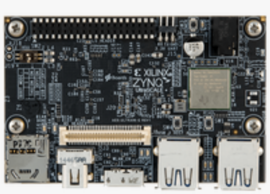
基于ultra96v2的amp方案验证

目标计划

- 1.zu3eg下4*apu部署linux+ubuntu16.04操作系统
- 2.zu3eg下2*rpu部署freertos系统
- 3.rpu的程序固件由apu的系统启动后再进行加载
- 4.apu与rpu完成可靠通信
- 5.rpu控制can外设，硬件定时器，完成在20ms的周期定时下向外发送can信号
- 6.在满足5的情况下完成rpu控制can接收数据并发送给apu的linux的可靠测试
- 7.测试apu与rpu的通信时延及从rpu接收can数据到apu接收完数据的时间

硬件环境

测试的硬件基于ultra96v2

 Ultra96 V2	Board based on Xilinx Zynq UltraScale+ MPSoC ZU3EG A484	Documentation

软件环境

vivado2018.2
xilinx sdk2018.2
petalinux2018.2
++在官网上找了好几个宣称适用的bsp发现都起不来,逛论坛貌似ultra96v2的bsp还没有发布++
最后在github上搜到了一个

```
https://github.com/KeitetsuWorks/SDSoC-Ultra96-V2
```

这个非官方的vivado工程至少可以让板子正常启动了，对于我们完成此次的测试目标够用了，所以基于这个vivado工程进行后续的开发

amp的开发基于openamp框架完成

重要参考文档

```
https://china.xilinx.com/support/documentation/sw_manuals/
xilinx2019_1/ug1186-zynq-openamp-gsg.pdf
```

```
https://china.xilinx.com/support/documentation/user_guides/
ug1085-zynq-ultrascale-trm.pdf
```

openamp的linux端demo在

```
 https://github.com/Xilinx/meta-openamp
```

因为需要涉及到将ubuntu移植到ultra96v2上，为了方便移植，参考开发板官网的镜像系统

```
http://zedboard.org/support/design/28476/181
```

板载了一个sdio接口的wifi模块，驱动在

```
https://github.com/Avnet/u96v2-wilc-driver
```

还有一些零散的参考在，注意这里面的标号为v2的包是针对ultra96v1的第二个版本的，而不是针对ultra96v2的包

```
https://github.com/Avnet/Ultra96-PYNQ
```


Avnet / Ultra96-PYNQ

Watch

Code | Issues 0 | Pull requests 0 | Projects 0 | Security | Insights

where is ultra96-v2 bsp???? #31

Closed tccxy opened this issue 8 days ago · 1 comment

tccxy commented 8 days ago

In the development I want to get ultra96-2 BSP source code package

I tried

xilinx-ultra96-reva-v2018.2-final.bsp from xilinx

Ultra96-V1 - PetaLinux 2018.2 BSP
Ultra96-V1 - PetaLinux 2018.3 BSP

and
sensors96b_v2.bsp
from
https://github.com/Avnet/Ultra96-PYNQ imagev2.4_v2 branch
but None of them can walk normally
so
where is ultra96_v2 bsp??????

focalplane commented 4 days ago • edited

Collaborator

There is a minimal BSP here for PYNQ, it's named sensors96b_v2.bsp for U96 V1 it is sensors96b_v1.bsp

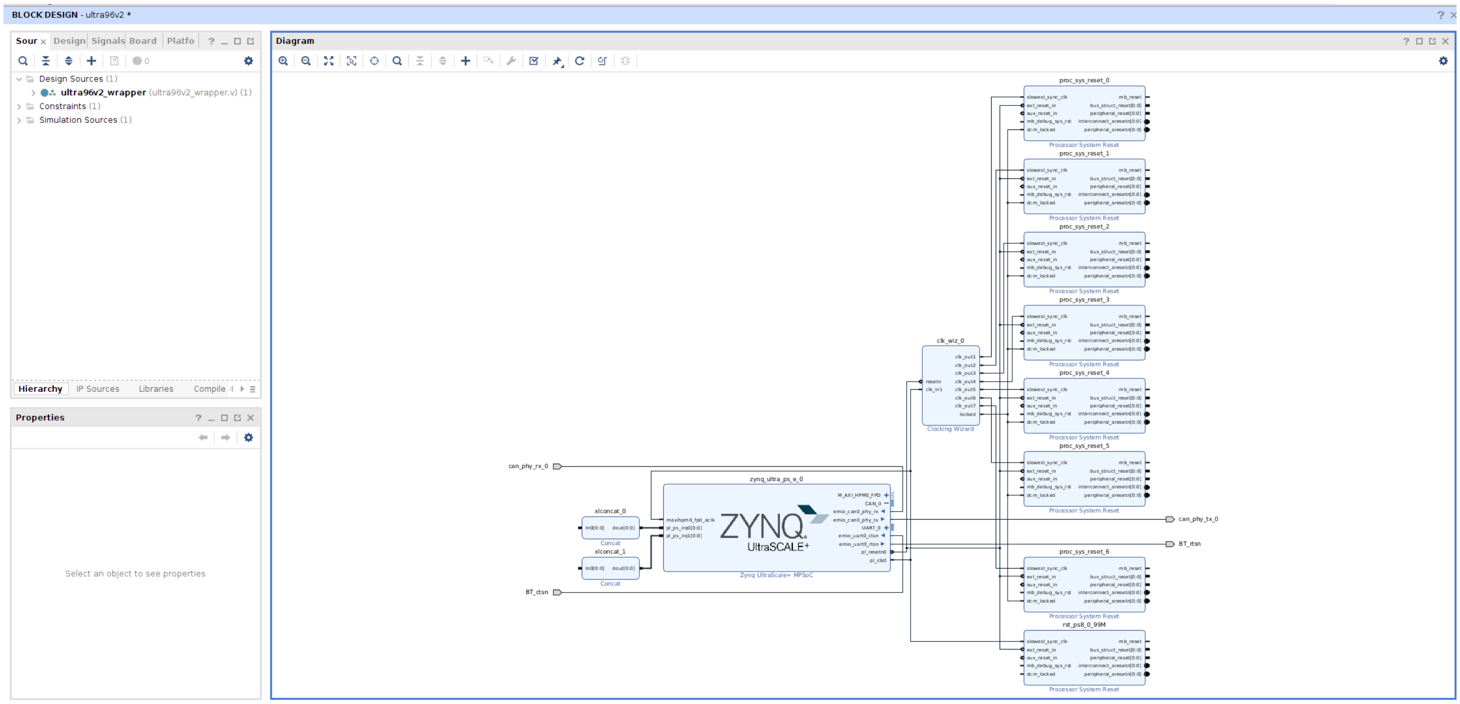
I fixed a confusing part of the readme but the bsp's have always been there since June. Make sure you are on the right branch image_v2.4_v2 (you said you were) or master. They are under ./Ultra96.

