Debugging the PineCone

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Additional requirements

To debug errors on the PineCone you need the following additional hardware:

- USB-JTAG adapter (like in Figure 1)
- Five female-male wires

For debugging purposes, the PineCone implements the JTAG protocol. This is a serial protocol that was developed to debug integrated circuits. The USB-JTAG adapter allows us to connect our PC with a device understanding the JTAG protocol.

Debugging with GDB and OpenOCD

To debug the PineCone using JTAG, we must connect the PineCone to your computer using USB. This cable is used to power the PineCone and can be used to flash applications on it. Furthermore, you must connect the USB-JTAG-adapter to your PC. Then, connect the following JTAG pins exposed by the adapter to the following GPIO pins of the PineCone:

- The JTAG pin TDO is connected to the IO pin 11.
- JTAG pin TMS is connected to IO pin 12.
- JTAG pin TCK is connected to IO pin 14.
- JTAG pin TDI is connected to IO pin 17.
- The ground pin of the JTAG adapter is connected to a ground pin of the PineCone.

Now your setup should similar to the one in Figure 2.

Besides setting up this connection, you need one more software tool, OpenOCD. This tool is used to remotely debug SoCs. Download OpenOCD from GitHub[1] and place it under `toolchain/openocd`.

Once you downloaded OpenOCD and the PineCone is connected to the PC via USB and JTAG we can start debugging:

[1] `https://github.com/xpack-dev-tools/openocd-xpack/releases/tag/v0.12.0-6`

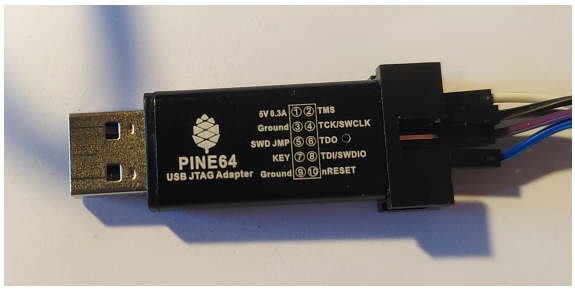

Figure 1: *USB-JTAG adapter.*

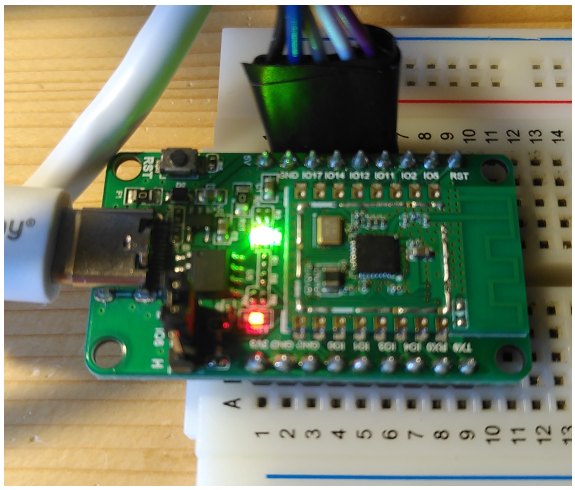

Figure 2: *PineCone connected to a PC via JTAG.*

1. Start OpenOCD:

```
./toolchain/openocd/bin/openocd -f ./tools/debug/openocd.cfg
```

2. Create a configuration for GDB (GNU Debugger):

```
cat > /tmp/gdb_tgt.cfg << EOF
target extended-remote :3333
EOF

cat ./tools/debug/602.init /tmp/gdb_tgt.cfg > /tmp/602.init
```

3. Start GDB:

```
./toolchain/compiler/bin/riscv32-unknown-elf-gdb -x /tmp/602.init --se=<ELF
    ↪ file>
```

   Where the ELF file is the file <project name>.elf inside the *build_out* directory of your project.

If you run Debian Trixie, you can also use the `debug.sh` script located in the `tools` directory. In this case, run the script from your project's root (`customer_app/project`):

```
../../tools/debug.sh
```

Then, you should have two terminal windows: one running OpenOCD and another one running GDB (similar to Figure 3). In the OpenOCD window you can see the connection state and with GDB you debug your program. The most important commands for GDB are the ones listed in Table 1 [2, pp. 7–10]. You can find more information about OpenOCD and GNU GDB in their manuals [1, 2].

`break <function>`	Sets a breakpoint for the given function, this means, the program is interrupted when the specified function is called. Then, you can enter further commands.
`run`	Starts running the specified program.
`c`	Continues running the program (e.g. after a breakpoint).
`n`	Runs the next line of code.
`s`	Steps into the next subroutine.
`l`	Shows up to the next 10 lines of code.
`bt`	Shows the backtrace (displays the stack for the currently running program part).
`p <variable>`	Prints the specified variable.
`p <variable> = <expression>`	Sets the variable to the given expression.
`lay next`	Switch layout of GDB.
`q`	Quits the session.

