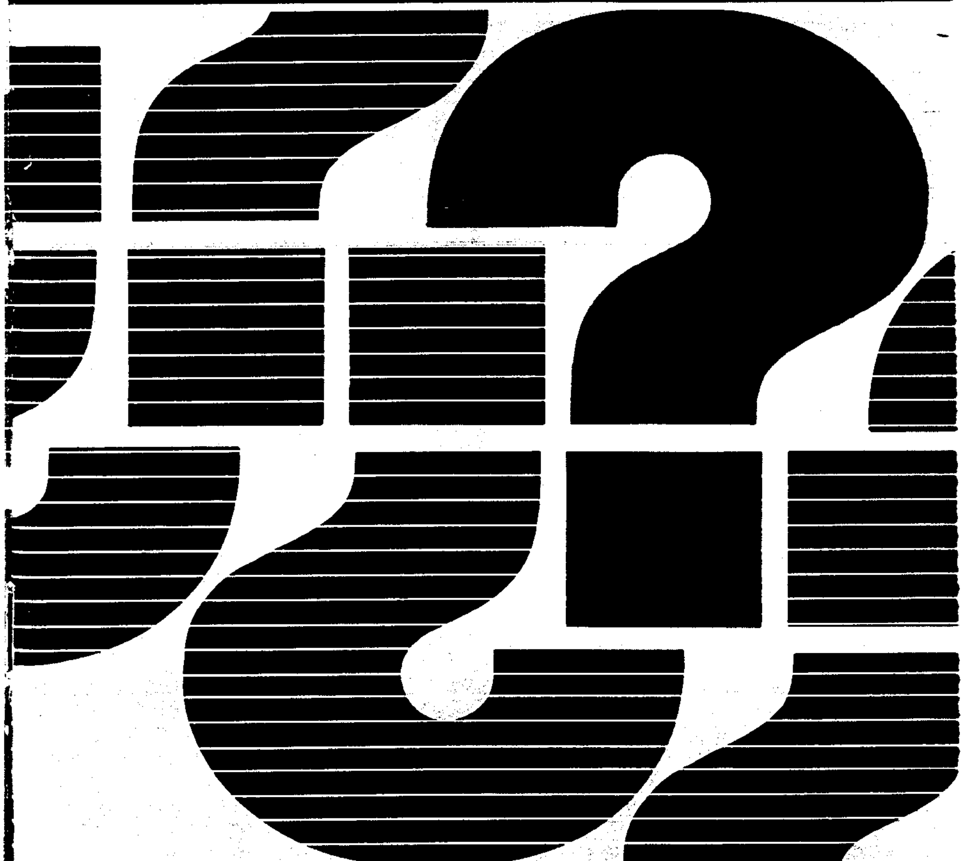
TUNING IN
UNDERSTANDING BROADCAST INTERFERENCE



Communications
Canada

TABLE OF CONTENTS

GENERAL QUESTIONS ABOUT THE SPECTRUM ....
AM BROADCASTING ....
FM BROADCASTING 1
TV BROADCASTING 1
CABLE RECEPTION 1

Introduction

Broadcasting is nothing new to Canadian Like the talking pictures or the closed-body car, it's been with us since the '20s. What's different these days is the tremendous increase in the rate and methods of broadcasting and indeed in all services that use the airwaves. In addition to broadcasting, mobile radios, satellite communications, radar stations, radio-navigation beacons, ham operators — all these sources are sending signals, and all these signals require space in the radio spectrum which contains the complete range of radio frequencies. Yo could say that the radio spectrum has becom very crowded.

The job of regulating the radio spectrum, and the many radiocommunications service that make use of it, falls under the mandate of the federal Department of Communications. The Department is headquartered in Ottawa, and maintains 51 regional and district offices.

Crowding the spectrum causes many prob lems, and finding solutions to them is one o the Department's chief concerns. To help you better understand some of these problems, the Department has prepared this boo let. It is written in simple question-and-answer form, and addresses many of the most common questions asked of the Depar ment's staff.

GENERAL QUESTIONS ABOUT THE SPECTRUM

How do radio signals travel?

Radio signals travel in waves, which are emitted from a transmitter. In the case of broadcasting, the word "broadcast" (originally applied to seed that was scattered rather than sown in drills) here describes the way radio waves radiate, or spread in all directions. Travelling at the speed of light (300,000 kilometres — or 186,000 miles — per second), radio waves reach the receiver almost instantaneously.

What is wavelength?

The distance between one peak and the next peak of a radio wave. In radio, wavelengths are most often measured in metres.

What is frequency?

The number of wave peaks that pass your receiver in one second. Frequency is measured in cycles per second, called hertz (Hz).

How are broadcast frequencies designated?

Radio signals are used in a variety of ways, for many different types of services. For the sake of order, an international regulatory agency assigns groups of nations certain blocks of frequencies for various uses. Canada, through the Department of Communications, divides these designated blocks into specific frequencies and allocates them to licensed users.

What is the radio spectrum?

