FM Blanketing Interference: A Case Study of Problems and Solutions for a Typical High Power FM Station

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ABSTRACT

FM broadcast stations in urban areas often operate from transmitter sites which are either surrounded by residential development or are being encroached upon by residences. Within the area close to a high power FM transmitting facility blanketing interference is very likely, affecting radios, television sets, and other consumer electronic devices exposed to the high field strength levels produced by the transmitter. This paper describes the FCC's rules and policies with respect to blanketing interference, the kinds of consumer electronic equipment typically affected by blanketing interference, the types of interference produced within the blanketing contour, and the technical and "public relations" measures which have been effective in ameliorating the effects of blanketing interference.

INTRODUCTION

Blanketing interference is a general term which refers to the interfering effects of very strong AM, FM or TV signals produced in the vicinity of a high power transmitter. One of the symptoms of blanketing interference is the disruption of the normal operation of radio and television receivers by a strong signal, which blocks the reception of other signals--hence the term "blanketing". As the term has come to be applied in specific cases, it actually describes several specific types of interference mechanisms which occur in the presence of a high level of radio frequency energy. These include: receiver front-end desensitization, production of intermodulation and other spurious products in receiver front-ends or in non-linear junctions (power and phone lines, chain link fences, tower members, etc.) near the transmitter; and rectification and detection of radio frequency signals in audio circuitry. The interference produced in the blanketing area can affect a wide range of electronic devices normally found in residences, including television receivers; AM, FM and shortwave radios; stereo and "home theater" equipment; intercoms; telephones (both wired and wireless), and computer equipment. Blanketing interference can both prevent the reception of desired radio and TV signals and cause undesired signals to be introduced into home electronic equipment (e.g. broadcast audio on a homeowner's telephone).

The typical blanketing interference problems and solutions described in this case study were drawn from the author's experiences in resolving blanketing interference complaints for Non-Commercial FM station KVTI(FM), Tacoma, Washington.

FCC RULES AND POLICIES

The FM Blanketing Rule

The present FM blanketing rule, §73.318, was adopted in October 1984, by Commission action in Docket 82-186; the rule became effective January 1, 1985. The pertinent part of the §73.318 reads as follows:

> *(b) After January 1, 1985, permittees or licensees who either (1) commence program tests, or (2) replace their antennas, or (3) request facilities modifications and are issued a new construction permit must satisfy all complaints of blanketing interference which are received by the station during a one year period. The period begins with the commencement of program test, or commencement of programming utilizing the new antenna. Resolution of complaints shall be at no cost to the complainant. These requirements specifically do not include interference complaints resulting from malfunctioning or mistuned receivers, improperly installed antenna systems, or the use of high gain antennas or antenna booster amplifiers. Mobile receivers and non-RF devices such as tape recorders or hi-fi amplifiers (phonographs) are also excluded.*

For purposes of administrative convenience, §73.318 (a) defines the area within which blanketing interference will be assumed to occur as the area within the 115 dBu/m contour. A licensee's financial responsibility for the resolution of complaints applies only to those

complainants who reside within the 115 dBu/m blanketing contour. Following the one year period, and for complainants who reside outside the blanketing contour, station licensees are obligated to provide "technical information or assistance to complainants on remedies for blanketing interference".

FCC Response to Blanketing Complaints

Over the past several years, the Commission has become increasingly assertive in its enforcement of the FM blanketing rule, largely in response to complaints from neighbors who have been affected by the operation of new FM facilities in locations where high power transmitters did not previously exist. In at least one case, the neighbors retained legal counsel in Washington to represent their interests before the FCC.

Two recent cases illustrate the importance of resolving blanketing interference problems and the potential consequences of an inadequate response to blanketing interference complaints. In Calvary Educational Broadcasting Network, Inc., an FCC Administrative Law Judge imposed a one-year license renewal term, accompanied with strict compliance and reporting requirements, on KOKS(FM), Poplar Bluff, Missouri. This action was later affirmed by the Review Board (9 FCC Rcd, 6412, 11/2/94). In the case of WRQI(FM), South Bristol Township, NY, the Commission staff ordered the station to abandon its construction permit site and to move back to its original licensed site. The station had operated from the CP site for four years and had not resolved all blanketing interference complaints to the satisfaction of either the neighbors or the FCC during that time.

Consumer Equipment Covered by §73.318

There are ambiguities in the language of §73.318 which leave open to question the specific types of consumer electronic equipment included in the blanketing station's area of responsibility. "Mobile receivers and non-RF devices" are specifically excluded by §73.318, but one must look to the Commission staff's actions in specific cases to determine how these exclusions will actually be applied. Based on the record in the KOKS(FM) case and on the Commission's official correspondence with WRQI and KVTI, it appears that any piece of equipment which contains a radio or television tuner and which is capable of being plugged into an AC outlet is considered to be covered by §73.318. This includes "boom boxes" and other portable stereo systems which may also operate from battery power supplies.

Telephones - Telephones, both hard-wired and wireless, are not protected under §73.318. In a letter to the legal counsel for WRQI (1800B#-MJF/RDG, July 14, 1994), the Commission staff's position with respect to telephones is very clearly stated:

> *Hard-wired telephones are considered non-RF devices under §73.318 and as such are not covered by this rule. Cordless telephones are covered by Part 15 of the Commission's Rules. Section 15.5(b) states, in pertinent part, that cordless telephones may not cause harmful interference and that interference to cordless telephones caused by the operation of an authorized radio station must be accepted. (P. 16*)

RF Devices with Non-RF Components - With respect to devices which contain both a radio receiver and a tape recorder (a common configuration for "boom-boxes" and modern component stereo systems) it is not clear from the record what the requirements of §73.318 are with respect to the tape recorder. Has the station satisfied the requirements of the rule if the radio portion of the unit functions normally? As a practical and "political" matter, apart from the question of compliance with the rule, it is clearly in the station's interest to resolve the interference to both the radio and the tape player.

