Supplementary Information

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Manuscript: Auditable Finite-Window Interface Qualification for Inverter Control and Relay Measurements.
This supplement contains the interface-state definitions, the declared error-budget components, the retained working-domain envelope, the per-topology follow-up counts, the complete nonideal-sensitivity table, the same-model solver cross-check, and four supporting figures. All values are reproduced from the retained executable records referenced in the manuscript's Data availability statement.

Supplementary Tables

Supplementary Figures

Table S1. Interface state semantics used in the audits

State	Meaning in this manuscript
ADMISSIBLE	Complete declared budget and margin support admission of the stated interface calculation.
MARGINAL	Declared budget is finite but too close to the margin for admission.
INVALID	Domain, budget, or physical constraint is violated; the record is retained as a rejection.
NOT_ASSESSED	Required downstream margin or complete budget is absent, so no permission is inferred.

Table S2. Declared error-budget components and evidence limits

Component	How it enters the ledger	Evidence limit in this study
Coefficient exchange	$-C$ from the finite-window product replacement	Bounded by the retained waveform/coefficient records; no independent sensor calibration
Inductor endpoint	$-L_s H$ from finite-window integration by parts	Uses the declared source inductance and sampled endpoints; external-line dynamics are excluded from the primary model
Actuator realization	$+P = (u - u_0) + z(i_s - i_0)$	Computed from the applied command; no hardware actuator-identification bound
Telemetry uncertainty	Reachable or rate-clipped interval under age/noise bounds	Deterministic synthetic bounds; no packet-loss, jitter, or field error distribution
Decision margin	Allocation and downstream margin used for state labels	The 0.05-p.u./0.02-p.u. scalar margins are declared diagnostics, not calibrated relay settings

Table S3. Physical tuples retained by the working-domain qualification audit

Topology	SCR	Fault resistance	Retained fault locations/types
Meshed	2.5	0.1	LG at 0.2, 0.5
Meshed	5.0	0.1	LL at 0.2; LG at 0.2, 0.5, 0.8
Radial	5.0	0.1	LL at 0.2; LG at 0.2, 0.5, 0.8

Table S4. Follow-up source-current domain-governor audit over the same physical grid

Topology	Physical tuples	Domain-valid	Max $\lvert i_s \rvert$	Max $\lvert v_A \rvert$
Meshed	54	54	0.4500	1.0312
Radial	54	54	0.4500	1.0372
All	108	108	0.4500	1.0372

Table S5. Exploratory causal sampled-data sensitivity. Command clipping is the fraction of command updates clipped over the complete 80-ms history. Each row contains 108 physical tuples evaluated at two deterministic noise phases; a tuple is retained only if both phases satisfy the sampled current–voltage domain.

Condition	Retained	Max $\lvert i_s \rvert$	Max $\lvert v_A \rvert$	Clipped (%)
Ideal, causal	108/108	0.4500	1.0372	0.0
Readback: 0.1 ms	108/108	0.5951	1.0598	0.0
Readback: 0.5 ms	108/108	1.1690	1.1187	0.5
Noise: 0.01 p.u.	108/108	0.4628	1.0438	0.0
Impedance: -10%	108/108	0.4500	1.0593	0.0
Impedance: +10%	108/108	0.4564	1.0372	0.0
Actuator: 0.5 ms	108/108	1.0166	1.0837	0.0
Detection: +2 ms	3/108	3.1044	1.0373	0.0
Combined	108/108	1.4778	1.0575	0.0
Current request: 0.9	105/108	1.5118	1.1272	25.0

Table S6. Same-model solver cross-check: maximum current error (p.u.)

