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TELECOMMUNICATIONS REGULATION CIRCULAR

SUPPRESSION OF APPLIANCES AND SMALL MOTORS

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TELECOMMUNICATION REGULATORY SERVICE

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SUPPRESSION OF INDUCTIVE INTERFERENCE

Suppression of Appliances and Small Motors

1. Interference from electrical appliances is nearly always due to the appliance containing either a commutator-type (A.C.-D.C., Universal) motor, or to electrical contacts which open and close frequently, such as a thermostat.

2. Interference from thermostats and other contacts can usually be readily cured by connecting a capacitor directly across the contacts, using as short leads as possible. A 0.1 microfarad or 0.05 microfarad size capacitor is usually best, though a 0.01 microfarad is often satisfactory, especially if the interference is principally to television frequencies. Plug-in suppressors, as described below, are also fairly effective. Inductances and feed-through capacitors are effective in the more difficult cases.

3. The simplest corrective action, to reduce the noise from small A.C.-D.C. motors, is to stiffen the brush springs. The pressure on the brushes has a pronounced effect on the intensity of radio noise generated. As the brushes wear, the spring pressure decreases; stiffening (stretching) the brush springs will often reduce the radio noise by as much as 20 decibels (ten times). When removing the brushes to stretch the springs, care should be taken not to rotate the brush a half turn, as it then will not fit the commutator properly until it is worn in, and consequently will be noisy in the interim.

4. There is a distinct limit to the amount of noise reduction which can be obtained by stiffening the brush springs, and the next simple step to obtain further suppression is to connect a 0.05 microfarad or a 0.1 microfarad capacitor across the power line, near the motor. The simplest way of doing this is to obtain a small plug-in EMI filter.

5. The next simplest type of suppression is the 0.05 or 0.1 μF capacitor across the power line, plus a 0.006 μF capacitor connected from each line to the frame of the motor. Capacitors which connect to the frame of an appliance should not be much larger than 0.006 μF as the current passing through larger capacitors will produce a perceptible shock. These can be installed inside the appliance case if there is room. This suppression

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5. (cont'd) arrangement has proved adequate in actual cases on quite a number of sewing machines and similar motors, though if the interference is heavy enough to tear the TV picture badly on a properly adjusted set, it is doubtful whether this amount of suppression will be sufficient to eliminate the interference completely.

6. The next step to obtain further suppression is to also connect a capacitor of 0.006 μF or less from each brush-holder to the frame of the motor, using as short leads as possible. The compactness of ceramic capacitors (Discaps, etc.) make them very convenient. Also small inductances should be placed in each lead coming from the motor to the capacitor assembly. The leads from the capacitor assembly to the power wires should be as short as possible, and where possible the line lead should be at right angles to the other two wires, to avoid coupling. Some further suppression can be obtained by also putting an inductance in each power line lead where it leaves the capacitor assembly on its way to the power supply.

7. The length of the leads of the capacitors which are connected from power line or brushes to frame is rather important. The leads should, in general, be kept as short as possible, but if the interference problem exists only in connection with a single television channel, additional suppression can be obtained at that particular frequency by co-ordinating the length of the capacitor leads and the capacitance value. The curves in the attached copy of Appendix "A" give the optimum capacitance, for various lead lengths, to obtain resonance, and maximum suppression, at a given frequency.

8. For suppressing television interference, the inductances mentioned above need merely be a solenoid of ordinary wire, close wound, in a single layer, on a fountain pen or broomstick, which is then removed. Maximum effectiveness occurs when the length of wire in the inductance is roughly one-third of a wavelength at the frequency at which suppression is most desired. The attached curve sheet (Figure 1) gives the length of wire to be used for each inductance, to obtain maximum suppression in the neighbourhood of the frequency indicated. (Curve is applicable to inductances whose diameter is between half and double their length.)

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9. EMI filters are manufactured which contain an assemblage of capacitors and inductances.

10. If further suppression is necessary, the best means of obtaining it is by means of feed-through capacitors. Ceramic type feed-through capacitors are very compact and consist of a threaded sleeve or bushing with the conductor passing through the centre. The outer sleeve is one plate of the capacitor and, in this way, the lead length is virtually zero. To take advantage of this zero lead length, however, it is necessary that each feed-through capacitor be mounted so that it passes through the wall of a metal enclosure which completely encloses the noise source. When a feed-through is so installed, the noise currents flow away from it radially in all directions and, under these conditions, the current path has zero inductance. The metal casing of an appliance often will serve this purpose, but it is important that the enclosure be as complete as possible, without long slits or large openings. If the enclosure is in several pieces, clean metal-to-metal contact throughout the length of the joints is very important.

