

PTX Tunneling Library-1.4.0 User Manual for Renesas e2studio

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1 Introduction

The PTX Tunneling library makes it very easy and fast to test and optimize the performance (antenna matching, system/RF configuration, etc.) of any custom-made device employing the PTX1xxR chip using SPI serial interface. Embedding this library into the firmware enables the translation of communication from **UART to SPI**, so that the full functionality of **PTX1xxR * Config Tool** can be used in a custom environment. This manual also provides a step-by-step tutorial to create a sample application using a [Renesas EK-RA4M2](#) development board.



2 Requirement

The footprint of the library is ~13kB Flash and 10kB RAM. Moreover, a hardware abstraction layer needs to be implemented by the user for the particular uC/Board, which executes the low-level commands requested by the library.

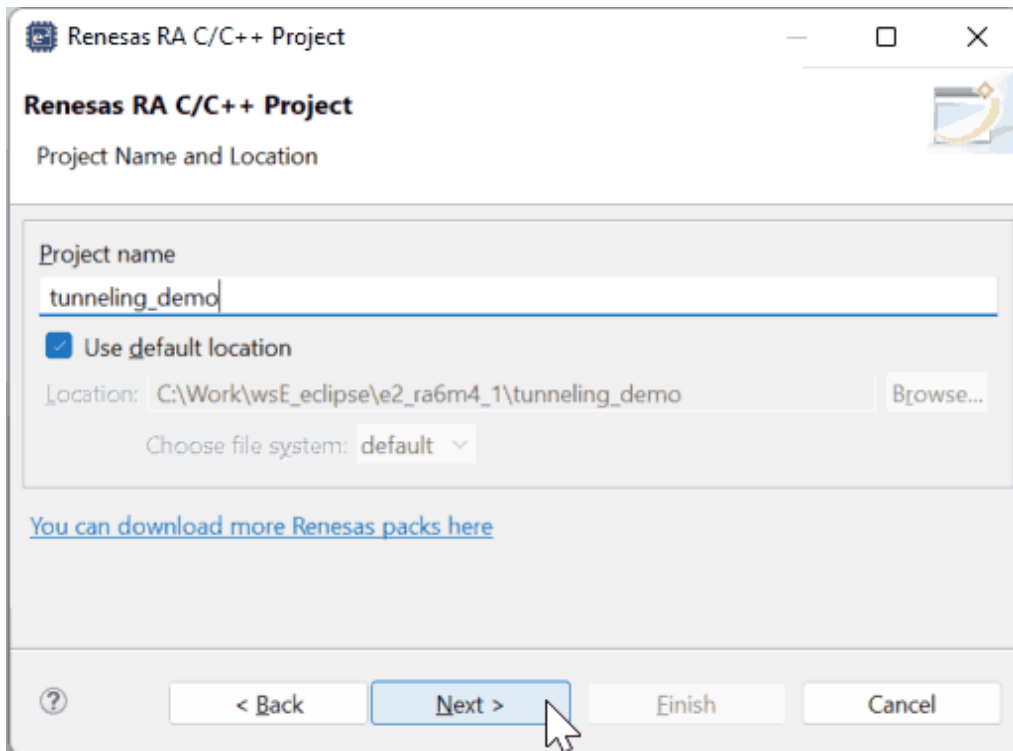
The library can be seamlessly integrated into a CMAKE project as well, please see [e2studio](#) is needed.

3 Sample firmware

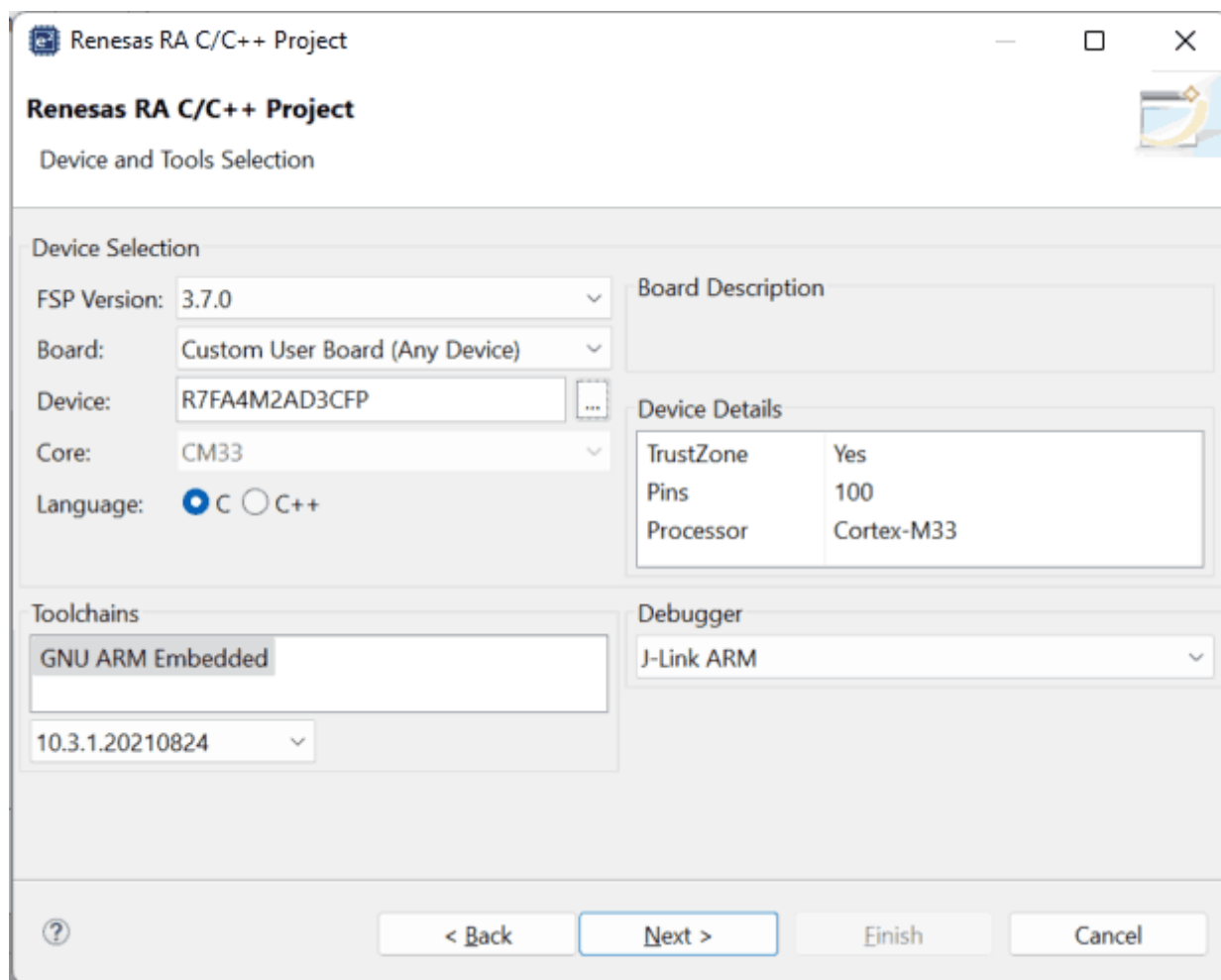
The sample application will have no other purpose than creating and serving the tunnel between the host PC UART interface and the PTX1xxR chip connected by SPI. The library can be used either as a precompiled static library or as a source-library, most steps are the same for both cases.

3.1 Creating the project

Please create a new project in *e2studio* from Menu **File** → **New** → **Renesas C/C++ Project** → **Renesas RA** with selecting **Renesas RA C/C++ Project**.



In the following step the device and board type can be selected.



The image shows the 'Renesas RA C/C++ Project' dialog box in the Renesas e2studio IDE. The dialog is titled 'Renesas RA C/C++ Project' and has a subtitle 'Device and Tools Selection'. It is divided into several sections: 'Device Selection', 'Board Description', 'Device Details', 'Toolchains', and 'Debugger'. In the 'Device Selection' section, 'FSP Version' is set to '3.7.0', 'Board' is 'Custom User Board (Any Device)', 'Device' is 'R7FA4M2AD3CFP', 'Core' is 'CM33', and 'Language' is set to 'C' with the radio button selected. The 'Board Description' section is empty. The 'Device Details' section shows 'TrustZone' as 'Yes', 'Pins' as '100', and 'Processor' as 'Cortex-M33'. The 'Toolchains' section shows 'GNU ARM Embedded' as the selected toolchain and '10.3.1.20210824' as the version. The 'Debugger' section shows 'J-Link ARM' as the selected debugger. At the bottom, there are four buttons: '< Back', 'Next >', 'Finish', and 'Cancel'. The 'Next >' button is highlighted.

Renesas RA C/C++ Project
Device and Tools Selection

Device Selection

FSP Version: 3.7.0
Board: Custom User Board (Any Device)
Device: R7FA4M2AD3CFP
Core: CM33
Language: ☒ C ☐ C++

