Interference to APT Satellite Reception

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Ten years ago, Alan Sewards compiled a seminal article detailing the various sources of interference that frequently bedevilled APT and Wefax weather satellite images. For many years, Alan's article appeared on the EUMETSAT website. As ever more hobbyists take up APT imaging for the first time and queries about interference appear on weather satellite Internet Forums, Alan has kindly updated his article for GEO readers.

Introduction

You have splashed out for that 137MHz wxsat receiver, software and some sort of aerial, hooked them all together, and waited for the first pass of one of the NOAA weather satellites. When it appears, you are very excited at the thought that you have picked up a remote sensing signal from a spacecraft, in real time, and are actually seeing the surface of the Earth.

After a while, you will very likely notice that the images you receive are impaired in one way or another. If you have bought the various parts of your system from well-known vendors, it is unlikely that there will be anything wrong with the receiving chain; the cause of the impairments is most likely to be interference.

Interference can arise from three main sources

- transmissions on or near the spacecraft frequency from terrestrial or space sources,
- emissions from your computer system,
- power line interference.

This article is aimed at explaining the sources of the various interference, showing how to recognise them, and suggesting ways of mitigating or eliminating the effects.

Things have moved on since this article first appeared 10 years ago and I felt that an update would be useful. In some ways the update is premature, as APT is giving way to new digital formats (HRIT and LRIT), but as there are still weather satellites using the APT signal format, there will be users who will find the article useful. LRIT in particular has not made much impression on the receiving market as few affordable systems have appeared. For myself, I have embraced the excellent EUMETCast service, which has provided me with huge amounts of superb data, with no worries about interference!

