RFI on Cable Channel 18

Chuck Manetta N4YJC August 5, 1991

To: All interested Amateur Radio operators! Distribution: World-wide

On June 11, 1991 I sent out a Bulletin through the Packet Bulletin Board System to "RFI @ ALLUS". This Bulletin was titled "ANY ANSWERS TO PACKET / CABLE 18 RFI YET?". This bulletin was concerning the interference created by Packet Radio to the Cable Channel 18, and vice versa Cable Channel 18 to Packet Radio. The response to this bulletin was nothing short of incredible! In approximately one month, I received in excess of 50 replies from the United States and Canada! A number of these replies were from hams that were very interested in what helpful information I might have found.

This overwhelming response to this bulletin, showed me that there was a major adverse interaction between the Cable Industry and the Amateur community. This caused me to research this problem with more vigor. The answers apply to all amateur VHF operation, in all modes.

I would like to give credit to all of the Amateurs and Professional Consultants who have helped me research this area of interest:

KY6V WB6KGB KB4FOW KA4OPZ N4LDG KP4OO KB4RLL N4VDM N4KWB N4UTO KC4BBM WD8KCT KG6XX KC4IEE WD4DPH KN4QH WB6CBJ WB2NGZ WN4ISX KC4WTX KM4ID KA7CGB KG7FU KA9NME WA2RCB WD4LYV KC2FD WB5BBW N5LDD K2TNN VE7BLZ AA9AW VO1MQ N2KZH VE7CJT VE7HGN N5HOF K0FPC WA2ZKD N8AHK N2DS W0BQH NJ8J KB5MGE W1CDM W9IUP N1CB W4NTG WB7NNF N7MWA KA4JEE WV9J W5NDG N7HFZ K6RAU KB6CYS

Ed Hare KA1CV, Senior Laboratory Engineer for The American Radio Relay League.

Roger Holbeg, Supervisory Attorney, Mass Media Bureau, Enforcement Division of The Federal Communications Commission. Washington DC.

Michael Lance, Electronics Engineer, Mass Media Bureau, Cable Television Branch of The Federal Communications Commission. Washington DC.

Engineers and Personnel from The Federal Communications Commission, Field Operations Bureau. Miami Office.

Thank you all for your help and guidance!

Interference to cable-TV channels from amateur VHF operation.

The problem exists because the cable-television spectrum covers a wide frequency range. It starts down in the low end of the VHF range and continues on through the UHF range. This spectrum, as you know, also includes a number of amateur bands! In theory, the cable system is supposed to be a "closed" system. By "closed", I mean entirely enclosed in shielded cable. No cable leaks out, and no amateur radio leaks in! But in reality we find that this is not true. There are many areas of improper shielding, loose connectors, substandard coax and even the possibilities of RFI or EMI (Electro-Magnetic-Interference) radiating through the cabinets of your TVs or being introduced into your TVs by the cable coax shielding itself!

As amateurs, before we start any investigation into the causes of a case of cable TVI, we should first make sure that our shack is clean. Make sure your equipment is properly grounded. Make sure that your TNC is not over-deviating your radio. Check that your transmission lines are in proper condition. If necessary, apply the needed cures to your own cable-connected television system. This demonstrates that the cures used do work and that they cause no harm.

..PART 2

The television channel is 6 Mhz wide! Any signal transmitted in this 6 Mhz spectrum will cause noticeable interference to a television signal! Even a signal that is 40 dB weaker than the television signal will result in perceptible interference.

There are a number of cable channels that we as amateurs can have problems with. These cable channels roughly, if not exactly, correspond with these Amateur Bands:

Cable 2	[2]	(55.55 Mhz)	=	6 Meters
Cable 17	[D]	(139.25 Mhz)	=	2 Meters
Cable 18	[E]	(145.25 Mhz)	=	2 Meters
Cable 23	[J]	(217.25 Mhz)	=	1.25 Meters
Cable 24	[K]	(223.25 Mhz)	=	1.25 Meters
Cable 64	[UU]	(421.25 Mhz)	=	70 Centimeters
Cable 65	[VV]	(427.25 Mhz)	=	70 Centimeters
Cable 66	[WW]	(433.25 Mhz)	=	70 Centimeters
Cable 67	[XX]	(439.25 Mhz)	=	70 Centimeters
Cable 68	[YY]	(445.25 Mhz)	=	70 Centimeters
Cable 69	[ZZ]	(451.25 Mhz)	=	70 Centimeters

Be advised that there are no stipulated rules as to what channel number designator has to be on what frequency. (This is supposed to be a closed system!) These channels and frequencies may vary from one cable area to the next, although most cable systems use one of three "standard" systems. (The nice thing about standards is that there are so many to pick from!)

