**Team Name:**

Radio Communication Innovators

**Team Members (maximum 4 members)**

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| --- | --- | --- | --- | --- |
| **Last Name** | **First Name** | **Email\*** | **Dept.** | **Signature** |
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**\*Email address will be used to develop Senior Design listserv. You will be required to check this address regularly (e.g. daily)**

**Advisor: By signing below, the faculty member agrees to be the Team Advisor and attests that the resources required for this project are available or obtainable.**

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| --- | --- | --- | --- | --- |
| **Last Name** | **First Name** | **Email** | **Dept.** | **Signature** |
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**Sr Design Course Coordinator:**

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| --- | --- | --- |
| **Last Name** | **First Name** | **Email** |
| **Sillage** | **Dennis** |  |

**If majority of team or project is CE: Dr. Ryan**

**EE: Dr. Sullivan**

**ME: Dr. Cohen**

**Project Title:**

K3TU: FPGA-based Terminal Node Controller in Amateur Packet Radio Communication

**Project URL:**

https://sites.google.com/a/temple.edu/ fpga-based-terminal-node-controller-in-amateur-packet-radio-communication

**Project Description:**

**4 Paragraphs:**

**1) What** is the problem you are addressing?

Traditional modems are designed and implemented using analog components. However, future modems will incorporate sophisticated modulation techniques that will dramatically increase circuit complexity. The result is a longer and more costly design process. In addition, the desire to increase data rates and security along with minimizing bit error rates means future modems will require flexibility and scalability; two attributes not currently associated with traditional analog modems.

**2)** **How** will you address the problem?

One area of research that is becoming increasingly popular is Software Defined Radio (SDR). SDRs allow communication engineers to implement traditional analog modems programmatically thus providing flexible and scalable solutions. In order to demonstrate the potential of SDRs, we consider amateur radio packet satellites (PACSATs) using 1200 bps BPSK modems. The modem will be designed using Verilog HDL and implemented on the Avnet's Xilinx Spartan-6 FPGA LX9 MicroBoard.

Our senior design objective is to demonstrate an alternative to the traditional terminal node controller. We plan to equip Temple University's Amateur Radio Club (K3TU) with a re-programmable terminal node controller consisting of a 1200 bps BPSK packet radio modem and an AX.25 frame assembler/disassembler all operating in an FPGA. By conjoining the re-programmable TNC with a personal computer equipped with a serial communication terminal and a Linux operating system (which natively supports the AX.25 protocol), the club's existing TNC can be replaced.

**3) How** will you validate your project through testing?

The re-programmable TNC will comprise the following: 1) Avnet's Xilinx Spartan-6 FPGA LX9 MicroBoard and, 2) a Digilent DAC and ADC compatible with the MicroBoard's Pmod expansion ports. The personal computer will comprise a recent Xubuntu distribution consisting of a recent Linux kernel natively supporting the AX.25 data link layer protocol (meaning it already has an AX.25 assembler/disassembler). Additionally, the Linux operating system will be equipped with LinPac, an AX.25 command line terminal. Thus, the entire amateur packet radio station will consist of our personal computer, the re-programmable TNC, one of K3TU's radio transceivers (operable on the 144 MHz AR band), and a couple of K3TU's Yagi antennas.

As mentioned earlier, the re-programmable TNC will be performing two overall tasks: AX.25 encoding/decoding and BPSK modulation/demodulation. Testbenches will be performed on each module comprising the HDL design. After the logic of each task is determined to be successful, the two tasks will be integrated together and testing will continue by using LabVIEW, and a National Instruments data acquisition tool to input random bit streams so that we can measure and record the resulting BPSK modulated signal. After capturing a simulated signal, Matlab’s communication and signal processing toolbox will be used to evaluate the performance of our modem by importing our captured signal and analyzing it in both the temporal and frequency domain. Specific metrics to evaluate performance will include signal to noise ratio and bit error rates.

Cedric:

**Rough draft:**

* Acquire a BPSK signal so it can be demodulated
  + We can use Matlab to generate a Manchester Encoded signal bury in some SNR level and try to extract the AX.25 signal back
* Create an AX.25 bit stream and modulate
  + Using a test-bench we generate a stream of random data
    - Assessment: Analyze the signal using Matlab
* Use different SNR and test how effective is the demodulation
* Adjust the Radio to the Doppler shift
* Finally our final goal will be to monitor an incoming satellite so we can communicate
  + PREDICT which was developed by John Magliacane looks really good

We intend on using a DAC, an ADC to analyze the modulated and demodulated waveforms from the Avnet's Xilinx Spartan-6 FPGA. Matlab’s signal processing and communication toolbox will help observe the waveforms in the frequency domain as well as the time domain. The modulated waveform will be created by generating a stream of data following the AX.25 protocol through testbenches in Xilinx’s ISE Design. Using Matlab we will ensure that the modulated waveform has the appropriate **carrier frequency** and a low amount of **phase jittering**.The demodulation procedure will be analyzed using Matlab’s toolboxes after being acquired from using a DAC. The demodulator’s analysis will be geared towards optimizing the Signal to Noise Ratio (SNR) of the demodulator. Providing different SNR we will observe the efficiency of the demodulator which will be configured to demodulate waveforms regardless of a low SNR.

Finally, to test our modem we plan on monitoring Amateur Satellites orbiting to transmit and receive packets. The satellite transponder will be tracked using the computer software PREDICT which allows to interactive monitor the satellite and provides us with the Doppler Shift needed.

**4) What** will you deliver at the end of the second semester?  
 At the end of the second semester, the current K3TU amateur packet radio setup will be configured with the modem implemented on the Spartan-6 FPGA. Consequently, we will modulate data streams and demodulate waveforms by using K3TU’s amateur radio station. Additionally, we may be able to deliver a fully operational amateur packet radio station capable of briefly communicating with low Earth orbiting amateur satellites with packet radio communication or packet repeating capabilities.