Board Description

Device Details

TrustZone	Yes
Pins	100
Processor	Cortex-M33

Toolchains

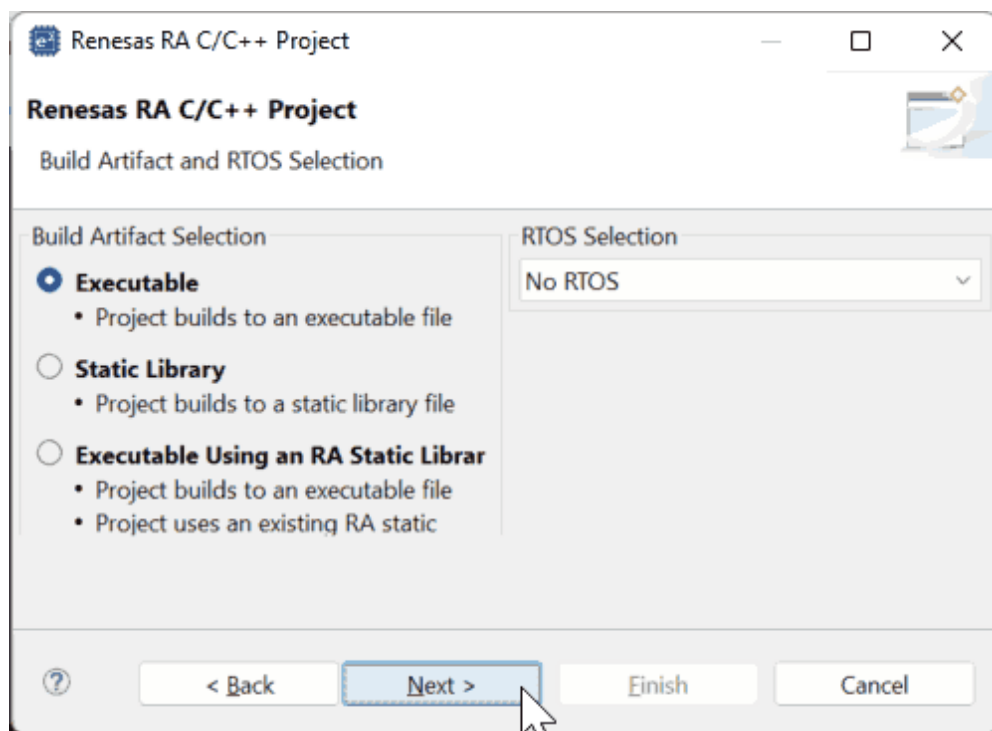
GNU ARM Embedded
10.3.1.20210824

Debugger

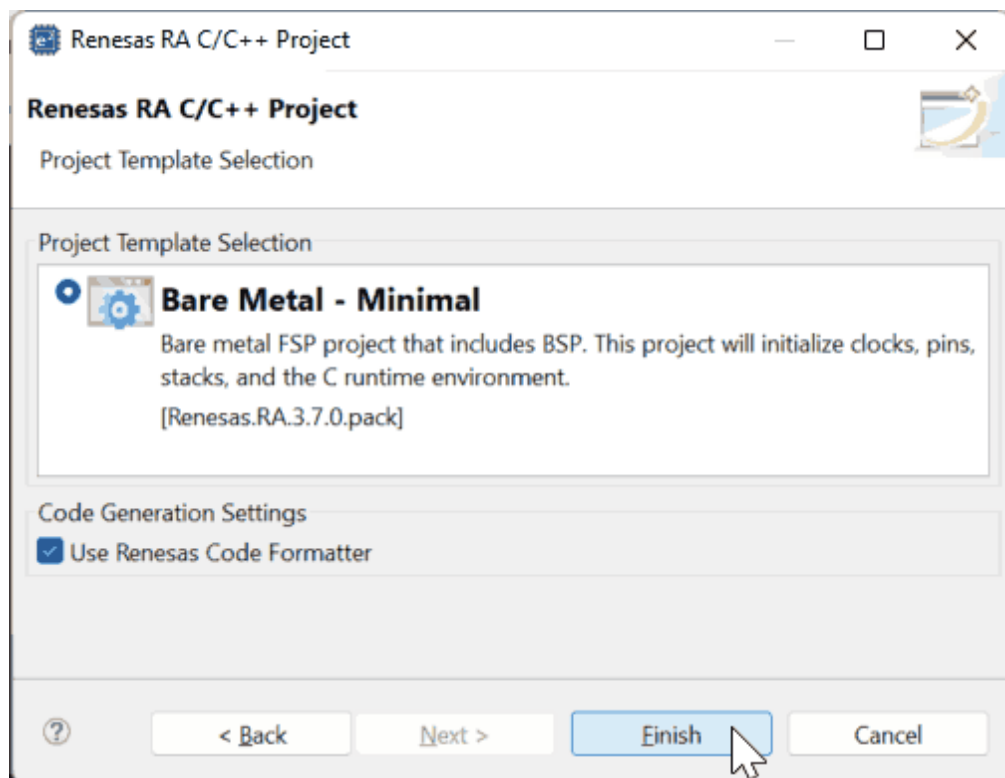
J-Link ARM

< Back Next > Finish Cancel

When asked, the project shall be a **Flat (Non-TrustZone) Project**. The project will have no operating system and will have a build artifact type of **Executable**



Finally, the **Bare Metal** template project could be selected, to create a minimal project.



3.2 Preparing peripherals

The generated empty project does not contain the required components from the SDK by default. For the demonstration, several peripherals and their drivers, like SPI, Timer, etc. need to be added to the project. The easiest way to do this is to open the file `configuration.xml` in a text editor and update its content to the following:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<raConfiguration version="7">
  <generalSettings>
    <option key="#Board#" value="board.custom"/>
    <option key="CPU" value="RA4M2"/>
    <option key="Core" value="CM33"/>
    <option key="#TargetName#" value="R7FA4M2AD3CFP"/>
    <option key="#TargetARCHITECTURE#" value="cortex-m33"/>
    <option key="#DeviceCommand#" value="R7FA4M2AD"/>
    <option key="#RTOS#" value="_none"/>
    <option key="#pinconfiguration#" value="R7FA4M2AD3CFP.pincfg"/>
    <option key="#FSPVersion#" value="3.7.0"/>
    <option key="#SELECTED_TOOLCHAIN#" value="gcc-arm-embedded"/>
    <option key="#ToolchainVersion#" value="10.3.1.20210824"/>
  </generalSettings>
  <raBspConfiguration>
    <config id="config.bsp.ra4m2.R7FA4M2AD3CFP">
      <property id="config.bsp.part_number" value="config.bsp.part_number.value"/>
      <property id="config.bsp.rom_size_bytes" value="config.bsp.rom_size_bytes.value"/>
      <property id="config.bsp.rom_size_bytes_hidden" value="524288"/>
      <property id="config.bsp.ram_size_bytes" value="config.bsp.ram_size_bytes.value"/>
      <property id="config.bsp.data_flash_size_bytes" value="config.bsp.data_flash_size_bytes.value"/>
      <property id="config.bsp.package_style" value="config.bsp.package_style.value"/>
    </config>
    <config id="config.bsp.ra4m2">
      <property id="config.bsp.series" value="config.bsp.series.value"/>
    </config>
    <config id="config.bsp.ra4m2.fsp">
      <property id="config.bsp.fsp.tz.exception_response" value="config.bsp.fsp.tz.exception_response.nmi"/>
      <property id="config.bsp.fsp.tz.cmsis.bfhfnmins" value="config.bsp.fsp.tz.cmsis.bfhfnmins.secure"/>
      <property id="config.bsp.fsp.tz.cmsis.sysresetreqs" value="config.bsp.fsp.tz.cmsis.sysresetreqs.secure_only"/>
      <property id="config.bsp.fsp.tz.cmsis.s_priority_boost" value="config.bsp.fsp.tz.cmsis.s_priority_boost.disabled"/>
      <property id="config.bsp.fsp.tz.csar" value="config.bsp.fsp.tz.csar.both"/>
      <property id="config.bsp.fsp.tz.rstsar" value="config.bsp.fsp.tz.rstsar.both"/>
      <property id="config.bsp.fsp.tz.bbfsar" value="config.bsp.fsp.tz.bbfsar.both"/>
    </config>
  </raBspConfiguration>
</raConfiguration>
```

```

    <property id="config.bsp.fsp.tz.sramsar.sramprcr" value="config.bsp.fsp.tz.sram
sar.sramprcr.both"/>
    <property id="config.bsp.fsp.tz.sramsar.sramecc" value="config.bsp.fsp.tz.srams
ar.sramecc.both"/>
    <property id="config.bsp.fsp.tz.stbramsar" value="config.bsp.fsp.tz.stbramsar.b
oth"/>
    <property id="config.bsp.fsp.tz.bussara" value="config.bsp.fsp.tz.bussara.both"
/>
    <property id="config.bsp.fsp.tz.bussarb" value="config.bsp.fsp.tz.bussarb.both"
/>
    <property id="config.bsp.fsp.cache_line_size" value="config.bsp.fsp.cache_line_
size.32"/>
    <property id="config.bsp.fsp.OFS0.iwdt_start_mode" value="config.bsp.fsp.OFS0.i
wdt_start_mode.disabled"/>
    <property id="config.bsp.fsp.OFS0.iwdt_timeout" value="config.bsp.fsp.OFS0.iwdt
_timeout.2048"/>
    <property id="config.bsp.fsp.OFS0.iwdt_divisor" value="config.bsp.fsp.OFS0.iwdt
_divisor.128"/>
    <property id="config.bsp.fsp.OFS0.iwdt_window_end" value="config.bsp.fsp.OFS0.i
wdt_window_end.0"/>
    <property id="config.bsp.fsp.OFS0.iwdt_window_start" value="config.bsp.fsp.OFS0
.iwdt_window_start.100"/>
    <property id="config.bsp.fsp.OFS0.iwdt_reset_interrupt" value="config.bsp.fsp.O
FS0.iwdt_reset_interrupt.Reset"/>
    <property id="config.bsp.fsp.OFS0.iwdt_stop_control" value="config.bsp.fsp.OFS0
.iwdt_stop_control.stops"/>
    <property id="config.bsp.fsp.OFS0.wdt_start_mode" value="config.bsp.fsp.OFS0.wd
t_start_mode.register"/>
    <property id="config.bsp.fsp.OFS0.wdt_timeout" value="config.bsp.fsp.OFS0.wdt_t
imeout.16384"/>
    <property id="config.bsp.fsp.OFS0.wdt_divisor" value="config.bsp.fsp.OFS0.wdt_d
ivisor.128"/>
    <property id="config.bsp.fsp.OFS0.wdt_window_end" value="config.bsp.fsp.OFS0.wd
t_window_end.0"/>
    <property id="config.bsp.fsp.OFS0.wdt_window_start" value="config.bsp.fsp.OFS0.
wdt_window_start.100"/>
    <property id="config.bsp.fsp.OFS0.wdt_reset_interrupt" value="config.bsp.fsp.OF
S0.wdt_reset_interrupt.Reset"/>
    <property id="config.bsp.fsp.OFS0.wdt_stop_control" value="config.bsp.fsp.OFS0.
wdt_stop_control.stops"/>
    <property id="config.bsp.fsp.OFS1.voltage_detection0.start" value="config.bsp.f
sp.OFS1.voltage_detection0.start.disabled"/>
    <property id="config.bsp.fsp.OFS1.voltage_detection0_level" value="config.bsp.f
sp.OFS1.voltage_detection0_level.280"/>
    <property id="config.bsp.fsp.OFS1.hoco_osc" value="config.bsp.fsp.OFS1.hoco_osc
.disabled"/>
    <property id="config.bsp.fsp.BPS.BPS0" value=""/>
    <property id="config.bsp.fsp.PBPS.PBPS0" value=""/>
    <property id="config.bsp.fsp.hoco_fll" value="config.bsp.fsp.hoco_fll.disabled"
/>
    <property id="config.bsp.common.main_osc_wait" value="config.bsp.common.main_os
c_wait.wait_8163"/>
    <property id="config.bsp.fsp.mcu.adc.max_freq_hz" value="500000000"/>

```

```

    <property id="config.bsp.fsp.mcu.sci_uart.max_baud" value="20000000"/>
    <property id="config.bsp.fsp.mcu.adc.sample_and_hold" value="0"/>
    <property id="config.bsp.fsp.mcu.sci_spi.max_bitrate" value="25000000"/>
    <property id="config.bsp.fsp.mcu.spi.max_bitrate" value="50000000"/>
    <property id="config.bsp.fsp.mcu.iic_master.rate.rate_fastplus" value="1"/>
    <property id="config.bsp.fsp.mcu.sci_uart.cstpen_channels" value="0x0219"/>
    <property id="config.bsp.fsp.mcu.gpt.pin_count_source_channels" value="0xFFFF"/>
  >
  </config>
  <config id="config.bsp.ra">
    <property id="config.bsp.common.main" value="0x400"/>
    <property id="config.bsp.common.heap" value="0"/>
    <property id="config.bsp.common.vcc" value="3300"/>
    <property id="config.bsp.common.checking" value="config.bsp.common.checking.disabled"/>
    <property id="config.bsp.common.assert" value="config.bsp.common.assert.none"/>
    <property id="config.bsp.common.error_log" value="config.bsp.common.error_log.none"/>
    <property id="config.bsp.common.soft_reset" value="config.bsp.common.soft_reset.disabled"/>
    <property id="config.bsp.common.main_osc_populated" value="config.bsp.common.main_osc_populated.enabled"/>
    <property id="config.bsp.common.pfs_protect" value="config.bsp.common.pfs_protect.enabled"/>
    <property id="config.bsp.common.c_runtime_init" value="config.bsp.common.c_runtime_init.enabled"/>
    <property id="config.bsp.common.early_init" value="config.bsp.common.early_init.disabled"/>
    <property id="config.bsp.common.main_osc_clock_source" value="config.bsp.common.main_osc_clock_source.crystal"/>
    <property id="config.bsp.common.subclock_populated" value="config.bsp.common.subclock_populated.enabled"/>
    <property id="config.bsp.common.subclock_drive" value="config.bsp.common.subclock_drive.standard"/>
    <property id="config.bsp.common.subclock_stabilization_ms" value="1000"/>
  </config>
</raBspConfiguration>
<raClockConfiguration>
  <node id="board.clock.xtal.freq" mul="24000000" option="_edit"/>
  <node id="board.clock.hoco.freq" option="board.clock.hoco.freq.20m"/>
  <node id="board.clock.loco.freq" option="board.clock.loco.freq.32768"/>
  <node id="board.clock.moco.freq" option="board.clock.moco.freq.8m"/>
  <node id="board.clock.subclk.freq" option="board.clock.subclk.freq.32768"/>
  <node id="board.clock.pll.source" option="board.clock.pll.source.xtal"/>
  <node id="board.clock.pll.div" option="board.clock.pll.div.3"/>
  <node id="board.clock.pll.mul" option="board.clock.pll.mul.250"/>
  <node id="board.clock.pll.display" option="board.clock.pll.display.value"/>
  <node id="board.clock.pll2.source" option="board.clock.pll2.source.disabled"/>
  <node id="board.clock.pll2.div" option="board.clock.pll2.div.2"/>
  <node id="board.clock.pll2.mul" option="board.clock.pll2.mul.200"/>
  <node id="board.clock.pll2.display" option="board.clock.pll2.display.value"/>
  <node id="board.clock.clock.source" option="board.clock.clock.source.pll"/>

```