VCRs and Camcorders - According to the current edition of FOB Bulletin No. 16, FM Interference to TV and FM Radio Reception, March 1991, VCRs are not subject to the requirements of §73.318:

> *You can sometimes hear FM radio signals on telephones and other home electronic entertainment equipment, such as Video Cassette Recorders (VCRs), stereos, and recording devices. The Commission offers no interference protection for these devices. Therefore, you should contact your dealer or manufacturer for assistance. (Page 4)*

However, in both the WRQI and KVTI cases, the Commission staff has considered VCRs to be protected under §73.318. Therefore, based on the more recent interpretations of §73.318 by the Commission staff, VCRs are subject to protection. Camcorders are specifically excluded from protection under §73.318, according to the Commission's correspondence with KVTI.

Technical Information and Assistance

The technical information and assistance provided to residents outside the blanketing contour and those who complain after the one-year period must be specific enough to allow the complainant to understand how to resolve blanketing interference problems to specific

equipment (i.e., how to install filters, ferrite cores, etc.). In the event that the corrective measures are not successful, the station must recommend replacement equipment which is less subject to interference.

A CASE STUDY: KVTI(FM)

KVTI(FM), Tacoma, Washington, is a Class C1 non-commercial FM station licensed to Clover Park Technical College. It operates with an effective radiated power of 51 Kilowatts (H & V). Its antenna (a 4-bay Jampro JSCP) is side-mounted on a uniform cross-section guyed tower with its radiation center 70 meters above ground level. The KVTI transmitter site is located in a residential neighborhood, at the south end of the campus of Lakes High School in Lakewood, Washington. There are residences located within 150 feet of the base of the KVTI tower. The KVTI 115 dBu/m blanketing contour extends 1.75 miles from the base of the tower.

The KVTI tower is located about 55 kilometers from the Seattle area FM and TV transmitter sites on Cougar Mountain, Queen Anne Hill, and Capitol Hill; about 60 kilometers from the FM broadcast site on West Tiger Mountain; and about 46 kilometers from the Channel 13 and Channel 20 transmitter sites on Gold Mountain. The majority of the off-the-air FM and TV signals available in Lakewood are from the Seattle area transmitter sites.

The station began operating from this transmitter site in May of 1991. Even before going on the air, the station initiated a program designed to resolve interference complaints, using the services of a local TV-radio service shop. Since the station initially went on the air, more than 100 complaints related to blanketing interference in the vicinity of the KVTI site have been resolved. In April of 1994, a group of neighbors living in the vicinity of the KVTI site filed a petition with the FCC, complaining of blanketing interference from KVTI.

In response to the petition, the Commission sent a letter (1800B3-MJF, dated August 22, 1994) to KVTI requiring the station to resolve 20 “previously referred” unresolved complaints and to provide “effective technical assistance” to 46 new complainants whose names were listed in the petition. The letter also required KVTI to submit a detailed report regarding the resolution of the complaints, including maps showing the locations of all the affected residences. The majority of the new complainants listed in the petition had never contacted KVTI prior to signing the petition.

Clover Park Technical college retained Hatfield and Dawson as project manager to help resolve the interference complaints and to prepare the report to the FCC. Mr. Joseph N. (Nick) Winter, Jr. of Broadcast Services Northwest was also retained by the College to assist with the field work and to carry out the station’s program of continuing assistance for neighbors with interference problems. The author, Mr. Winter, and Mr. Stephen Lockwood, P.E. of Hatfield & Dawson performed all the site visits and equipment tests required for the project.

The blanketing interference symptoms described in this paper and the techniques used to ameliorate them are based on what we learned in our visits with the residents of Lakewood.

Affected Equipment, Symptoms of Blanketing Interference, and Measures Employed to Ameliorate Interference

Described below are the types of equipment found to be susceptible to various forms of blanketing interference and the corrective measures which were successfully used to ameliorate the interference:

! **Television Receivers** - A wide range of television receivers were affected by blanketing interference, ranging from 5" portable models to 48" projection TVs. Many households had a number of affected TV’s; some households had as many as 12 affected receivers, often with accompanying VCR’s. TVs connected to off the air receiving antennas or using “rabbit ears” were usually most severely affected when tuned to channels 4, 5, and 7. The effects of the interference ranged from very slight “fuzziness” in the picture to a “herringbone” pattern in the video. In the most extreme cases, the herringbone pattern completely obliterated the picture. In some cases, audio from the radio station could be heard on the TV speakers. The severity of the interference depended upon the D/U ratio between the desired TV signal and the undesired blanketing signal.

TVs connected to the cable system often exhibited similar symptoms to those connected to off-the-air antennas, depending upon the level of the blanketing signal leaking into the cable distribution system. In addition, TVs connected to home cable systems used to feed multiple sets from a single CATV drop often exhibited mild to moderate herringbone patterns on cable channels 8 and 34 (corresponding to the frequency of the 2nd harmonic and 3rd harmonic of the FM station). Measurements at the FM transmitter demonstrated that the signals producing this interference were not being radiated directly by the transmitter. This type of interference appeared to be produced by spurious products produced in non-linear junctions in the cable feed systems, in external metallic junctions (power lines, phone lines, metal fences, etc.), or in the front ends of other TV receivers connected to the

cable feed system. The only effective techniques we found to correct these problems were to increase the level of the desired signals on channels 8 and 32 and/or to replace the television set with a model less susceptible to this type of interference.