The full range of radio waves used in mobil and fixed communications systems, radar and radio-navigation systems, radio and tel€ vision broadcasting, etc. The spectrum is divided into a number of frequency ranges, called bands. Various services use various bands. For example, AM radio broadcasts on frequencies between 535 and 1605 kHz (to be extended to 1705 kHz by 1990) are par of the medium-frequency band (300 kHz to 3 MHz).

The chart below shows most of the frequencies in the spectrum, and illustrates some familiar terms such as "shortwave," "UHF," and "microwave." AM radio operates near 1 megahertz (MHz), which is equiv alent to 1,000 kilohertz (kHz). VHF (very high frequency) is used for TV channels 2 to 13 and the FM broadcasting band. UHF (ultra high frequency) is used for TV channels 14 t(69. Off the high side of the chart are some of the common satellite signals, which run up to 12,200 MHz, or 12.2 gigahertz and beyond

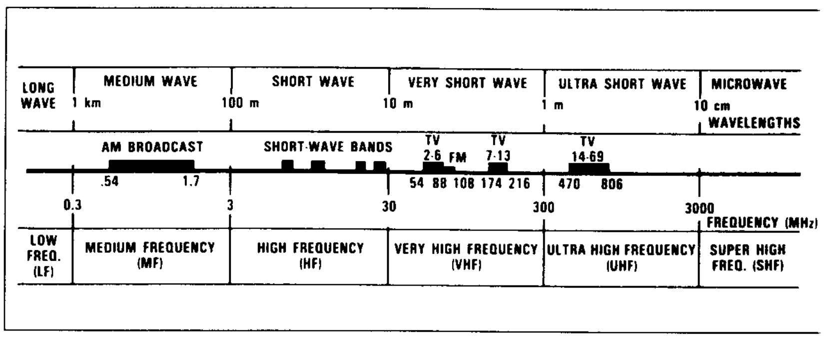


Figure 1: Part of the radio spectrum

Is there any connection between frequency and wavelength?

The frequency of a wave determines its length. The higher the frequency, the shorter the length of the wave. Multiplying the frequency of a wave by its length results in the constant speed of radio waves: 300,000 km/s. or the speed of light.

AM BROADCASTING

What does AM mean?

Amplitude modulation. Since the sound frequencies of voice and music are too low to be effectively transmitted, they are superimposed, in a process called modulation, on a wave of higher frequency, called a carrier wave. In amplitude modulation, the *amplitude* (peak energy level) of the carrier wave is varied in accordance with the amplitude and frequency of the sound wave. [See next section: *What does FM mean?*]

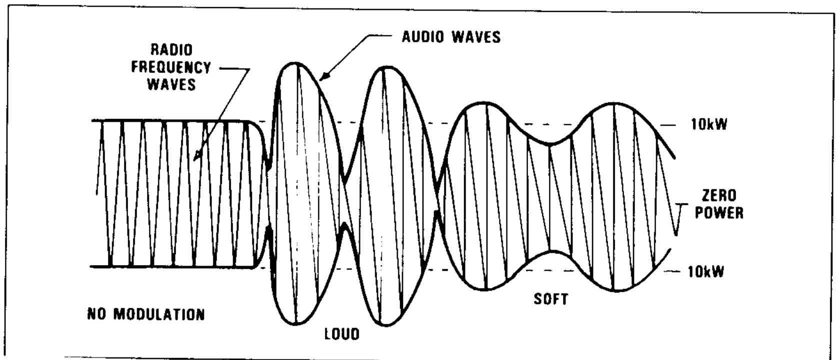


Figure 2: Amplitude modulation

What do transmitters and receivers do?

Transmitters generate the carrier waves, superimpose the voice or music frequencies on them, i.e. modulate them and feed the modulated wave to the antenna. Receivers separate the carrier wave from the sound signals by a demodulation process that gives back the original audio.

What is a transmitting antenna?

One or more vertical steel towers, mounte on base insulators and connected to the transmitter. From these towers, radio wave spread out in ever-widening circles. The height of the towers is proportional to the length of the radio wave to be transmitted: high towers are used for low frequencies, low towers for high frequencies.

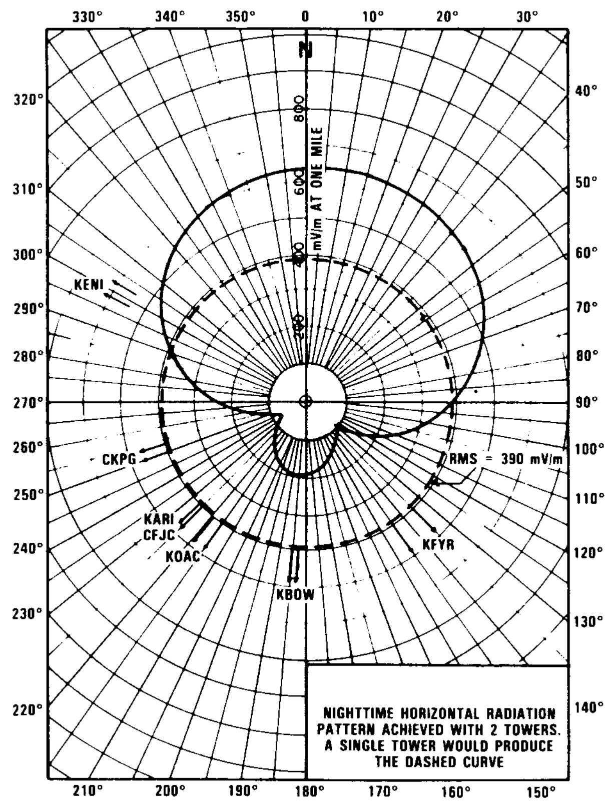


Figure 3: AM Directional Pattern
[Nighttime horizontal radiation pattern]

What are directional antennas?

