissible intensity of industrial interference created by the different sources is regulated by special standards. (State Radio Inspection.

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Ministry of Communications USSR, Normy predel'no dopustimykh industrial'nykh radiopomekh [Standards for Maximum Permissible Industrial Interference], third edition, Svyaz'izdat, 1954, items 9a-g). In these standards, according to the location of the source of interference and the purpose of the power supply system, all telegraph equipment is divided into the following three categories: a, equipment installed in a non-residential building and fed from an industrial power system; b, equipment intended for use in a residential building or connected to the public power system; c, equipment located in the immediate vicinity of a radio receiver. All three categories of telegraph equipment are rated according to the field intensity and according to the voltage between the terminals and the housing of the equipment (ground).

Moreover, in cities with cable telegraph systems a central telegraph office occupying an individual building is regarded as one general source of radio interference. The radio interference created by such enterprises is rated only according to the field intensity at a distance of ten meters from the building, since it has been established that the radio interference of a cable system attenuates rapidly and does not carry over to systems connected with receiving antennas.

The standards distinguish sources of radio interference connected to the power lines of residential buildings as (a) with a duration of more than one second regardless of the rate of recurrence and (b) with a duration of one second or less but repeated more often than once every five minutes.

Radio interference caused by circuit breakers and knife switches is not included in the standards.

The intensity of radio interference is determined by means of special instruments, circuit noise meters. In order that the results of measurements under different conditions may be compared, the methods of measurement of interference and the parameters of typical meters are also specified in the standards. The IP-12 circuit noise meter has found wide use in the Soviet Union for measurements in the long-, medium-, and short-wave ranges (0.15-20 Mc) and the IP-14 meter for measurements in the ultrashort-wave range (20-150 Mc).

Suppression of radio interference is usually achieved by means of filters connected to the interference-carrying conductors of telegraph equipment as well as by shielding the sources of interference in those cases where it is necessary to eliminate the fields of directly radiated interference.

In order that the equipment required for suppression of radio interference may be as simple and economical as possible it is necessary to search for possibilities of reducing the intensity of interference created by the sources themselves. In certain telegraph equipment this may be achieved by careful connection of the components of the telegraph circuits, wherein the equivalent internal impedance of the source of interference relative to high frequencies is as great as possible. From the formula

$$U_L = \frac{E}{\frac{Z_i}{Z_L} + 1}$$

(here E is the emf of the source of interference, Z_i is the internal impedance of that source, and Z_L is the load impedance) in determining the

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interference voltage drop across the load it is apparent that, all other conditions being equal, an increase in the internal impedance Z_1 is accompanied by a decrease in the interference voltage across the load. Hence in developing telegraph circuits it is desirable, wherever possible, to connect components with resistors and inductances at the sending end and to place them in the immediate vicinity of the source of interference. Such connection, in increasing the impedance of the transmitting section of the circuit, permits reduction of the interference voltage in the network and in the load, and in a few cases permits limiting the use of blocking capacitors to single units so that the intensity of residual interference meets the requirements of the standards.

The balancing method proves especially effective in suppressing radio interference. This method consists in the symmetrical connection of all the windings of electrical equipment of a given circuit relative to the spark contact: the windings are divided into two equal sections and are connected to both conductors of the source of interference, wherein they play the role of an inductor and at the same time balance the asymmetrical interference voltages between each conductor and the ground. With the voltages between the conductors and ground equal in value and sign relative to ground, there are created mutually compensating electromagnetic fields having no effect on the antenna.

In balanced schemes the suppression of interference in compliance with the standards can in most cases be achieved by simple means without significantly increasing the cost of the equipment. Failure to take advantage of the possibilities for interference suppression by electrical balancing often leads to an unjustified increase in the ultimate cost of equipment. For example, in the ST-35 telegraph equipment produced in 1954 interference is suppressed by a bulky arrangement consisting of a two-section motor filter and three single-section filters -- a line filter, a transmitter filter, and a receiver filter. On the other hand, if in developing the arrangement for interference suppression consideration had been given to the possibility of symmetrical connection of the exciter windings of the DTA-40 motor relative to its contact speed regulator and symmetrical connection of the windings of the receiving electromagnet or the receiving relay relative to the contacts of the telegraph transmitter, then the interference suppressing arrangement of the equipment could have been simpler and less expensive.

