ALP LAB

I²C Bus Scanning and Sensor Bring-up

AN-001 · E1M and E1M-X SoMs

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1 Scope

This application note shows how to walk the on-EVK I²C bus, identify which peripherals respond, and read a first byte from a known device. It applies to **all** E1M and E1M-X SoMs through the Alp SDK™'s cross-family `<alp/peripheral.h>` I²C API.

Audience	Firmware engineers writing their first peripheral driver against the SDK.
Prerequisites	**QS-E1M-EVK-001** or **QS-E1M-X-EVK-001** completed (hello-world running).
Outcome	`i2c-scanner` running on the EVK, printing a list of responding addresses, including the on-board current monitors.
Time	10 minutes.
Source	`examples/peripheral-io/i2c-scanner/` and `docs/tutorials/02-i2c-scan.md` in alp-sdk.

Table 1 Scope summary

2 Hardware Setup

No external wiring is required — the EVKs already populate devices on the primary sensor bus, exposed portably as `BOARD_I2C_SENSORS` (`E1M_I2C0` on the E1M EVK, `E1M_X_I2C0` on the E1M-X EVK).

A SoM carries two separate I²C buses, and the scanner in this note walks only the first:

- **The sensor bus** (`BOARD_I2C_SENSORS`): the SoM's 24C128 identity EEPROM plus the carrier's own parts. This is the bus the example scans.
- **The on-module board bus** (`BRD_I2C`): the SoM's housekeeping devices (TMP112 temperature sensor, RV-3028-C7 RTC, and on E1M-X the clock generator, supervisor bridge and PMICs). These do **not** appear in the scan.

EVK + SoM	Devices that answer the scan
E1M EVK + AEN801	On-module (`E1M_I2C0`, pads AD2 / AE2): 24C128 identity EEPROM only, answering at `0x50` and `0x58` (`0x58` is the identity page and factory Unique ID of the same chip; do not use `0x50` or `0x58` for carrier devices). On-board (E1M EVK): six INA236 current monitors (`0x40`, `0x41`, `0x42`, `0x49`, `0x4A`, `0x4B`) and two INA228 module-supply monitors (`0x43`, `0x47`), see Table 3, and the TAS2563 amplifier pair (U27 `0x4D`, U28 `0x4E`, `0x48` broadcast; addresses from the four-level `AD0` straps: 10 kΩ to 0 V on U27, 10 kΩ to `+VIO_SW` on U28; confirm with a scan). The E1M EVK carries no IMU, barometer or I/O expander. The current monitors answer on this bus only when slide switch S6 is set to the module-bus (`I2C0`) position. The amplifiers answer only while `AMP.ENABLE` (pad AG16) is driven high: it has a 100 kΩ pull-down, so by default both are in hardware shutdown.
E1M-X EVK + V2N101	On-module (`E1M_X_I2C0`): 24C128 identity EEPROM at `0x50` (and its identity page at `0x58`). On-board (X-EVK): TCAL9538 main I/O expander (`0x73`) and PCIe I/O expander (`0x71`), INA236 current-monitor array, and the sensors listed in the **E1M-X EVK User Guide**.

Table 2 Expected I²C bus map on `BOARD_I2C_SENSORS` per EVK (7-bit addresses)

Monitor	Rail	Address
U21 INA236	+3V3	`0x40`
U31 INA236	+1V8	`0x41`
U33 INA236	`+VIO_SW`	`0x42`
U29 INA228	Module 5 V supply, high range (0.1 Ω shunt)	`0x43`
U53 INA228	Module 5 V supply, low range (10 Ω shunt)	`0x47`

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Monitor	Rail	Address
U34 INA236	+V_CAM1	0x49
U30 INA236	+5V	0x4A
U32 INA236	+V_CAM0	0x4B (0x48 on pre-respin boards)

Table 3 E1M EVK current monitors on alp-i2c0

The INA236A address bank is 0x40–0x43 (this board uses 0x40–0x42) and the INA236B bank is 0x48–0x4B (this board uses 0x49–0x4B). The two INA228 parts sit at 0x43 and 0x47, so 0x43 is the INA228 U29, not an INA236A. No two monitors share an address. The E1M EVK has no TCAL9538 I/O expander fitted, so nothing answers at 0x71 or 0x73 on this board.

> **Warning:** **Pre-respin E1M EVK boards.** On those boards the +V_CAM0 monitor sits at 0x48, the same address as the TAS2563 hardware broadcast page-write address. The monitor is then unreadable. Firmware that must support both board revisions should issue two targeted writes to the individual amplifier addresses (0x4D, 0x4E) instead of using the 0x48 broadcast. Do not assume a 0x48 ACK is a TMP112: the TMP112 is at 0x40 on the on-module board bus, not on this bus.