Antennas that do not radiate equally in all directions. Arrangements of more than one transmitting tower can shape the radiation pattern, strengthening it where necessary, and weakening it to prevent interference with other stations on the same frequency.

I notice that the pattern in Figure 3 says "nighttime." What about the day?

In the medium-frequency band AM employs, most of the power is sent along the earth in what is called a "groundwave." Some of this power, however, shoots up into space as a "skywave." During the day, most of the sky-wave is absorbed by the atmosphere; but at night much of it bounces back to earth, and can be received or cause interference hundreds, or even thousands, of kilometres from where it was broadcast.

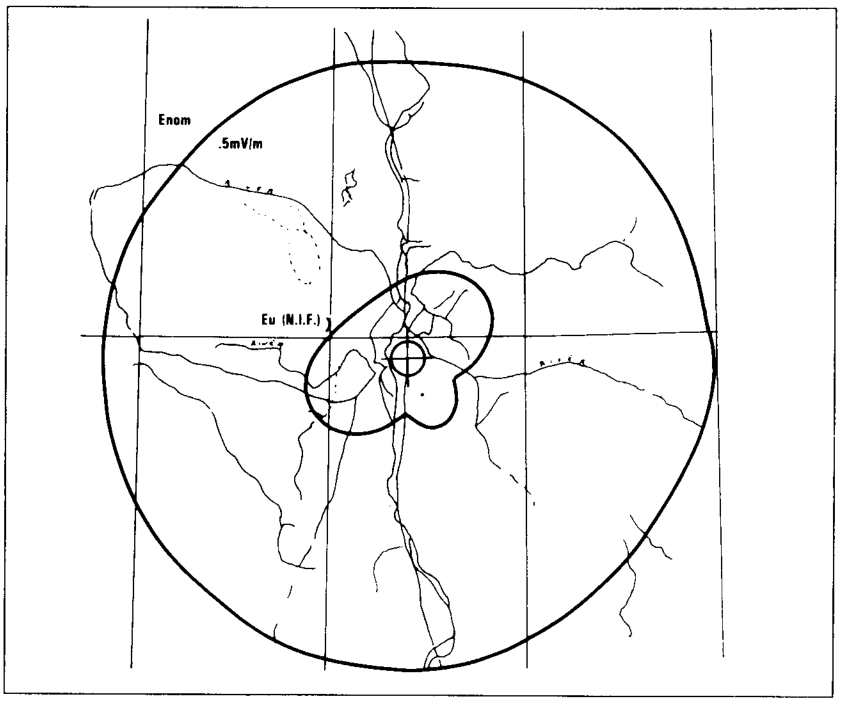


Figure 4: Map of "Enom" and "Eu" for a station

In areas protected from interference, nighttime skywaves can provide radio service. However, this protection exists for onl 70 of North America's 5,000 stations, less than 2% and these can be heard in distant places. For the rest, nighttime interference severely reduces broadcast quality. Many stations, in order to provide protection to others, limit their nighttime skywave radiation by power reductions, directional antennas, or both. That is why in some cases nighttime antenna patterns are different from daytime.

Figure 4 is an example. "Enom" is the daytime coverage, "Eu" the limited coverage possible at night.

I live in the protected service area of our local stations, but I still hear buzzing, clicks, or static at times. What causes this interference?

Fluorescent lights, door bell transformers, battery chargers and light dimmers can cause most of the buzzing. Static usually comes from electric razors, vacuum cleaners, food mixers, or ignition systems in cars. Clicks generally originate from electric blankets, ovens, elevators, thermostatically controlled heaters, and other devices that turn on and off periodically. Often interference can be reduced by moving the radio away from electric wires in the walls, by plugging the radio into a different power cir cuit, or by turning the radio around until its internal antenna gets a better signal from the station.

I listen to CZYX, but on the way to work I hear CIZL in the background.

The road you use runs just north of the CIZL transmitter site. Those tall towers you see are its antenna array. Near the towers, the station's signals are very strong, too strong for your receiver to handle. So for a while, it "blocks" your receiver, two signals mix, and you get interference. If you use the other road, not so close to CIZL, your receiver should be OK.

On my kitchen radio, I get all the stations from a neighbouring city pretty well except CLEF on 580. I hear our local station right on top of CLEF, even though its frequency is way up on 1490. My other radio gets CLEF perfectly. Why?