Table 1: *Most important GDB commands.*

Notes

Please note that the PineCone's LEDs are used by OpenOCD to indicate the connection status (a green LED means everything is alright). Consequently, you can not debug applications making use of the PineCone's internal LEDs. To debug those applications you either have to disable the LED usage by your application or you must remap the pins of the PineCone[2].

References

[1] The OpenOCD Project. *Open On-Chip-Debugger: OpenOCD User's Guide*. online. Dec. 2022. URL: `https://openocd.org/doc-release/pdf/openocd.pdf`.

[2] Richard Stallman, Roland Pesch, and Stan Shebs. *Debugging with GDB*. online. 2025. URL: `OpenOCD2022`.

[2] More information about pin remapping: `https://lupyuen.org/articles/openocd`

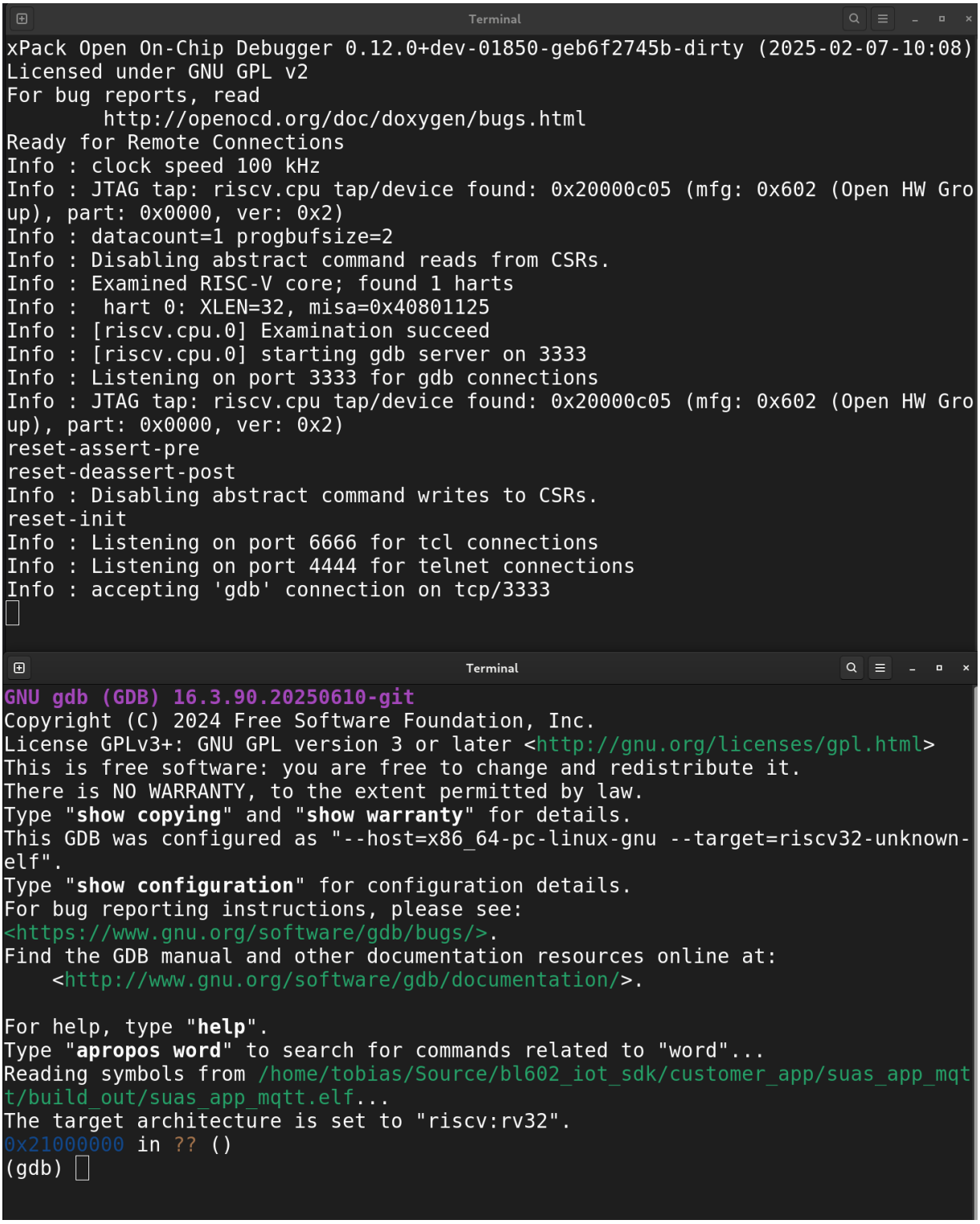

Figure 3: *PineCone connected to OpenOCD and GCB. Top: OpenOCD. The address `0x20000c05` refers to the PineCone. Bottom: GNU GDB.*