



ADS Application Notes

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System Simulation of A RF Transmitter System for Smart Antenna Using Agilent Advanced Design System

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Introduction

This application notes describes a RF transmitter system simulation using Agilent Advanced Design System (ADS). When using RFIC chipset to design a RF transmitter system, it is important to select a suitable set of chips, which match the required performance. ADS gives us a visual lab for selecting RFIC chip. In this application notes, the key steps in building the system schematic and computer simulation results using ADS are presented.

System Schematic and Parameter Setting

The smart antenna transmit system consists of one base band up-converter, one IF amplifier, two IF filters, one RF up-converter, two RF filters, one RF pre-amplifier, and one RF power amplifier. We need to make sure that the system will have enough output power, linearity and sufficient attenuation on unwanted frequency spectrum.

The entire component models can be selected from RF/Analog library. Amplifier and mixer models can be obtained from the system amplifier and mixer library. Filter models are acquired from band pass filter library. The two local oscillator models are obtained from sources in frequency domain library. P_1 tone source in harmonic balance library is selected to simulate the base band input signal. Finally, a 50 Ohm terminal in harmonic balance library is used to terminate the transmitter output.

Because all the RFIC chips have detailed specifications, the parameter settings in each corresponding model should be set up as close as what can be gotten from the specifications. In setting parameter to an amplifier, it is important to use correct parameter such as noise figure, gain, power saturation point (P_{sat}), three order intercept (TOI) power. The gain compress characteristic parameter of amplifier is fundamental to system non-linearity characteristic simulation. While setting parameter of a mixer, $P_{lo\min}$ should be taken care of. The meaning of $P_{lo\min}$ is the minimum Local oscillator input power before mixer starved. But for some unknown reason, it had better to leave it blank. Otherwise, an error convention gain would occur.

Filter is the only kind of component determining the system band pass characteristic; correct filter models should be selected to emulate real filter performance. In the design, all the filters selected are Butterworth type. All the parameters of filters, such as center

frequency, insertion loss, pass band width, stop bandwidth, pass band ripple, and stop band attenuation, etc., are adopted from the real filter specifications.

PLL frequency synthesizers are used as the first local oscillator and the second local oscillator for up conversion, in order to achieve enough short term and long-term frequency stability. The phase noise of the two synthesizers is derived from the performance of selected reference frequency and VCO. Both of the two local sources use oscillator with phase noise in frequency domain source library to simulate. The phase noise parameter of the two models depends on the derived result.

The following is the system schematic in ADS.

