E2.04 Electric Field Mill

TEXAS STATE
INGRAM SCHOOL OF ENGINEERING

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ELECTRIC FIELD MILL
LIGHTNING PREDICTOR

Background

- Electric Field Mill is used to determine the strength and direction of atmospheric electric fields
- General trend of electric fields over time is used to predict lightning strikes
- Used in scientific research, human safety, and in safeguarding electronic devices, onboard electronic instruments in aviation and aerospace
- Rocket launches can induce lightning strike if atmospheric electric fields are sufficiently high

"If any of the mills within 5 nautical miles (NM) of the launch pad registers 1,000 volts per meter or greater, a launch is postponed."[1]

[1] NASA, Marshall Space Flight Center

Design Requirements

- Capable of measuring atmospheric electric field
- Time-stamped data written to removable SD card in .csv format
- Fully contained within one cubic foot
- Water resistant housing design
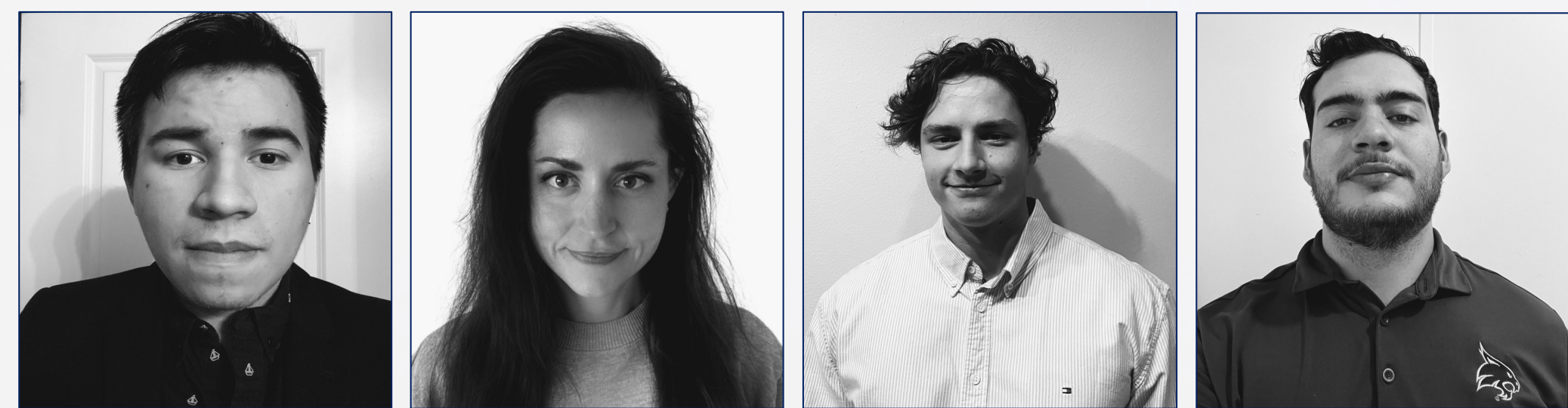- Power: 12 VDC, less than 0.5 A total power consumption