In nearly all cases, the installation of a Microwave Filter Company 5KFM-90.9 notch filter at the RF input connector of the TV and a Fair-Rite 04433164151 "clip-on" ferrite core or a Fair-Rite 5943003801 toroid core on the AC power cord eliminated the interference. (This technique was not effective for the channel 8 and channel 32 interference, since it was produced by a spurious signal on a frequency far outside the range of the notch filter, and because the use of a notch at the channel 8 or channel 32 frequencies would have eliminated the desired signals as well.) In some cases, the interference could not be eliminated using these techniques, and the TV had to be replaced with a new model known to be less susceptible to interference. Most of the TV's which had to be replaced were older models without an "F" connector integral to the tuner module. These TV's were usually overloaded by the FM radio frequency energy entering the tuner directly through the TV's case.

Figure 3 shows the installation details for the filters and toroid cores. Drawings similar to those in Figure 3, along with detailed written instructions were provided to complainants as part of a "handbook" prepared by our firm, which describes how to resolve common blanketing interference problems.

! **VCRs**-The interference effects observed in VCR tuners were very similar to those observed in TVs. The same remedial measures used for TVs were successfully used for VCRs. In many cases, the VCR tuners were less susceptible to interference and produced better picture quality than TV receivers of the same vintage. It was not necessary to replace any VCRs in the blanketing area.

! **Home CATV Cabling** - Many of the households we visited had extensive internal cable distribution systems, often using a single feed from the cable company and multiple splitters to feed as many as 10 TV receivers. This resulted in very low TV signal levels at the "downstream" end of these systems, which made the receivers connected to the cable much more susceptible to interference from the strong FM signal. In many cases, even replacing the cable in these systems with double-shielded coax did not reduce the level of the FM signal leaking into the system to eliminate the interference. In these cases, powered splitters were installed to increase the level of the desired TV signals at the downstream receivers. Notch filters were installed at the input of the powered splitter to prevent amplifier overload by the strong FM signal, as shown in Figure 3.

! **Rooftop Antennas** - In a several cases, rooftop antenna systems had to be modified to increase the level of desired TV signals and/or to reduce the level of the interfering FM signal entering FM and TV receivers. 300 ohm twinlead downlead connections were replaced with double-shielded coax and splitters were added in place of parallel-connected downleads. These modifications both helped to reduce the interference and improved the signal quality at the TV receivers.

! **AM/FM/Shortwave Radios and Boomboxes -** The strong FM signal did not affect the operation of the Broadcast Band AM tuners in most radios; a significant level of 60 Hz power line noise in the neighborhood tended to limit the availability of AM signals to those with high signal strength. The FM tuners in many boomboxes, inexpensive "all-in-one" component stereo systems, and a significant number of quite expensive FM component receivers exhibited symptoms of receiver desensitization, intermodulation, and the production of multiple images of the blanketing station. On most receivers, these effects were observed below about 93 MHz on the FM band, but in some cases, the entire FM band was wiped out.

On receivers with coaxial antenna connectors, the installation of a notch filter usually eliminated the interference effects. Receivers with 300 ohm twinlead antenna connectors proved to be more of a problem, though it was frequently possible to use a combination of two 300/75 ohm baluns and a notch filter to restore the normal operation of the receiver with a 300 ohm twinlead antenna.

In many cases, even after the FM tuner section of a system was restored to normal operation, the FM station's detected audio could still be heard in the tape player output or in the power amplifier of a component system. These problems could usually be solved by the installation of ferrite cores on the AC power lead, the speaker leads, and all the audio interconnections in a component system. Figure 4, also taken from the "handbook", shows the installation details for the ferrite cores. In some cases, even these measures were unsuccessful, and the receiver or compact component system had to be replaced with a unit less susceptible to interference.

Boomboxes were an especially difficult problem, since many models have either a telescoping monopole external antenna or use the AC power cord as an antenna. Also, most boomboxes have plastic cases which provide little or no shielding against unwanted RF signals. In some cases, where the tuner section of the boombox functioned normally, but the tape player or the amplifier section suffered from RF rectification, it was possible to restore

normal operation by installing ferrite cores on the speaker leads and the AC power cord, as shown in Figure 4.

We encountered several boomboxes with AM/FM/Shortwave tuners (there are many retired military residents of Lakewood, and these receivers had all been imported from overseas). The shortwave sections of these tuners were universally obliterated by the strong FM signal. These units were replaced with separate shortwave radios and AM/FM boomboxes.

! **Intercoms** - These units tended to suffer mainly from RF detection in their amplifier sections, which was relatively easy to eliminate by the installation of ferrite cores on the speaker and remote unit leads. One unit which included an integral radio was more difficult to deal with because it did not have any kind of external antenna, and did not have any obvious connection between the tuner circuit board and the outside world. This unit required some custom modification.

! **Clock Radios** - Surprisingly, some clock radios functioned normally in the high ambient RF field, and others had severe problems. Since these units all had plastic cases and most did not have external antenna connectors, the only available remedial measure for affected radios was to replace them.

! **Telephones** - Although telephones are specifically excluded from protection under §73.318, complaints about telephone interference comprise the single largest category in blanketing interference areas. Because the telephone is used often on a daily basis, the presence of a radio station's audio in the background on the phone is a constant irritant which will generate ill will in the neighborhood surrounding an FM transmitter site. In all cases we encountered it was possible to eliminate audio rectification in telephones by installing filters fitted with the appropriate modular connectors at the line cord and the handset cord of the telephone. We used filters custom manufactured by Coilcraft. In some cases, it was also necessary to install a clip-on ferrite core on the line cord or headset cord of the phone close to the body of the phone in order to eliminate the interference.

Some cases of telephone interference were produced by the 1 kW daytime AM station which operates from a transmitter site at the north end of the Lakes High School campus. Because residents did not tend to distinguish one form of radio interference from another, the most expedient solution to this problem, was the installation of appropriate filters designed to attenuate medium wave frequencies.

Most cordless telephones did not suffer from blanketing interference. The majority of the cordless phones in the Lakewood area were models manufactured by GE and Southwestern Bell.

