**IV Flow‑Meter – IR Emitter Timing Strategy***Design report v1 – 25 May 2025*

### **1 Objective**

Define a single LED‑pulse schedule that (i) preserves > 95 % detection reliability for **adult (20 gtt mL⁻¹), micro‑drip (60 gtt mL⁻¹)** and **neonatal (100 gtt mL⁻¹)** sets, and (ii) minimises average current so the device can operate > 360h from one AA cells.

### **2 Empirical baseline (adult set)**

Oscilloscope captures of 23 May 2025 showed a **minimum drop‑shadow length Lₐ = 4.50 ms** through the adult chamber with continuous LED. A 20 % contingency is reserved for manufacturing spread and temperature:

Lₐ,design = 0.8 × 4.50 ms ≈ 3.60 ms.

### **3 Scaling to finer drip sets**

Drop volume V scales with drop diameter D³, hence the shadow length is proportional to D. Using

| **Set** | **Nominal calibration** | **Volume ratio V/Vₐ** | **Diameter ratio k** | **Predicted Lmin (ms)** |
| --- | --- | --- | --- | --- |
| Adult | 20 gtt mL⁻¹ | 1.00 | 1.00 | 3.60 † |
| Micro | 60 gtt mL⁻¹ | 0.333 | 0.693 | 0.693 × 3.60 ≈ **2.50** |
| Neonatal | 100 gtt mL⁻¹ | 0.200 | 0.585 | 0.585 × 3.60 ≈ **2.10** |
| † after contingency. |  |  |  |  |

### **4 Pulse‑period selection**

For the “missing‑dip” algorithm to catch every drop, the LED‑ON **period P must be shorter than the shortest shadow**. Selecting

**P = 1.80 ms (≈ 555 Hz)**

satisfies P < 2.10 ms with 14 % additional headroom.

### **5 LED‑ON width**

The front‑end envelope has τ = R·C = 2.7 kΩ × 220 nF ≈ 0.59 ms. A 150 µs burst charges the capacitor to

(i.e. 24 % of full swing ≈ 110 mV), comfortably above the ±70 mV hysteresis even after a 10 % LED‑output loss with ageing or +40 °C.

**TON = 150 µs** (unchanged from adult prototype)

### **6 Power budget**

Duty = 150 µs / 1.80 ms ≈ 8.3 %. With IPK = 18 mA:

*Average ILED ≈ 1.5 mA*Total quiescent (comparator + MCU Stop 2) ≈ 65 µA → **~1.56 mA overall**, still > 12 × lower than the continuous‑LED V₁ mode.

### **7 Comparator reference ladder**

Current BOM uses **47 kΩ / 47 kΩ** (1.65 V midpoint, 35 µA). Options:

| Divider | VREF (V) | IDIV (µA) | Pros | Cons |
| --- | --- | --- | --- | --- |
| 47 k / 47 k | 1.65 | **35** | Good noise immunity; proven | Higher static draw |
| 100 k / 100 k | 1.65 | 16 | Halves divider current | Slightly higher thermal noise; must verify LM393 offset vs RSRC |
| 33 k / 47 k | 1.30 | 46 | Larger ΔV headroom → could shorten TON to 120 µs | Highest draw |

**Recommendation:** retain **47 k / 47 k** for the first low‑power boards; revisit after micro‑drip testing if a longer headroom proves desirable.

### **8 Ageing & tolerance allowance**

* **IR LED:** radiant intensity derates ~0.35 % K⁻¹ and ~5 % over 5 kh of operation. Allow 10 % lifetime loss.
* **Photodiode & RC:** X7R cap ±15 % over –20…+50 °C. R ±1 %.
* **Hysteresis:** present ±70 mV gives ~30 % optical margin at launch, ~18 % at end‑of‑life.

This is compatible with the 150 µs / 1.80 ms schedule without changing component values.

### **9 Next actions**

1. **Firmware** – implement 150 µs / 1.80 ms scheduler; enable comparator 3 µs after LED ON.
2. **Data capture** – acquire oscilloscope traces for 60 gtt mL⁻¹ and 100 gtt mL⁻¹ chambers.
3. **Validation** – verify ≥ 1 missing‑dip per drop at 25 gtt s⁻¹ (adult) and 40 gtt s⁻¹ (neonatal), across –20 °C…+50 °C.
4. **Power audit** – confirm average draw ≤ 1.6 mA at 3.3 V.
5. **Document** – log results in /data/derived\_data/drop\_shadow/ and update test‑plan spreadsheet.