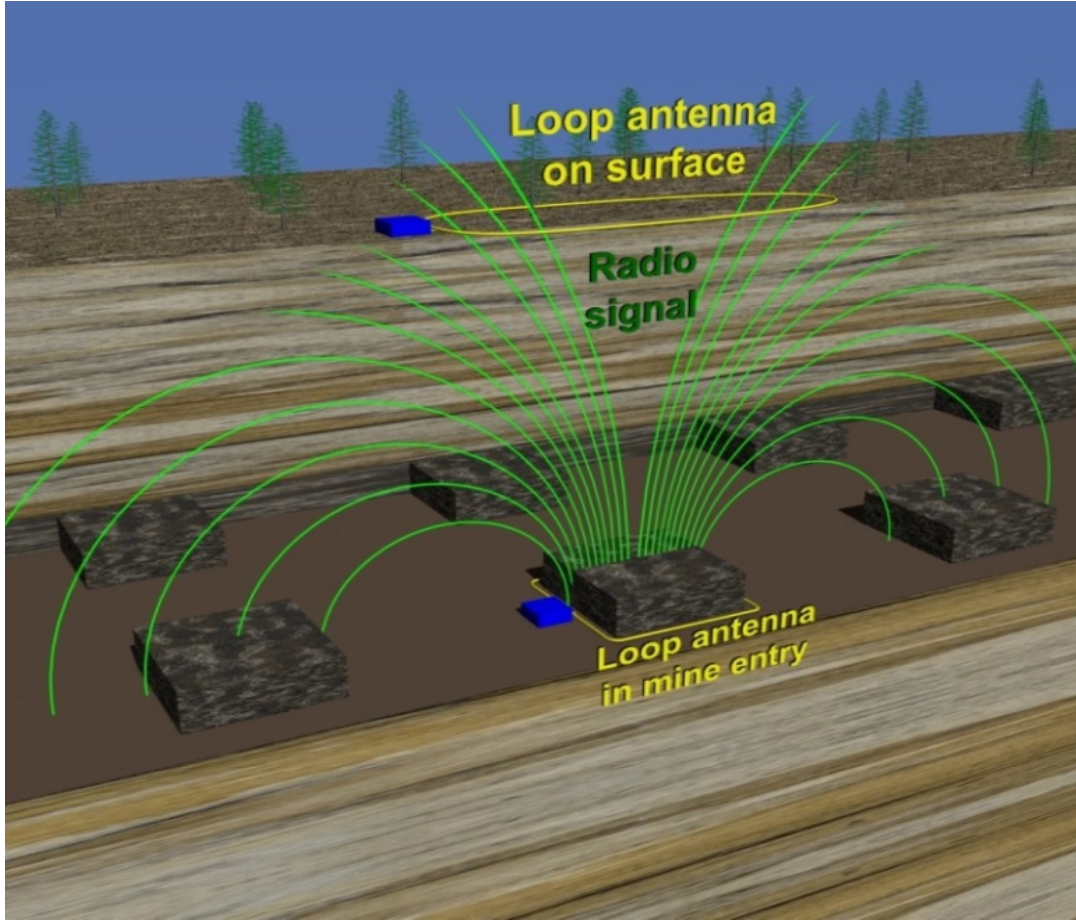


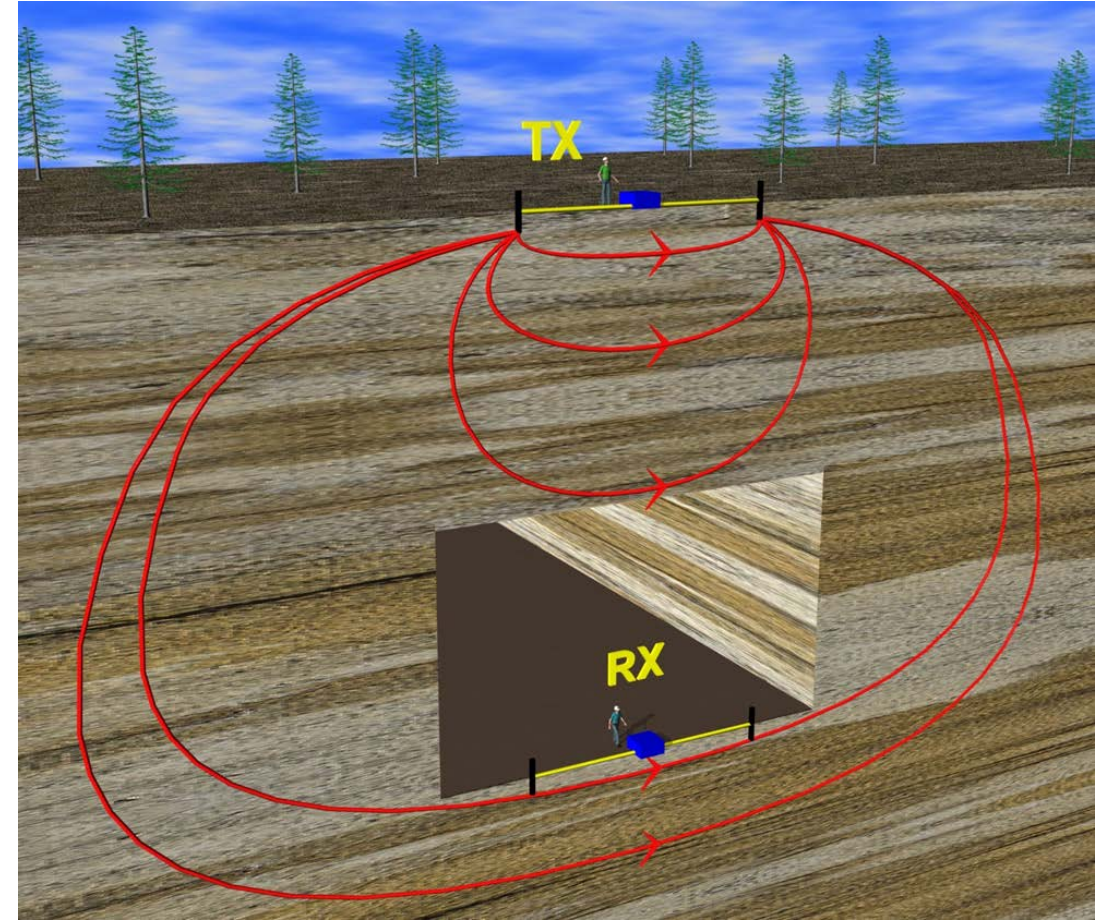
**Will Through-the-earth (TTE)
communications work in an underground
coal mine refuge alternative?**

Overview of TTE communication systems

- 5 year NIOSH communication and tracking modeling and performance project
- Two types of MINER act compliant TTE systems