Other Sources of Interference

Several other sources of interference to radios and TVs were identified during the site visits. It is important to identify and categorize the effects of these other sources because residents affected by blanketing interference do not have the technical background or any means of distinguishing various forms of interference, and tend to attribute all interference to the FM station.

! **AM Radio Stations** - On some AM tuners, the strong local signal from the daytime AM station produced intermodulation products which appeared at several locations on the dial. Turning the FM transmitter on and off had no effect on these products.

! **Power Line Noise** - Some residents lived adjacent to a power utility substation in an area which was located behind a small hill and was shadowed from all the Seattle area TV transmitter sites. The 60 Hz noise level in this neighborhood was especially severe in this neighborhood, especially after long periods with no rain increased the level of corona discharge across high voltage insulators in the power distribution system. The low-band VHF TV signals received off-the-air in this neighborhood were very noisy; even after on/off tests were used to demonstrate that this interference was not caused by the FM station, complaints were still received about this type of interference.

! **Touch Lamps and Light Dimmers** - One residence had several "touch lamps" which used a capacitive touch switch in the base of the lamp as an on/off switch. When these lamps were turned on they produced fairly high level noise pulses spaced about 100-150 KHz intervals from the VLF band up through 20 MHz. The noise produced by these lamps severely disrupted reception on medium wave and shortwave radios, showing up as a loud buzz at regular intervals across the operating band of the receiver. At first, this interference appeared to be produced by the FM station, because when a shortwave radio was tuned to a frequency occupied by one of the noise pulses, turning off the FM station appeared to cause the interference to go away. Further investigation using a spectrum analyzer revealed that turning the FM transmitter on and off merely shifted the frequency of the entire noise pulse spectrum generated by the touch lamps, but that it did not affect the amplitude of the RF noise these devices produced. With the FM transmitter turned off, it was possible to retune the affected receiver and to find the interference at its new frequency.

SCR light dimmers produced a similar noise pattern, but it was much less severe than the noise produced by the touch lamps.

Signal Measurement Procedure Used During Site Visits

At each household, detailed note sheets were made for each piece of equipment, and, for the majority of the households, spectrum analyzer measurements were made showing the received television signal strength levels and the FM signal levels provided by outdoor receiving antennas or by the local cable system. The signal level measurements were made in as many cases as possible to provide data regarding the level of television signal strength required at typical television sets to overcome the effects of interference from the strong FM signal. In many cases a measurement was made of the ambient KVTI field strength in the vicinity of the equipment affected by blanketing interference. The measured KVTI (FM) field intensity inside homes in the blanketing area ranged from 100 mV/m in houses located more than a few thousand feet from the transmitter site to more than 1 V/m in houses located immediately adjacent to the KVTI tower.

Quality of Off-the-Air TV Signals in Lakewood

Our measurements and site visits showed that off-the-air television reception in the absence of FM blanketing interference from was adequate (though generally not what one would call a high quality signal) in some areas of Lakewood using a pair of "rabbit ears" mounted on top of the TV set. In other areas, reception was sometimes poor to totally unusable, even with a rooftop antenna.

Both the measurements and the observations of the quality of received TV signals showed that there was a very pronounced diurnal (day-to-night) variation in the strength of both the TV and the FM signals from the Seattle broadcast transmitter sites on Queen Anne Hill, Capitol Hill, Cougar Mountain, and West Tiger Mountain. Given the distances between the transmitter sites and the receiver locations, the nature of the intervening terrain, and the fact that none of the receiver locations had adequate Fresnel zone clearance from the Seattle FM and TV transmitter sites, these variations were not entirely surprising.

At some locations, the change in propagation conditions from mid-day (when the air near the surface was well mixed) to early morning or late afternoon or evening (when the air tended to be more stratified) was significant to change the video and audio signal quality of the TV signals from good quality typical of a line-of-sight path to very noisy and "ghosty" poor quality typical of a diffraction path. This type of variation even caused all but a few of the available Seattle FM station signals to drop below the muting threshold of one FM receiver as day changed to night.

Notch Filter Characteristics

Microwave Filter Company 5KFM-90.9 notch filters were used to attenuate the KVTI signal at the input to TV and FM receivers. These filters have a 60 dB notch and a 3 dB bandwidth of +/- 3 MHz, so they can be used with minimal detrimental effect on the other off-the-air FM signals or on the Channel 6 aural carrier in cable systems. A spectrum analyzer plot of the frequency response of this filter is shown shown in Figure 1:

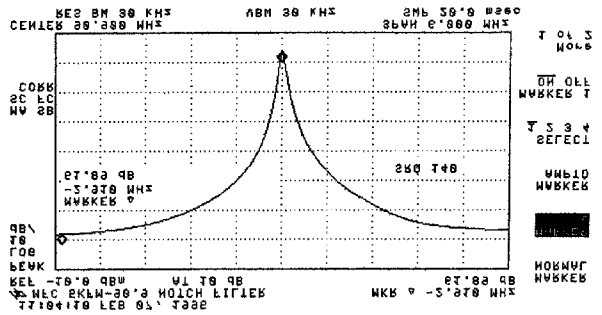


Figure 1 - MFC 5KFM-90.1 Filter Response

For purposes of comparison, the frequency response of a Radio Shack FM Trap (Part # 15-577), which has sometimes been used (often unsuccessfully) to attempt to mitigate blanketing interference is shown in Figure 2:

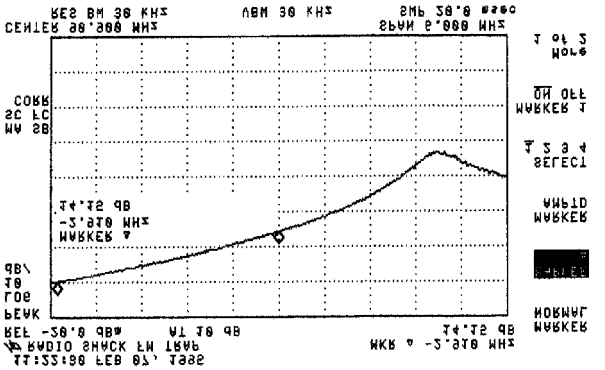


Figure 2 - RS FM Trap Frequency Response

As shown in Figure 2, the Radio Shack FM trap has less than 15 dB of rejection relative to the 3 dB point of the MFC notch filter, while the MFC notch provides more than 60 dB. The RS FM trap also has a relatively high insertion loss, has nearly 10 dB of amplitude response variation over the band occupied by Channel 6, and tends to degrade the quality of TV signals in low signal environments.

