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Our Team



Aaron Loh

Hardware
System



Dipak Shrestha

Hardware
System



Idil Bil

Software GUI



Kerem Oktay

Embedded
System



Peggy Yuan

Hardware and
Mechanical
System

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The Client



Orca Advanced Materials Inc.

- Startup based in Vancouver, BC
- Specializing in functional thin film devices and their applications
- Need to measure the electrical characteristics of thin films

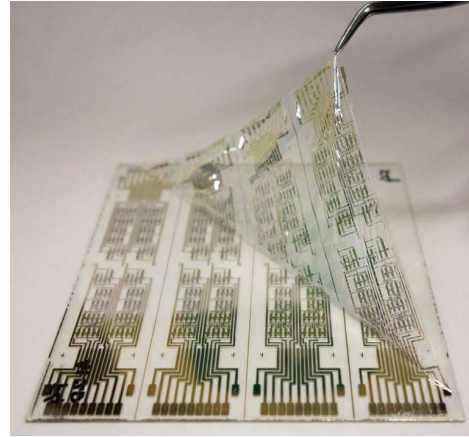
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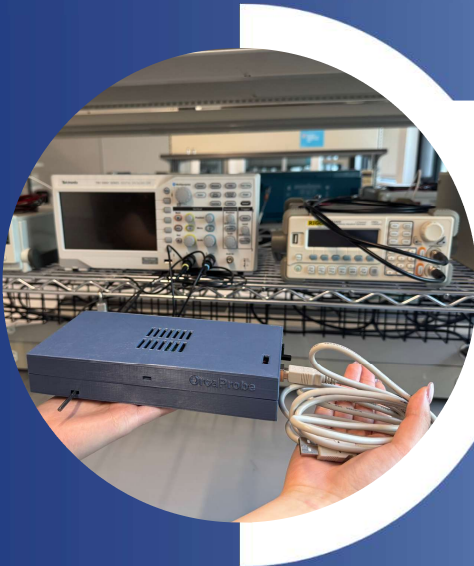
The Problem

- Different tests require different lab equipment to perform
- Multimeter, oscilloscope, spectrum analyzer, power supply...
- Process is labour-intensive and inefficient due to the manual setup of each tool and material



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The Solution: OrcaProbe!



5 to 10 times
process
speedup



Far below
off-the-shelf
pricing



Less than
5% total
error



Full ownership
with a modular
design

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Functional Requirements



Complete System

- 11 measurement methods
- 2, 3 & 4-probe configurations
- DC/AC voltage & current sourcing and measuring capabilities



Device Hardware

- 0-5 V and 0-10 mA signal range support
- USB link for power and data
- Automated control of measurement execution



Software GUI

- User control over device functionality
- Supports multiple input configurations
- Outputs results as plots, data logs, and calculations



Mechanical Chassis

- Enclosure for dedicated hardware
- User ports: USB, power jack, LEDs
- Slider switches for individual probe control

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Non-Functional Requirements



Speedup & Automation

- Automates process to minimize user labor
- Reduces testing time by at least x5 times



Accuracy

- Maximum $\pm 5\%$ error when compared to conventional tool results



Modular & Flexible

- Individually designed systems with future upgradeability



Minimum Material Damage

- Contact method minimizes damage to thin-film samples

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Constraints



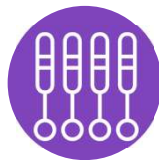
Low Power Consumption



Compatibility



Chassis Size



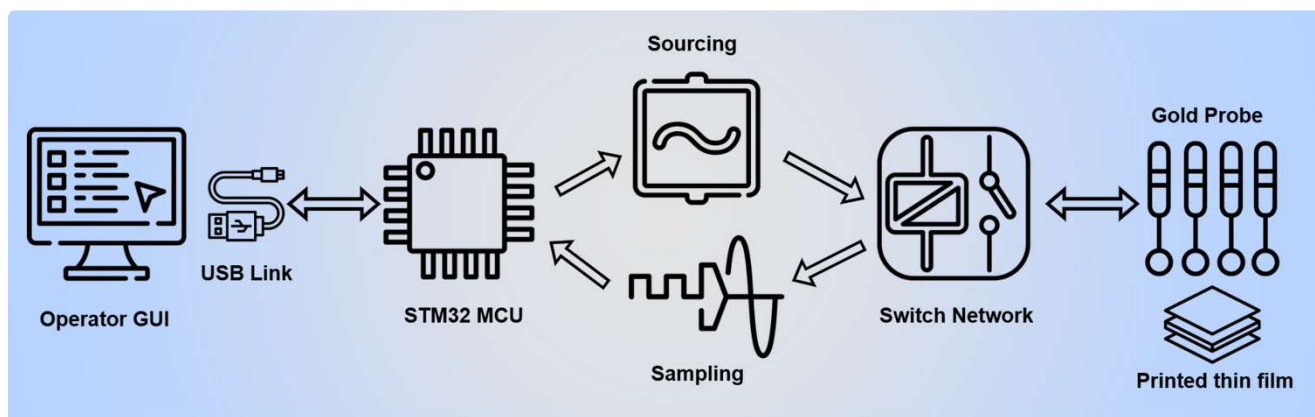
Pitch Distance of the Probes

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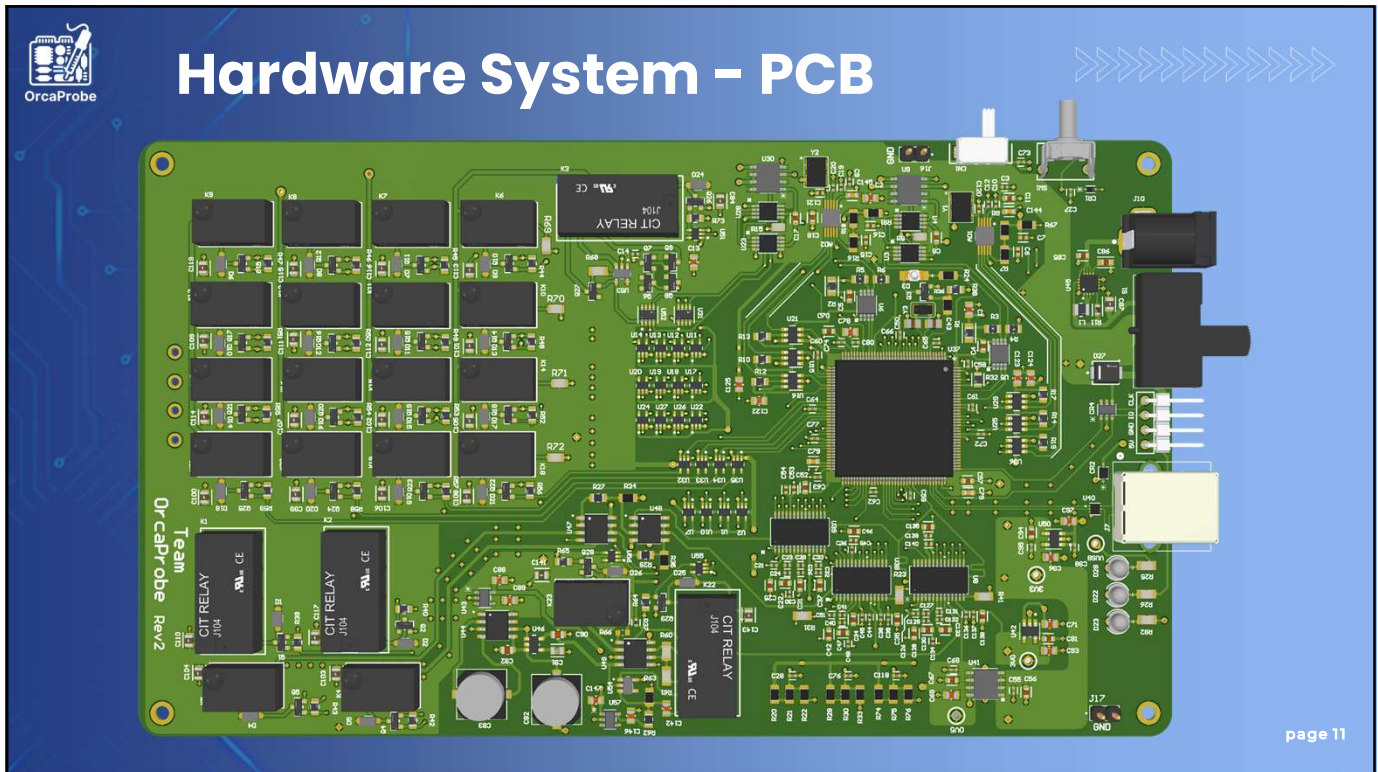


