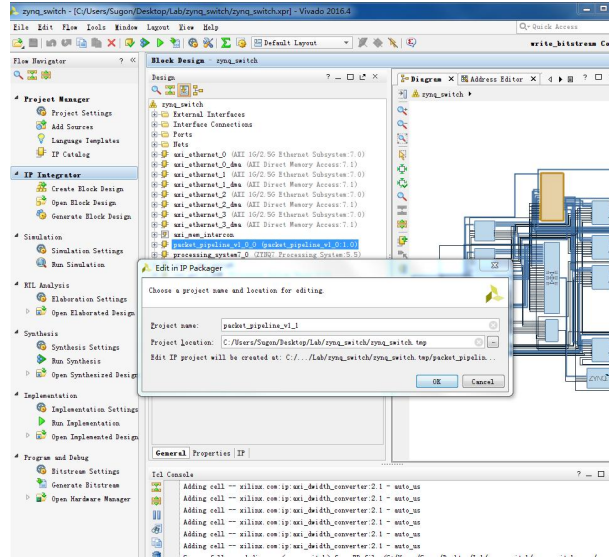


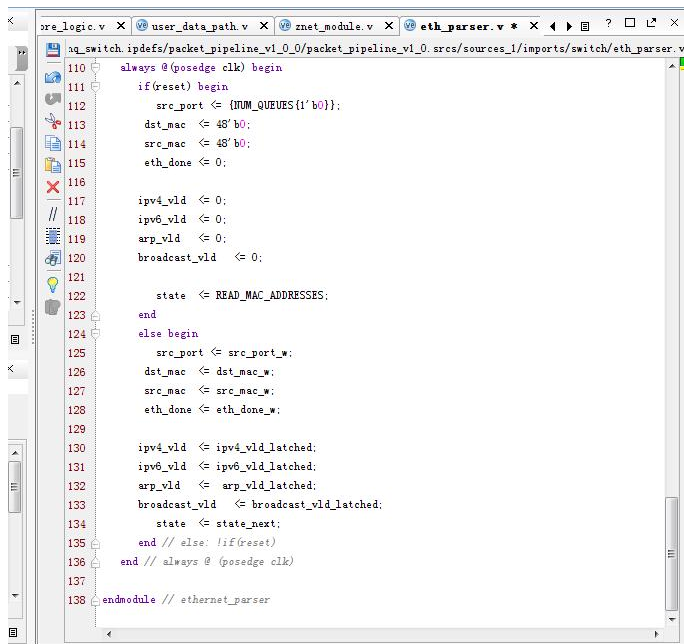
三、实验过程或算法（源程序）

1. 创建 BOOT 镜像文件

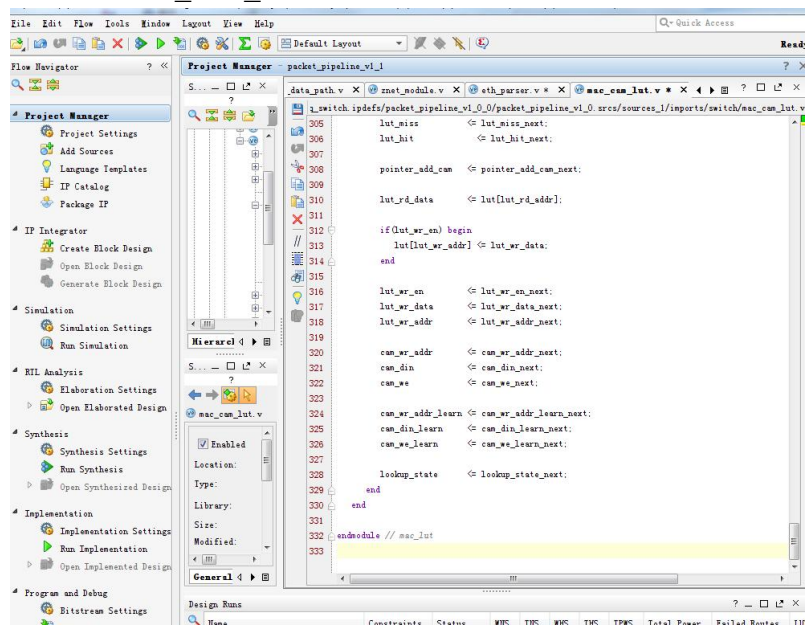
1.1 Edit in IP Packager 选项，保存 pipeline 文件于 zynq_switch.tmp 文件夹