SoM	Devices (7-bit addresses)
E1M-AEN801 / E1M-AEN803	TMP112 temperature sensor (0x40), RV-3028-C7 RTC (0x52). No E1M-AEN SKU fits the OPTIGA Trust M, so nothing ACKs at 0x30 on any E1M-AEN module. On hw_rev R3 modules the RTC address (0x52) is unchanged for firmware.
E1M-X V2N (e.g. V2N101)	OPTIGA Trust M (0x30), TMP112 (0x40), RV-3028-C7 RTC (0x52), 5L35023B clock generator (0x69), GD32G553 supervisor bridge (0x70), ACT8760 PMIC pages (0x25 / 0x26), DA9292 PMIC (0x1E), TPS628640 (0x4D, optional).
E1M-X V2N-M1 (V2M)	As V2N, plus the three DEEPX-rail TPS628640 instances at 0x44, 0x48 and 0x4F (see AN-009).

Table 4 On-module board bus (BRD_I2C) devices — not part of the scan

> **Warning:** **Do not blind-scan BRD_I2C on E1M-AEN.** Probe the on-module board bus only with a targeted, per-device access (for example a single read of the TMP112 at 0x40), never by walking every address. **On E1M-X V2N and V2N-M1, BRD_I2C belongs to the Cortex-A55 (Linux)** — the Cortex-M33 must not master it, and a scan from M33 firmware would collide with the PMICs the A55 and U-Boot manage.

The full populated-parts list per SoM lives in metadata/e1m_modules/<SKU>.yaml in the SDK.

3 Software Walkthrough

Step	Command
1. Build	tan build --project examples/peripheral-io/i2c-scanner --sdk-root <alp-sdk> (the target comes from som.sku in the example's board.yaml, e.g. E1M-AEN801 → alp_e1m_aen801_m55_hp)
2. Flash	tan flash examples/peripheral-io/i2c-scanner
3. Watch console	tio -b 115200 <serial-port> (see **QS-** guide for the per-OS device name)

Table 5 Build / flash / run

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Build through `tan` as shown rather than invoking `west build -b` with a bare board name: under Zephyr 4.x the board target needs its full SoC and cluster qualifier, which `tan` resolves from `som.sku`. The target strings for reference are `alp_e1m_aen801_m55_hp` for AEN and `alp_e1m_v2n101_m33_sm` for V2N (see your EVK Getting Started Guide).

The scanner opens `BOARD_I2C_SENSORS` at 100 kHz via `alp_i2c_open()` and walks 7-bit addresses `0x08`–`0x77`. At each address it issues a single 1-byte `alp_i2c_read()` probe — a present chip ACKs its address byte (the data is discarded), an empty address NACKs — and prints a row for every responder. A 1-byte read is used rather than a zero-length write because some controllers (e.g. the DesignWare I^{2}C on the Alif Ensemble) put nothing on the bus for a zero-length transfer, so no device would ever ACK.

> **Note: E1M EVK I^{2}C timing.** The monitors at `0x42` (U33) and `0x4A` (U30) have `A0` strapped to SDA; TI requires at least 100 ns of SDA hold time for them. Configure the bus master's SDA hold time accordingly.

4 Expected Output

```
[i2c] open BOARD_I2C_SENSORS @ 100 kHz
[i2c] addr 0x40 acked   (INA236, EVK)
[i2c] addr 0x41 acked   (INA236, EVK)
[i2c] addr 0x42 acked   (INA236, EVK)
[i2c] addr 0x43 acked   (INA228, EVK)
[i2c] addr 0x47 acked   (INA228, EVK)
[i2c] addr 0x48 acked   (TAS2563 broadcast, EVK)
[i2c] addr 0x49 acked   (INA236, EVK)
[i2c] addr 0x4a acked   (INA236, EVK)
[i2c] addr 0x4b acked   (INA236, EVK)
[i2c] addr 0x4d acked   (TAS2563, EVK)
[i2c] addr 0x4e acked   (TAS2563, EVK)
[i2c] addr 0x50 acked   (24C128 EEPROM, on-module)
[i2c] addr 0x58 acked   (24C128 EEPROM identity page, on-module)
[i2c] scan complete, 13 responder(s)
[i2c] done
```

The above is the `alp_e1m_aen801_m55_hp` + E1M EVK case (the device names in parentheses are annotations — the scanner reports addresses only, not chip identities). The exact set depends on the EVK + SoM combination. Any device listed in **Table 2** for your EVK that is missing from the scan is a wiring or power issue. On a 2641-R3 E1M EVK with E1M-AEN801, slide switch S6 in the module-bus position and the amplifiers enabled (AG16 high), the scan reports 13 responders: the two EEPROM addresses plus the 11 carrier addresses above (the `0x48` row is the TAS2563 broadcast address, not an extra part). With the amplifiers in their default shutdown state the three TAS2563 rows are missing (10 responders); with S6 in the RP2040 position the eight monitor rows are missing as well.

5 Troubleshooting

Symptom	Likely cause / fix
Empty scan (no ACKs)	Pull-ups missing. The SoM's `I2C0_SCL` / `I2C0_SDA` need pull-ups to the module I/O level (4.7 kΩ to `VIO_OUT` is typical on a custom carrier). On the E1M EVK they are fitted: R279 and R122, 2.2 kΩ to `+VIO_SW`.
Only on-module devices ACK, no carrier sensors	`VIO_OUT` is up but the carrier-side sensor power gate is off. On the E1M-X EVK this is controlled by the TCAL9538 I/O expander at `0x73` (output bit TBD).
Bus locks up mid-scan	Pull-down on SDA or SCL (shorted trace, dead sensor). Probe both lines with a scope; idle state should be 1V8.