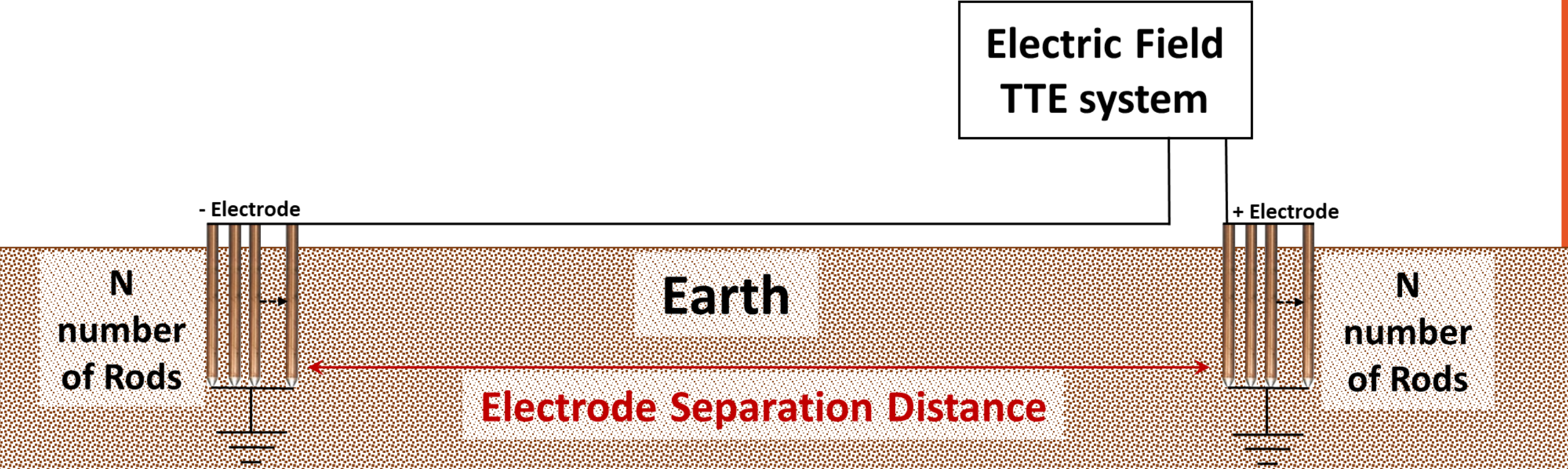


Magnetic field



Electric field

A diagram of an electric field TTE system deployed on the surface



Laptop

Amplifier

Receiver

Current Transformer

Wire

Electrode

Electrode



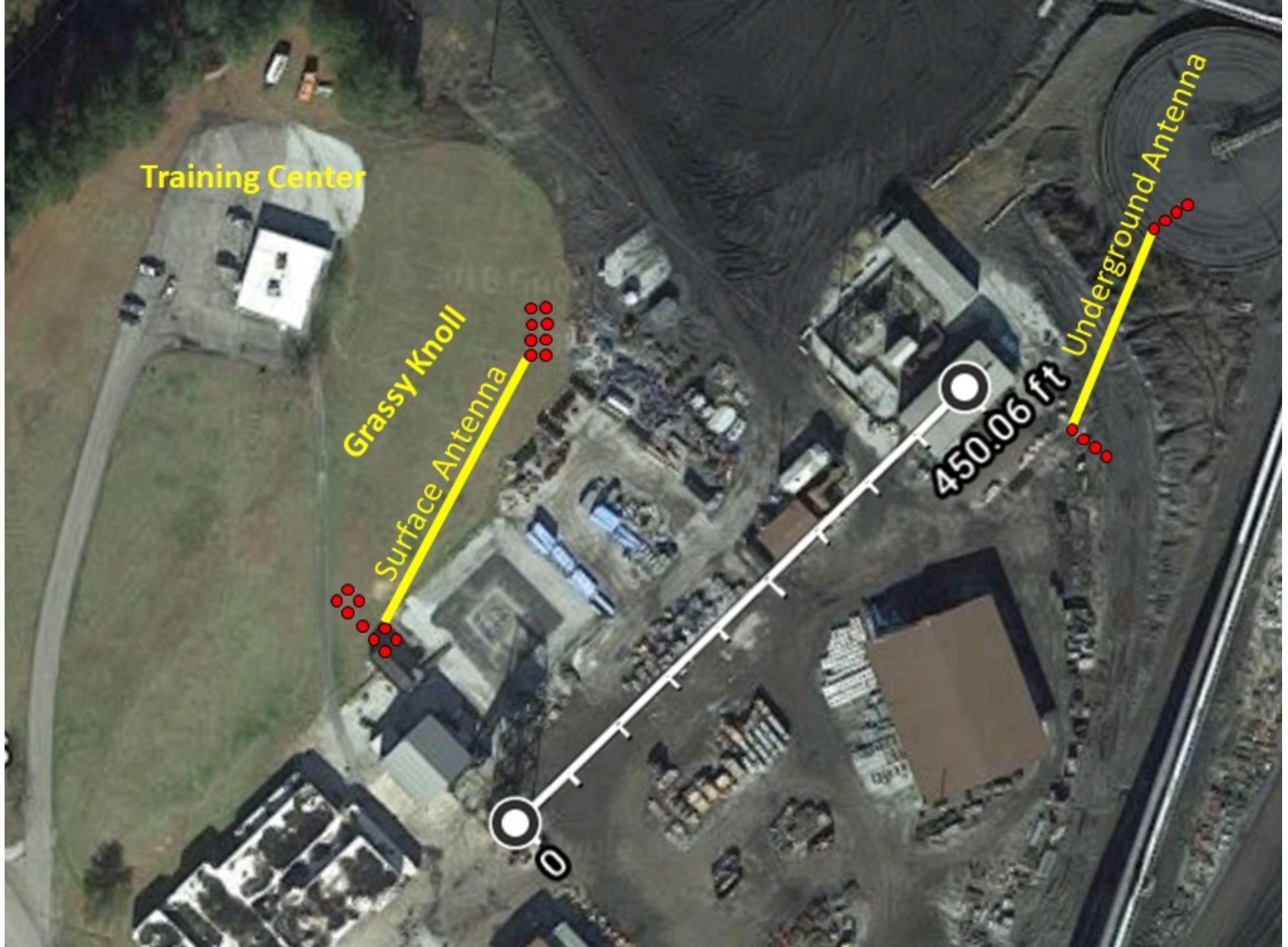
Ground Rods



Warrior Met Coal's Mine No. 7 - Alabama - Sept 18th



West Portal ~1860' deep



Training Center

Grassy Knoll
Surface Antenna

450.06 ft

Underground Antenna









Ground impedance should be low for electric field TTE systems

- **Impedance must be measured at the site**
- **Transmission frequency affects the measured impedance**