```

<node id="board.clock.clkout.source" option="board.clock.clkout.source.disabled"/
>
<node id="board.clock.uclk.source" option="board.clock.uclk.source.disabled"/>
<node id="board.clock.iclk.div" option="board.clock.iclk.div.2"/>
<node id="board.clock.pclka.div" option="board.clock.pclka.div.2"/>
<node id="board.clock.pclkb.div" option="board.clock.pclkb.div.4"/>
<node id="board.clock.pclkc.div" option="board.clock.pclkc.div.4"/>
<node id="board.clock.pclkd.div" option="board.clock.pclkd.div.2"/>
<node id="board.clock.fclk.div" option="board.clock.fclk.div.4"/>
<node id="board.clock.clkout.div" option="board.clock.clkout.div.1"/>
<node id="board.clock.uclk.div" option="board.clock.uclk.div.5"/>
<node id="board.clock.iclk.display" option="board.clock.iclk.display.value"/>
<node id="board.clock.pclka.display" option="board.clock.pclka.display.value"/>
<node id="board.clock.pclkb.display" option="board.clock.pclkb.display.value"/>
<node id="board.clock.pclkc.display" option="board.clock.pclkc.display.value"/>
<node id="board.clock.pclkd.display" option="board.clock.pclkd.display.value"/>
<node id="board.clock.fclk.display" option="board.clock.fclk.display.value"/>
<node id="board.clock.clkout.display" option="board.clock.clkout.display.value"/>
<node id="board.clock.uclk.display" option="board.clock.uclk.display.value"/>
</raClockConfiguration>
<raComponentSelection>
  <component apiversion="" class="Common" condition="" group="all" subgroup="fsp_co
mmon" variant="" vendor="Renesas" version="3.7.0">
    <description>Board Support Package Common Files</description>
    <originalPack>Renesas.RA.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="HAL Drivers" condition="" group="all" subgroup="r
_ioport" variant="" vendor="Renesas" version="3.7.0">
    <description>I/O Port</description>
    <originalPack>Renesas.RA.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="CMSIS" condition="" group="CMSIS5" subgroup="Core
M" variant="" vendor="Arm" version="5.8.0+renesas.0.fsp.3.7.0">
    <description>Arm CMSIS Version 5 - Core (M)</description>
    <originalPack>Arm.CMSIS5.5.8.0+renesas.0.fsp.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="BSP" condition="" group="Board" subgroup="custom"
variant="" vendor="Renesas" version="3.7.0">
    <description>Custom Board Support Files</description>
    <originalPack>Renesas.RA_board_custom.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="BSP" condition="" group="ra4m2" subgroup="device"
variant="R7FA4M2AD3CFP" vendor="Renesas" version="3.7.0">
    <description>Board support package for R7FA4M2AD3CFP</description>
    <originalPack>Renesas.RA_mcu_ra4m2.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="BSP" condition="" group="ra4m2" subgroup="device"
variant="" vendor="Renesas" version="3.7.0">
    <description>Board support package for RA4M2</description>
    <originalPack>Renesas.RA_mcu_ra4m2.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="BSP" condition="" group="ra4m2" subgroup="fsp"
variant="" vendor="Renesas" version="3.7.0">

```

```

    <description>Board support package for RA4M2 - FSP Data</description>
    <originalPack>Renesas.RA_mcu_ra4m2.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="HAL Drivers" condition="" group="all" subgroup="r
_dtc" variant="" vendor="Renesas" version="3.7.0">
    <description>Data Transfer Controller</description>
    <originalPack>Renesas.RA.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="HAL Drivers" condition="" group="all" subgroup="r
_gpt" variant="" vendor="Renesas" version="3.7.0">
    <description>General PWM Timer</description>
    <originalPack>Renesas.RA.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="HAL Drivers" condition="" group="all" subgroup="r
_sci_spi" variant="" vendor="Renesas" version="3.7.0">
    <description>Serial Peripheral Interface on Serial Communications Interface</
description>
    <originalPack>Renesas.RA.3.7.0.pack</originalPack>
  </component>
  <component apiversion="" class="HAL Drivers" condition="" group="all" subgroup="r
_sci_uart" variant="" vendor="Renesas" version="3.7.0">
    <description>SCI UART</description>
    <originalPack>Renesas.RA.3.7.0.pack</originalPack>
  </component>
</raComponentSelection>
<raElcConfiguration/>
<raIcuConfiguration/>
<raModuleConfiguration>
  <module id="module.driver.ioport_on_ioport.0">
    <property id="module.driver.ioport.name" value="g_ioport"/>
    <property id="module.driver.ioport.elc_trigger_ioport1" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioport2" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioport3" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioport4" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioportb" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioportc" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioportd" value="_disabled"/>
    <property id="module.driver.ioport.elc_trigger_ioporte" value="_disabled"/>
    <property id="module.driver.ioport.pincfg" value="g_bsp_pin_cfg"/>
  </module>
  <module id="module.driver.uart_on_sci_uart.728447659">
    <property id="module.driver.uart.name" value="g_uart0"/>
    <property id="module.driver.uart.channel" value="2"/>
    <property id="module.driver.uart.data_bits" value="module.driver.uart.data_bits
.data_bits_8"/>
    <property id="module.driver.uart.parity" value="module.driver.uart.parity.parit
y_off"/>
    <property id="module.driver.uart.stop_bits" value="module.driver.uart.stop_bits
.stop_bits_1"/>
    <property id="module.driver.uart.baud" value="115200"/>
    <property id="module.driver.uart.baudrate_modulation" value="module.driver.uart
.baudrate_modulation.disabled"/>
    <property id="module.driver.uart.baudrate_max_err" value="5"/>
  </module>
</raModuleConfiguration>

```

```

    <property id="module.driver.uart.flow_control" value="module.driver.uart.flow_c
ontrol.rts"/>
    <property id="module.driver.uart.pin_control_port" value="module.driver.uart.pi
n_control_port.PORT_DISABLE"/>
    <property id="module.driver.uart.pin_control_pin" value="module.driver.uart.pin
_control_pin.PIN_DISABLE"/>
    <property id="module.driver.uart.clk_src" value="module.driver.uart.clk_src.int
_clk"/>
    <property id="module.driver.uart.rx_edge_start" value="module.driver.uart.rx_ed
ge_start.falling_edge"/>
    <property id="module.driver.uart.noisecancel_en" value="module.driver.uart.nois
ecancel_en.disabled"/>
    <property id="module.driver.uart.rx_fifo_trigger" value="module.driver.uart.rx_
fifo_trigger.max"/>
    <property id="module.driver.uart.rs485.de_enable" value="module.driver.uart.rs4
85.de_enable.disabled"/>
    <property id="module.driver.uart.rs485.de_polarity" value="module.driver.uart.r
s485.de_polarity.high"/>
    <property id="module.driver.uart.rs485.de_port_number" value="module.driver.uar
t.rs485.de_port_number.PORT_DISABLE"/>
    <property id="module.driver.uart.rs485.de_pin_number" value="module.driver.uart
.rs485.de_pin_number.PIN_DISABLE"/>
    <property id="module.driver.uart.callback" value="uart_callback"/>
    <property id="module.driver.uart.rxi_ipl" value="board.icu.common irq.priority1
2"/>
    <property id="module.driver.uart.txi_ipl" value="board.icu.common irq.priority1
2"/>
    <property id="module.driver.uart.tei_ipl" value="board.icu.common irq.priority1
2"/>
    <property id="module.driver.uart.eri_ipl" value="board.icu.common irq.priority1
2"/>
</module>
<module id="module.driver.spi_on_sci_spi.1549399989">
    <property id="module.driver.spi.name" value="g_spi0"/>
    <property id="module.driver.spi.channel" value="0"/>
    <property id="module.driver.spi.operating_mode" value="module.driver.spi.operat
ing_mode.mode_master"/>
    <property id="module.driver.spi.clk_phase" value="module.driver.spi.clk_phase.c
lk_phase_edge_odd"/>
    <property id="module.driver.spi.clk_polarity" value="module.driver.spi.clk_pola
rity.clk_polarity_low"/>
    <property id="module.driver.spi.mode_fault" value="module.driver.spi.mode_fault
.mode_fault_error_disable"/>
    <property id="module.driver.spi.bit_order" value="module.driver.spi.bit_order.b
it_order_msb_first"/>
    <property id="module.driver.spi.p_callback" value="sci_spi_callback"/>
    <property id="module.driver.spi.rxi_ipl" value="board.icu.common irq.priority12
"/>
    <property id="module.driver.spi.txi_ipl" value="board.icu.common irq.priority12
"/>
    <property id="module.driver.spi.tei_ipl" value="board.icu.common irq.priority12
"/>

```

```

    <property id="module.driver.spi.eri_ipl" value="board.icu.common.irq.priority12
"/>
    <property id="module.driver.spi.bitrate" value="8000000"/>
    <property id="module.driver.spi.bitrate_modulation" value="module.driver.spi.bi
trate_modulation.disabled"/>
  </module>
  <module id="module.driver.timer_on_gpt.453360959">
    <property id="module.driver.timer.name" value="g_timer0"/>
    <property id="module.driver.timer.channel" value="0"/>
    <property id="module.driver.timer.mode" value="module.driver.timer.mode.mode_pe
riodic"/>
    <property id="module.driver.timer.period" value="10"/>
    <property id="module.driver.timer.unit" value="module.driver.timer.unit.unit_pe
riod_msec"/>
    <property id="module.driver.timer.gtior.gtioa.initial_output_level" value="modu
le.driver.timer.gtior.gtioa.initial_output_level.low"/>
    <property id="module.driver.timer.gtior.gtioa.cycle_end_output_level" value="mo
dule.driver.timer.gtior.gtioa.cycle_end_output_level.retain"/>
    <property id="module.driver.timer.gtior.gtioa.compare_match_output_level" value="
module.driver.timer.gtior.gtioa.compare_match_output_level.retain"/>
    <property id="module.driver.timer.gtior.gtioa.count_stop_retain" value="module.
driver.timer.gtior.gtioa.count_stop_retain.disabled"/>
    <property id="module.driver.timer.gtior.gtioa.initial_output_level" value="modu
le.driver.timer.gtior.gtioa.initial_output_level.low"/>
    <property id="module.driver.timer.gtior.gtioa.cycle_end_output_level" value="mo
dule.driver.timer.gtior.gtioa.cycle_end_output_level.retain"/>
    <property id="module.driver.timer.gtior.gtioa.compare_match_output_level" value="
module.driver.timer.gtior.gtioa.compare_match_output_level.retain"/>
    <property id="module.driver.timer.gtior.gtioa.count_stop_retain" value="module.
driver.timer.gtior.gtioa.count_stop_retain.disabled"/>
    <property id="module.driver.timer.gtior.gtioa.custom_waveform_enable" value="module.d
river.timer.gtior.custom_waveform_enable.disabled"/>
    <property id="module.driver.timer.duty_cycle" value="50"/>
    <property id="module.driver.timer.gtioa_output_enabled" value="module.driver.t
imer.gtioa_output_enabled.false"/>
    <property id="module.driver.timer.gtioa_stop_level" value="module.driver.timer
.gtioa_stop_level.pin_level_low"/>
    <property id="module.driver.timer.gtioa_output_enabled" value="module.driver.t
imer.gtioa_output_enabled.false"/>
    <property id="module.driver.timer.gtioa_stop_level" value="module.driver.timer
.gtioa_stop_level.pin_level_low"/>
    <property id="module.driver.timer.count_up_source" value=""/>
    <property id="module.driver.timer.count_down_source" value=""/>
    <property id="module.driver.timer.start_source" value=""/>
    <property id="module.driver.timer.stop_source" value=""/>
    <property id="module.driver.timer.clear_source" value=""/>
    <property id="module.driver.timer.capture_a_source" value=""/>
    <property id="module.driver.timer.capture_b_source" value=""/>
    <property id="module.driver.timer.gtioa_filter" value="module.driver.timer.gti
oc_filter.gtioa_filter_none"/>
    <property id="module.driver.timer.gtioa_filter" value="module.driver.timer.gti
oc_filter.gtioa_filter_none"/>
    <property id="module.driver.timer.p_callback" value="NULL"/>

```