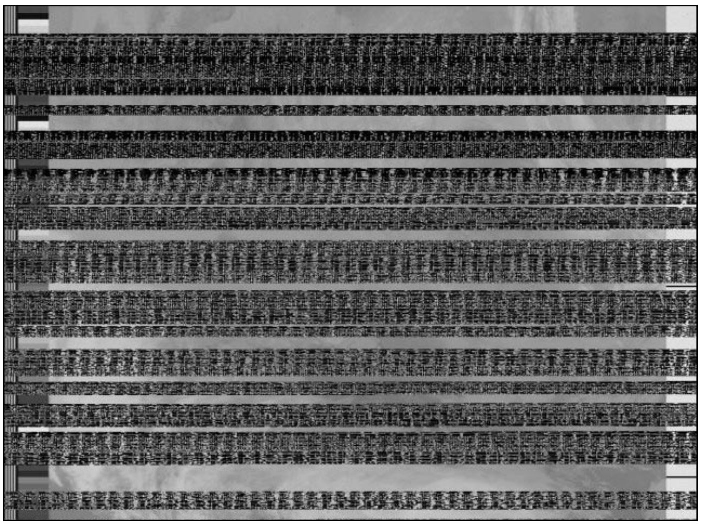

Figure 1 - Typical pager interference

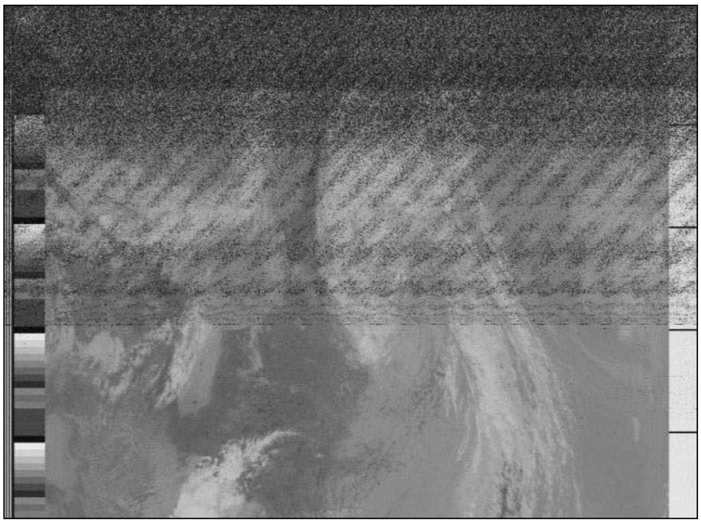

Figure 2 - CRT monitor interference

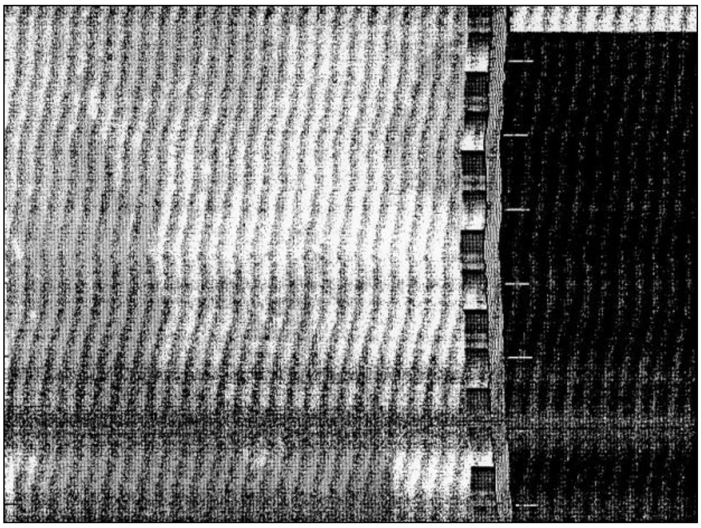

Figure 3 - Power line interference

Causes of Interference

Pagers

Interference from terrestrial transmissions was rare until the late 1990s, when the craze for pagers took off and the countryside became liberally sprinkled with high power transmitters operating within a few megahertz of the frequencies used by the NOAA Tiros-type satellites for their APT signals. These transmitters have effective radiated powers of 10 - 50 watts, and may be located in your neighbourhood. In my case, there were two transmitters situated at 500 and 800 metres distance respectively, with ERPs of 30 W and 120 W. Although these transmissions are on lawfully allotted frequencies and the bandwidth and power are (supposed to be) strictly controlled, they are close enough in frequency to the satellite signal for the RF selectivity of the weather satellite (wxsat) receiver to experience problems. If the pager signal is strong enough it overloads the RF stages or the mixer of the receiver and breakthrough of the pager signal on to the satellite frequency to which the receiver is tuned. Those wxsat APT receivers designed before the pager revolution tend not to have adequate RF selectivity and ability to handle strong interfering signals: more recent designs are much better in this respect.

Computers

Computers can produce interference in several ways. Most obvious is the general hash produced by all the fast edges of the clocks and other waveforms in the computer. This is often very bad in the shortwave frequency band. Stable signals from the master clocks of the CPU and the bus, and their harmonics, can also be found. However, for many people these do not seem to cause significant problems with APT reception, probably because the hash is fairly well attenuated by the time we get to 137 MHz, and the harmonics of the clocks do not fall on the frequencies of interest. Others, however, do experience strong interference, and sometimes resort to recording the satellite audio on a tape recorder and turning the computer off. 14400 bps modems have a strange quirk in that most of them seem to generate a strong signal on 137.62 MHz, the NOAA-17 APT frequency, but such modems are rare these days. The other major culprit is the CRT monitor, which can radiate strong RF interference over a wide band, modulated at the refresh rate, even though it may be labelled 'low emission'. In these days of flat screen LCD monitors, this problem will likely be going away.

Power Lines

Power line interference is often a mystery, as it comes and goes in a seemingly random manner and its source may be quite distant. In general, it is caused by a poor contact somewhere on an outdoor overhead power line. The contact may be intentional, such as two cables spliced together, or unintentional, such as a piece of wire like a coat hanger hooked over the line. High voltage insulators can produce corona discharges under certain conditions, such as dirt on them or dampness. The poor contact causes arcing, which generates the RF spectrum, which is modulated at 50 or 60 Hz depending on which continent you live in. Winds, rain, fog and snow can all have an effect on power line interference, sometimes increasing it dramatically and at other times reducing it, depending on the type of faulty connection. One feature of certain types of power line interference is that it tends to build up slowly over a period of months or longer as an insulator or joint on a line degrades. Power line interference on an APT image is very similar in appearance to the interference caused by a computer monitor.

