Measurements of ASTRA Satellite Signal Parameters

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Abstract. *In this work, after a basic theoretical background on the ASTRA satellite constellation and their satellite signal and channels, our model for measuring the satellite signal reception in our laboratory is presented. The satellite signal was received with a parabolic antenna, led over an LNB converter and satellite in-line amplifier to a digital satellite receiver and a television set. The strength of satellite receiver's input signal was measured with a spectrum analyzer. The communication channel width was analyzed.*

Keywords: ASTRA, Satellite Link, Satellite Signal Reception, Measuring Peak Power Signal Strength, Communication Channel Width, Intermodulation Products

1. Introduction

Planned broadcasting directly to home TV receivers takes place in the Ku band. These services are known as direct broadcasting satellite services. ASTRA is one of the major TV satellite services in Europe and is located at the 19.2° east orbital position downlinking in the 10.7 – 12.70 GHz range [1]. Their satellites have a geostationary orbit, meaning that they are at the hight of 36000 km and have a 24 hour period. Output power of the travelling wave tube is P = 63 W and the loss of the downlink may be calculated as follows:

$$L(dB) = 20\log_{10}\left(\frac{4\pi d}{\lambda}\right), \qquad (1)$$

where λ is the wave length [m] and d [m] represents the path length from satellite to earth station where the earth station receives the signal via a parabolic antenna [2]. The diameter D [m] of the parabolic reflector defines an antenna gain:

$$G = \eta\left(\frac{\pi D}{\lambda}\right)^2, \qquad G(dB) = 10\log_{10} G, \qquad (2)$$

where η is the aperture efficiency (and usually has the value η = 0.7).

The parabolic antenna received the signal from a satellite transponder. In laboratory after measuring parameters of received signal, relation between the symbol and code rate and the channel width, as well as the signal strength at the satellite receiver was tested.

2. Measuring setup

Figure 1 shows a setup for measuring the satellite signal from satellite service provider, ASTRA. The outdoor unit consists of a parabolic antenna feeding directly into a low-noise block downconverter (LNB). Used parabolic reflector has the diameter of D = 0.9 m. In Croatia this is the usual diameter for parabolic antennas according to the ASTRA recommendations for good signal reception [1].

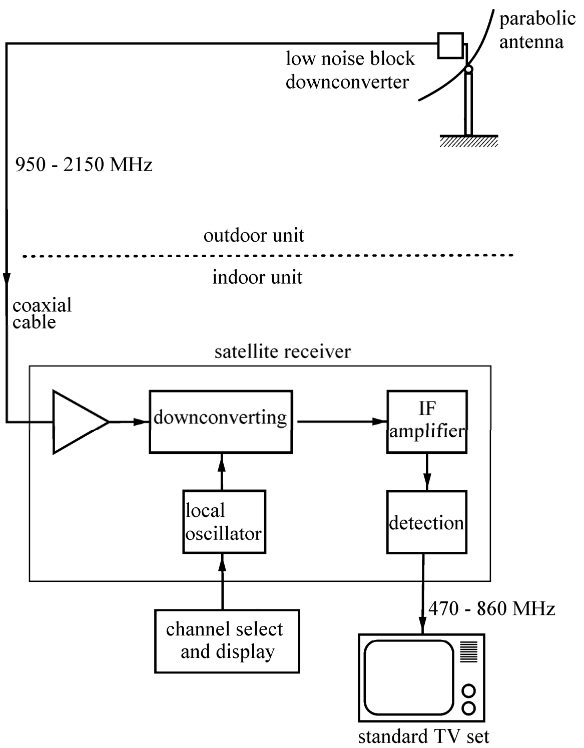

Fig. 1. Setup scheme for measuring the satellite signal from the ASTRA satellite service provider.

Fig. 2. Setup realisation for measuring the satellite signal.

From satellite receiver the signal was led to Microelectronics inc. LNB converter. The LNB amplifies the received signal by 55 dB and converts it to a lower frequency range. The frequency conversion is performed by mixing the received signal at the LNB input with the frequency produced by a local oscillator with frequencies of f_{LO} = 10.6 or 9.75 GHz. The LNB coverts the satellite signal's frequency to 950-2150 MHz. This converter has a noise figure of 0.6 dB, where noise figure is defined as the ratio of the amount of noise in the output to the amount in the input. Therefore a coaxial cable can be used as feeder to the indoor unit. This way the signal travels with much less attenuation and more signal is left at the satellite receiver end of the cable [3].

