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Television Interference Filters

By the Engineering Department, Aerovox Corporation

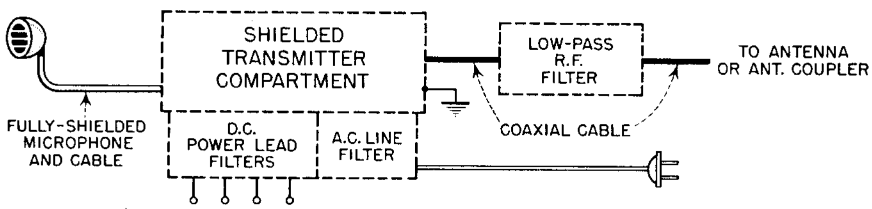
THE advent of television broadcasting has brought about many new problems in interference elimination. Much of this interference is caused by spurious radiations from transmitters of other services. The burden of finding solutions to such problems rests upon the licensee of the transmitter causing the interference, and upon the owner of the set being interfered with — or his service technician. Usually, a satisfactory solution can only be arrived at through the complete cooperation of all parties concerned.

The American amateur radio operator, because of greater numbers, closer proximity to owners of TV sets, has spear-headed the technical battle to find cures for this threat to his hobby. Now, with many "hams" again able to operate at full one-kilowatt input in the midst of dozens of TV receivers, the battle has been won. There remains only the job of educating others in the methods employed.

The most powerful tool which has been applied to the elimination of television interference (TVI) is the frequency selective filter. The theory and design of such filter networks has been treated at some length in the AEROVOX RESEARCH WORKER in the past. (See March, 1940; September, 1942—February, 1943; August-December, 1944.) This issue discusses the application of filter networks to television interference elimination and describes the construction of practical filters for use at the source of the interference, as well as at the TV set.

Causes of Interference

Because of the lack of selectivity inherent in modern television receivers, they are particularly prone to interference by spurious signals of many kinds. When one considers that the minimum band-pass for tuned receiver "front-ends" is about 6 mc. and that many using untuned grounded-grid r.f. stages will accept signals over a band many times this width, it is seen why this is so. For example, an amateur transmitter operating at 7 mc. may radiate a small amount of power at each of the harmonics (multiples) of this frequency. The amplitudes of these harmonics diminish rapidly with frequency, but multiples up to the sixteenth or eighteenth may be of sufficient strength to interfere with a weak television signal, depending upon the proximity of the amateur transmitter and its adjustment. Thus, with a harmonic falling every 7 mc., the transmitter stands a good chance of interfering with TV channels 2, 3, 4, and 5, since the 8th through 11th harmonics of 7 mc. fall within them. The degree of interference is usually determined by the proximity of the harmonic to the frequency of the picture carrier. If it is close, the harmonic must be weaker by about 50 db. to avoid interference.



ILLUSTRATING USE OF COMPLETE SHIELDING AND FILTERING AT TRANSMITTER
FIG.1

By far the most serious harmonic interference is that caused by the second harmonic of "ham" stations operating in the 28 mc. band, since this harmonic falls directly in channel 2 and is usually quite strong. Another such case of troublesome interference is occasioned by the second harmonics of **FM** stations which fall within the high-band TV channels. The commercial solution to this problem has been similar to that adopted by amateurs — the use of filters to prevent spurious radiation.

TVI may also be caused by low-frequency signals getting into the receiver i.f. stages, either through the tuner or by direct pick-up in the set wiring. Cases have been observed where picture reception was prevented by signals from European short-wave broadcast stations leaking into the 21.25-25.75 mc. i.f. channel. This type of interference is usually characterized by the fact that all TV channels are effected, regardless of tuning.

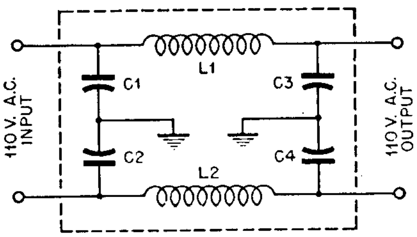
TVI Reduction at the Transmitter

Of course, the most effective approach to interference elimination is to start at the source. The harmonic content of the transmitter signal is tremendously affected by circuit adjustments such as grid bias, grid drive, modulation percentage, and tank circuit L-C ratio. If the generation of harmonics and parasitics is first minimized by the selection of the proper values for these variables, the job of preventing the radiation of the remainder is considerably simplified.

