EEC 134 AB

Application Note

Radar System Designing

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You have learned about the radar system in quarter one labs, but the quarter one system was already designed for you. When redesigning you own system, there are a few things that you don't worry about in quarter one labs need to be considered in your own design.

First, you should start with the block diagram. Every component in your system has its own specifications, you should always check the datasheet and make sure that the component can work properly in the system. My suggestion is that you can start with the transmitting side of your system and then decide what components you will need for the receiving side. When I was designing the system, I followed the block diagram and started with the VCO. The most important specs for the VCO are its tuning voltage and the corresponding frequency. You have to make sure that not only the frequency of your VCO covers 2.4GHz, but also your function generator can satisfy the tuning voltage. In my case, I chose ROS-2536C-1194 as our VCO, but unfortunately it was out of stock and the only alternative was ROS-2490+. The alternative VCO requires a tuning voltage of 5.5 V to have a 2.4 GHz frequency and the max output of the teensy output triangle wave is 5 V. In order to raise the tuning voltage, we designed a voltage divider and connected it between the Teensy output and the VCO input, so we finally were able to get the teensy triangle wave from 1.8V to 6.7V, which covers the tuning range of the VCO for 2.4 GHz. The rest of the components on the transmitting side can be chosen by searching and sorting for those meet the design requirement on the supplier website. From my experience, ideal transmitted power should be over 15 dBm for 50 meters range. When you increase the power, don't forget to check the max operating power for each component.

The next step is to choose the right antenna for your system. We learned form the previous designs and found that Yagi PCB antenna is a good choice because it is cheap, light, and has a great gain of 10~11 dBi, but it has very narrow bandwidth. Therefore, we decided to keep and use the coffee can as our transmitting antenna since it has larger bandwidth that covers the VCO frequency range.

After choosing your antenna, it is time to do some calculations. You can first calculate the effective aperture of the antenna, A_{eff}, by

$$G_r = \frac{4\pi A_{eff}}{\lambda^2},$$

where Gr is the gian of the receiving antenna and λ=c/f. Then the received power at the radar receiver is

$$P_r = \frac{P_t G_t \sigma}{4\pi R^2} \frac{A_{eff}}{4\pi R^2}$$

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where P_r is the received power, P_t is the transmited power, G_t is the gain of the transmitting antenna, σ is the cross-sectional area of the reflector, R is the range. You can plug in different range into the equation to see how much power you will get. In our case, P_r will be -41 dBm when the object is 5 meters away and -81 dBm when 50 meters away.

Now we have things that we need to design the receiving side of the system. To have the best resolution, the ideal output signal should be 1 V. However, when you choose the LNA, its gain can't be too big since there is a LO-RF isolation for the mixer. In our case, we choose a level-10 mixer with 23 LO-RF isolation. Make sure that you have the correct power for the LO port according to the mixer level. The max power we can have for RF port is 10-23=-13 dBm. The maximum received power is the power we get when the object is 5 meters away, which is -41 dBm. The conversion loss of the mixer is 5 dB. The LNA value should be -13-(-41)-(-5)=34dB. You can then calculate the value for 50 meters and see how much gain you need for the baseband amplifier to have a 1 V output.

After having your complete paper design, remember to run a simulation to check if the power matches your calculation and the system works properly. Our complete design is shown in Fig.1 and the simulation for transmitter and receiver are in Fig.2 and Fig.3.