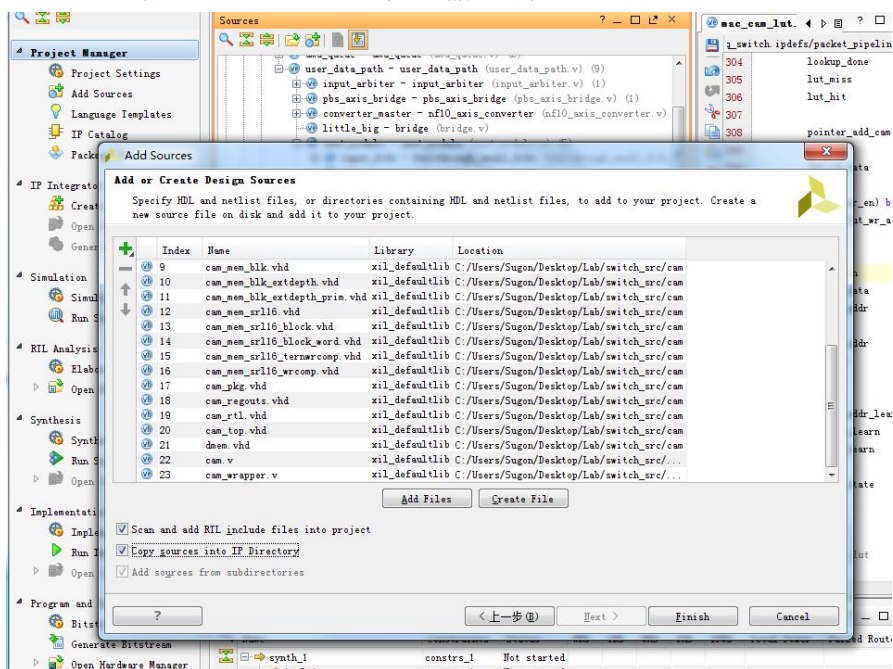
1.2 打开并修改 eth_parser.v 文件



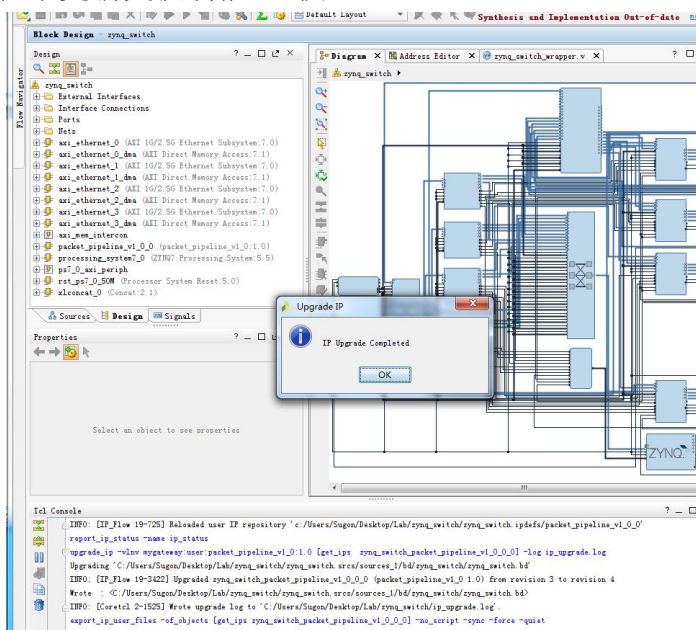
1.3 打开并修改 mac_cam_lut.v 文件。



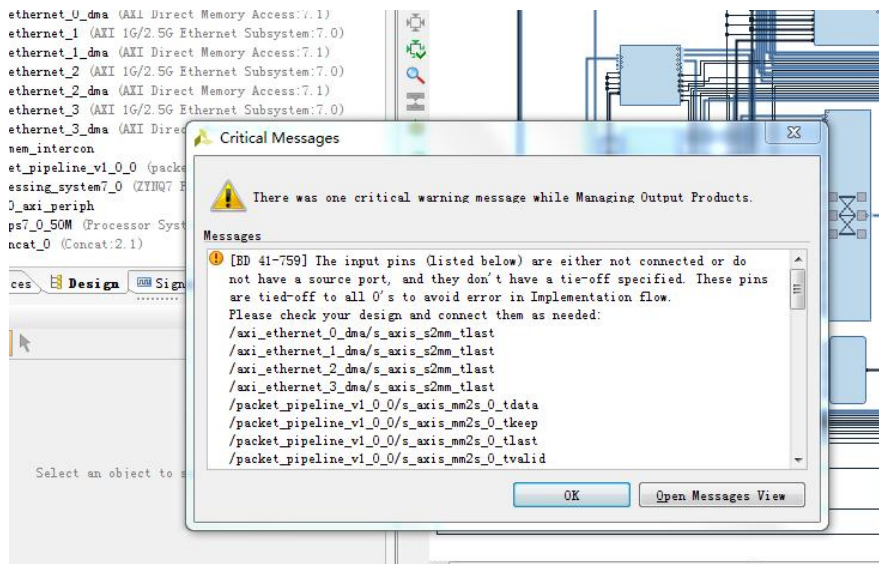
1.4 双击 Source 界面中 mac_cam_lut.v, 并右击选择 Add Sources..