```

<property id="module.driver.timer.ipl" value="_disabled"/>
<property id="module.driver.timer.capture_a_ipl" value="_disabled"/>
<property id="module.driver.timer.capture_b_ipl" value="_disabled"/>
<property id="module.driver.timer.trough_ipl" value="_disabled"/>
<property id="module.driver.timer.extra" value="module.driver.timer.extra.disabled"/>
<property id="module.driver.timer.poeg_link" value="module.driver.timer.poeg_link.poeg_link_poeg0"/>
<property id="module.driver.timer.output_disable" value=""/>
<property id="module.driver.timer.adc_trigger" value=""/>
<property id="module.driver.timer.dead_time_count_up" value="0"/>
<property id="module.driver.timer.dead_time_count_down" value="0"/>
<property id="module.driver.timer.adc_a_compare_match" value="0"/>
<property id="module.driver.timer.adc_b_compare_match" value="0"/>
<property id="module.driver.timer.interrupt_skip.source" value="module.driver.timer.interrupt_skip.source.none"/>
<property id="module.driver.timer.interrupt_skip.count" value="module.driver.timer.interrupt_skip.count.count_0"/>
<property id="module.driver.timer.interrupt_skip.adc" value="module.driver.timer.interrupt_skip.adc.none"/>
<property id="module.driver.timer.gtioca_disable_setting" value="module.driver.timer.gtioca_disable_setting.gtioc_disable_prohibited"/>
<property id="module.driver.timer.gtiocb_disable_setting" value="module.driver.timer.gtiocb_disable_setting.gtioc_disable_prohibited"/>
</module>
<module id="module.driver.transfer_on_dtc.1741066903">
<property id="module.driver.transfer.name" value="g_transfer0"/>
<property id="module.driver.transfer.mode" value="module.driver.transfer.mode.mode_normal"/>
<property id="module.driver.transfer.size" value="module.driver.transfer.size.size_2_byte"/>
<property id="module.driver.transfer.dest_addr_mode" value="module.driver.transfer.dest_addr_mode.addr_mode_fixed"/>
<property id="module.driver.transfer.src_addr_mode" value="module.driver.transfer.src_addr_mode.addr_mode_fixed"/>
<property id="module.driver.transfer.repeat_area" value="module.driver.transfer.repeat_area.repeat_area_source"/>
<property id="module.driver.transfer.p_dest" value="NULL"/>
<property id="module.driver.transfer.p_src" value="NULL"/>
<property id="module.driver.transfer.interrupt" value="module.driver.transfer.interrupt.interrupt_end"/>
<property id="module.driver.transfer.length" value="0"/>
<property id="module.driver.transfer.num_blocks" value="0"/>
<property id="module.driver.transfer.activation_source" value="_disabled"/>
</module>
<module id="module.driver.transfer_on_dtc.730821984">
<property id="module.driver.transfer.name" value="g_transfer1"/>
<property id="module.driver.transfer.mode" value="module.driver.transfer.mode.mode_normal"/>
<property id="module.driver.transfer.size" value="module.driver.transfer.size.size_2_byte"/>
<property id="module.driver.transfer.dest_addr_mode" value="module.driver.transfer.dest_addr_mode.addr_mode_fixed"/>

```

```

    <property id="module.driver.transfer.src_addr_mode" value="module.driver.transf
er.src_addr_mode.addr_mode_fixed"/>
    <property id="module.driver.transfer.repeat_area" value="module.driver.transfer
.repeat_area.repeat_area_source"/>
    <property id="module.driver.transfer.p_dest" value="NULL"/>
    <property id="module.driver.transfer.p_src" value="NULL"/>
    <property id="module.driver.transfer.interrupt" value="module.driver.transfer.i
nterrupt.interrupt_end"/>
    <property id="module.driver.transfer.length" value="0"/>
    <property id="module.driver.transfer.num_blocks" value="0"/>
    <property id="module.driver.transfer.activation_source" value="_disabled"/>
</module>
<module id="module.driver.transfer_on_dtc.1206570453">
    <property id="module.driver.transfer.name" value="g_transfer2"/>
    <property id="module.driver.transfer.mode" value="module.driver.transfer.mode.m
ode_normal"/>
    <property id="module.driver.transfer.size" value="module.driver.transfer.size.s
ize_2_byte"/>
    <property id="module.driver.transfer.dest_addr_mode" value="module.driver.transf
er.dest_addr_mode.addr_mode_fixed"/>
    <property id="module.driver.transfer.src_addr_mode" value="module.driver.transf
er.src_addr_mode.addr_mode_fixed"/>
    <property id="module.driver.transfer.repeat_area" value="module.driver.transfer
.repeat_area.repeat_area_source"/>
    <property id="module.driver.transfer.p_dest" value="NULL"/>
    <property id="module.driver.transfer.p_src" value="NULL"/>
    <property id="module.driver.transfer.interrupt" value="module.driver.transfer.i
nterrupt.interrupt_end"/>
    <property id="module.driver.transfer.length" value="0"/>
    <property id="module.driver.transfer.num_blocks" value="0"/>
    <property id="module.driver.transfer.activation_source" value="_disabled"/>
</module>
<module id="module.driver.transfer_on_dtc.415632937">
    <property id="module.driver.transfer.name" value="g_transfer3"/>
    <property id="module.driver.transfer.mode" value="module.driver.transfer.mode.m
ode_normal"/>
    <property id="module.driver.transfer.size" value="module.driver.transfer.size.s
ize_2_byte"/>
    <property id="module.driver.transfer.dest_addr_mode" value="module.driver.transf
er.dest_addr_mode.addr_mode_fixed"/>
    <property id="module.driver.transfer.src_addr_mode" value="module.driver.transf
er.src_addr_mode.addr_mode_fixed"/>
    <property id="module.driver.transfer.repeat_area" value="module.driver.transfer
.repeat_area.repeat_area_source"/>
    <property id="module.driver.transfer.p_dest" value="NULL"/>
    <property id="module.driver.transfer.p_src" value="NULL"/>
    <property id="module.driver.transfer.interrupt" value="module.driver.transfer.i
nterrupt.interrupt_end"/>
    <property id="module.driver.transfer.length" value="0"/>
    <property id="module.driver.transfer.num_blocks" value="0"/>
    <property id="module.driver.transfer.activation_source" value="_disabled"/>
</module>
<context id="_hal.0">

```

```

    <stack module="module.driver.ioport_on_ioport.0"/>
    <stack module="module.driver.uart_on_sci_uart.728447659">
        <stack module="module.driver.transfer_on_dtc.1741066903" requires="module.driver.
ver. uart_on_sci_uart.requires.transfer_tx"/>
        <stack module="module.driver.transfer_on_dtc.415632937" requires="module.driv
er. uart_on_sci_uart.requires.transfer_rx"/>
    </stack>
    <stack module="module.driver.spi_on_sci_spi.1549399989">
        <stack module="module.driver.transfer_on_dtc.730821984" requires="module.driv
er. spi_on_sci_spi.requires.transfer_tx"/>
        <stack module="module.driver.transfer_on_dtc.1206570453" requires="module.dri
ver. spi_on_sci_spi.requires.transfer_rx"/>
    </stack>
    <stack module="module.driver.timer_on_gpt.453360959"/>
</context>
<config id="config.driver.ioport">
    <property id="config.driver.ioport.checking" value="config.driver.ioport.checki
ng.system"/>
</config>
<config id="config.driver.sci_spi">
    <property id="config.driver.sci_spi.param_checking_enable" value="config.driver
.sci_spi.param_checking_enable.bsp"/>
    <property id="config.driver.sci_spi.dtc_support_enable" value="config.driver.sc
i_spi.dtc_support_enable.enabled"/>
</config>
<config id="config.driver.dtc">
    <property id="config.driver.dtc.param_checking_enable" value="config.driver.dtc
.param_checking_enable.bsp"/>
    <property id="config.driver.dtc.vector_table" value=".fsp_dtc_vector_table"/>
</config>
<config id="config.driver.sci_uart">
    <property id="config.driver.sci_uart.param_checking_enable" value="config.driv
e.r.sci_uart.param_checking_enable.bsp"/>
    <property id="config.driver.sci_uart.fifo_support" value="config.driver.sci_ua
r.t.fifo_support.disabled"/>
    <property id="config.driver.sci_uart.dtc_support" value="config.driver.sci_uart
.dtc_support.enabled"/>
    <property id="config.driver.sci_uart.flow_control" value="config.driver.sci_ua
r.t.flow_control.disabled"/>
    <property id="config.driver.sci_uart.rs485" value="config.driver.sci_uart.rs485
.disabled"/>
</config>
<config id="config.driver.gpt">
    <property id="config.driver.gpt.param_checking_enable" value="config.driver.gpt
.param_checking_enable.bsp"/>
    <property id="config.driver.gpt.output_support_enable" value="config.driver.gpt
.output_support_enable.disabled"/>
    <property id="config.driver.gpt.write_protect_enable" value="config.driver.gpt.
write_protect_enable.disabled"/>
    <property id="config.driver.gpt.gpt_core_clock" value="module.driver.timer.gpt_
core_clock.pclk"/>
</config>
</raModuleConfiguration>

```

