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Sensor Testing System for Monitoring Plants and Growing Media

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BACKGROUND

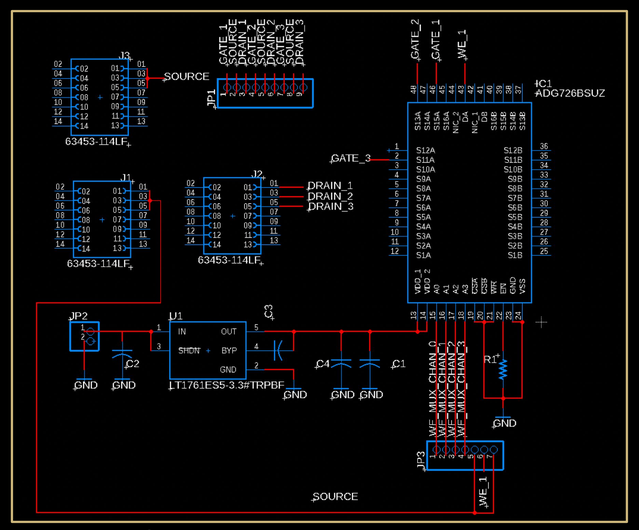
- BEEM Lab has developed screen-printed NPK (Nitrogen, Phosphorus, Potassium) sensors to make nutrient testing more beneficial to hydroponic farmers
- Each sensor is composed of three separate transducers
- Our team designed an integrated housing unit to quickly and accurately read data from these sensors

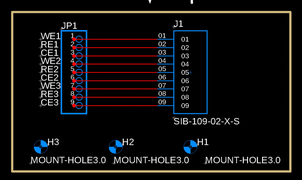
KEY REQUIREMENTS

- Easily portable (maximum size 6 x 6 x 6 inches)
- Operations are intuitive and user friendly
- Easy insertion and removal of the single use sensors
- Internal input will connect to external devices for reading

ELECTRONICS

- Electronics system interfaces with Palmsens' EmStat MUX16 board
- Dual channel potentiostat holding constant gate-to-drain and source-to-drain voltages while recording the source-to-drain current
- Ion concentration in the test fluid alters the channel resistance and changes the current reading
- Multiplexed to read all transducers on a given sensor sequentially