选项, 补充完整 cam.v 模块及其子模块, 使之实现功能: 根据源 MAC 地址实现地址自学习, 根据目的 MAC 地址获取输出端口。



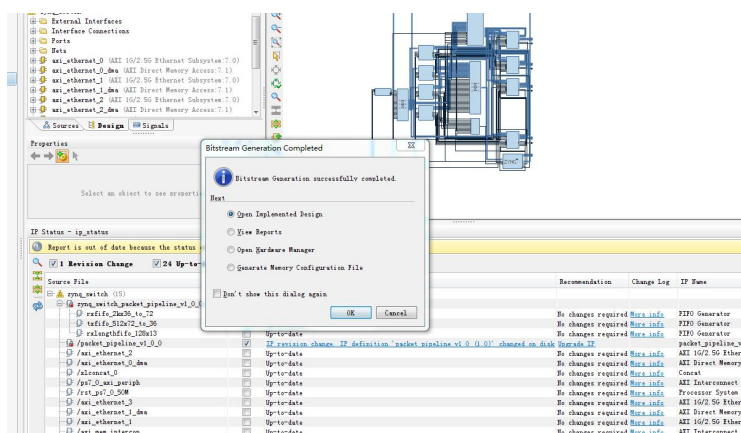
1.5 实验工程中更新交换功能 IP 核:



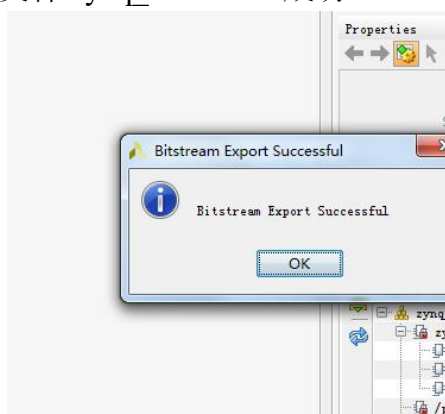
1.5 实出现警告，暂时忽略。该警告是因为交换功能 IP 中有些接口在本实验中没有被用到。