The non PYNQ bsps if they exist should be on the zedboard.org for now.

开始

vivado阶段

这块只是在原有的基础上加了一个ps端的can0控制器通过emio的方式引出到板子的40pin上，未做其他的改动



apu部署linux+ubuntu

本节主要叙述如何在ultra96v2上部署一个可以正常使用的Ubuntu系统，这是后续章节的前提

linux内核基于petalinux2018.2进行编译即可
ubuntu16.02-base的移植之前的文档也有过专门的叙述
到ultra96v2的板子上实际上主要涉及到一个sdio的wifi驱动的适配
petalinux目录下添加一个wifi驱动模块的支持

```
petalinux-create -t modules --name wilc --enable
```

在recipes-modules的bb文件中替换为如下文件

```
SUMMARY = "Recipe for building an external wilc Linux kernel module"
SECTION = "PETALINUX/modules"
LICENSE = "GPLv3"
LIC_FILES_CHKSUM = "file://${COMMON_LICENSE_DIR}/GPL-3.0;
md5=c79ff39f19dfec6d293b95dea7b07891"

inherit module

SRC_URI =  "git://github.com/Avnet/u96v2-wilc-driver;
protocol=http;branch=master"

SRCREV = "master"

DEPENDS += "virtual/kernel"

S = "${WORKDIR}/git/wilc"

EXTRA_OEMAKE = 'CONFIG_WILC=y \
                WLAN_VENDOR_MCHP=y \
                CONFIG_WILC_SDIO=m \
                CONFIG_WILC_SPI=n \
                CONFIG_WILC1000_HW_OOB_INTR=n \
                KERNEL_SRC="${STAGING_KERNEL_DIR}" \
                O=${STAGING_KERNEL_BUILDDIR}'
```

执行petalinux build

编译完成后将image/linux下的rootfs/lib/modules下的文件拷贝到ubuntu的/lib/modules下

将官方镜像包中的/home下的文件拷贝到ubuntu的/home/autobrain下

```
autobrain@localhost:~$ ls
ble.sh  bt.sh  test.sh  wifi.sh  wpa_supplicant.conf
autobrain@localhost:~$
```

修改wpa_supplicant.conf中的wifi参数

然后sd卡分区fat分区存放petalinux编译的BOOT.BIN和image.ub

ext4分区存放ubuntu的系统

板子上电，可以正常启动

以root用户执行wifi.sh，wifi可以正常使用

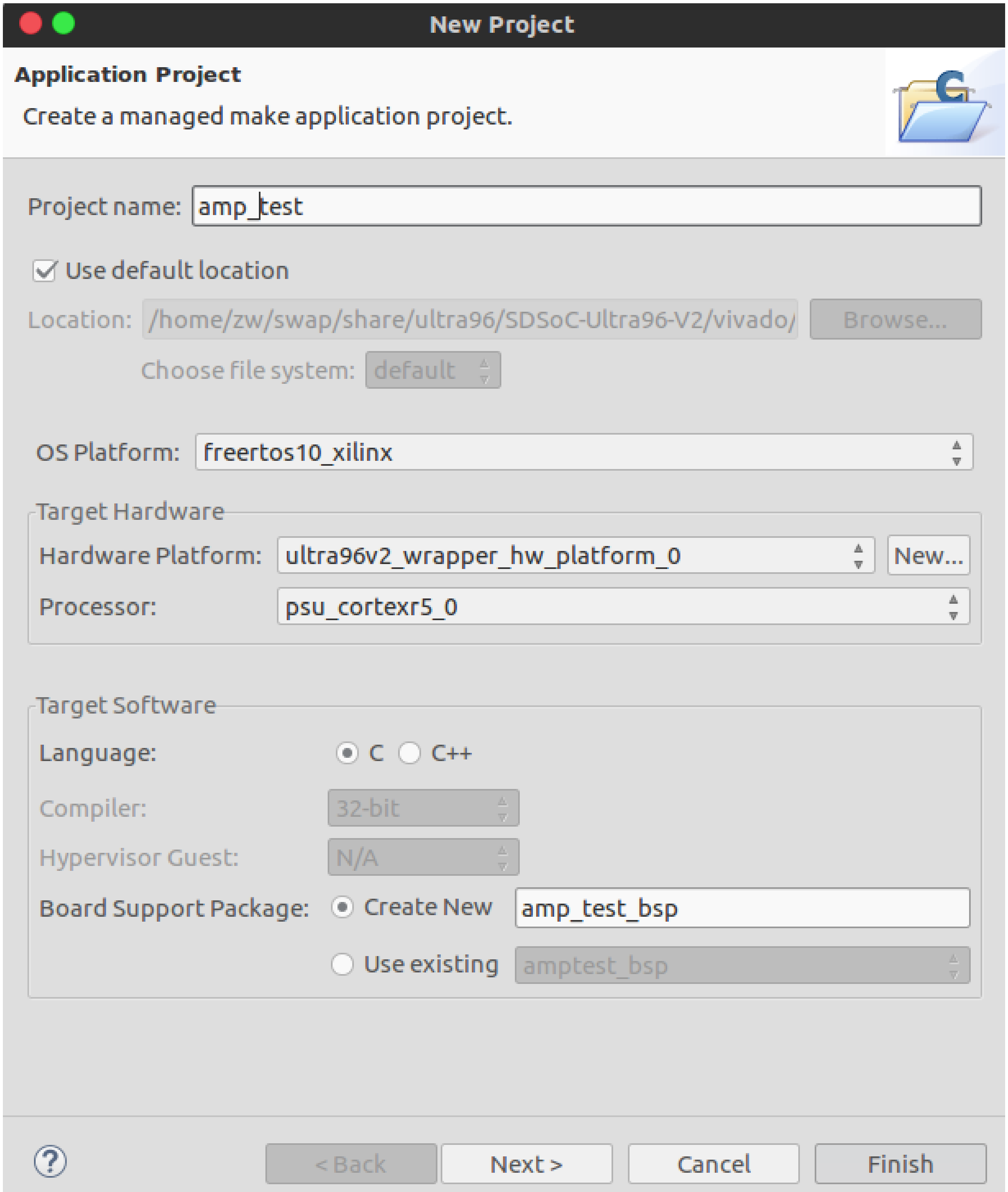
```
autobrain@localhost:~$ sudo ./wifi.sh
[sudo] password for autobrain:
Successfully initialized wpa_supplicant
autobrain@localhost:~$ ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

wlan0     Link encap:Ethernet  HWaddr f8:f0:05:c4:1f:58
          inet addr:192.168.0.102  Bcast:192.168.0.255
          Mask:255.255.255.0
          inet6 addr: fe80::faf0:5ff:fec4:1f58/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:26 errors:0 dropped:0 overruns:0 frame:0
          TX packets:16 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:5065 (5.0 KB)  TX bytes:2199 (2.1 KB)

autobrain@localhost:~$
```

