

MPPT Algo State Machine

S0: Init

- one-shot hardware checks
- read V/I/T/G
- start DC-DC
- mini coarse sweep to seed V_{mp_guess}



S1: Normal

- Control: Inc Cond w/ variable step
 - micro-dither near lock
- Inputs: V_{pv} , I_{pv} (Compute P , $\frac{dP}{dV}$), ripple-filtered
- Outputs: duty/voltage setpoint u
- Background: maintain rolling models
 - V_{mp_hist} (T , G_{bin}) and P_{hist}

↓ on faults

S5: Safety

- Triggers: DVP/UVP, OCP, over-temp, converter sat., sensor fault
- Actions: freeze search, back off setpoint to safe region/open-loop limp
- auto recover when fault clears
- persistent faults → safe mode / exit

↑ on faults

if partial shadling
heuristics fire

if tests fail
(w/ cooldown heuristics)

when stable

S2: PSD Detector

- Quick probes to test for multiple peaks
- sign flips / inconsistency in $\frac{dP}{dV}$ around current point
- unexplained power drop at ~constant V (ΔV small, ΔP large)
- underperformance vs $P_{expected}(T, G_{bin})$ by $> \theta$ for K samples
- optional: 5-8 point coarse scan over window = $V_{mp_guess} \pm W\%$
- Debounce for M cycles to avoid false positives

↓ if 2+ tests positive or coarse shows multi-peaks

S3: Global Search

- Goal: find global MPP across multi-peak P-V
- Search Window: $V \in [V_{min}, V_{max}] = \text{clamp}(V_{mp_guess} \pm 15-25\%, \text{limits})$
- Run PSD/FA/Fuzzy for N iters., particles 5-8
 - early stop when $\Delta P_{best} < \epsilon$ for R iters.
- Safety: rate-limit setpoint steps; abort to S5 on faults
- output: V^*

↓ handoff

S4: Lock/Hold

- Switch controller back to incCond centered @ V^* w/ smaller step; tiny dither
- Hold until:
 - Stability: $\left| \frac{dP}{dV} \right| < \delta$ for H cycles and
 - PSD tests are quiet for J cycles (hysteresis)
- Update V_{mp_hist} / P_{hist} bins with new point

if shadling signatures
reappear

When stable, quiet for J cycles