This is what's called "image interference." Broadcast receivers use a process called "superheterodyne" ("hetero": different; "dyne": a measure of force), which amplifies the incoming signal and lowers its frequency. When you tune to a station, the receiver's tuner produces its own very weak signal separated from the wanted station signal by the "intermediate frequency" (IF), usually 455 kHz. This weak signal cancels the broadcast carrier wave, leaving an audible signal. Superheterodynes have trouble rejecting an unwanted strong signal that is twice the IF above the wanted frequency.

Your local station on 1490 is strong; CLEF on 580 is weak. The difference in frequencies is 910 kHz. Thus your kitchen radio uses a half-910 or 455 kHz IF. If a service shop retuned your IF to a slightly different frequency, the image would move away from CLEF and your interference would stop.

More expensive receivers provide better protection against image interference. A different IF such as 450 kHz wouldn't get interference in your area, unless the local station were on 1480 kHz. Your other receiver may be one of these types.

The Department has a rule in place to prevent this type of interference. CLEF, when switching to frequency 580 several years ago to gain a net improvement in service, agreed to accept this problem.

My kitchen set seems to whistle when I tune in to CXYC on 910, but the other set doesn't. Why?

If the whistle note changes frequency as you tune through the 910 kHz station, your set is causing the interference itself. Being a "superheterodyne" (see previous question), it generates a signal at the intermediate frequency (IF) of 455 kHz.

Even the slightest amount of distortion in the 455 kHz amplifiers produces "harmonics" or multiples of 455 kHz. The second harmonic, i.e. 2 x 455 falls at 910 kHz, the CXYC frequency. If this 910 kHz is able to leak back into the antenna circuits, you will hear the whistle on CXYC. A service shop could solve your problem by changing your IF slightly. On good receivers, shielding of the IF circuits is adequate to prevent this leakage.

CIZL keeps saying it's in AM stereo, but it doesn't sound like it on my stereo or on my other set.

CIZL transmits AM stereo. To get it, however, you must have an AM stereo receiver designed to decode it. Otherwise, the reception will be normal monophonic programming. Unless your set is designated "AM stereo" the word "stereo" on it usually refers to FM stereo — but not AM, which uses a different system. AM stereo is relatively recent and you can buy AM stereo receivers in the stores.

FM BROADCASTING

What does FM mean?

Frequency modulation. Since the sound frequencies of voice and music are too low to be effectively transmitted, they are superimposed, in a process called modulation, on a wave of higher frequency, called a carrier wave. In frequency modulation, the *frequency* of the carrier wave is varied in accordance with the amplitude and frequency of the sound wave. [See previous section: *What does AM mean?*]

How does FM compare with AM broadcasting?

FM is less affected by noise or static than AM, however AM is less susceptible to reflections than FM. The range of FM is generally more limited, and does not change at night. FM waves travel through space in a straight path; they do not follow the curve of the earth or bounce off the ionosphere like AM. Thus, they can be received only as far as the horizon.

How are FM signals transmitted?

Generated at frequencies about a hundred times those of AM, FM waves behave much like light, though they can penetrate buildings to some extent. The antenna may radiate signals in all directions, or it can be designed to radiate in a directional pattern.

My favourite station used to come in fine until that new station came on the air. Now I can't get it. Why do you allow this interference?

FM has a remarkable ability to reject background noise, and good FM receivers, especially with outdoor antennas, can operate well beyond the designated range of a given station. Only this designated range, however, is protected from interference caused by other stations.

By limiting the range of protection, we are able to maximize the number of stations we protect. Each station, when it comes on the air, is assigned a specific location and power class within an overall allotment plan. It is licensed to serve only that area.

Your home is located outside the service area of your favourite station and close to that of the newer station. Result: interference. You could improve reception by using an outdoor directional antenna, which would reinforce the desired signal over the intrusive one.

I used to receive all my local FM stations fine, although in-between them are a lot of other stations that are badly distorted. One of these now sits right on CXXX-FM which I like and I used to get OK. What happened?

The signals reaching an FM receiver may differ in strength by as much as 10,000 to 1. In your case the local signals are very strong, and your receiver cannot process them without distortion. They mix with each other, producing false signals right in your receiver. The new local station that came on the air last year caused your set to generate the interference on top of CXXX-FM. Many sets provide a LOCAL/DISTANT switch to correct this situation. If you have such a switch, place it in the LOCAL position. This may clear up the interference with CXXX-FM.

The Department has rules to ensure that stations themselves do not produce this interference. When it occurs, it is usually the fault of the receiver.

I usually listen to CXYZ-FM in the car, but on the way to work, I suddenly get that other station instead, then I get CXYZ again.

This is called "channel hopping." It often occurs when a very strong signal is next to a weaker one on the dial. Although channel hopping can sometimes be attributed to inaccurate tuning, it is more often caused by a malfunction of the automatic frequency control (AFC), a feature found on most receivers. Here's what happens.

When you adjust your tuning to the approximate frequency of a station, the AFC "locks on" to the signal, pulling the tuning to its correct setting. It will do this even if the knob is set past the correct frequency, close to that of the next station on the dial. If the next station carries the stronger signal, the AFC may lose control and jump the tuning to the more powerful station. On an automobile receiver, where signal strengths vary every metre or so of travel, the receiver sometimes switches back and forth between two stations.