Tests of TV and Radio Receivers

Prior to making site visits with replacement equipment, a number of TV and radio receivers were tested at or near the KVTI transmitter site to determine which units were likely to function well in the high level RF field environment of the blanketing area.

The results of the TV receiver tests are shown in Tables 1 and 2. Table 1 shows the interference caused to each receiver when connected directly (with no filters) to a test receiving antenna at the KVTI transmitter site. Table 2 shows the reduction in interference for each receiver which resulted from the installation of an MFC 5KFM-90.9 notch filter between the antenna downlead and the antenna input connector on the TV. Based on these measurements, the best four out of six receivers were selected for use as replacement TVs in households in the blanketing area. Although it is not shown in the data, a further reduction in interference caused to some of the TVs resulted from winding several turns of the antenna downlead through a toroid core before connecting the downlead to the MFC filter. This reduced the level of RF energy conducted along the coax cable shield, which eliminated some residual interference effects in some cases. Even though two out of the six TVs had some problems at the KVTI transmitter site, we found in general that most modern TV receivers can be made to function correctly in the blanketing environment if appropriate filters and toroids are used and if a desired signal of adequate level is provided at the receiver antenna input.

Several AM/FM boomboxes and micro and mini component stereo systems were also tested in advance of installation in households. All the radios tested had digital tuning indicators and synthesized tuners. The following units were found to operate well in the blanketing environment:

- JVC PC-X105 AM/FM/Dual Cassette/CD
- JVC RC-QS11 AM/FM/Cassette/CD
- JVC UX-T1 AM/FM/CD/Cassette Micro Component System
- Sony MHC-450 AM/FM/CD/Cassette Micro Component System
- Samsung SCM-8300 AM/FM/CD/Cassette Mini Component System (with RIAA phono inputs)

The Samsung unit was used in cases where a system with a turntable needed to be replaced. Shortwave receivers were replaced with a Grundig YB-400 “Yachtboy” portable model. A larger and more expensive Grundig model did not function adequately in the blanketing environment.

Establishing and Maintaining Good Public Relations

Efforts to resolve blanketing interference complaints can be most successful if the following general guidelines are followed:

- Set up a system for receiving and tracking complaints before you turn on the transmitter at a new site.
- Retain experienced and competent technical help; sending out inexperienced people who do not know how to resolve interference problems will only cause more problems later.
- Document everything you do.
- Communicate with the neighbors; let them know what you are doing to resolve their problems; follow up after site visits.
- Don’t minimize your complainants problems or attempt to blame them on the equipment they are using. Put yourself in their shoes.
- Go the extra mile; even if you are not required by the Commission’s Rules to solve every problem, the more problems you actually do solve, the more good will you will generate among your neighbors.

Received Signal			Television Receiver Manufacturer and Model Number					
Off-the Air TV Channel	Measured TV Signal Strength at Receiver (dBmV)	TV/FM D/U Ratio (dB)	Toshiba CF19C20 20 inch TV (August 1993)	JVC C-20CL5 20 inch TV (May 1994)	Hitachi 20MA1B 20 inch TV (October 1993)	Mitsubish CS-20101 20 inch TV (October 1993)	Samsung TTB2012 20 inch TV (April 1994)	Panasonic CF20S2S 20 inch TV (June 1994)
Channel 4	-12.4	-64.6	Good quality video and audio	Severe herringbone on video; audio OK	Severe herringbone on video; audio OK	Picture completely obliterated; audio OK	Severe herring-bone on video; audio OK	Moderate herring-bone on video; audio OK
Channel 5	-11.9	-64.1	Severe herring-bone on video; audio cuts in/out	Severe herring-bone on video; no color; audio OK	Severe herringbone on video; audio OK	Picture completely obliterated; audio OK	Severe herring-bone - no picture; audio OK	Very slight "fuzzi-ness on video; audio OK; ghosts
Channel 7	-10.8	-63.0	Excellent video & audio quality	Moderate herringbone on video; audio OK	Slight herringbone on video; audio OK	Severe herring-bone on video; audio OK	Slight herringbone on video; audio OK	Very slight herringbone on video; audio OK
Channel 9	-5.1	-57.3	Slight herring-bone on video	Severe herringbone on video; color on/off; audio OK	Moderate herringbone on video; audio OK	Severe herring-bone on video--no picture; audio OK	Severe herring-bone - picture just visible in noise; audio OK	Moderate herring-bone; picture at noise level; audio OK
Channel 11	-3.0	-55.2	Excellent video and audio quality	Slight herringbone on video; audio OK	Excellent video and audio quality **(Ch. 12 also OK)**	Moderate herring-bone on video; audio OK	Very slight herringbone on video; audio OK	Very good quality video and audio
Channel 13	0.0	-52.2	Excellent video and audio quality	Slight "fuzziness" on video; audio OK	Excellent video and audio quality	Slight herringbone on video; audio OK	Good quality video and audio	Excellent quality video and audio
Channel 20	-8.0	-60.2	Not tested	Not tested	Not tested	Not tested	Good quality video and audio	Very good quality video and audio
Channel 22	-13.6	-65.8	Excellent video and audio quality	Slight "fuzziness" on video; audio OK	Excellent video and audio quality	No signal; below RX squelch level	Slight herringbone on video; audio OK	Very good quality video and audio
Channel 28	16.9	-35.3	Not tested	Not tested	Not tested	Not tested	Very good quality video and audio	Excellent quality video and audio
KVTI (90.9 MHz)	52.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A