```

<raPinConfiguration>
  <symbolicName propertyId="p413.symbolic_name" value="PTX_PLAT_SPI_CS_PIN"/>
  <symbolicName propertyId="p414.symbolic_name" value="PTX_PLAT_SPI_IRQ_PIN"/>
  <pincfg active="true" name="R7FA4M2AD3CFP.pincfg" selected="true" symbol="g_bsp_p
in_cfg">
    <configSetting altId="debug0.mode.jtag" configurationId="debug0.mode"/>
    <configSetting altId="debug0.tck.p300" configurationId="debug0.tck"/>
    <configSetting altId="debug0.tdi.p110" configurationId="debug0.tdi"/>
    <configSetting altId="debug0.tdo.p109" configurationId="debug0.tdo"/>
    <configSetting altId="debug0.tms.p108" configurationId="debug0.tms"/>
    <configSetting altId="p108.debug0.tms" configurationId="p108"/>
    <configSetting altId="p108.gpio_mode.gpio_mode_peripheral" configurationId="p10
8.gpio_mode"/>
    <configSetting altId="p109.debug0.tdo" configurationId="p109"/>
    <configSetting altId="p109.gpio_mode.gpio_mode_peripheral" configurationId="p10
9.gpio_mode"/>
    <configSetting altId="p110.debug0.tdi" configurationId="p110"/>
    <configSetting altId="p110.gpio_mode.gpio_mode_peripheral" configurationId="p11
0.gpio_mode"/>
    <configSetting altId="p112.sci2.txd" configurationId="p112"/>
    <configSetting altId="p112.gpio_mode.gpio_mode_peripheral" configurationId="p11
2.gpio_mode"/>
    <configSetting altId="p113.sci2.rxd" configurationId="p113"/>
    <configSetting altId="p113.gpio_mode.gpio_mode_peripheral" configurationId="p11
3.gpio_mode"/>
    <configSetting altId="p300.debug0.tck" configurationId="p300"/>
    <configSetting altId="p300.gpio_mode.gpio_mode_peripheral" configurationId="p30
0.gpio_mode"/>
    <configSetting altId="p410.sci0.rxd" configurationId="p410"/>
    <configSetting altId="p410.gpio_mode.gpio_mode_peripheral" configurationId="p41
0.gpio_mode"/>
    <configSetting altId="p411.sci0.txd" configurationId="p411"/>
    <configSetting altId="p411.gpio_mode.gpio_mode_peripheral" configurationId="p41
1.gpio_mode"/>
    <configSetting altId="p412.sci0.sck" configurationId="p412"/>
    <configSetting altId="p412.gpio_mode.gpio_mode_peripheral" configurationId="p41
2.gpio_mode"/>
    <configSetting altId="p413.output.high" configurationId="p413"/>
    <configSetting altId="p413.gpio_mode.gpio_mode_out.high" configurationId="p413.
gpio_mode"/>
    <configSetting altId="p414.input" configurationId="p414"/>
    <configSetting altId="p414.gpio_mode.gpio_mode_in" configurationId="p414.gpio_m
ode"/>
    <configSetting altId="sci0.mode.spi.b" configurationId="sci0.mode"/>
    <configSetting altId="sci0.pairing.b" configurationId="sci0.pairing"/>
    <configSetting altId="sci0.rxd.p410" configurationId="sci0.rxd"/>
    <configSetting altId="sci0.sck.p412" configurationId="sci0.sck"/>
    <configSetting altId="sci0.txd.p411" configurationId="sci0.txd"/>
    <configSetting altId="sci2.mode.asynchronous.free" configurationId="sci2.mode"/
>
    <configSetting altId="sci2.rxd.p113" configurationId="sci2.rxd"/>
    <configSetting altId="sci2.txd.p112" configurationId="sci2.txd"/>
  </pincfg>

```

```
</raPinConfiguration>
</raConfiguration>
```

Also the pin configuration file `R7FA4M2AD3CFP.pincfg` needs to be updated the same way with the following content:

