Nonlinear effects on antennas

by Igor Grigorov/RK3ZK

TVI and RFI appeared suddenly when my transceiver worked on amateur ranges of 10-20 meters. Earlier the transceiver worked everywhere without TV and FM radio interferences. I did not do anything either to the transceiver or the antennas.

For search of the cause of interferences the transceiver was switched off from the outside antenna and loaded to a dummy load. No interferences! The transceiver was switched on to the indoor magnetic loop. Again, no interferences! Interferences appeared when the transceiver was switched on to the outside antenna. An additional low-pass filter at transceiver output did not influence the level of arising interferences. ***So, located on a roof antenna was the source of interferences.***

But how can the antenna create TV and FM radio interferences? Why did the interferences disappear some days later and the antenna worked well again?

The heart of the effect

These interferences are caused by a nonlinear conductivity (like a semi-conductor) at an oxide film covered metal parts, which comprise the antenna or are located near the antenna**.** For example, a copper oxide is a good semi-conductor. The oxides of many other metals are good semi-conductors too. A pressing junction of one metal to another, especially if a galvanic couple is formed there, often has a semiconductor's effect.

Let's examine the things that take place if a transmitting antenna or metal objects which are placed near this antenna have parts causing the nonlinear effect. When the antenna works at transmitting mode, RF currents flow through these semi-conductor sites, and these RF currents can be significant. The antenna or metal objects placed near an antenna, that have sites keeping nonlinear conductivity through which RF currents flow, will work like a mixer or a multiplier of radio signals. In this case, radio signals emitted by a ham's transceiver, can be mixed in different combinations with radio signals from a television center or from VHF broadcast or service stations, with main buzz of 50 (60) Hz, or multiplied by each other.

The secondary signals, obtained as a result of it, with frequencies formed by different linear combinations of frequencies of original signals, can be radiated back in the ether. It will cause different electronic equipment interferences at the activity of a ham transmitter.

The nonlinear effect of mixing signals can appear at a power going to an antenna starting from several watts.

Everything depends on the location of these nonlinear sites. At placing them directly on the antenna, on the antenna mast, on guys, a small power will be enough for forming secondary signals. At removing the nonlinear sites from the antenna, a considerable power going to the antenna will be needed for forming secondary signals.

If the nonlinear sites are placed on the metal objects that have resonances at the operating frequencies of a ham's transmitter, a small power going to the antenna will be enough for creating secondary signals. If the metal objects keeping the nonlinear sites have resonances on the frequencies of the secondary signals, the radiation of the secondary signals will be especially great.

The causes of sudden occurrence of the nonlinear effect

Let's examine the effects that can cause sudden occurrence of the effect of nonlinear conductivity. I think that acid rains and dust containing particles of metals can cause these effects.

Acid rains cause a strengthened corrosion of metal, and, hence, occurrence of an oxide film keeping the effect of nonlinear conductivity. Many hams observed that sometimes after rains the transceiver that worked before without interferences suddenly started to create interferences. The dust, containing particles of metal and suddenly brought with a strong wind, can create sites keeping the effect of nonlinear conductivity.

Metal dust covers the metal objects placed on and near the antenna, acid rains cause some chemical reactions between the metal dust and metal that this dust covers. As a result of it, after a strong wind which contains particles of the metal dust and acid rains, a transceiver starts to create TV and FM radio interferences.

As a rule, suddenly created sites, keeping the effect of nonlinear conductivity, suddenly disappear. Some time after the rain and dusty storm, the sun dries up the oxidized surfaces, and (in my opinion) destroys the film of oxide formed by acid rains. The effect of nonlinear conductivity disappears, and a ham's transceiver does not create interferences in its work.

Dangerous nonlinear sites

The sites, keeping the effect of nonlinear conductivity, that are created for a long time, are the most dangerous, because, as a rule, they do not lose the properties under effect of the sun. The sites, keeping the effect of nonlinear conductivity, that are created for a long time, at first create weak interferences. In the course of time the sites produce still stronger interferences.

For example, if a drop of water gets under paint cover of an antenna, the drop can create a site keeping the effect of nonlinear conductivity. To find the site is rather difficult! Copper and brass antenna parts, and copper and brass objects placed near the antenna, which are unprotected by paint, in the course of time are oxidized. Aluminum antenna parts with scratches are also subjected to oxidation. This oxide can have the effect of nonlinear conductivity.