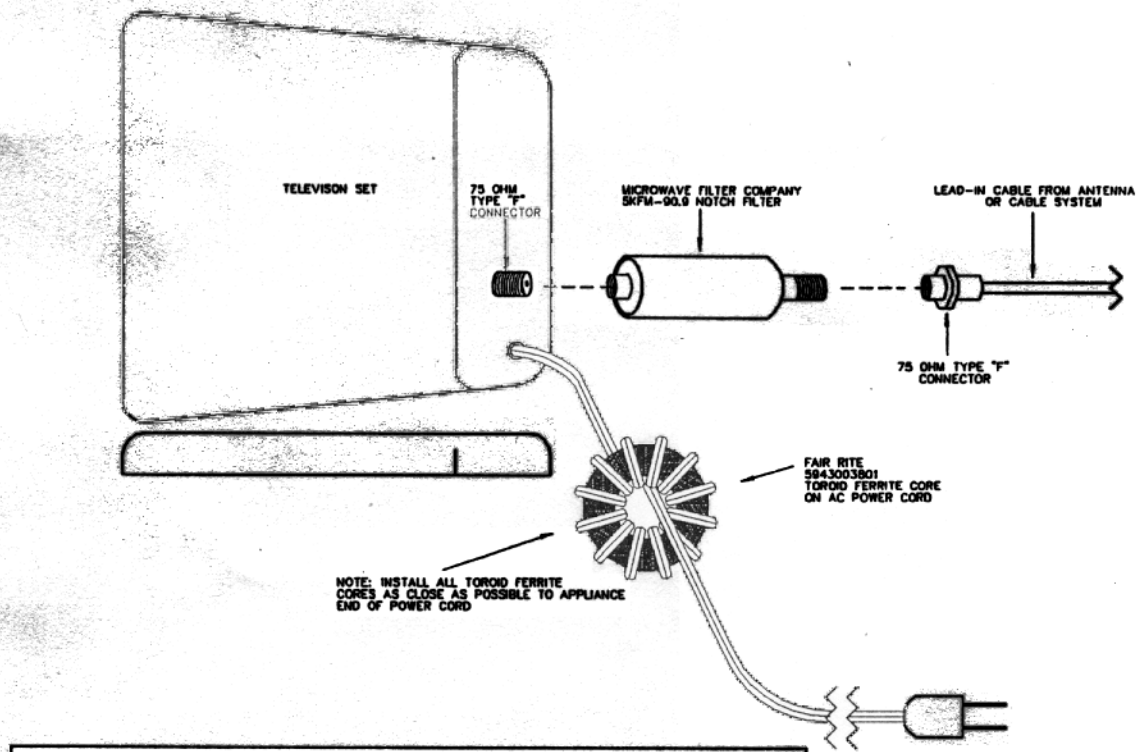
Table 1 - FM Interference to Representative TV Receivers (Direct Connection to Receiving Antenna)

Received Signal			Television Receiver Manufacturer and Model Number					
Off-the Air TV Channel	Measured TV Signal Strength at Receiver (dBmV)	TV/FM D/U Ratio (dB)	Toshiba CF19C20 20 inch TV (August 1993)	JVC C-20CL5 20 inch TV (May 1994)	Hitachi 20MA1B 20 inch TV (October 1993)	Mitsubishi CS-20101 20 inch TV (October 1993)	Samsung TTB2012 20 inch TV (April 1994)	Panasonic CF20S2S 20 inch TV (June 1994)
Channel 4	-12.4	-3.0	Good quality video and audio; some noise on video	Noisy signal; no difference with FM on or off	Good quality video and audio; just perceptible change with FM on	Good quality audio and video; "fuzziness" on video; audio OK	Moderate herring-bone on video; audio OK	Very slight herringbone on video; audio OK
Channel 5	-11.9	-2.5	Excellent video and audio quality	Very high quality video and audio	Very slight "fuzziness" in video	Slight "fuzziness" on video; audio OK	Slight herringbone on video; audio OK	Very slight herringbone on video; audio OK
Channel 7	-10.8	-1.4	Excellent video and audio quality	Good quality video and audio	Very good quality video and audio	Slight "fuzziness" on video; audio OK	Slight herringbone on video; audio OK	Very slight "fuzzi-ness" on video; audio OK
Channel 9	-5.1	4.3	Excellent video and audio quality	Slight herringbone in video; audio OK	Good quality video and audio	Very good quality video and audio	Very slight herring-bone on video; audio OK	Excellent quality video and audio
Channel 11	-3.0	6.4	Excellent video and audio quality	Slight "fuzziness" in video; entering set through case	Very good quality video and audio	Very slight herring-bone in video; audio OK	Good quality video and audio	Excellent quality video and audio
Channel 13	0.0	9.4	Excellent video and audio quality	Slight "fuzziness" in video; entering set through case	Excellent quality video and audio	Very slight herring-bone in video; audio OK	Very good quality video and audio	Excellent quality video and audio
Channel 20	-8.0	1.4	Not tested	Not tested	Not tested	Not tested	Very good quality video and audio	Excellent quality video and audio
Channel 22	-13.6	-4.2	Excellent video and audio quality	Slight "fuzziness" on video; entering set through case	Excellent quality video and audio	No signal; below RX squelch level	Good quality video and audio	Excellent quality video and audio
Channel 28	16.9	26.3	Not tested	Not tested	Not tested	Not tested	Excellent quality video and audio	Excellent quality video and audio
KVTI (90.9 MHz)	-9.4 (with MFC notch filter)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

