Covering Optimization with DVB-T Signal in the Urban Areas using SFN

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Abstract: - This paper presents a method to increase the signal quality and to use efficiently the frequency specter in the case of DVB-T emitters, using SFN. The advantages of this technology but also the implications and limitations regarding the equipment performances and the cover of different areas are shown. Measurements on DVB-T signal have been made, using a SFN experimental network made from two emitters implemented by SNR in Bucharest on the channel 59, using a performing device that highlights the network operating parameters.

Key-Words: - DVB-T, SFN, MFN, OFDM, DTV

1 Introduction

In [1], the authors propose an algorithm for the improving DVB-T coverage in SFN (Single frequency network). The new proposed model by authors in SFN planning is adopted by the CEPT/FM PT24 group.
The DTV reception quality field tests and the obtained results of a measurements campaign in the Madrid town for the study of the relationship between B.E.R(Bit Error Rate) and C/N for the portable outdoor reception of DTV signal in a SFN are presented in [2]. The authors describe the factors which has influenced the SFN reception in the urban environments.
The advantages of the SFN networks are presented by Mattsson A., in [3]. The author outlines that SFNs offer a better coverage and the using of radio spectrum in efficient manner. In SFNs, the propagation models are simple and the Signal to Interference performance is improved.
According to the engagements taken by Romania, the implementation of the DVB-T service has to be finalized until the end of 2012. In this perspective, starting with this year, experimental DVB-T emitters have been implemented in Bucharest and Sibiu by SNR and a license process for three multiplex at national level will start.
Also experimentally, SNR implemented in Bucharest 2 networks of the SFN (Single Frequency Network) type on 54 and 59 UHF channels, to evaluate and dimension such a solution.

2 SFN Structure

Generally, classical analogical TV emitter networks use a MFN (Multiple Frequency Network) structure in which each emitter has its own frequency, reused at a distance depending on the interference conditions.
SFN – Single Frequency Network – is a network made from emitters which illuminate the same area using identical frequencies, which is not possible in the case of analogical emitters.
To implement such a structure some conditions must be fulfilled:
- The emitters have to operate exactly on the same frequency, so to avoid a degradation of the BER
- the emitters must be synchronized so as the digital signal to be send exactly in the same time, and the signal received by a receiver from the covering area to be in the guard interval; the signals coming from different receivers of the network being interpreted as echoes from the same emitter thus contributing to the efficient reception of the useful signal.
The level of the received signal by a receiver from the covering area must have a value higher than the minimum level so as to ensure a good SNR in the possible interference areas.
In this way, a SFN network can optimize the use of frequency specter and the balance between the SFN emitters’ powers, decreasing these values so as to cover the available zone with a quality signal.
To accomplish these conditions for SFN operating one use a MIP (Mega-frame Initialization Packet) sequence in the transport stream MPEG DVB-T[1]
which structure is described in the ETSI – TS 101.191.-v.1.3.1[5] document. The implementation architecture is presented in the Fig. 1:

MIP contains the temporal print which indicates the moment on which the mega-frame must be send, in respect of the UTC and reference frequency GPS, used for synchronization. In respect of the emitter equipment, this supposes that the transport stream has a transparent flow through the equipment and the modulators parameters can be reconfigured by the MIP.

According to the EBU recommendations [6], SFN networks can be implemented in the following ways:
- at the national level – this supposes that all the network emitters use the same frequency and the emission is multiplex. This architecture is hard to be implemented since the frequencies of the neighbour countries must in concordance and due to the auto interference phenomenon that can occur
- at the regional level - case in which in a region all the emitters use the same frequency but other frequencies in the peripheral areas; such structures are used at the European level till a diameter of 200 km of the covering areas, the frequencies being used for other regions. For national or regional levels, 6 channels multiplex are used.
- at the local level – it is a similar structure with the regional one but smaller areas and 2-3 channels per multiplex are used

The SFN structures have some limitations:
- auto interference – the power of all signals from SFN, signals that are in the limits of the guard interval are interpretated as echoes of the same signal and contributes to the total reception power. If from different reasons, the signals from different emitters arrive with higher gaps to the receiver and they are not in the limits of the guard interval, then they provide the inter-symbol interference and the degradation of the BER
- limitations due to the dimension of the guar interval,– according to the DVB-T specifications, the guard interval can be selected from the values of 1/32, 1/16, 1/8 or 1/4 from the duration of the active symbol.