In addition, it has usually proven necessary to completely shield the offending transmitter before the work of harmonic suppression by the use of filters can proceed. Otherwise, harmonic radiation may occur from the final tank coil and other parts of the transmitter. Since the wavelength of the harmonics which cause TVI are relatively short, leads of moderate length may act as efficient antennas.

The need for shielding may be determined by loading the transmitter with a "dummy" lamp-load substituted for the antenna. If the TVI clears up, it indicates that the interfering signal is being radiated by the antenna and that the present degree of shielding is adequate. If this test shows that more shielding is needed, the type required need not be elaborate, but must be complete. Commercially built metal cabinets, although neat in appearance, do not always provide effective shielding because of poorly-bonded joints, doors, cracks, and ventilating louvers. The most popular method of shielding employed in amateur practice is to enclose the entire transmitter r.f. chassis in a box made up of close-mesh copper screening, soldered at all junctions to make it absolutely r.f.-proof. This shielded chassis and panel may then be mounted in a standard rack or cabinet to improve the appearance.

With the r.f. portions of the transmitter thus completely shielded, it



L1, L2 – 30 T. No.12 E., 3/4" FORM
C1,C2,C3,C4 – .005 MFD. MICA (Aerovox Type 1467)

LOW-PASS LINE FILTER
FIG. 2

becomes a relatively simple matter to filter all leads entering this metal enclosure, in the manner indicated in Fig 1. It must be remembered that the key or microphone lead is a potential source of r.f. leakage and must be either shielded or filtered. Any a.c. power leads which enter the chassis must also be filtered. For this purpose, a balanced single pi-section, low-pass filter as shown in Fig. 2 may be employed. A unit of this type may be constructed in a small metal box and bonded solidly to the outside of transmitter shield box for maximum effectiveness. The line filter should not be assembled inside of the transmitter housing because of the danger of the components coupling to harmonics from the tank circuit.

For d.c. leads which enter the shielded compartment, a single L-section low-pass filter of the type illustrated in Fig. 3 has proven effective in preventing r.f. leakage. The values of the components are not critical, but they should be of high quality. Inductances should be of a universal-wound type so that distributed capacitance is reduced. Mica capacitors* should be chosen, according to voltage requirements. A filter of this kind should be used in each d.c. lead which might conduct r.f. out of the shielded housing. Like the line filter, these d.c. filters should also be assembled in a separate metal box which is fastened to the outside of the main shield compartment. A common housing may be used for all power lead filters.

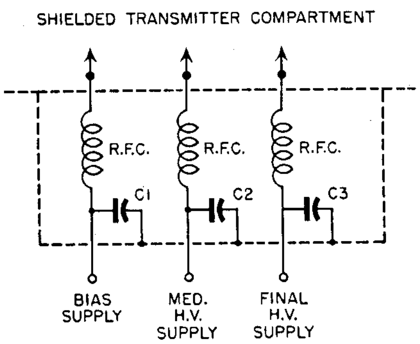
After the job of shielding the transmitter and filtering all power leads has been completed, it should be checked again for TVI. If all signs of interference to nearby television receivers have disappeared when full transmitter power is applied to a dummy load *inside* of the shielded compartment under conditions of full modulation or keying, this part of the job is satisfactory.

*Aerovox Type 1445-47.

If the interference appears when the antenna is again connected, the TVI is reaching the receiver by radiation from the antenna. It may be of the harmonic type or the receiver overloading type. At this point it is well to determine which, since further changes at the transmitter will not eliminate the latter type. The harmonic content of the transmitter signal may be checked by listening on the multiples of the operating frequency with a good VHF receiver, or by building a crystal "harmonic checker." The circuit of a simple device which fulfills this requirement is shown in Fig. 4. It consists of a parallel L-C circuit which tunes to the low TV frequencies and which is link coupled to a crystal rectifier and indicating meter. The tuned circuit must be calibrated in frequency so that harmonics may be identified. Several of the commercial absorption wavemeters may be used for harmonic checking by the addition of the crystal indicating circuit. Alternatively, a grid-dip meter of the type which has provisions for operating the oscillator tube as a diode detector may be employed for locating harmonics.

