FSK Receiver Design Description for ECE 432/532

Spring 2016

This project is based on Furse et al [1] which discusses this project in detail. The overall circuit and architecture of the receiver are presented in Figure 1. You will be designing the same type of receiver but with some modifications.

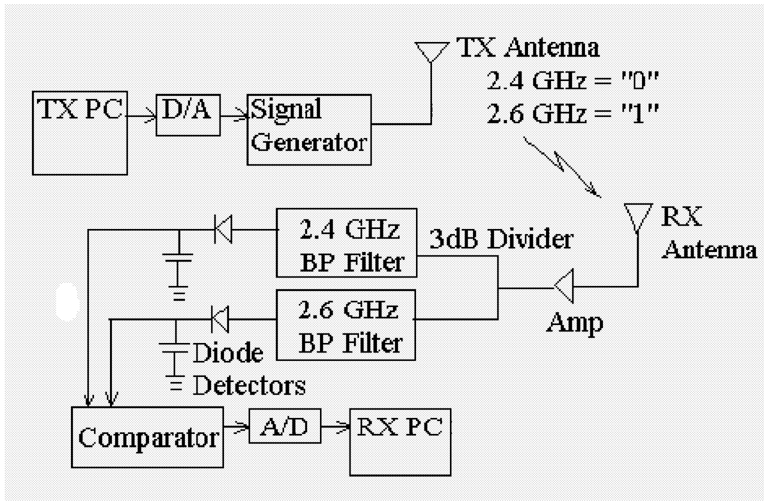

Figure 1 Block diagram of the overall receiver design.

Figure 2 gives a more detailed look at one possible implementation of the circuit.

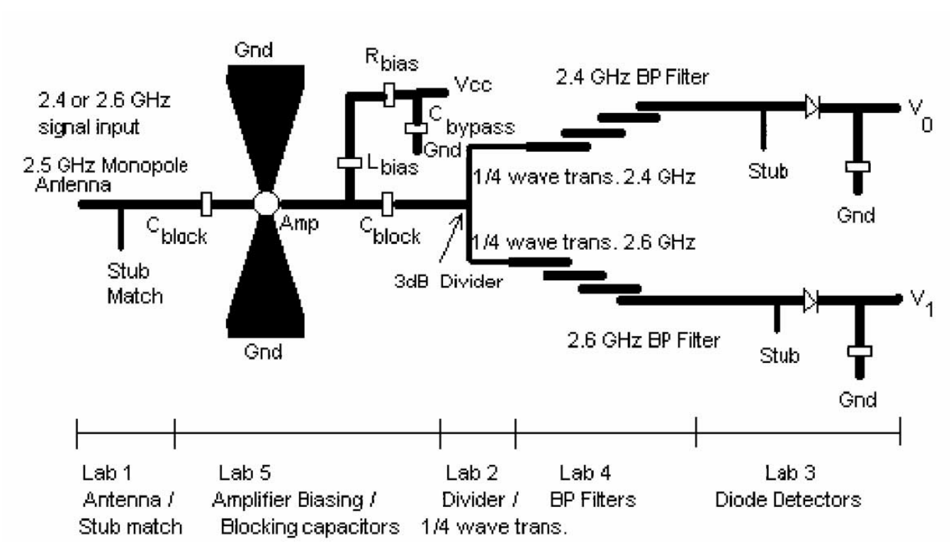

Figure 2. One implementation of FSK receiver. Modifications for this project are explained in text.

Specification for the design include:

1. It should operate at 2.4 GHz and 2.6 GHz
2. It should reliably distinguish between 2.4 and 2.6 GHz signals
3. It should incorporate:

a. Amplifier stage with at least 10 dB of gain and input return loss better than 10 dB (=S11)
b. 3 dB power divider that will separate 2.4 and 2.6 GHz signals
c. Incorporate 2.4 and 2.6 GHz band-pass filters with specifications given in the project for 431/531 (see Figure 3 for filter characteristics)
d. Utilize one form of diode detector to convert high frequency signals to DC voltage
e. All stages should be properly matched
f. If possible, all stages can be fabricated on the same board but if you have components that you have tested and you would like to re-use then use separate stages, connected by cable(s).
g. Rogers 4003C substrate is recommended but FR4 is also acceptable (but it has more variability)

