RESEARCH EVIDENCE / OCTOBER 2026

FARO vs FIXED PID UNIFIED PHYSICAL BENCHMARK

Five controlled evidence blocks across ARM and RISC-V physical plants, with the two new R6 tests integrated and every protocol boundary kept explicit.

5	3/3	3/3	6/6
evidence blocks	ARM paired FARO wins	RISC-V paired FARO wins	R6 degradation profiles

TESTS INCLUDED

1 / ARM matched tracking - 2 / RISC-V matched tracking - 3 / physical disturbance evidence
4 / R6 generalization - 5 / R6 degradation

Prepared from the 35-page OSH Unified Physical Evidence dossier and the canonical R6 TODO-CUENTA physical record. Results are not pooled across non-equivalent protocols.

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00 / EXECUTIVE SUMMARY

Five evidence blocks. Protocols kept separate.

This report consolidates three established control-evidence sections from the 35-page dossier with the two new R6 physical tests completed on 19 October 2026.

7.46%
ARM lower mean IAE

10.37%
RISC-V lower mean IAE

0.0478%
R6 generalization edge

2.7861%
R6 degradation edge

Evidence block	Physical scope	Primary result	Correct interpretation
1. ARM matched tracking	STM32F446RE physical DAC/ADC plant	FARO 3/3; mean IAE 7.46% lower	FARO outperformed one fixed PID under this frozen ARM protocol
2. RISC-V matched tracking	CH32V307 physical DAC/ADC plant	FARO 3/3; mean IAE 10.37% lower	Independent physical-plant result; not an ISA ranking
3. Disturbance response	ARM and RISC-V physical injection	FARO disturbance confirmation PASS on both	No valid RISC-V PID recovery winner due to predeclared gate caveat
4. R6 generalization	CH32V307, 6 profiles, TODO-CUENTA	FARO IAE 0.0478% lower; profiles 3/6 vs 3/6	Numerical edge only; practically indistinguishable, not robust superiority
5. R6 degradation	CH32V307, 6 profiles, TODO-CUENTA	FARO IAE 2.7861% lower; profiles 6/6	Consistent advantage against this fixed PID within the declared degradation protocol

NO ARTIFICIAL GLOBAL WINNER

The raw IAE totals come from different plants, controller states, PID settings and evaluation families. They must not be summed into a single global score. Each result stands only within its own frozen protocol.

01 / COMPARATOR BOUNDARIES

Comparable questions, non-identical protocols.

The tests share the principle of paired physical measurement, but the exact controller state, PID gains and plant differ. This page prevents overclaiming.

Variable	Tests 1-2 / 35-page dossier	Tests 4-5 / R6 TODO-CUENTA
Controller location	Host FARO V2 and host fixed PID	Host FARO Compacta V2 and host fixed PID
Physical I/O	ARM or RISC-V DAC-to-ADC loop	CH32V307VCT6 PA4 DAC -> PA5 ADC
PID parameters	Kp 0.800 / Ki 0.008 / Kd 0.080	Kp 3.0 / Ki 8.0 / Kd 0.036 / Tf 0.12 / Tt 0.48
State policy	Fresh FARO and PID state each phase	Equal preparation: 4,416 decisions each; prepared dynamic states preserved symmetrically
Observation	Median of 5 ADC samples	5 raw ADC samples before + 5 after each decision
Performance accounting	Three interleaved pairs per plant	Every complete pair counts once; zero exclusions; zero local retries
Primary metric	Cumulative IAE; lower is better	raw IAE at nominal 0.12 s per decision; lower aggregate IAE per family

Scope rule. The older paired studies establish two physical benchmark outcomes against their documented fixed PID. R6 asks two harder but different questions: transfer to reserved generalization profiles, and behavior under declared degradation. The report preserves those distinctions.

MEASURED, NOT ASSUMED

The claim is not that FARO defeats every PID. The defensible claim is that these specific FARO implementations achieved the recorded outcomes against the specified fixed comparators under the physical protocols shown here.

02 / TEST 1 - ARM MATCHED TRACKING

ARM paired study: FARO 3 of 3.

The first established control comparison from the 35-page dossier. Lower cumulative IAE is better.

3/3
paired FARO wins

7.46%
lower mean IAE

0
reported ADC failures



Run	FARO IAE	PID IAE	PID - FARO	FARO reduction	Winner
PAIR 1	114,977	123,481	8,504	6.89%	**FARO**
PAIR 2	112,577	123,511	10,934	8.85%	**FARO**
PAIR 3	115,199	123,373	8,174	6.63%	**FARO**
MEAN	**114,251**	**123,455**	**9,204**	**7.46%**	**FARO**

MEASURED END POINT

FARO produced lower cumulative IAE in all three complete ARM pairs. This supports superiority only to this single fixed PID under the frozen ARM protocol; it does not establish universal controller superiority.