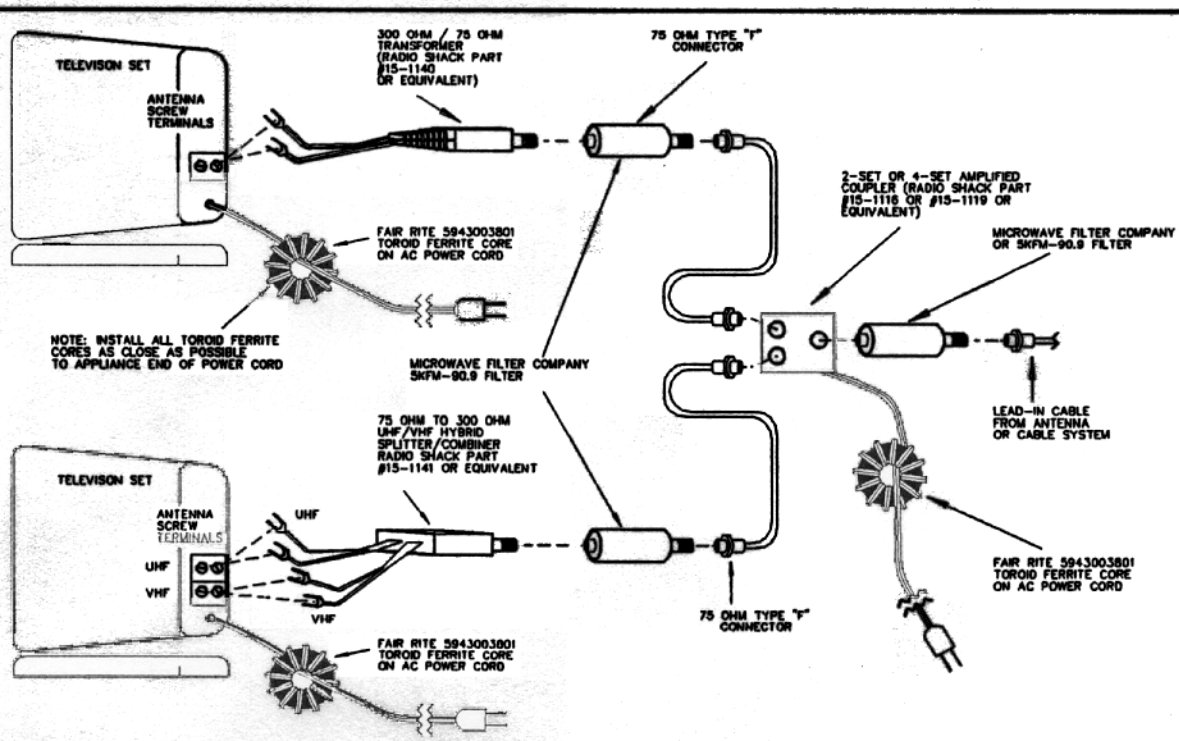
Table 2- FM Interference to Representative TV Receivers (MFC 5KFM-90.9 Notch Filter)

Received Signal			Television Receiver Manufacturer and Model Number					
Off-the Air TV Channel	Measured TV Signal Strength at Receiver (dBmV)	TV/FM D/U Ratio (dB)	Toshiba CF19C20 20 inch TV (August 1993)	JVC C-20CL5 20 inch TV (May 1994)	Hitachi 20MA1B 20 inch TV (October 1993)	Mitsubish CS-20101 20 inch TV (October 1993)	Samsung TTB2012 20 inch TV (April 1994)	Panasonic CF20S2S 20 inch TV (June 1994)
Channel 4	-12.4	-3.0	Good quality video and audio; some noise on video	Noisy signal; no difference with FM on or off	Good quality video and audio; just perceptible change with FM on	Good quality audio and video; slight "fuzziness" on video; audio OK	Slight herring-bone on video; audio OK	Slight "fuzziness" in video; audio OK
Channel 5	-11.9	-2.5	Excellent video and audio quality	Very high quality video and audio	Very good quality video and audio	Slight "fuzziness" in video; audio OK	Slight "fuzziness" in video; audio OK	Very slight "fuzziness" in video; audio OK
Channel 7	-10.8	-1.4	Excellent video and audio quality	Good quality video and audio	Very good quality video and audio	Good quality video and audio	Very slight "fuzziness" in video; audio OK	Very good quality video and audio
Channel 9	-5.1	4.3	Excellent video and audio quality	Very slight "fuzziness" in video; audio OK	Good quality video and audio	Very good quality video and audio	Very good quality video and audio	Excellent quality video and audio
Channel 11	-3.0	6.4	Excellent video and audio quality	Very slight "fuzziness" in video; entering set through case	Very good quality video and audio	Very good quality video and audio	Good quality video and audio	Excellent quality video and audio
Channel 13	0.0	9.4	Excellent video and audio quality	Very good quality video and audio	Excellent quality video and audio	Very good quality video and audio	Very good quality video and audio	Excellent quality video and audio
Channel 20	-8.0	1.4	Not tested	Not tested	No tested	Not tested	Very good quality video and audio	Excellent quality video and audio
Channel 22	-13.6	-4.2	Excellent video and audio quality	Good quality video and audio	Excellent quality video and audio	No signal; below RX squelch level	Good quality video and audio	Excellent quality video and audio
Channel 28	16.9	26.3	Not tested	Not tested	Not tested	Not tested	Excellent quality video and audio	Excellent quality video and audio
KVTI (90.9 MHz)	-9.4 (with MFC filter and torroid core)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