For this mine:

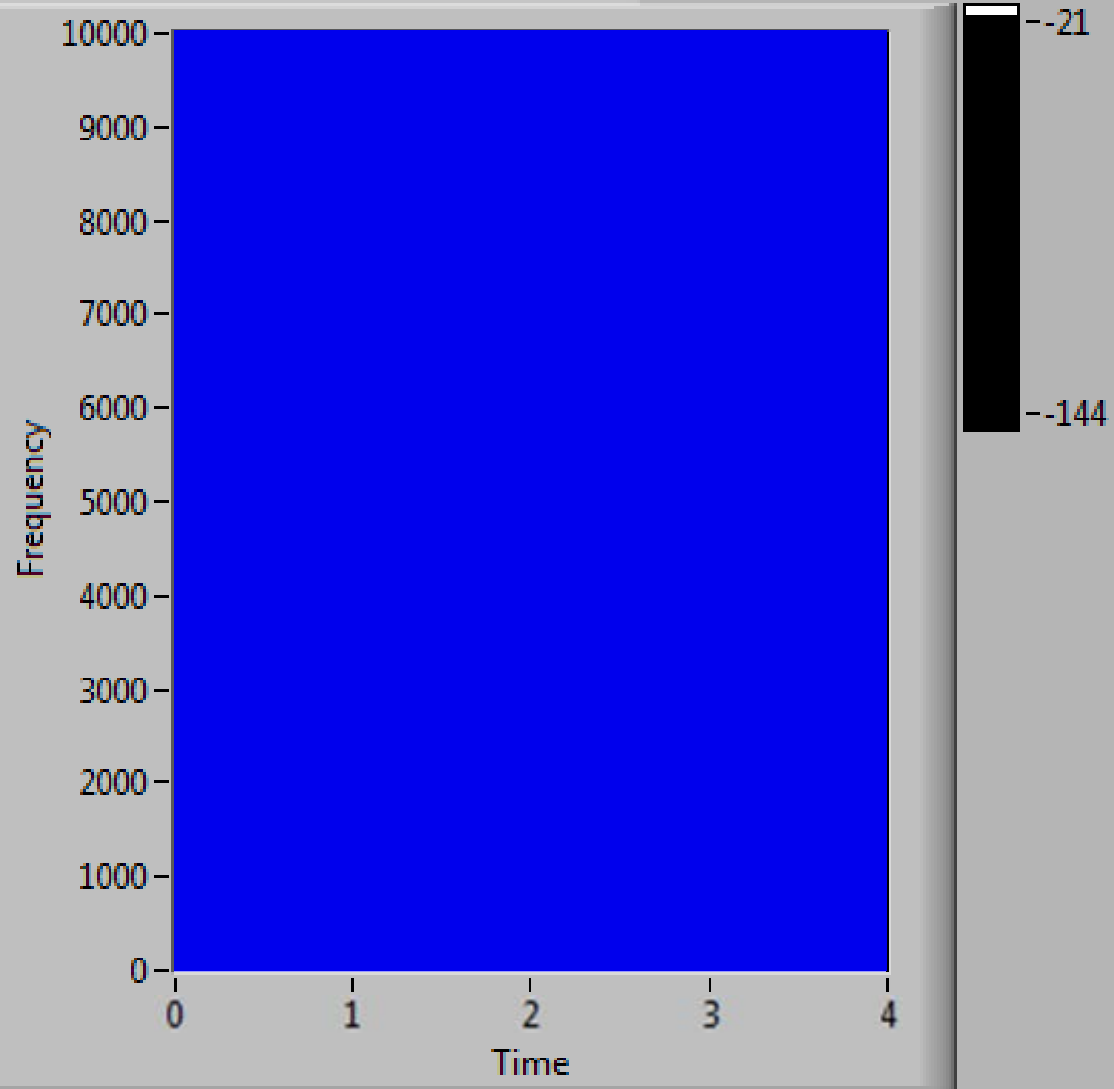
- **Surface antenna – Eight 4-foot rods per electrode, 20-30 ohms**
- **UG antenna – 4 rods and 8 roof bolts per electrode, 5-15 ohms**