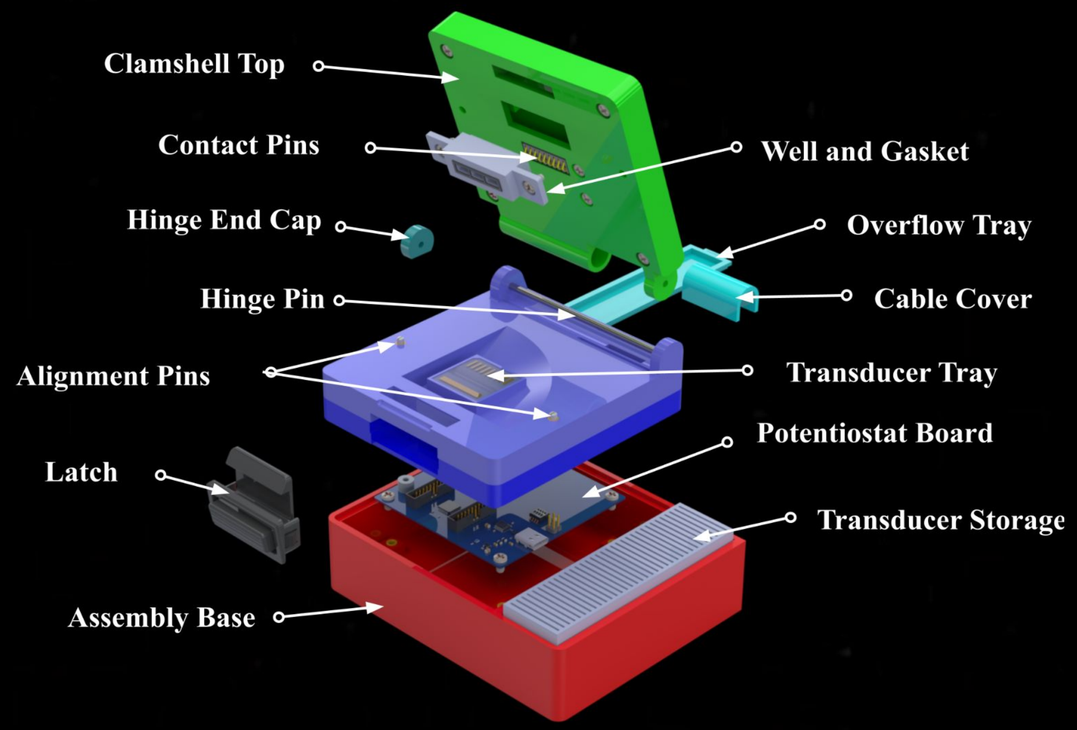




EMSTAT MUX16 BOARD

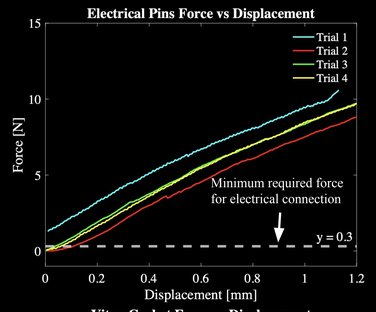
COMPUTER

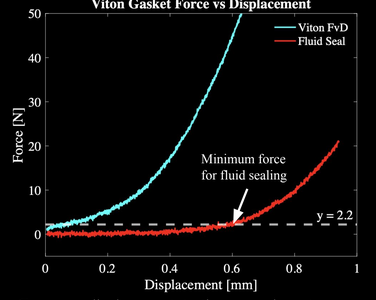
DESIGN



TESTING & ANALYSIS

COMPONENT TESTING

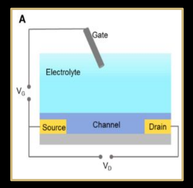




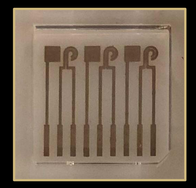
Force vs displacement testing was done to gauge how much force should be applied to both the gasket and contact pins in order to obtain both electrical connection and fluid sealing with the transducer

SYSTEM TESTING

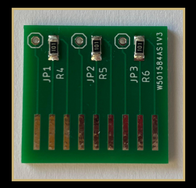
The accuracy of the current reading was checked using a custom test PCB. Resistors of known values where soldered between the source and drain terminal, and the current measured across these resistors.



Transducer Diagram



BEEM Lab transducer



Test PCB

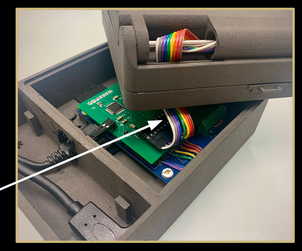
1kΩ Resistor Test	Mean Current Value (μA):	σ (μA):	Theoretical (μA):	Mean % Diff:
Sensor 1:	-498.117	0.000	-500.000	-0.377
Sensor 2:	-498.117	0.000	-500.000	-0.377
Sensor 3:	-498.383	0.060	-500.000	-0.323

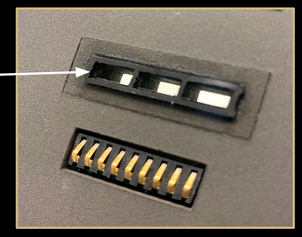
10kΩ Resistor Test	Mean Current Value (μA):	σ (μA):	Theoretical (μA):	Mean % Diff:
Sensor 1:	-50.008	0.000	-50.000	0.016
Sensor 2:	-49.953	0.000	-50.000	-0.095
Sensor 3:	-49.996	0.060	-50.000	-0.009

DISCUSSIONS

CHALLENGES

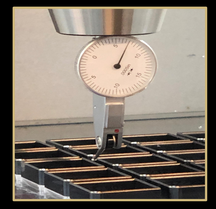
- Start Up Company / Scope of Product
- Additive Manufacturing
- 3D Printing Tolerances
- Size and Spacing for Electronics and Cables
- Mechanical Design
  - Hinge
  - Fluid Well / Gasket
  - Crush ribs



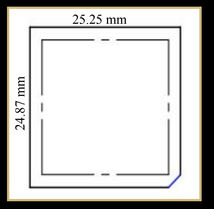


TOLERANCE ANALYSIS

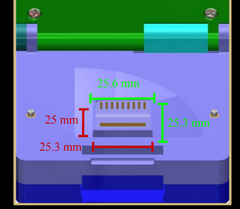
Part	Tolerance [mm]	Validation	Source
Pin Housing	0.13 - 0.2	Inspection (Caliper)	Drawing
Transducer Bedding	0.2 - 0.3	Inspection (Caliper)	Drawing
Transducer	0.1	Inspection (Caliper)	Drawing
Die Cutter	0.07 - 0.13	Inspection (CNC)	Drawing



CNC Inspection



Die Cutter Dimensions



Parts Dimensions

CONCLUSION

RESULTS

- Functioning, user-friendly design with dimensions (5.32 x 4.33 x 2.85 inches)
- Similar readings as lab equipment (Keithley DAQ)
- Die-Cutter provided accurate cutting of transducers to correct dimensions
- Laser-Cut Viton Gaskets sealed fluid in the well
- Budget: $1,325 out of $2,000
- Cost of housing materials : $125-$175

FUTURE CONSIDERATIONS

- Injection molding for high-volume quality production
- Well designs for different transducer orientations
- Design for varying transducer sizes and geometry
- Wireless and app capabilities

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