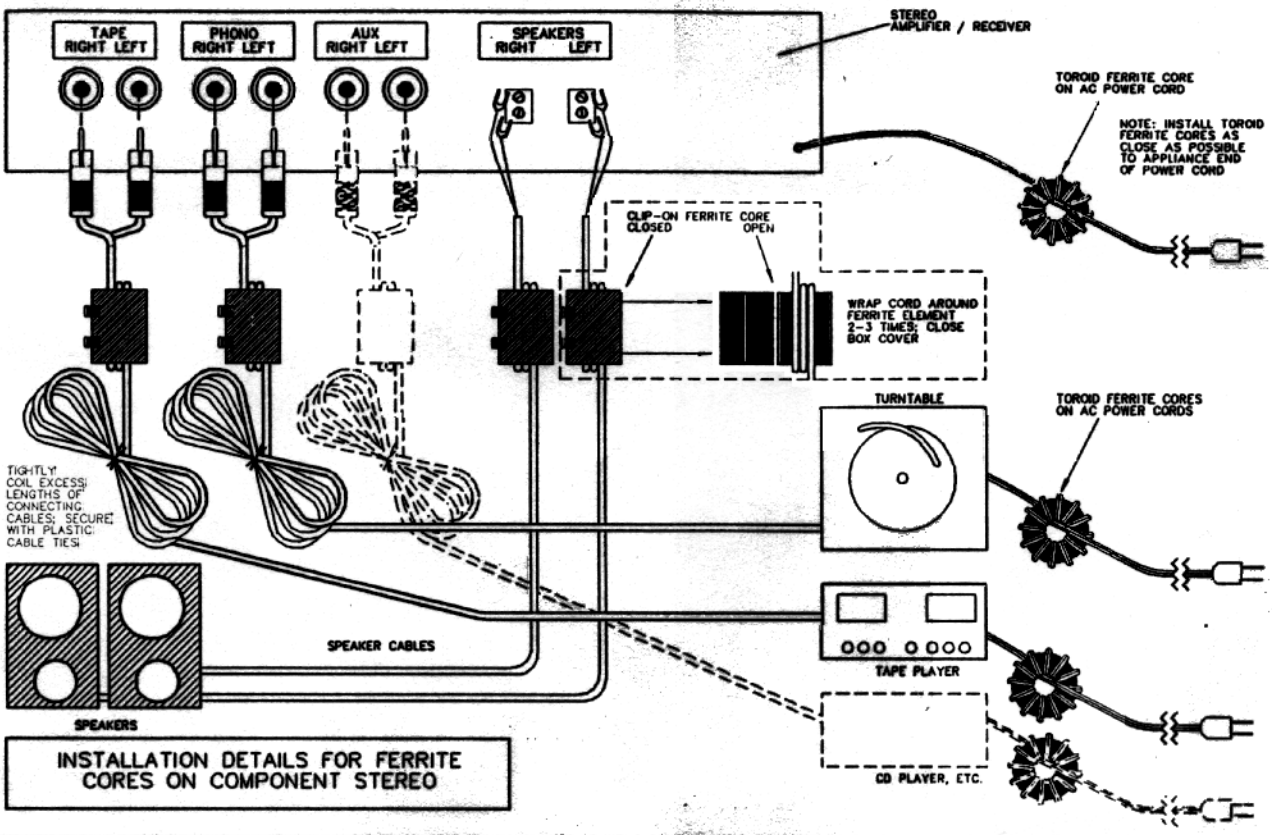
Table 3 - FM Interference to Representative TV Receivers (5KFM-90.9 Notch Filter & Fair-Rite 5943003801 Ferrite Core)



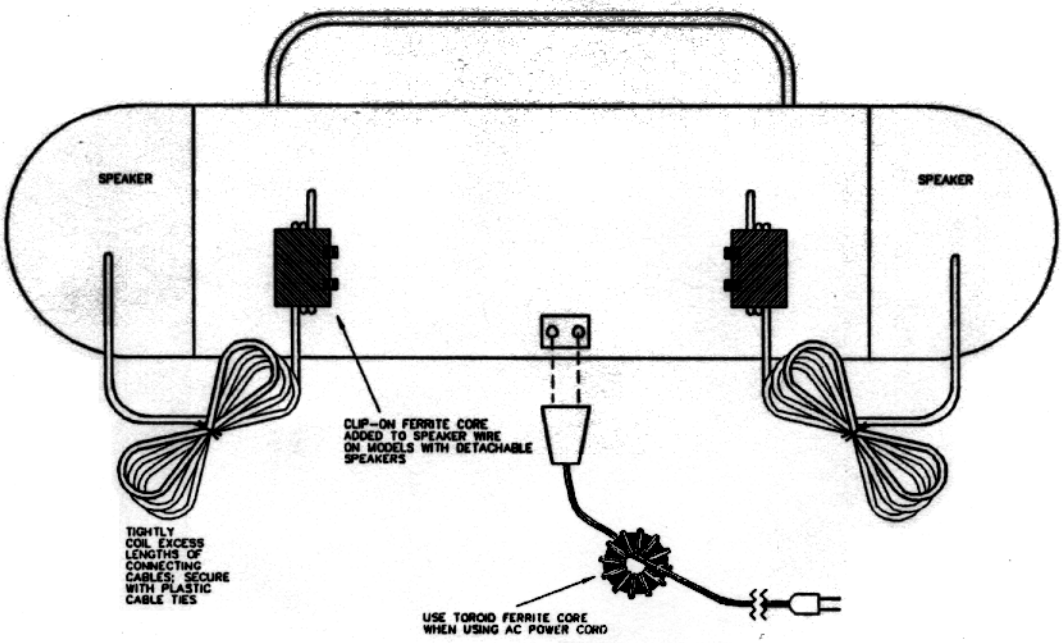
INSTALLATION DETAILS FOR TV FILTERS & FERRITE CORES



HATFIELD & DAWSON CONSULTING ENGINEERS	INSTALLATION DETAILS FOR POWERED TV SPLITTER	FIGURE 3



INSTALLATION DETAILS FOR FERRITE CORES ON COMPONENT STEREO



HATFIELD & DAWSON CONSULTING ENGINEERS	FERRITE CORES AND TOROID FILTER ON PORTABLE STEREO "BOOMBOX"

FIGURE 4