Surface

FREQ RANGE

START 0
END 10000

Antenna Volts

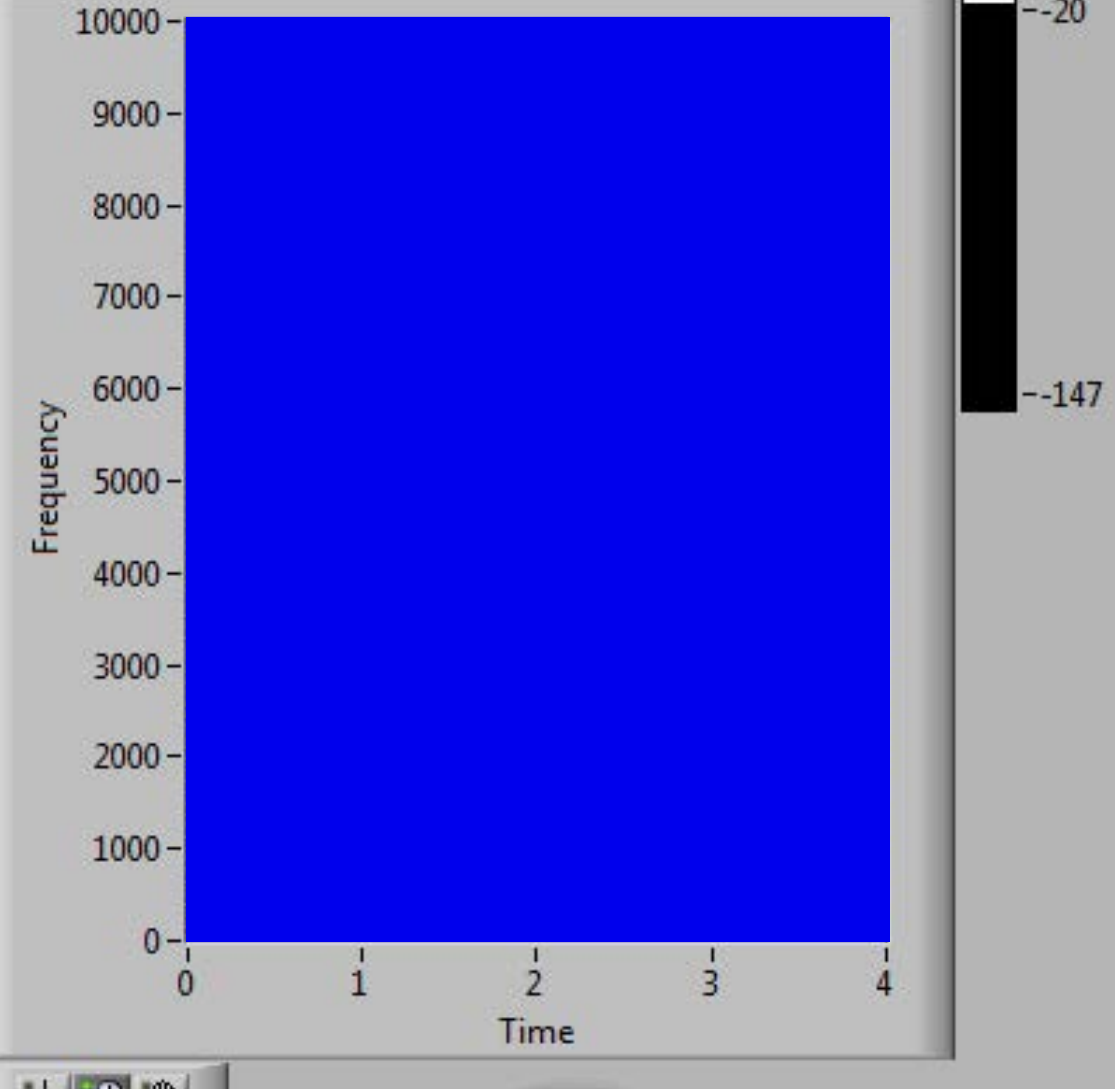


Underground

FREQ RANGE

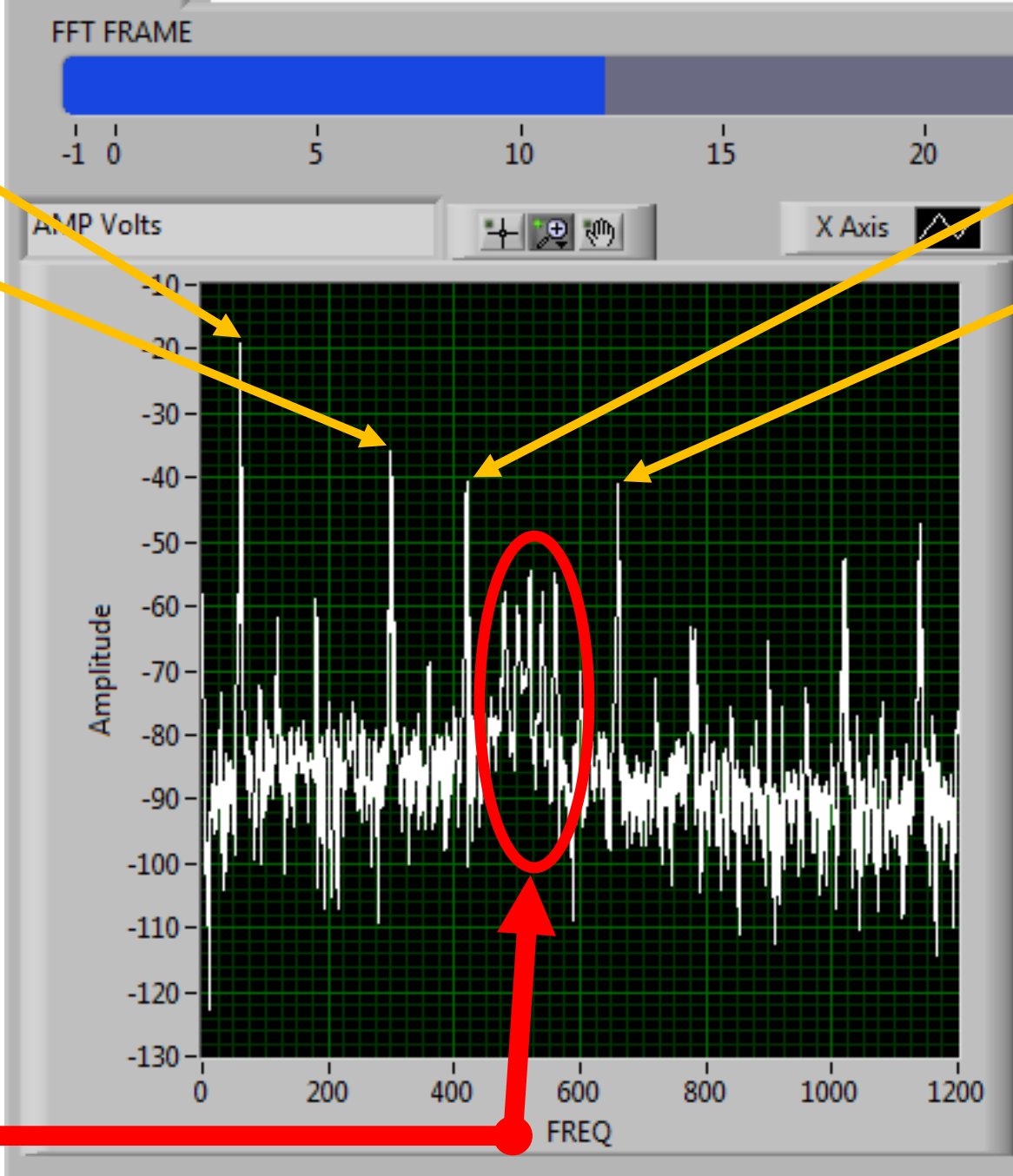
START 0
END 10000

AMP Volts



60 Hz Noise
300 Hz Noise

420 Hz Noise
660 Hz Noise



TTE Signal

Underground signals detected on the surface with a TX current of 1 amp

