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Research Opportunity To Estimate The Energy Gain Of The Received Signal Of The Cluster DVB-T2 SFN SISO

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***Abstract*— In this article, we explore the practical opportunity to estimate the energy gain of the signal, induced at the terminals of the receiving antenna, located in the service area of a cluster DVB-T2 SFN SISO. In order to achieve the research goal, it was assumed that two plane waves reach the input of the receiving antenna, but the reception of the signal is performed through the reference antennas with circular and directional diagrams.**

Keywords—DVB-T2; SFN; SISO; MISO; reference antenna R&S HL 040; reference antenna RSH 4786; field strength; fading; intersymbol interferences; antenna factor; voltage induced

I. Introduction

A digital terrestrial television network with a single frequency SFN (Single Frequency Network), is made up of a group of transmitters that simultaneously transmit the same informational signal, on the same carrier frequencies, without essentially interfering with each other and at the same time forming the same area of service [1].

The network of single-frequency DVB-T2 transmitters can transmit the data flow either in SISO (Single Input, Single Output) operating mode or in MISO (Multiple Inputs, Single Output) operating mode.

In the MISO regime; the cluster transmitters do not emit exactly the same signal. An additional processing step with Alamouti modified coding, divides the DVB-T2 signal between two groups of transmitters on the same frequency, so that the two groups do not interfere with each other. Due to this, the fading of the induced signal at the receiving antenna terminals from several transmitters is insignificant. The application of the Alamouti algorithm reduces the speed of network traffic.

In SISO mode, it is assumed that each receiver will demodulate and decode a signal from TV transmitter, ignoring other signals. In reality, the receiver starts demodulating the first signal at its input (provided that its level exceeds the receiver's sensitivity threshold), but all the following network signals are evaluated by the receiver as interference. Under these conditions, may occur significant fading of the summary signal at the receiving antenna terminals.

Earlier, in the article [2],[3] it was shown that the interferences will be maximum when the levels of the received signals at the receiver input will be equal (comparable). To reduce interference it is necessary to use the directional receiving antenna oriented to the falling wave with the highest intensity.

This article investigates the practical opportunity to evaluate the summary level of the induced signal at the receiving antenna terminals, located in the service area of a DVB-T2 SFN SISO cluster.

II. Problem Formulation for Research

In order to achieve the proposed objective, was formulated the research problem:

1. There are 2 transmitters in the cluster - Station 1 and Station 2;
2. At the input of the receiving antenna reach the plane falling waves E1 and E2, where $E1 \geq E2$;
3. The reception of falling waves is ensured via directional reference antenna R&S HL 040, or via the circular reference antenna RSH 4786;
4. Both reference antennas are connected to the consecutive receiver by the same feeder and their suspension height remaining constant;
5. Received signal frequency: F = 500 MHz;
6. Following some simulations of the reception mode, which are expressed mathematically, it is necessary to check - what correlation exists between the increase of the signal level, induced at receiving antenna terminals in

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the service area of the DVB-T2 SFN SISO cluster, in relation to the case when a single falling wave of the network is received, with the highest intensity, with the condition that the receiving antenna is oriented strictly in the direction of this maximum radiation.

III. THE METHOD OF MEASURING THE FIELD STRENGTH AT THE INPUT OF THE RECEIVING ANTENNA

The intensity of the E field characterizes the energetics of the radio frequency signal that reaches the reception point in the form of a plane electromagnetic wave [4]. The value of the field strength is an important energy parameter, on which it depends the quality of the received signal, after its demoding and decoding.

To find out the field strength at the input of the reference antenna, it is necessary to measure the voltage at the antenna terminals connected to a load of 50 Om. The value of the field strength E [dμV/m] can be calculated by formula (1) [5]:

$$E = U_{50\Omega} + F_a + A_f \quad (1),$$

where F_a [dBm-1] is the antenna factor in the direction of maximum radiation; $U_{50\Omega}$ [dμV] is the voltage induced at load 50 Om connected to the antenna terminals, Af [dB] are losses in the feeder.

The directivity diagrams of the reference antennas are shown in Figure 2 and Figure 3. From Figure 3 we notice that the directivity diagram of the RSH 4786 antenna in the horizontal plane has an almost ideal circular shape. Table I also shows the R&S HL 040 antenna factor. Table II shows the antenna factor RSH 4786.