03 / TEST 2 - RISC-V MATCHED TRACKING

RISC-V paired study: FARO 3 of 3.

A second physical DAC-to-ADC plant produced an independently recorded result.

3/3
paired FARO wins

10.37%
lower mean IAE

0
new UART errors



Run	FARO IAE	PID IAE	PID - FARO	FARO reduction	Winner
PAIR 1	107,651	124,072	16,421	13.24%	**FARO**
PAIR 2	114,395	124,081	9,686	7.81%	**FARO**
PAIR 3	111,611	124,109	12,498	10.07%	**FARO**
MEAN	**111,219**	**124,087.33**	**12,868.33**	**10.370384%**	**FARO**

EXECUTION BOUNDARY

Both comparator controllers ran on the host and used physical CH32V307 DAC/ADC measurements. This result is separate from the native 100K OSH execution qualification inside the MCU.

04 / TEST 3 - PHYSICAL DISTURBANCE RESPONSE

Recovery demonstrated; limits disclosed.

The third established control-evidence block is preserved with its original PID qualification caveat.

Field	ARM FARO	RISC-V FARO
Reference	3,071	3,071
Injected step	-240 DAC counts	-240 DAC counts
Pre / post windows	120 / 120	120 / 120
Confirmed disturbance	**PASS**	**PASS**
Recovery step	19	22
Post-disturbance IAE	3,267	3,239
Final error	4 counts	2 counts

RISC-V PID CAVEAT

The fixed PID entered the RISC-V injection point with a high baseline median error of 346 counts. After the -240 DAC-count change, the recorded error was 148 counts, so the event did not exceed the required baseline +150 confirmation threshold. Its reported recovery step cannot be used as a valid causal recovery comparison.

Truth over optics. It remains valid to report FARO disturbance confirmation PASS and the separate 3/3 matched IAE result. It would exceed the evidence to claim that PID failed recovery in this test.

05 / R6 TODO-CUENTA PROTOCOL

The new physical battery: no exclusions, no local retries.

Tests 4 and 5 came from one canonical CH32V307 physical battery completed on 19 October 2026.

35/35	70	22,512	225,120
completed pairs	physical runs	decisions	ADC samples

Protocol element	Frozen R6 value
Platform	CH32V307VCT6 / QingKe V4F RISC-V; host Python; COM4; PA4 DAC -> PA5 ADC
Firmware / production changes	No flash and no firmware, kernel or overlay changes during the battery
Preparation	4,416 decisions per controller; dynamic state preserved symmetrically
Fixed PID	Kp 3.0; Ki 8.0; Kd 0.036; Tf 0.12; Tt 0.48
Accounting rule	One attempt per job; every complete pair counts; zero exclusions; zero retries
Timing	11 pairs carried timing warnings; all remained visible and counted
Audit result	PASS_AUDITORIA_R6_TODO_CUENTA

WHY R6 REPLACES THE FILTERED R5 VERDICT

R6 retained the same comparison family but removed the mechanism that excluded completed pairs on timing criteria. Timing anomalies were reported, never used to erase or replace a completed performance result.

