THE IMPACT OF DECORATIVE METALLIC COVERING OF BUILDINGS ON EMC OF VHF/UHF RADIO COMMUNICATION SYSTEMS

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Abstract. The influence of buildings decorative metallic coating on radiation pattern of antennas, allocated at buildings, and on electromagnetic environment (EME) on places of its allocation are studied. The analysis is based on MoM calculations of directivity diagrams for typical variants of antenna allocation on buildings and on experimental EME analysis near buildings with decorative metallic coating. A danger of arising the spurious couplings between nearly allocated antennas of VHF/UHF radio communication systems allocated on these buildings or in vicinities of these buildings, and danger of generating of intensive passive intermodulation (nonlinear interferences) at accommodation of these buildings near to powerful sources of radio emissions (the transmitting centers of an on-air broadcasting, VHF/UHF radars, etc.) are exposed.

Introduction

Use of decorative metallic coverings, in particular, an aluminum laminar covering, for improvement of buildings external appearance and protection against external influences considerably changes buildings electrodynamics characteristics, and is capable to influence essentially on EME in a vicinity of these buildings, and also on EMC of radio systems of the various radio services using these buildings for placement of its combined antennas, or radio systems, located on small distances from these buildings. The given influence, as a rule, is developed in the following [1-4]:

– In changing of directivity diagrams (DD) of antennas placed on these buildings, including changing of directions of main beams of antennas DD;

– In changing of conditions of radio waves diffraction on elements of buildings and in increasing of radio waves reflectance factor of buildings surfaces;

– In formation of secondary intermodulation radiation (passive intermodulation) due to nonlinear transformation of the high-frequency currents induced on elements of a metallic decorative covering (detecting on the erodibilited electric contacts between these elements) at an irradiation of a building by a powerful electromagnetic field.

The abovementioned effects are especially representative in local aggregations of VHF/UHF radio communication stations and systems (base stations of professional mobile communications) with weakly directional antennas. Typical variants of its allocation on building are resulted in Fig. 1.

The analysis of the reasons of occurrence of electromagnetic interferences in stationary and mobile VHF/UHF radio communication stations used on corresponding object (building) and in its vicinity have been undertaken. This analysis is made on the basis of the real facts of EME changing in a vicinity of one of buildings, allocation of pin antennas of VHF/UHF radio stations on which is similar to the case shown in Fig. 1, after its covering by a decorative aluminum lamination. The given object is located on distance of up to 10 kilometers from the powerful radio transmitting center having more then 10 radio transmitters of sound (AM, FM) and TV broadcasting on hectometer, meter and decimeter radio waves.

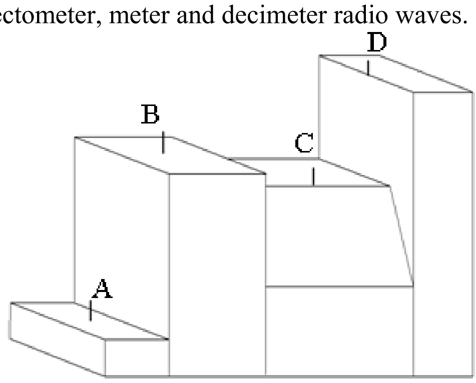


Fig. 1.

DD of the pin antennas placed near conductive surfaces

Let's consider in details geometry of object in Fig. 1 and probable variants of allocation of VHF/UHF antennas on its roof. For considered situations the following is significant and must be taken into account:

– Complex multilevel geometry of the top metal surface, presence of scarcements (elevator towers, superstructures etc.) and inclined surfaces (a metal roof);

– Antennas placement on various distances from the facets formed by horizontal and vertical (inclined) metal surfaces.

The practical majority of VHF/UHF radio communication stations, including radio stations on considered object, have dipole antennas and width of an operating frequency band ≈20% of the central tuning frequency. The typical variants of antenna arrangement are the following:

– Antenna arrangement on a plane conducting surface (horizontal or having an insignificant inclination) on distance not less than wavelength λ [m] from roof surface boundary (antennas A and B in Fig. 1);

– Antenna arrangement in an immediate closeness from a roof surface boundary formed by horizontal and inclined (antenna C in Fig. 1), or horizontal and vertical (antenna D in Fig. 1) conducting surfaces;

– Mutual arrangement of antennas on direct visibility (antennas B and C in relation to antenna D), and also in the regions of a radio shadow (antennas B,C,D in relation to antenna A).

DD numerical modeling for the dipole antennas placed on the top surfaces of object, is carried out by a method of the moments. At MoM calculations two models of conducting surfaces (Fig. 2) are used: model 1: a metal surface is approximated by system of radial conductors, and model 2: a metal surface is approximated by system of metal conductors as a grating.