1.6 重新生成顶层文件，综合实现生成 bit 文件，生成成功。

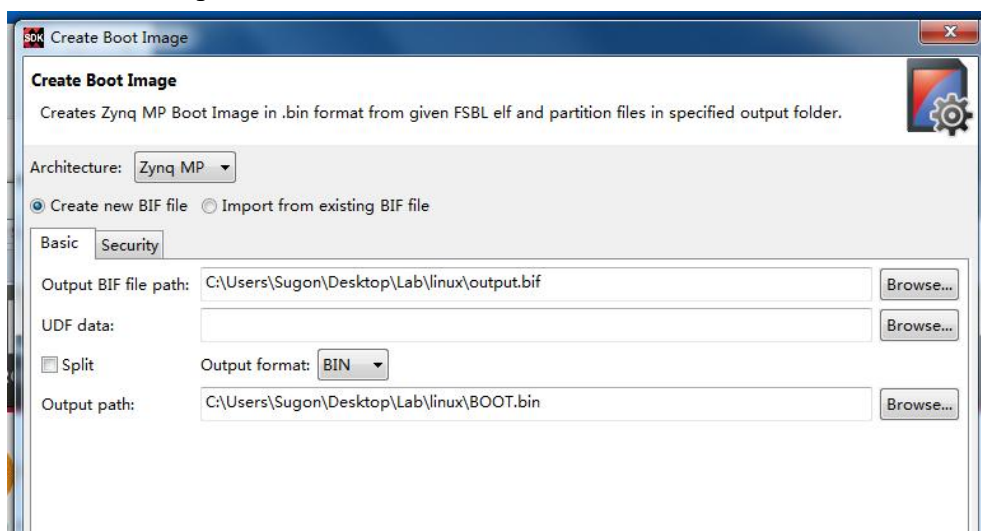


1.7 导出 FPGA 配置文件 zynq_switch.bit 成功

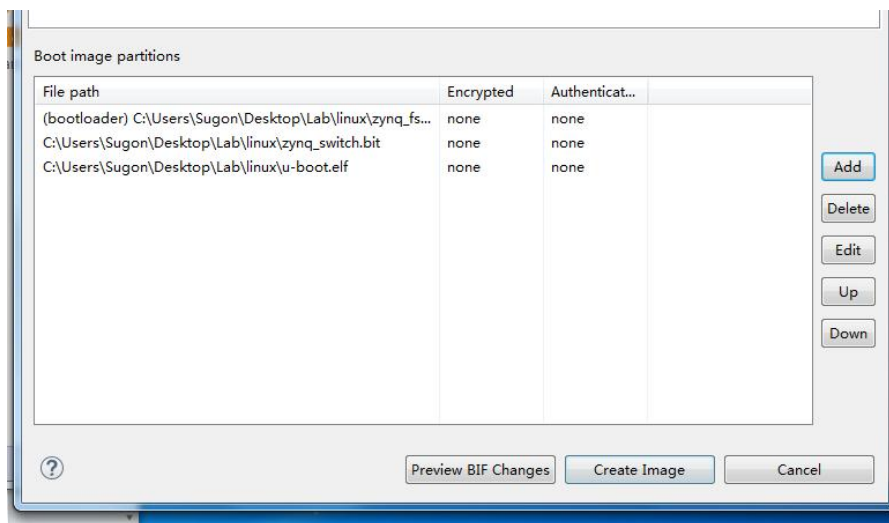


1.8 创建 Boot.bin 启动文件

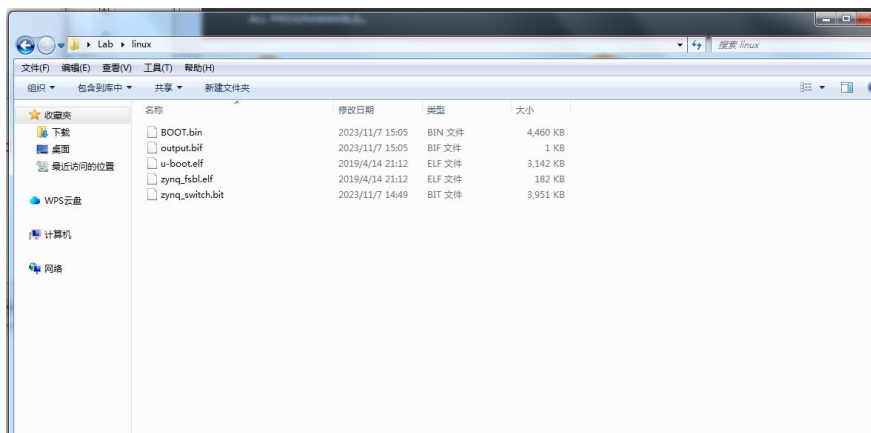
- 定义输出 output.bif 和 BOOT.bin 目录



- 导入以上生成的文件，文件顺序保持不变：



- 生成的五个文件保存在 linux 目录下：



2. 交换机配置软件开发(linux 环境下)

2.1 创建使用 petalinux 工具的环境变量:

```
iwin@ubuntu: ~/zynq_waitch
iwin@ubuntu:~$ ls
Desktop  Downloads  Music  Public  Videos
Documents  examples.desktop  Pictures  Templates
iwin@ubuntu:~$ cd zynq_switch
bash: cd: zynq_switch: No such file or directory
iwin@ubuntu:~$ mkdir zynq_waitch
iwin@ubuntu:~$ cd zynq_waitch/
iwin@ubuntu:~/zynq_waitch$ source /opt/pkg/petalinux/settings.sh
PetaLinux environment set to '/opt/pkg/petalinux'
WARNING: /bin/sh is not bash!
bash is PetaLinux recommended shell. Please set your default shell to bash.
INFO: checking free disk space
INFO: Checking installed tools
INFO: Checking installed development libraries
INFO: Checking network and other services
WARNING: No tftp server found - please refer to "PetaLinux SDK Installation Guide" for its impact and solution
iwin@ubuntu:~/zynq_waitch$
```