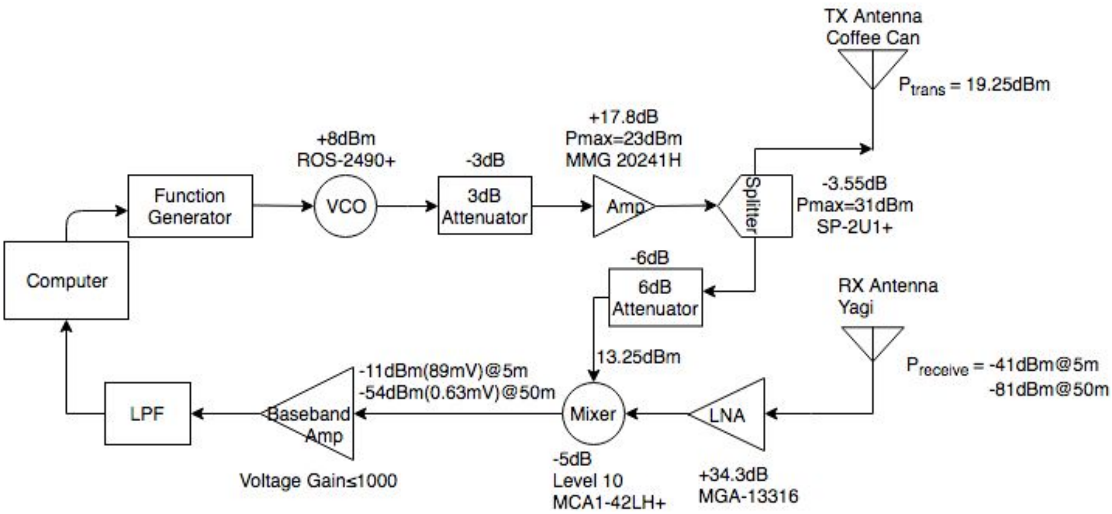

Fig.1 Complete Design Block Diagram

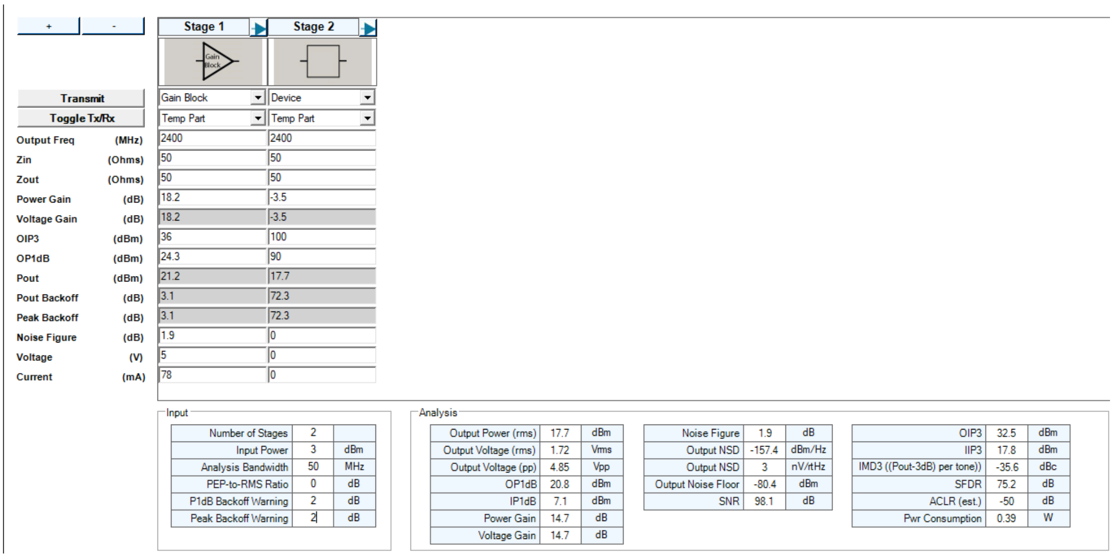

Fig.2 Transmitter Simulation

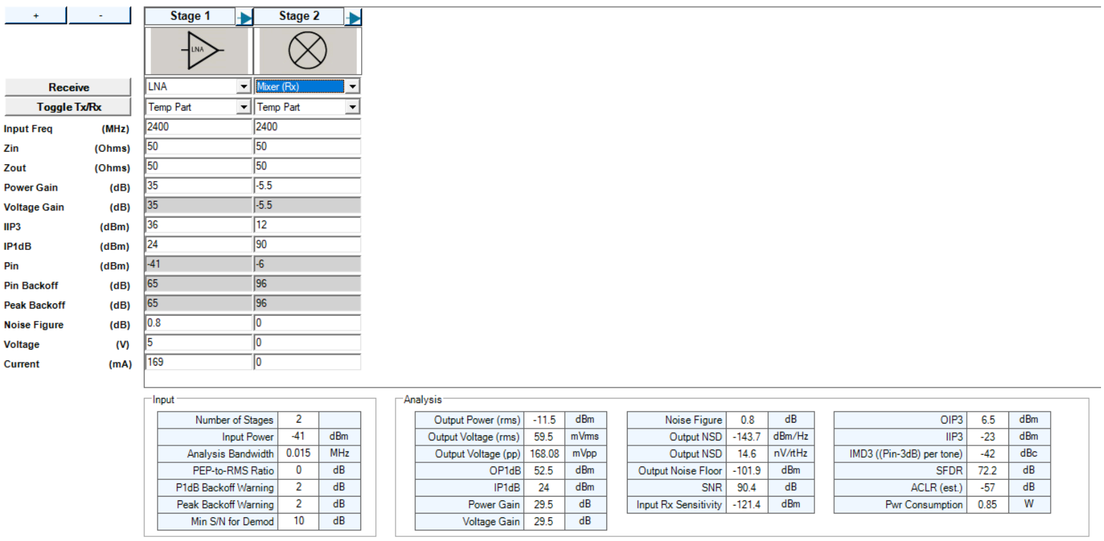

Fig.3 Receiver Simulation