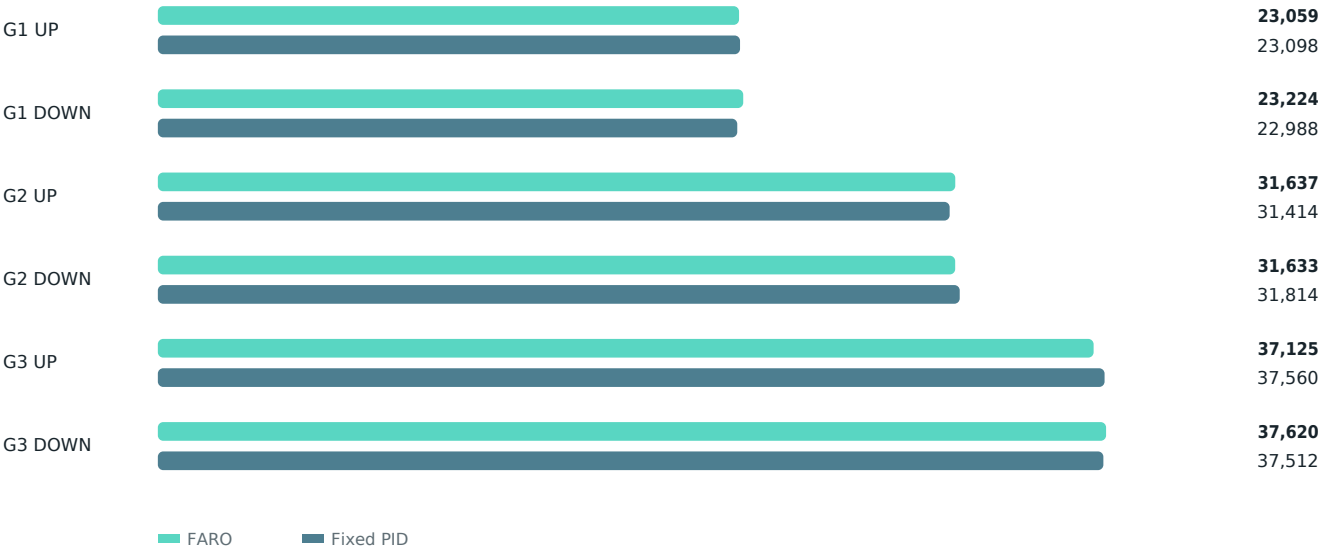
06 / TEST 4 - R6 GENERALIZATION

Numerical FARO edge; no robust superiority.

Six reserved physical profiles, every complete pair counted exactly once.

184,297.20	184,385.28	0.0478%	3 / 3
FARO total IAE	PID total IAE	FARO symmetric edge	profile wins split

Profile	Order	FARO IAE	PID IAE	Winner	FARO adv.	Warnings
G1 UP	PID -> FARO	23,058.60	23,097.84	**FARO**	+0.1700%	1
G1 DOWN	FARO -> PID	23,223.96	22,987.68	**PID**	-1.0226%	0
G2 UP	FARO -> PID	31,636.56	31,413.96	**PID**	-0.7061%	0
G2 DOWN	PID -> FARO	31,633.20	31,813.56	**FARO**	+0.5685%	0
G3 UP	FARO -> PID	37,125.12	37,559.88	**FARO**	+1.1643%	0
G3 DOWN	PID -> FARO	37,619.76	37,512.36	**PID**	-0.2859%	0



INTERPRETATION

FARO recorded 88.08 fewer aggregate IAE units, but the 0.0478% difference and 3-to-3 profile split are practically indistinguishable. The honest conclusion is numerical parity with a minimal FARO edge, not robust superiority.

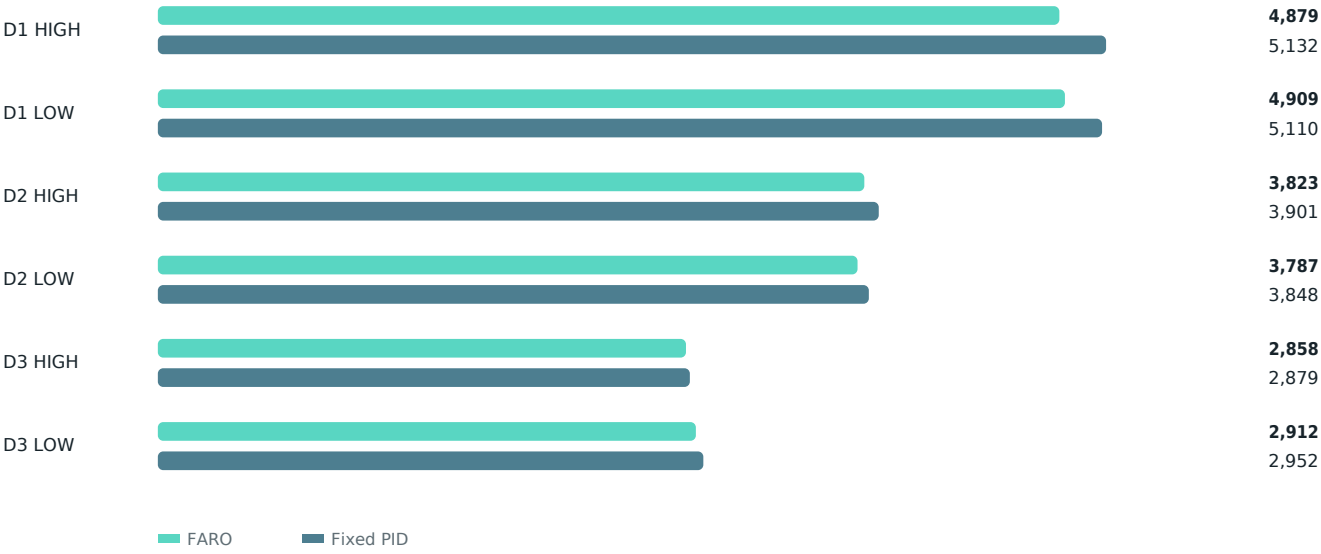
07 / TEST 5 - R6 DEGRADATION

FARO lower IAE in all six degradation profiles.

