# **IR Photodiode Drop Detector – Design Notes (Rev A)**

## **1 Purpose**

This document supersedes **tia\_bandwidth\_selection.odt** and captures the up‑to‑date design rationale for the IR beam‑break sensor used to count IV‑line droplets. It consolidates bench measurements taken on 23‑May‑2025 and the schematic/layout now frozen for PCB Rev A.

## **2 Sensor Hardware Overview**

| **Element** | **Part** | **Notes** |
| --- | --- | --- |
| Photodiode | **BPV10NF** | Ø5 mm epoxy, peak λ ≈ 850 nm, 25 nA dark current @ 25 °C. |
| Emitter LED | **VSLY5940** | 870 nm, 15 mW/sr @ 20 mA, aimed normal to diode. |
| Supply | **VMAIN = 3.3 V** | Shared with MCU & LED driver. |

Two operating modes are supported:

1. **Continuous** – LED on 100 %; droplet produces a 4–7 ms shadow (≈ +350 mV at diode node).
2. **Pulse‑Save** – LED 150 µs pulses at 8 % duty; droplet suppresses synchronised 100 mV spikes.

## **3 Analog Front‑End Topology**

**** VMAIN 3V3 ─┬─ R16 10 kΩ (pull‑up)

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├───▶ V\_PD ──┬─ C15 100 pF ─┐ LMV331

│ │ │

│ └─ C16 100 pF ─┘ +IN ────┤>O OUT (open‑collector)

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└─ R17 (DNP, 10–47 kΩ) │

to GND (optional pull‑down) └─ R14 1 MΩ (hysteresis)

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  **Photodiode orientation:** anode → GND, cathode → V\_PD. Photocurrent sinks from node, producing lower voltage when the beam is present.
* **Comparator reference:** R18 = R19 = 100 kΩ → V\_REF ≈ 1.65 V (rail/2). LMV331 inputs are valid 0 – ( VCC – 0.7 V ). Keeping V\_PD ≤ 2.6 V at 3.3 V supply ensures guaranteed operation.
* **Hysteresis:** R14 injects ≈ 35 mV of positive feedback, eliminating chatter on slow edges.

### **Optional Components**

| **Designator** | **Function** | **Populate in mode** |
| --- | --- | --- |
| **C17** 2.2 nF | Long‑time constant integrator; filters out < 50 Hz ripple | **Continuous** only |
| **R17** see above | Pulls node towards ground, reducing bias & common‑mode | As needed after bring‑up |

## **4 Time‑Constant & Bandwidth Choices**

* **Continuous mode:** C17 × R16 ≈ 22 µs → f\_c ≈ 7 kHz (suppresses HF noise; settles 99 % in 100 µs ‑ safely below 4 ms drip shadow).
* **Pulse‑Save mode:** leave C17 open. C15/C16 ( ≈ 100 pF each) with 10 kΩ give τ ≈ 1 µs so the 150 µs LED pulse appears with > 90 % amplitude.

## **5 Empirical Bench Data (23‑May‑2025)**

* **Setup:** BPV10NF + 2.7 kΩ to 3.3 V, LED on; CSV captured on Tek scope.
* **Results:** baseline 2.60 V (σ ≈ 6.8 mV); droplet peak 2.97 V → Δ ≈ +365 mV.
* **Inference:** SNR ≈ 53 dB; node exceeded VICR spec (► motivation for R17 divider).

## **6 Layout Notes**

* Comparator, photodiode, R16/R17, C15/16/17 placed within 5 mm cluster to minimise stray C.
* Guard copper (GND) surrounds V\_PD trace; comparator output routed on opposite side.
* 100 nF X7R placed < 1 mm from LMV331 VCC pin.

## **7 Bring‑Up Checklist**

1. Stuff **R16 = 10 kΩ**, **R17 not fitted**, **C17 not fitted**.
2. Apply 3.3 V, LED continuous: verify V\_PD ≈ 1.3–1.5 V (beam present).
3. Interrupt beam: V\_PD should climb < 2.3 V; comparator OUT toggles once.
4. If V\_PD tops > 2.6 V, fit R17 = 22 kΩ; repeat.
5. Switch to 150 µs LED pulsing; ensure ≥ 100 mV spikes cross threshold each cycle.
6. Finalise R18/R19 to reposition threshold if ambient‑light bias differs.

## **8 Future Iterations**

* Consider rail‑to‑rail CMOS comparator (e.g. TLV3701) to remove VICR limit.
* Add solder‑bridge jumper across C17 pads for on‑the‑fly mode switching.
* Evaluate auto‑calibration of threshold using MCU DAC + window comparator.