

Incidence Perfect NG

User Manual (Beta)



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Incidence Perfect NG is a compact 2-axis inclinometer/incidence meter built around an ESP32-S3 + AMOLED touchscreen. It measures **roll** and **pitch** and provides workflows for **ZERO**, **OFFSET CAL**, **MODE**, **ROTATE**, and **ALIGN**.

Beta note: This manual describes the current firmware behavior. If something differs on your device, report the **firmware version shown on the splash screen**.

1) Getting Started

Power + Boot

- Connect the device over USB power.
- On boot you'll see the splash screen with the firmware version in the lower-right.
- After boot, the live readout screen appears (roll/pitch).

What You're Looking At

- **Top status line** shows:
 - orientation mode (SCREEN UP OR SCREEN VERTICAL)
 - axis view (BOTH, ROLL, PITCH)
 - rotation (ROT 0 or ROT 180)
 - live state (LIVE or FROZEN)
 - **Readouts:**
 - ROLL (left) and PITCH (right) in degrees
 - colors shift for large angles (warning, then critical)
 - **Bottom buttons:**
 - ZERO, AXIS, MODE, ALIGN, ROTATE
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2) Touch Controls (Everyday Use)

ZERO / OFFSET CAL

Use when the tool is resting in the reference position.

- Tap ZERO.
- ZERO opens a guided workflow:
 - CONFIRM to start stillness + averaging
 - CANCEL to abort

- During apply, a progress bar is shown.
- On completion, values settle around 0.00.
- Long-press ZERO to start guided OFFSET CAL (confirm/cancel workflow).

AXIS

Choose what you want to focus on:

- Tap AXIS to cycle: BOTH -> ROLL -> PITCH -> BOTH.

ROTATE (180 degrees)

Use when the device is physically hard to read and you want to flip the UI.

- Tap ROTATE to toggle ROT 0 / ROT 180.
- Rotation persists after reboot.

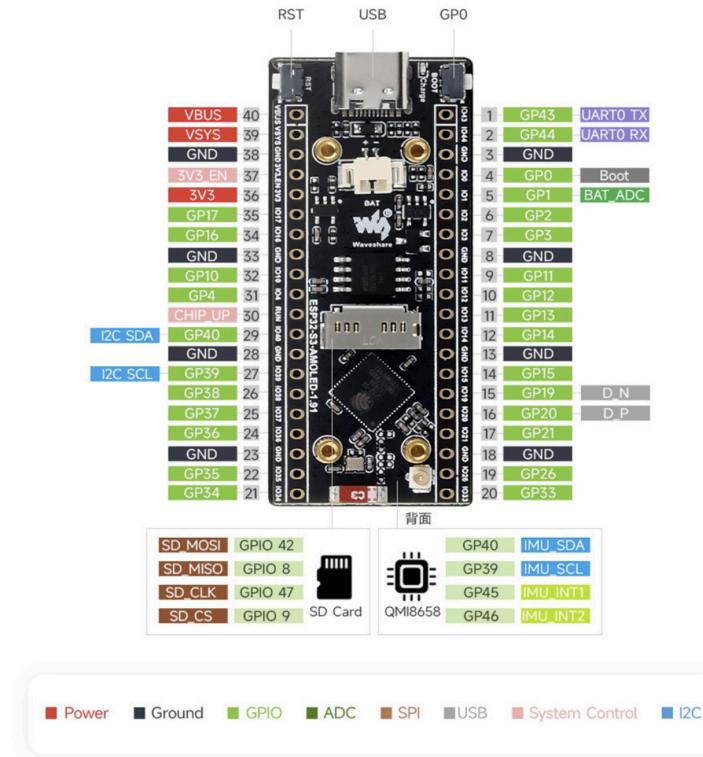
Freeze / Unfreeze

Use freeze when you want to capture a reading without chasing tiny motion.