rpu固件启动

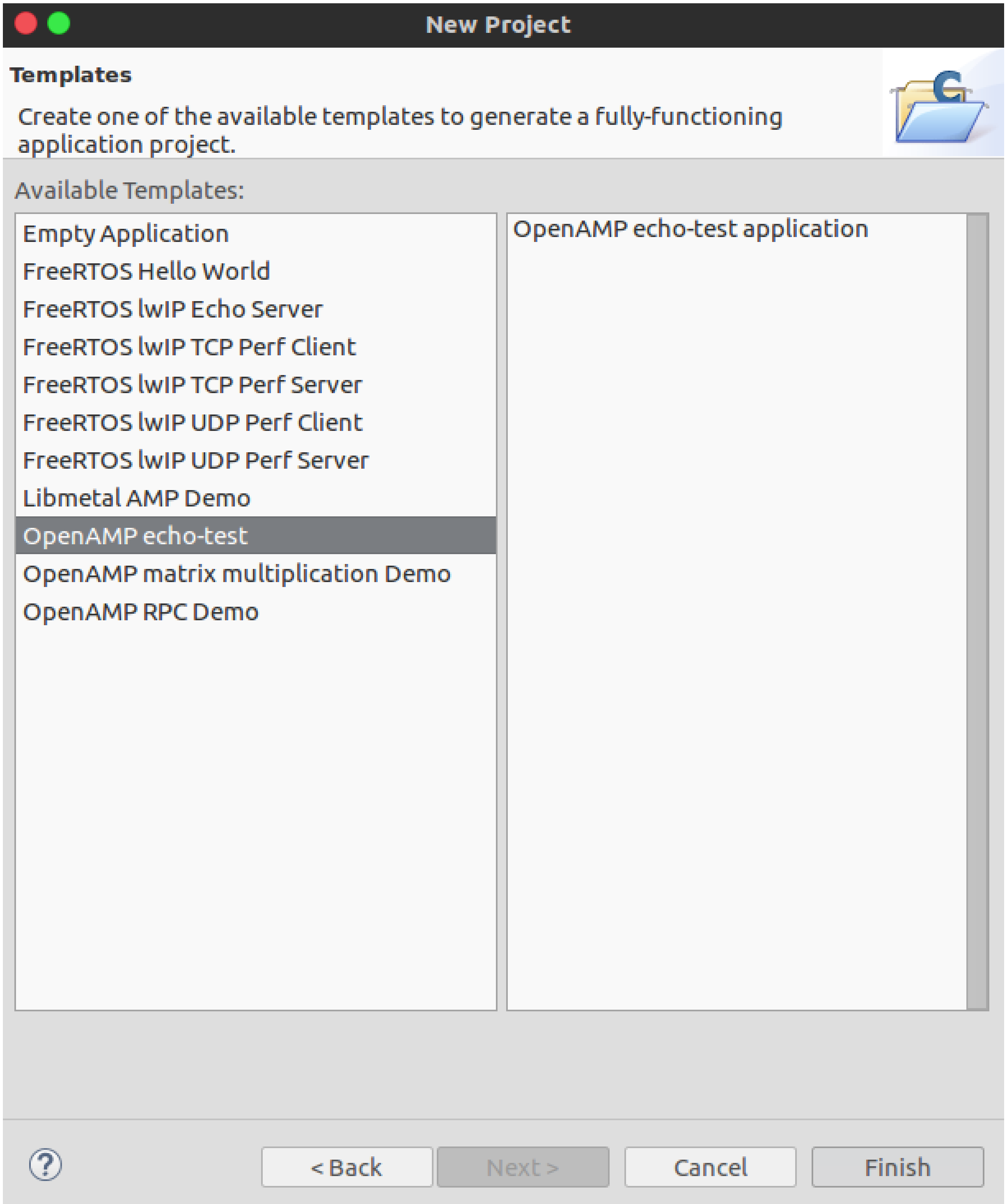
本节主要叙述如何完成rpu上freertos系统的部署以及如何通过apu的linux启动rpu的固件，并完成通信demo的测试