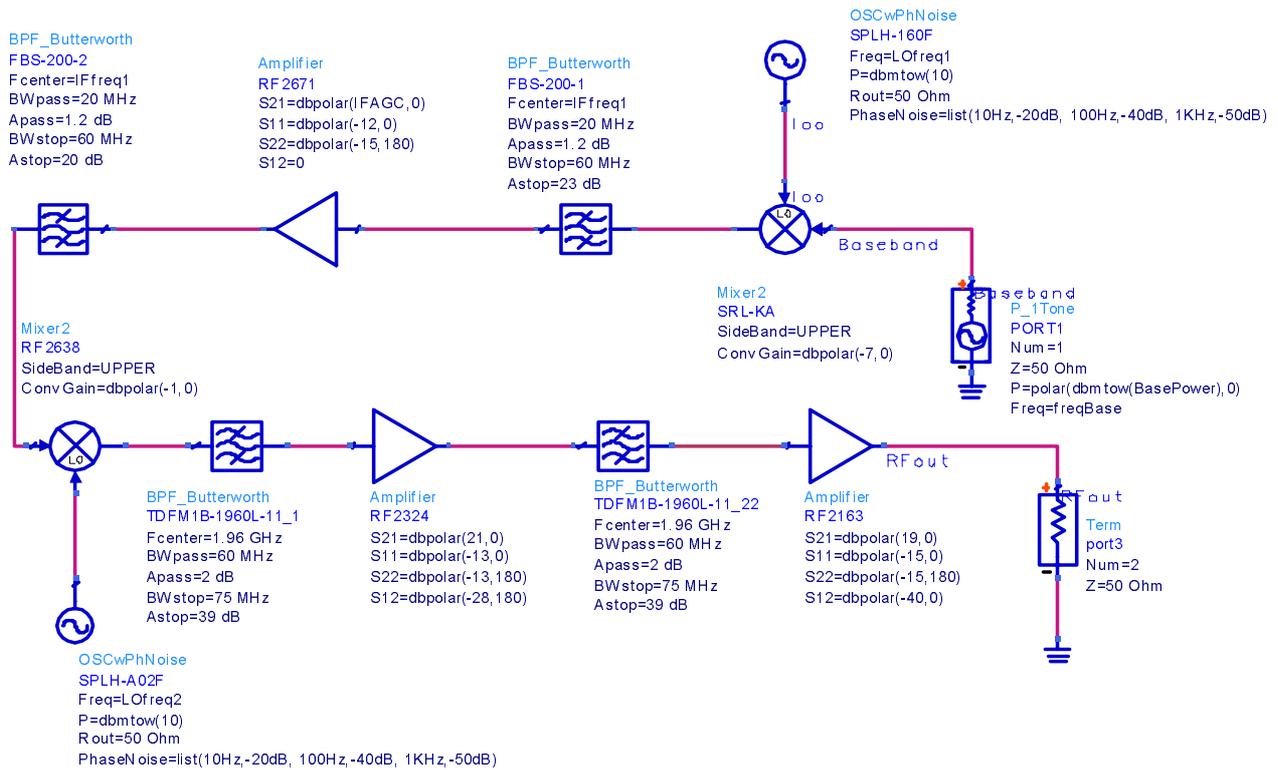


Fig. 1 System schematic

Simulation Result

The simulation setup shown in Fig.2 is used to simulate the system performance.

Harmonic Balance simulator HB1 is used to investigate the performance of the system output spectrum. While doing the harmonic balance simulation, the base band frequency is 40MHz. The frequencies of the two local oscillators are 160MHz and 1750 MHz. The simulation result is shown in Fig. 3. Large signal S parameter simulator HB2 is also used to simulate the system band pass performance by using parameter sweep controller to control the base band frequency sweep from 20MHz to 200MHz. The system band pass performance is presented in Fig. 4. In order to find the output power performance and system saturation performance versus input base band power variation, a LSSP simulator, HB3 that incorporates a parameter sweep controller sweep2 to control the input power sweep is used. In conducting these simulations, the gain compression calculator is used to calculate gain compression. Through out the simulation, the IF amplifier gain is set to 10dB. Fig.5 and Fig. 6 show the performance curve of the simulation. Fig.7 illustrates the power at output port in dBm versus the input base band power variation. Finally, the sweep variable parameters in

sweep2 are changed to IFAGC, which is the gain of the IF amplifier. The system gains performance versus IF gain variation is presented in Fig. 8.

The image shows several configuration panels for ADS simulation tools:

- PwrGain:**
 - PwrGain1
 - PwrGain1=pwr_gain(S,PortZ1,PortZ2)
- GainComp:**
 - GainComp1
 - GainComp1=gain_comp(S2[1],0)
- GainRipple:**
 - GainRipple1
 - GainRipple1=ripple(mag(S21))
- HARMONIC BALANCE:**
 - HarmonicBalance1
 - HB1
 - Freq[1]=LOfreq1
 - Freq[2]=LOfreq2
 - Freq[3]=freqBase
 - Order[1]=3
 - Order[2]=3
 - Order[3]=3
- OPTIONS:**
 - Options1
 - Temp=16.85
 - Topology Check=yes
 - V_RelTol=1e-6
 - I_RelTol=1e-6
 - GiveAllWarnings=yes
 - MaxWarnings=10
- LSSP (top):**
 - LSSP1
 - HB2
 - Freq[1]=freqBase
 - Freq[2]=LOfreq2
 - Freq[3]=LOfreq1
 - Order[1]=3
 - Order[2]=3
 - Order[3]=3
 - LSSP_FreqAtPort[1]=freqBase
 - LSSP_FreqAtPort[2]=freqBase+LOfreq1+LOfreq2
- LSSP (bottom):**
 - LSSP1
 - HB3
 - MaxOrder=4
 - Freq[1]=freqBase
 - Freq[2]=LOfreq1
 - Freq[3]=LOfreq2
 - Order[1]=3
 - Order[2]=3
 - Order[3]=3
 - LSSP_FreqAtPort[1]=freqBase
 - LSSP_FreqAtPort[2]=freqBase+LOfreq1+LOfreq2
- PARAMETER SWEEP (top):**
 - ParamSweep1
 - Sweep1
 - SweepVar="BasePower"
 - SimInstanceName[1]="HB3"
 - SimInstanceName[2]=
 - SimInstanceName[3]=
 - SimInstanceName[4]=
 - SimInstanceName[5]=
 - SimInstanceName[6]=
 - Start=30
 - Stop=26
 - Step=
- PARAMETER SWEEP (bottom):**
 - ParamSweep1
 - Sweep2
 - SweepVar="IFAGC"
 - SimInstanceName[1]="HB3"
 - SimInstanceName[2]=
 - SimInstanceName[3]=
 - SimInstanceName[4]=
 - SimInstanceName[5]=
 - SimInstanceName[6]=
 - Start=5
 - Stop=25
 - Step=1