It was noticed by me, the sites, keeping the effect of nonlinear conductivity, which were created during long time, demand some "additional charging" so as not to lose the nonlinear effect. That is, if an antenna, that has the sites, keeping the effect of nonlinear conductivity, is not used to transfer, the sites lose the qualities But as soon as the antenna starts to work to transfer, the sites, keeping the effect of nonlinear conductivity, restore the nonlinear qualities for a short while. Thus, external atmospheric conditions influence a little the restoration of these nonlinear qualities, work of the antenna to transfer influences much. Nonlinear qualities can be restored both in dry and rainy weather, both in heat in the summer, and in a frost in the winter.

Searching of sites keeping the effect of nonlinear conductivity

Let's examine how it is possible to find out the sites keeping the effect of nonlinear conductivity.

I used two methods for search of the sites. The first method is a visual method, the second one is a tool method.

The visual method consists of a visual inspection of the antenna design and places located near the antenna. By using this method we visually find suspicious oxidized places and suspicious pressing junctions of one metal to another. We also find metal objects located near the antenna that should have resonances within the antenna operation ranges.

After that a tool method is used. This method confirms or denies whether the visually found places can create interferences, or, that is the same, they have the effect of nonlinear conductivity or not.

Nonlinear effects in resonant objects

Using the tool method we can measure resonances of metal objects that are near the antenna or used in the design of the antenna (for example, masts, guys, etc.). It is possible to find resonances with the help of a GDO. This method of measuring resonances of masts and guys with the help of a GDO is described in reference **[1]**.

If metal objects have resonances within operational ranges of a ham's transceiver, significant RF currents can flow on surfaces of these metal objects when the transceiver works to transfer. When significant RF currents flow on surfaces of objects that have sites keeping nonlinear conductivity, these objects will work like a mixer or a multiplier of radio signals. In this case, radio signals emitted by ham's transceiver, can be in different combinations mixed with radio signals from a television center or from VHF broadcast or service stations, with main buzz of 50 (60) Hz, or multiplied by each other. My experience shows that a pressing junction of such resonance objects produces a very high level of interferences.

Photo: Finding of resonance of the mast ith help a GDO

Photo: Finding of resonance of the guys with help a GDO

If to change the resonance frequencies of these objects, a level of the RF currents, caused by work of the antenna to transfer, will be sharply decreased. In this case the level of the interferences will be considerably decreased too, or the interferences will disappear entirely. It is possible very simply to change a resonance frequency of a metal mast (to shift it downwards), if at its base to install a ferrite ring from a deflection system of a TV.

Photo: Ferrite core installed at the antenna mast base

Nonlinear effects on antennas

For example, a metal mast with television antennas was near my transmitting antenna. There were strong TV interferences when my transceiver worked to transfer at a range of 30-M. As it appeared, this mast had a resonance frequency 10100 kHz, or on the amateur range of 30 30-M. When a ferrite ring from a deflection system of an old TV was installed at the base of the mast, the resonance frequency of the mast became equal to 9800 kHz. TV interferences disappeared when my transceiver worked on the 30-M range.

Photo: Finding of resonance of the antenna mast with the ferrite core at its base with help a GDO

Unfortunately, when the ferrite ring was installed, a resonance on a range of 15-M appeared at the mast. TV interferences appeared too. For elimination of this resonance I used a magnetic tape from an old videocassette. When I wound the centre of the mast with the tape, my GDO did not fix any resonance on amateur ranges. By means of an old magnetic tape from old videocassettes it is possible to eliminate easily parasitic resonances of masts and guys on high-frequency amateur ranges of 15-6 meters

There is one more way of eliminating parasitic resonances of metal objects. It consists in painting these objects in graphite paint. This way, and also manufacturing of the graphite or coal paint, is described in reference **[1]**. It is the most effective way of struggle against this phenomenon.

Direct detection of sites keeping the effect of nonlinear conductivity

When the parasitic resonances of metal objects placed near the antenna are eliminated, start a further search of the places creating interferences. For that a transceiver is turned on to a small RF power, when the effect of nonlinear conductivity begins only to appear in the antenna system and objects placed near the antenna.

Try to find places where the interferences are formed by an indicator of interferences.