11. In arranging such an enclosure it is well to keep in mind what is a similar arrangement on a larger scale:- the screened room, or cage, with a filter where the power supply enters the cage, and no other openings. A good cage commonly gives nearly 120 dB, (one million times) isolation, as between the noise on the inside and on the outside, including the power line. If a motor can be contained in a metal (or metal screen) enclosure with the power supply entering via feed-through capacitors which pass through the wall of the enclosure, suppression of a comparable order can be obtained, at television frequencies. A bag of bronze window screening wrapped around the motor is highly effective. Inductances can be added, but they are not usually necessary.

12. The feed-throughs should, of course, be limited in capacitance to about 0.006 μF to avoid shocks. This amount of capacitance is rather too small to give good suppression in the Standard Broadcast band so it is usually necessary to add a 0.05 μF or 0.1 μF capacitor across the line, preferably inside the enclosure.

13. In the case of electrical apparatus which is permanently grounded, or completely insulated, so that there is no danger of shock, instead of 0.006 μF capacitors, 0.05 μF or larger capacitors can be used to advantage in any of the above arrangements, if difficulty is being experienced with Broadcast, rather than TV, interference.

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14. Each Departmental radio interference car carries a set of plug-in and other type suppressors, and the nearest Department of Communications Radio Inspector is glad to advise as to the most economical and effective method of suppressing interfering appliances or apparatus. Circulars are also available at Radio Inspection Offices concerning the suppression of interference from oil burners, fluorescent lights, various industrial apparatus and equipment, etc.

G H Stewart

for W.J. Wilson,
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Attachments.

FIGURE - 1

SELF-RESONANT FREQUENCY
Vs
LENGTH OF WIRE

IN A SINGLE LAYER SOLENOID, WHOSE DIAMETER IS BETWEEN HALF AND DOUBLE ITS LENGTH

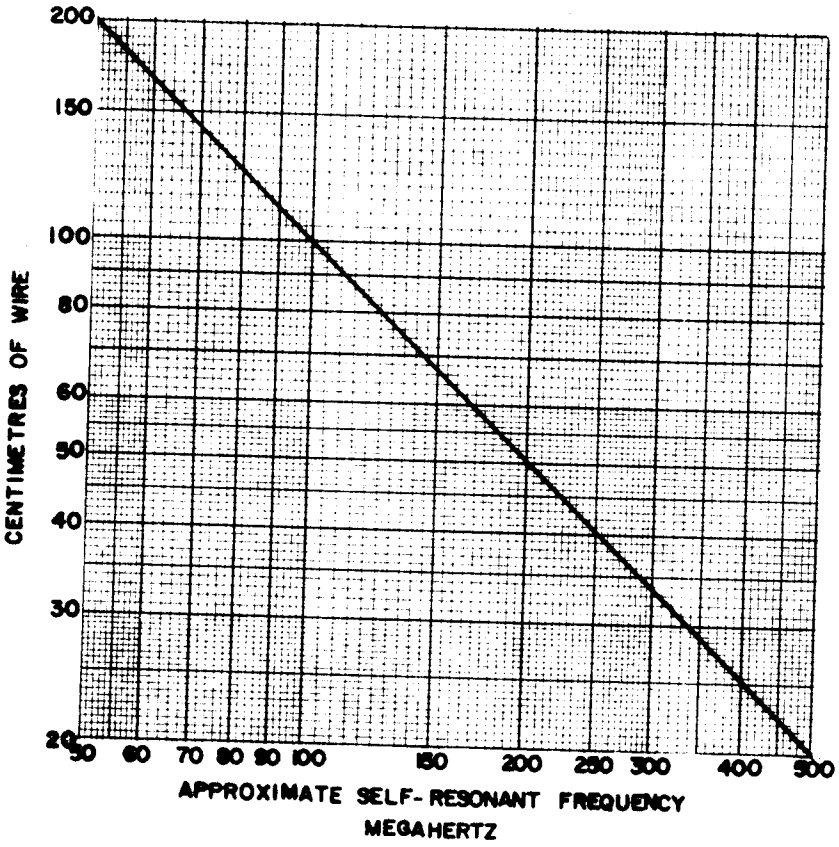
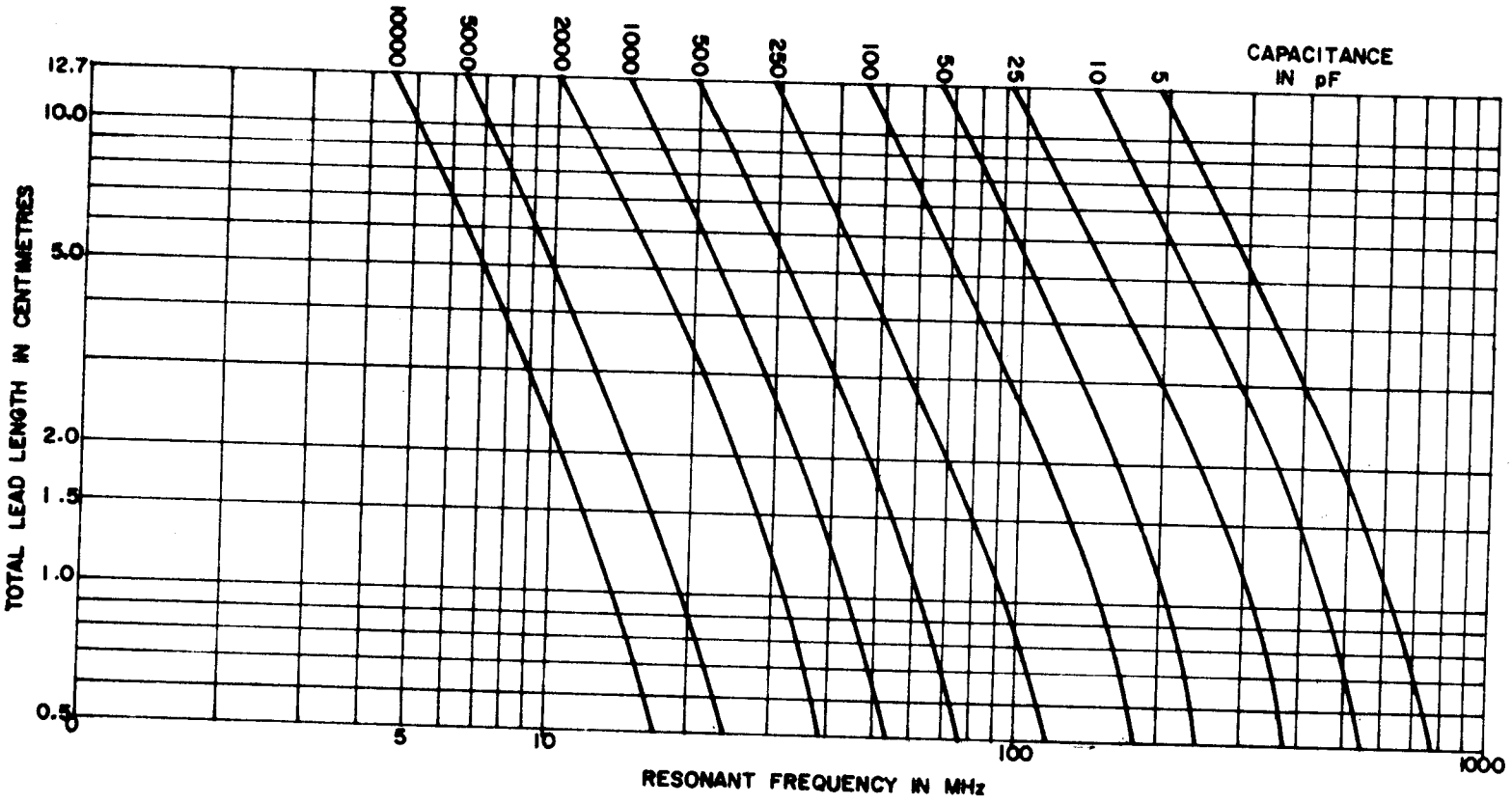