Your problem occurs when you pass close to the transmitter site of the other station. Here the intruding signal becomes much more powerful, and the receiver flips to it until the car leaves the stronger field. On some receivers, the AFC can be switched on or off. If your receiver has an AFC disabling switch, your problem is easily solved by switching the AFC off.

To correct channel hopping on a home receiver, always approach the weaker station's dial setting from the side opposite the stronger signal. The AFC will lock on to this first signal, and is not likely to lose control.

When I'm in the car downtown, the stereo from my radio keeps going "phut-phut-phut." The mono hardly ever does this. Why?

FM signals are often blocked in highrise areas. Waves bounce around between buildings, and two or more can reach your antenna together. When this happens, depending on the position of the waves, the signal either gets stronger or cancels itself out. In the case of cancellation, the receiver finds itself without an adequate signal, and lets out a burst of noise. This is worse on stereo, since the stereo signal is more vulnerable to noise.

Why does one FM station sometimes sound so much louder than another?

The range between the loudest and the softest sounds is called "dynamic range." In the concert hall, where background sounds are very low, dynamic range can be very large. At a rock concert dynamic range is limited, since there is not much difference between the loud and the not-so-loud.

When sound is recorded, the dynamic range must be compressed to retain it through the broadcast chain. The amount of compression employed is a program choice made by the station, based on the intended audience and the probable listening environment. The wide range often used by some stations sounds best when listening in a quiet place. In a car or other noisy environment, the compressed range is more suitable.

TV BROADCASTING

I see from Figure 1 that TV channels occupy several places in the spectrum. Why not have them all together like the AM or FM stations?

When TV first started in the late 1940s, the then usable spectrum was already so crowded that it was impossible to put all the channels together — except at frequencies too high to deliver acceptable signals. This crowding is even more acute today.

Does TV use AM or FM transmissions?

Actually, it uses both: AM for the picture, FM for the sound. Two separate transmitters, AM and FM, supply signals to the transmitting antenna. Since each one lies within the 6 MHz channel, when you tune your receiver to a channel, both signals appear. After travelling together through a part of the receiver, they are split into separate FM sound and AM picture signals for use in the speaker and the screen.

Are the transmitting antennas like those used by FM broadcasters?

They're similar, but more complex and diverse. TV antennas have to maintain high performance levels throughout the 6 MHz channel. And the wide difference in frequencies necessitates variations in size: An antenna for Channel 2 would be about 14 times as large as one for Channel 69.

As in FM broadcasting, a number of antennas are stacked vertically, usually at the top or on the sides of a high tower. Height is very important for coverage: the higher, the better.

Why is the reception on indoor antennas not very good?

Height counts here, too. The higher the receiving antenna, the better the reception. Generally speaking, waves penetrate buildings only at a considerable loss of strength. Much depends on where the indoor antenna is located, and whether it can "see" in the direction of the transmitting station.

Indoor VHF antennas are usually of the "rabbit ears" type; the "loop" or "bow-tie" antenna design is generally used for UHF. If you are in a strong-signal area, they may be satisfactory — but they often prove inadequate. Waves from the stations bounce off any metal object, and these reflected waves sometimes cancel the direct signal, causing poor picture or sound.

An outdoor antenna receiving the direct radiation from the station should get a much stronger signal, with fewer reflections.

What causes "ghosts?"

Sometimes the transmission waves from your TV station hit and bounce off a mountain or a tall building, creating a second, longer signal path to your receiver. Because the reflected path is longer, the waves travelling it arrive at your set slightly late and to the right (picture lines are drawn from left to right) of your main signal. The second picture thus formed is known as a "ghost."

These ghosts can induce smearing, multiple images, reversals of black and white, and loss of colour fidelity. The only proven "ghostbuster" for over-the-air reception is the roof-mounted rotational receiving antenna.

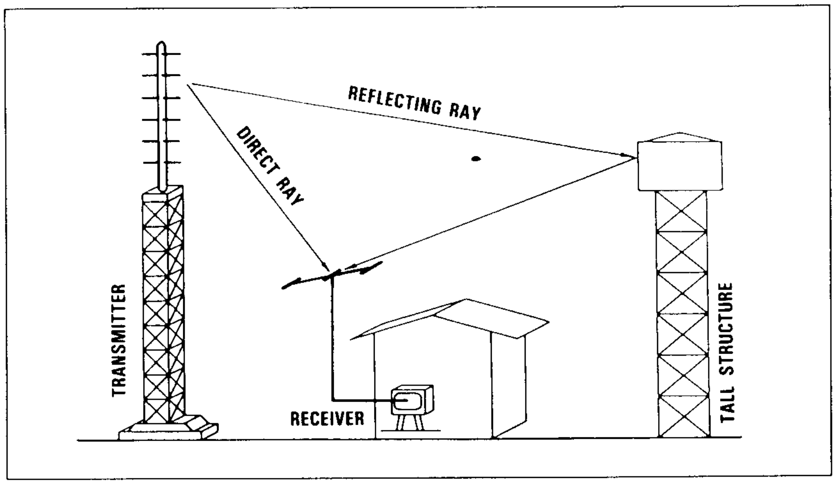


Figure 5: Ghosting

Why are some stations I get clear, others grainy, and some quite snowy?