2.2 给 petalinux 工程导入硬件工程描述:

```
iwin@ubuntu: ~/zynq_switch/zbox

*** End of the configuration.
*** Execute 'make' to start the build or try 'make help'.

[INFO] sourcing bitbake
[INFO] generating plaxtool conf
[INFO] generating meta-plnx-generated layer
~/zynq_switch/zbox/build/misc/plnx-generated ~/zynq_switch/zbox
~/zynq_switch/zbox
[INFO] generating machine configuration
[INFO] generating bbappends for project . This may take time !
~/zynq_switch/zbox/build/misc/plnx-generated ~/zynq_switch/zbox

~/zynq_switch/zbox
[INFO] generating u-boot configuration files

[INFO] generating kernel configuration files
[INFO] generating kconfig for Rootfs
Generate rootfs kconfig
[INFO] oldconfig rootfs
[INFO] generating petalinux-user-image.bb
iwin@ubuntu:~/zynq_switch/zbox$
```

2.3 第一次编译 Linux 系统: petalinux-build -v

```
iwin@ubuntu: ~/zynq_switch/zbox

linux-xlnx-4.9-xilinx-v2017.4+gitAUTOINC+b450e90fd-r0 do_diffconfig: Config fragment has been dumped into:
/home/iwin/zynq_switch/zbox/build/tmp/work/plnx_arm-xilinx-linux-gnueabi/linux-xlnx/4.9-xilinx-v2017.4+gitAUTOINC+b450e90fd-r0/fragment.cfg
NOTE: recipe linux-xlnx-4.9-xilinx-v2017.4+gitAUTOINC+b450e90fd-r0: task do_diffconfig: Succeeded
NOTE: Tasks Summary: Attempted 22 tasks of which 21 didn't need to be rerun and all succeeded.

generate_bbappend /home/iwin/zynq_switch/zbox/build/tmp/work/plnx_arm-xilinx-linux-gnueabi/linux-xlnx/4.9-xilinx-v2017.4+gitAUTOINC+b450e90fd-r0/user_2023-11-06-23-44-00.cfg /home/iwin/zynq_switch/zbox/project-spec/meta-user/
recipepetool appendsrcfile -w /home/iwin/zynq_switch/zbox/project-spec/meta-user/ virtual/kernel /home/iwin/zynq_switch/zbox/build/tmp/work/plnx_arm-xilinx-linux-gnueabi/linux-xlnx/4.9-xilinx-v2017.4+gitAUTOINC+b450e90fd-r0/user_2023-11-06-23-44-00.cfg
NOTE: Writing append file /home/iwin/zynq_switch/zbox/project-spec/meta-user/recipes-kernel/linux/linux-xlnx_*.bbappend
NOTE: Copying /home/iwin/zynq_switch/zbox/build/tmp/work/plnx_arm-xilinx-linux-gnueabi/linux-xlnx/4.9-xilinx-v2017.4+gitAUTOINC+b450e90fd-r0/user_2023-11-06-23-44-00.cfg to /home/iwin/zynq_switch/zbox/project-spec/meta-user/recipes-kernel/linux/linux-xlnx/user_2023-11-06-23-44-00.cfg

Loading cache: 100% [#####] Time: 0:00:01
Loaded 3257 entries from dependency cache.
Parsing recipes: 100% [#####] Time: 0:00:04
Parsing of 2466 .bb files complete (2433 cached, 33 parsed). 3259 targets, 226 skipped, 0 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies
Initialising tasks: 100% [#####] Time: 0:00:06
NOTE: Executing RunQueue Tasks
NOTE: Tasks Summary: Attempted 2 tasks of which 0 didn't need to be rerun and all succeeded.
[INFO] successfully configured kernel
iwin@ubuntu:~/zynq_switch/zbox$
```

```

iwin@ubuntu: ~/zynq_switch/zbox
Parsing recipes: 100% |#####| Time: 0:00:04
Parsing of 2466 .bb files complete (2433 cached, 33 parsed). 3259 targets, 226 skipped, 0 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies
Initialising tasks: 100% |#####| Time: 0:00:06
NOTE: Executing RunQueue Tasks
NOTE: Tasks Summary: Attempted 2 tasks of which 0 didn't need to be rerun and all succeeded.
[INFO] successfully configured kernel
iwin@ubuntu: ~/zynq_switch/zbox$ petalinux-build -v
[INFO] building project
[INFO] sourcing bitbake
INFO: bitbake petalinux-user-image
Loading cache: 100% |#####| Time: 0:00:01
Loaded 3257 entries from dependency cache.
Parsing recipes: 100% |#####| Time: 0:00:04
Parsing of 2466 .bb files complete (2434 cached, 32 parsed). 3259 targets, 226 skipped, 0 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies
Initialising tasks: 100% |#####| Time: 0:00:09
Checking sstate mirror object availability: 100% |#####| Time: 0:00:06
NOTE: Executing SetScene Tasks
NOTE: Executing RunQueue Tasks
fsbl-2017.4+gitAUTOINC+77448ae629-r0 do_compile: NOTE: fsbl: compiling from external source tree /opt/pkg/petal
nux/tools/hsm/data/embeddedsw
NOTE: Tasks Summary: Attempted 2444 tasks of which 1884 didn't need to be rerun and all succeeded.
INFO: Copying Images from deploy to images
INFO: Creating images/linux directory
NOTE: Failed to copy built images to tftp dir: /tftpboot
[INFO] successfully built project
iwin@ubuntu: ~/zynq_switch/zbox$