This interference can go both ways! In the majority of the cases reported, the interference was caused to the cable by the amateur. But there have been instances where there have been large enough leaks from the cable system to interfere with the amateur! From what I have seen, these instances have been created by either an improperly terminated cable ends (unconnected!), or by customer-installed "illegal" hookups. Rarely, the problem can be caused by a bad cable distribution amplifier or shield break somewhere on the pole cable.

As an example, I was receiving a S9 carrier on 145.250 on my packet radio. My radio was an Icom 28H and I had an 11 element vertical beam at 60 feet. I reported this to my cable company. A few days later they sent out their Engineer and DF Vehicle. I brought him up in my shack and showed him the interference. We used my beam antenna to determine that the interference was coming from a beam heading of 315 degrees (NW). We went to our vehicles and found on that heading, the offending equipment 500 yards away! It was an improperly terminated connector inside someone's house! An illegal hook up! So you can imagine what a bad distribution amplifier outside your window will do! Most of these leaks can be easily located with your HT or a hand held scanner. These are a few frequencies to listen for:

Cable Channel 17 (D) --- Audio at 143.75 Mhz.
Cable Channel 18 (E) --- Video at 145.25 Mhz.
Cable Channel 18 (E) --- Audio at 149.75 Mhz.
Cable Channel 23 (J) --- Audio at 221.75 Mhz.
Cable Channel 23 (J) --- Video at 223.25 Mhz.

With an FM Handi-Talkie or scanner receiver the audio frequencies will seem to be distorted and over deviated , but obviously

audio! On either the FM or AM the video carrier will sound just like an unmodulated carrier.

If leakage from the cable system caused harmful interference, it is the responsibility of the cable operator to eliminate the interference, regardless of the cause. If they determine that the leakage is coming from a subscriber's home, they must, if necessary, disconnect that home until the cause of the interference is found and corrected.

Part 76 of The Federal Communications Commission Rules and Regulations, which governs the Cable Industry, clearly states:

76.613 Interference from a cable television system.

(a) Harmful interference is any emission, radiation or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter.

(b) The operator of a cable television system that causes harmful interference shall promptly take appropriate measures to eliminate the harmful interference.

There is much more to be read out of this part of the FCC Rules and Regulations and can be seen at your local Field Operations Bureau if you are interested.

In these bulletins, I am going to focus mostly on the type of interference caused to the Cable Channel 18, 24, and 64-68. The reason for this is two-fold. One, is because these are the channels that most commonly experience fundamental overload interference from amateur stations, and, two, because any interference caused by amateur stations to these cable television channels is clearly not the legal responsibility of the amateur. Depending on the ultimate cause of the problem, it may be the responsibility of the cable operator, the TV manufacturer or the subscriber.

..PART 3

Now if you are causing interference to your or your neighbors cable system there are many causes, suspected pieces of equipment, and possible cures that can be found.

But first I would like to address the situation of fielding your neighbors complaints. Your average neighbor probably does not understand the simplest aspects of radio theory. All they know is that they just spent $1000 on a brand new cable television system and you are messing it up! Well, it is hard to make this person understand that the cable company decided to put their channel right on top of our amateur frequency! And quite possibly, he may never be able to understand. Well there are many areas of the country that have local interference committees comprised of amateurs to help you deal with this situation. It is a great advantage if possible to have a neutral third party meet with the offended neighbor and attempt to assist him in isolating the problem. This third party is most often your ARRL section Technical Coordinator (TC). To find your TC, contact your ARRL Section Manager (SM). A list of SMs appears on page 8 of any recent QST.