1.rpu的固件编译

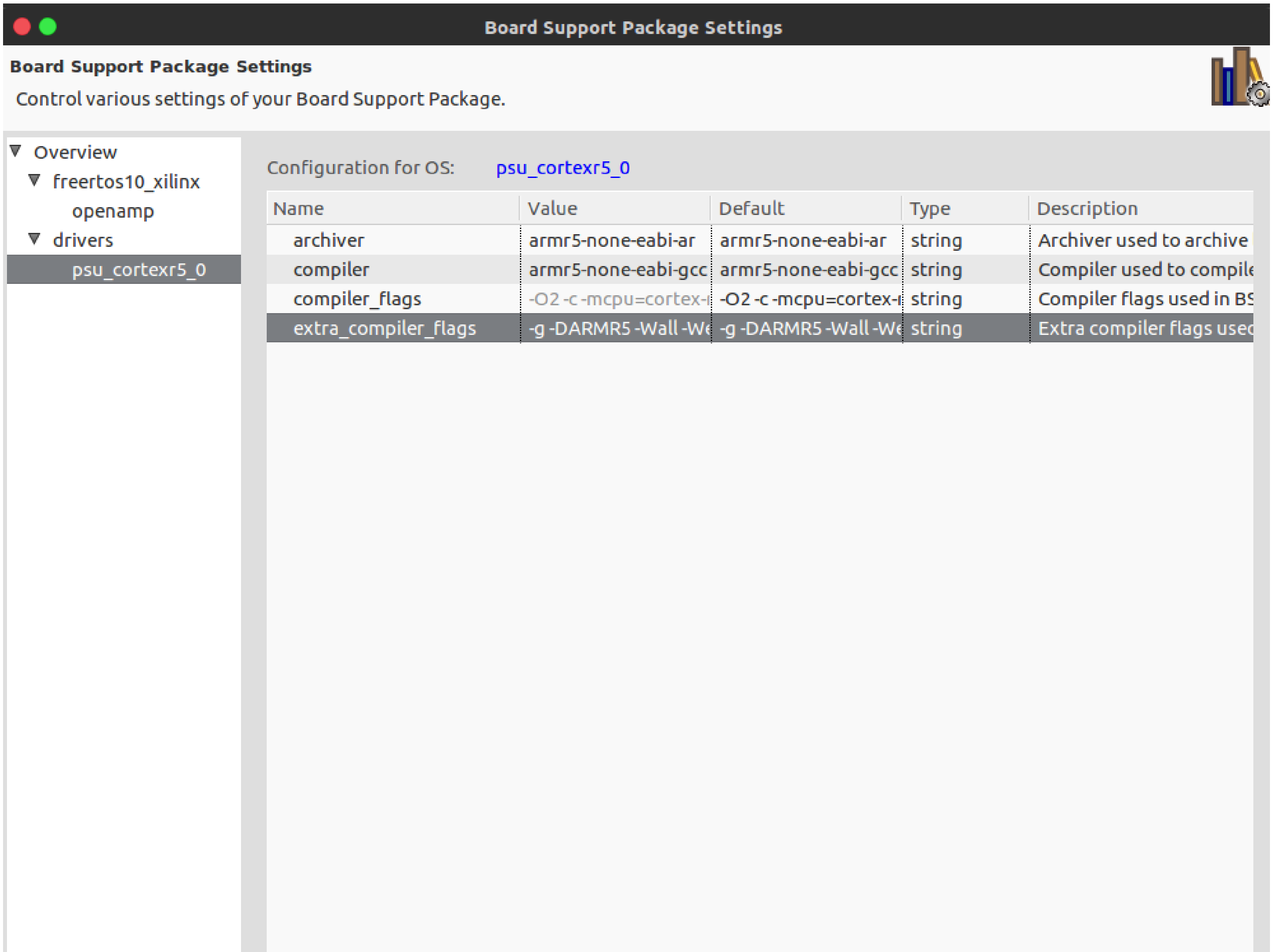
点击vivado中的File > launch SDK
在SDK的界面中点击File > New > Application Projects
在 Processor中选择psu_cortexr5_0 或 psu_cortexr5_1 .
os选择freertos



