Tunable S-band RF Front End Receiver for LEO Mission

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Abstract— This paper presents the design strategy, simulation results and final schematic of Radiofrequency front end (receiver) block level designing with a flexible centre frequency for S-band (2025–2110 MHz). The idea behind this is basically a planning for communication such as data, voice and video communication. In this study, with a Radio-frequency (different channel frequencies) the required specifications were achieved such as gain < 130 dB, noise figure 2 dB, bandwidth 6 MHz which is targeted for LEO mission. This design is having very low noise figure, high gain and low spurious levels and RF-Front end circuit includes low noise amplifier, filter, mixer and local oscillator. To obtain proper output frequency and determination of a system performance, the measured data including gain, noise figure and S parameter agree well with the simulation results on ADS Software.

1. INTRODUCTION

S-band is very popular band for the mobile satellite system (MSS). The receiver front end architecture is a part of ground terminal which is connected with the s-band satellite for the data-reception and transmission. The function of receiver front-end is to provide the gain to the very weak signal without adding of much noise and convert it to the Intermediate-Frequency (IF). Low noise, high gain and the low spurious output with the compact size are the main advantage of the developed unit. The Radio frequency (RF) front end receiver needed because of amplification to compensate for the transmission loss, selectivity to separate the desired signal from others and tenability to select the desired signal [1].

At the receiver input, diplexer will give direction to the different channel frequency to be tuned at same input, the suppression of transmitted signal is very important because over received signal is 2025–2110 MHz. To make the system compatible and in order to meet the (PFD) constraints, Code division multiple access (CDMA) which is a spread spectrum technique is used for communication and it also fulfil the standard spreading of 6 MHz bandwidth requirement. A two-stage LNA allows achieving extremely good receiver sensitivity. This paper describes the flexible s-band front end receiver in which frequency are tuned to different channel frequencies.

2. RECEIVER CONCEPT

Receiver design is started by selecting Local-Oscillator (LO) and IF so that no significant spurious and harmonics will fall in opposite frequency band or near this band. Gain is distributed in RF and IF frequency. Figure 1 shows the block level designing of the receiver front end with sub-blocks such as; LNA, BPF, HPF, LPF, Single balanced mixers, IF-amplifiers and Circulators.

2.1. Low Noise Amplifier

It is the first component in any RF part. The fundamental goal of LNA is to amplify a very weak signal received from the antenna, while adding as little noise as possible. An ideal amplifier increases the desired signal without adding distortion or noise. It requires low noise, high gain, good return loss, low power dissipation and high reliability as well as compact size. In a receiver chain the first amplifier after the antenna contributes most to the system's noise-figure. Since LNA is a first gain stage in a receiver system, its noise-figure dominants that of the entire system. LNA purposes are many, it provides the isolation between the LO or mixer stages and the antenna, it improves the image frequency selection and lastly; provides some selectivity. Four LNA blocks are placed in the designing in which three of them having 38 dB as an input gain and one is put in a variable namely; x for varying its input gain according to the flexibility requirement [3].

2.2. Circulator

The 3-port device is terminated by a resistor of 50 ohms to make it perform as an isolator because it absorbs the power for propagation in one direction and thus; provides lossless transmission in the opposite direction. In general case, isolator is used to improve frequency stability. It's typical performance is about 0.1 dB loss and 1.05 VSWR.

2.3. Filters

Filter circuits are the key components in any high frequency wireless systems. In modern trends the implementation of filter using Digital Signal Processing (DSP) is replacing analog filtering. The background and the tools for designing filter circuits at microwave frequencies begins with the review of two-port circuits and definition of gain, attenuation and return-loss (RL). The various filters are described such as; BPF, LPF, HPF in order to show how these affects the roll-off of the gain response [4, 6].

2.3.1. Bandpass Filter (BPF)

Apart from received signal, this filter is purposed for the rejection of the transmitted signal 2025–2110 MHz. The resultant rejection of 20 dB is first achieved at the given transmitted signal. Filter's passband is 2028.6–2062.6 MHz and the insertion loss (IL) is 0.4 dB [2].

2.3.2. Lowpass Filter (LPF)

LPF is used here for harmonic rejection. It exists in many forms and passes all the frequencies lower than its cutoff which is 70 MHz which is kept as an IF output for 2nd mixer [2].

2.3.3. Highpass Filter (HPF)

HPF passes all the higher frequencies and attenuates the signal with the frequency lower than the cutoff frequency. In the designing of Receiver, HPF acts as a blocker of DC and having a cutoff frequency of 200 MHz. It will pass all the frequencies more than its cutoff value that is 200 MHz.