The Electric Field Mill
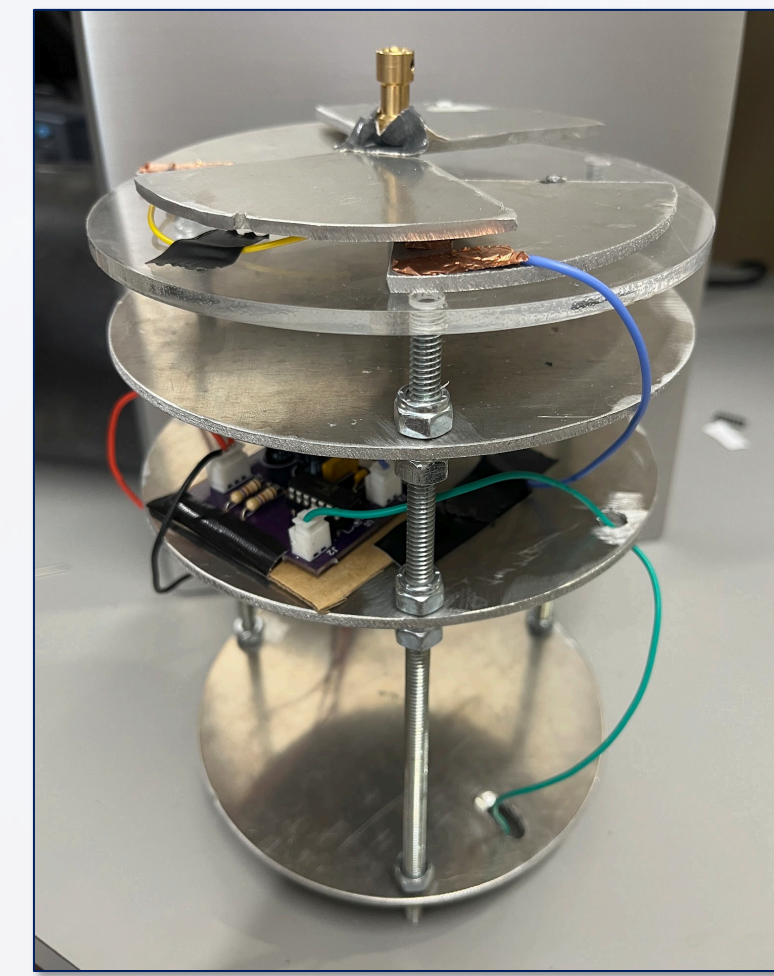
Includes:
- Stepper motor and chopper-regulated sensor plate
- Aluminum housing
- Highly sensitive AC signal processing