Case	0.2 ms	0.1 ms	0.05 ms
Radial, 3ph	0.01425	0.003606	0.0009335
Weak radial, 3ph	0.01876	0.004751	0.001215
Meshed, LG proxy	0.01057	0.002802	0.0007158
Radial, LL proxy	0.01348	0.003402	0.0008597

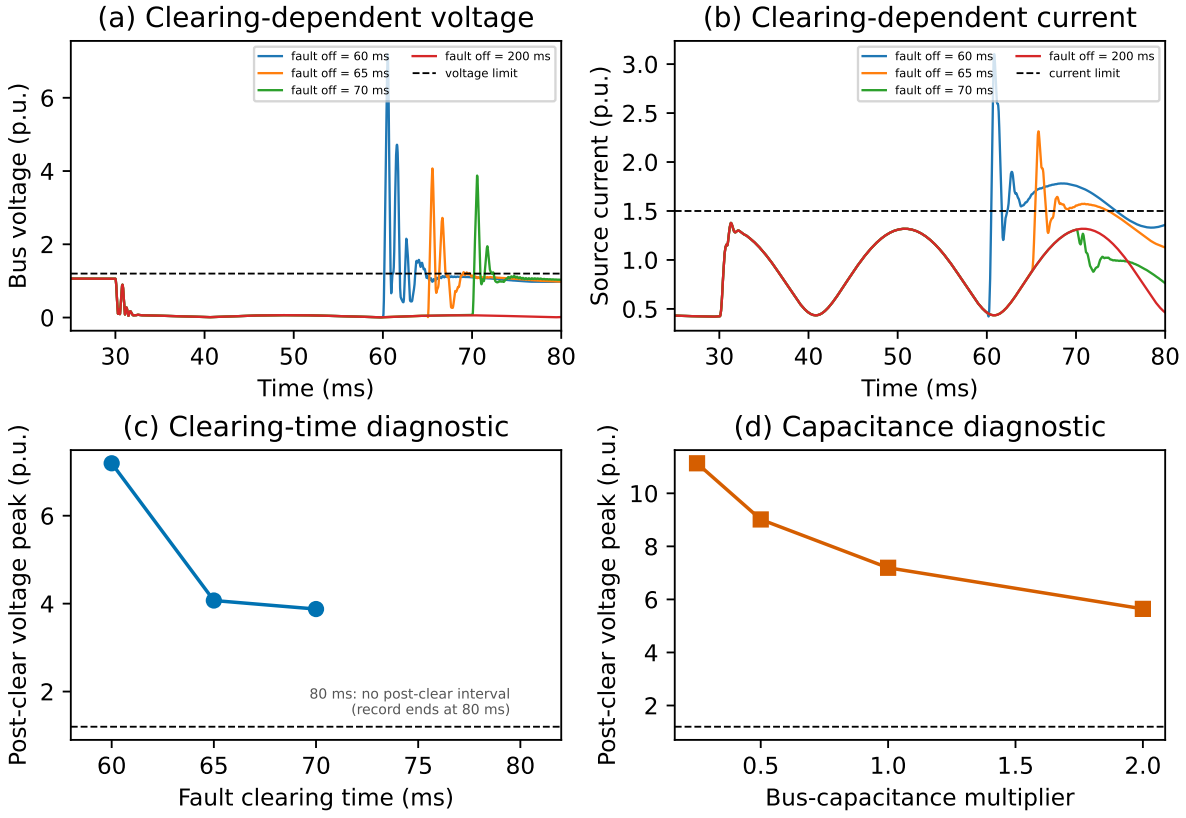
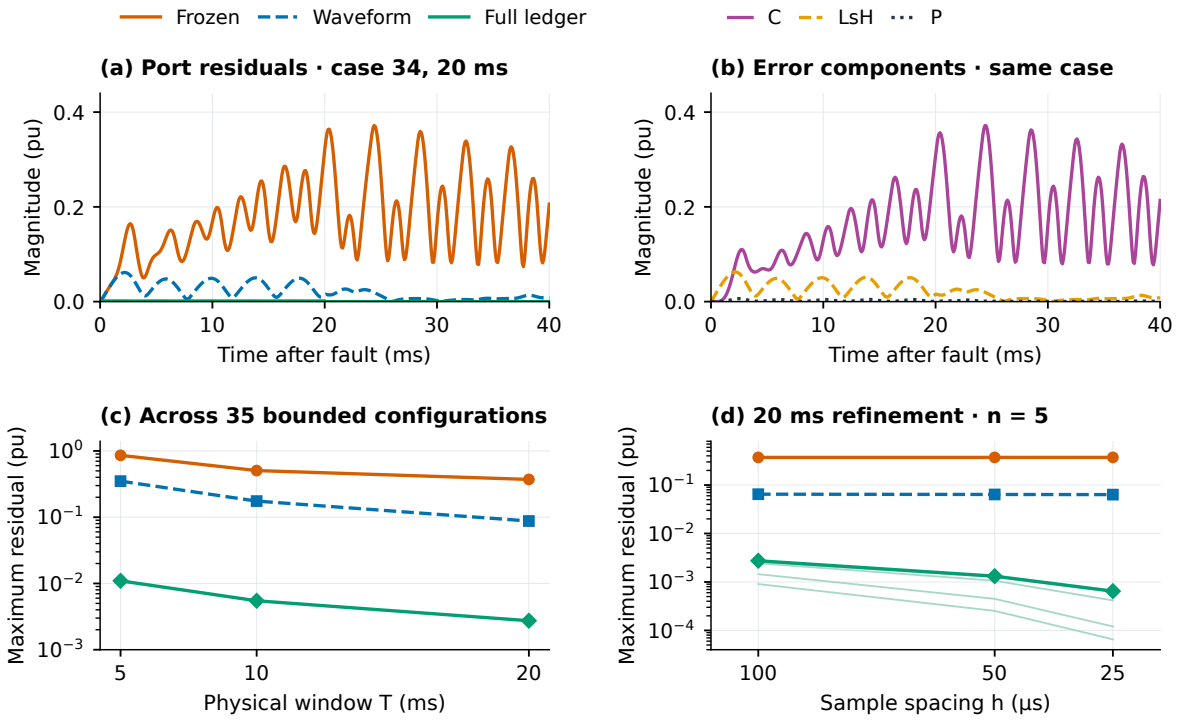
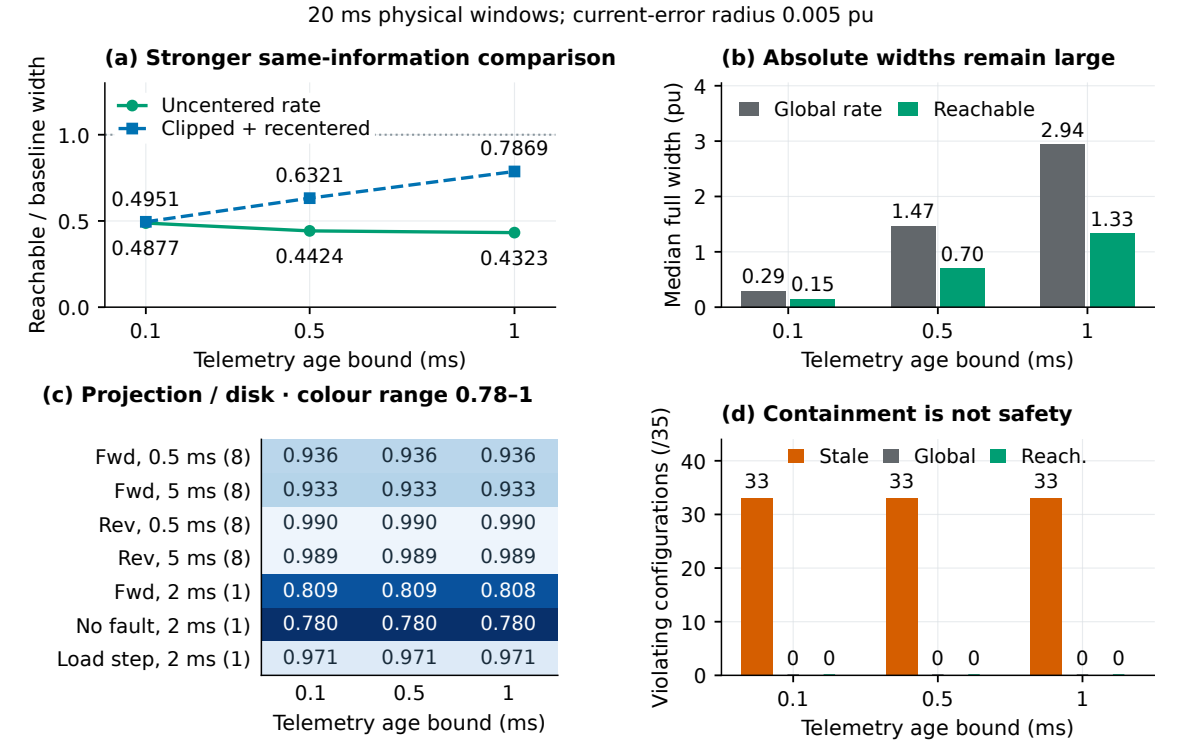


