Microwatt Secure Boot Debug Report

This document summarizes the debugging and development progress of the **Microwatt Secure Boot** project. It captures the key issues encountered, their causes, fixes, and a few technical insights to help beginners understand the full bring-up process — from environment setup to simulation success.

1 Initial Setup and Environment

Issues and Fixes:

- **Issue:** GHDL failed to locate standard Unisim components on Ubuntu 22.04.
- **Cause:** The default GHDL installation did not include the LLVM backend.
- **Fix:** Switched to Ubuntu 24.04 and later containerized the setup using Docker for reproducibility.

  Error Snippet:

  ```
  ghdl-llvm:error: cannot open sim-unisim/unisim_vcomponents.vhdl
  ```

  Other Issues:

  - OS package mismatches (missing LLVM-18).
  - Non-reproducible builds on different systems.

2 Docker Setup

Issues and Fixes:

- **Issue:** Installing `pyserial` via pip3 caused an environment restriction error.
- **Cause:** Ubuntu 24.04 enforces PEP 668 (externally managed Python).
- **Fix:** Installed `python3-serial` via apt instead of pip.

  Error Snippet:

  ```
  error: externally-managed-environment
  ```

  Other Issues:

  - Docker image built but did not open interactive shell after build.
  - Fixed by adding container run command in Makefile's docker target.

3 Simulation Build System

Issues and Fixes:

- **Issue:** Compilation order in `sim_build.sh` caused dependency failures.
- **Cause:** User-defined files were analyzed before core Microwatt modules.
- **Fix:** Adjusted order — Microwatt core first, custom hardware next, then testbench.

Error Snippet:

```
third_party/microwatt/icache.vhdl:312:31:error: unit "predecoder"
    not found in library "work"
```

Other Issues:

- Added auto-cleaning of old work directories.
- Integrated build/run flow under single Makefile command.

4 VHDL Syntax and Structural Errors

Issues and Fixes:

- **sha256_wb.vhdl:** Array declaration error fixed using named subtype.
- **tb_top.vhdl:** Non-ASCII em dash replaced with standard hyphen.

Error Snippets:

```
type mark expected in a subtype indication
invalid character not allowed, even in a string
```

Other Issues:

- Minor warnings about signal initialization order.
- Cleaned syntax for GHDL 0.39+ compliance.

5 Microwatt Core Integration

Issues and Fixes:

- **Issue:** Unresolved entity reference to `core`.
- **Cause:** Missing compile order and incorrect library binding.
- **Fix:** Added Microwatt core files before top-level and verified using `grep "entity core"`.

Error Snippet:

```
unit "core" not found in library "work"
```

Other Issues:

- Missing `insn_helpers`, `predecoder`, and OSVVM dependency.
- Fixed by installing `ghdl-osvvm` and updating build paths.

6 Top-Level Integration

Issues and Fixes:

- **Issue:** Mismatched Wishbone port naming.
- **Cause:** Microwatt uses record-based Wishbone interfaces, not flat signals.
- **Fix:** Used `wishbone_data_out.adr`, `.dat`, and defined intermediate signals.

Error Snippet:

```
actual must be a static name
```

Other Issues:

- Added 32-bit address resizer.
- Cleaned non-static expressions in signal assignments.

7 Simulation and Runtime Behavior

Issues and Fixes:

- **Issue:** Simulation appeared stuck for 20 minutes.
- **Cause:** Full Microwatt bring-up typically takes several hours in interpreted mode.
- **Fix:** Verified progress via instruction trace logs and confirmed normal CPU activity.

Error Snippet:

```
core_debug.vhdl:375: Assertion violation
NUMERIC_STD.TO_INTEGER: metavalue detected, returning 0
```

Other Issues:

- Assertion warnings from uninitialized memory regions.
- Decode errors until boot ROM firmware integration.

8 Current Status and Next Steps

- Stable Docker environment with Ubuntu 24.04 + LLVM-18 + GHDL-LLVM.
- Microwatt core + SHA-256 + top + testbench compile successfully.
- Simulation runs with expected warnings.
- Next: integrate boot payload, add UART output verification.