MODELING THE SPECTRUM OF THE OUTPUT SIGNAL TO A RESPONSE SIGNAL GENERATOR FOR A RADIO TRANSMITTER IN AN INTER-SATELLITE COMMUNICATION LINK

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ABSTRACT

In the modern world, the use of inter-satellite communication links presents engineering challenges: increasing demands on the precision of onboard antenna stabilization and pointing, radio link power potential, interference immunity, and information security, while the protocol organization of space networks becomes more complex. It is also noted that key tasks for such systems include ensuring electromagnetic compatibility, selecting multiple access methods, and rationally distributing functions between onboard systems and the ground control system. With the transition to large orbital constellations of small satellites in low-Earth orbits, typically using high and ultra-high frequency bands, analyzing the requirements for data transmission quality in inter-satellite communication links becomes a determining factor in selecting the architecture of the entire system. This article presents an experiment simulating the spectrum of the output signal fed to a response signal generator. This modeling is necessary to assess whether the generated radio signal meets output power requirements and the permissible level of out-of-band and spurious emissions. At the design stage of a radio transmitter, this allows one to take into account the influence of filter parameters and amplifier operating modes, identify excess spectral components outside the central frequency band, and adjust the device circuit.

KEYWORDS: *Inter-satellite communication link (ISL), radio transmitting unit (RTD), spacecraft, information and telecommunications systems, generator.*

1 Introduction

The response signal generator (RSG) is a critically important component designed to generate, filter, and maintain the required signal level at the device's output.

Based on modern requirements for response signal generators, its functional diagram will include a modulator, a secondary power supply, a frequency synthesizer, a multiplier, a waveguide filter, a mixer, and an amplifier.

This article, in particular, presents a possible option for modeling the output signal spectrum in a response signal generator for the further design of a radio transmitting device.

2 Requirements for the Design of a Response Signal Generator

Based on the modern technical characteristics of a radio transmitting device for an intersatellite communication link, the following output signal requirements are imposed on the response signal generator:

1. The center frequency at he output is 26260 MHz;
2. The outp signal power level should be (2 ± 2) dBm;
3. Attenuation of spurious spectral components in the frequency band fout ± 500 MHz – at least 45 dBc;
4. Attenuation of spurious spectral components in the frequency band fout ± 2 GHz outside the band fout ± 500 MHz – at least 50 dBc;
5. Local scillator frequency suppression must be at least 45 dBc;
6. Two-p ition phase-shift keying of the output signal 0 + 180°.
7. Req rements for the input voltage of the on-board network supply:
8. The power s ply for the response signal generator is provided via a two-wire DC power supply line with a voltage of 25.5 to 32 V. The device consumption from the on-board network is no more than 2 A.

When designing a response signal generator, it is impractical to combine all of the above functional elements in a single structural unit, especially given the high frequency of the output signal.

Secondary power supplies and digital components are significant sources of electromagnetic interference, which can degrade the phase noise and spectral frequency of the synthesizer and master oscillator signals, as well as increase intermodulation distortion in the gain path. Separating sensitive components will provide better shielding of the microwave section.

The 26.26 GHz frequency requires the use of specialized microwave substrates. Combining all components in a single unit will lead to technological difficulties, increased losses, and degraded matching.

Based on the above, we propose dividing the response signal generator into two blocks, using the design shown in Figure 1 as a basis. The first block includes a secondary power source, a modulator, and a frequency synthesizer. The second block includes a master oscillator, a frequency synthesizer, and provides frequency conversion to 26.26 GHz.