Above all, and this cannot be stressed strongly enough, be polite, courteous and as civil as possible when you are dealing with your neighbors! This same cooperative, friendly attitude should be used when communicating with your local cable company. There are all kinds of "big" problems that can be caused by undiplomatically just telling someone "It's your problem!"

And there may be no practical way to cure any specific problem! It may be that the only possible cure is for the local cable company move their premium channels to another frequency. And I have been told by other amateurs that this is exactly what the cable company in their areas have done.

Now for a little theory!

There really are only three ways an unwanted signal can interfere with wanted television signal:

Radiated Interference - This type of interference is usually the fundamental frequency and is usually radiated directly out of your antenna! But this method can also include signals radiated through your shielding, off of your shielding, off of your ground wire or anything else that could directly radiate your signal.

Conducted Interference - This interference is propagated directly via a conductor such as A/C wiring or a common ground system. There are two different types of conducted interference, differential and common mode. I will explain these shortly.

And Induced Interference - Induced interference starts out as radiated interference and is picked up or received by some internal or external part of the affected television or its associated wiring. This type of interference is usually common mode.

Now to explain in more detail the distinct differences between differential mode and common mode interference. In any electrical circuit there must be two paths, the forward path and the return path.

In the differential mode signal, it is conducted via a two wire pair, such as your A/C power cord or your antenna lead in. In this case the circuit is created between the two wires in the system. In one wire and out the other! It is called differential because under normal circumstances these two wires are out of phase with each other. This circuit occurs without the necessity of an earth ground.

With the common mode signal, the unwanted signal can either overpower the normal out of phase signal and make the multi-wire appear to be a single phased long wire antenna with the return path being through the internal circuitry (IE: Capacitors) of the television to the earth ground, thus completing the circuit. Or, the signal can ride the outer coaxial shield and find the earth ground through the same internal circuitry to chassis ground.

It is important to make the distinction between the two, because leakage into or from the cable system, a differential-mode phenomenon, is clearly a cable company responsibility, but a common-mode signal conducted only via the coaxial shielding clearly is not.

Sidebar by Ed Hare, KA1CV, Senior ARRL Laboratory Engineer

Who is to blame?

There is a lot of misunderstanding between the cable subscriber, the cable-company service personnel and the amateurs. The subscriber often feels that the amateur is to blame. After all, if the amateur wasn't operating, there wouldn't be a problem. The amateur often feels that the problem is always the responsibility of the cable company, and that it can always be fixed if the cable system is better shielded. The cable-company repair personnel are often stuck in the middle. Sometimes they tell the subscriber that the ham must be transmitting signals outside of the ham bands, thus causing the problem (he really ought to know better!), or, just as bad for him, believes that the interference

problem is always due to some defect in the cable system.

In reality, any, or all, of the parties may have some responsibility. Let's take a close look at what is really going on!

Although it is not usually related to cable TVI to channel 18 or channel 24, I must point out that the amateur is, by law, required to ensure that any spurious emissions from his or her station do not cause interference to other services. The ham must, and will, make any necessary adjustments to the station equipment to ensure that it is in compliance with FCC regulations.

In the case of channel 18, or channel 24, the cable company makes use of amateur frequencies for these channels. The problem is being caused by the amateur's fundamental signal. Any leakage, anywhere in the system, can allow that signal to get inside the cable. Once this happens, the interference cannot be filtered out.

If the leak is in the cable company's wiring, it is their responsibility to fix it. Keep in mind that they are not legally bound to fix leakage INTO the cable, only leakage OUT of the cable, but most operators will take whatever steps are necessary to ensure that their customers enjoy top-notch service.

If the channel-18 video carrier can be readily heard on the test 2-meter receiver, the cable company will probably need to locate and repair a leak. If this carrier is nearly inaudible, it may be best to try some of the following cures first:

There are several other forms of "leaks" that are not the responsibility of the cable company, although they are usually willing to help if they can. Some cable ready TVs and VCRs, and even some set-top converters, can be affected by the strong amateur signal present on the OUTSIDE of the coaxial shield (this signal is a common-mode signal). Many a cable operator has spend days changing perfectly good wiring when the real problem was common-mode interference. They, the ham or the subscriber can put a common-mode choke on the incoming cable line. In many cases, this will now allow for interference-free viewing.

