

ArenaController Binary Pattern Long-Run Performance

PLAY_PATTERN_MODE (SD-backed), binary frames (grayscale=false) with 500 Hz refresh and 2 ms frame-update timer

TL;DR

- Sustained **~500.0 Hz refresh** for **100.00 minutes** (window_ms=6,000,156) with **0 drops, 0 defers, 0 late frames**.
- Refresh interval (IFI) was tightly centered at **2000 us**; p99=2124 us; jitter range -176..143 us.
- Per-refresh transfer time was stable: xfer mean=987 us, p99=992 us, max=1044 us (transfer duty=49.33%).
- SD read tail stayed below the 2 ms refresh period: SD max=1141 us; **over2000=0, over5000=0** over ~2,991,035 reads.
- Estimated headroom at 500 Hz remained healthy: p99 headroom=864 us; worst-case headroom=807 us.

Test setup

Metric	Value
Mode	PLAY_PATTERN_MODE (SD-backed)
Frame type	Binary (grayscale=false)
Target refresh rate	500 Hz (period 2000 us)
Pattern frame-update timer	frame rate ticks=2 (approx 2 ms/update; intended ~500 updates/s)
Requested runtime	6,000,000 ms (100 min)
Measured window	6,000,156 ms (100.00 min)
Total refresh frames completed	2,999,999

Detailed results

All timings are microseconds (us) unless otherwise noted.

Refresh-loop health (drops/defers/late)

Metric	Value	Notes
fps (measured)	499.99	Completed refresh transfers per second
tick_hz (measured)	499.99	Refresh timer tick rate
frames/tick	1.000	Should be ~1.0 when every tick triggers one transfer
defers	0	Refresh tick arrived while transfer was still busy; deferred
late frames	0	Late means transfer exceeded period (2000 us)
drops (total)	0	Missed refresh opportunities (post failures or defer overflow)
drops: post failures	0	Refresh ISR could not post event
drops: defer overflow	0	Deferred refresh queue overflow

Inter-frame interval (IFI) jitter

Statistic	Value
Samples (n)	2,999,998
Mean IFI	2000 us
Std dev	9 us
p95	2007 us
p99	2124 us
Min / Max	1824 us / 2143 us
Jitter vs target period	-176..143 us (target 2000 us)

Transfer pipeline (SPI + overhead)

Metric	Mean (us)	p99 (us)	Max (us)	Notes
Frame transfer (xfer_us)	987	992	1044	Duty=49.33% of wall time
SPI portion (spi_us)	882	886	936	Duty=44.08% of wall time
Transfer overhead (ovh_us)	105	-	114	Non-SPI software overhead inside xfer window
Panel-set transfer (panelset_us)	80	80	134	n=35,999,988; 12 panel-sets per frame

CPU stages and SD tail behavior

Counts are accumulated over the full run; tail counters report how often SD read duration exceeded key thresholds.

Stage	n	c/f	mean	p99-ish	max	duty	Tail counters
SD read	2,991,035	1.00	43	1084	1141	2.16%	>500us: 11,953 (0.39%, ~1/250) >1000us: 8,965 (0.29%, ~1/334) >2000us: 0 (0.00%) >5000us: 0 (0.00%)
Decode	2,991,035	1.00	34	34	34	1.67%	Stable (deterministic)
Fill	2,991,035	1.00	17	18	18	0.83%	Stable (deterministic)

Estimated safe max FPS (heuristic)

The estimator uses a critical-path time plus a guard band and reports the implied maximum sustainable rate. For this run it reported limiter=**CPU** (crit_p99_us=1136 us, crit_max_us=1193 us). At 500 Hz (period 2000 us), measured headroom was **864 us** (p99) and **807 us** (worst observed).

Metric	Value
safe_fps_p99	748
safe_fps_max	717
crit_p99_us + guard	1136 + 200 = 1336 us
crit_max_us + guard	1193 + 200 = 1393 us
headroom_p99_us (period - crit_p99)	2000 - 1136 = 864 us
headroom_min_us (period - crit_max)	2000 - 1193 = 807 us

Raw QS summary excerpt (for reference)

```
PERF_SESSION ... window_ms=6000156 target_hz=500 period_us=2000 runtime_ms=6000000 fps=499.99
tick_hz=499.99 ... defers=0 late=0 drops=0
PERF_TIMING IFI_us n=2999998 mean=2000 std=9 p95=2007 p99=2124 min=1824 max=2143 jitter_us=[-176..143]
PERF_XFER ... xfer_us mean=987 p99=992 max=1044 spi_us mean=882 p99=886 max=936 panelset_us mean=80
p99=80 max=134
PERF_CPU SD n=2991035 mean=43 p99ish=1084 max=1141 over500=11953 over1000=8965 over2000=0 over5000=0
DEC mean=34 FILL mean=17
PERF_EST safe_fps_p99=748 safe_fps_max=717 limiter=CPU headroom_p99_us=864 headroom_min_us=807
```