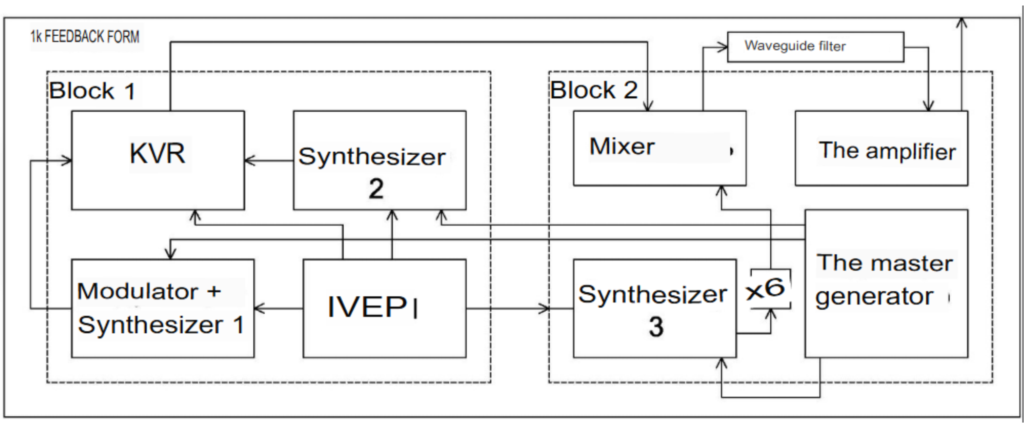

Figure 1. Response signal generator (RSG)

The two response signal generator sub-units are equipped with two control boards. They execute commands received through the switching board, generate control signals, collect and generate telemetry, and trigger automatic protective responses.

3 Spectrum Modeling Experiment and Substantiation of Requirements for Its Implementation

In this article, spectrum modeling was performed in the Genesys automated design environment. Using models of microwave paths, filters, and nonlinear amplifiers, this allowed us to obtain a spectrum image close to real-world conditions and construct a level diagram.

Figure 2 shows the block diagram of the second block, the response signal generator, with the specified input parameters of the signal from the output of the first block and the frequency synthesizer (FS). However, in this circuit, filters have been replaced with attenuators in order to demonstrate the signal spectrum in the absence of filtering.