Along with the TV signal you receive from a station, there is always a measurable amount of noise, and the signal-noise quantities influence your picture quality. If the picture signal is at least 200 times stronger than the noise level, all should be clear on the screen. If the signal is only 50 to 100 times more powerful than the noise, you will usually get a slight graininess. If the signal is not at least 25 times stronger, you're in for heavy snow. On UHF, your set itself generates almost all the noise, and it needs a stronger signal from the station to compensate.

What causes those wavy diagonal lines on my picture?

Intruding radio frequencies always cause interference, usually in the form of diagonal lines. The interaction between the intruding frequency and the one carrying your picture creates a third frequency, called a beat frequency. The character of this beat frequency affects the appearance of the diagonal lines. Variable beat frequencies cause rotating lines; beats from FM or unstable frequencies result in lines that waver; stable interference signals cause steady lines.

Besides beats from an intruding signal, there are two others that can cause problems. One is intentionally formed to assist in audio tuning; another may occur as a result of the difference between your picture signal and the sound signal of the next channel down. Your set is equipped with "traps" to eliminate these two beats from your picture. If sets are not correctly tuned, however, the traps don't work and wavering diagonal lines appear. Automatic frequency control (AFC), a feature contained in many sets, assures correct tuning.

When diagonal lines form in accordance with your audio, the source of interference is your own sound signal. Again, if you do not have AFC, make sure that your tuning is properly set.

If proper tuning fails to eliminate your diagonal lines, an external source of radio interference is probably the cause. The Department's brochure, *Radio and Television Interference*, has some good advice on dealing with such interference.

What causes "venetian blind" interference?

Interference from stations on the same channel. The venetian blinds can be of three types: a few horizontal bars, coarse venetian blinds, or fine venetian blinds. The exact frequencies assigned to stations on the same channel will determine which type of interference is seen.

I get the local station on both channels 5 and 6, but it is better on 6. Why?

In your area there is no station on channel 5 , but channel 6 is strong. When your set is tuned to channel 5, and it is without a signal of its own, the channel-6 signal is apt to leak through and provide a picture. Since this picture will be inferior, always make sure that your set is tuned to the correct channel.

Note that when you tune to channel 7, there is no picture from channel 6. This is because these two are not adjacent in the spectrum. There are gaps between channels 4 and 5, 6 and 7, and 13 and 14.

Our TV station says it is "stereo," but my set sounds the same.

The form of stereo now approved for television in Canada is called BTSC stereo. It can be heard only on receivers equipped to decode it. On ordinary sets, only the mono program sound can be heard. Stereo TV is relatively new and only recent sets have this feature.

CABLE RECEPTION

Why can't the cable company use ordinary wires like the telephone company?

Telephone wires need to handle audio frequencies up to only a few thousand hertz, or cycles per second. Cable signals are sent at radio frequencies up to hundreds of megahertz. These frequencies require special "coaxial cables."

A coaxial (having a common axis) cable consists of a single wire sheathed by a conducting outer shell, with insulating material in the space between. Coaxial cables are designed to limit energy losses and reduce interference from external sources.

Where do cable systems put all the extra channels? I know they don't show if I connect the cable to the UHF terminals on my set.

The "basic" cable channels are 2 to 13, and use the same frequencies as the off-air stations. FM signals occupy the normal FM band, though their frequencies are usually rearranged.

When "converter service" is offered, "mid-band" channels (A to I or 14 to 22) use frequencies between 120 and 174 MHz. "Super-band" channels (J and up, or 23 and up) are above 216 MHz, the top of channel 13. Number designations are more commonly used than letters, because numbers are preferred for electronic readouts on the converting equipment. Note that cable 14 (120 to 126 MHz) has a frequency different from that of UHF channel 14 (470 to 476 MHz).

On cable there's a "sub-band" below 54 MHz. It is not normally used for distribution, but for special transmissions, often sent in the reverse direction. Two-way cable systems can offer interactive services such as burglar alarm, home shopping, or metre reading, without resorting to telephone company facilities.

How does a cable system work?

As you see from the following diagram signals enter the cable at the "head end." These may be local off-air signals, distant signals relayed by microwave, satellite signals, or "local originations," i.e., program provided by the local cable company.

The major highways of the distribution network are the trunk lines. Originating at the head end, they carry signals to the general area of service. From there, feeder lines branch off the trunks to extend service further. These are the cables passing by the homes. Finally drop lines, splitting off from feeders through "taps", carry the signal to subscribers.

Along the way, the signal weakens by passing through the cable, and amplifiers of various kinds at designated distances increase the strength of the signal to the appropriate level. Each amplifier is supplied with power by hydro connections down the line.