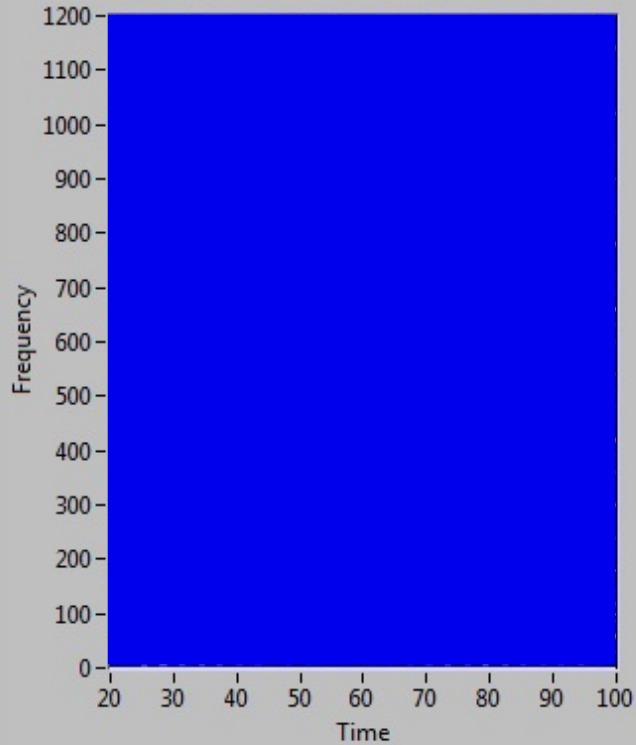
8 AMPS

FREQ RANGE

START 0

END 1200

Antenna Volts



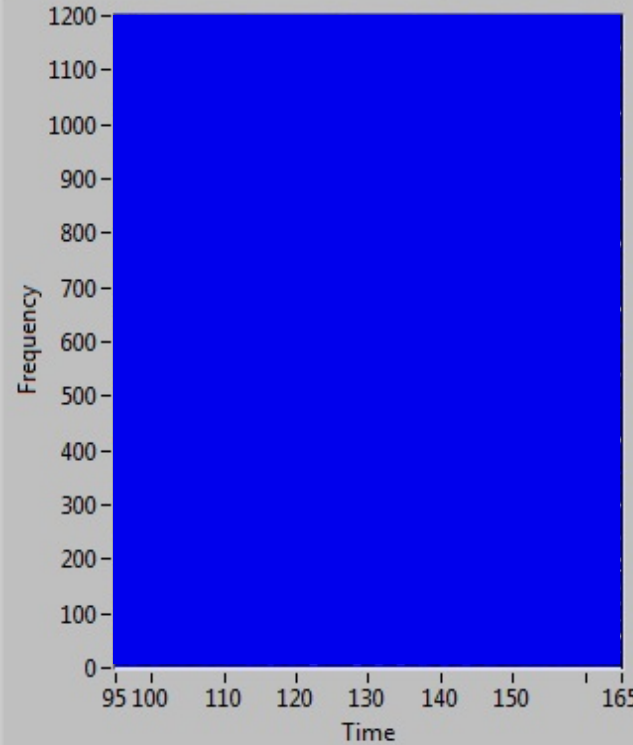
4 AMPS

FREQ RANGE

START 0

END 1200

Antenna Volts



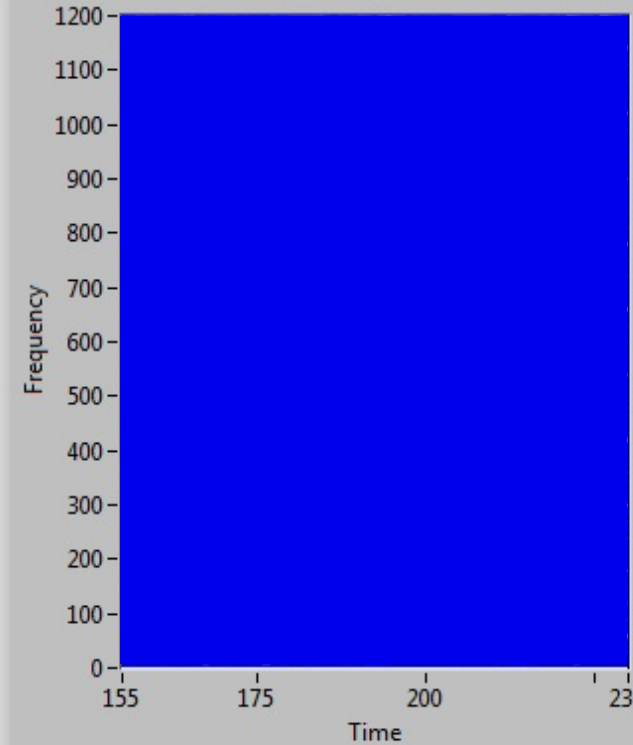
1 AMP

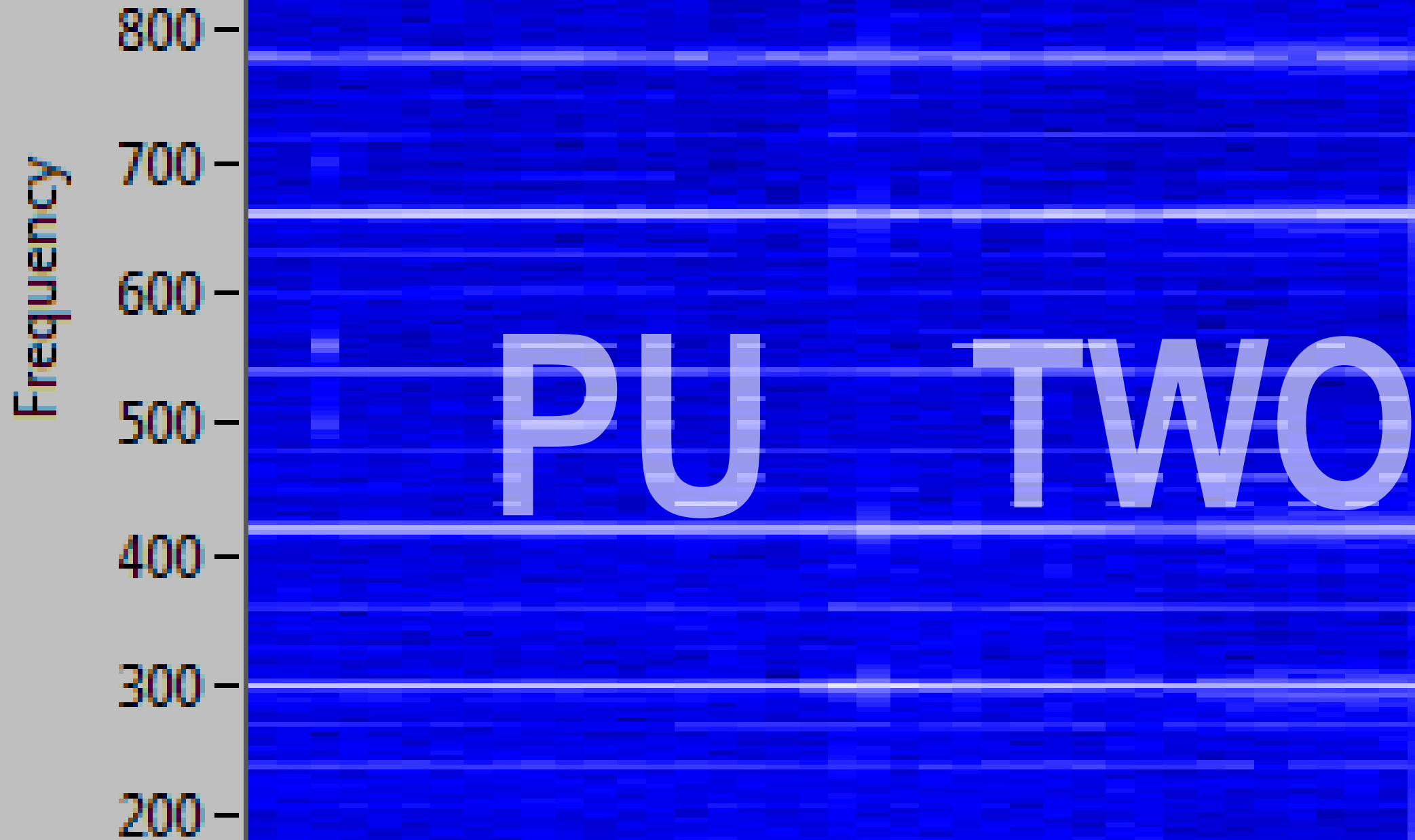
FREQ RANGE

START 0

END 1200

Antenna Volts





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Summary

- **Conducted 4 types of measurements**
 1. Noise – 60 Hz and odd order harmonics were the strongest interference
 2. Signal power level – transmit signal received as low as 1 amp
 3. Signal frequency – antenna impedance varied with frequency
 4. Text messages – banner text messages were successful
- **TTE signal detected in both directions diagonally through approximately 1900 feet of overburden**
- **Future Work**
 - Electromagnetic interference (from electrical distribution systems)
 - Conduct electrode separation measurements

Questions?