The LNB's output signal is led to the indoor unit where it is amplified via a coaxial satellite in-line amplifier and brought to the satellite receiver. The line amplifier is useful since a long cable run of about 30 m was used and an excessive loss of 2 dB in the lead to the receiver is expected. Amplifier's specifications are given in Table 1. and receiver's specifications are in Table 2.

Measuring instrument set up is given in Fig. 2. Spectrum analyzer was used for measuring the peak power signal strength at receiver. To ensure that the

Table 1. Satellite in-line amplifier performance specifications.

Performance specifications	
Passband	950 – 2250 MHz
Gain	20 dB
Impedance	75 Ω
Noise figure	5 dB
Output strength	max.105 dB/ μ V

Table 2. Satellite receiver specifications.

Quadro DR-9000FTA satellite receiver performance specifications	
RF input frequency range	950 – 2150 MHz
RF input power levels	-65 to -25 dB
IF output frequency	55 MHz
RF output frequency range	470 – 860 MHz
Video output impedance	75 Ω

spectrum analyzer was able to identify the signal from background noise, the input attenuation was set to 10 dB. The span, specifying the range between the start and stop frequencies that has to be monitored was set to 5 or 10 MHz. The resolution bandwidth, that determines how close the frequency components in the signal spectrum can be and still be displayed as distinct components, was set to 3 MHz. For each channel the carrier frequency, f_{ch} was calculated since the information of the sent signal's frequencies at transponder f_t, was visible in the configuration menu of the used television set [2]:

$$f_{ch}=f_t-f_{LO}. \tag{3}$$

On spectrum analyzer's monitor the signal strength peak value was detected for each channel. Next step was to find the channel bandwidth, i.e. the frequency interval where signal strength is no lower than 3 dBm from measured peak power signal strength.

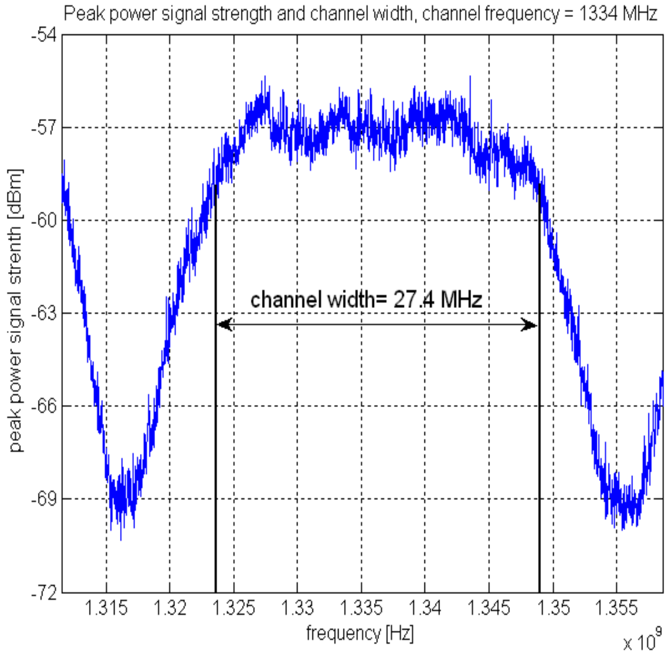

Fig. 3. Signal at f_{ch} = 1334 MHz (transponder frequency f_t = 11934 MHz).

Satellite signal reception was measured in five different channels. The signal frequencies at the satellite transponder and satellite receiver, as well as the symbol and code rates are given in Table 3. The measured peak power signal strength at the satellite receiver's input and the measured channel width are also listed in Table 3.

Figure 3 is a representative figure showing measurement results from channel with signal frequency f_t = 11934 MHz at the satellite transponder and the signal frequency f_c = 1334 MHz at the satellite receiver. On spectrum analyzer the peak power signal strength at the receiver's input was measured, $P_{LN B}$ = -55.4 dBm. By moving to the left and right of the P_{LNB}, the channel width is defined and measured: B = 27.4 MHz.

Table 3. Measured channel parameters.