During operation it is necessary to maintain the telegraph equipment and mechanisms in working condition. It is necessary that the motor brushes make good contact with the commutator and that the contact surfaces of the relay and the speed regulator not be corroded, for otherwise the intensity of radio interference will be considerably increased. Vibration of the components and interference suppressing filters lowers the effectiveness of the suppression. Hence, careful fastening of all the components and wiring in the equipment is necessary.

Let us examine a few examples of suppression of radio interference in telegraph equipments. (I. A. Aleshin took part in developing the described methods of interference suppression.)

1. Suppression of Radio Interference Created by the M-44 (Morse) Telegraph Equipment

Equipments of the M-44 type are installed in communications offices and departments in which communications equipment and radio equipment may be placed close together in the same premises. The intensity of radio interference caused by the M-44 equipment is as high as 700 times greater than allowed under the standards (item 9c); with a radio receiver turned

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on telegraph keying is clearly heard in the loudspeaker, interfering with the reception of radio broadcasts.

Figure 2 shows a method of suppressing interference caused by the M-44 equipment operating on d-c with a line voltage not exceeding 200 v. The coils of the electromagnet are symmetrically connected to the line and battery conductor relative to the operating contact of the key. The telegraph key is placed in a grounded shield. However, in connection with the difficulty of making the shields, equipment already placed in operation may be operated with the key placed on a grounded metal plate -- on the condition that the radio receiver employs an external antenna and the telegraph equipment is located not less than two meters away from the radio receiver.

The knob of the key must be made of an insulating material, for if during keying the hand of the operator is in contact with the metal army of the key, the strength of the intereference will be increased by several times.

The components of spark quencher R_{sp} and C_{sp} must be placed in the immediate vicinity of the key so that the connecting wires between the key and the filter will be as short as possible. Filter capacitors C_f must be fastened inside the base of the equipment close to the coils of the electromagnet. The housing of the clockwork mechanism must be grounded. It is desirable that the telegraph circuit of the M-44 equipment and the antenna circuit of the radio receiver have separate grounds.

2. Suppression of Radio Interference Created by TRM and RP-4 Telegraph Relays

Polarized TRM and RP-4 relays, designed for operation in the circuits of telegraph equipment installed on the premises of central telegraph offices and city communications departments, cause radio interference considerably in excess of that allowed under the standards.

Figure 3 shows the circuit of an interference suppressing filter for telegraph relays with polarential keying, which circuit insures compliance with item 9b of the standards. The circuit contains one inductor, consisting of two coils (L_1 = 33 millihenries) of 1,110 turns of PEL-0.2 wire each. The two-section coil form is fitted over a core of transformer steel. The dimensions of the plates are 3.8 x 43 mm with a thickness of 0.35 mm. The stack is 3.8 mm thick.

With grounding of the auxiliary winding of the RP-4 relay the residual interference voltages at terminals 1-8 of the operating windings are decreased. Hence, if the layout of the telegraph equipment permits such connection, it is recommended that terminal 12 of the RP-4 relay be grounded.

All the components of the filter (capacitors, coils, resistors) must be placed in a grounded shielding container with output posts. In order to minimize coupling between the input and output posts of the filter they must be placed on opposite sides of the container. The filter itself must be located next to the relay terminals in order that the wires connecting the two will be as short as possible. The wires leading to the input and the output of the filter must not be led through a common braid.

The relays must be covered with shield jackets and the terminal strips must be placed on a metal panel.

Connection of the interference suppressing filters does not increase the distortion of telegraph signals; it merely causes a negligible rounding of the leading edge of the signal.

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3. Suppression of Radio Interference Caused by the Call Set of the Automatic Subscriber Telegraph (AAVP-1)

The AAVP-1 call set contains contact mechanisms (digit selector, push-buttons, telegraph and telephone relays) which cause interference with radio reception. The call sets are installed in institutions, industrial enterprises, and also in the city communications sections usually found in residential buildings.

The most intense source of radio interference in the call set is the digit selector. In dialing a number the interference voltage in the long-wave range reaches 25,000 microvolts in a duplex telegraph circuit and 3,500 microvolts in a simplex circuit.