PCB with user switch for each field range
- Analog-to-Digital signal processing circuity
- Status LED
- Microprocessor and SD card
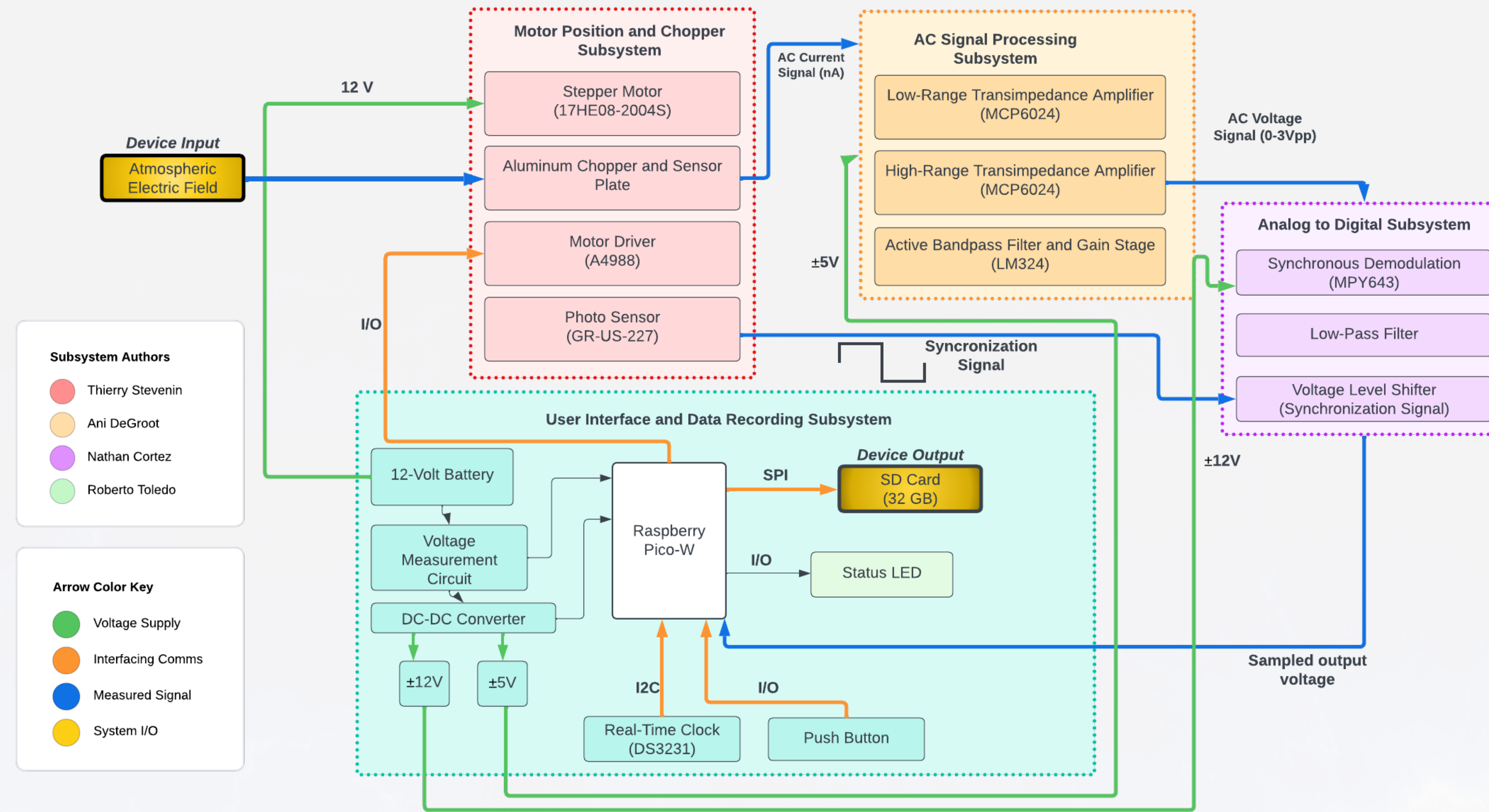
The Team