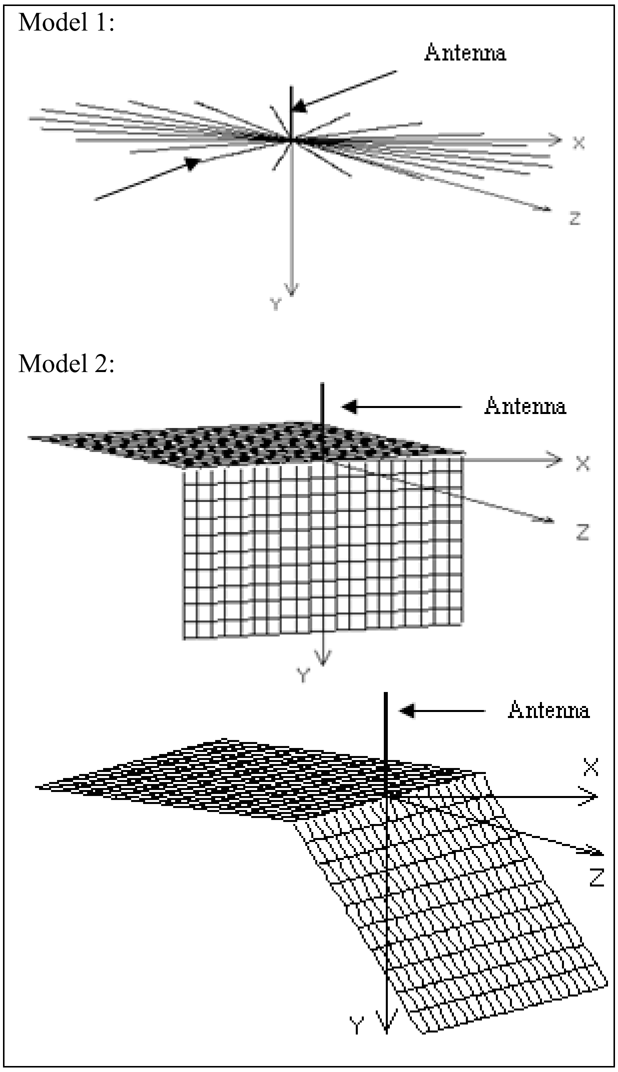


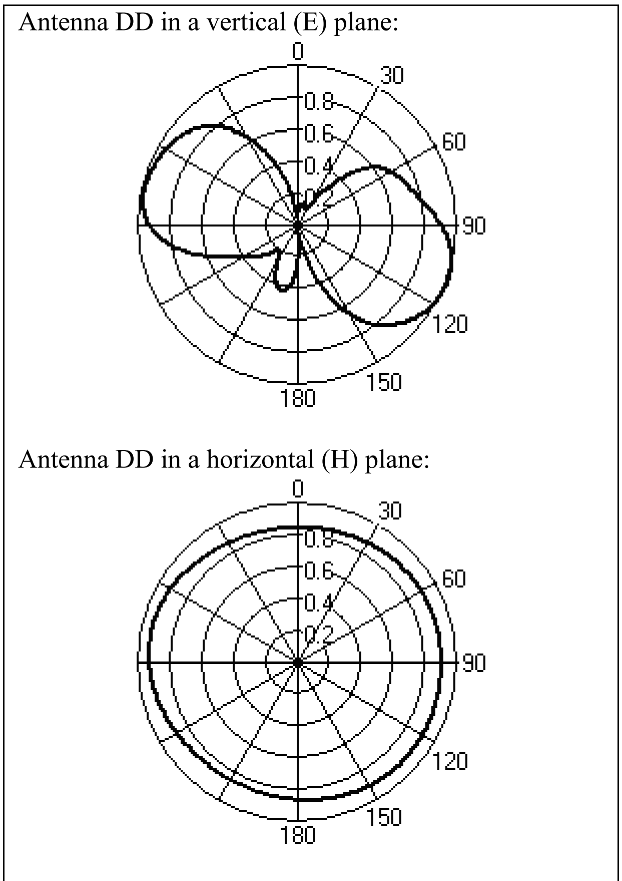
Fig. 2

Certain results of modeling for the some cases are illustrated below.

Case 1: the vertical vibrator is located in depth of a horizontal metal surface far from the edge of conducted roof, model 1 (Fig. 2) and the following initial data are used: the length of the vibrator is a quarter of length of a wave (0,224 λ), length of approximating conductors is limited to length of a wave (λ).

Case 2: the vertical vibrator is located at the edge of the horizontal metal surface passing to an inclined conducting surface with a corner of an inclination β =60º in relation to a horizontal, model 1 (Fig. 2) and the initial data corresponding to the previous case are used.