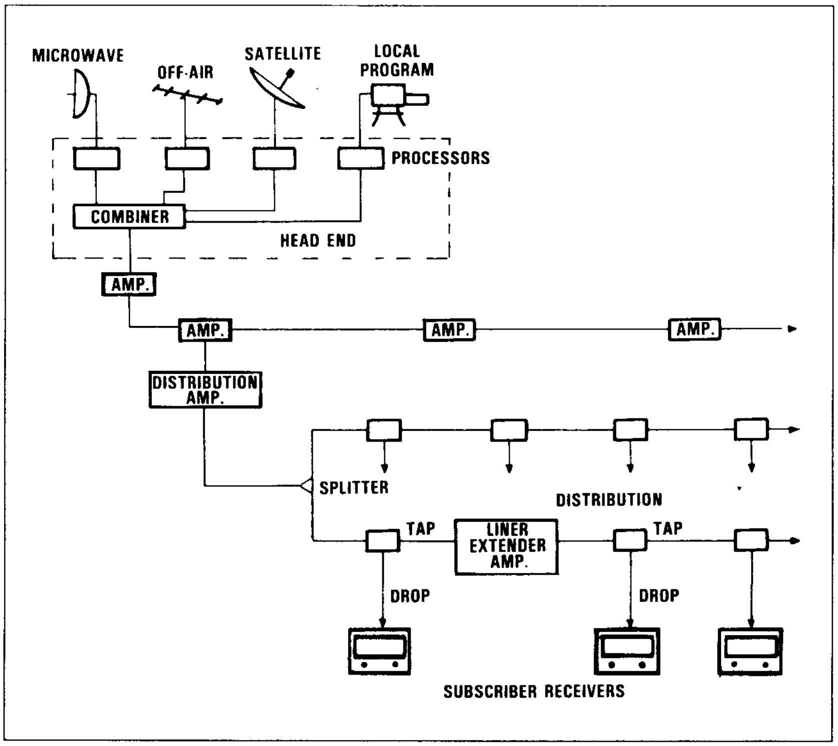


Figure 6: The cable system

Some of my cable channels have good pictures, but others are poor. Can you explain why?

Signal quality on the cable system is only as good as the quality picked up at the head end. Because the best antennas are used, and the best locations chosen, signals to subscribers are generally better than any they could receive off-air.

Deterioration in picture quality generally occurs with distant signals. Over long receiving paths, fading is prevalent. Where cable networks must pass near high-tension power lines, static discharges sometimes produce short bursts of noise. Varying with the weather are the common but usually intermittent problems of noise (snow) and channel interference (venetian-blind bars).