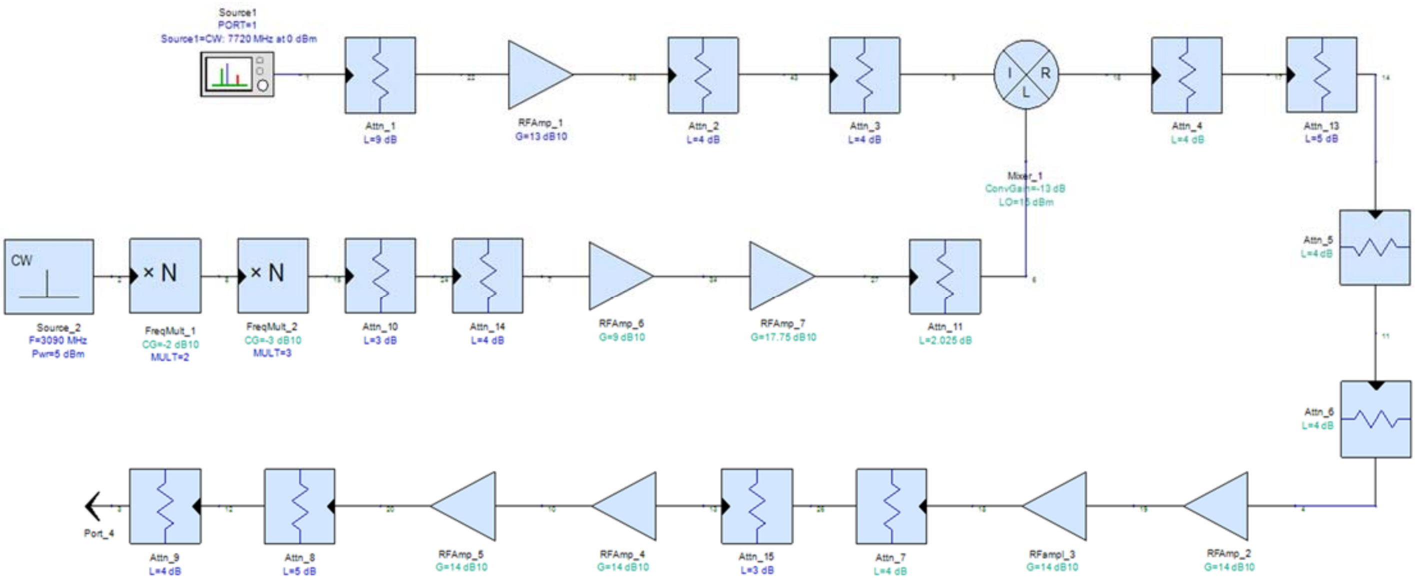

Figure 2. Structural diagram without filters

Figure 3 shows the result of modeling the spectrum at the output of the response signal generator without filters.

Figure 4 shows the structural diagram of the second block of the response signal generator with the characteristics of the selected filters entered.

Figure 5 shows the result of modeling the spectrum at the output of the response signal generator using the selected filters. This demonstrates that the filters were selected correctly. The modeling result meets modern requirements.

Figure 6 shows the level diagram of the presented structural diagram.