System Overview

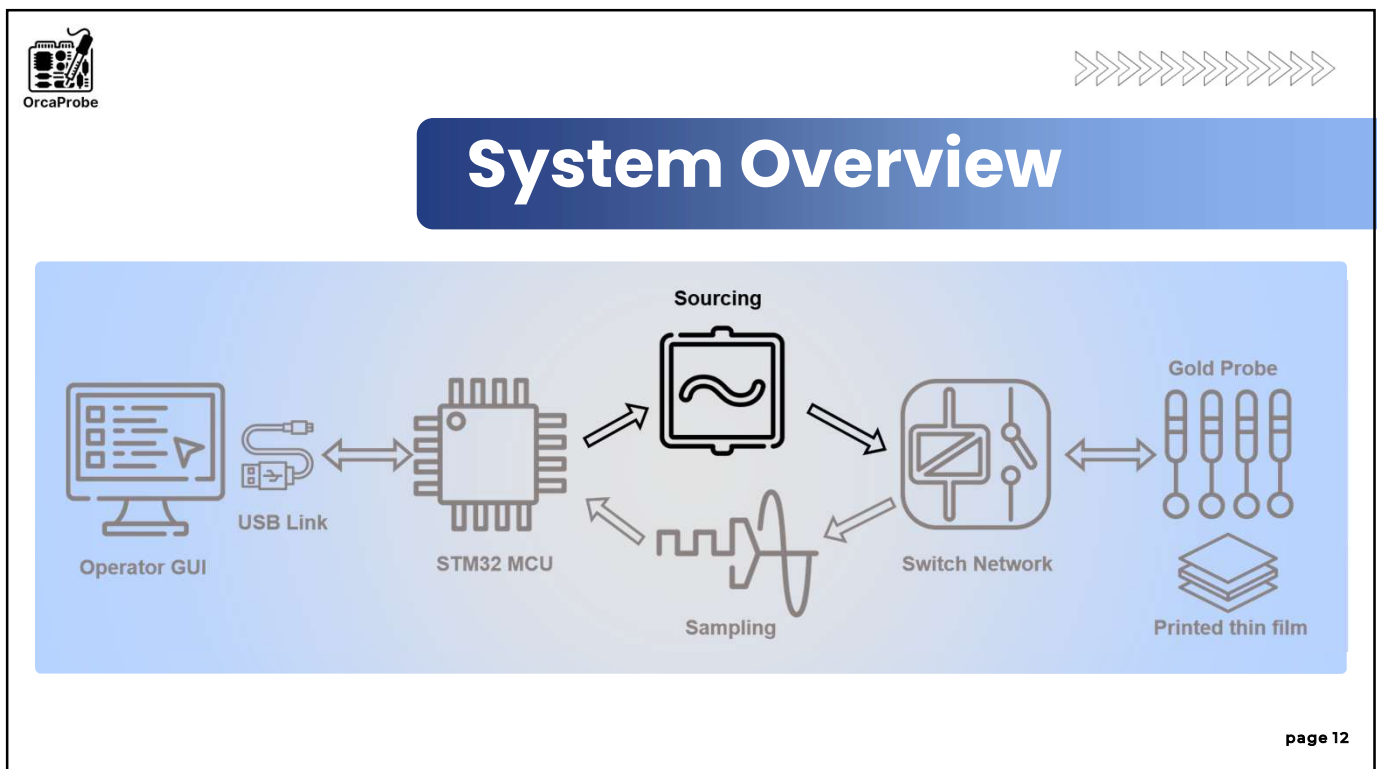


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Hardware System – Drive

Voltage Sourcing System

DDS

amplitude and offset control

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Hardware System – Drive

Current Sourcing System

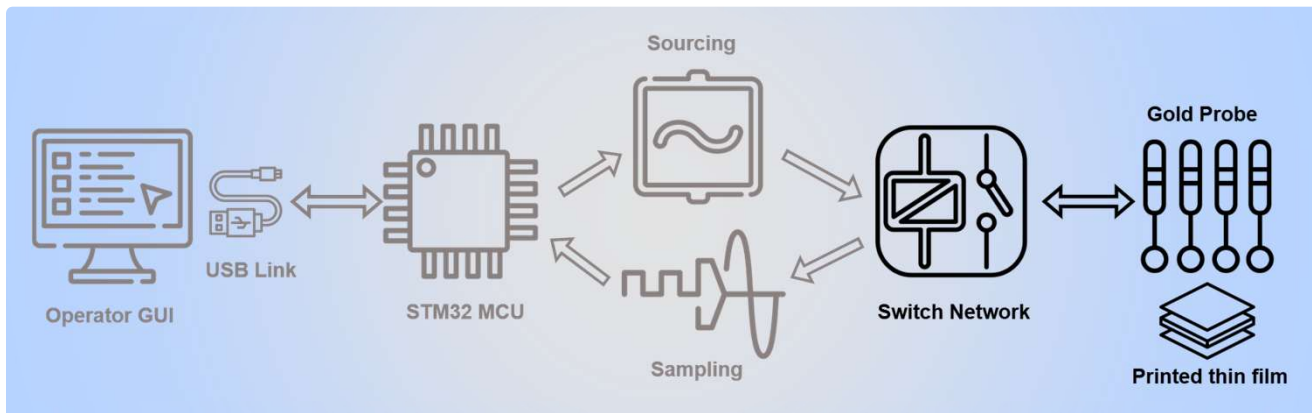
current bias control

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System Overview

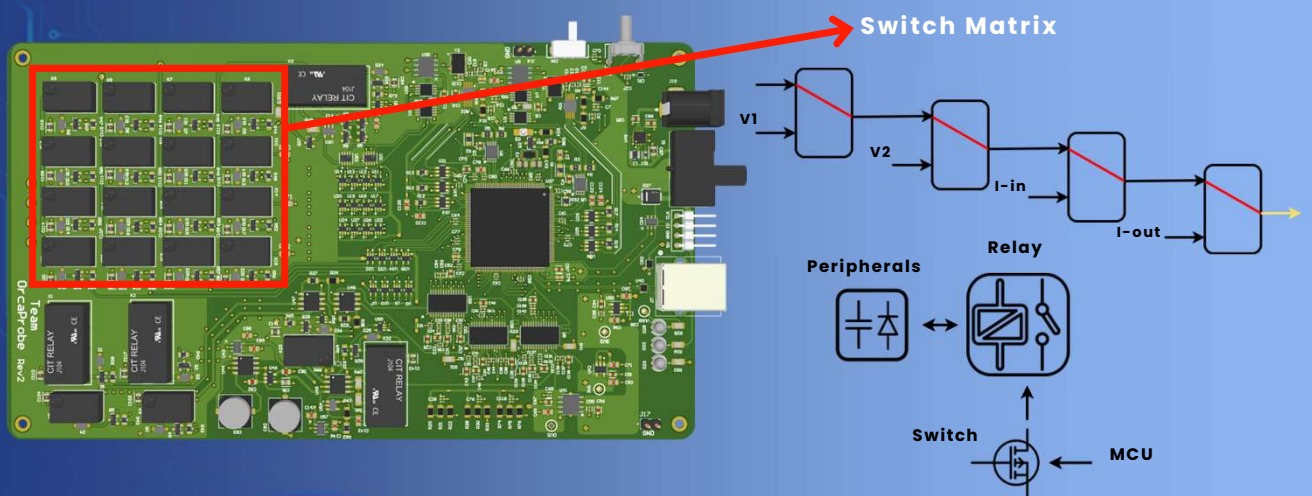


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Hardware System – Switch



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Hardware System – Switch

The block diagram on the right illustrates the signal flow. It shows four inputs labeled "Probe 1", "Probe 2", "Probe 3", and "Probe 4" entering a rectangular block labeled "ADC Selection". From this block, a single output line leads to another rectangular block, which then connects to a final output arrow. A red line is drawn across the diagram, connecting the highlighted area on the PCB to the "ADC Selection" block.

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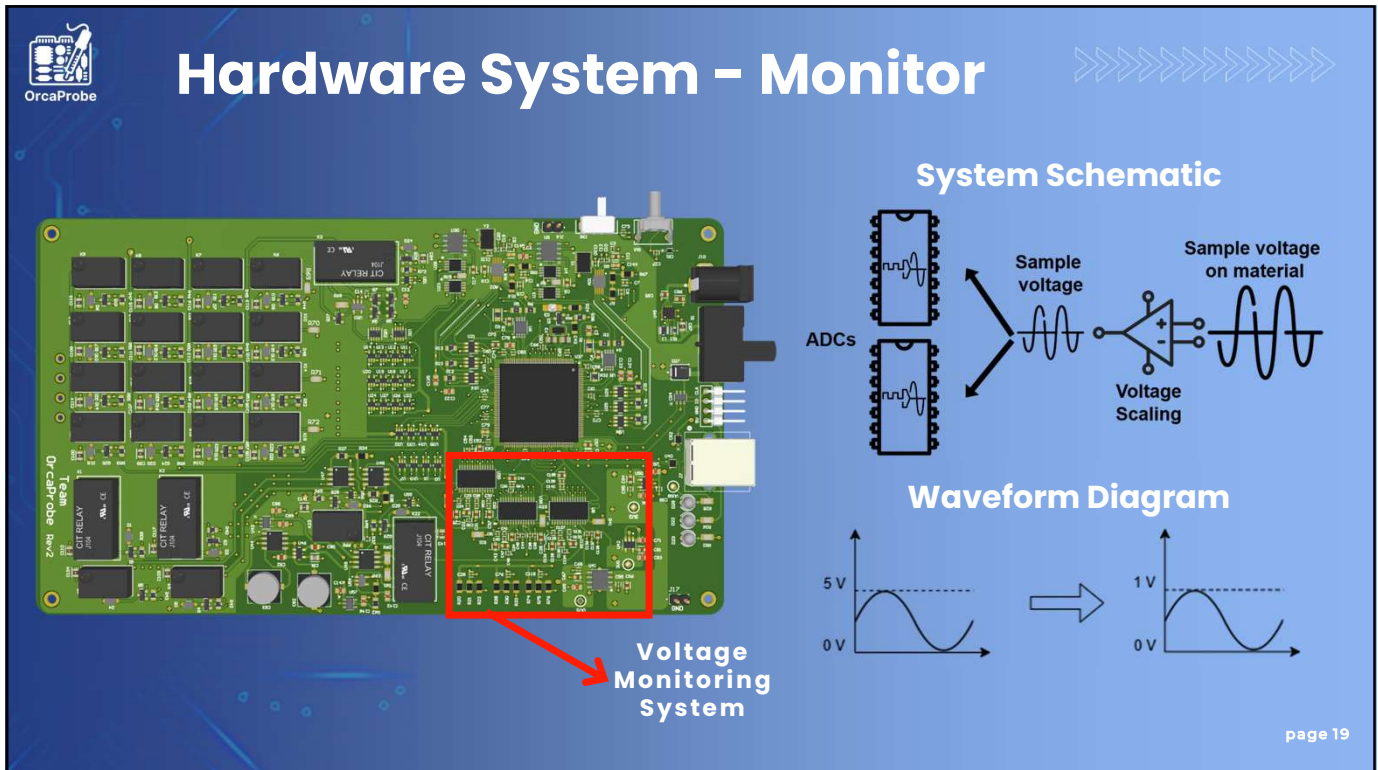
System Overview

The diagram illustrates the system architecture. It shows the following components and their interactions:

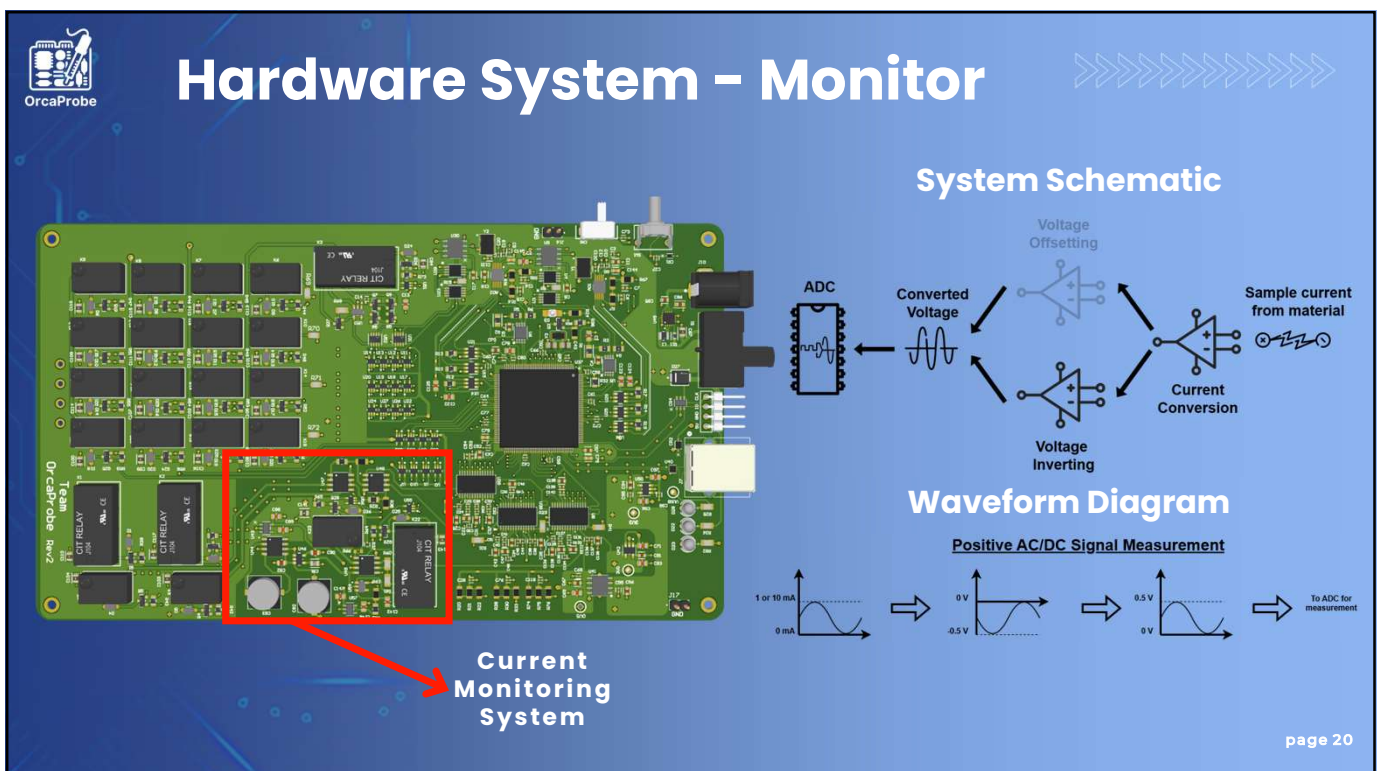
- Operator GUI**: Connected to the **STM32 MCU** via a **USB Link**.
- STM32 MCU**: The central processing unit, connected to the **Sourcing** and **Sampling** blocks.
- Sourcing**: A block representing the signal source, connected to the **STM32 MCU** and the **Switch Network**.
- Sampling**: A block representing the signal acquisition, connected to the **STM32 MCU** and the **Switch Network**.
- Switch Network**: A block representing the signal routing, connected to the **Sourcing**, **Sampling**, and **Gold Probe** blocks.
- Gold Probe**: A block representing the measurement probe, connected to the **Switch Network** and the **Printed thin film**.
- Printed thin film**: The final output of the system, connected to the **Gold Probe**.

