ALP LAB

E1M-AEN EMC Pre-Compliance Assessment

Standards, test plan & emitter risk assessment

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1 Purpose & Status

The E1M-AEN is a **System-on-Module (a component)**, not finished equipment. Under the EMC Directive (2014/30/EU) and equivalent regimes, **EMC compliance is demonstrated on the final host product**, not on the module in isolation. This document exists to **de-risk that host-level test**: it identifies the module's likely emission sources from the design, gives integrators a ready test plan, and will carry Alp Lab's own **pre-compliance bench results** once measured.

What this document can and cannot contain: The standards, test plan and **emitter risk assessment** (Section 4) are derived from the netlist and are complete. The **measured emission/immunity results** (Section 6) are **not predictable** — they depend on the host board, cabling and enclosure and can only be obtained on an EMC bench. Those sections are placeholders until a pre-compliance scan is run. This document does not constitute a Declaration of Conformity to the EMC Directive.

This assessment applies to E1M-AEN module hardware revision R3.

2 Applicable Standards

The governing standard is set by the **host product's** market and class. For an industrial host the generic standards apply; for IT/multimedia, the CISPR 32/35 pair. Both are listed; the integrator selects per their product.

Aspect	Industrial	IT / multimedia
Emissions	EN IEC 61000-6-4	EN 55032 (CISPR 32)
Immunity	EN IEC 61000-6-2	EN 55035 (CISPR 35)
Radio (Wi-Fi/BLE, 2.4 GHz)	EN 300 328 + EN 301 489-1 / EN 301 489-17 (RED 2014/53/EU)	same
North America	FCC Part 15 B (unintentional) + Part 15.247 (2.4 GHz Wi-Fi / BLE)	same

Table 1 Candidate EMC standards (host-product dependent)

Note: The on-module Wi-Fi/BLE radio (BDE-BW3501N, 2.4 GHz) is an **intentional radiator**. Its modular FCC/ISED/RED approvals are **pending** (see DS-AEN-001, Regulatory Information). Once granted, the integrator inherits them **subject to the module's integration conditions** (antenna type/gain, labelling, host-port limits). The unintentional-emitter assessment below excludes the radio's intentional transmissions.

3 Pre-Compliance Test Plan

Test	Method	Setup notes
Radiated emissions	CISPR 32 / 61000-6-4, 30 MHz–6 GHz	Upper limit to 6 GHz: internal clocks and Gbit-class MIPI lanes above 108 MHz (CISPR 32 upper-frequency rule), and the 2.4 GHz Wi-Fi/BLE harmonics. Near-field probe scan first, then chamber.
Conducted emissions	CISPR 32 / 61000-6-4, 150 kHz–30 MHz	On the 5 V DC input and any host I/O leaving the enclosure; LISN / cap-voltage-probe on the DC rail.
ESD immunity	IEC 61000-4-2, ±4 kV contact / ±8 kV air	Exposed connectors / host surfaces; verify SoM survives and recovers.

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Test	Method	Setup notes
Radiated RF immunity	IEC 61000-4-3, 3 V/m (10 V/m industrial)	Watch the analog/ADC, MIPI and Ethernet paths for upset.
EFT / burst	IEC 61000-4-4	DC power + signal ports.
Surge	IEC 61000-4-5	Host-level on external ports (not module-intrinsic).
Conducted RF immunity	IEC 61000-4-6, 3 V (10 V industrial)	Cabled ports.

Table 2 Pre-compliance test plan (host-representative fixture)

4 Emitter Risk Assessment (from netlist)

The following sources are ranked by likely contribution to radiated emissions, derived from the E1M-AEN clock tree and power architecture. This guides where to probe first and where layout/filtering effort pays off.