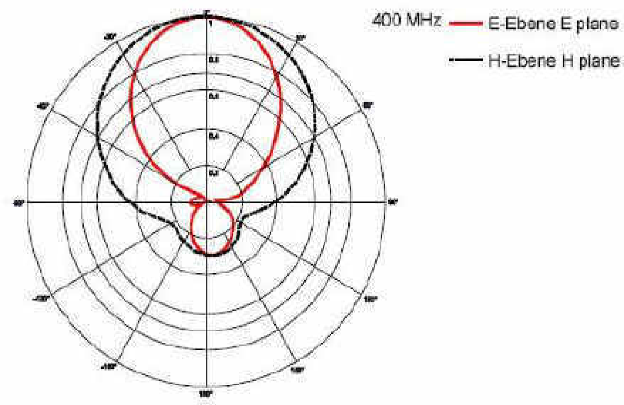

Figure 1. Directivity diagram of the R&S HL 040 reference antenna.

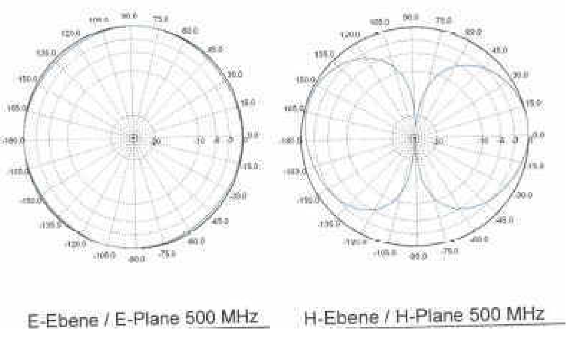

Figure 2. Directivity diagram of the RSH 4786 reference antenna.

TABLE I. THE R&S HL 040 ANTENNA FACTOR

Freguency, MHz	**Antenna factor, dBm-1**
500	16.37

TABLE II. THE RSH 4786 ANTENNA FACTOR

Freguency, MHz	**Antenna factor, dBm-1**
500	23.49

As a first step of the research, we will compare the voltage level induced at the receiving circular and directional antenna terminals. Reception conditions: works only Station 1, the directional reception antenna is strictly oriented in the direction of the falling wave E_1.

E_1 [dBμV/m] = $U_{c\,1}$ [dBμV] + 23.49 [dBm^{-1}] + A_f[dB],

E_1 [dBμV/m] = $U_{d\,1}$ [dBμV] + 16.37 [dBm^{-1}] + A_f[dB]

$U_{c\,1}$ [dBμV] + 23.49 [dBm^{-1}] + A_f[dB] = $U_{d\,1}$ [dBμV] + + 16.37 [dBm^{-1}] + A_f[dB] =>

$U_{d\,1}$ [dBμV] = $U_{c\,1}$ [dBμV] + 7.12 dB.

Therefore, at the terminals of the directional antenna R&S HL 040 oriented in the direction of the maximum radiation of the falling wave E_1 is induced the voltage level by 7.12 dB, higher compared to the circular antenna RSH 4786. Already, considering only this aspect, we can talk about the opportunity to use directional antennas in the service area of a DVB-T2 SFN SISO network.

IV. SIGNAL RECEPTION VIA ANTENNA WITH CIRCULAR DIAGRAM

The following mathematical reports were prepared for the simultaneous reception of waves E_1 and E_2 by means of the antenna with the ideal circular directivity diagram. In this case, the plane waves E_1 and E_2, will induce at the receiving antenna terminals, connected to the load 50 Om, the voltages $U_{c\,1}$ and $U_{c\,2}$. Therefore, at the antenna terminals we will obtain a summary level of the signal:

U_c [μV] = ($U_{c\,1}$ + $U_{c\,2}$), or

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U_c [dBμV] = 20lg ($U_{c\,1} + U_{c\,2}$).

1. We will examine the case when $E_1 > E_2$ =>

$U_{c\,1} > U_{c\,2}$ => U [μV] = ($U_{c\,1} + U_{c\,2}$) < 2 $U_{c\,1}$ =>

U_c [dBμV] = $U_{c\,1}$ [dBμV] + ΔU_c [dB],

where 0 dB < ΔU_c < 6 dB.

$U_{c\,1}$ [dBμV] = 20lg $U_{c\,1}$ =>

20lg $U_{c\,1}$+ ΔU_c [dB] = 20lg ($U_{c\,1} + U_{c\,2}$), or

ΔU_c [dB] = 20lg ($U_{c\,1} + U_{c\,2}$) – 20lg $U_{c\,1}$ (2)

Therefore, when the intensities of waves E_1 and E_2 are comparable, the voltages $U_{c1} \approx U_{c2}$ will be induced at the receiving antenna terminals, and increasing the level of the summary signal of ΔU_c in relation to the signal U_{c1}, induced by the wave with greater intensity, will be comparable to the value of 6 dB. Consequently, at the receiving antenna terminals will appear the significant fading of the summary signal and respectively quite significant intersymbol interventions.