For the mode 8k (2k) this means periods of 28(7)us, 56(14)us, 112(28)us and 224(56)us for the guard interval so that this value can be an optimization factor to avoid the interferences. The choice of the guard interval has an important influence on the SFN network topology in the sense of establishing the maximal duration in which the echoes can be received from the receiver and so the maximal distance between the emitters that use the same frequency is known.
- The maximal distance between the emitters and the maximal dimension of the covering area - the delaying” of the signal from the SFN emitters must be situated in the guard interval so that the maximal distance between these emitters is limited.

In accordance with the content of ETSI – TS 101.191.v1.3.1 document, the distance between the adjacent emitters is:
- for the mode 2k FFT, the guard intervals are of 7, 14, 28 and 56 us, distances being of 2.1, 4.2, 8.4 and 16.8 Km.
- for the mode 8k FFT the guard intervals are of 28, 56, 112 and 224 us which corresponds to distances of 8.4, 16.8, 33.6 and 67.2 Km.

On the other hand, the emitter’s number in the SFN area can not be increased over the limit on which the interferences are under a certain level.
- Interoperability of the modulators – referring to the fact that different types of modulators provide different synchronization durations in SFN networks
- Bit-rate Jitter – depending on the emitter’s program alimentation, the jitter of the received signal is different and it is cumulated with the final signal providing the degradation of performances [8].

From the previous considerations, we conclude that if we want a SFN characterization, we have to take measurements of all parameters that can influence the service quality.

2.1 Measurements
As a case study, measurements have been done on a SFN network implemented by SNR in Bucharest on
the channel 59. The network consists in two synchronized emitters, one of 1,2 KW placed on the Herastrau area, and one of 200W in Vacaresti area, both on 59 UHF channel and at a distance of 10,86 Km. The position of the two emitters is represented in the Fig. 2.

The measurements were made using a Tektronix MTM400EA device, on a COFDM DVB-T measurement interface. The input interface has a high stability frequency reference, so as to avoid the measurements errors.

The measurements have been made in an in-door location at approximate 1.2 Km from the central emitter, with an Omni directional passive antenna and they took into account the parameters of quality and the SFN characteristics[7].

Thus, by the signal processing, the multiplex packages structure was measured, process represented in the Fig. 3.

In multiplex a number of 5 broadcasting programs are included in SD with 64 QAM from which three are operational. (TVR 3, TVR Cultural and National TV ) and two are experimental.

An image of the received programs is presented, which indicates a good reception quality (Fig. 4).

For an objective estimation, the SNR, MER, BER values have been measured before Viterbi and constellation indicated below (Fig.5 and Fig. 6), that confirms the subjective conclusions presented before, parameters having normal values for a good reception[4].
In respect of the SFN measurements, the package implemented for this goal was first measured. The process is shown below in Fig. 7.

Fig.7 The configuration for SFN measurements

In respect of the synchronization parameters, the measurements were jitter, frequency deviation, and retard measurements, using a CIR (Circuit Impulse Response) measurement type that the measurement device can perform [10]. The measurements show that the jitter and frequency deviation values are in normal limits and that the echo provided by the secondary emitter is also in the limits of the guard interval [5]. The measurement results are shown below in Fig. 8.
References:
[6] EBU Technical – Media technology & Innovation 13/03/09 - General Issue to be considered When Planning SFN’s

**Conclusion**
Measurements have been made on the SFN experimental network from Bucharest on the channel 59.
The measurements on the SFN channel indicate a correct operation mode in respect of the synchronization and reception conditions.
No terrain measurements were made, case in which a Gap Filler would be necessary to cover the shade areas (typically for urban areas) and could change the SFN structure in the sense of the addition of a new emitter with all the consequences resulted from this change.