The house AC wiring may also pick up a fair amount of signal. A common-mode choke, sometimes in conjunction with an AC-line filter, may help here. In extreme cases, it may be necessary to install both types of filters in the TV, the VCR and the set-top converter.

If the cable system doesn't leak (as evidenced by your 2-meter receiver) and the application of the common-mode filters and ac-line filters do not effect any improvement, you may be dealing with a case of direct pickup by the television set circuitry. There is (almost) nothing the cable company or the amateur can do in this case. Contact the manufacturer of the TV for assistance.

I say almost, because after the common-mode and ac-line filters are installed, it may now be possible to get good reception by using a set-top converter or VCR to tune in the desired channel. Keep in mind, when you are using an external tuner, the TV will not be tuned to the amateur frequency, so it may not be susceptible. Most set-top converters and modern VCRs are pretty well shielded, so after you solve the common-mode problem, they may now function just fine. The result is a happy subscriber, amateur and cable repair person.

In summary, all parties concerned are responsible for conducting themselves in a courteous and neighborly manner. The amateur is responsible for the proper operation of the amateur equipment, the cable operator is responsible for leakage within the cable wiring, and the manufacturers of the TVs and VCRs are responsible for ensuring that their equipment will continue to function

properly near strong radio transmitters. Remember, if you have a hole in your roof, you don't blame the rain when your furniture gets wet! 73, Ed Hare, KA1CV, Senior ARRL Laboratory Engineer.

..PART 4

In Part 3, I explained in very simple terms the difference between differential and common mode signals. I went into this area because there are different ways to eliminate the two different types of interference. Understanding the difference between the two will assist you in locating the path of the interference into the television! The interference may be entering the system by one method, or by any combination of different methods. Finding the pathway of the interference can sometimes be a very complex, and at times very frustrating piece of detective work.

There are many areas or pieces of equipment where this interference can enter your system. Let me mention a few that I have heard of: (I am sure that there are many more.) Bad, loose, corroded or improper size cable connectors; improperly grounded cable systems; poorly-shielded (cheap) patch cords between cable boxes, VCRs, TVs and the like; poor 300 - 75 Ohm cable transformers; any twin lead wire; distribution amplifiers (either in your house or in the cable company distribution system); splitters; A/B Switches; video games; TVs; FM broadcast radios.

In fact, anything that is connected to your cable antenna system, cable ground, or A/C source to any equipment that is connected to any part of your cable system, or any combination of them all can be the culprit!! Well, that kind of narrows it down! Are we having fun yet?

But do not despair yet. With the right amount of perseverance and a little luck, you might be able to solve the problem.

First of all, let's focus on the simple and most obvious solutions. Sometimes, we as amateurs, as soon as we think of RFI, we think of either low pass filters, high pass filters, baluns, SWR, proper grounds or the like, when in fact the #1 influencing factor is our fundamental frequency radiating out of our best radiator, the antenna! Let's use the least amount of power necessary to accomplish the communication. Try to avoid putting our antennas or transmission lines right next to cable installations.

Maybe you will be lucky and find a leaky connection with your H/T as described in Part 2! If this is the fact, then eliminate that and you are all set! If not, we have a little detective work to do using the process of elimination.

In an ideal typical cable installation, the cable will be brought in from the pole, parallel to the ground with the shortest run possible, connected to a lightning arrestor which is connected to a good low resistance earth ground. This ground should be exclusively for the cable system, although more often than not, the earth ground is shared with the telephone system. This in itself is not really a problem, as long as the cable ground is connected directly to the ground source and not some kind of terminal block in the telephone system. The cable then should continue downward to ground level and run under the house to the appropriate rooms. All runs of coax up the walls and in the attic or ceilings should be avoided if at all possible. In many locations this is not possible. The people in apartments with multiple units and distribution systems are really at a disadvantage because of the amount of cable run all over the place. All of this excess cable can act as a long wire antenna system for both differential and common mode interference.

..PART 5

Now let me tell you some of the ideas for solutions that I have found:

First of all, if you contact your cable company, have them make sure that you have a good strong signal at all of your TV outlets. Then, the most useful piece of "equipment" that I have seen is the ferrite choke. They come in a number of shapes and sizes. They come in the form of rods, split cores, toroidal cores, beads and many others. They also come made in many different mixes, each having a certain capacity to choke out different frequency ranges. Obviously they are not a miracle cure for all purposes, but they do work great on most types of common-mode and some of the differential-mode interference. For the frequencies that we are working with (VHF), the most effective material to use is the #43 mix.