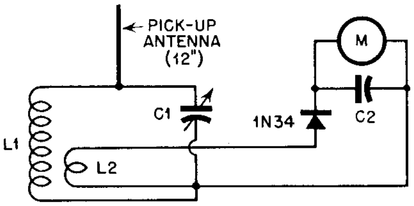
The harmonic checker should be loosely coupled to the output of the transmitter and a systematic search for spurious frequencies made. The sensitivity of the indicator will be better if a low range microammeter is used. The frequency of all signals detected, other than the carrier, should be carefully tabulated, since this information will prove of value in determining filter requirements.

If *any* radiation is detected in the television bands, a filter between the transmitter and the antenna is necessary. Ideally, this filter should be a unit which transmits the amateur frequencies without loss, while present-



R.F.C. – 5 to 10 MICROHENRIES, V.H.F. CHOKE
C1,C2,C3 – .001 to .01 MFD. (SEE TEXT)

SHOWING METHOD OF FILTERING TRANSMITTER D.C. LEADS
FIG. 3



C1 – 25 MMFD. MIDGET VARIABLE
C2 – 50 MMFD. (Aerovox Type 1468)
L1 – 8 T. No.12, ½" I.D. X 1" LONG
L2 – 2 T. No. 18 D.C.C. WOUND OVER L1
M – LOW RANGE CURRENT METER

CRYSTAL HARMONIC CHECKER
FIG.4

ing infinite attenuation to all TV band frequencies. Actually, these conditions may be approached with modern low-pass filters of the "m-derived" type. With such networks of relatively simple design it is possible to obtain attenuations greater than 100 db. at all television frequencies. If high quality components are used, the "insertion loss" in the amateur bands below 30 mc. may be less than .2 db. In addition, the attenuation at any given frequency within the rejection band may be "peaked up" by special design. In this way, added attenuation may be provided at specific frequencies where harmonic output is greatest.

A practical low-pass filter for use with amateur transmitters is shown in Fig. 5. This network starts attenuating at 45 mc. and should provide over 65 db. attenuation at all frequencies above 55 mc. It consists of four sections; two series m-derived end sections, one constant-K type intermediate section with maximum rejection at infinite frequency, and one series m-derived intermediate section with maximum attenuation at 71.25 mc. The filter is designed for use with shielded coaxial transmission line having 52 ohms characteristic impedance. The problems associated with transmitter shielding and output filtering are appreciably simplified if shielded cable is used.

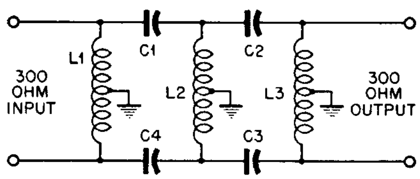
The filter is assembled in a suitable metal shield can having a tight-fitting cover. The transmission line enters the filter box through coaxial cable connectors which are soldered solidly to the metal box for perfect shielding. The lay-out of the parts is approximately as indicated in the schematic (Fig. 5). The capacitors are small air-padders which have sufficient spacing for the power to be handled. They should be adjusted to the capacitance values indicated in Fig. 5. All coils are self-supporting and must be kept one diameter away from other metal objects to insure accurate inductance values. The coil lengths specified in Fig. 5 are measured between the ends of the first and last turns. Lead lengths should be limited to about one-half inch.

The completed filter should be tested for proper functioning. A rough check may be made by exploring the frequency range near the intended cut-off frequency by means of a signal generator coupled to the input of the filter and an indicating device coupled to the filter output. If sufficient output is available from the signal source, a 50 ohm terminating resistor may be placed across the filter output and the power in it monitored with the crystal harmonic checker. The power transmitted through the filter should drop very abruptly at 45 mc.

TVI Reduction at the Receiver

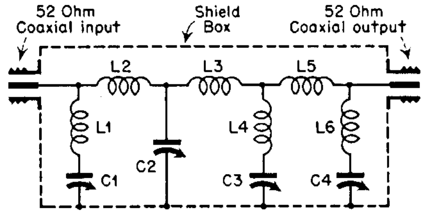
A transmitter of another service may cause television interference even though its signal is in accordance with the best engineering practices. If it is located in the immediate vicinity of the TV set, as is usually the case with amateur transmitters, it may produce picture interference by overloading the TV receiver front-end and so produce local harmonics. This, of course, is not the fault of the transmitter, be it amateur or commercial. It is merely a consequence of the close spacing between the transmitter and the receiver, and of certain deficiencies in the TV set front-end design. Most receivers now incorporate one or two high-pass filter sections between the antenna terminals and the first r.f. or mixer stage. This filter is intended to prevent the passage of strong, low-frequency signals into the tuner, but to accept the TV signals.