Photo: Wrapping the antenna mast by magnetic tape

Indicator of interferences

It is possible to use either a portable TV-set or a hand-held receiver working on a wide range of frequencies as an indicator of interferences. A TV - set quickly and reliably helps to find a place where interferences are formed and shows the influence of TV interferences. It is very simple to find interferences with the help of a broadband receiver. The receiver hisses and rattles and receives imaginary stations near the places keeping the effect of nonlinear conductivity.

I prefer to use a broadband receiver for finding places keeping the effect of nonlinear conductivity. A hand – held receiver has smaller sizes than a portable TV, but a receiver, as well as a portable TV, allows quickly to find interferences and places where the interferences are formed. For example, for a long time I have used a broadband radio receiver “Tecsun-R1012” for finding interferences. This receiver works at MW, SW (5-22 MHz), VHF-FM (60-110 MHz) and VHF – TV (1 - 12 TV channels).

This receiver allows to search for the interferences on a wide range of frequencies.

Finding the interferences

Smoothly moving a TV set or a receiver around an antenna, try to find places where the level of interferences is maximum (see **Fig. 1**). Try to find the interferences near the already visually found oxidized sites, places of pressing junctions of metals, near metal parts that have parasitic resonances. Usually in this case the pattern of interferences is very spread. It is clear, combination frequencies are created on small nonlinear segments, where there are conditions for their appearance, and they are radiated through sizable parts - guys, metal enclosure of a roof, antenna, etc. However, the maximum of intensity of interferences will be near the places where they are created.

Photo: Finding of the interferences

After that proceed with searching of the exact places where interferences are formed.

Localization of the interferences

To determine the placement of a site keeping the effect of nonlinear conductivity the suspicious place is irradiated by RF energy.

Figure 1 Search of sites keeping the effect of nonlinear conductivity

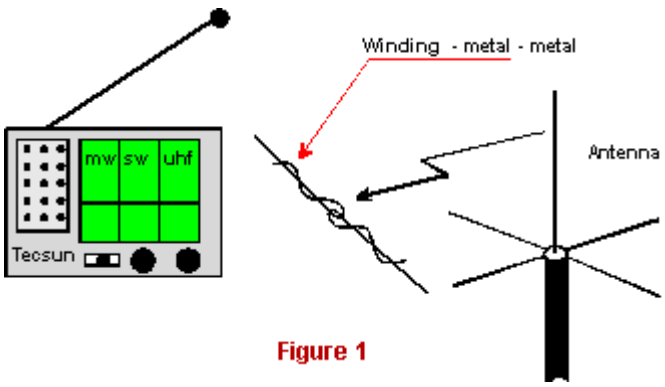

Figure 1

An RF Lantern is used for this purpose. The design of the RF Lantern is simple.

RF Lantern

A dummy load that is connected to the end of the feeder going from a ham's transceiver can serve as a RF Lantern. The dummy load must be unscreened. 10- 40 watt going to the dummy load will be enough for the RF Lantern to work. It is possible to use an incandescent bulb that has a resistance equal to the wave resistance of the feeder and a proper power as a dummy load.

A dummy load has a small field of radiation at immediate proximity near it. It allows to irradiate a suspicious site placed near the dummy load and check the site to keeping the effect of nonlinear conductivity. **Fig. 2** shows the method. A TV set or a radio receiver should be near that place where occurrence of nonlinear effect is supposed to be.

Photo: Localization of a suspicious place

Figure 2 Localization of a suspicious place

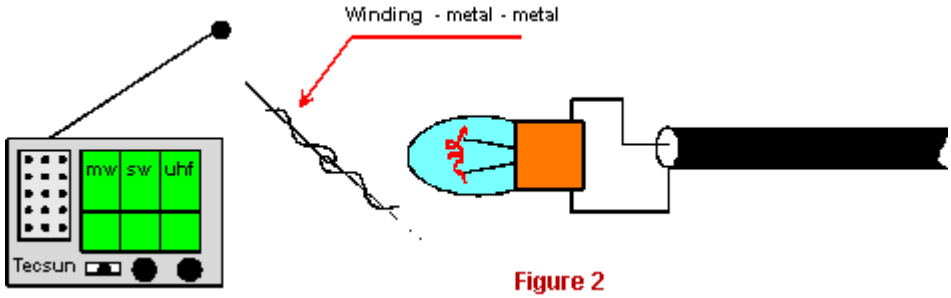

Figure 2

"Shining" by the radio field of the RF Lantern the suspicious places, such as the oxidized surfaces of metals and pressing junctions of metals, it is possible very precisely to define whether interferences are created there. The coaxial cable that feed the RF Lantern should provide free moving around the places that are suspected of keeping the effect of nonlinear conductivity. RF Lantern on the base of an incandescent bulb is especially convenient to search for such places. In this case, "shining" a suspicious place by the light of the bulb, we check this place on the creation of secondary frequencies.