2.4. Mixer

RF mixer is an essential part of the wireless communication system. In order to optimize the overall system performance and compromises between figure of merit such as linearity gain, dynamic range, noise figure and port to port isolation is limited by first down conversion mixer. It perform frequency translation by multiplying two signals (and possibly their harmonics). The RF frequency is 2025–2110 MHz, the RF rejection which is given to the mixer is 20 dB. The LO frequency is tunable on the frequencies like 1828.6, 1835.6, 1842.6, 1849.6, 1856.6. The flexibility for s-band in LEO-mission comes from these frequencies at 6 MHz bandwidth each. Since the frequency translation process will generate some unwanted spurious signal to degrade signal to noise ratio (SNR), the linearity becomes an important factor in mixer design. In most of the front-end receiver, the linearity of mixer affects overall linearity. This design architect proposes a reasonably good conversion loss and also a good isolation from LO-RF. Whereas in architecture, mixer translate all the channel frequencies in which bandwidth and frequency both are vary for good simulation [7].

3. RECEIVER SPECIFICATION

S. No.	1	2	3	4	5	6
Parameter	RF-frequency	IF-Frequency	Nominal Input Power	Nominal Output Power	Noise-Figure	Gain Stability
Unit	MHz	MHz	dBm	dBm	dB	dBp-p
Values	2025–2110	70	−130	0	2	1.5
S. No.	7	8	9	10	11	
Parameter	Gain Flatness over any channel	Gain Flatness overall	Translation Frequency	Channel Frequency	Centre-Frequency; F_c	
Unit	dB	dB	MHz	MHz	GHz	
Values	1	2	1828.6 1835.6 1842.6 1849.6 1856.6	2031.6 2038.6 2045.6 2052.6 2059.6	2.045	

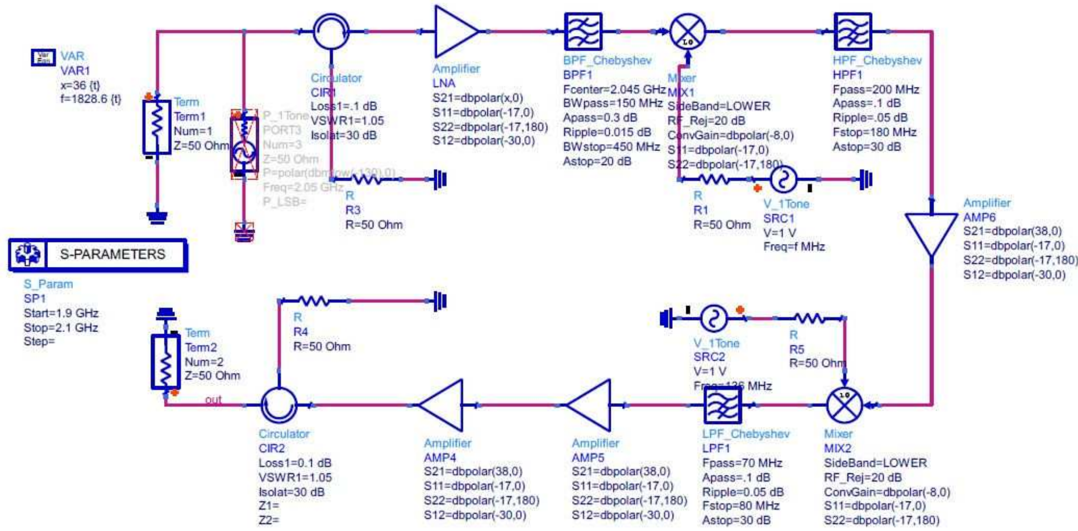

Figure 1: Schematic level diagram of RF-front end.

4. SIMULATION RESULTS

In this paper, the following scenarios are considered: Noise figure and Gain, for each translation frequencies. By changing the value of LO frequency of first mixer (f_1) in MHz, it shows the result