In many cases, where the TV antenna intercepts a very strong low-frequency signal, the built-in high-pass filter may not provide adequate attenuation to prevent interference of the "overloading" type. It usually becomes the responsibility of the TV



C1,C2,C3,C4 – 20 MMFD. MICA (Aerovox Type 1469)
L1, L3, – 23 T. No.24 E., 3/16" I.D. CLOSE WOUND
L2 – 11 T. No. 24 " " " " "

HIGH-PASS FILTER FOR TV RECEIVER
FIG.6



C1,C4 – 41 MMFD. (50 MMFD. AIR PADDER)
C2 – 136 " (150 " " ")
C3 – 106 " (150 " " ")
L1,L6 – 4 T. No.12 E. ½" I.D. X ½" LONG
L2 – 5 T. No.12 E. ½" I.D. X ⅝" LONG
L3 – 6 T. No.12 E. ½" I.D. X 13/16" LONG
L4 – 4 T. No.14 E. ¼" I.D. X ⅝" LONG
L5 – 5 T. No.12 E. ½" I.D. X ¾" LONG

LOW-PASS TRANSMITTER FILTER
FIG.5

service technician to diagnose this trouble and to provide a cure. For this purpose several additional sections of high-pass filter may be necessary. Such filters are available commercially or may be made up. A typical design is detailed in Fig. 6. This filter is a balanced configuration for 300 ohm "twin-lead" and is of the double pi-section type. It is designed to have a high-pass cut-off at about 53 mc. so as to provide maximum attenuation to all amateur frequencies up to the ten-meter band (30 mc.).

The high-pass receiver filter should be constructed in a metal box similar to that described for the low-pass transmitter filter. Complete shielding is not too important in this case, since unshielded transmission line is used. High quality components should be selected. The capacitors should be of the silvered mica* variety. Two 10-micromicrofarad units may be used in parallel to form the required capacitance value and to minimize lead inductance. The coils are close-wound on a three-sixteenth inch low-loss form and are center-tapped by twisting a half-inch loop in the center turn of each. These loops are then tinned and soldered to ground, leaving a quarter-inch lead. All coils should be mounted at least one inch apart to avoid coupling.

Receiver interference of the "i.f. channel" type mentioned above will also be reduced by the high-pass filter if it is being picked up by the antenna. However, interference of both this type and the "overloading" type may gain access to the receiver through the power line, or by exposed wiring in the receiver. In such cases, a low-pass line filter of the type shown in Fig. 2 should be used. It may also be necessary to improve the receiver shielding by adding a bottom plate to the chassis.

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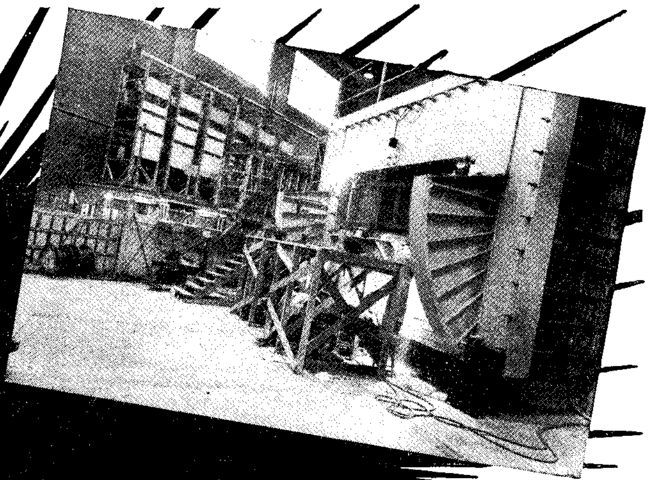
*Aerovox Type 1469.

ATOM SMASHING with AEROVOX CAPACITORS



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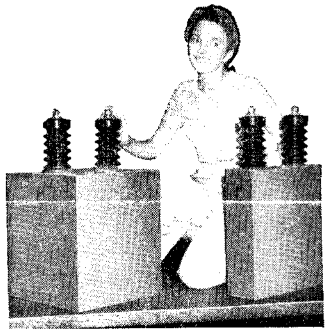

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