Co-channel Interference from another Satellite

There are two types of co-channel interference, that seen on GOES WEFAX and Meteosat signals is the result of using a receiving antenna with too wide a beamwidth or excessively high side-lobes. Such an antenna receives not only the signal from the desired satellite (say, GOES 10), but also the signal from another satellite located at a different longitude. As all GOES and (I believe) Meteosat geostationary weather satellites radiate on 1691 MHz, this results in a beat pattern on the images, often called herringbone interference. This effect could also occur with the NOAA TIROS satellites, except that the *Spacecraft Control Center* takes care to turn off the transmitter of one of the satellites if their orbits coincide. Co-channel interference from terrestrial transmitters is rare, because of frequency allocation regulations. More recently another source of co-channel interference has appeared, with the deployment of the *Orbcomm* satellite constellations. These digital data communications satellites are also in low-earth orbits (LEO) but not in the same planes as the polar orbiting NOAA and METOP satellites. But their frequency allocations are in the 137 MHz band and the frequencies used are very close, so interference is occasionally experienced.

Illustrated Interference Examples

Figure1 shows a typical case of pager interference. It is characterised by bars of interference lasting tens of seconds, and within the bar can be seen blank periods and periods with dotted lines. These correspond to the tones, intervals and data (and sometimes voice) of the pager burst. Like most interference, pagers have worse effects at low angles of elevation of the satellite where the signal is weakest, so they are usually seen at the beginning and end of passes. Because the interference is the