```
<?xml version="1.0" encoding="utf-8"?>
<v1:pinSettings xmlns:v1="http://www.tasking.com/schema/pinsettings/v1.1">
  <v1:pinMappingsRef version="2.05" file="" />
  <v1:deviceSetting id="renesas.ra4m2_fp" pattern="R7FA4M2***FP">
    <v1:packageSetting id="renesas.100lqfp" />
  </v1:deviceSetting>
  <v1:configSetting configurationId="debug0.mode" altId="debug0.mode.jtag" />
  <v1:configSetting configurationId="p108.gpio_mode" altId="p108.gpio_mode.gpio_mode_
peripheral" />
  <v1:configSetting configurationId="p108" altId="p108.debug0.tms">
    <v1:connectionSetting altId="debug0.tms.p108" />
  </v1:configSetting>
  <v1:configSetting configurationId="debug0.tms" altId="debug0.tms.p108">
    <v1:connectionSetting altId="p108.debug0.tms" />
  </v1:configSetting>
  <v1:configSetting configurationId="p109.gpio_mode" altId="p109.gpio_mode.gpio_mode_
peripheral" />
  <v1:configSetting configurationId="p109" altId="p109.debug0.tdo">
    <v1:connectionSetting altId="debug0.tdo.p109" />
  </v1:configSetting>
  <v1:configSetting configurationId="debug0.tdo" altId="debug0.tdo.p109">
    <v1:connectionSetting altId="p109.debug0.tdo" />
  </v1:configSetting>
  <v1:configSetting configurationId="p110.gpio_mode" altId="p110.gpio_mode.gpio_mode_
peripheral" />
  <v1:configSetting configurationId="p110" altId="p110.debug0.tdi">
    <v1:connectionSetting altId="debug0.tdi.p110" />
  </v1:configSetting>
  <v1:configSetting configurationId="debug0.tdi" altId="debug0.tdi.p110">
    <v1:connectionSetting altId="p110.debug0.tdi" />
  </v1:configSetting>
  <v1:configSetting configurationId="p300.gpio_mode" altId="p300.gpio_mode.gpio_mode_
peripheral" />
  <v1:configSetting configurationId="p300" altId="p300.debug0.tck">
    <v1:connectionSetting altId="debug0.tck.p300" />
  </v1:configSetting>
  <v1:configSetting configurationId="debug0.tck" altId="debug0.tck.p300">
    <v1:connectionSetting altId="p300.debug0.tck" />
  </v1:configSetting>
</v1:pinSettings>
```

After editing the files and opening the `configuration.xml` in the e2studio configuration editor, the following **Project Summary** should be seen:

Project Summary

Board:	Custom User Board (Any Device)
Device:	R7FA4M2AD3CFP
Toolchain:	GCC ARM Embedded
Toolchain Version:	10.3.1.20210824
FSP Version:	3.7.0
Project Type:	Flat
Location:	C:/Work/wsE_eclipse/e2_ra6m4_2/tunneling_demo 

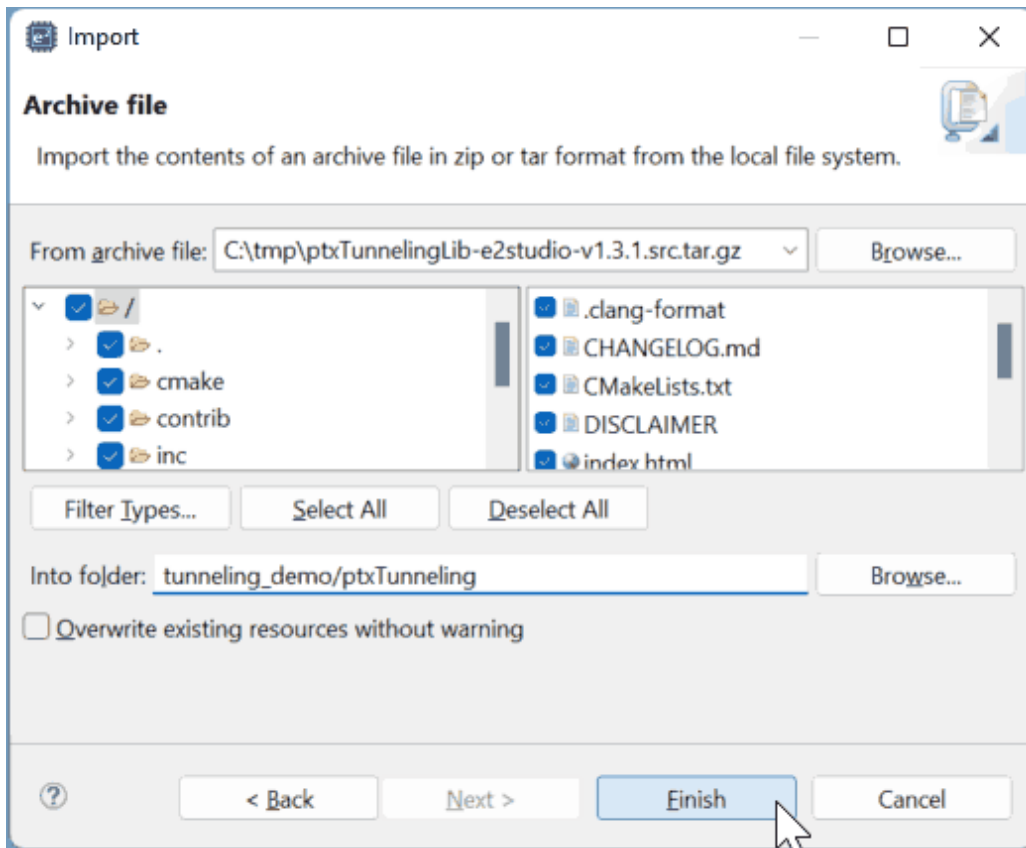
Selected software components

Board Support Package Common Files	v3.7.0
I/O Port	v3.7.0
Arm CMSIS Version 5 - Core (M)	v5.8.0+renesas.0.fsp.3.7.0
Custom Board Support Files	v3.7.0
Board support package for R7FA4M2AD3CFP	v3.7.0
Board support package for RA4M2	v3.7.0
Board support package for RA4M2 - FSP Data	v3.7.0
Data Transfer Controller	v3.7.0
General PWM Timer	v3.7.0
Serial Peripheral Interface on Serial Communications Interface	v3.7.0
SCI UART	v3.7.0

The source code describing the modules can now be generated by clicking on the **Generate Project Content** in the top right corner.

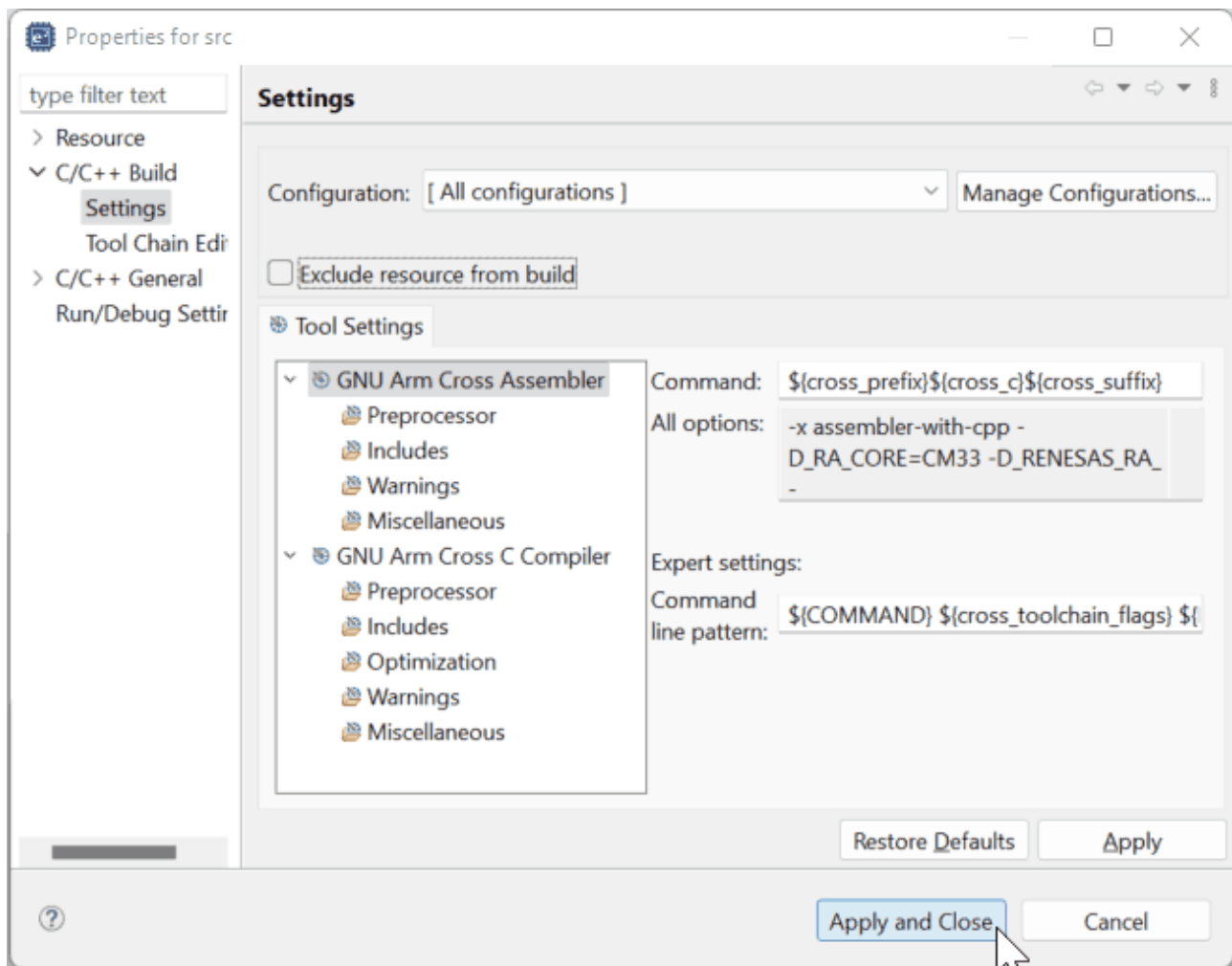
3.3 Importing the library

It does not make any difference whether the source or the precompiled package is being used, the library archive needs to be imported to the project with **File** → **Import...** → **Archive File** option.



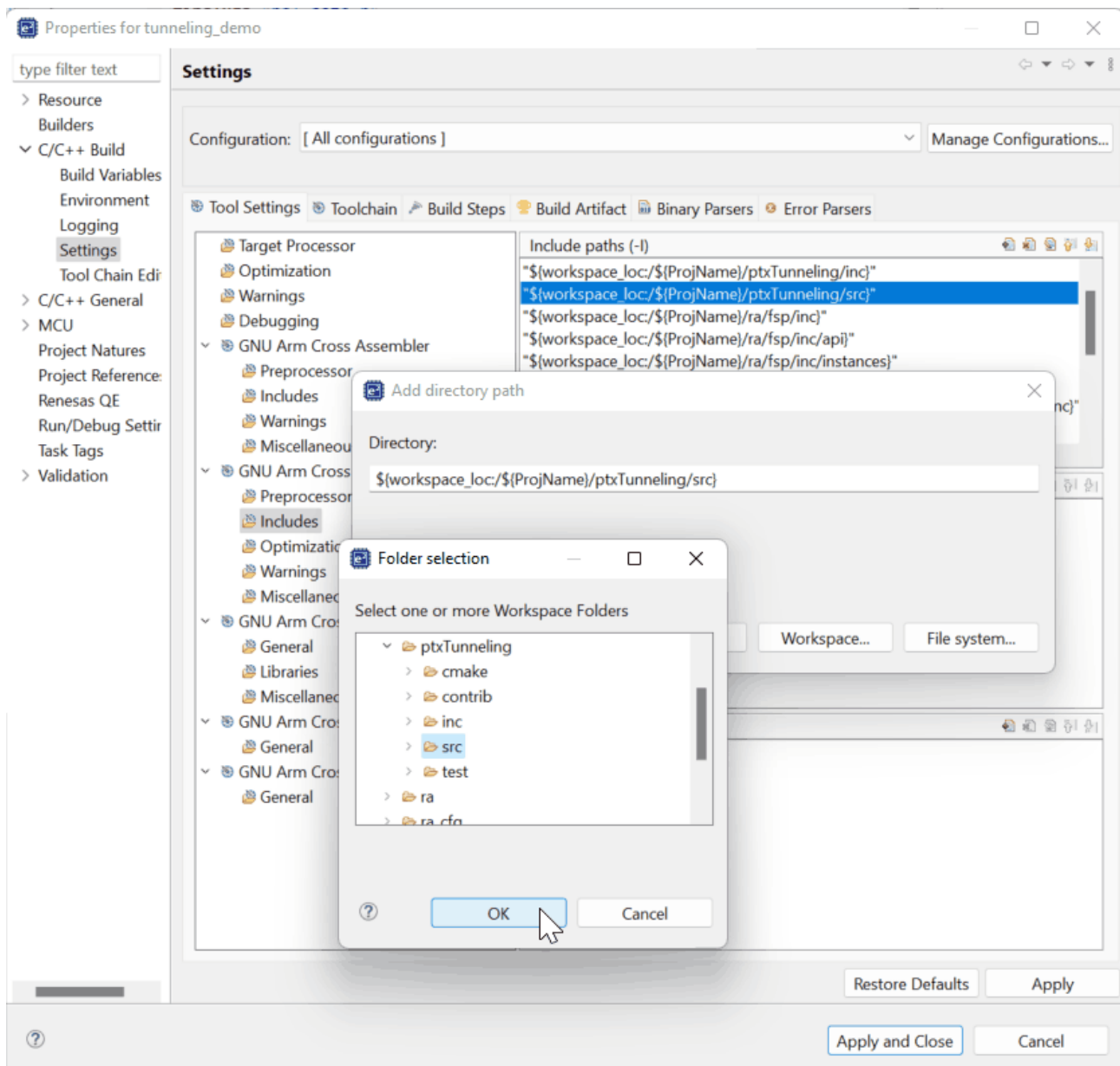
To keep the folder structure clean, the library will be imported to the `ptxTunneling` subfolder by appending the default location shown on picture.

In case the library will be used in source form, its `src` folder needs to be included in the build. This can be done by opening the context menu with right mouse click on the folder name in the **Project Explorer** and selecting **Properties**. The checkbox **Exclude resource from build** found in *C/C++ Build* → *Settings* needs to be unchecked, see picture:



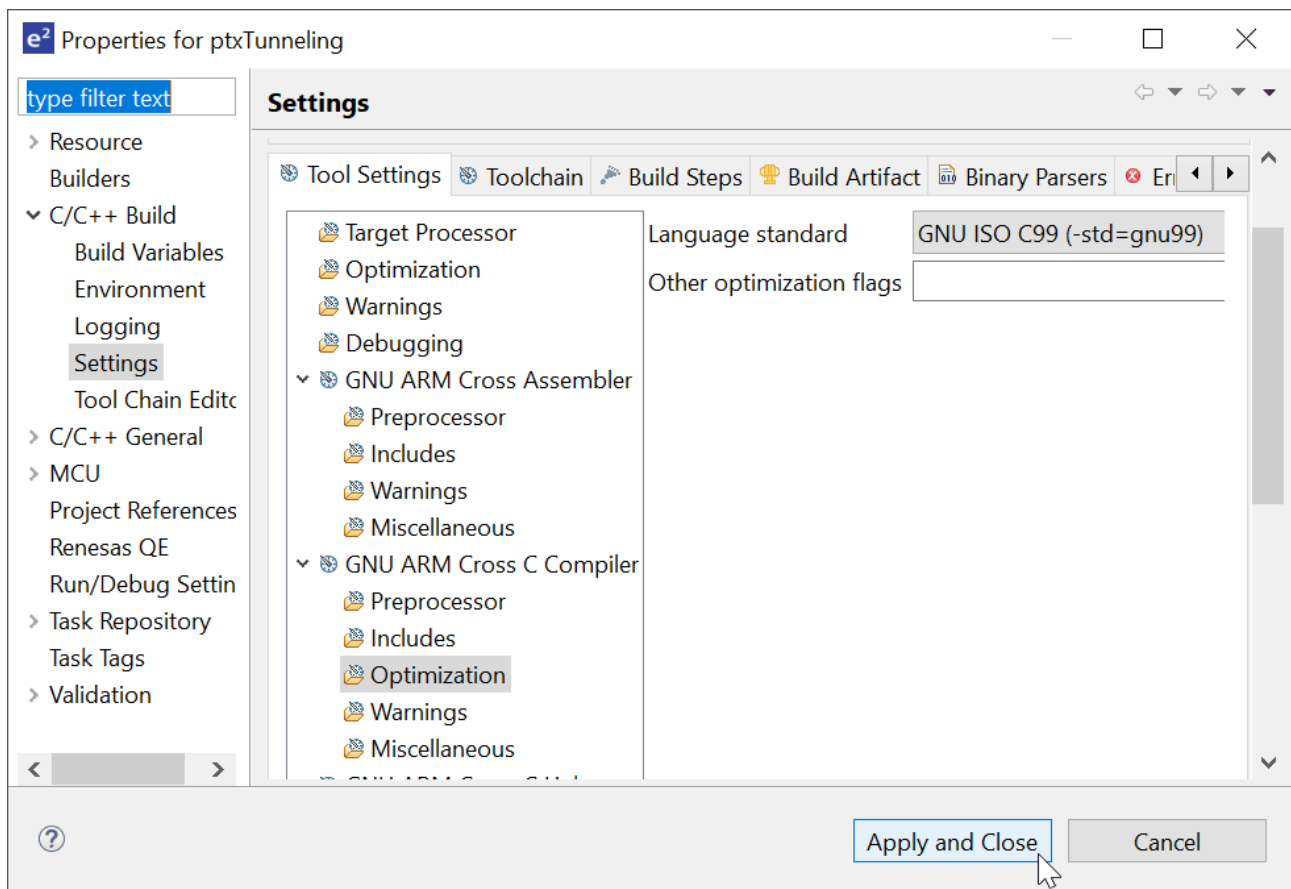
3.3.1 Add include path

In order that the compiler can find the header (.h) files containing the API functions, the library folder `inc` (and also `src` if using the source package variant) needs to be added to the list of user defined include directories. This can be done by navigating to **Project** → **C/C++ Build** → **Settings** → **Tool Settings** → **GNU ARM Cross Compiler** → **Includes**. Clicking on the **Add...** button on the right side of the small toolbar and using **Workspace** button in the popup window to locate the folder.



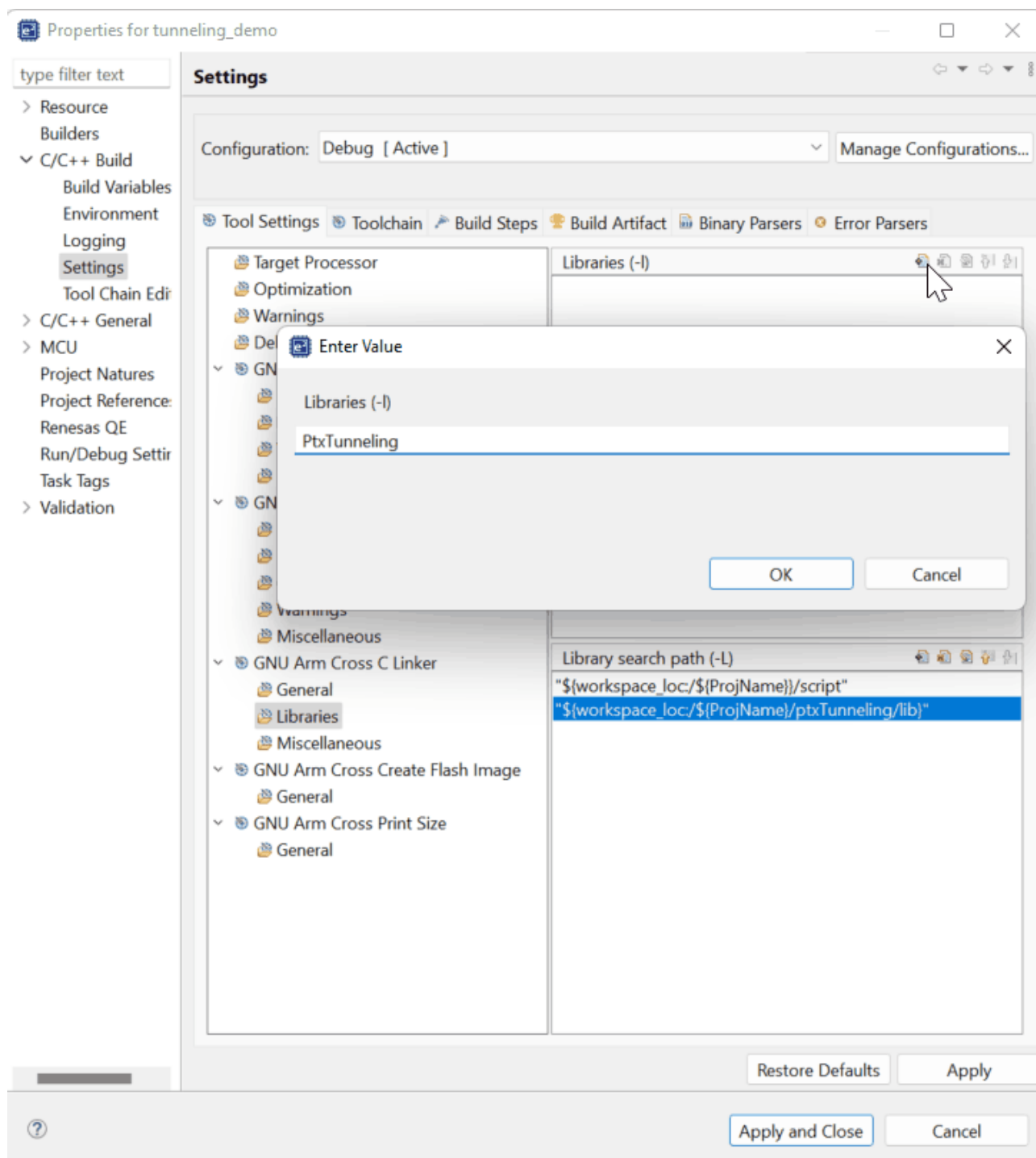
3.3.2 Set language standard

This step is required only if you use the source package. Please make sure that the **GNU ISO C99** is selected among the **GNU ARM Cross C Compile** → **Optimization** settings. Since there is the `typeof()` statement used in the source code, the project needs to be compiled with the GNU extensions enabled, otherwise compilation will fail.



3.3.3 Adding library file

This step is required only if working with the precompiled binary package. Since there is no source code to be compiled, the linker need to be able to find the referenced library functions. In the same dialog window, changing to **GNU ARM Cross C Linker** section, the `ptxTunneling/lib` folder can be added to the list of folders (lower pane) where the compiler is looking for external libraries. Additionally, the exact library needs also to be referenced (upper pane) by its name `PtxTunneling`. From this the compiler will automatically find the static library file `libPtxTunneling.a`:



3.4 Implement the HAL

The library functions cannot access the underlying hardware or software resources, they will access the Hardware Abstraction Layer (HAL), which then performs the requested action. Since this layer depends on the hardware, it needs to be implemented for the exact setup.

The PtxTunneling library comes with the header file `ptx_tunneling_hal.h`, that contains all the functions that need to be provided by the host platform.

For the current case there shall be the file `src/ptx_tunneling_hal.c` created in the project folder with the following content:

```
#include "ptx_tunneling_hal.h"
#include "ptx_tunneling.h"

#include "hal_data.h"

#define OFFSET_CMD_LENGTH_BYTE 1U
#define COMMS_MAX_MESSAGE_LENGTH 280U
#define COMMS_HEADER_SIZE 2U
#define CMD_CODE_TUNNELING_MSG 0x55

static uint8_t uartRxBuf[2048];
static uint16_t readPos = 0;
static uint16_t writePos = 0;
static uint8_t rx[COMMS_MAX_MESSAGE_LENGTH];
static uint8_t tx[COMMS_MAX_MESSAGE_LENGTH];
static uint16_t rxi = 0;
static volatile bool txDone;
static volatile bool uartComplete;

uint32_t hal_TimerGetTime(void);
void tunneling_init();
void tunneling_demo();

uint32_t hal_TimerGetTime(void)
{
    timer_status_t time;
    g_timer0.p_api->statusGet(g_timer0.p_ctrl, &time);
    return time.counter;
}

void uart_callback(uart_callback_args_t *arg)
{
    // read 1 byte
    if (arg->event == UART_EVENT_RX_CHAR)
    {
        // receive the header and the length byte
        rx[rxi] = (uint8_t)arg->data;
        if (rxi != 0 || rx[rxi] == CMD_CODE_TUNNELING_MSG)
        { // if there are some invalid data received while waiting for sync byte,
just discard them
            rxi++;
        }

        if (rxi >= COMMS_HEADER_SIZE)
        {
            uint16_t packLen = COMMS_HEADER_SIZE +
```

```

(rx[OFFSET_CMD_LENGTH_BYTE] == 0 ? 256 :
rx[OFFSET_CMD_LENGTH_BYTE]);
    if (rxi >= packLen)
    {
        // whole packet has been received
        memcpy(uartRxBuf + writePos, rx, rxi);
        writePos += rxi;
        rxi = 0;
    }
}
else if (arg->event == UART_EVENT_TX_COMPLETE)
{
    uartComplete = true;
}
}

bool ptxTunneling_GPIO_IsIrqPinAsserted(ptxHal_t *context)
{
    FSP_PARAMETER_NOT_USED(context);

    bsp_io_level_t pinLevel = 0;

    g_ioport.p_api->pinRead(g_ioport.p_ctrl, PTX_PLAT_SPI_IRQ_PIN, &pinLevel);

    return (bool)pinLevel;
}

int ptxTunneling_UART_rxLength(ptxHal_t *context)
{
    FSP_PARAMETER_NOT_USED(context);
    __disable_irq();
    const uint16_t count = writePos - readPos;
    __enable_irq();
    return count;
}

int ptxTunneling_UART_read(ptxHal_t *context, uint8_t *buf, unsigned int len)
{
    FSP_PARAMETER_NOT_USED(context);
    assert(len < sizeof(uartRxBuf));
    __disable_irq();
    int readCount = writePos - readPos;
    if (readCount > (int)len)
        readCount = (int)len;

    memcpy(buf, uartRxBuf + readPos, (size_t)readCount);

    readPos = (uint16_t)(readPos + readCount);
    if (readPos == writePos)
    {
        readPos = 0;
        writePos = 0;
    }
}

```

```

    }
    __enable_irq();
    return readCount;
}

int ptxTunneling_UART_write(ptxHal_t *context, const uint8_t *buf, unsigned int len)
{
    FSP_PARAMETER_NOT_USED(context);
    if (len)
    {
        while (!uartComplete)
        {
            R_BSP_SoftwareDelay(100, BSP_DELAY_UNITS_MICROSECONDS);
        }
        uartComplete = false;
        memcpy(tx, buf, len);

        g_uart0.p_api->write(g_uart0.p_ctrl, tx, len);
    }
    return 0;
}

void ptxTunneling_Timer_stopwatchStart(ptxHal_t *context, ptxTimeDiff_t *startVal)
{
    FSP_PARAMETER_NOT_USED(context);

    *startVal = hal_TimerGetTime();
}

void ptxTunneling_Timer_stopwatchStop(ptxHal_t *context, ptxTimeDiff_t *startStopVal)
{
    FSP_PARAMETER_NOT_USED(context);

    *startStopVal = hal_TimerGetTime() - *startStopVal;
}

void ptxTunneling_Timer_ThreadSleep(ptxHal_t *context, uint32_t msSleep)
{
    FSP_PARAMETER_NOT_USED(context);

    R_BSP_SoftwareDelay(msSleep, BSP_DELAY_UNITS_MILLISECONDS);
}

int ptxTunneling_SPI_trx(ptxHal_t *context, uint8_t *const txBuf[], const size_t
txLen[],
size_t numBuffers, uint8_t *rxBuf, size_t *rxLen)
{
    FSP_PARAMETER_NOT_USED(context);

    bool status = true;
    if ((NULL != txBuf) && (NULL != txLen))
    {
        /* At this point the SPI transfer operation is triggered */
    }
}

```

```

    g_ioport.p_api->pinWrite(g_ioport.p_ctrl, PTX_PLAT_SPI_CS_PIN,
    BSP_IO_LEVEL_LOW);

    uint8_t index = 0;
    while ((true == status) && (index < numBuffers))
    {
        if ((txBuf[index] != NULL) && (txLen[index] > 0) && (rxBuf != NULL))
        {
            txDone = false;
            if (g_spi0.p_api->writeRead(
                g_spi0.p_ctrl, txBuf[index], rxBuf, txLen[index],
                SPI_BIT_WIDTH_8_BITS))
            {
                status = false;
            }
            while (!txDone && status)
                R_BSP_SoftwareDelay(100, BSP_DELAY_UNITS_MICROSECONDS);
        }
        else
        {
            status = false;
        }
        index++;
    }
    /* Tx part of the overall transaction. */
}
else
{
    /* Let's see if there is something to read. */
    if ((NULL != rxBuf) && (NULL != rxLen))
    {
        txDone = false;
        if (g_spi0.p_api->read(g_spi0.p_ctrl, rxBuf, (uint32_t)*rxLen,
            SPI_BIT_WIDTH_8_BITS))
        {
            status = false;
        }
        while (!txDone && status)
            R_BSP_SoftwareDelay(100, BSP_DELAY_UNITS_MICROSECONDS);
    }
    else
    {
        status = false;
    }
}
/* In any case, at this point the SPI transfer operation is finished */
g_ioport.p_api->pinWrite(g_ioport.p_ctrl, PTX_PLAT_SPI_CS_PIN,
BSP_IO_LEVEL_HIGH);
return (!status);
}

void sci_spi_callback(spi_callback_args_t *p_args)
{

```

```

    if (p_args->event == SPI_EVENT_TRANSFER_COMPLETE)
        txDone = true;
}

void ptxTunneling_NVIC_disableInterrupts()
{
    // disabling interrupts not needed in this sample, since the SPI/UART
    // communication uses neither
    // interrupts nor multithreading, therefore no race conditions can occur during
    // queue operations
}

void ptxTunneling_NVIC_enableInterrupts()
{
    // enabling interrupts not needed in this sample, since the SPI/UART
    // communication uses neither
    // interrupts nor multithreading, therefore no race conditions can occur during
    // queue operations
}

void tunneling_init()
{
    g_spi0.p_api->open(g_spi0.p_ctrl, g_spi0.p_cfg);
    g_uart0.p_api->open(g_uart0.p_ctrl, g_uart0.p_cfg);
    g_timer0.p_api->open(g_timer0.p_ctrl, g_timer0.p_cfg);
    g_timer0.p_api->start(g_timer0.p_ctrl);
    uartComplete = true;
    __enable_irq();
}

void tunneling_demo()
{
    ptxTunneling_init();
    tunneling_init();
    while (true)
    {
        ptxTunneling_poll(NULL);
    }
}

```

This example implementation is specific to the Renesas EK-RA4M2 development board. It is not guaranteed to work on any other hardware.

3.5 Implement the main function

The firmware will provide the tunneling functionality by calling the library's superloop function, the `ptxTunneling_poll()` after initializing the modules. This function does the data processing and translation and also drives the SPI communication. The e2studio has already generated the default user-entry source file `hal_entry.c`. Please update this file according to the following code:

```

void tunneling_demo();

```

```
void hal_entry(void)
{
    tunneling_demo();
}
```

This code change is responsible to involve the main loop of the tunneling firmware once the MCU initialization is finished and the user-code gets started.

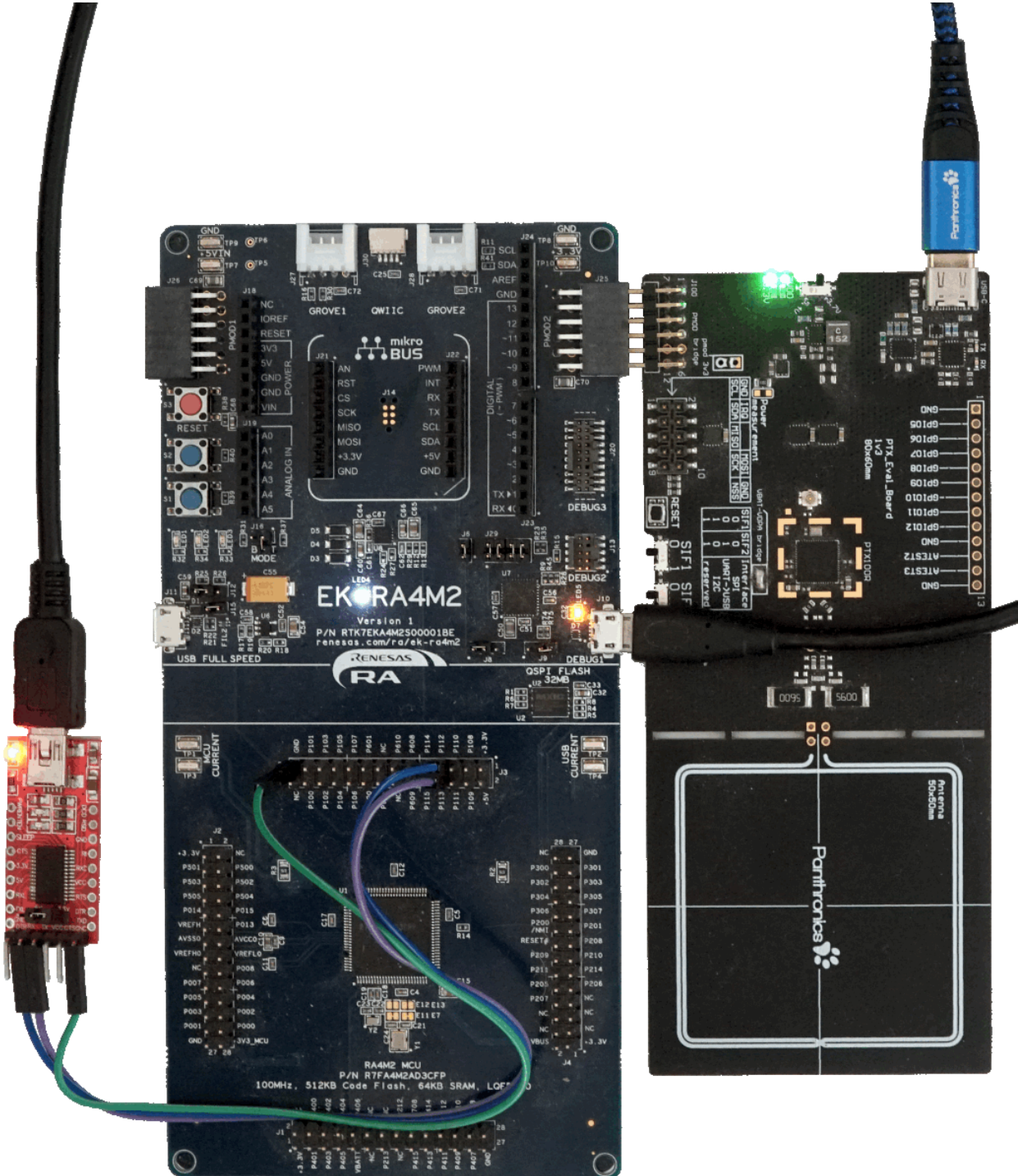
3.6 Building the Firmware

After all the source file have been created, the project can be built with the **Project** → **Build Project**. Once the build process has been finished successfully, a similar table will be shown with the footprint sizes:

```
arm-none-eabi-size --format=berkeley "tunneling_demo.elf"
  text    data    bss     dec      hex filename
 14588     80    8048   22716   58bc tunneling_demo.elf
```

4 Prepare the hardware

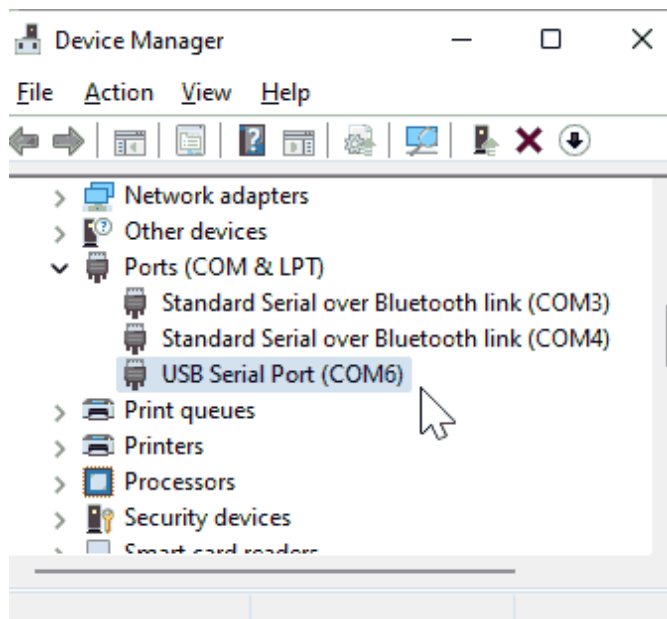
To demonstrate the usage of the tunneling functionality, a PTX100R Evalboard needs to be connected to the Renesas evaluation board through the **PMOD2** connector.



Before powering up from the USB-C port, it is important to remove the jumper "pmod 3v3 bridge" and set both switches **SIF1** and **SIF2** on the PTX100R Evalboard to **"0"** state to select the SPI communication protocol.

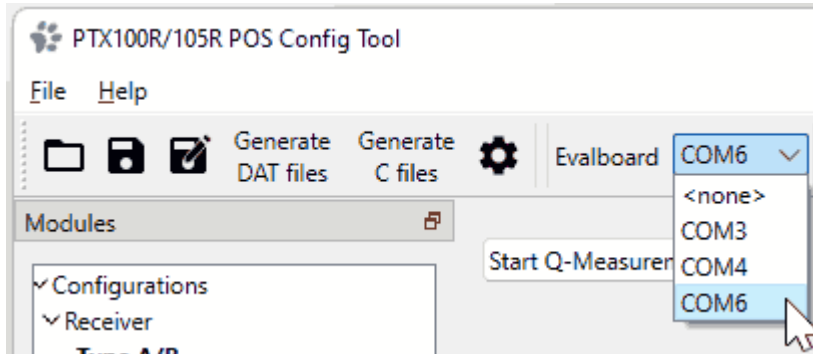
The Renesas-board needs to be connected to the host PC by a micro-USB cable using the "Debug1" connector. This way, the firmware can be easily flashed and started with the **Run** → **Run** command from the menu.

Once the firmware starts successfully, it will listen for incoming commands on the on-chip UART using pins **P112** and **P113**. To use the tunneling functionality, an external USB/UART converter shall be connected to those pins. Windows will show a notification about the connected USB/UART device with the communication port name indicated. Should the notification be missing, opening the **Device Manager** will reveal the newly configured com port.

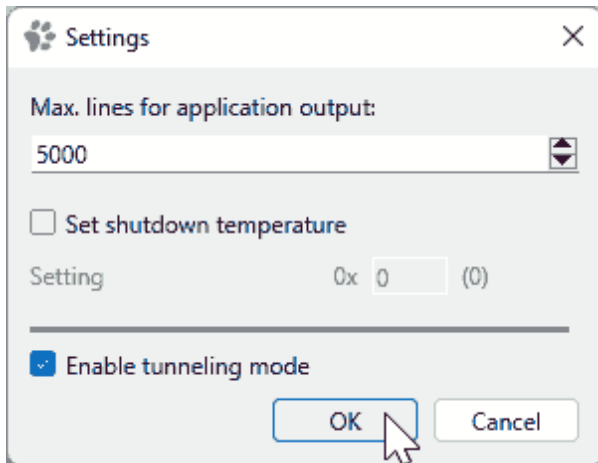


5 Using the tunneling feature

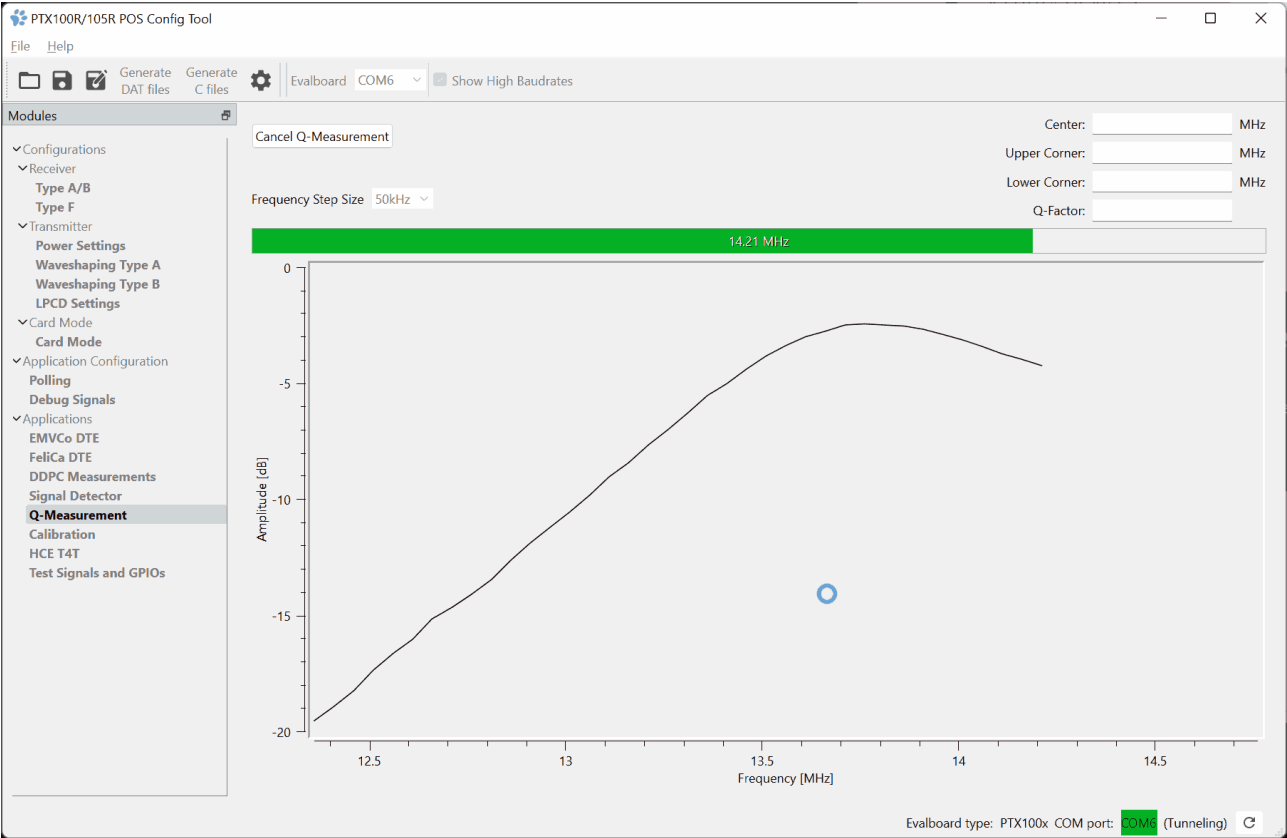
In order to make use of the tunneling functionality, the **PTX1xxR * Config Tool** needs to be started and configured to use the USB communication port by selecting the correct entry in the dropdown list in toolbar.



The config tool is using the hardware flow control functionality of the UART by default, which is not provided in this case, therefore the **tunneling mode** shall be enabled in the **File** → **Settings** menu.



The configuration is ready, any config tool application (eg. Q-Measurement) started now will communicate with the PTX100R via the tunneling firmware.



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