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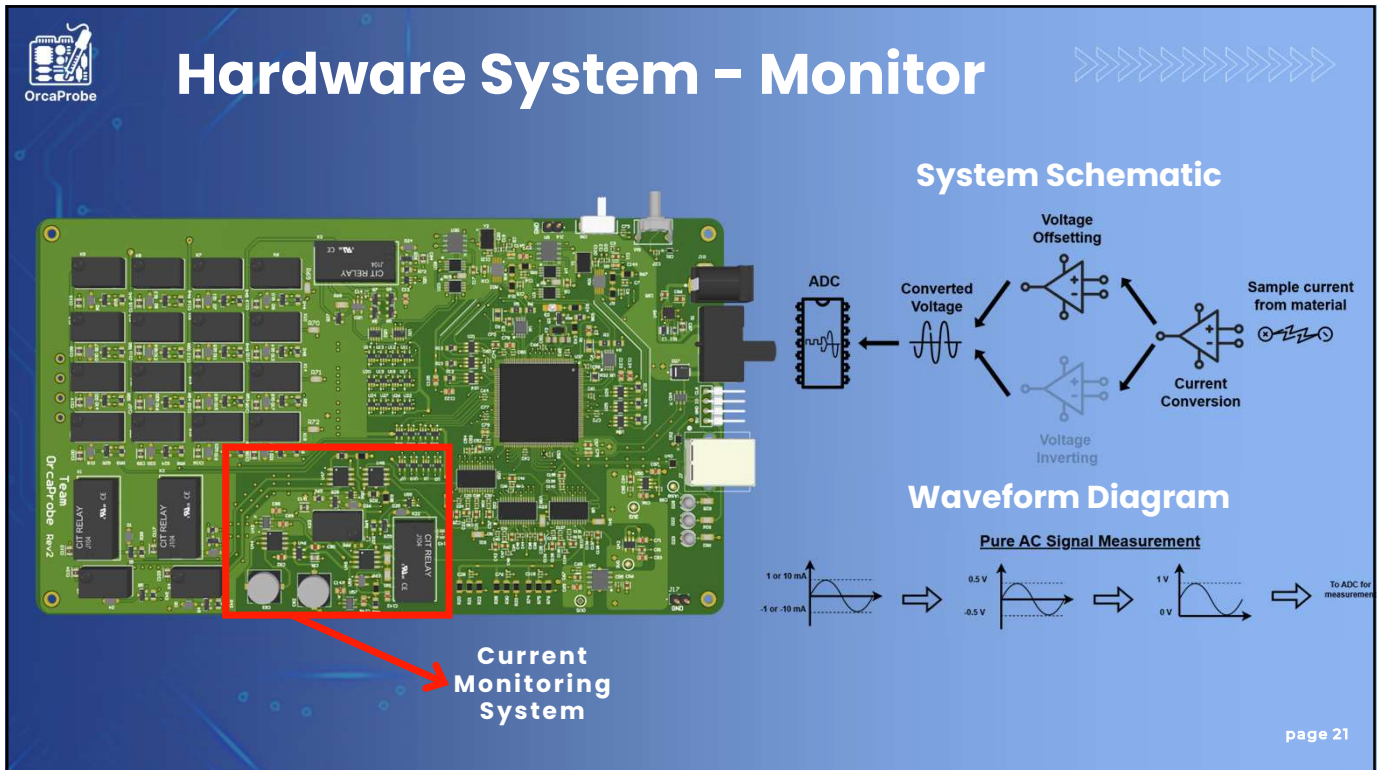
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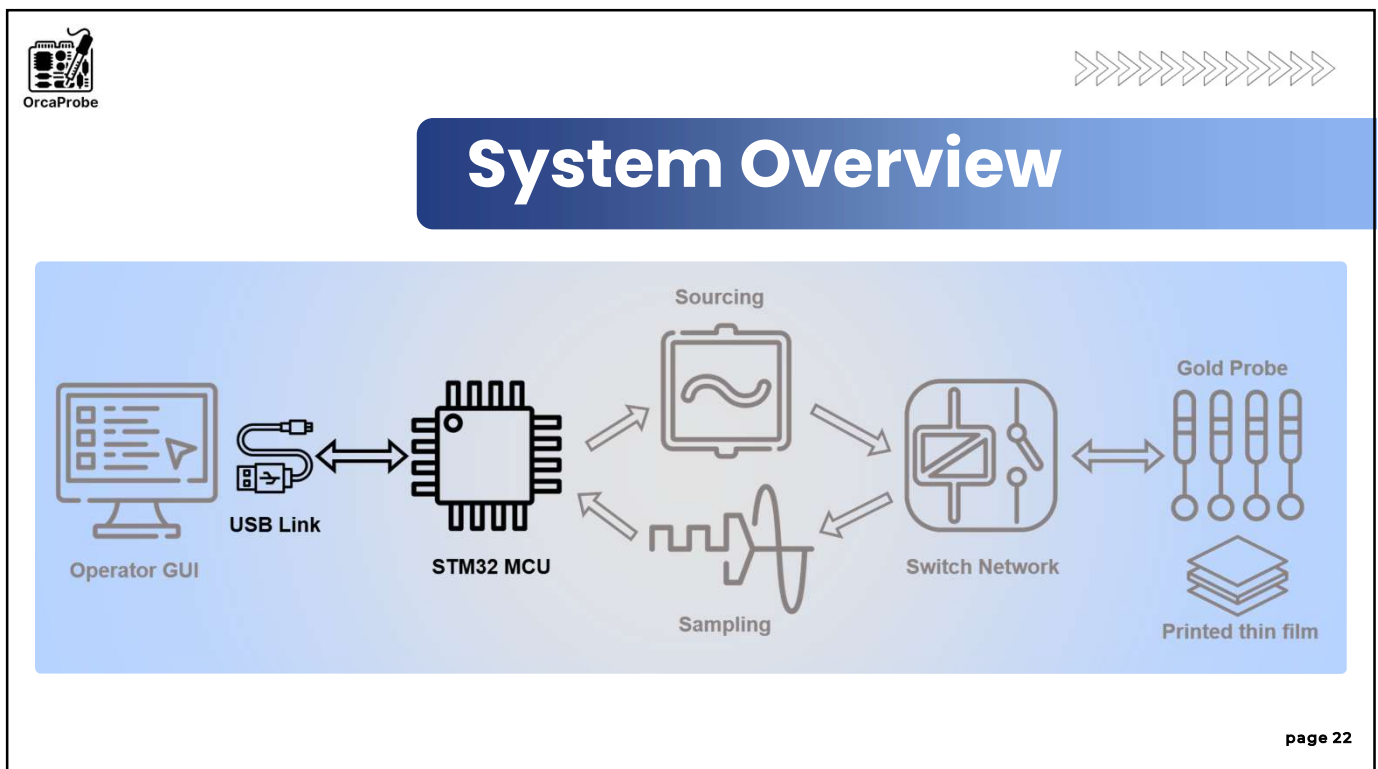
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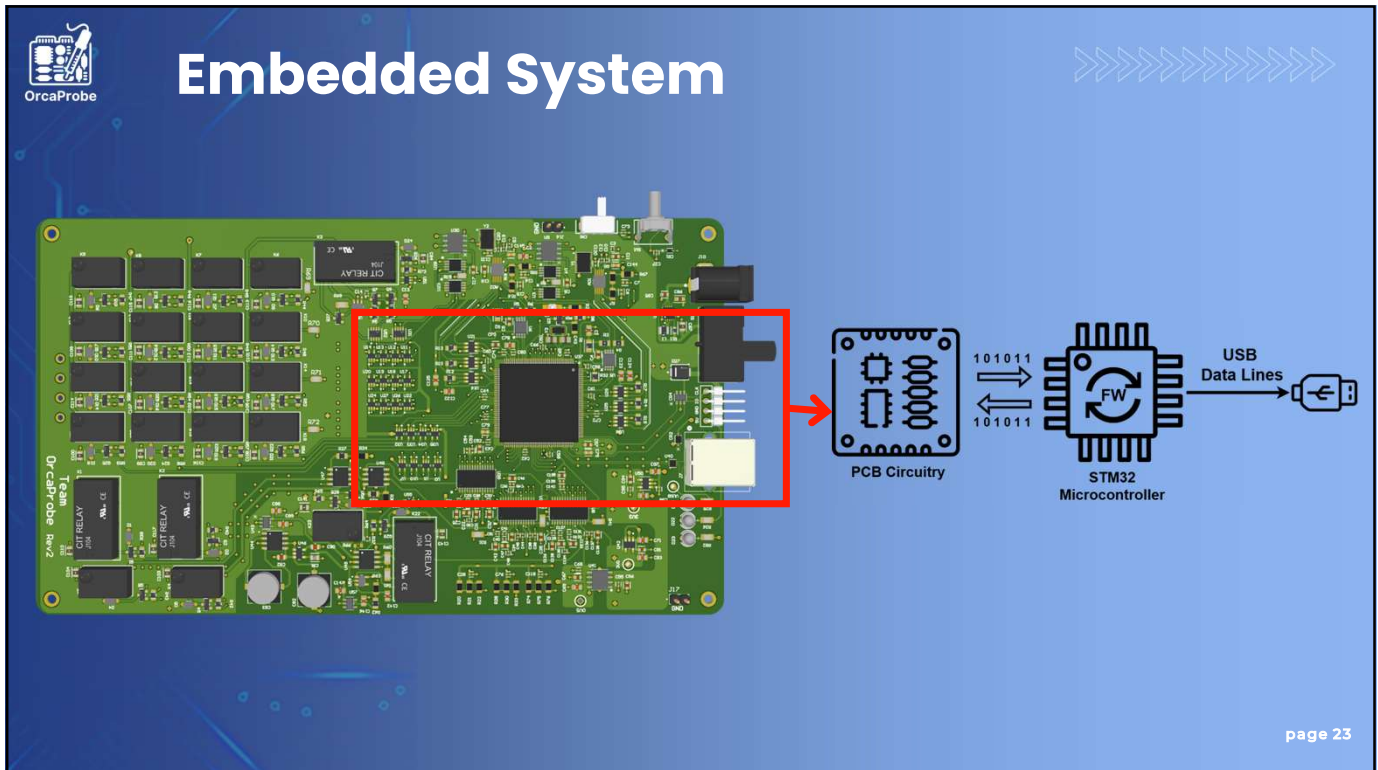
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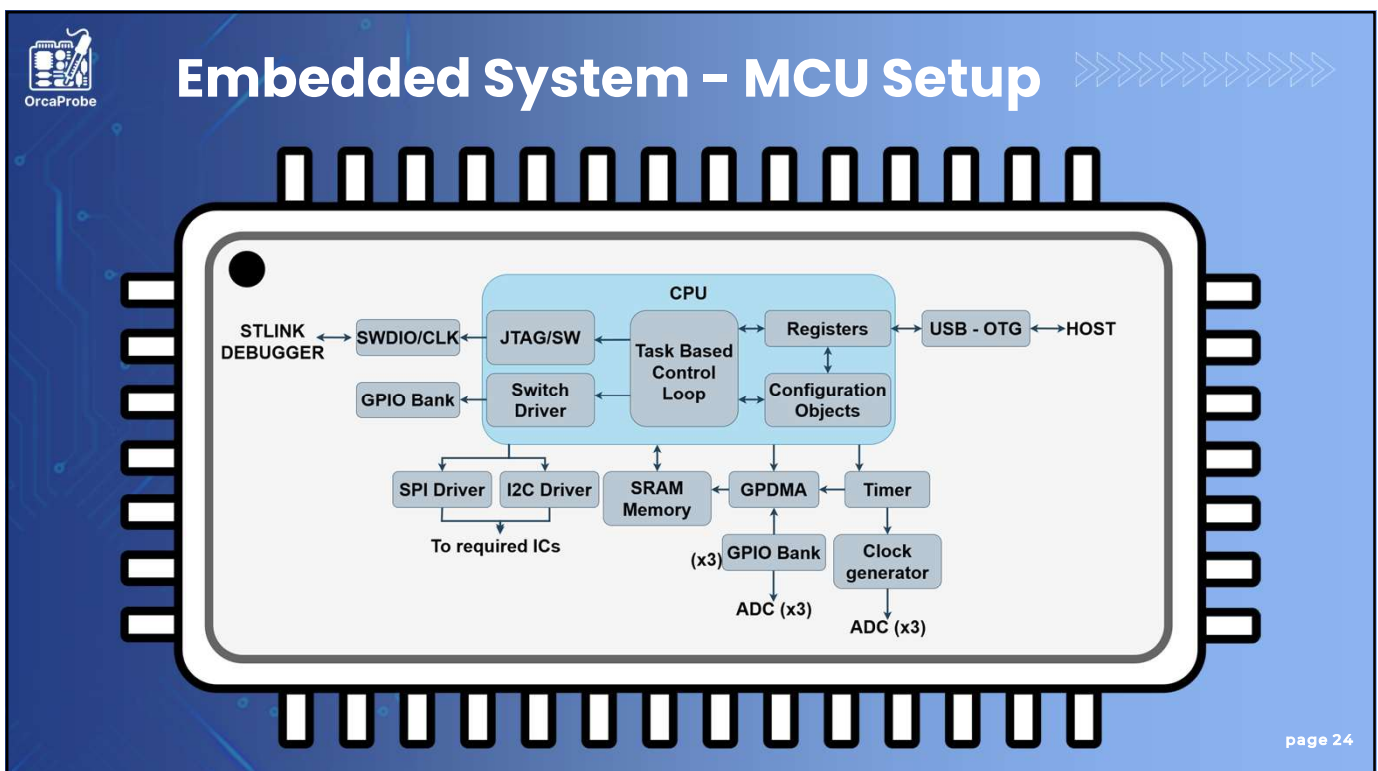