Figure S1. Post-hoc mechanism diagnostic for the representative held-out three-phase tuple (SCR=1.5, $R_f = 0.01$ p.u., location 0.8). Panels (a)–(b) show sampled bus-voltage and source-current envelopes under alternative clearing times; panels (c)–(d) summarize post-clear voltage peaks versus clearing time and bus-capacitance multiplier. Panel (c) omits clearing times at or beyond the record end because no post-clear interval is observed. The diagnostic is model-conditional, uses no parameter fitting, and is not part of gain selection.



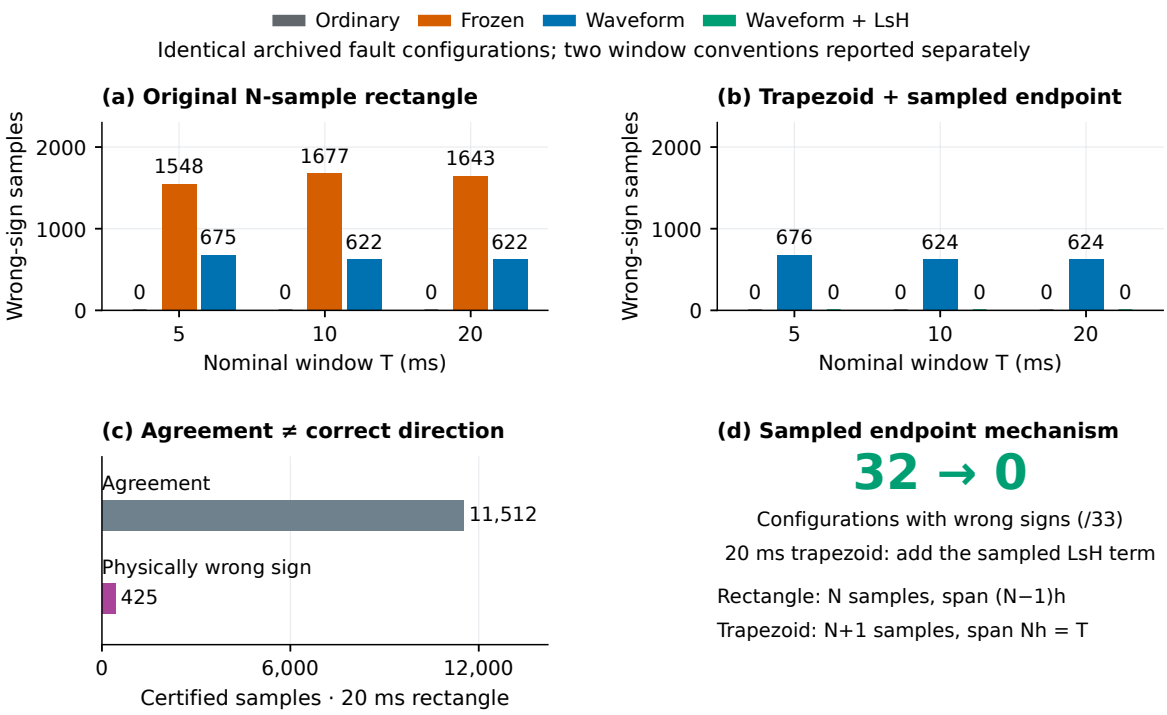
Peaks over 0–40 ms; pale: individual full ledgers. Case 34 is locally unstable; case 35 excluded.

Figure S2. (caption missing)



Projected audit: 0 violations / 3,150 records on 35 configurations; correlated windows, not independent trials.

Figure S3. (caption missing)



0 certified disagreements; 425 physically wrong certified samples across 31 configurations (20 ms rectangle).
$0 < t < 50$ ms; sign tolerance 10^{-8} pu². No pickup/trip logic, no relay-misoperation-rate claim.

Figure S4. (caption missing)