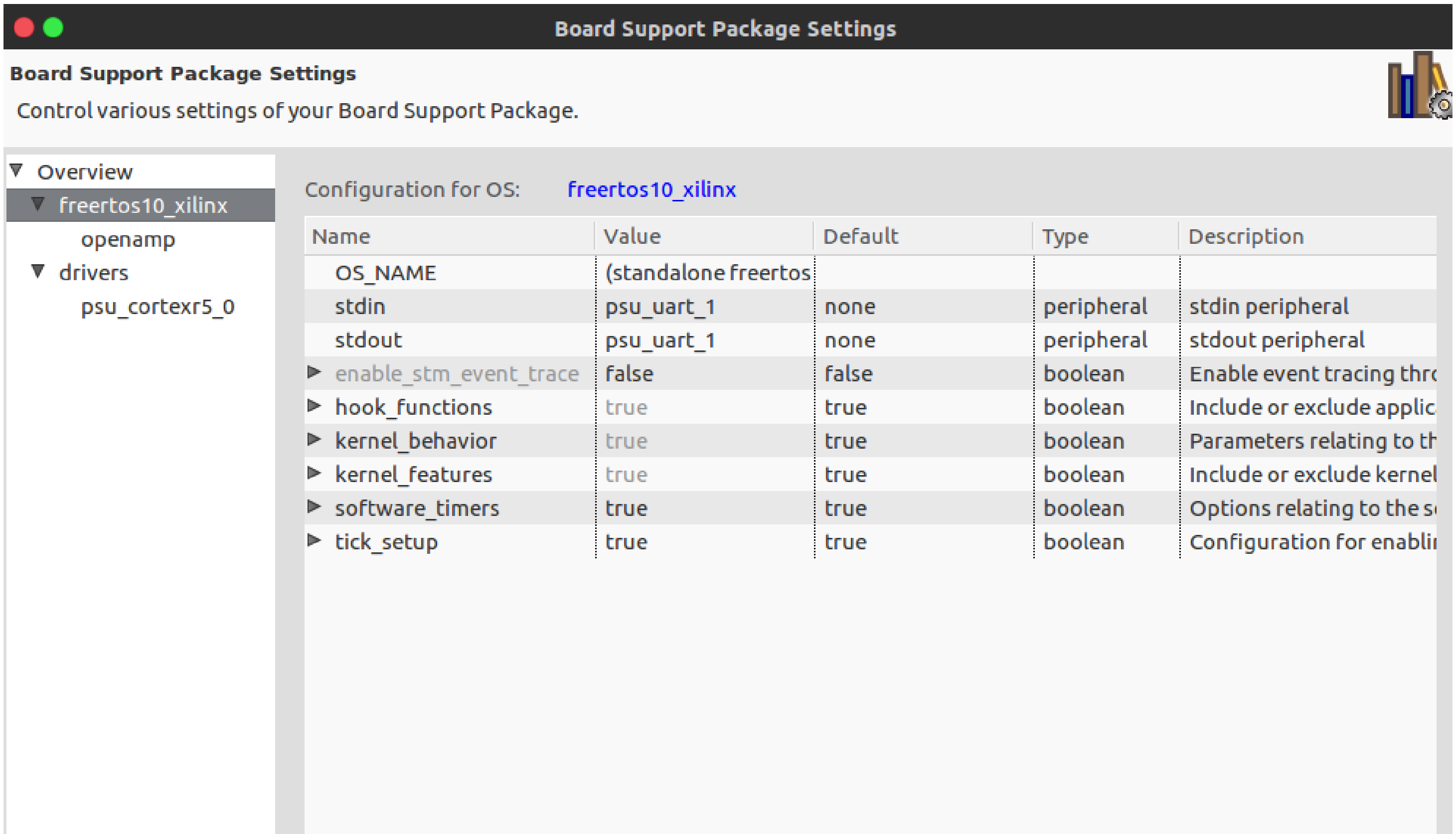
在Demo中选择OpenAMP echo-test



在 Board Support Package Settings中的psu_cortexr5_0中的extra_compiler_flags中的Value中添加-DUSE_AMP=1



调试串口选择uart1，ultra96v2引出来的uart为uart1



执行Project > Build All就可以生成对应的.elf固件了

2.linux+ubuntu上添加openamp的支持

linux内核中添加
petalinuxconfig -c kenel

```
[*] Enable loadable module support --->


Device Drivers --->
Generic Driver Options --->
<*> Userspace firmware loading support


Device Drivers --->
Remoteproc drivers --->
<M> ZynqMP_r5 remoteproc support
```

设备树中system-user.dtsi添加文件系统中添加

```
reserved-memory {
        #address-cells = <2>;
        #size-cells = <2>;
        ranges;
        rproc_0_reserved: rproc@3ed000000 {
                no-map;
                reg = <0x0 0x3ed00000 0x0 0x1000000>;
        };
};

power-domains {
        pd_r5_0: pd_r5_0 {
                #power-domain-cells = <0x0>;
                pd-id = <0x7>;
        };
        pd_tcm_0_a: pd_tcm_0_a {
                #power-domain-cells = <0x0>;
                pd-id = <0xf>;
        };
        pd_tcm_0_b: pd_tcm_0_b {
                #power-domain-cells = <0x0>;
                pd-id = <0x10>;
        };
};

amba {
        r5_0_tcm_a: tcm@ffe00000 {
                compatible = "mmio-sram";
                reg = <0x0 0xFFE00000 0x0 0x10000>;
                pd-handle = <&pd_tcm_0_a>;
        };
        r5_0_tcm_b: tcm@ffe20000 {
                compatible = "mmio-sram";
                reg = <0x0 0xFFE20000 0x0 0x10000>;
                pd-handle = <&pd_tcm_0_b>;
        };

        elf_ddr_0: ddr@3ed00000 {
                compatible = "mmio-sram";
                reg = <0x0 0x3ed00000 0x0 0x40000>;
        };

        test_r50: zynqmp_r5_rproc@0 {
                compatible = "xlnx,zynqmp-r5-remoteproc-1.0";
                reg = <0x0 0xff9a0100 0x0 0x100>,
                <0x0 0xff340000 0x0 0x100>,
                <0x0 0xff9a0000 0x0 0x100>;
                reg-names = "rpu_base","ipi","rpu_glbl_base";
                dma-ranges;
                core_conf = "split0";
                srams = <&r5_0_tcm_a &r5_0_tcm_b &elf_ddr_0>;
```

```
                        pd-handle = <&pd_r5_0>;
                        interrupt-parent = <&gic>;
                        interrupts = <0 29 4>;
                } ;
        };
```

petalinuxconfig -c rootfs

```
Filesystem Packages --->
misc --->
openamp-fw-echo-testd --->
[*] openamp-fw-echo-testd
openamp-fw-mat-muld --->
[*] openamp-fw-mat-muld
openamp-fw-rpc-demo --->
[*] openamp-fw-rpc-demo
```

```
Petalinux Package Groups --->
packagegroup-petalinux-openamp --->
[*] packagegroup-petalinux-openamp
```

执行petalinux build
编译完成后将image/linux下的rootfs/lib/modules下的文件拷贝到ubuntu的/lib/modules下
将image/linux下的rootfs/lib/firmware下的文件拷贝到ubuntu的/lib/firmware下

3.openamp通信demo测试
这个例子中用到的rpu的固件和linux端的执行程序都是petalinux的rootfs中带的
在/home/autobrain 目录下创建脚本添加以下内容

```
#!/bin/sh
modprobe zynqmp_r5_remoteproc
echo image_echo_test > /sys/class/remoteproc/remoteproc0/firmware
echo start > /sys/class/remoteproc/remoteproc0/state
modprobe rpmsg_user_dev_driver
modprobe virtio_rpmsg_bus
echo_test

exit 0
```

以root用户执行该脚本
可以看到控制台打印

```
Echo test start

 Open rpmsg dev /dev/rpmsg0!

 **************************************

  Echo Test Round 0

 **************************************

 sending payload number 0 of size 17
echo test: sent : 17
 received payload number 0 of size 17

 sending payload number 2 of size 18
echo test: sent : 18
 received payload number 2 of size 18

 sending payload number 3 of size 19
echo test: sent : 19
 received payload number 3 of size 19

 sending payload number 4 of size 20
echo test: sent : 20
 received payload number 4 of size 20

...
```

对应的源代码在软件环境提到的openamp 的linux demo中
4替换自己的源码编译的程序进行测试
将第一步生成的.elf固件文件拷贝到ubuntu的/lib/firware中
在petalinux的目录执行

```
petalinux-create -t apps --name amptest --enable
```