- Tap the **readout area** (the roll/pitch values) to toggle LIVE / FROZEN.
 - When frozen, the displayed values hold steady.
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3) ACTION Button (Physical Control)

The board has a physical **ACTION button** (electrically GPIO0, labeled BOOT/GPO on the board). It mirrors key actions so you can operate the device when the screen is hard to reach.



In normal measurement mode:

- **Short press:** toggle freeze (LIVE <-> FROZEN)
- **Long press (~1.2s):** cycle AXIS (BOTH -> ROLL -> PITCH)
- **Very long press (~2.2s):** toggle MODE (SCREEN UP <-> SCREEN VERTICAL)
- **Ultra long press (~3.2s):** start guided OFFSET CAL workflow

While holding the ACTION button, an on-screen hint shows what will happen on release and a progress indicator for the next threshold. Countdowns are shown as x.x s (with a space before s).

In guided OFFSET CAL workflow:

- **Short press:** CONFIRM
- **Long press (~1.2s):** CANCEL

In guided ZERO workflow:

- **Short press:** CONFIRM
- **Long press (~1.2s):** CANCEL

4) MODE (Orientation Change)

MODE changes how the device interprets orientation.

- SCREEN UP: standard “screen facing up” use case
- SCREEN VERTICAL: use case where the tool is used on a vertical surface

Touch Workflow

1. Tap MODE.
2. Orientation switches immediately between SCREEN UP and SCREEN VERTICAL.
3. Mode-specific stored calibration/zero references are loaded automatically.

Serial / Web

- Serial:
 - m: toggle mode
 - u: set SCREEN UP
 - v: set SCREEN VERTICAL
- Web:
 - MODE toggles immediately

5) ALIGN (Mechanical Alignment, 6 Steps)

Use ALIGN after mounting/enclosing the device to remove systematic bias.

This is a guided, 6-orientation capture procedure. The device will prompt you through the positions and ask you to capture each one.

Touch Workflow

1. Tap ALIGN.
2. Follow the on-screen instruction (example: Place tool: SCREEN UP).
3. Tap CAPTURE to record that step.
4. Repeat until all steps are captured.
5. Tap CANCEL to abort safely at any time.
6. After step 6, ALIGN completes immediately and returns to normal operation.

Important:

- ALIGN and OFFSET CAL are separate operations.

- ALIGN does **not** run OFFSET CAL automatically.
- Run guided OFFSET CAL separately in the active MODE when needed.
- If you use both SCREEN UP and SCREEN VERTICAL, run OFFSET CAL in each mode so both mode-specific references are updated.

ACTION Button in ALIGN Workflow

If the screen is hard to access (for example screen-down steps):

- ACTION button short press = CAPTURE
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6) Serial Control (Optional)

If connected to a PC, you can control the same workflows via serial (115200).

Core commands:

- z: start guided ZERO workflow
- a: AXIS cycle (BOTH -> ROLL -> PITCH)
- r: ROTATE 180 toggle
- c: start ALIGN workflow
- o: start guided OFFSET CAL workflow
- c: context action
 - in ALIGN: CAPTURE
 - in ZERO pending: CONFIRM
 - in OFFSET CAL pending: CONFIRM
 - otherwise: start+confirm guided OFFSET CAL
- y: explicit CONFIRM (ZERO/OFFSET CAL workflows)
- p: explicit CAPTURE (ALIGN only)
- m: toggle mode immediately
- u: set SCREEN UP immediately
- v: set SCREEN VERTICAL immediately
- x or n: cancel active workflows
- d: toggle raw IMU debug stream (5 Hz)
- D: print one raw IMU sample now
- s: print runtime status snapshot
- h or ?: print serial help
- After each serial command response, live scrolling output pauses so you can read feedback.
 - Press Enter, Space, or send g to resume live stream.

Serial and touch workflows are designed to stay synchronized.

7) Web Control (Phone Remote)

Use your phone browser as a remote panel:

1. Connect to the device AP:
 - o SSID: IncidencePerfectNG-XXXX
 - o Password: incidence-ng
2. Open <http://192.168.4.1>.