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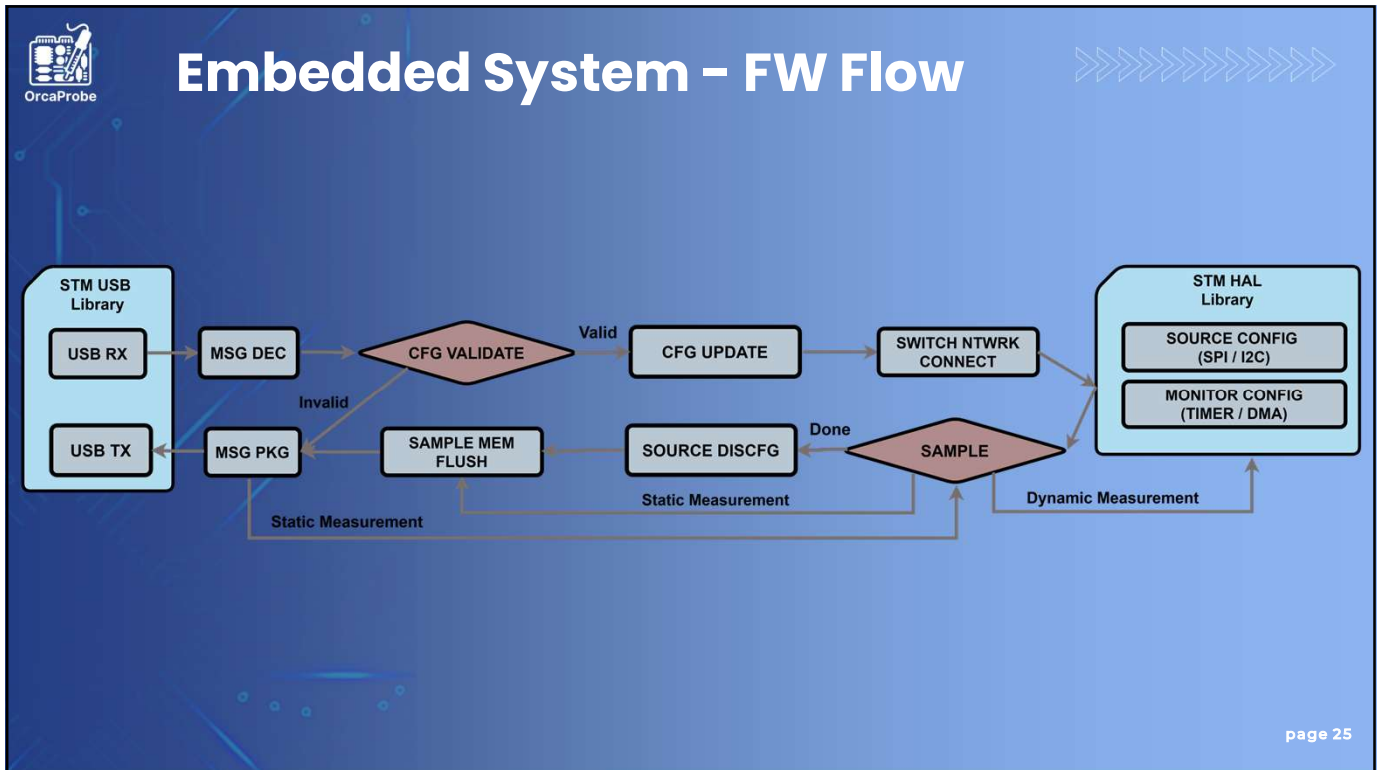
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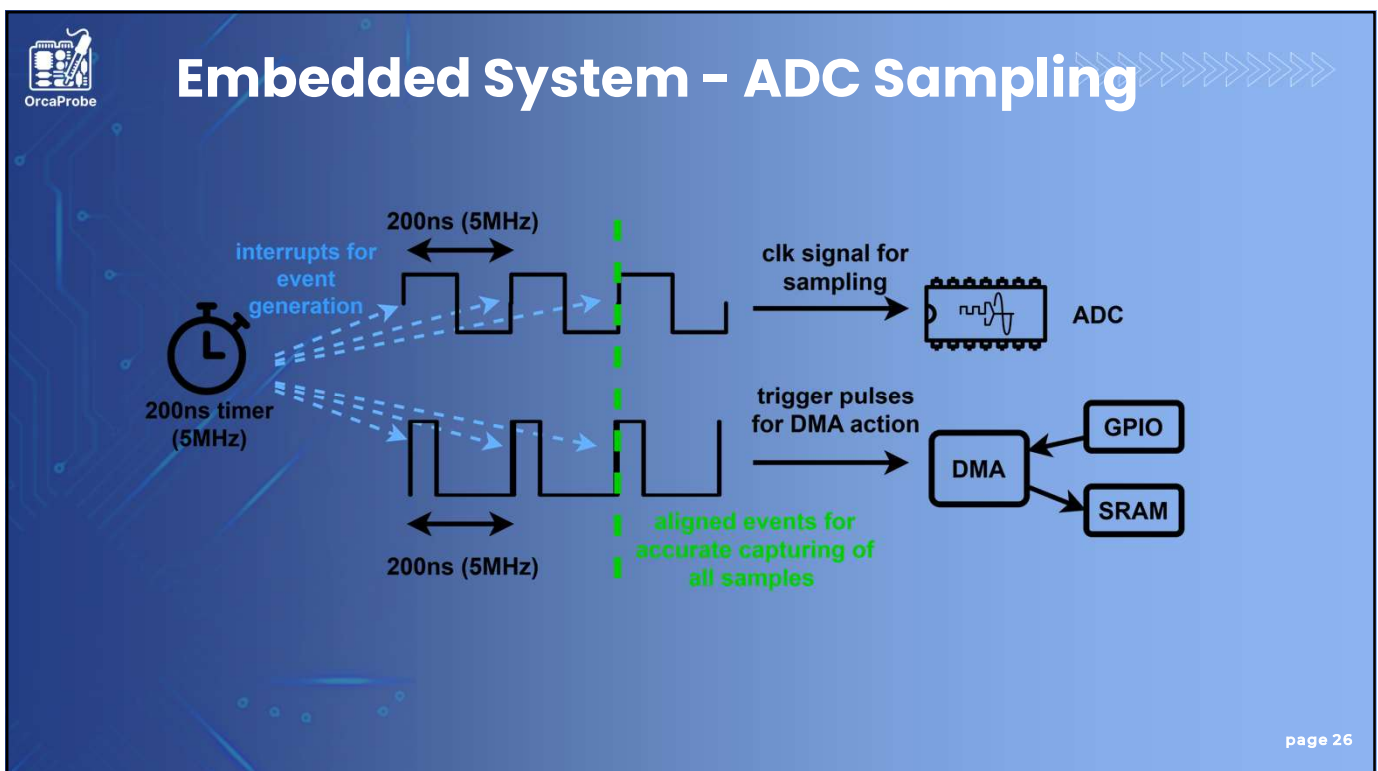
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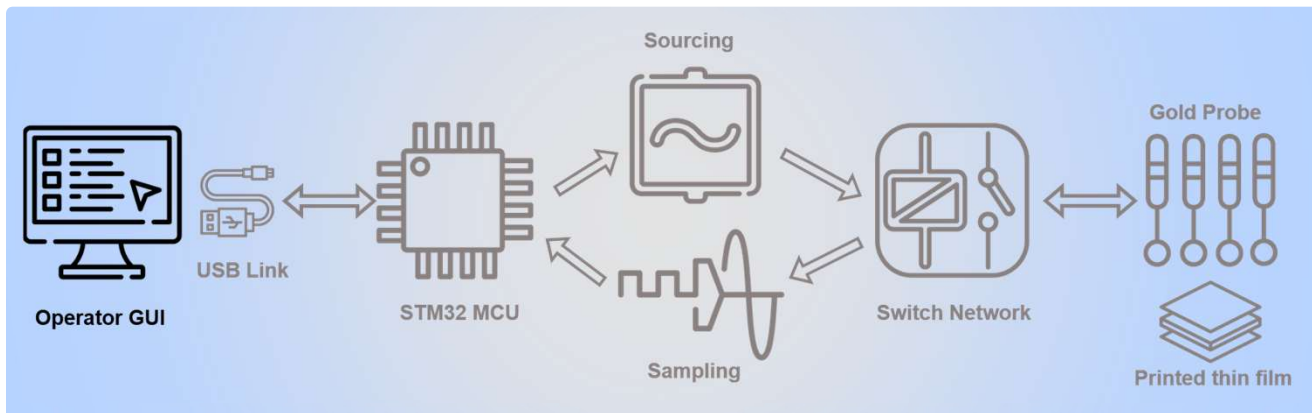
25