As an example DD in vertical (E) and horizontal (H) planes and also values of directive Gain, input resistance (R+iX), VSWR in lines with wave resistance 50Ω and 75Ω and antenna pattern unevenness in a horizontal plane calculated for Case 2 are given in Fig. 3.



R = 58,4Ω, X = 1,5Ω, f = 150 MHz, Gain = 2,79 dB
VSWR(50 Ω) = 1,171, VSWR(75 Ω) = 1,285
Antenna pattern unevenness on H-plane is 0,57 dB

Fig. 3

Case 3: the vertical vibrator is located at edge of the horizontal metal surface passing to a vertical conducting surface; model 2 (Fig. 2) and the initial data corresponding to the previous cases are used.

The analysis of DD calculated for this case, and also the analysis of MoM-modeling results for other antenna lengths (up to 0,5λ) and for other VHF/UHF frequencies testify to the following:

1. The allocation of antenna in depth of a conducting surface far from its edge is accompanied by "squashing" of DD main beam upwards, that results in increasing of antenna power gain in directions 20º-60º on an angle of elevation. It can worsen EMC of radio communication stations on object if their transmitting-receiving antennas are allocated at various levels under the ground surface (if antennas mutual angles of sight get in the specified range).

2. The allocation of antenna at the edge of the horizontal metal surface passing to an inclined conducting surface (a metal roof) or passing to a vertical conducting surface (a vertical wall covered by a decorative metal lamination) is accompanied by declination of DD main beam downwards, that results in decreasing of antenna power gain in directions 20º-60º on an angle of sight in a direction «away from object» and on 20º-40º upwards in a direction «towards an object» at appreciable reduction of antenna power gain in a horizontal plane. It also can be the reason of following:

– degradation of EMC of radio communication systems on object and in its vicinity if their transmitting-receiving antennas are allocated at various levels under the ground surface (if antennas mutual elevation angles get in the specified range),

– reducing of communication quality and operating distances of mentioned radio communication systems due to reduction of its antennas power gains in a horizontal plane on 1,5 … 2,5 dB.

3. In case of antennas allocation at various levels their DD declination upwards from a horizontal conducting surface and downwards "along" a vertical or inclined conducting surface in aggregate with improvement of conditions of radio waves reflection from an object surfaces and their diffraction on the numerous sharp edges formed by conducting surfaces, can provide a following cumulative reduction of losses of radio waves propagation:

– up to 3-4 dB and more between antennas located within the direct visibility, and

– up to 5-10 dB between antennas divided by conducted shielding surfaces or structure elements.

– It is capable to result in essential growth of spurious couplings between radio stations allocated on object and to inadmissible growth of levels of interferences between them.

Results of modeling of radio waves reflection

Numerical modeling of reflection of the electromagnetic field radiated by the dipole antenna, from the decorative metal covering, also executed by a MoM, allows to make the following conclusions:

1. Application of a decorative metallic covering is accompanied by increase in intensity of the radio waves reflected from corresponding surfaces (walls, roof, etc.) of buildings and/or structures, on 2-3dB and more. It also is capable to result in essential extension of electromagnetic spurious couplings between radio stations allocated on object and to inadmissible growth of levels of interferences between them.

2. Other well-known variants of realization of a decorative metallic covering (laminations of metals having rather small electric conductivity, in particular, stainless steel of various composition, or non-conducting decorative materials with superficial metallization, etc.) practically does not give effect in comparison with widely used covering by aluminum.

3. The extension of walls shielding ability of buildings due to application of a decorative metallic covering is capable to worsen quality of a mobile radio communication of various types and services, and also ecological safety of cellular communications, inside these buildings. The last is caused by increase in radiated power of the user's radio stations in conditions of increase in base losses of radio waves propagation between base and user's stations of a cellular network.

Results of EME experimental analysis

Experimental EME monitoring and analysis on the object under consideration covered by a decorative aluminum lamination, with use of a measuring receiver SMR4518 and measuring biconical antenna П6-61, and also with analysis of EME group spectrum on the outputs of separated fixed dipole antennas of radio stations exposed by interference have been executed. As a result effects mentioned above in sections 2,3 were found out, and also non-stationary passive intermodulation with levels, on 20-25 dB exceeding a level of sensitivity of typical VHF/UHF radio receivers was detected. Last is a very seldom and unpredictable type of interference in on-ground aggregations of radio equipment.

In Fig. 4 the EME spectrogram (on average and peak values at 9 kHz band of the analysis) measured on the output of feeder of dipole antenna placed on object is resulted. The overwhelming majority of narrow-band components of this spectrogram are radiated passive intermodulation formed on semiconducting contacts of laminations of an aluminum decorative covering of object. This interference was observed periodically during 10-20 s. on periods of simultaneous illumination of object by few powerful electromagnetic fields generated by radio transmitters located not far from object. The similar EME spectrogram measured on period of noncoincidence of sessions of object illumination by separated radio transmitters is resulted in Fig. 5.