To demonstrate this case, were measured the levels U_{c1} and U_{c2} induced at the RSH 4786 antenna feeder output of two falling waves that are transmitted in 31 TV channel. The results of the measurements are shown in Figure 3 and Table III.

We notice that the values U_{c1} and U_{c2} are comparable. At the antenna terminals there is a significant fading of frequencies (see the frequency band of the 8 MHz channel), which speaks of the presence of quite significant intersymbol interferences. The quality parameter MER (Modulation Error Ratio) of the received signal has a rather low value MER = 20.6 dB. The value ΔU_c = 51.6 dBμV - 48.2 dBμV = 3.4 dB.

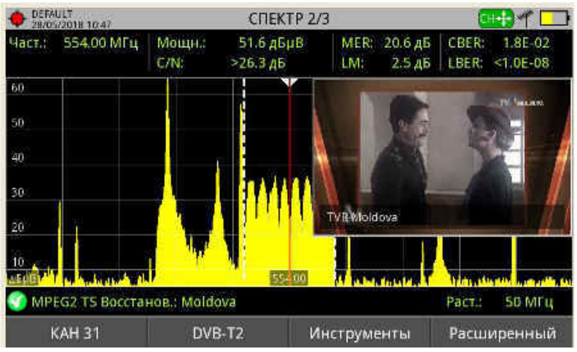

Figure 3. RSH 4786 antenna feeder output signal (Station 1 - On, Station 2 - On)

TABLE III. RESULTS OF DVB-T2 SIGNAL MEASUREMENTS VIA RSH 4786 CIRCULAR ANTENNA

Technical parameters	**Station 1 On Station 2 Off**	**Station 1 Off Station 2 On**	**Station 1 On Station 2 On**
U, dBμV	45.8	48.2	51.6
MER, dB	-	-	20.6

2. We will examine the case when $E_1 = E_2$ =>

$U_{c\,1} = U_{c\,2}$ => U_c [μV] = ($U_{c\,1} + U_{c\,2}$) = 2$U_{c\,1}$ =>

U_c [dBμV] = $U_{c\,1}$ [dBμV] + ΔU_c [dB],

where ΔU_c = 6 dB.

In this case, the interference at the receiving antenna terminals will be maximum, but signal reception will be impossible.

V. SIGNAL RECEPTION VIA ANTENNA WITH DIRECTIONAL DIAGRAM

As a first step we will appreciate the voltage level induced at the terminals of the R&S HL 040 antenna, in case when only Station 2 is working. For this we orient the R&S HL 040 antenna strictly in the direction of the falling wave E_2. Therefore, the voltage will be induced at the receiving antenna terminals:

$U_{d\,2}$ [dBμV] = E_2 [dBμV/m] – 16.37 [dBm^{-1}] – A_f[dB].

For the simultaneous reception of the signals E_1 and E_2, we will direct the receiving antenna strictly in the direction of the arrival wave E_1. In this case, the plane waves E_1 and E_2, will induce at the receiving antenna terminals, connected to the load 50 Om, the voltages $U_{d\,1}$ and $U'_{d\,2}$, where $U'_{d\,2} << U_{d\,2}$ due to the directional properties of this, see Figure 1.

Therefore, at the antenna terminals we will get a summary level of the signal:

U_d [μV] = $U_{d\,1} + U'_{d\,2}$.

To evaluate the value of ΔU_d, were developed the following mathematical expressions:

$E_1 \geq E_2$ => $U_{d\,1} > U_{d2} > U'_{d\,2}$ =>

U_d [μV] = ($U_{d\,1} + U'_{d\,2}$) < 2 $U_{d\,1}$ =>

U_d [dBμV] = 20lg ($U_{d\,1} + U'_{d\,2}$), or

U_d [dBμV] = $U_{d\,1}$ [dBμV] + ΔU_d [dB],

where 0 dB < ΔU_d < 6 dB, but

ΔU_d [dB] = 20lg ($U_{d\,1} + U'_{d\,2}$) – 20lg $U_{d\,1}$ (3)

From the expressions (2) and (3) we observe that, when the values $Uc_1 \approx Uc_2$ but $U'_{d2} << U_{d2} < U_{d1}$, we obtain inequality, $\Delta U_d < \Delta U_c$. In conclusion, we can make a more detailed precision of the value ΔU_d, namely

0 dB < ΔU_d < ΔU_c < 6 dB.