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System Overview

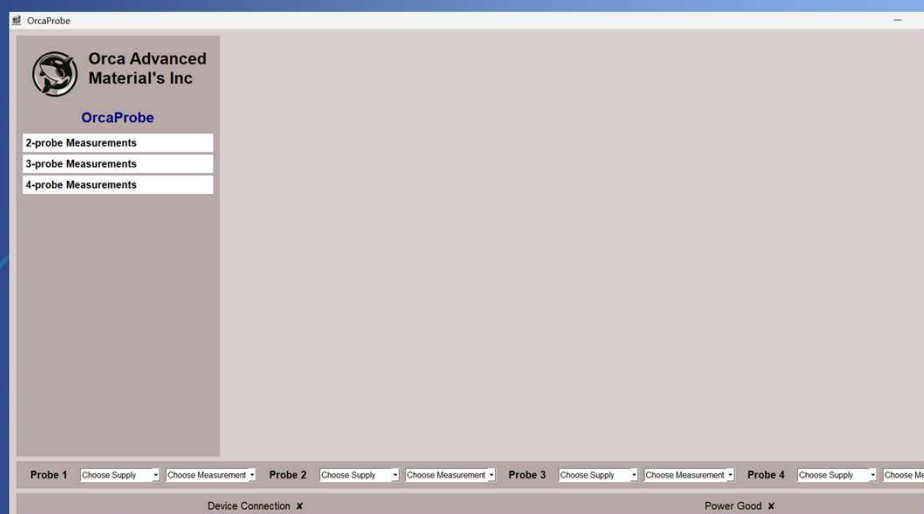


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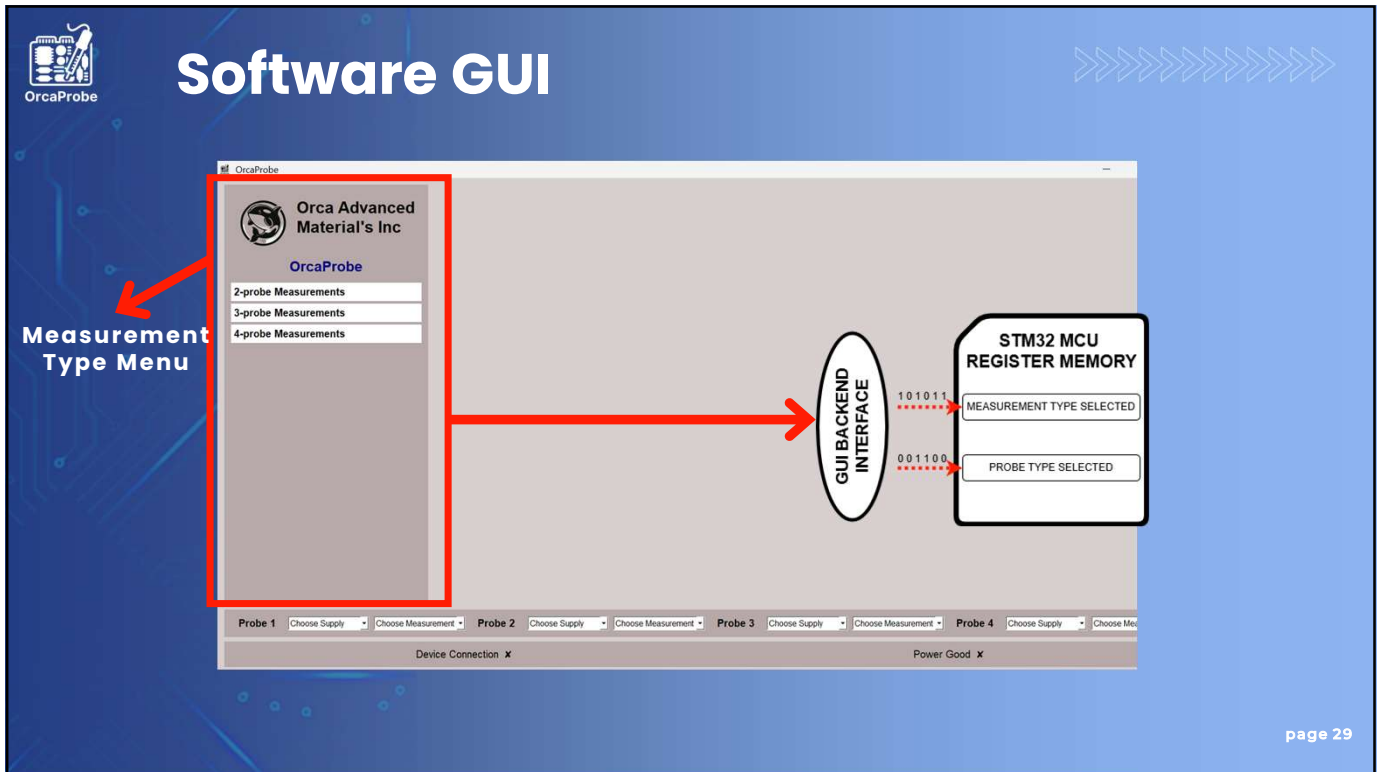


Software GUI

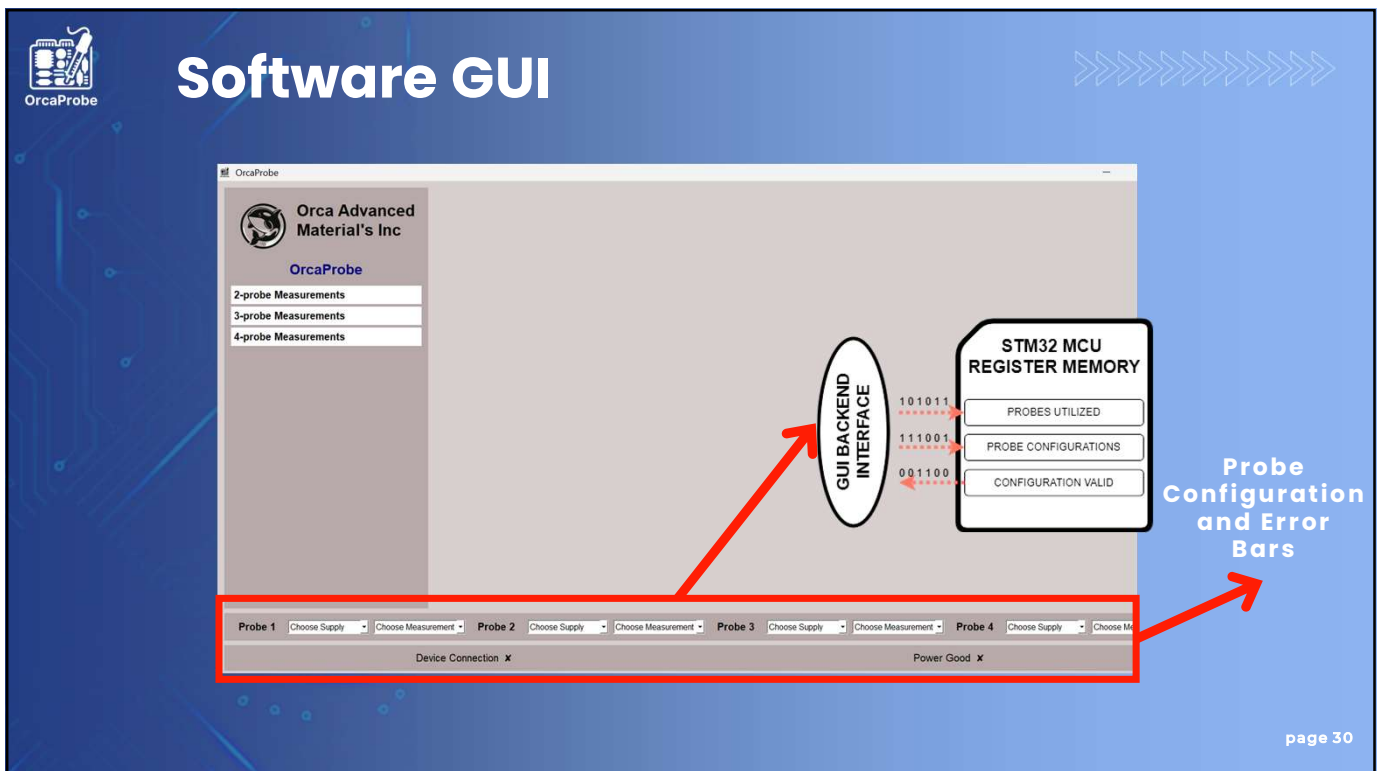


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Software GUI – Static Measurement

Orca Advanced Material's Inc
OrcaProbe

2-probe Measurements

DC Resistance

Current-Voltage

Capacitance-Voltage (2-p)

Impedance Spectroscopy (2-p)

3-probe Measurements

4-probe Measurements

DC Resistance Measurement

Log data into a .CSV file

Log data into a .JSON file

Start

Inputs

GUI BACKEND INTERFACE

STM32 MCU REGISTER MEMORY

MEASUREMENT INPUTS

MEASUREMENT RESULTS

Probe 1 Choose Supply Choose Measurement Probe 2 Choose Supply Choose Measurement Probe 3 Choose Supply Choose Measurement Probe 4 Choose Supply Choose Measurement

Device Connection x Power Good x

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Software GUI – Dynamic Measurement

Orca Advanced Material's Inc
OrcaProbe

2-probe Measurements

DC Resistance

Current-Voltage

Capacitance-Voltage (2-p)

Impedance Spectroscopy (2-p)

3-probe Measurements

4-probe Measurements

Capacitance-Voltage Measurement (2-probe)

Log data into a .CSV file

Log data into a .JSON file

Starting AC Offset Voltage (V)

Enter value

Ending AC Offset Voltage (V)

Enter value

Increment AC Offset Voltage (V)

Enter value

Start Measurement

Inputs

GUI BACKEND INTERFACE

STM32 MCU REGISTER MEMORY

MEASUREMENT INPUTS

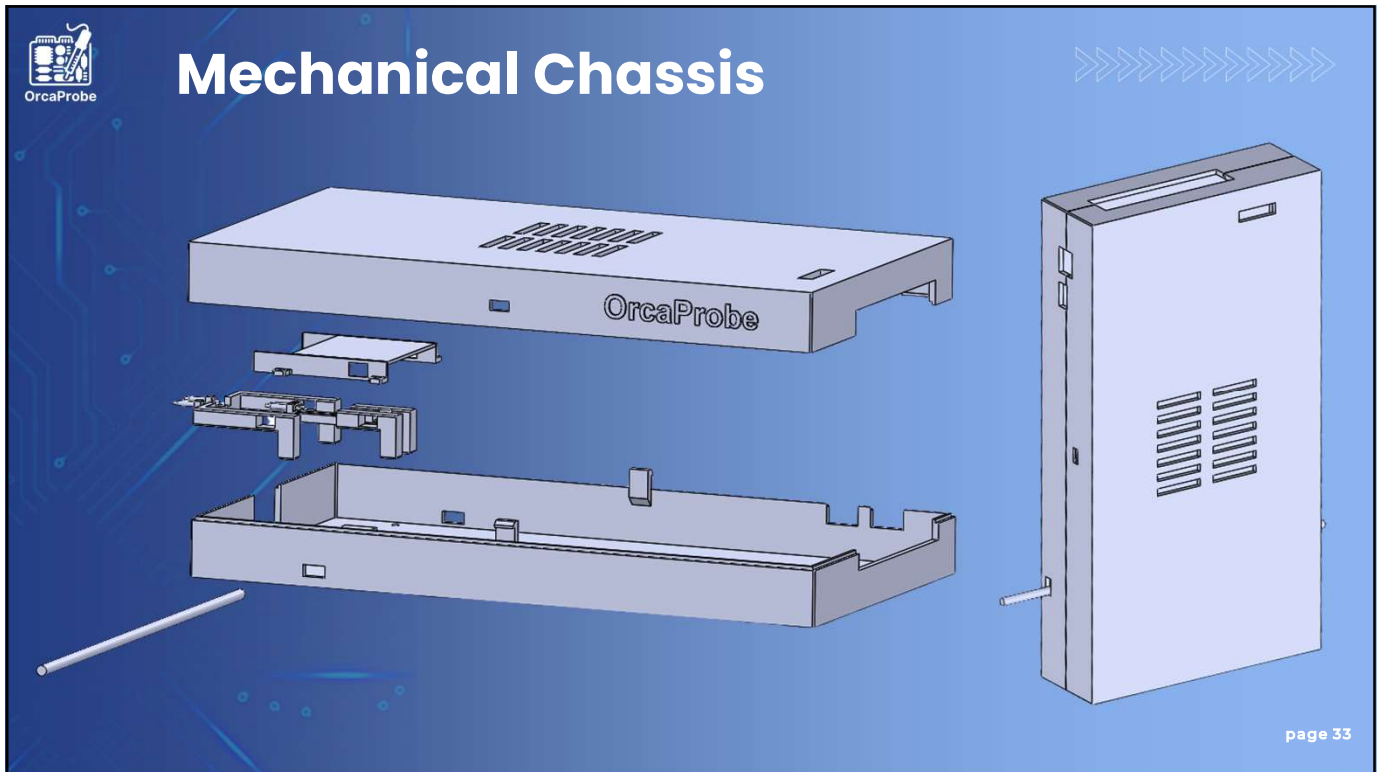
MEASUREMENT RESULTS

Probe 1 Choose Supply Choose Measurement Probe 2 Choose Supply Choose Measurement Probe 3 Choose Supply Choose Measurement Probe 4 Choose Supply Choose Measurement