FIGURE-2


CAPACITANCE IN pF
0.0005
0.0002
0.0001
500
250
100
50
25
10
5
12.7
10.0
5.0
2.0
1.5
1.0
0.5
0
5
10
100
1000
TOTAL LEAD LENGTH IN CENTIMETRES
RESONANT FREQUENCY IN MHz

APPENDIX "A"

Suppression Capacitors for Television Frequencies

1. Large capacitors often are not very effective in suppressing radio noise at very high frequencies, from household appliances and other apparatus. Particularly if interference is arising on only a single television channel, or a small band of frequencies, much better results can be obtained by using a small capacitor whose capacitive reactance will just equal, and cancel, the inductive reactance of its leads.

2. Figure 2 gives the capacitor size which will series resonate with the inductance of various lengths of lead, at any given frequency.

3. Best suppression occurs when a given capacitor, with leads, is at its series resonant frequency, but at frequencies above resonance it is more effective than larger capacitors would be, with the same length leads. It is also more effective (impedance is less) at frequencies somewhat below resonance than much larger capacitors would be, down to about three-quarters of its resonant frequency, but not lower.

4. On commutator motors, suppression capacitors may be most effective if connected from each brush holder to the frame, or across the brush holders, or from each line to the frame, or a combination of these. They should always be installed with the shortest possible leads and the appropriate capacitance to resonate this length should be used. While the lead length may not greatly affect the suppression obtained at the resonant frequency, it should be noted that the impedance of the capacitor-plus-leads at frequencies above or below resonance is directly proportional to the reactance, and hence length, of the leads at resonance.

5. The C.S.A. has shock hazard standards that specify the maximum amount of current that can be carried in a wire connected from an appliance to ground. This varies with the appliance involved though in most cases it is 0.5 mA. These specifications will place a limit on the value of suppression capacitors connected between the power leads and the chassis of an un-grounded appliance. C.S.A. should be referred to for the applicable specification and rigidly adhered to.