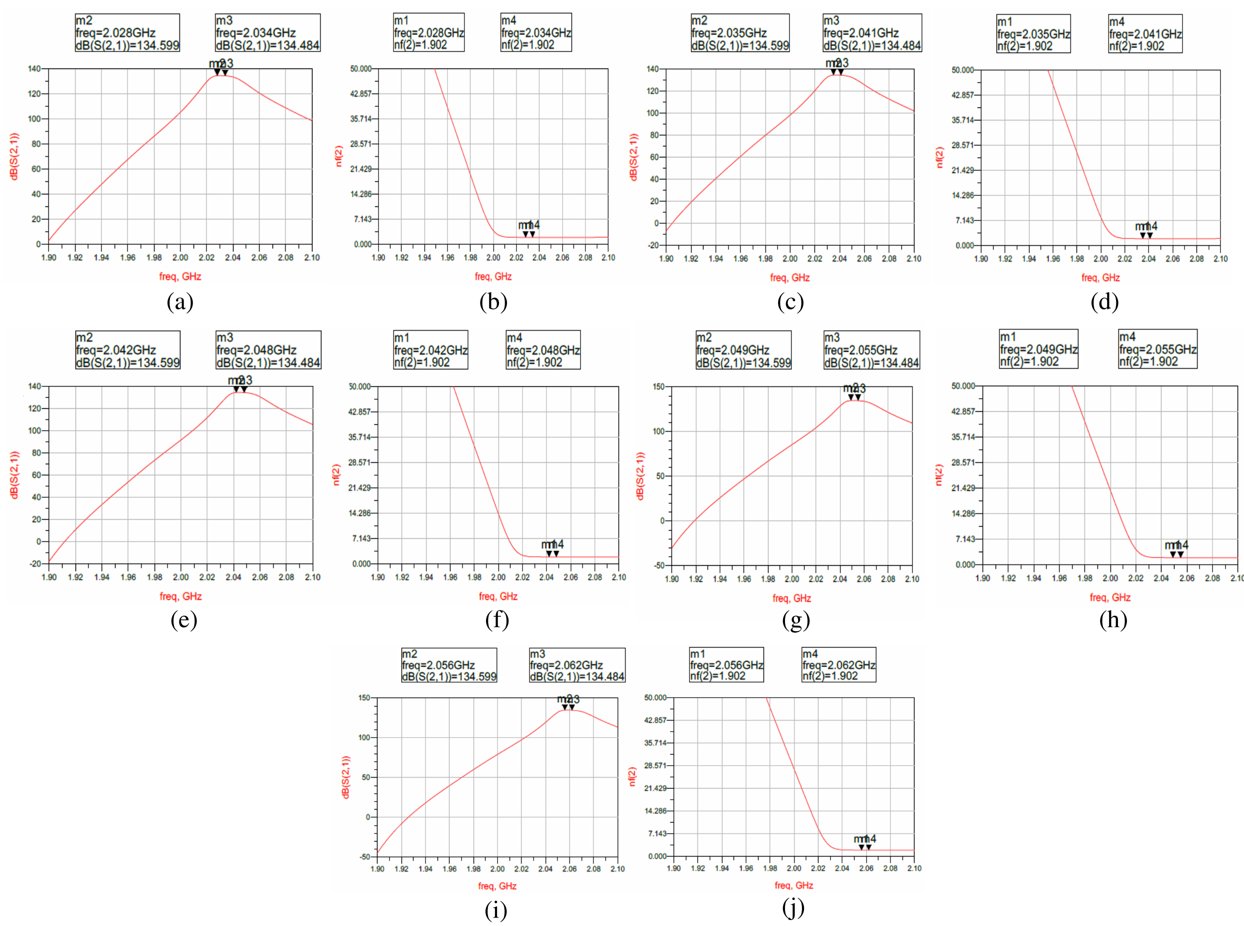

Figure 2: Shows (a) 134.59 dB gain and (b) 1.9 dB noise figure for $f_1 = 1828.6$ MHz; (c) 134.59 dB gain and (d) 1.9 dB noise figure for $f_1 = 1835.6$ MHz; (e) 134.59 dB gain and (f) 1.9 dB noise figure for $f_1 = 1842.6$ MHz; (g) 134.59 dB gain and (h) 1.9 dB noise figure for $f_1 = 1849.6$ MHz; (i) 134.59 dB gain and (j) 1.9 dB noise figure for $f_1 = 1856.6$ MHz.

of tuning of center frequency with the same output. The expected output has been realized during simulation. Fig. 2 shows the spectrum of s-band in which the different channel frequencies and their translation frequencies are seen. The analysis result shows that if we tune or vary center frequency or if relocate the satellite in the define spectrum for communication. We can have same gain and noise figure throughout the defined band.

5. CONCLUSION

According to the fixed noise figure, i.e., 2 dB, nominal input power is decided while designing an system block level designing of Receiver for s-band. It shows optimize performance in terms of gain and noise figure. Dealing with all translation frequencies in the system design, output can be seen at different channel frequencies which show a good gain and a fixed low noise figure which can purposely make an effective use for communication. A good agreement is achieved between simulated and targeted data.

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