These ferrite chokes can be used on just about every wire in your house. Make certain that you choose a ferrite mix that will function on the frequency you are trying to suppress. In a cable coaxial antenna the desired signal is restricted to the center conductor and a large toroid can be placed over the coaxial antenna, thus suppressing any common-mode current flowing down the shield without affecting the desired VHF signal inside the cable. Test have shown that 300 ohm twin lead wire can be protected in the same manner, as long as you run both leads through the same toroid. If you put a toroid on each lead, the primary VHF signal will be attenuated also. Obviously this would not be desired.

Since the object is to interrupt the common-mode rf current path, thus breaking that RFI circuit, sometimes it is much easier to wind your A/C power cord through the toroid, rather than trying to wind the stiff coaxial wire through it.

Let's say that you take your A/C power cord and run it through a toroidal core or wrap it around a ferrite rod. This will attenuate the given frequency for that ferrite mix (X) amount. If you wrap it two times it will attenuate it, (X) times 2. Three times, (X) times 3, and so on. The usual way to use these devices is to take your cable coax or A/C power cord that is leading into your TV and wrap it around a ferrite 14-15 turns, as close to the set as possible. Now, if you don't have enough coax, just make up a section out of new coax, wrap it, put end connectors and a barrel connector on it and connect it to your cable connector. (I like to bring a few of these with me when I do a troubleshooting "service call".) With the A/C power line, you can use an extension cord to wind the toroid if you don't have enough free line.

* I really don't think this is a good idea. It will form a transformer, of sorts. This could couple unwanted energy from the AC line to the coaxial line, and vice versa. I recommend separate cores in all cases - KA1CV. If you have a big enough ferrite, you can wind your A/C line and Coax through it. This may quadruple the effect of the toroid. But, you must wind the wires in opposite directions so that the coupling of the rf current from the common-mode interference is maximized. If you are not sure which direction to wind them, try it both ways. The difference will be fairly obvious.

These toroids can be found in many locations. There are advertisements in most amateur magazines, you can find them in electronic supply stores.

In a pinch, you can even use discarded TV reflection yokes. After the wiring has been removed from these yokes, just tape the two ferrite sections together to form a large toroid. This MAY work, but keep in mind that the ferrite material was designed for 15 kHz. Who knows what it may do at VHF!

There are also other types of cures that we can try, like A/C

line filters and tuned stubs at the television antenna lead.

First let's try to find out how the RFI is getting in.

..PART 6

Let's eliminate all unnecessary components of the cable system, such as old video games that you never use anymore, and temporarily eliminate all but one TV (and its converter box, if necessary). Tighten all connections. Cable connectors should be finger tight, plus a quarter of a turn with a wrench. Check to see if the cable connectors are properly secured to the cable. All unused inputs or outputs of the cable system should be properly terminated with a terminating resistor. These are available in most any electronics supply store. Eliminate any 300 Ohm twin lead antenna wire that for whatever reason may be around and check to make sure that all cable coax is of the 100% shielded type.

Now, it would be of some help if you had a fellow ham with a H/T to help you in this endeavor. This way you can operate the packet station and he or she can tell you if the RFI is still present at the television. If you use the H/T on low power, you will probably find that it is about the same signal strength as the packet station. If it causes the same type of interference, it will let you do a lot of troubleshooting right in the neighbor's house.

These steps can be approached from many different directions. Choose which is easiest for you. But for an example:

Take the antenna leads off of your TV or cable converter if this is what receives cable channel 18. Terminate the antenna input on the equipment with the proper resistor. 300 ohm for a 300 ohm set and 75 ohm for a 75 ohm set. Keep the leads as short as possible. Transmit on 2 meter packet. If you still have RFI, there is a good chance that the RFI is entering through the A/C line, or being directly picked up by the television circuitry. Wrap the A/C line around the toroid. Transmit again. If the RFI is eliminated or reduced, you have found the path and cured the problem. If the RFI is still there, check to see if there are any other wires or conductors attached to the TV. Remember, any thing that can transform itself into an antenna, can be the source of the RF current. If this is the case, more experimenting with more toroids may be necessary. Now after these areas have been eliminated and the RFI is still present, the RFI is either stronger than the toroids and more turns or toroids are needed or the RFI is being induced through the case of the TV.