What you get in web UI:

- Live ROLL/PITCH readout with the same status line as the device.
- Normal controls: ZERO, AXIS, FREEZE, ROTATE, OFFSET CAL, MODE, ALIGN.
- Context controls only when needed:
 - o CONFIRM/CANCEL during guided ZERO and OFFSET CAL
 - o CAPTURE/CANCEL during ALIGN
- Progress bar during:
 - o ZERO hold/sampling
 - o OFFSET CAL hold/sampling
 - o ALIGN capture windows
- Expandable diagnostics panel with grouped values:
 - o raw sensor vectors
 - o mapped vectors
 - o corrected vectors
 - o physics angles + conditioning
 - o calibration references (bias/zero/align)

Important:

- Web, touch, serial, and ACTION button all share the same workflows and states.
 - If one interface starts a workflow, the other interfaces should reflect it.
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8) Troubleshooting

Touch Feels Hard To Trigger

- Use ACTION button alternatives for critical actions.
- Try deliberate taps (not swipes) centered on the button.

Serial Monitor Doesn't Resume After Reset

- Some setups require closing/reopening the serial monitor after reset.
- Always report the firmware version shown on splash if you see inconsistent serial behavior.

MODE Doesn't Apply

- MODE is immediate in current firmware.
- If orientation does not change, verify command source:
 - touch MODE,
 - serial m/u/v,
 - ACTION very-long press.

9) Measurement Math (How It Works)

This device estimates orientation from gravity measured by the accelerometer and short-term rate from the gyro.

Accelerometer Tilt Angles

In the tool frame (ax , ay , az), the firmware computes:

```
roll_acc = atan2(ay, az)
pitch_acc = atan2(-ax, sqrt(ay^2 + az^2))
```

Then values are converted to degrees.

Why pitch uses $\sqrt{ay^2 + az^2}$:

- It uses the gravity component orthogonal to the pitch axis.
- This reduces cross-coupling from roll.
- It stays better conditioned as pitch approaches large angles.

Sensor Fusion

The live angles are fused with a complementary filter:

- Gyro integration gives smooth short-term motion response.
- Accelerometer tilt gives long-term absolute reference to gravity.

This combination is stable and responsive for field use.

Why Roll Becomes Weak Near +/-90 deg Pitch

Near pitch +/-90 deg, gravity aligns mostly with one axis, so roll information in the other components becomes very small. At that geometry, roll is effectively underdetermined from gravity alone.

Current firmware behavior:

- Above about $|\text{pitch}| > 80$ deg, roll is intentionally attenuated to avoid unstable swings.

Practical Guidance For Large-Angle Work

For tasks near vertical (for example checking a table-saw blade relative to the table):

1. Use the orientation/mode that makes your primary measurement axis map to PITCH.
 2. Switch AXIS to PITCH for focus.
 3. Run OFFSET CAL and ZERO in the same physical setup/orientation you will measure in.
 4. Treat ROLL near +/-90 deg as secondary information.
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10) Beta Tester Checklist + Feedback

If you're testing externally, use:

- `../release/beta-checklist.md`
- `../release/tester-handoff-note.md`

When reporting an issue, include:

1. Firmware version (from splash)
 2. Exact steps to reproduce
 3. Expected vs actual result
 4. Photos/video if UI-related
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Appendix A: Hardware Notes

For reference bring-up settings (Arduino IDE), see:

- `../hardware/board-settings.md`
 - `../hardware/board-settings-arduino-ide.jpg`
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Authorship

This firmware and UI were developed by **Per Takman**, with assistance from **OpenAI Codex (Codex CLI)**.

License And Warranty

- The project source code is released under the MIT License.
- The software is provided "AS IS", without warranty of any kind.
- Third-party manuals, schematics, and library dependencies remain under their respective original licenses/terms.