Source	Risk	Character & mitigation
DC-DC switchers (4 × buck: TPS62849, TPS628438, TPS6282533, TPS6282518)	High	Switching fundamental + broadband harmonics on power planes and inductor nodes. The two Wi-Fi-rail bucks run only while Wi-Fi is enabled. Keep hot loops tight; input/output filtering; shield/guard the SW nodes.
OSPI memory bus (flash + HyperRAM)	High	Fast wide parallel bus, high edge rate → broadband 100 MHz–1 GHz. Series-termination resistors (present); controlled-impedance routing; minimise stub length.
Ethernet: 50 MHz XO + DP83825 PHY	Med-High	Narrowband spurs at 50 MHz and harmonics; differential TX/RX edges. Guard the XO; common-mode chokes / magnetics at the host RJ45.
SoC core + 38.4 MHz HFXO	Medium	Core clock harmonics; HFXO fundamental. Decoupling (extensive MLCC present); keep crystal loop tight.
MIPI CSI/DSI high-speed lanes	Medium	Gbit-class differential serial; well-contained if matched/length-controlled, but a radiator if stubs/imbalance exist.
USB 2.0 (high-speed, 480 Mbit/s)	Low-Med	Edge-rate broadband on D±; common-mode choke at host port.
Backlight boost converter (KTD2801, 1 MHz)	Medium	Step-up switch node up to 36 V and LED current loop leaving the module on the backlight pads. Keep the carrier LED return tight; filter or shield the backlight cable; scan with the backlight on.
32.768 kHz RTC	Low	Low frequency, low energy; negligible radiator.

Table 3 Unintentional-emitter risk ranking

> **Note:** **Highest-leverage targets:** the four buck regulators and the OSPI memory bus dominate the broadband risk; the 50 MHz Ethernet clock dominates the narrowband risk. A near-field probe pass over these three areas is the fastest route to an early pre-compliance read before chamber time is booked.

5 Integrator Mitigation Checklist

1. **Power entry:** filter the 5 V input at the host connector (π-filter / ferrite); the module's bulk MLCCs handle local decoupling but not host-cable common mode.
2. **Ethernet:** use a magnetics/MagJack with integrated common-mode chokes; keep the 50 MHz XO away from board edges and connectors.

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3. **Enclosure:** a conductive enclosure or shield can over the buck + OSPI region is the single most effective radiated-emissions fix if the near-field scan flags it.
4. **Cabling:** treat every cable leaving the enclosure as an antenna — common-mode chokes on high-speed and power cables.
5. **Wi-Fi:** respect the module's antenna and keep-out integration conditions to retain the modular radio approval.

6 Measured Pre-Compliance Results

> **Note: Pending bench characterisation.** Radiated-emission and conducted-emission limit-line plots, immunity pass/fail, and the margin to the selected class limits are inserted here after a pre-compliance scan on a host-representative fixture. Until then no measured EMC performance is claimed.

7 Limitations

1. **Module, not product.** Formal EMC compliance is the host product's responsibility; this assessment is design-level support, not a DoC.
2. **Predicted, not measured (§4–5).** The risk ranking is analytical; only a bench scan produces compliance evidence (§6).
3. **Host-dependent.** Real emissions depend on the carrier board, cabling, enclosure and software activity — all outside the module.
4. **Radio handled separately.** Intentional Wi-Fi/BLE emissions follow the module's modular RED/FCC/ISED approvals (pending), not this unintentional-emitter assessment.

8 Revision History

Revision	Changes	Date
0.1	• Initial pre-compliance scaffold: applicable standards, test plan, and netlist-derived emitter risk assessment (bucks + OSPI + 50 MHz Ethernet dominant). • Measured results pending bench characterisation.	June 2026
0.2	• Updated for module hardware revision R3: four buck converters, backlight boost converter added, radio standards limited to 2.4 GHz, USB 2.0 only.	October 2026
0.3	• Release history: every entry formatted as a bullet list.	October 2026
0.4	• Table of Contents: each entry links to its section; the front-matter lists are set tighter.	October 2026
0.5	• Product name on page 1 links to the product page on alplab.ai.	November 2026

Table 4 Document revision history

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