

Supplementary Information

Development and Validation of an Optical Sensor-Based Automated Urine Flow Meter for Real-Time Patient Monitoring

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Table S1. Current Automated UO Monitoring Devices.

Device (Company)	Technology/Sensing Method	Key Features & Resolution	Status/Validation
kUO Plus [26] (Fize Medical)	Proprietary in-line sensing; incremental volume detection.	Microliter-level resolution; continuous flow-rate calculation; alarm notifications.	Commercial; minimizes user dependence and positioning errors.
Urinfo 2000 [27] (FlowSense/Baxter)	Custom infrared drop detector; dual-chamber system for precise droplet formation.	Measures volumes >1 mL; interfaces with ICU systems.	Commercial; validated against manual measurement using a cylinder reference.
ClarityRMS [18,32] (RenalSense)	Thermal method; measures temperature change from thermal energy pulses.	Cost-effective; accurate even at low volumes.	Commercial; validated in clinical trials (cardiac surgery patients) using weight measurement as the gold standard.
Accuryn (Potrero Medical) [31]	Active drainage (controlled low vacuum); fused sensors (pressure, acoustic/ultrasound).	Measures UO rate, intra-abdominal pressure (IAP), and core temperature in real-time.	FDA-approved; undergoing large-scale clinical studies (Accuryn Registry).
Sentinel (Serenno Medical)[20]	Proprietary in-line sensing module.	Continuous real-time measurement; alerts for early kidney dysfunction detection; 96% accuracy demonstrated in initial trials.	In development/clinical trials.
Otero Prototype [17]	Capacitive sensor in a 90 mL container; magnetic stopper for periodic drainage.	Minute-by-minute measurements; Bluetooth data transmission.	Laboratory testing only.
Art Medical [35]	Droplet counting; uses a photosensor and fast-gated camera for individual drop volume estimation.	Software calculates flow rate based on estimated volume and timing.	Patented, prototype stage.
Piyapema Prototype [34]	Drop generator; NTC thermistor sensing in a drip chamber.	Low-cost disposable sensor; Raspberry Pi control; IoT connectivity for cloud data storage.	Prototype stage.
Padilla Prototype [33]	Two infrared reflective sensors along the drain tube; measures travel time.	Measures UO volume and turbidity; uses an Arduino microcontroller.	Laboratory testing only (urinary system model).

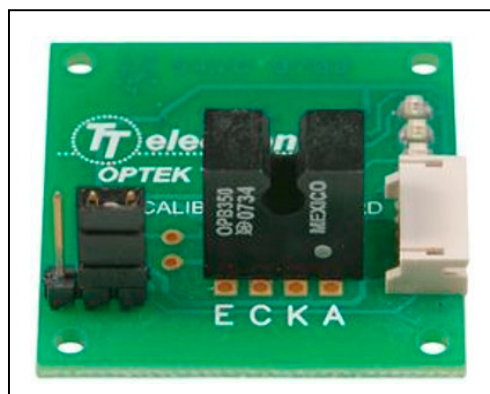


Figure S1. OCB350L250Z Sensor Module [39]

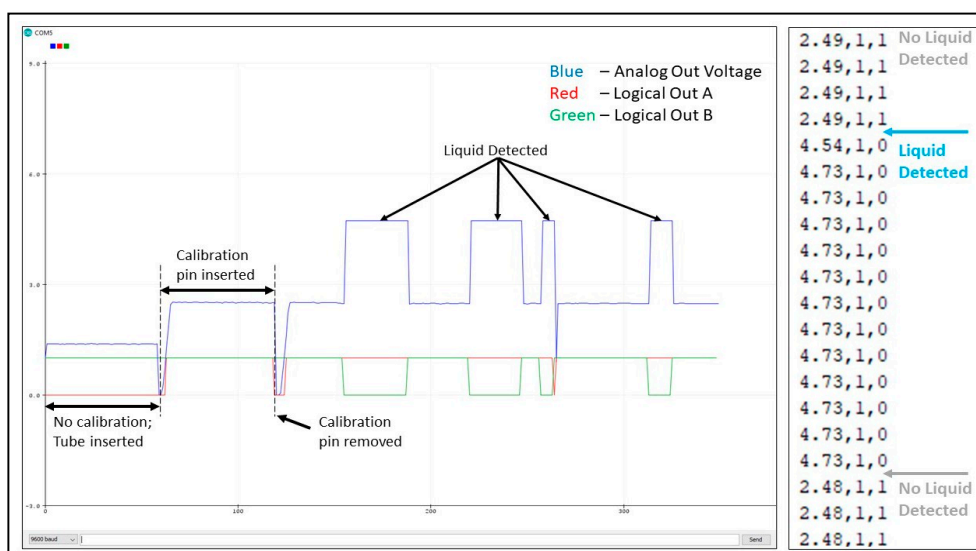


Figure S2. OCB350L250Z Sensor Output.



Figure S3. Atlas Scientific EZO-PMP Pump [40]

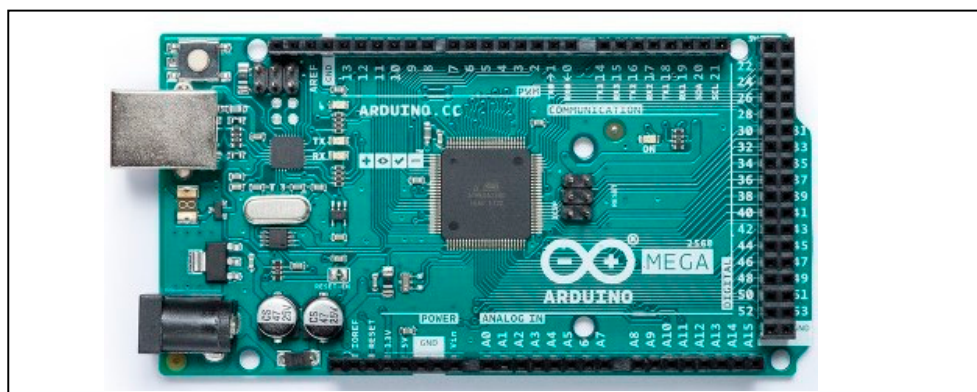


Figure S4. Microcontroller Arduino Mega 2560 [41]

Table S2. Hardware evolution across P-meter prototypes.

Feature	V1	V2	V3
Micro-controller	Arduino Mega 2560	Arduino Mega 2560	Micro-chip PIC 32MX470F512H
Pump	Atlas Scientific EZO-PMP	Atlas Scientific EZO-PMP	Boxer Pumps 9QQ Stepper
Sensors	TT Electronics OCB350L250Z	TT Electronics OCB350L250Z	TT Electronics OCB350L250Z
Chamber Volume	25ml	7.5ml	25ml (optimized)
Vent/Filter	Basic Vent	Integrated Vent	Custom Hydrophobic PTFE membrane
Housing	Open bench	IP52 enclosure	Modular /sealed