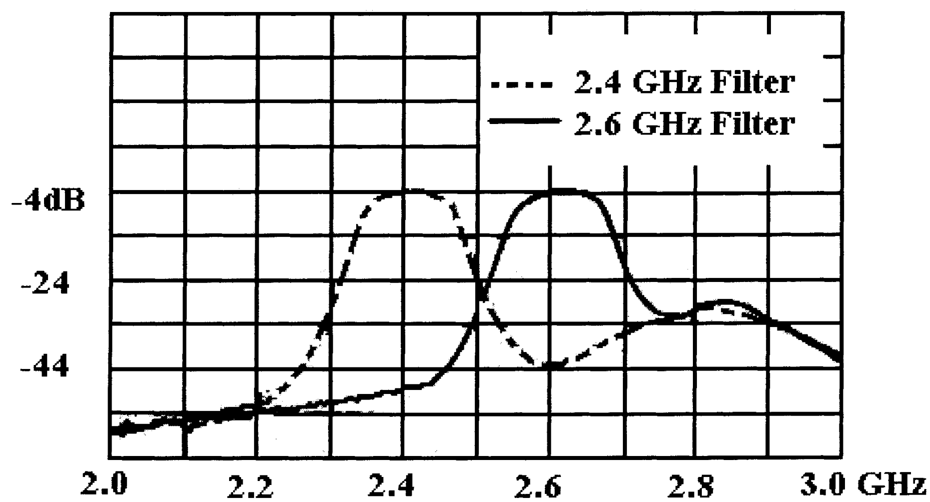

Figure 3. Filter characteristics for FSK design.

Note these difference relative to the original [1] design:

- I recommend using PSA4-5043+ from Minicircuits amplifier which is available in IEEE store
- We will not be building antennas nor will be using them to receive signals. Instead, we will drive the signal into LNA directly from a signal source.

Your design procedure should roughly follow this procedure:

1. **"Paper" design**: this can be something using Smith chart, tables from books, etc., and the main goal is to get the outline of the circuit (e.g. what order of the filter is required) and some preliminary component values. The circuit should be examined for overall practicality (e.g. if you find out that you need capacitors much less than 1 pF you may want to reconsider the circuit). If you do this stage literally on paper, then please scan the most important page or two (e.g. scan of Smith chart that you used).
2. **Simulation using ADS**: several levels of complexity are likely to be required just as we did in other designs. You will want to start with idealized design and verify that your paper design and simulation are in agreement (it may not be perfect). Document each stage. Make the final simulation stage as close to "realistic" as you can. Make sure that you can get the required values of SMD components or that you can combine them from the "standard" values. Note: Murata component library is available for inclusion in your designs but you may have to find and install other libraries.

3. **Design variability**: examine in simulation how variability of various components will affect your final result. Try to do this systematically. If you know how to use some advanced ADS functions to accomplish this that would be great. If not, you can make some simplifying assumptions and explain how you got your result.
4. Extra credit 1: coming up with a different topology or design procedure than the ones discussed in the paper or in class. However, circuit still has to work ☺ . I would recommend attempting temperature compensated circuit – there are app notes and papers on how to do this. In your report you will have to specifically indicate the section(s) that you consider as "extra credit".
5. **Generate a layout** for use in LID. More info is here http://psu-epl.github.io/ . You can also stop by and ask – they are in FAB 84-20, where IEEE store is. At a minimum you will need to use their router.
6. Given that you have access to LCR meter you should verify the (low-frequency) values of your components.
7. **Make a PCB** for your circuit, solder components and connectors.
8. **Measure (test) the circuit** using equipment available in EMAG lab (preferred) or ICDT lab (some students have access to it and we arrange for access). Reuse your calibration structures from LNA project.
9. **Redesign**: If you do not meet your design specifications try to identify and fix the problem(s). Rebuild your circuit and test again. One iteration should suffice – if you would need more "tweaking" on your circuit explain how you would proceed and why it is necessary.
10. **Demonstrate**: you will demonstrate your design and how it is measured.
11. Extra credit 2: Repeat the design-build-test procedure for one additional design, e.g. SMD-based filter instead of couple-line one (or vice-versa).
12. Extra credit 3: Design and/or integrate an antenna with your receiver.

You will have to solder all of your components and test the final board. Your report should include comparison of measured data with simulated – try to do these on the same plot. One report per team is required (one submission). Your report should include description of any alternative designs that you considered, any items that were especially troublesome, and in your conclusions you should include a "lessons learned" section with suggestions on how you might to do this if you had to do it again. You should also explain individual team member's contributions.

Rubrics for report assessment will also be posted (they are the same as for ECE 431/531 project). You will also have to demonstrate that your receiver works and how you measured its characteristics. You will also have to archive your design from ADS and upload it to D2L.

Any extra credit effort must be identified in your report.

Deliverables:

1. Written report describing your design process and results. Include schematic and layout pictures, as appropriate – I do not need to see everything you have done, just the most important parts.
2. Demonstration of your final design and explanation of the measured results
3. Archive of your ADS system simulation, i.e. schematic containing all of the relevant parts that can be executed within ADS. If you are using ADS to generate layout then include it along with the schematic pages. If you are using a different layout program then provide picture of the final layout generated by the program and include it in your report.

References:

[1] C. Furse, R.J. Woodward, and M.A. Jensen, "Laboratory Project in Wireless FSK Receiver Design," IEEE Trans. Education, vol. 47, no. 1, pp. 18-25, Feb. 2004.