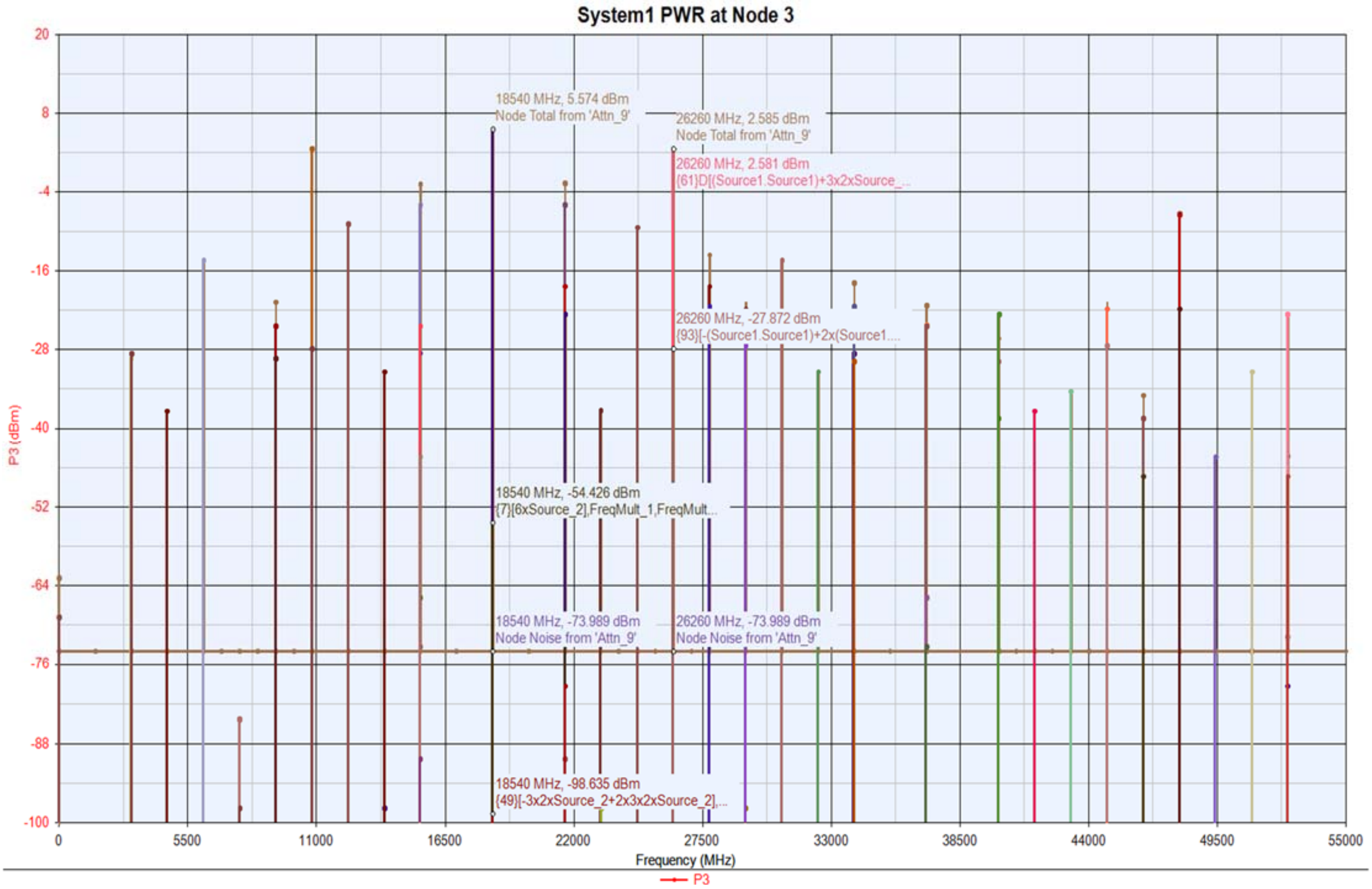

Figure 3. Signal spectrum without filters

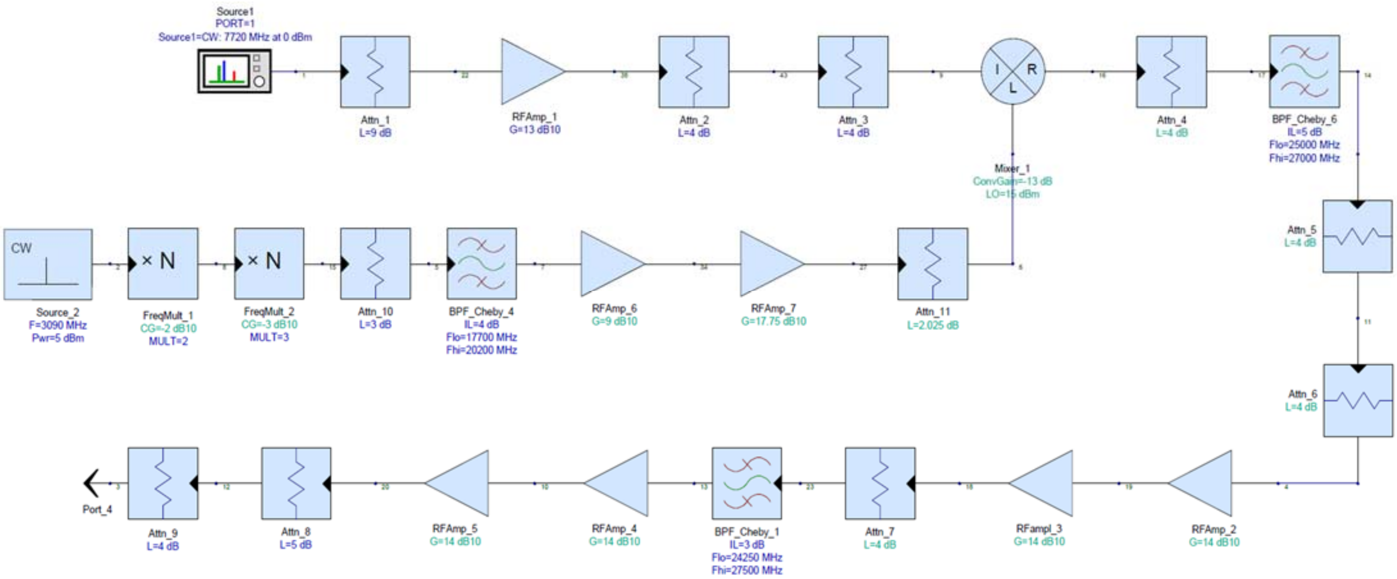

Figure 4. Structural diagram with filters

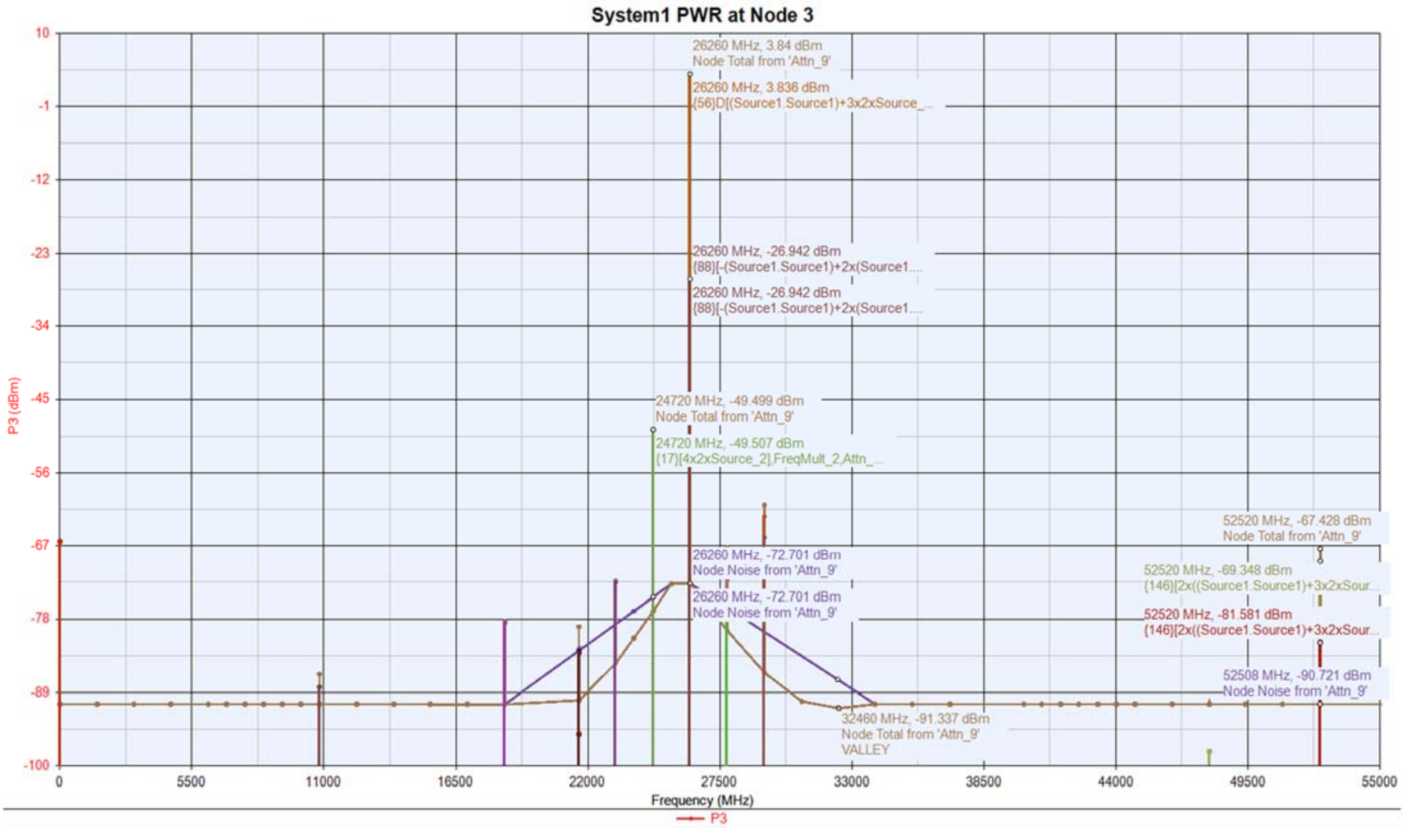

Figure 5. Signal spectrum at the output of the response signal generator

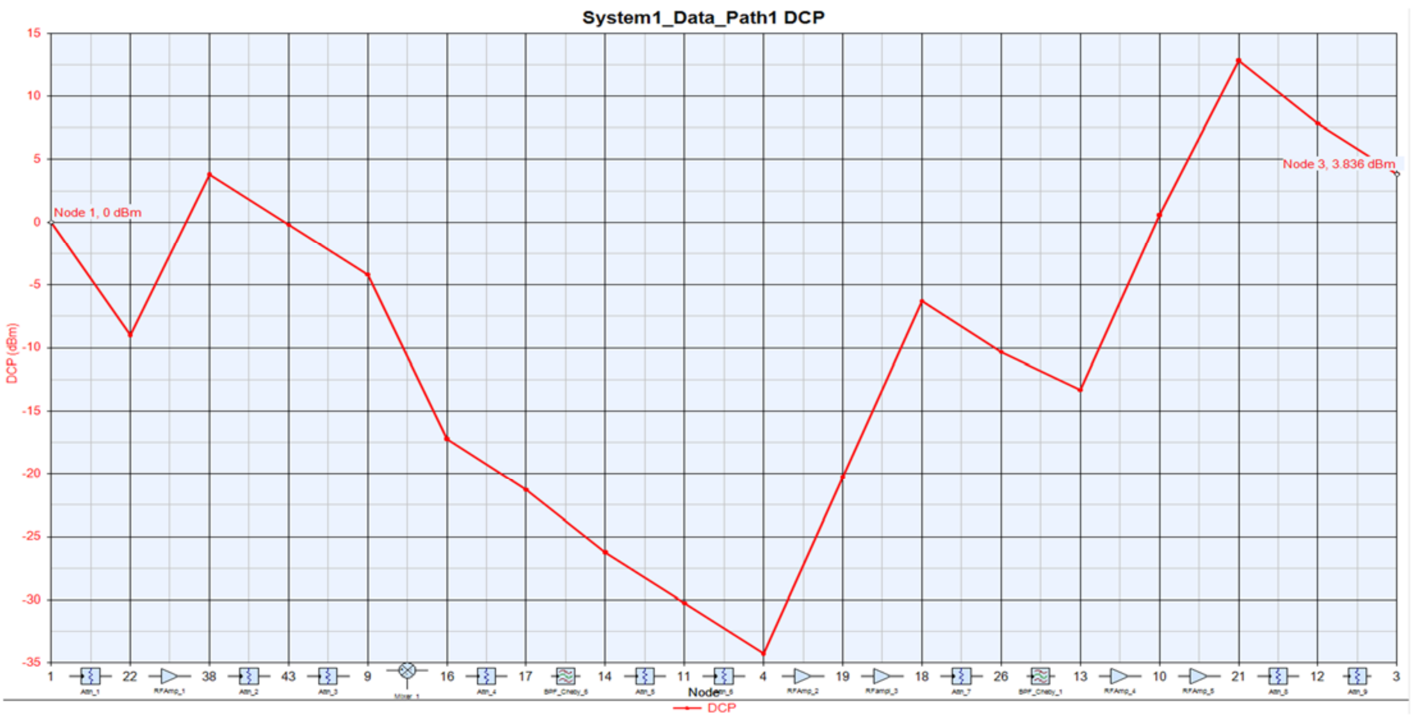

Figure 6. Level diagram

4 Conclusion

Thus, this article plans an experiment to model the output signal spectrum of a response signal generator and substantiates the requirements for its implementation.

The objective of modeling the output signal spectrum of the response signal generator is defined, and the modeling results confirm the correctness of the filter selection and compliance with modern requirements.

The modeling of the output signal spectrum of the response signal generator is performed. It is confirmed that the selected filters and the path structure provide the required suppression of spurious and out-of-band components. The modeling results confirm the correctness of the adopted circuit design solutions.

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