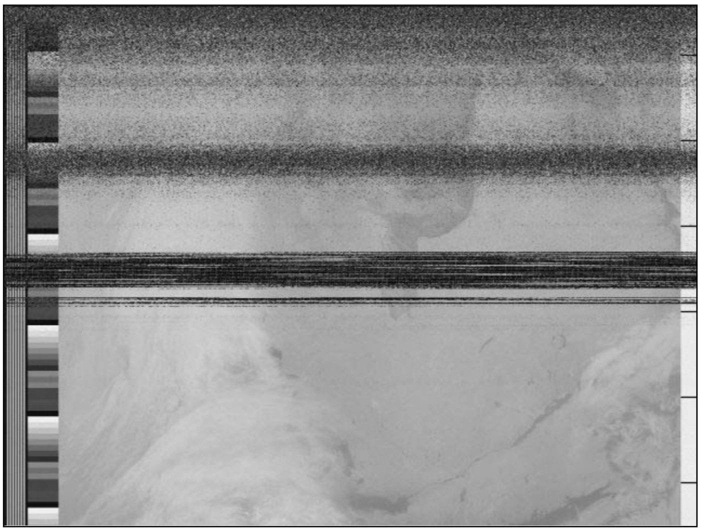

Figure 4 - Antenna problem

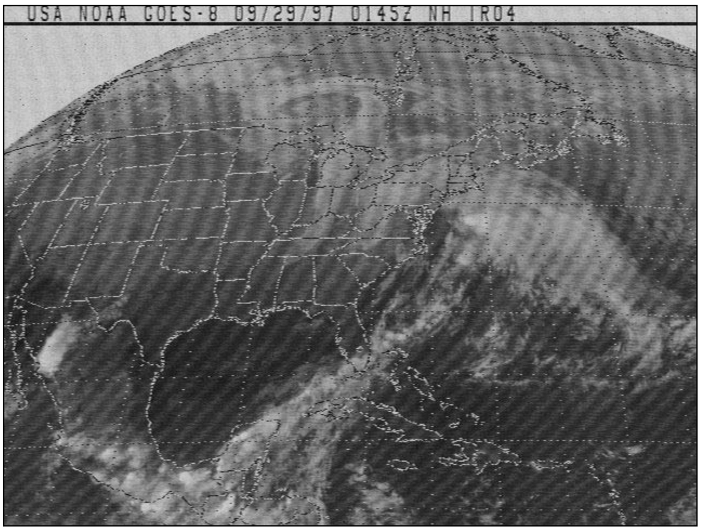

Figure 5 - GOES Co-channel interference

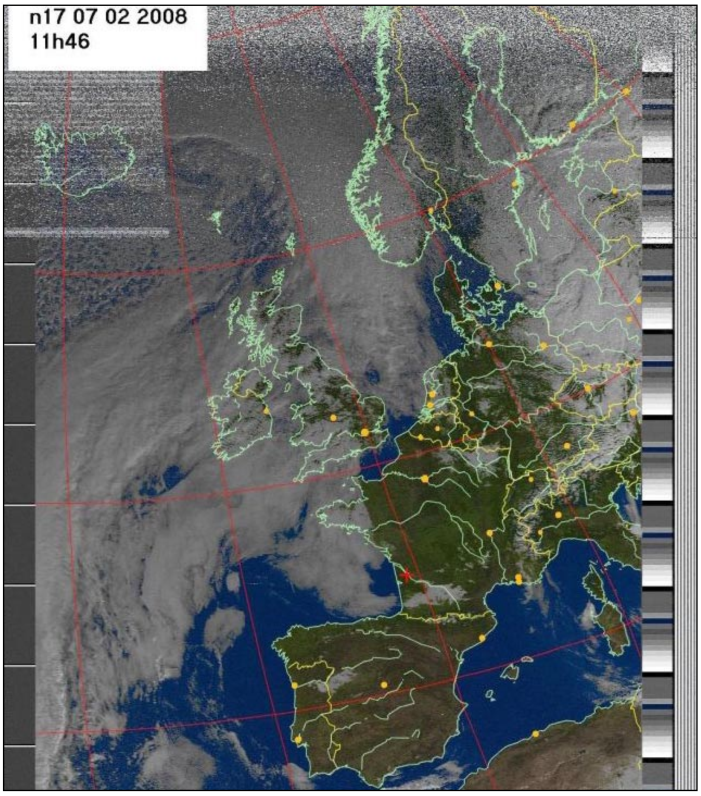

Figure 6 - Orbcomm satellite interference

result of a non-linear process in the receiver, it is often highly specific to one of the weather satellite frequencies: in my case 137.62 MHz is much more affected than 137.50 MHz.

Figure 2 illustrates the effect of CRT monitor interference. This shows up as diagonal bars across the image and, like the pagers, is worst at the beginning and end of passes. By counting the number of bars across the image and doubling it (to allow for the fact that the image width corresponds to 0.5 seconds), you obtain the frequency. In the example shown there are 44 bars, which translates into a rate of 88 Hz. The monitor vertical scan rate is supposed to be 85 Hz: near enough!

Power line interference (***Figure 3***) also looks just like this, except that each half-cycle of the a.c. generates a bar; so there will be twice as many bars as the line frequency.

Modem interference is rather more subtle. As noted, many 14400 bps modems seem to generate a signal at 137.62 MHz and not at the other frequencies used by weather satellites. This signal is fairly stable and co-channel, and it affects the image in two ways. By interfering with the satellite signal it tends to prevent receiver lock-up, delaying acquisition and collection of the image. During collection, it shows up as a faint herringbone pattern or streaky pattern all over the image. I have not observed this type of interference with other types of modem: in particular 2400 bps, 33.6 kbps, and V92.

General computer interference is similar to noise: it can be heard aurally from the receiver as noise and tends to raise the receiver noise floor, delaying signal synchronisation and shortening the pass duration. You can check if you have it by listening to the audio output of the receiver and turning the computer off.

Problems are sometimes encountered with antennas which appear to be due to interference but are not. ***Figure 4*** illustrates this, with a portion of an image which has a pager bar but also a noise bar. In this case, the antenna in use was an experimental one (a quadrifilar) possessing a null in the reception pattern which gave rise to the noise bar. It also had a more rapid drop in signal strength at low elevations than is normal. This type of problem can be recognised by the fact that the signal fades smoothly into noise and then back out of it.

Figure 5 shows a GOES 8 image exhibiting co-channel interference from GOES 10. Although GOES 10 was not operational at the time the picture was taken, its 1691 MHz transmitter had been turned on to warm the spacecraft during the eclipse season, with the results shown. My antenna was a 44 element yagi, which had enough gain to receive the WEFAX signal, but not enough directivity to exclude the GOES 10 signal which was about 40° in azimuth away from GOES 8. Four-foot dishes also fall into this category.

Figure 6 (thanks to Alain Nierveze) shows interference experienced from an *Orbcomm* satellite when receiving NOAA-17. The Orbcomm satellites use 137.56 and 137.6625 MHz, very close to the NOAA frequency of 137.62 MHz, and uses data frequencies of 57.6 kHz in bursts, one of which can be seen in the upper left hand corner of the image. It is interesting to note that the interference burst is almost perfectly synchronised with the NOAA-17 APT scan, giving rise to the straight lines running down the screen.