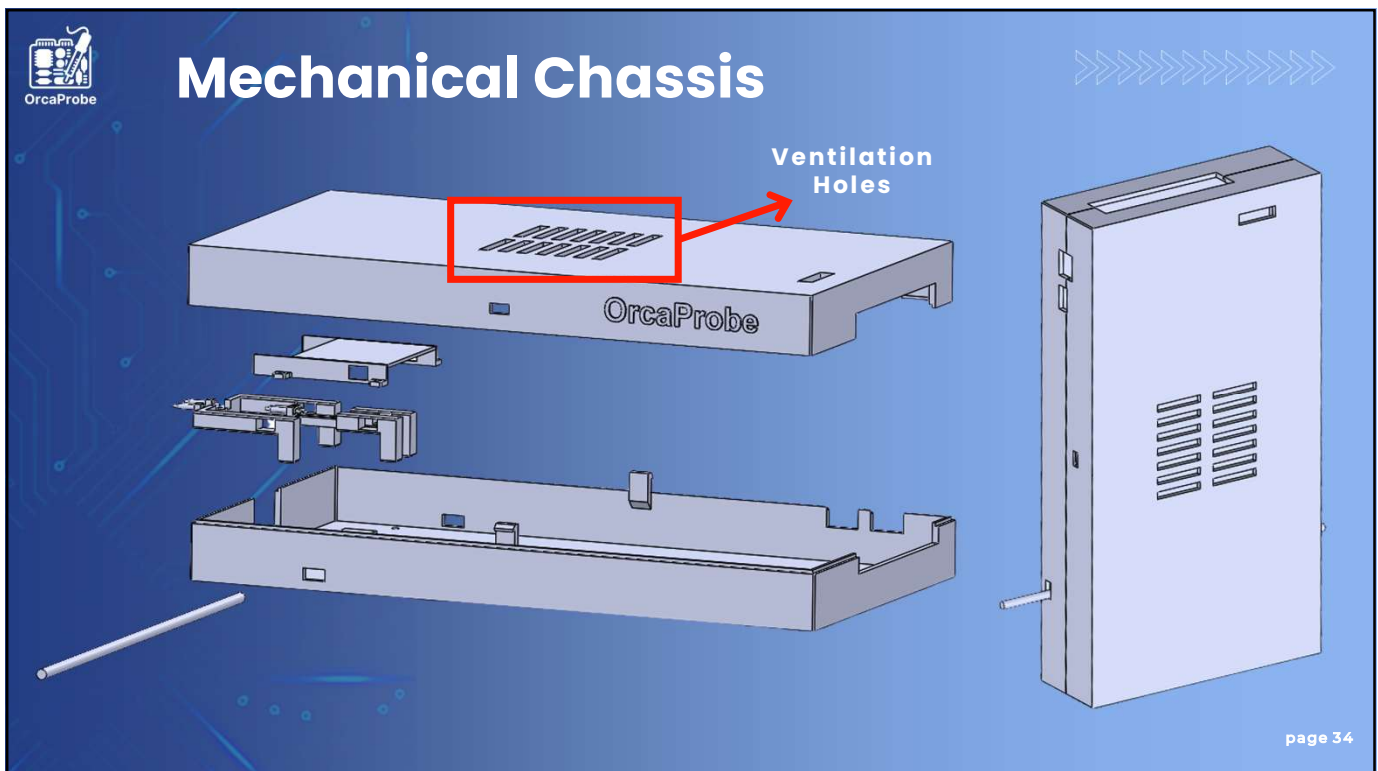
Device Connection x Power Good x

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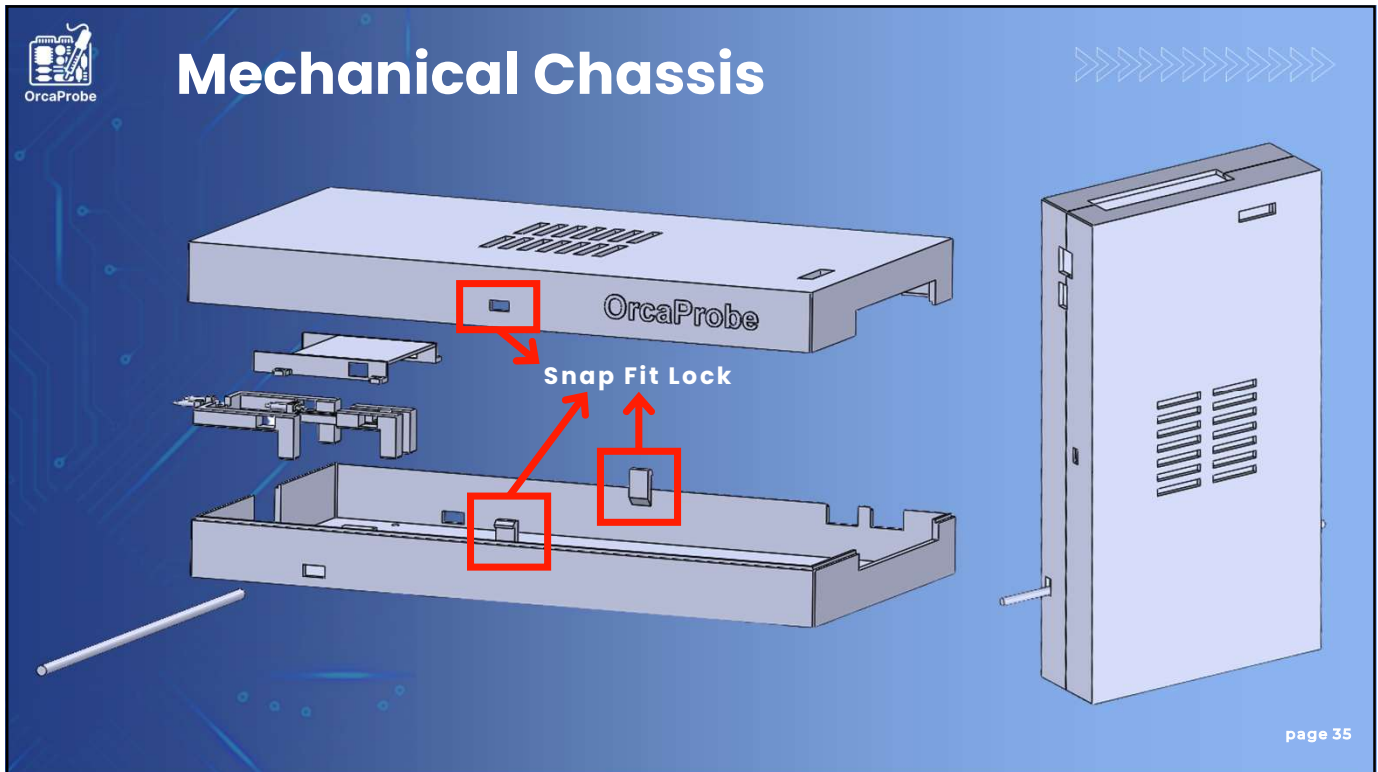
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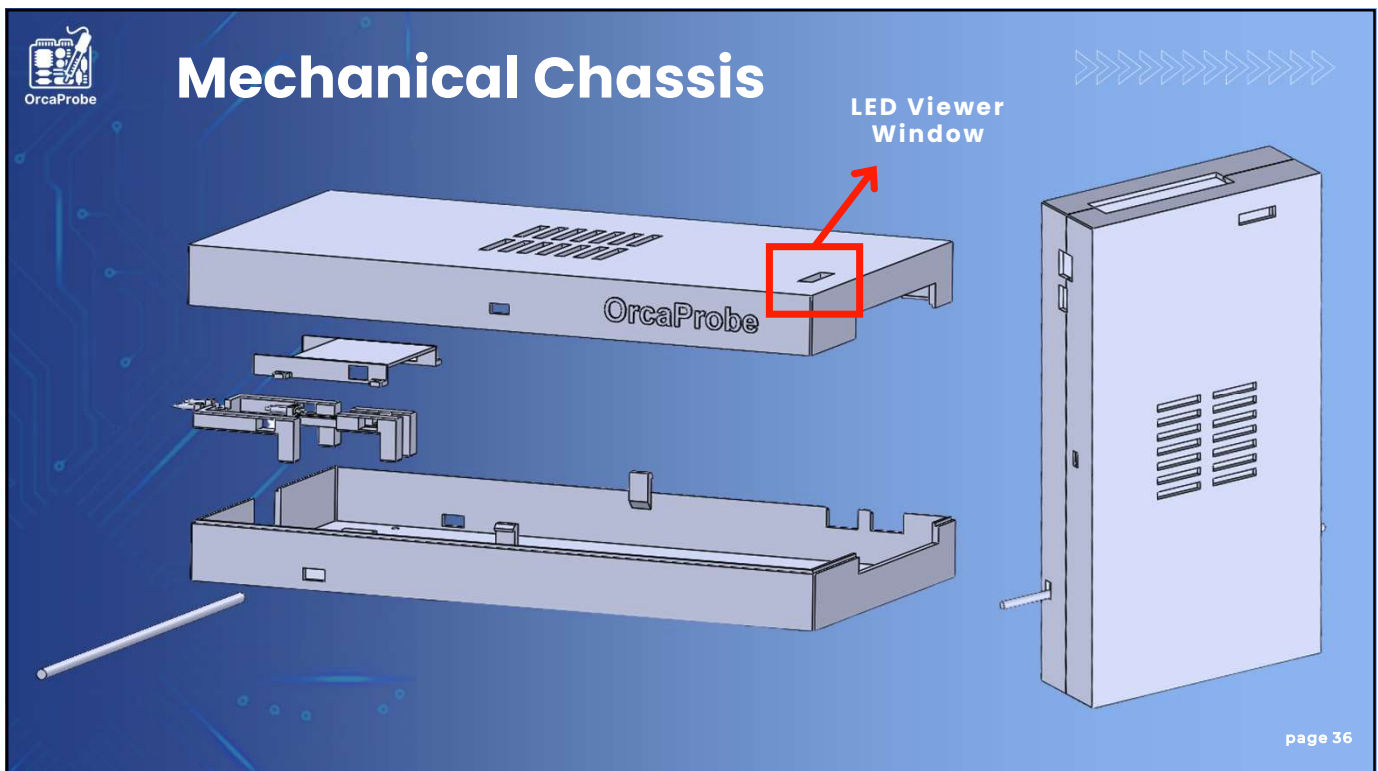
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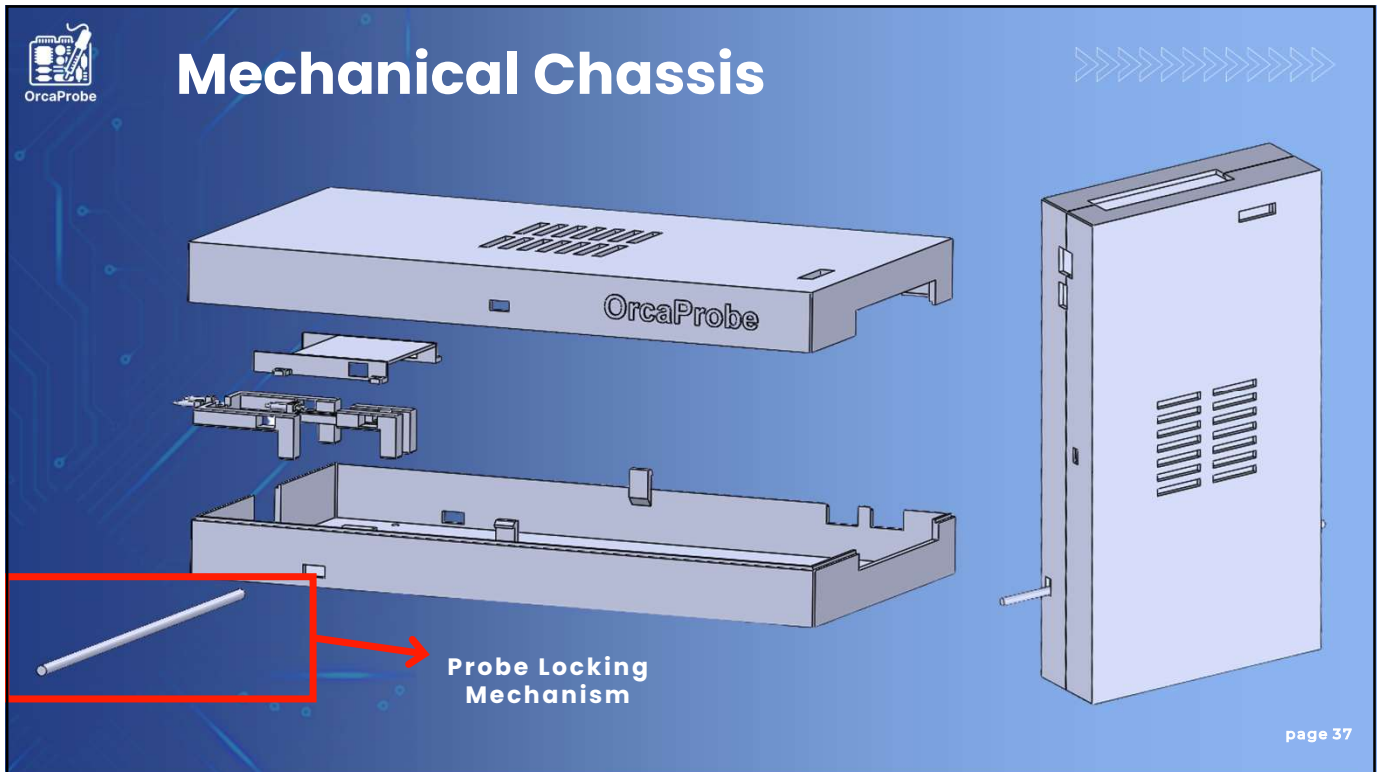
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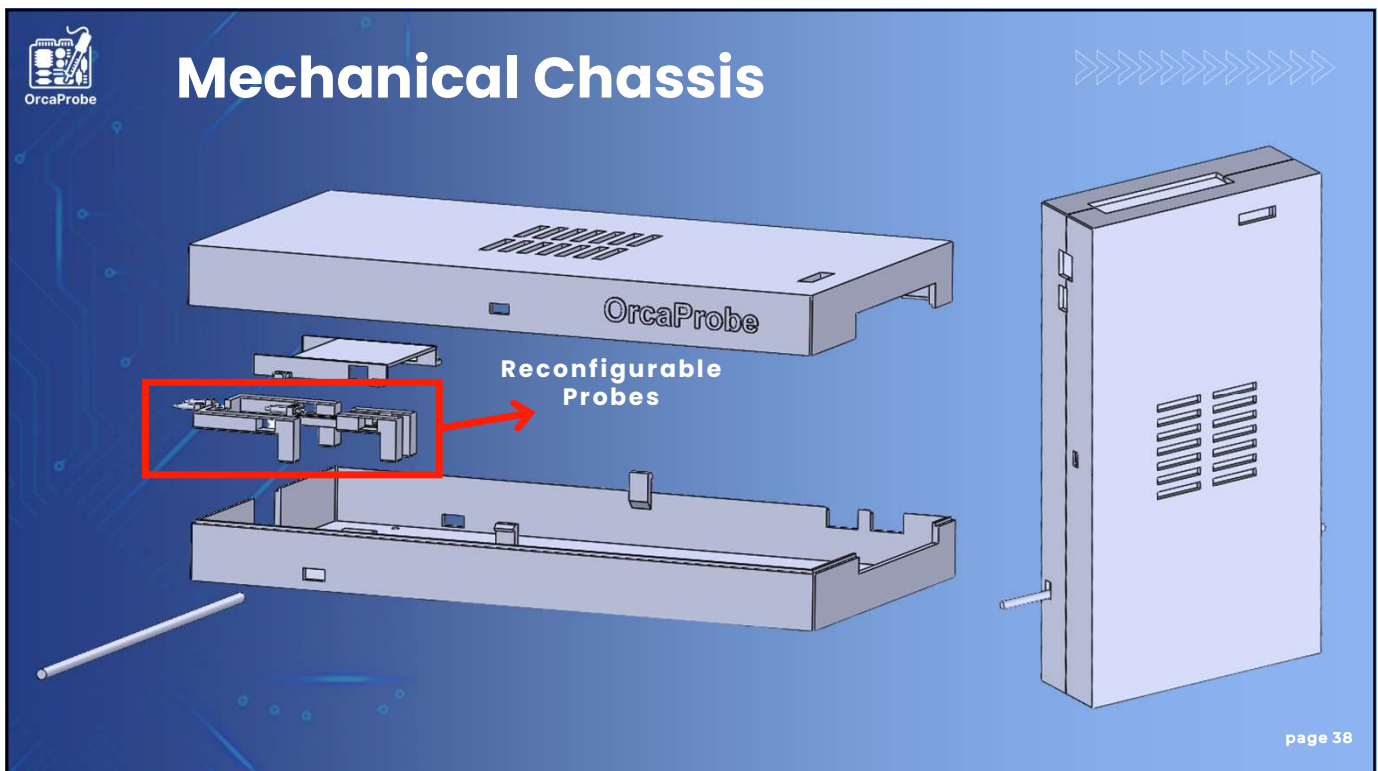
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Mechanical Chassis