When the places keeping the effect of nonlinear conductivity are found, start to eliminate the effect of nonlinear conductivity. Ways of liquidating nonlinear effects depend on the reasons for their occurrence. Let's examine the ways of eliminating interferences arising at a place of pressing junction of metals.

Touching metals

The effect of nonlinear conductivity arising at places of pressing junctions of metal, for example, at places of winding of metal guys or at a touch of a metal guy to a metal mast, could be eliminated by isolating metals from each other.

Metal guys are broken by insulators, a touching place of a metal guy to a metal mast is broken by an insulator plate or tape.

However, in some cases it is not possible to eliminate the touch of metals to an antenna mast or an antenna guy. Some samples of antenna metal masts have designed pressure junctions of metals among themselves. That is why the elimination of these pressing junctions of metals will entail alteration of the mast.

For elimination of the effect of nonlinear conductivity arising at places of pressing junctions of metals that are impossible to break by insulators, use food foil or graphite paint. For this wrap up this place in a food foil or paint it in graphite or coal paint.

Graphite paint

The universal way of eliminating the effect of nonlinear conductivity consists in covering the places keeping the nonlinear effect with graphite or coal paint. The way of manufacturing graphite or coal paint is described in reference **[1].**

Photo: Wrapping a suspicious place by aluminum foil

It is possible to rub the places with graphite or coal if a ham has no graphite or coal paint. What is the effect of rubbing metal objects or parts of these objects, keeping the effect of nonlinear conductivity, with graphite or coal paint?

Firstly, by covering metal objects or parts of these objects with graphite paint we will essentially reduce Q- factor of these objects on high frequencies that results in significant decrease of a level of high-frequency currents which are induced at work of a closely located transmitting antenna. Elimination of resonances in the field of frequencies of work of the transmitter considerably will lower the efficiency to create secondary frequencies. Elimination of resonances in the field of the secondary frequencies, produced at places keeping the effect of nonlinear conductivity, will lower the efficiency to radiate the interferences.

Secondly, the layer of graphite, located atop of a site keeping the effect of nonlinear conductivity, provides additional absorption of a high-frequency energy in a wide spectrum of radio frequencies. The graphite layer provides absorption of the signal radiated by the ham's transmitter, affecting the site keeping the effect of nonlinear conductivity and being the reason for creating secondary frequencies. The same graphite layer provides additional absorption of the secondary frequencies created on sites keeping the effect of nonlinear conductivity. It will considerably reduce an overall performance of the sites keeping the effect of nonlinear conductivity to create secondary frequencies.

Thirdly, the layer of graphite located atop of a film of oxide or atop of pressing junctions of metals creates an equalized effect of an RF- potential on the surface where this graphite layer is allocated. It considerably lowers an overall performance of sites keeping the effect of nonlinear conductivity as a mixer of radio signals.

Nonlinear effects on antennas

It was repeatedly noticed by me that painting of pressing junctions of metals or oxidized places of metals usually reduces to full elimination nonlinear effects arising on these sites.

Panoramic Spectrum Analyser in search of nonlinear sites

If a ham has a possibility to use a ***Panoramic Spectrum Analyser***, he is capable not only of finding interferences, radiated from the sites keeping the effect of nonlinear conductivity, but also in defining parameters of the interferences. Hence, it will be possible to assume what equipment will be affected by the interferences. A Panoramic Spectrum Analyser allows to see the effect of painting in graphitic paint the places, where there are nonlinear phenomena or to see the effect from separation pressing junctions of metals from each other.

A source of nonlinear effects can be most unexpected. In one of my cases, a bay of a bimetallic wire (copper cover above iron wire) placed on a roof near my transmitting antenna caused TV interferences. After the bay was removed to the other side of the roof, the interferences were stopped.

I wish successes in struggle against nonlinear effects!

Reference:

Grigorov I.N.: Antennas: Adjustment and Tuning. Moscow, RadioSoft, 2002, ISBN: 5- 93037-087-7 (in Russian)