Therefore, this signal reception option is the most favorable for the DVB-T2 SFN SISO system, because $U_{d1} = U^{max}$, but $\Delta U_d = \Delta U^{min}$. In this case, the fading of the signal at the receiving antenna terminals will be non-essential, but the interference between the symbols will be minimal. To demonstrate this case, were measured the quality parameters of the signal induced at the output of the R&S HL 040 antenna feeder by the same two falling waves, as in the case presented in Fig. 3. The measurement results are shown in Figure 4,5,6 and Table IV.

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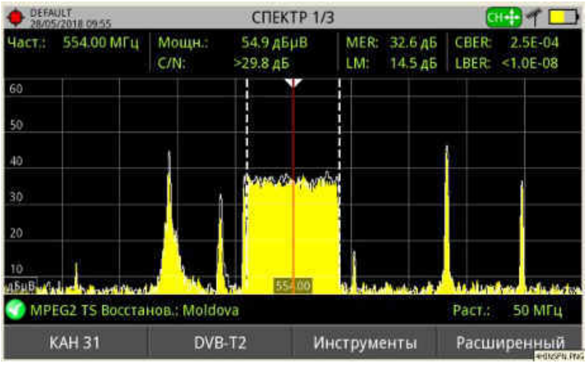

Figure 4. R&S HL 040 antenna feeder output signal, oriented towards Station 1,(Station 1 - On, Station 2 - On)

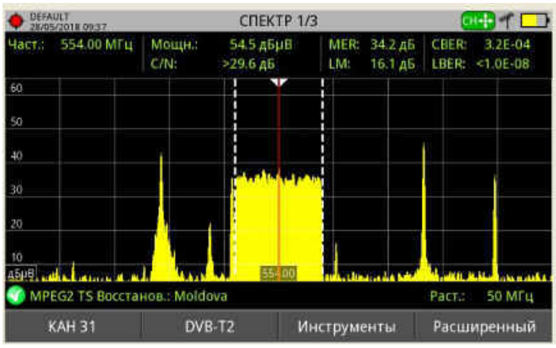

Figure 5. R&S HL 040 antenna feeder output signal, oriented towards Station 1, (Station 1 - On, Station 2 - Off)

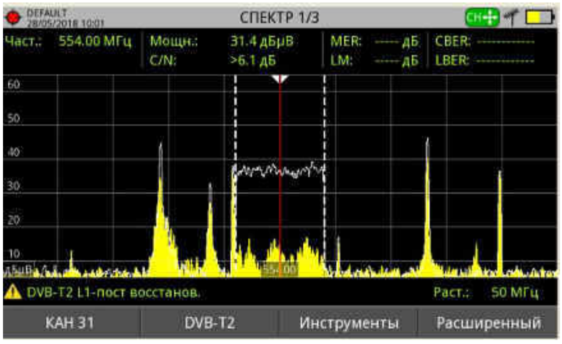

Figure 6. R&S HL 040 antenna feeder output signal, oriented towards Station 1, (Station 1 - Off, Station 2 – On)

TABLE IV. RESULTS OF DVB-T2 SIGNAL MEASUREMENTS VIA RSH 4786 CIRCULAR ANTENNA

Technical parameters	**Station 1 On Station 2 Off**	**Station 1 Off Station 2 On**	**Station 1 On Station 2 On**
U, dBμV	54.5	54.9	31.4
MER, dB	34.2	32.6	-

We notice that U'_{d2} = 31.4 dBμV << U_{d1} = 54.5 dBμV but ΔU_d = (54.9 dBμV - 54.5 dBμV) = 0.4 dB. So the fading of the summary signal is insignificant, but the interferences are minimal. Compared to the case of the circular antenna, the MER quality parameter increased by 12 dB (32.6 dB - 20.6 dB).

VI. CONCLUSIONS

Following the research opportunity to estimate the energy gain of the induced signal at the receiving antenna terminals in the service area of DVB-T2 SFN SISO cluster, were reached the next conclusions:

1. It is inappropriate to increase the summary level of the ΔU signal, induced at the receiving antenna terminals in the SFN SISO mode, in relation to the case when is received a single fall wave with the highest intensity;
2. Estimation of the value ΔU may be appropriate only in the case of indirect estimation, at reception, of intersymbol interference. When ΔU ≈ 0 dB – the interferences will be minimal. If ΔU ≈ 6 dB (relative to U [dBμV]) or ΔU ≈ 3 dB (relative to U [dBm]) - the interferences will be maximum. As an example, when the value of ΔU becomes comparable to 6 dB (3 dB) we can talk about the fact that the signal reception is organized incorrectly.

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