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Verification Test Results

Test Category	Pass	Incomplete	Fail
Basic PCB Functionality	3	0	0
Probe Sourcing	6	0	0
Probe Monitoring	4	0	0
Probe Switching	1	0	0
Embedded System	6	0	0
Software GUI	8	0	0
Device-to-Host Communication	4	0	0
Mechanical Chassis	5	0	0
End-to-End Measurements	9	1	1
Total	46	1	1

- Discrete components were used for quick testing cycles.
- Some end-to-end measurements are performed on the client's thin-film samples.

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Validation Test Results

Material & Test Category	Pass	Incomplete	Fail
Carbon Nanotube Resistors			
Measurement Accuracy	3	0	0
Device Reconfigurability	3	0	0
Process Speedup	3	0	0
Polymer Capacitors			
Measurement Accuracy	3	0	0
Device Reconfigurability	3	0	0
Process Speedup	3	0	0
Carbon Nanotube Transistors			
Measurement Accuracy	2	0	1
Device Reconfigurability	2	0	1
Process Speedup	3	0	0
Total	25	0	2

- **Limitations:**
 - Resistor samples degraded over time
 - Low transistor yield made most samples unusable

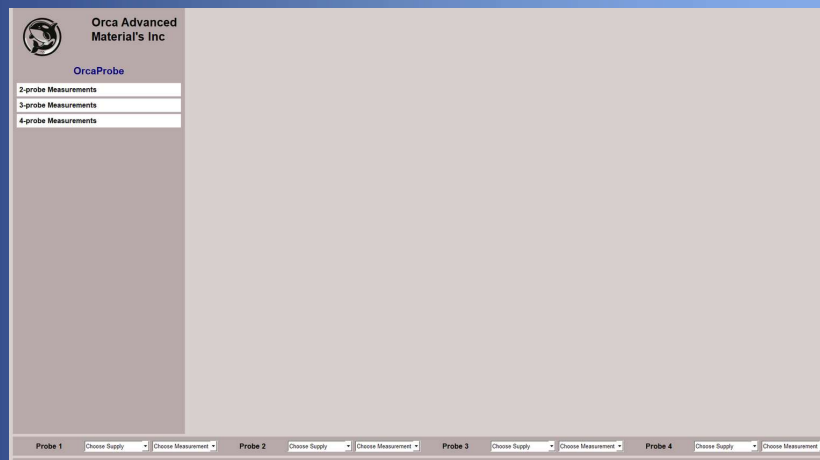
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Product Demo

1. Connect the device and launch the GUI




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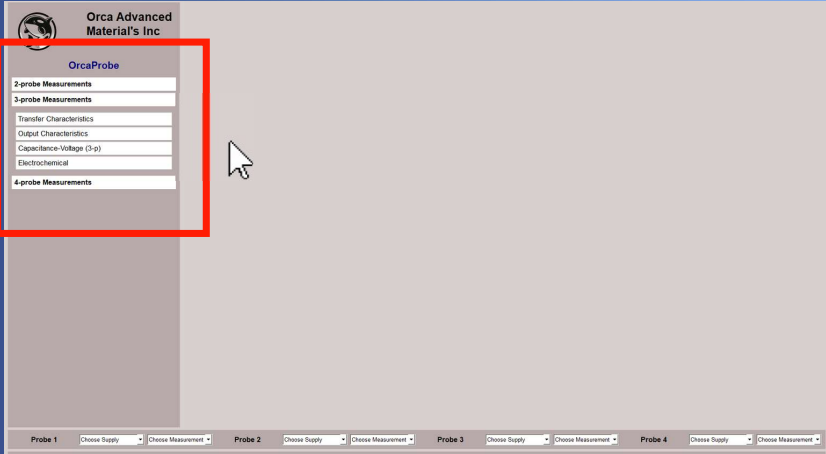
42



Product Demo




2. Select a measurement category from the left menu




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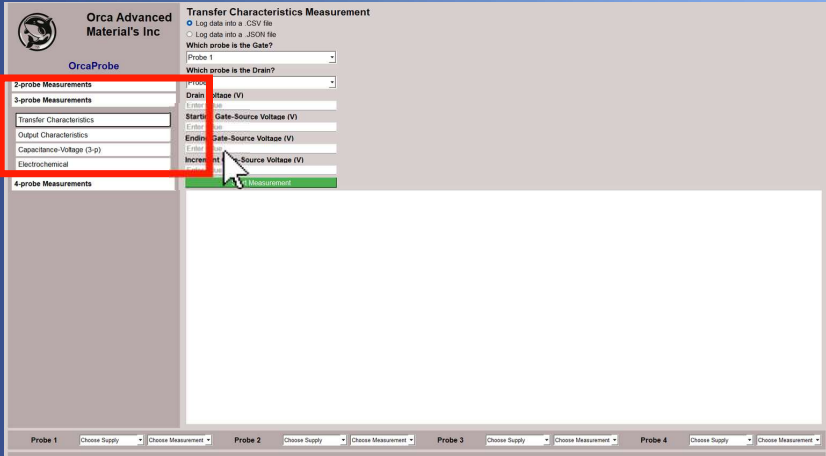
43



Product Demo




3. Choose the desired measurement type




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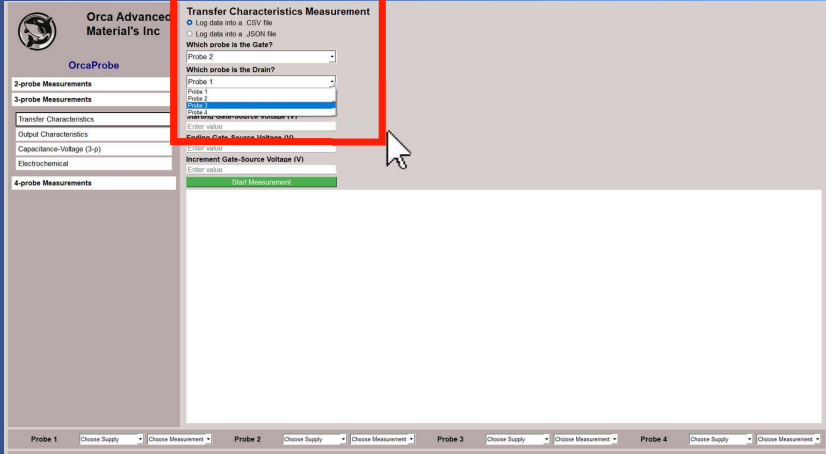
44



Product Demo




4. Enter initial settings




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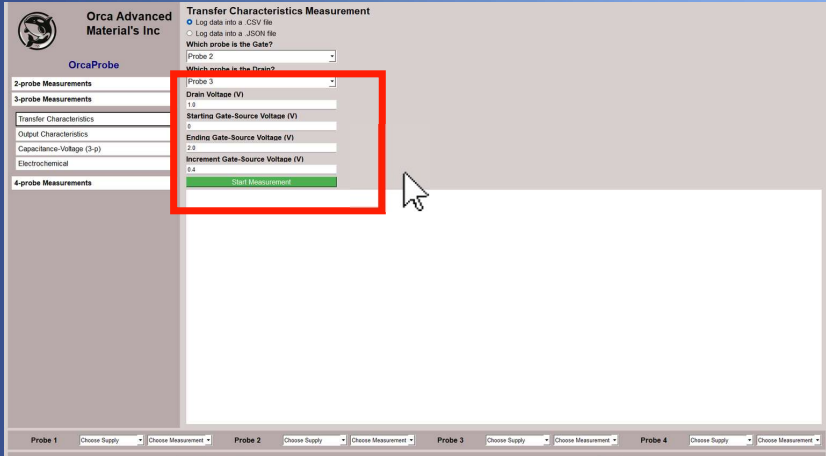
45



Product Demo




5. Input numerical parameters




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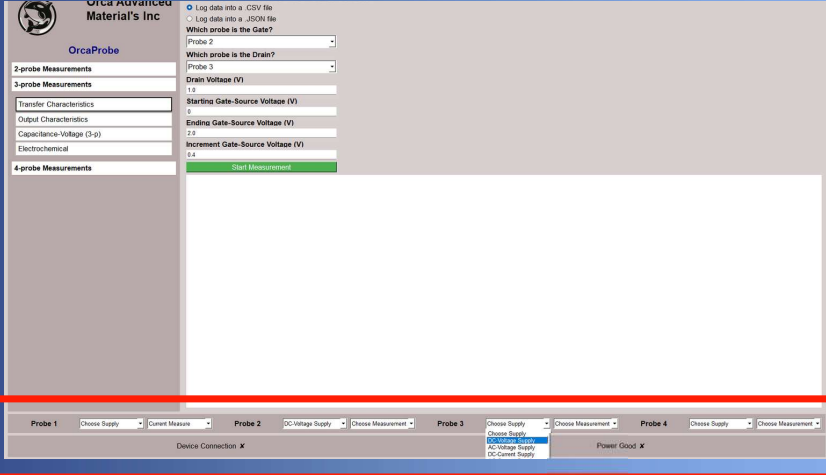
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Product Demo