Fig. 2 Simulation Tools used in ADS

Conclusions

The RF system for smart antenna transmitter presented in this application notes is a typical communication up convention channel. All the components work in large signal condition. The main tasks of the system simulation are (1) to ensure the system has enough linear output power, (2) to find out the system AC parameter limits, and (3) to tune the component parameter to keep the system in the best working status. The system simulated is an experimental transmitter, in which many practical factors are not considered, such as the fast frequency hopping and large amount user etc. More simulations, such as ACPR characteristics, PLL time domain and frequency domain responding characteristics, and inter-modulation characteristics, etc., should also be carried out in designing commercial products.

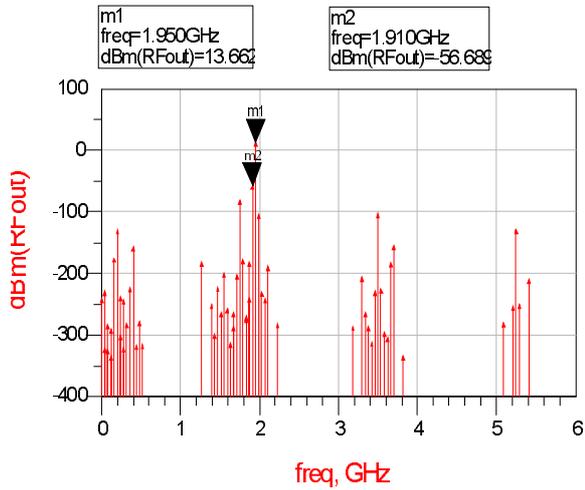


Fig.3 Spectrum at Output Port

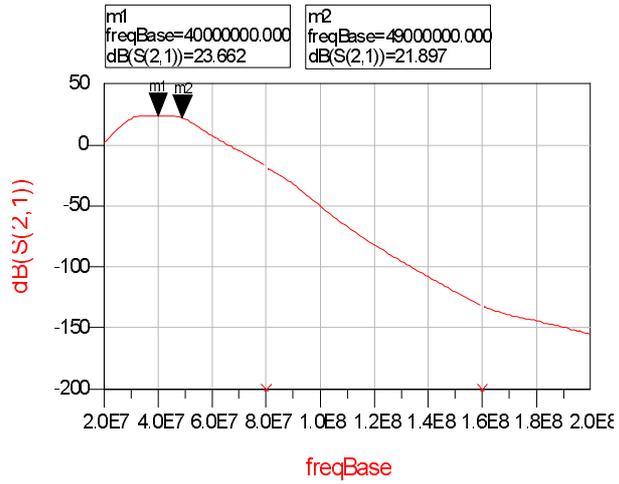


Fig.4 System Band Pass Characteristics.