Conclusion

1. Application of metallic decorative covering of buildings on the objects equipped with large number of VHF/UHF radio communication stations, can affect essentially on object “inrtasystem” and “intersystem” EMC due to essential changing of characteristics of

spurious electromagnetic couplings between antennas, changing of conditions of an interference and diffraction of radio waves owing to essential increase in electric conductivity of a surfaces of buildings.

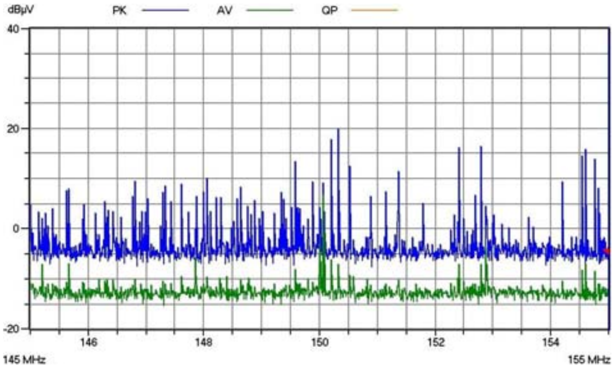


Fig. 4

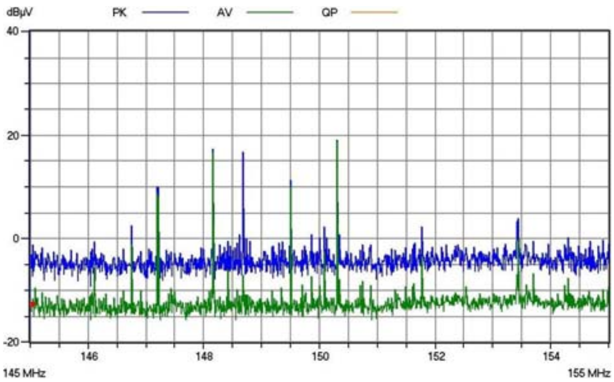


Fig. 5

2. In the cases of accommodation of weakly directional antennas of VHF and UHF ranges on buildings covered by a metallic decorative laminations it is necessary to take into account distortions of antennas DD in vertical and horizontal planes subject to character and peculiarities of positional relationship of antennas and object conducting surfaces.

3. In connection with increase in danger of emission of passive intermodulation formed on semiconducting contacts of laminations and by zones of corrosion it is necessary to abstain from application of decorative metallic coverings of buildings and constructions, allocated near to powerful radio transmitters and radio transmitting centers (especially functioning in the bottom part of the developed frequency span (frequency ranges No. 4-9 according to **Ошибка! Источник ссылки не найден.**), and on rather small distance from high-sensitivity radio receiving equipment (the backbone radio communication centers, radio navigation complexes, radars, etc.).

At that sufficiently rare concurrence of circumstances when the area of a building surface with a decorative metallic covering is large, and this building is located not far from powerful sources of comparatively a low-frequency radio emission, passive intermodulation can be the cause of interference for radio reception of low-level signals on distances up to 3-4 km from this building.

4. For reduction of danger of radiation of passive intermodulation due to occurrence of nonlinear properties of electric contacts of elements of a decorative metal covering at its corrosion under influence of an environment (atmospheric oxygen, precipitations, dews, etc.) it is necessary to develop special technological technique of fastening of metal coverings on surface of buildings or constructions which would exclude electric contacts between elements of a decorative covering or, on the contrary, would provide well protected contact connection of these elements of a covering, for example, with a welded seam.

5. The decorative metallic covering of building is capable to increase essentially the shielding of its internal premises with respect to external sources of radio emission. In result a quality of cellular communication inside building, and also its ecological compatibility and electromagnetic safety can become worse. It occurs because an inserted additional attenuation at radio waves propagation between external base station (BS) of cellular communication and indoor user's cell phones, will be compensated by BS by adequate increase in radiation power of user's cell phones, because in cellular communication networks of the second and third generations (GSM, CDMA (IMT-MC), UMTS (IMT), etc.) the user's cell phones forced power control is used.

6. Shielding of building internal premises with respect to external radio transmitters is capable to improve EMC between the radio systems used in premises, and the external radio systems using the same frequencies. In particular, it concerns EMC of equipment of local wireless broadband access networks used inside buildings and constructions (Wi-Fi), and equipment of wireless broadband access networks working outside of buildings and constructions (WiMAX), in coincident frequency bands of the 2 GHz, 3 GHz and 5 GHz ranges (2,4-2,4835 GHz, 5,15-5,35 GHz, etc.).

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