Mastering Embedded C Debugging

- "Debugging embedded code isn't just stepping through breakpoints—it's an art."
- From Rookie Mistakes to Pro Techniques

The Golden Rule

- "Assume nothing. Verify everything."
- Your code might be perfect, but Murphy's Law governs embedded systems.
- Hardware and software bugs look identical until proven otherwise.

Level 1: The Fundamentals

- LED Debugging – Blink patterns are your first line of defense
- UART/Serial Logging – Your embedded printf() lifeline

Level 2: Hardware Reality Check

- Logic Analyzers – Protocol decoding, timing violations
- Oscilloscopes – Power supply noise, signal integrity
- Multimeters – Sometimes it's just a loose wire

Level 3: Advanced Forensics

- Assert Macros – Fail fast, fail clearly
- Post-Mortem Analysis – Stack trace capture, system snapshots
- JTAG/SWD with GDB – Hardware breakpoints, memory watchpoints

Assert Macro Example

```
• #define ASSERT(x) if(!(x)) {
•       log_error(__FILE__, __LINE__);
•       while(1);
• }
• // Usage:
• ASSERT(ptr != NULL);
• ASSERT(value < MAX_LIMIT);
• ASSERT(state == READY_STATE);
```

Level 4: Proactive Debugging

- Unit Testing – HALs, mock interfaces
- Static Analysis Tools – PC-Lint, Cppcheck, Coverity
- Code Coverage Analysis – What paths aren't tested?

Pro Tips from the Trenches

- Build Debug Hooks Early – Add test points and debug pins
- Version Everything – HW, FW, toolchain versions
- Reproduce First – Can't fix what you can't reproduce
- Power Supply First – Many 'bugs' are power issues

The Debugging Mindset

- Start with the simplest explanation
- Question your assumptions constantly
- Hardware/software bugs look identical until proven otherwise
- The bug is in the last place you expect
- Prevention > Detection > Correction

ROI Reality Check

- 1 hour debugging in dev = 10 hours saved in field
- Logging infra pays for itself after the first field issue

Key Takeaways

- Systematic debugging approach is key
- Use right tool for the right problem
- Start simple, escalate to complex tools
- Document everything – quirks today, bugs tomorrow
- Best engineers = hardware detectives

Thank You!

- "Questions & Discussion"
- What's your favorite embedded debugging war story?
- #EmbeddedSystems #FirmwareEngineering #DebuggingTips #EmbeddedC