Curing the Interference

Pagers

Much has been written on the problem of pager interference. It would take up too much space to repeat it all here, so I will give a short summary. As the problem is in the receiver, and due to overload of the receiver's early stages, it helps to reduce the interfering signal if this can be done without reducing too much of the wanted satellite signal. For example, antenna preamplifiers are good for the system noise factor, but amplify the already very large pager signal by 30 dB or more. Removing the preamp can often effect a significant reduction in interference, if not a cure. You may then want to replace the co-axial cable connecting the antenna to the receiver with a low-loss variety such as *Belden 9913*. Make sure you select double screened cable, as this helps avoid pick up of various types of interference, such as computer emissions, on the feeder.

If the interference persists after taking these steps, the addition of a helical filter before the receiver may help. In my case, a three-stage custom helical filter was built which gave 1.1 dB of loss to the wanted frequencies while attenuating the unwanted pager signals by 57 dB and 26 dB. (Fortunately, the pagers were on 140.16 and 141.40 MHz.) If your pagers are within a few hundred kHz, as some are in the UK, the filter will not be able to help you. All other simple types of filter, such as tuned stubs, have inadequate Q to discriminate between the wanted and unwanted signals.

Computer

It is difficult to offer advice with computer interference, as it is invariably picked up by the antenna (or feed coax), and is therefore very sensitive to relative location and orientation. Moving the computer around the room to find a quiet spot is one solution. If the receiver is connected to the PC via a screened cable, check that the cable is of good quality with well attached connectors. Looping the cable through ferrite rings can prevent interference being transmitted along the outer conductor. Checking the connectors on the co-axial cable from the antenna to the receiver can also pay off, if there is poor contact to the outer screening.

Some 14400 baud modems can be turned off by issuing the command 'ATS24=1' in a terminal window—this sets the internal timer to turn the modem off after 1 second. (This command is meant for use with battery operated modems but the commands have been carried through into desktop modems in some cases). You will have to repeat the command if the phone rings! If this does not work with your modem, removing or replacing it with another type seems to be the only cure.

The monitor should be kept well away from the feed cable between the antenna and the receiver. Changing the relative orientation of the monitor, the cable run and receiver may also do the trick. The monitor can be turned off during passes if a quiet location cannot be found. The energy-saving mode can be used for this if desired. I would note here that my old monitor (SVGA, circa 1990) did not produce any interference, but my newer one (1995, with 'low emission'), does produce a lot, as Figure 2 shows.

If all else fails, resorting to recording the signal on a tape recorder for later playback into the computer is one approach which enables the computer to be switched off during satellite passes.

Power Lines

This type of interference, once identified, has to be handled through the owners of the power lines concerned. At least in the continent I lived in (N. America), most authorities are aware of the potential for problems and are sympathetic to doing something about it provided you can demonstrate to them that it is a power line problem. To do this you must exclude all other possibilities and, by counting the number of bars, get a strong indication that the interference is at power line frequency. If the interference varies with weather, log the severity and the weather conditions, keeping copies of the imagery you get in each case. To the expert from the power company, a statement that the interference is worse when the wind is blowing, or better when it is raining, contains much useful information about the likely cause of the problem. When I suffered power line interference the culprit turned out to be 3300 volt insulators on a pole about 500 metres away. The same pole also carried 11 kV and 33 kV lines, and I had a 275 kV line about 300 metres away. The expert tracked down the source of the problem within an hour or so and fixed it the same day.

Co-channel Interference

These days, this type of interference with APT signals is almost exclusively a problem with Orbcomm as the Meteosat and GOES geostationary satellites have long since discontinued the dissemination of Wefax.

There is little or nothing that can be done about co-channel interference as the satellites are using allotted frequencies and

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APT receiving antennas are (or try to be) omnidirectional. Fortunately, the orbits of the Orbcomm and NOAA satellites are sufficiently different that the interference is relatively rare.

Conclusion

This brief article has attempted to describe several commonly encountered types of interference that may be experienced by amateurs receiving weather satellite transmissions. As with many problems of this type, every case tends to be different, because of the different locations, receiver types, feeder cables and antennas in use. Because of this, a certain amount of try-it-and-see experimentation is called for if the approaches described in the article do not work straight off. Good luck!

The author of this article is willing to offer advice on the subject of interference. Please email

alan.sewards@free.fr

If you can attach a small image to the email, preferably in jpg format, which shows the problem, together with a description of your receiving system, this will greatly help the diagnosis.