6. Select the required probe configuration




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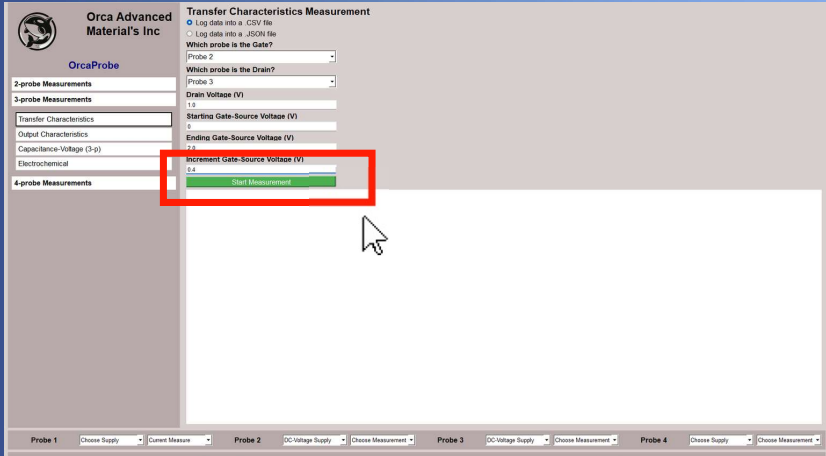
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Product Demo



7. Start the measurement



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Product Demo



8. Observe the results



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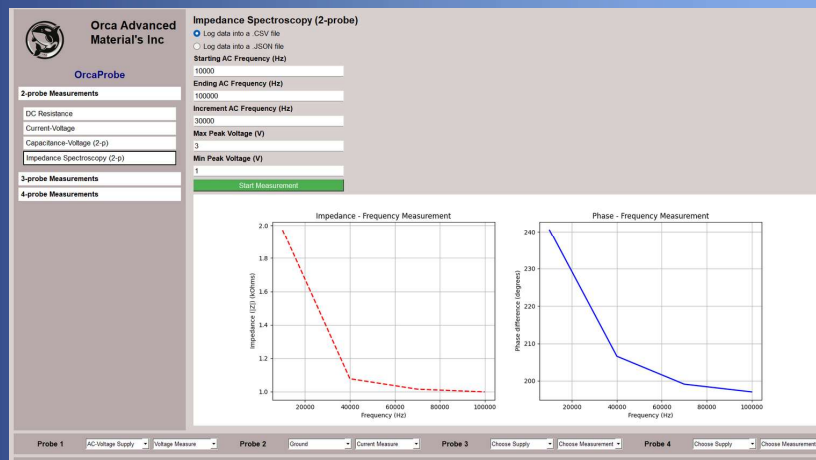
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Example Measurement 1



Impedance Spectroscopy



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The screenshot displays the OrcaProbe software interface for a Capacitance-Voltage Measurement (2-probe). The interface is divided into several sections:

- Top Bar:** Shows the OrcaProbe logo and the title "Orca Advanced Material's Inc".
- Left Panel:** Contains a navigation menu with options: "2-probe Measurements", "DC Resistance", "Current-Voltage", "Capacitance-Voltage (2-p)", "Impedance Spectroscopy (2-p)", "3-probe Measurements", "Transfer Characteristics", "Output Characteristics", "Capacitance-Voltage (3-p)", "Electrochemical", "4-probe Measurements", "Probe Resistance", "Low-Resistance", and "Impedance Spectroscopy (4-p)".
- Main Panel:**
 - Configuration:**
 - Log data into a CSV file (selected)
 - Log data into a JSON file
 - Starting AC Offset Voltage (V): 1.0
 - Ending AC Offset Voltage (V): 3.0
 - Increment AC Offset Voltage (V): 0.5
 - Start Measurement button
 - Graph:**
 - Title: Capacitance - Voltage Measurement
 - Y-axis: Capacitance (pF), ranging from 99.9 to 100.4.
 - X-axis: Voltage offset level (V), ranging from 1.00 to 3.00.
 - Data Series: A red dashed line representing the measured capacitance. The capacitance starts at approximately 100.01 pF at 1.00 V, decreases to a minimum of about 99.96 pF at 1.50 V, then increases to about 100.04 pF at 2.00 V, remains relatively flat until 2.50 V, and finally increases to about 100.35 pF at 3.00 V.
- Bottom Panel:** Contains four tabs for different measurement types: "Probe 1" (AC Voltage Supply), "Probe 2" (Ground), "Probe 3" (Choose Supply), and "Probe 4" (Choose Supply). Each tab has a "Choose Measurement" button.

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A red circular icon containing a white browser window graphic with the text "Error 404" inside.

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Impact on Client

- Saves money and time
- Test automation
- Streamlined R&D cycles
- Freedom to alter as needed

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OrcaProbe

Thank you! Any Questions?

Team JY-85

Aaron Loh, Dipak Shrestha, Idil Bil, Kerem Oktay, Peggy Yuan



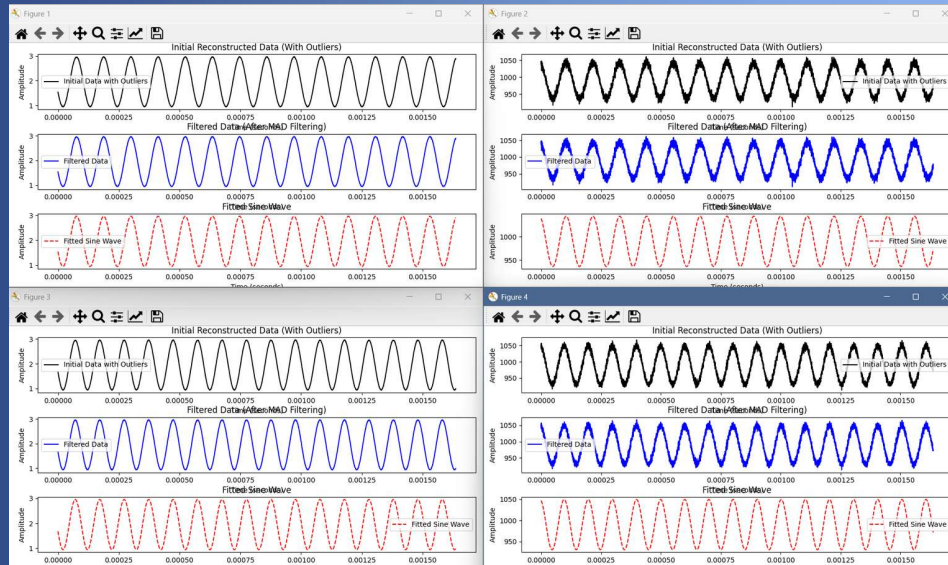
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Appendix A



Signal Reconstruction in the Software



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Appendix B



Cost Breakdown

DATE	DESCRIPTION	CATEGORY	AMOUNT
2024-Oct-28	Waveform generator dev board	Component	\$ 21.27
2024-Nov-04	Breadboard prototyping	Component	\$ 25.15
2024-Nov-12	Breadboard prototyping	Component	\$ 82.36
2024-Nov-18	Breadboard prototyping	Component	\$ 82.93
2024-Nov-25	Breadboard prototyping	Component	\$ 75.07
2024-Dec-11	Breadboard prototyping	Component	\$ 64.02
2025-Jan-22	Mechanical component	Mechanical	\$ 11.19
2025-Jan-28	Breadboard prototyping	Component	\$ 83.62
2025-Feb-03	Breadboard prototyping	Component	\$ 32.84
2025-Feb-19	PCB Rev1 Components	Component	\$ 119.55
2025-Feb-22	Customs Clearance Fee	PCB_customs_clearance	\$ 59.25
2025-Feb-22	PCB Rev1	PCB circuit board	\$ 392.50
2025-Mar-25	PCB Rev2	PCB circuit board	\$ 97.65
2025-Mar-26	PCB Rev2 Components	Component	\$ 88.85
Total			\$ 1,236.25

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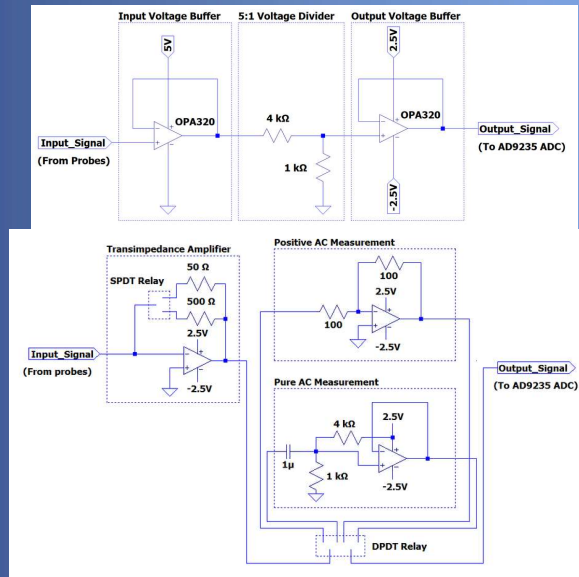
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Appendix C



Monitoring System Schematics



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Appendix D



MCU Alternatives

Part Number	Freq	Pin Count	Capabilities	Cost
CMOD ST FPGA	234 MHz max	48	FPGA - custom logic design Softcore MicroBlaze proc Dedicated DSP blocks x80 Dedicated mem blocks 1620kb 4MB flash external with QSPI	1455
STM32 Nucleo board	depends on series low-power ones go upto 160MHz high-perf ones go upto 250MHz	64-144	ARM arch. processor on chip flash and sram (depends on package) dedicated peripherals for common protocols on certain arm proc. dedicated cores for DSP	at most 50\$ for the highest end device can be as low as 15\$ for an opt. device
PIC32	usually around 120 MHz some parts go upto 300MHz	64-144	ARM arch. processor on chip flash and sram (depends on package) dedicated peripherals for common protocols on certain arm proc. dedicated cores for DSP	30\$-250\$ for eval boards
dsPIC	usually around 200MHz	28-64	dedicated to DSP applications on chip ADC with 40Mbs/s lower on chip storage	~30\$ for eval boards

MCU - STM32		FPGA - Xilinx/AMD Artix/Spartan 7	
Pros	Cons	Pros	Cons
Easier to dev	sequential events	parallel control / processing	pin count (for our case)
existing libraries	pin current capabilities for relays	existing IPs	expensive
USB OTG	processing overhead	custom interface design chance	probably limited to eval board
Broad range of parts	difficult to control lots of stuff	more test methods via testbench	need extra stuff for USB comm
High pin count		hardware more robust than sw	power hungry
Low power		no processing overhead	softcore proc (still pretty good)
easier h/w design		processor only handle mem r/w	need for AXI implementation
hardcore processor ARM		control lots of stuff	less on chip mem
easier improvements later on		timing "perfect"	no need for custom HW
high on-chip mem space		no learning curve for our team	
cheaper			

MCU Options				
Series/Part	Freq	Power	Features	Cost
STM32U5A5	160MHz	26uA/MHz	2MB flash 786kB RAM	CAS\$50.00
STM32U575	160MHz	26uA/MHz	2MB flash 786kB RAM	CAS\$35.00
STM32H5	250MHz	80uA/MHz	2MB flash 640kB RAM	CAS\$40.00
STM32F4	180MHz	90uA/MHz	varies a lot from pkg tp pkg	CAS\$20.00
STM32F7	216MHz	80uA/MHz	varies a lot from pkg tp pkg	CAS\$35.00
STM32G4	170MHz	80uA/MHz	512kB flash 128kB RAM	CAS\$20.00

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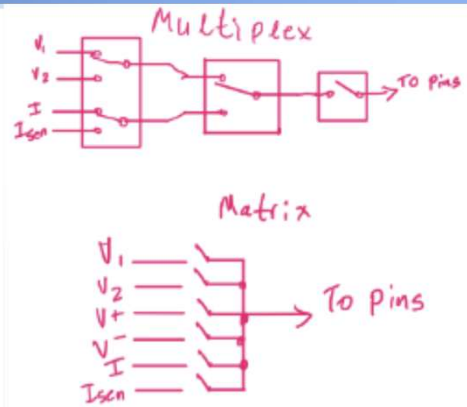


Appendix E



Relay Alternatives

	Matrix	Hybrid	Tree
	SPST	SPDT/DPDT	SPDT/DPDT/SPST
Cost	\$39.93	\$37.51	\$34.97
Relay Number	25	21	17
Max Power Consumption (mW)	1000	750	1350
Min Power Consumption (mW)	800	600	900
Power Reduction Capability	1/2	1/3	1/3
Relay Path Number (avg)	1.5	3	3.5
Area (cm ²)	50	21.81	22.31
Robustness	High	High	Low
Control Complexity	Low	Medium	High



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