Signal frequency at transponder	Signal frequency at receiver	Symbol rate
f_t = 11934 MHz	f_{ch} = 1334 MHz	R = 2750
f_t = 11836 MHz	f_{ch} = 1236 MHz	R = 2750
f_t = 11778 MHz	f_{ch} = 1178 MHz	R = 2750
f_t = 11538 MHz	f_{ch} = 1788 MHz	R = 2200
f_t = 11509 MHz	f_{ch} = 1759 MHz	R = 2200

These steps were repeated for each channel and peak power signal strength at the satellite receiver, as well as the channel bandwidth were measured (Table 3, Figure 3-5).

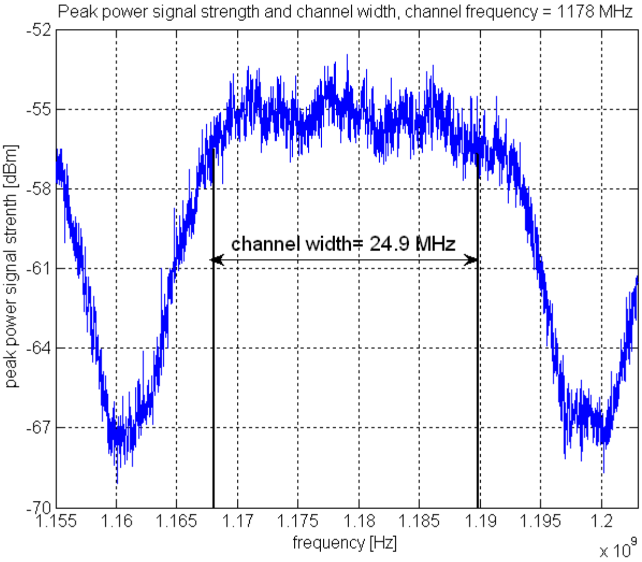

Fig. 4 Signal at f_{ch} = 1178 MHz (transponder frequency f_t= 11778 MHz).

3. Discussion and conclusion

Analyzing Table 3, when sending and receiving the message with higher symbol rate (R = 27500), the power of the in-line amplifier input signal is higher than with lower symbol rate (R = 22000). On the other hand, when a higher code rate (5/6) is used, compared to a lower code rate (3/4), the power of the signal strength is lower. Higher symbol rate (R = 27500) and lower code rate (3/4) showed a wider channel width of approximately B = 27 MHz and B = 25 MHz. When the message was sent with a lower symbol and a higher code rate (R = 22000, 5/6), according to our measurement results in Table 3, the channel width was B = 21 MHz.

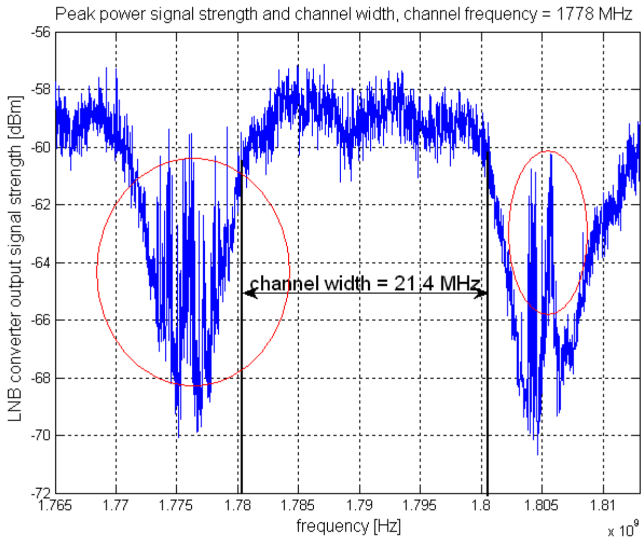

Fig.5. Signal at f_{ch} = 1778 MHz (transponder frequency f_t = 11538 MHz) with intermodulation products (circled).

During measuring of channels with frequencies f_{ch} = 1788 MHz and f_{ch} = 1759 MHz (corresponding frequencies at transponder are f_t = 11538 MHz and f_t = 11509 MHz), an effect called the intermodulation distortion or product could be observed. Intermodulation distortion occurs when the non-linearity of a device or system with multiple input frequencies causes undesired outputs at other frequencies [4]. In satellite communication this means that signals in one channel can cause interference with adjacent channels. The detected intermodulation products are given in Fig. 5. The next step in our research is to determine source of unwanted interference in order to avoid these effects.

References

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