If this is the case, you may need to stop right here. Most state laws prohibit you from fixing your neighbor's TV without a state electronic repair license. Besides, if anything goes wrong when you have the back off the set, you will be assuredly (and expensively) blamed! Contact the set manufacturer through the Electronic Industries Association (EIA), 2001 Eye St NW, Washington, DC 20006. The EIA maintains a database of EMI/RFI contact persons at each of their member companies.

On the other hand, if after you properly terminate the cable input with the resistor, and the RFI disappears, then you know that the RFI is entering via the cable before your TV. This can either be via common-mode on the shielding of the cable coax, or by the RFI penetrating the shield of the coax itself and entering via the center conductor. The latter is a more difficult problem to fix and you may need the help and cooperation of your cable company, and a lot of perseverance.

A quick check to see if there is leakage into the cable system is to determine if there is leakage out. Tune your H/T receiver to 145.250 and see if there is a carrier present. If there is not,

or only a very weak one, then the cable system itself is "clean". You will have to look elsewhere.

This method of locating the path of the RFI current and eliminating it can be used with most all types of appliances and radios. You just have to use the process of elimination.

Now there are a number of factors that we really can't do too much about. Some televisions have only a 300-ohm balanced input. For these TVs, we need a 300 - 75 Ohm transformer in line. These pieces of equipment have been known in many instances to be a major contributor to the problem. In many other TVs, you have a coaxial 75 ohm input, but your TV converts it right back to 300 ohm inside the case! And in the cases where the RFI is induced through the case of any essential piece of equipment, depending on what piece of equipment is suspect the only things that you can do are:

Contact a licensed television repair technician if your television is suspect and see if the television can be modified to prevent RFI. Some manufacturers have good information about these types of modifications.

Contact your cable company if their cable converter box is suspect.

Reduce the intensity of the Electro-Magnetic Field.

Increase the distance to the Electro-Magnetic Field.

Or, shield the equipment from the Electro-Magnetic Field.

..PART 7

In closing, I would like to point out a few things that may help you in this endeavor.

Anything in your house that is conductive can be an effective antenna for RFI. This includes water pipes and grounds. Remember if your ground wire is more than a half wave long in respect to your fundamental frequency, it may be an effective safety ground, but, it also may be a very effective long wire antenna for RFI. How long and where are the water pipes in your house? How long is your station ground wire before it gets to the ground rod? If your station ground is shared with the cable ground, or the electrical ground (shame on you!), this could be a real problem.

Do not modify or fix your neighbors equipment. If something should happen coincidentally to his television, they are going to blame you!

Terminating your Amateur Radio activities is not an acceptable (permanent) solution to the problem. As long as your station is in order, and the interference is not caused by spurious emissions from your station, the FCC will allow you the privilege to continue operating.

But if you decide to be diplomatic about it, there are other ways to enter the packet network, such as 440 Mhz or other bands depending on your location. It also might be a good idea to refrain from operating if you are in conflict with the Super Bowl, or a community-access viewing of your neighbor's grand-daughter's dance recital.

There are many sources where you can find information on the RFI phenomenon. I would recommend first contacting The American Radio Relay League. They have several free informational packages, and a new book on interference; "Radio Frequency Interference - How to Find It and Fix It." You can also contact The Federal Communications Local Field Office in your area. They

too have information on the subject. You can contact your local cable company or The National Cable TV Association, Director of Engineering, Science and Technology Department, 1724 Massachusetts Ave., Washington, DC 20036.

Now if you find an unusual solution to any type of RFI (EMI), I would urge you to fill out an EMI Report Form, which is available from the ARRL. Hopefully your discovery and knowledge can be passed on to other amateurs who may be experiencing the same type of interference.

I sincerely hope that these bulletins have been informative and helpful in solving your RFI problems.

Good Luck and Good Hunting!

Sincerely,

Chuck Manetta N4YJC

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info@arrl.org