Table 6 Common failures

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6 References

- **Canonical tutorial**: `docs/tutorials/02-i2c-scan.md` in alp-sdk.
- **Example source**: `examples/peripheral-io/i2c-scanner/` in alp-sdk.
- **SDK API**: `<alp/peripheral.h>` (`alp_i2c_open` / `alp_i2c_read` / `alp_i2c_write` / `alp_i2c_close`).
- **Per-SoM populated parts**: `metadata/e1m_modules/<SKU>.yaml` in alp-sdk.
- **EVK Getting Started**: **QS-E1M-EVK-001** (E1M EVK), **QS-E1M-X-EVK-001** (E1M-X EVK).

7 Revision History

Revision	Changes	Date
0.1	• Initial draft. • Customer-facing reference card pointing at the SDK tutorial as canonical source.	May 2026
0.2	• Re-synced to current alp-sdk: ▸ example path `examples/peripheral-io/i2c-scanner/` ▸ API header `<alp/i2c.h>` → `<alp/peripheral.h>` (`alp_i2c_open/read/write/close`) ▸ V2N board target `alp_e1m_v2n101_m33_sm` ▸ bus named `BOARD_I2C_SENSORS` ▸ corrected I²C bus maps and expected scanner output against `docs/tutorials/02-i2c-scan.md` and `metadata/` (TMP112 `0x48` on AEN, DA9292 `0x1E` on V2N, TCAL9538 `0x72` I/O expander) ▸ scanner described as a 1-byte read probe.	June 2026
0.3	• Corrected the E1M-X EVK + V2N101 bus map: TMP112 was listed at `0x40`, which the part cannot strap to — its ADD0 strap only permits `0x48–0x4B`, and `0x40–0x46` is the INA236 array's range. • Corrected to `0x48`, matching the SDK's own bus model. • Updated the AEN board target to `alp_e1m_aen801_m55_hp` (no AEN701 board wrapper exists). • Fixed the Alp SDK repository links (`alpDevs` → `alplabai`).	July 2026
0.4	• Re-verified against Alp SDK™ v0.17.0. • Separated the sensor bus (`BOARD_I2C_SENSORS`, what the scanner walks) from the on-module board bus (`BRD_I2C`). • Corrected the TMP112 address to `0x40` on every module (the `0x48` value in earlier revisions was wrong, and the INA236 range quoted in revision 0.3 as the reason for that value was wrong too: the INA236 monitors sit in the `0x40–0x43` and `0x48–0x4B` banks, not `0x40–0x46`). • Corrected the 5L35023B clock generator to `0x69` and the TCAL9538 I/O expander to `0x73` on both EVKs. • Added the E1M EVK INA236 address map and the pre-respin `0x48` collision with the TAS2563 broadcast address. • OPTIGA Trust M is not fitted on E1M-AEN801 / E1M-AEN803. • Added the V2N-M1 DEEPX-rail TPS628640 addresses, the 15-responder scan result, and the warnings not to blind-scan `BRD_I2C` on E1M-AEN and that `BRD_I2C` belongs to the A55 on V2N. • Build command now takes `--sdk-root`.	October 2026
0.5	• E1M EVK I²C map aligned with the 2641-R3 netlist. • Added the INA228 module-supply monitors U29 (`0x43`) and U53 (`0x47`); `0x47` was previously listed as a BMP581. • Removed the BMI323 (`0x68`), ICM-42670 (`0x69`), BMP581 and TCAL9538 (`0x73`): none of them is fitted on the E1M EVK.	October 2026

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Revision	Changes	Date
	• `+VIO` renamed to `+VIO_SW`; the current monitors reach the module bus only with slide switch S6 in the module-bus position. • TAS2563 addresses confirmed as `0x4D` (U27) / `0x4E` (U28) from the 2641-R3 `AD0` straps and TAS2563 Table 7-3; the amplifiers answer only while `AMP.ENABLE` (AG16) is high. • EVK `I2C0` pull-ups corrected to 2.2 kΩ to `+VIO_SW`. • Added the SDA hold-time note for the monitors with `A0` strapped to SDA (`0x42`, `0x4A`). • Expected scan: 13 responders with S6 on the module bus and the amplifiers enabled.	
0.6	• On-module board bus table: no E1M-AEN SKU fits the OPTIGA Trust M (DS-AEN-001 0.13), so nothing ACKs at `0x30` on any E1M-AEN module; the E1M-AEN801 / E1M-AEN803 row no longer implies that other E1M-AEN SKUs fit it. The targeted-access example in the `BRD_I2C` warning is a TMP112 read (was the `aen-secure-element-sign` example, which addresses a part no E1M-AEN fits).	October 2026
0.7	• Release history: every entry formatted as a bullet list.	October 2026
0.8	• Product name on page 1 links to the product page on alplab.ai.	November 2026

Table 7 Revision History

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