Since a subscriber's number may consist of several digits and one second is required for the transmission of a digit, operation of the digit selector may have a prolonged disturbing influence on radio reception. Hence, interference from the digit selector of the call set must be suppressed.

The problem of suppressing radio interference created by the other sources is solved differently. While the intensity of these interferences is also considerable (for example, at the terminals of the call set in turning the motor on and off, the interference voltage at a frequency of 0.16 Mc reaches 8,000 microvolts), their duration does not exceed a second. Moreover, they appear in the form of distinct clicks, and the number of connections of subscriber equipment during maximum traffic does not exceed six per hour. Hence these are not included in the standards for maximum permissible radio interference and their suppression is optional. Thus, notwithstanding the fact that the call set contains several sources of intense radio interference, only the interference from the digit selector is suppressed.

Figure 4 shows the diagram of the transmitting circuit of an AAPV-1 call set in which the digit selector is connected with an interference suppressing filter L_1C_1. The arrangement contains an inductor consisting of two coils (L_1 = 20 millihenries) of 850 turns of PEL-0.2 wire each. The two-section coil form is fitted over a core of transformer steel. The dimensions of the plates are 3.8 mm x 43 mm with a thickness of 0.35 mm. The stack is 3.8 mm thick.

In order that interference from the digit selector will not be induced in the receiving and motor circuits the interference suppressing filter must be placed in the immediate vicinity of the digit selector.

4. Suppression of Interference Created by TV-39 Automatic Telegraph Subscriber Exchanges

The most intense sources of radio interference in TV-39 exchanges are the telegraph relays. Hence, panels for line-balancing units and subscriber panels contain filters for suppression of interference caused by telegraph keying. Connection of these filters to the relay circuits is achieved by means of jumpers on the filter housings.

In cites with cable telegraph facilities the measures adopted for suppression of interference at TV-39 exchanges insure compliance with item 9d of the standards.

In cities with open-wire telegraph systems residual interference must meet the requirements of item 9a of the standards. Hence, additional measures are needed to reduce the voltage level of interference in calling, connecting, and clearing. It is recommended that the microfilter line and that a 1-microfarad blocking capacitor be inserted in the d-c supply line (at the supply post).

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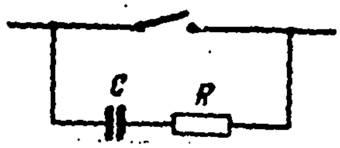


FIGURE 1

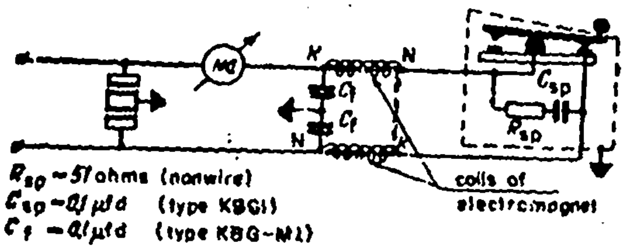
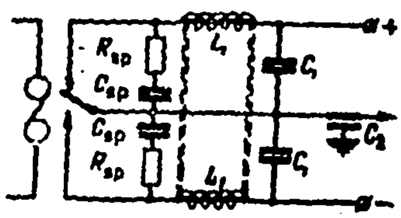


FIGURE 2



R_{sp} ~ 100 ohms (nonwire)
C_{sp} ~ 0.1 μfd (type KBGI)
C_1 ~ 0.05 μfd (type KBGI)
C_2 ~ 0.05 ufd (type KBP)

FIGURE 3

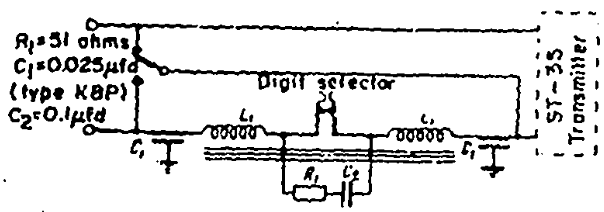
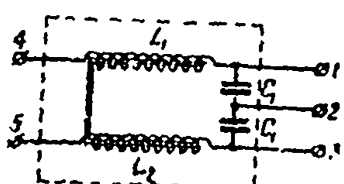


FIGURE 4



L_1 ~ 0.5 mh C_1 ~ 0.05 μfd

FIGURE 5

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