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Faculty Advisor: Mark Welker
And special thanks to our former advisor, Dr. William Stapleton

System Block Diagram

Subsystem Authors
- Thierry Stevenin
- Ani DeGroot
- Nathan Cortez
- Roberto Toledo

Arrow Color Key
- Voltage Supply
- Interfacing Comms
- Measured Signal
- System I/O

Signal Processing Analysis

The output of the AC Signal Processing subsystem contains information of both the magnitude of the electric field (amplitude) and the direction (seen as phase shift).

The output of the Analog to Digital subsystem uses synchronous demodulation to produce a DC voltage value (pink), which contains information of both the magnitude and direction of the electric field.
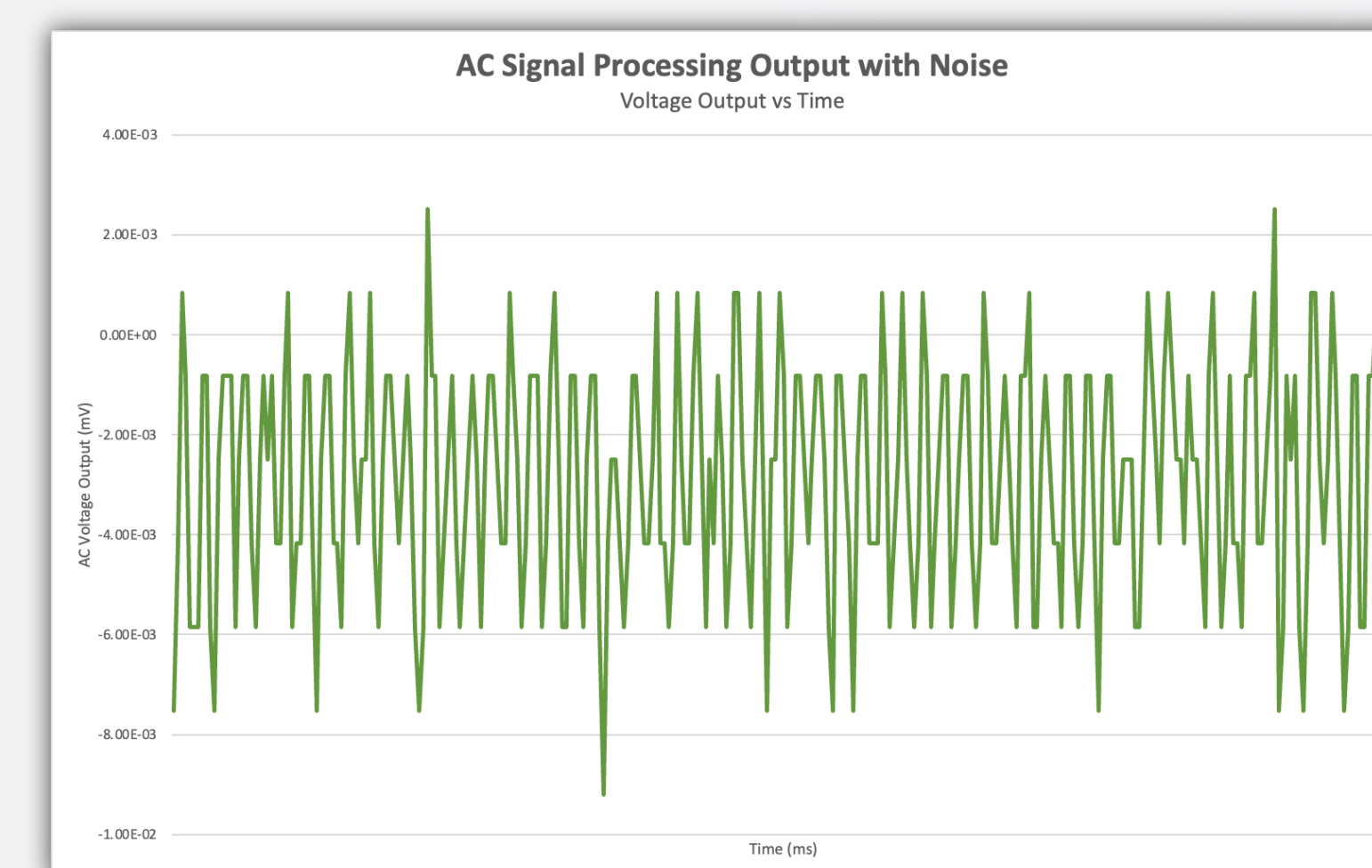
When an electric field is applied to the filed mill, the AC Signal Processing output has more noise across the frequencies included in the active bandpass filter—most notably at 60 Hz—the operating frequency of most electronics. This noise is further removed in the low-pass filter of the Analog to Digital Subsystem.

The output of the AC Signal Processing when an applied electric field is removed shows the natural noise in the signal from internal and external sources.

Sensor Plate Output

Electric Field Strength (V/m)	Sensor Plate Output (pA)
100	74
200	149
300	224
400	229
500	374
750	560
1000	740

User Interface and SD Card Readings
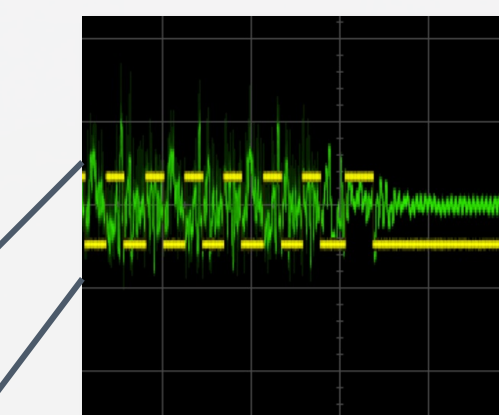
Electric Field Strength User Data

Time Stamp	Electric Field Strength (V/m)
21:00:00	525
21:01:00	500
21:02:00	600
22:02:00	575
23:02:00	325
0:02:00	575
1:02:00	600
2:02:00	125
3:02:00	325
4:02:00	175

Electric Field Reading Over 10-Min Period