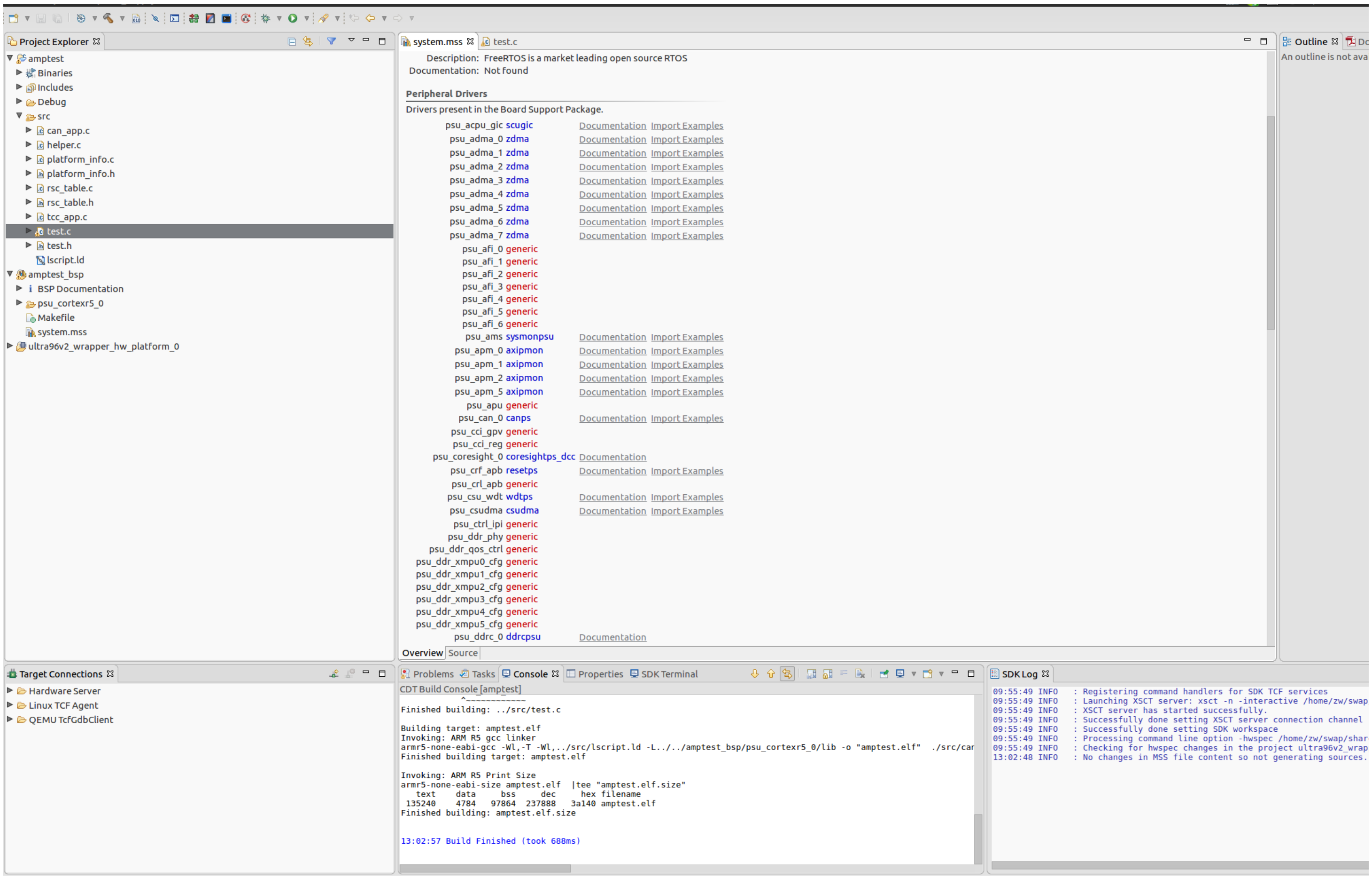
在recipes-apps/amptest/files文件夹中添加下面的文件夹内的全部内容，为了便于区分将名字改成amp_test

```
https://github.com/Xilinx/meta-openamp/tree/master/
recipes-openamp/rpmsg-examples/rpmsg-echo-test
```

在上层的bb文件中也替换上述git文件的bb文件，注意名字要更改成一致的
执行petalinux build
编译后将image/linux下的rootfs/usr/bin下的amptest文件拷贝到ubuntu的/usr/local/sbin下

替换第3步中的shell的image_echo_test为rpu的.elf，echo_test为linux的amptest
以root用户执行脚本，可看到与第3步同样的控制台输出

这个amptest的就是后续测试的apu的linux侧的源码基础
rpu的xsdk的工程是后续测试的rpu侧的工程
xsdk的开发界面如下，在裸机这一侧，xsdk提供了很多的bsp库函数
位于_bsp > psu_cortexr5_0 > libsrc 下
同时在system.mss中也给了一定的example参考
ug1085也就是Zynq UltraScale+ Device的trm



后续的测试中因为rpu与apu对同一个外设有同样的访问权力，为了可以直观的看到调试效果，将uart1作为rpu的打印输出，linux的调试输出放在网口的telnet中进行

rpu与apu协同测试

本节主要涉及到目标的5、6
涉及到的代码有点多，无法截图了，会传到gitlab上，需要注意的是，如果rpu中用到的外设在apu中应该禁掉，具体的就是dts中应当将相应的节点disable掉
rpmsg的相应API只能在上下文中使用，不能在中断中使用

rpmsg_send

Description

Sends a message containing data and payload length to the destination address of the remote processor respective to the rpdev channel using the source and destination address of the `rpdev`. If there are no Tx buffers available, the function remains blocked until one becomes available, or a time-out of 15 seconds elapses. When the latter occurs, `ERESTARTSYS` is returned. Presently, this API can be called from process context only.