The same TODO-CUENTA rules applied: one attempt, no performance exclusion and no local retry.

23,167.56	23,822.16	2.7861%	6 / 6
FARO total IAE	PID total IAE	FARO symmetric edge	FARO profile wins

Profile	Order	FARO IAE	PID IAE	Winner	FARO adv.	Warnings
D1 HIGH	PID -> FARO	4,878.84	5,131.68	**FARO**	+5.0515%	4
D1 LOW	FARO -> PID	4,908.96	5,109.96	**FARO**	+4.0124%	3
D2 HIGH	FARO -> PID	3,823.32	3,901.44	**FARO**	+2.0226%	2
D2 LOW	PID -> FARO	3,786.60	3,847.80	**FARO**	+1.6033%	1
D3 HIGH	FARO -> PID	2,858.16	2,879.16	**FARO**	+0.7320%	1
D3 LOW	PID -> FARO	2,911.68	2,952.12	**FARO**	+1.3793%	0



INTERPRETATION

FARO achieved 654.60 less aggregate IAE, a 2.7861% symmetric advantage, and lower IAE in every evaluated degradation profile. The two-sided descriptive sign-test value is 0.03125. This supports a consistent advantage against this fixed PID within this physical degradation protocol.

08 / CROSS-TEST SYNTHESIS

A stronger evidence chain, not a pooled score.

The five blocks collectively show repeated physical competitiveness while preserving the limits of each experiment.

Test	FARO outcome	Strength of statement
ARM matched tracking	3/3 pairs; 7.46% lower mean IAE	Clear result against one fixed PID on one ARM plant
RISC-V matched tracking	3/3 pairs; 10.37% lower mean IAE	Independent clear result against one fixed PID on one RISC-V plant
Disturbance response	FARO confirmation PASS on ARM and RISC-V	Valid FARO recovery evidence; no valid RISC-V PID recovery winner
R6 generalization	0.0478% lower aggregate IAE; 3/6 vs 3/6	Near parity; no robust superiority claim
R6 degradation	2.7861% lower aggregate IAE; 6/6	Consistent advantage inside the declared degradation family

What the evidence supports. FARO repeatedly operated competitively on physical control loops and recorded lower IAE than the declared fixed PID in both earlier matched studies and the R6 degradation family. The new generalization family is equally important because it shows where the numerical difference is minimal.

What the evidence does not support. These tests do not prove universal superiority over PID, do not identify the best possible PID tuning, do not rank processor ISAs, and do not substitute for independent replication or application-specific qualification.

PUBLIC WORDING

Across multiple physical control studies, FARO outperformed the specified fixed PID in the ARM and RISC-V matched benchmarks, remained numerically level in R6 generalization, and achieved a consistent 6-of-6 advantage under R6 degradation. Every statement remains bounded to its own declared protocol.

09 / EVIDENCE ANCHORS

Source identity and audit trail.

Cryptographic anchors link this consolidated benchmark to the source dossier and the R6 physical record.

Artifact	SHA-256 / identifier
35-page unified physical evidence PDF	cbc561d44fa20acb9cbe7dd39983b37c7f0fcb948a3ff6e29eacb710b9b637f9
R6 final runner	651cab4df388bcf33ea47030e7e2e473e7864898eb580f07bc6d86c5db114968
R6 frozen protocol	7b1b2d900b0edd20f5c3be1705e532f35998f3aae33cbfeaf41013a46fd16814
R6 progress record	b07084a14bf39ca093bff8a728df0901f754ab0f841536d6de5b455d59313c3c
R6 audit record	d00d6f9d0e87a57ef19c4d7e455a5059d99afc029e3e6fb7732a73b1593aae40
R6 summary record	4d35bb50c51e80cf8501b75c17defa79be3c8e469b65a3a90f78a3f68dc7702d
R6 FARO prepared-state digest	45d4c743dd6068f1eaba28eb409da5f6ad2e4fb89952bd5877c0da90509480de
R6 PID prepared-state digest	f7804bf2e100099f93462c80a979a7cf6e47300a03f4cb36940d2c513b763e2c

Canonical R6 archive. FARO_COMPACTA_PID_R6_TODO_CUENTA_FISICO_20261019_083951_0c74480e_20261019_093123_9abe7292.zip

Audit note. Hashes establish byte identity and traceability. They are not substitutes for raw traces, independent reproduction or third-party review.

FINAL STATUS

Tests 1-3 are retained from the 35-page public dossier. Tests 4-5 are the canonical R6 TODO-CUENTA physical results. The attempted RC mutant-plant test is not included because no valid FARO-vs-PID performance pair was completed.

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