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NeoLightGuard

A low-cost real-time irradiance monitoring system for neonatal phototherapy



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THE PROBLEM

A lit lamp is not a therapeutic dose

Intensive phototherapy needs at least 30 µW/cm²/nm in the 460–490 nm band at the mattress plane. A lit unit can still under-deliver.

Lamps age unmonitored

Output drifts down, unseen by eye.

Distances vary widely

Small height changes alter the dose.

Meters are used intermittently

Output goes unobserved between checks.

THE EVIDENCE

Under-delivery is well documented

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units in Nigerian nurseries reached 30 µW/cm²/nm

13.2%

of 38 devices in Jos reached the intensive level

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hospitals on Java failed to reach the intensive level

Owa et al. 2011 · Ofakunrin et al. 2018 · Sampurna et al. 2019

THE GAP

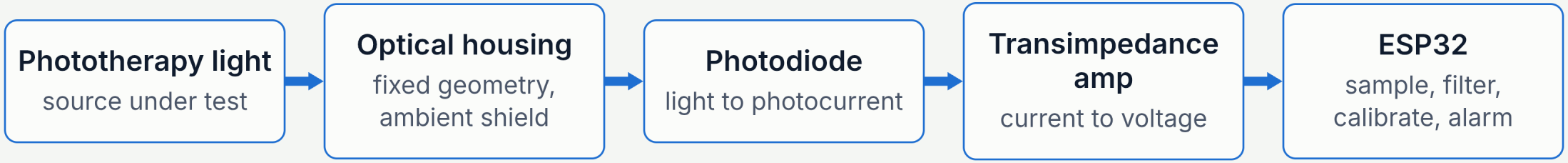
Spot meters or lamp-bound sensors

Approach	Reported	Limitation
Commercial meters	US$1,679–3,200+	Costly, intermittent
Open-source meter [11]	R^2 = 0.9994	Spot check
Smartphone meter [12]	On par with standard	Operator-driven
Lamp-integrated [13], [14]	Sensors and alarms	One lamp design
NeoLightGuard	Calibration pending	Stand-alone node

> Aim: a low-cost, stand-alone monitor for existing cots

THE DEVICE

NeoLightGuard signal path



An LCD shows the reading; a red LED flags low or unstable output.

> Until calibrated against a reference meter, it reports relative intensity only.

THE BUILD

Low-cost, off-the-shelf parts

Component	Specification
Photodiode	BPW21R (BPW34 / BPX 65 considered)
Amplifier	LM358P stage, Rf = 100 kΩ, Cf = 10 nF
Controller	ESP32 DevKit V1, 16×2 I2C LCD, red LED
Power	18650 Li-ion 2600 mAh, TP4056, 5 V boost
Housing	3D-printed PLA, 8 mm aperture
Build cost	[add total from your bill of materials]

THE SIGNAL CHAIN

From photons to a calibrated reading

Photocurrent	**Iph = A × Reff × Eb**	Area × responsivity × irradiance
Amplifier output	**Vout = Iph × Rf + Vos**	Rf sets the gain; Vos is the offset
Calibrated irradiance	**E = k × (Vcal − V0)**	Fitted to a reference meter (planned)

THE METHOD

What is done, and what is still to do

Completed

- Staged bring-up to a finished enclosure
- Amplifier, ADC, LCD and LED integrated
- Bench baseline: 23 consecutive samples

Defined, not yet done

- Calibration against a reference meter
- Five-position mapping on a unit
- IEC 60601-2-50 verification

No patients were involved in any test.

BENCH BASELINE · 23 CONSECUTIVE SAMPLES

Readings sit at the ADC floor

0.89–9.22

filtered ADC counts, only 0.02–0.23% of the 12-bit range

142–162 mV

calibrated voltage; mean 147.4 ± 6.5 mV, CV 4.4%

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samples read exactly 142 mV (35%)

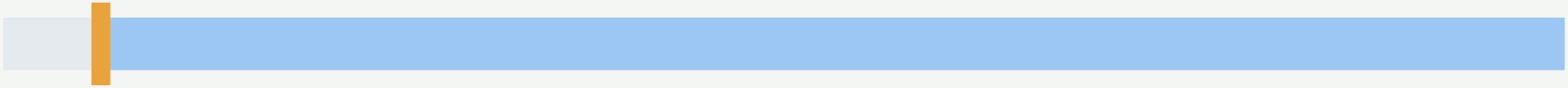
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samples at or above the 150 mV lower limit of the ADC range (39%)

WHAT THE DATA MEAN

Offset and noise floor, not irradiance

Measured: 142–162 mV



Below the range

Offset dominates at the bottom.

Weak link, r = 0.57

Likely filter lag; to confirm.

Diagnostic only

Gain is too low for a usable signal.

NEXT STEPS

Fix the front end, then calibrate

Circuit changes

- Raise Rf, add DC level bias
- Rail-to-rail op-amp; 16-bit ADC
- Blue filter or spectral correction
- Lookup-table linearisation

Validation

- Calibrate against a reference meter
- Five-position mapping on cots
- Remote logging via ESP32
- IEC 60601-2-50 verification

LIMITATIONS

What this work does not yet show

- Baseline data only: relative intensity until calibrated
- Broadband photodiode may respond outside 460–490 nm
- One hardware revision, no long-term drift testing
- Measures delivered dose, not bilirubin clearance
- Not yet clinically validated

CONCLUSION

A characterised signal chain and a clear fix

What we built

A low-cost, battery-powered ESP32 monitor to check delivered phototherapy dose.

What we found

Gain is too low: 142–162 mV sits at the ADC's 150 mV lower limit.

What comes next

More gain and offset, calibration, five-position mapping, clinical verification.

Thank you

Questions and feedback welcome

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