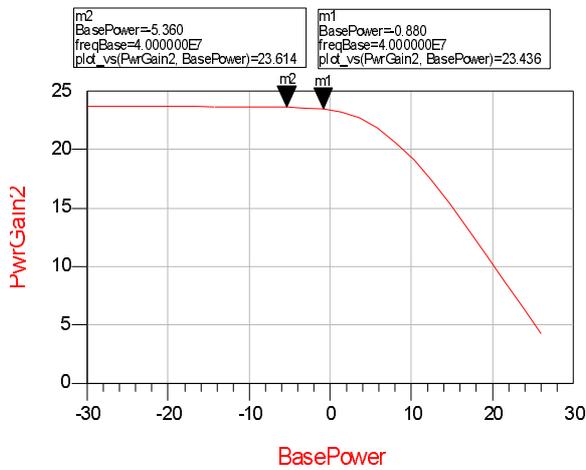


Fig.5 Channel Gain vs. Base Band Signal Power Variation

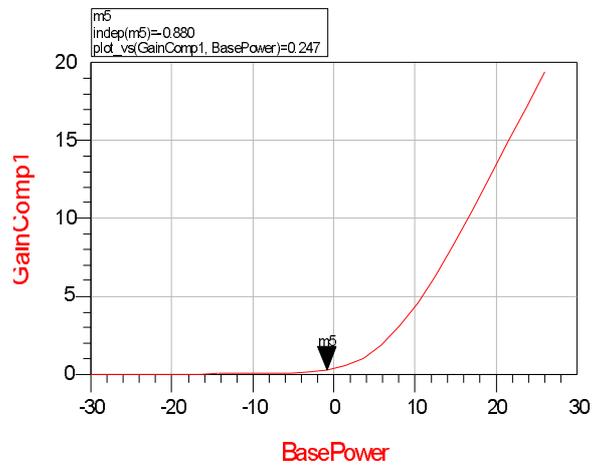


Fig.6 Gain Compression vs. Base Band Signal Power Variation

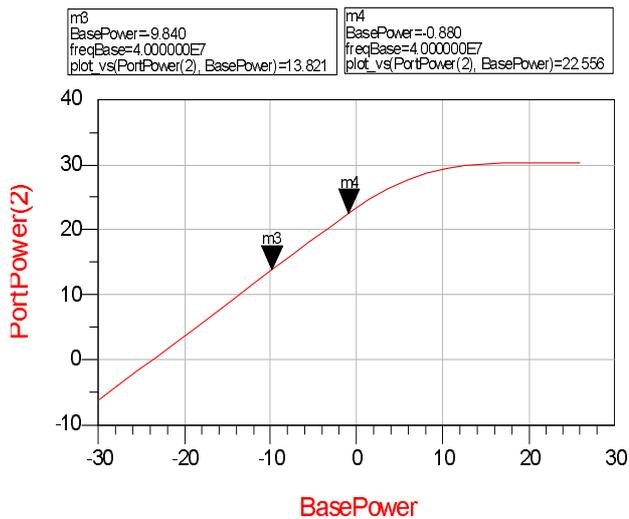


Fig.7 Output Power(dBm) vs. Base Band input Power variation

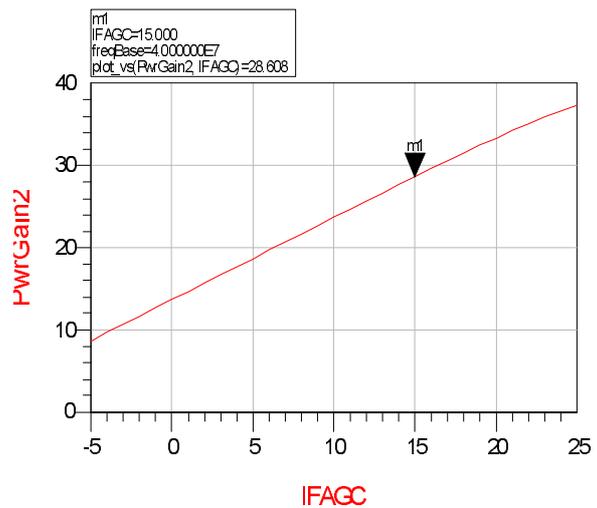


Fig.8 System gain vs. IF gain variation