1. Student name: SeungGoo Kang

2. Faculty mentor name: Dr. Lei Liu

3. Project title: Initial study and demonstration of terahertz adaptive wireless communication

4. Briefly describe any new skills you acquired during your summer research:

Through the summer research, I explored the field of terahertz wireless communication. The main focus was on terahertz beam scanning to do terahertz imaging. The terahertz imaging captures the terahertz radiation emitted by the object. To find the object that emits terahertz radiation power, the Planck radiation law was integrated to calculate the power of terahertz radiation of an object. I used MATLAB to generate different Fresnel zone plates for beam scanning. I also had hands-on experiences such as using the vector network analyzer to measure the power. Last, I learned to use AutoCAD to design the experimental setup in 3D.

5. Briefly share a practical application/end use of your research:

Terahertz communication has more bandwidth and ultra-fast wireless communications than conventional communication system. Its application includes high performance terahertz imaging. Terahertz imaging is better than diagnostic X-rays because it has low health risk. Our research team expects to do beam steering and forming to establish a THz link in both line-of-sight and non-line-of-sight modes.

For terahertz imaging, an object that emits detectable terahertz power was needed. For terahertz radiation power calculation, the Planck radiation law was integrated over the terahertz range from 735GHz to 740GHz. The equation for the radiation power generated by any object was derived: $P = \varepsilon\sigma A T^4$ (ε is the emissivity (from 0 to 1), σ is the constant, A is the area, and T is the temperature). The VNA was only sensitive enough to detect a few microwatts of power. The terahertz radiation power generated by 2cm by 2cm cotton cloth at room temperature was around 0.2 microwatts. Because it was not possible for any object at room temperature to be detected with the VNA, one of the VNA was used as a source to generate 740GHz terahertz radiation. The source was placed in different places for terahertz imaging. The DLP projector projected different Fresnel zone plates (FZP) for beam scanning. Different FZP patterns were generated with MATLAB. FZP alternates between opaque and transparent zones. Light transmitted by the transparent zones constructively interferes at the desired focus. For beam steering and forming, FZPs for different beam-steering angles were designed as shown in Figure 1.

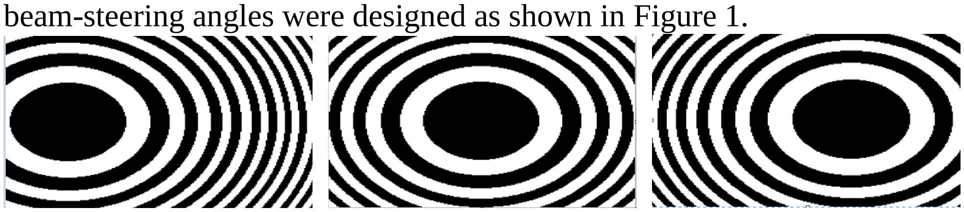

Figure 1. Fresnel Zone Plate -8° (left), 0° (center), 4° (right)

The experimental setup is shown in Figure 2. The receiver received the THz beam that was reflected from the ITO.

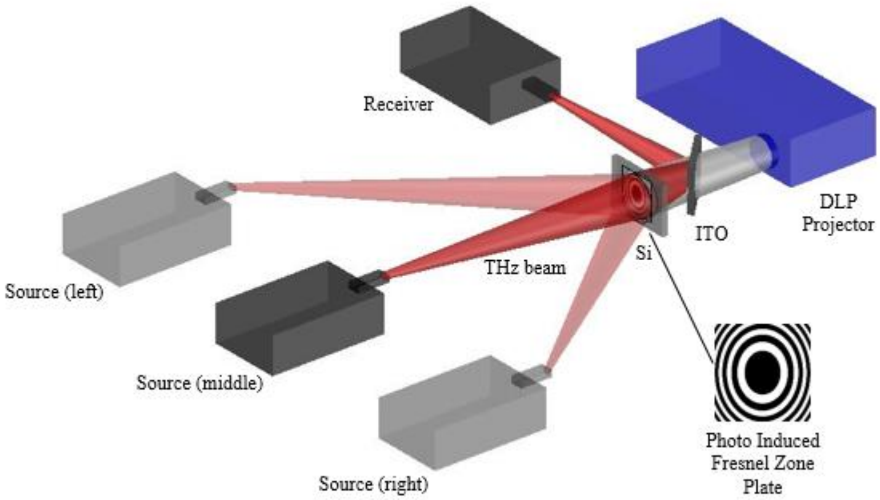

Figure 2. Experimental Setup

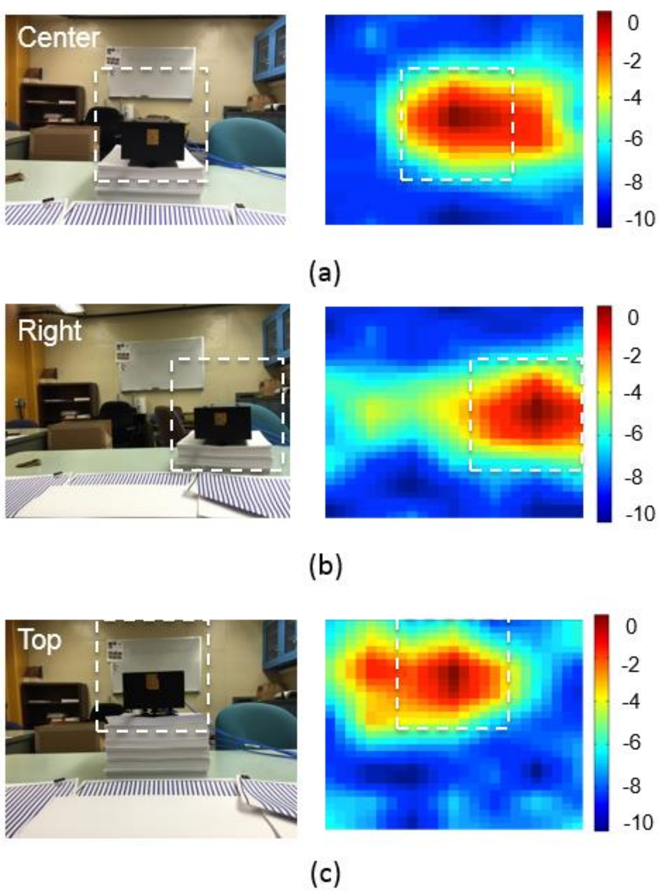

Figure 3. Result of Terahertz Scanning

As shown in Figure 3, the source was placed in three different places: center, right and top. The terahertz beam scanning started from upper left corner to lower right corner. It went from -12° to 12° horizontal and -12° to 12° vertical. The power measured at the VNA was mapped in the terahertz image as shown on the right. In the terahertz image, the red zone is where the terahertz source is located and blue zone shows the background. The red zone has the greatest measured power because the beam is directed at the receiver. The result verify that terahertz imaging of a terahertz source works. In the future, we would like to establish a THz link after beam scanning and switch to a different mode for high speed data communication in both LOS and NLOS propagation.