Usage

```
static inline int rpmsg_send(struct rpmsg_channel *rpdev, void *data, int len)
```

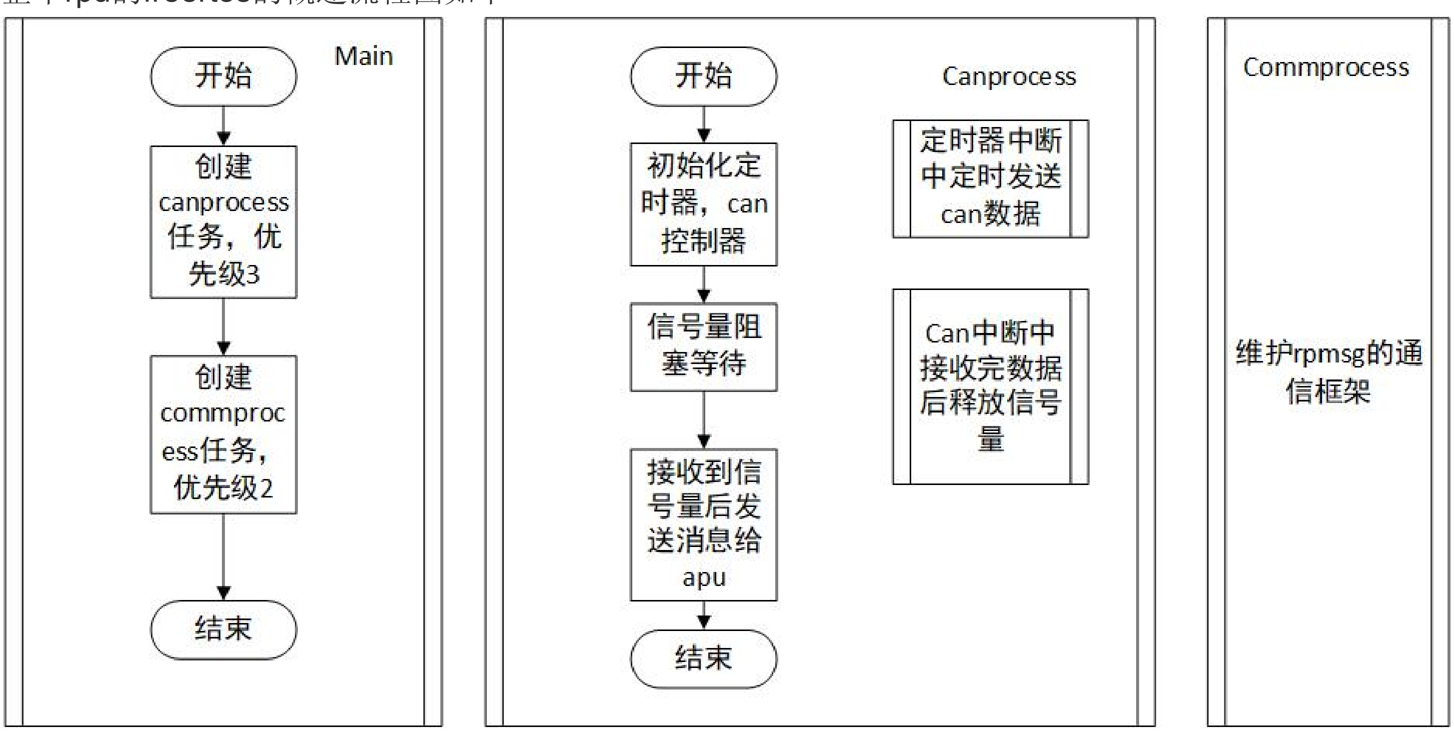
Arguments

`rpdev`	The `rpmsg` channel
`data`	Payload of message
`len`	Length of payload

Returns

Returns 0 on success, and an appropriate error value upon failure.