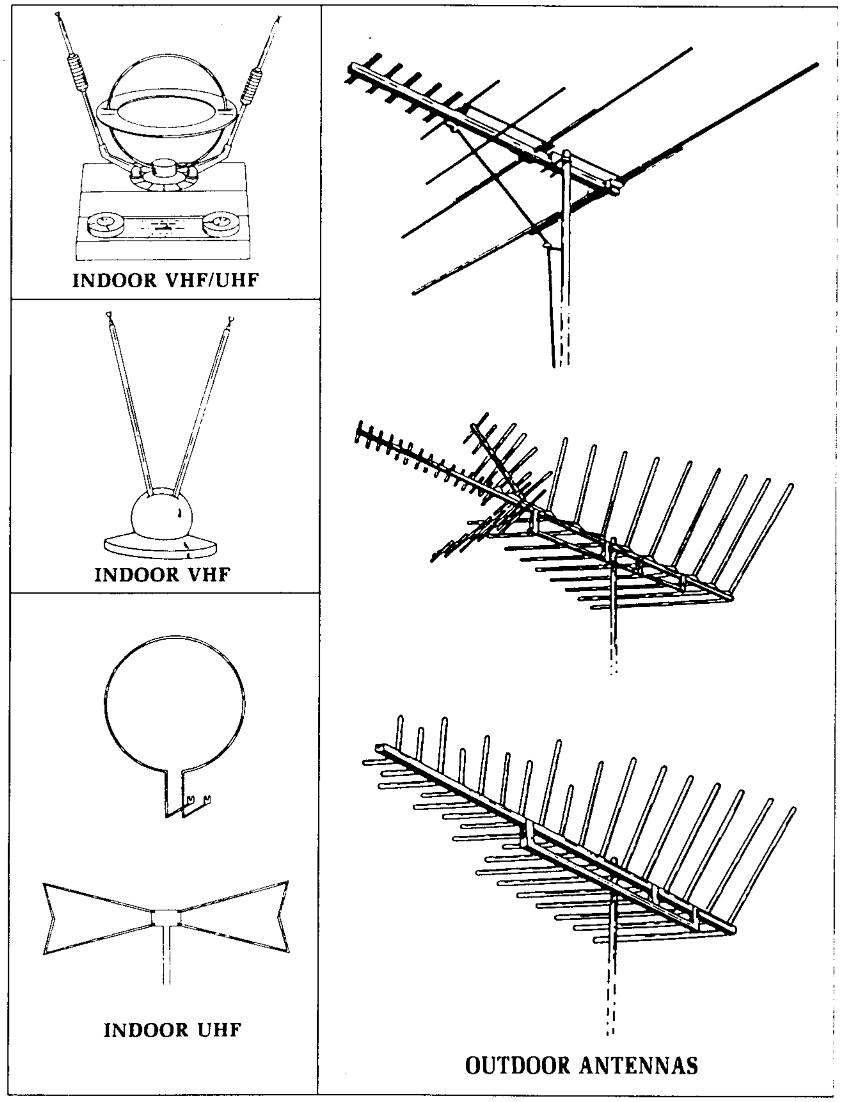


Figure 7: Antennas

When I use my roof antenna, there is interference on channel 4 from a neighbouring channel 3. But on the cable system, both signals are good. The cable has stations on every channel and they don't seem to have any trouble.

If two adjacent channels receive equal signals, the lower channel's sound signal will often cause wavy diagonal lines on the picture of the upper channel. Cable companies avoid this by reducing the level of all sound carriers while processing the signals at the head end. Since the signals fed to subscribers are nearly ideal for reception, they encounter no sound problems.

I see two faint bars moving up the picture; they show on most of the channels.

These are likely "hum bars" getting into the cable system's signals. Advise your cable company if these are not corrected within a reasonable time.

On my cable channel 2, there are traces of other pictures, sometimes negative, appearing in the background.

If this occurs only on a cable channel with the same channel number as a local channel, you are watching an "impaired channel." Channel 2 is impaired because it is used by your local station.

The picture traces you see are caused by interference between the cable signal and that of your local station.

This interference may be caused when:

- The cable signal is placed on an impaired channel, and
- The wire between the antenna terminals and the input tuner of your receiver (see figure 8) is a twinlead which could act as an antenna, allowing the local signal to reach the tuner directly.
- The coaxial cable is insufficiently shielded.

Impairment is rarely a problem if:

- The receiver has a direct coaxial antenna receptacle and a well shielded coaxial cable from there to the tuner, or
- A converter is used.

If problems persist after either of these solutions has been tried, there is probably a break somewhere in the cable system's coaxial shielding. In this case, notify the cable company.

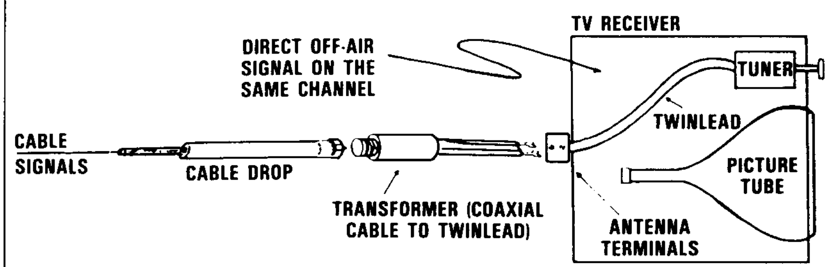


Figure 8: Reception on the impaired channel

Last week all the cable channels were bad. There seemed to be traces of other pictures in the background of a lot of the channels.

That type of interference is called "intermodulation," and it is normally caused by a bad amplifier in the cable system.

If an amplifier fails, other amplifiers further along in the system attempt to restore the signal level to normal. They automatically increase their signal power to maximum, causing noise and putting background signal traces in subscribers' pictures. If this happens, call your cable company.

There are double images on the picture of some channels.

The double images mean that reflections are occurring on these channels. Coaxial cables are so sensitive that even a small kink or dent will affect their performance. When a signal reaches one of these cable faults, they sometimes reflect back, bounce off the previous amplifier, and come forward again, causing reflections similar to TV ghosts. If such reflections appear on your cable system, call the company. They will want to track down and replace the faulty piece of cable as soon as possible. There are standards requiring that reflections be kept to a level that does not impair viewing.

I bought a very expensive stereo cable ready TV and now I find that I don't get stereo sound and that I require a separate converter to be able to get Pay TV.

To obtain stereo sound the original TV signal must be broadcast in stereo and be carried on the cable encoded with the stereo signal. Your cable company can advise you whether they are providing stereo sound; if so, you should be able to receive it.

Most companies encode their Pay TV signals and a specialized decoder is required at your home to unscramble them. These decoders are not presently built into the TV set. That is why you require a tuner (converter) to provide an input to the decoder.

So cable systems really do a pretty good job, don't they?

Considering all the connectors, cables, amplifiers, splitters, and hydro connections, you will appreciate the various adjustments that a signal has to go through to reach your set. The technical capabilities of the cable companies, together with the standards of the Department of Communications, should assure you of top-quality TV signals most of the time.

Endnote

We at the Department of Communications want to help Canadian broadcasters serve you, the public. If you have any further questions, contact our nearest district office. Remember, the radio spectrum is a limited natural resource, and all of us have a stake in keeping it fit for use.

For more information . . .

The Department has also published, in both French and English, a brochure entitled *Radio and Television Interference.* This practical guide describes common home interference problems, and shows you how to troubleshoot them for yourself. You can obtain a copy by contacting the nearest district office.