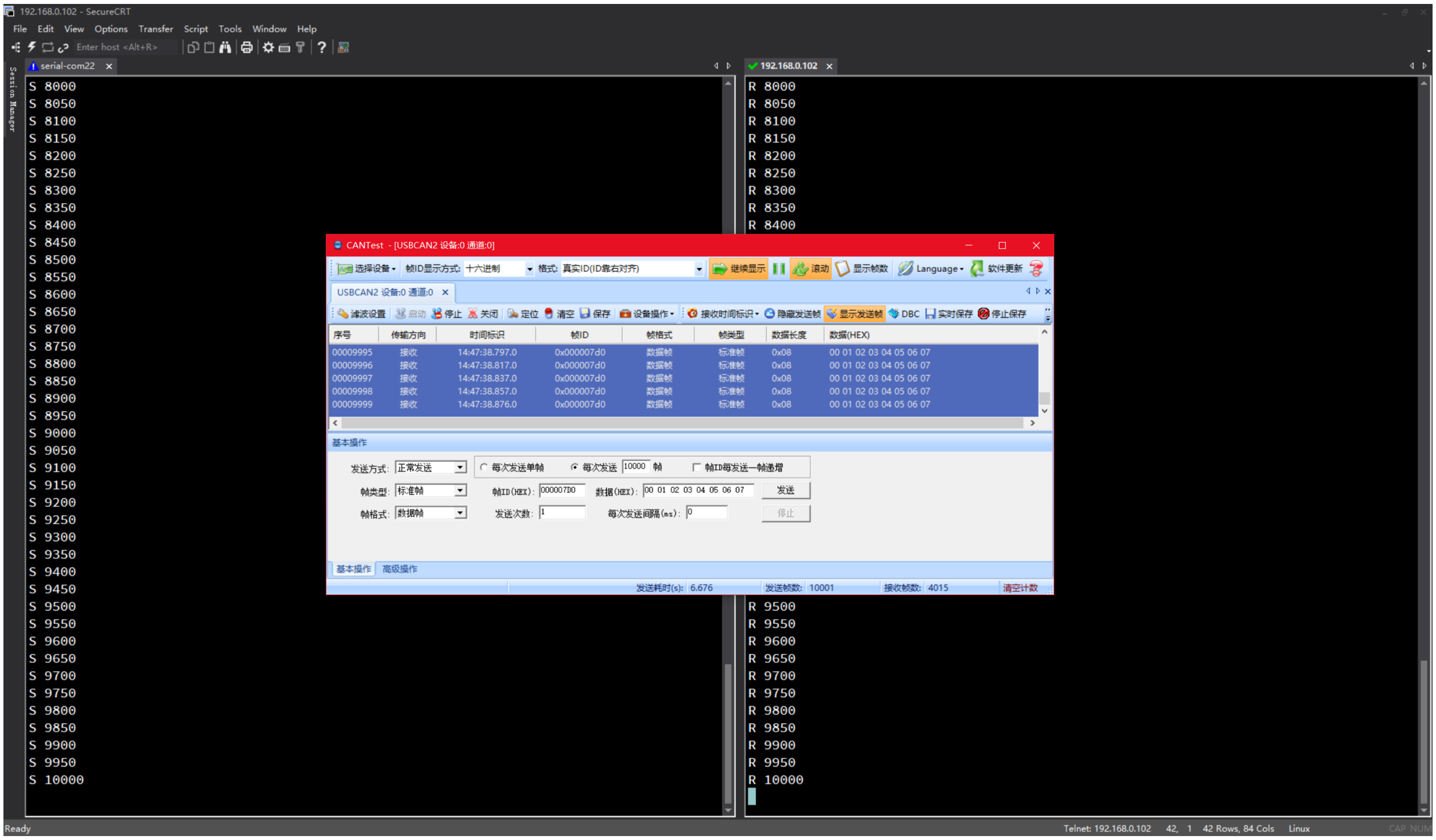
整个rpu的freertos的概述流程图如下



测试效果

左侧为rpu的打印共转发了10000帧，右侧为apu的接收打印共接收了10000帧

同时rpu以20ms的周期向外发送can数据

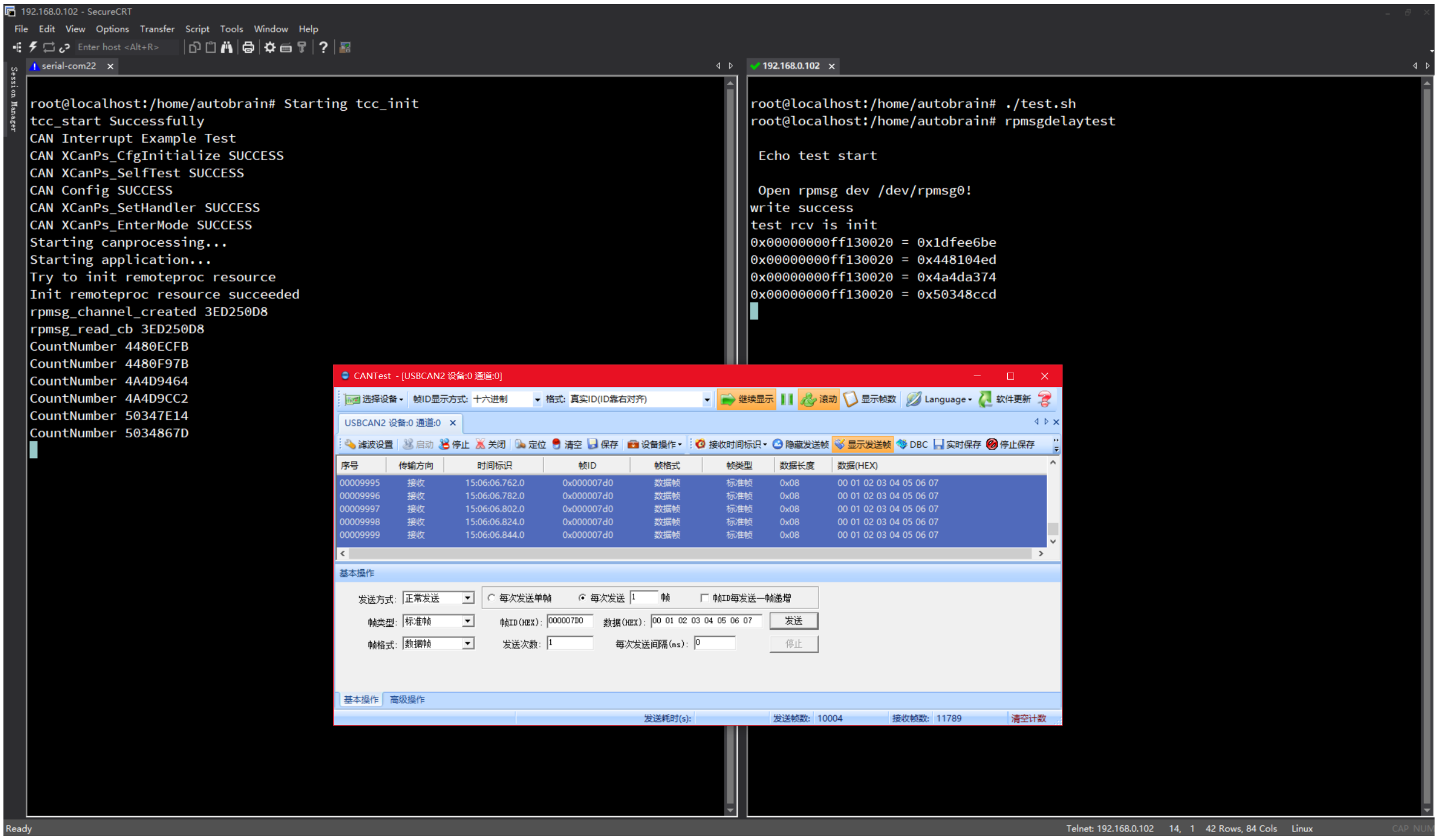


通信时延测试

为了掌握openamp框架的通信时延级别，进行此测试，可以不是十分精确，但是需要测量出为us级还是ms级别

通过在rpu端配置使能一个计数器，当can中断接收数据完成后读取一下计数器的值，rpu端发送完数据后读取一下计数器的值，linux端接收完数据后读取一下寄存器的值

以此来计算通信时延级别



如上图可以看到，计数器的时钟为100M

数据从can中断接收完成到linux接收到该数据的时间大概为37.69us

$$(0x50348ccd - 0x50347E14)/100000000$$

而rpmsg的通信时延大概为16.16us

$$(0x50348ccd - 0x5034867D)/100000000$$