```

2.4 在 zbox 工程路径下创建 switch-config 应用:

```

iwin@ubuntu: ~/zynq_switch/zbox
[INFO] building project
[INFO] sourcing bitbake
INFO: bitbake petalinux-user-image
Loading cache: 100% |#####| Time: 0:00:01
Loaded 3257 entries from dependency cache.
Parsing recipes: 100% |#####| Time: 0:00:04
Parsing of 2466 .bb files complete (2434 cached, 32 parsed). 3259 targets, 226 skipped, 0 masked, 0 errors.
NOTE: Resolving any missing task queue dependencies
Initialising tasks: 100% |#####| Time: 0:00:09
Checking sstate mirror object availability: 100% |#####| Time: 0:00:06
NOTE: Executing SetScene Tasks
NOTE: Executing RunQueue Tasks
fsbl-2017.4+gitAUTOINC+77448ae629-r0 do_compile: NOTE: fsbl: compiling from external source tree /opt/pkg/petal
nux/tools/hsm/data/embeddedsw
NOTE: Tasks Summary: Attempted 2444 tasks of which 1884 didn't need to be rerun and all succeeded.
INFO: Copying Images from deploy to images
INFO: Creating images/linux directory
NOTE: Failed to copy built images to tftp dir: /tftpboot
[INFO] successfully built project
iwin@ubuntu: ~/zynq_switch/zbox$ petalinux-create -t apps --template c --name switch-config --enable
INFO: Create apps: switch-config
INFO: New apps successfully created in /home/iwin/zynq_switch/zbox/project-spec/meta-user/recipes-apps/switch-co
nfig
INFO: Enabling created component...
INFO: sourcing bitbake
INFO: oldconfig rootfs
INFO: switch-config has been enabled
iwin@ubuntu: ~/zynq_switch/zbox$

```

2.5 在 zbox 工程路径下创建 router-config 应用:

```

iwin@ubuntu: ~/zynq_switch/zbox
Initialising tasks: 100% |#####| Time: 0:00:09
Checking sstate mirror object availability: 100% |#####| Time: 0:00:06
NOTE: Executing SetScene Tasks
NOTE: Executing RunQueue Tasks
fsbl-2017.4+gitAUTOINC+77448ae629-r0 do_compile: NOTE: fsbl: compiling from external source tree /opt/pkg/petal
nux/tools/hsm/data/embeddedsw
NOTE: Tasks Summary: Attempted 2444 tasks of which 1884 didn't need to be rerun and all succeeded.
INFO: Copying Images from deploy to images
INFO: Creating images/linux directory
NOTE: Failed to copy built images to tftp dir: /tftpboot
[INFO] successfully built project
iwin@ubuntu: ~/zynq_switch/zbox$ petalinux-create -t apps --template c --name switch-config --enable
INFO: Create apps: switch-config
INFO: New apps successfully created in /home/iwin/zynq_switch/zbox/project-spec/meta-user/recipes-apps/switch-co
nfig
INFO: Enabling created component...
INFO: sourcing bitbake
INFO: oldconfig rootfs
INFO: switch-config has been enabled
iwin@ubuntu: ~/zynq_switch/zbox$ petalinux-create -t apps --template c --name router-config --enable
INFO: Create apps: router-config
INFO: New apps successfully created in /home/iwin/zynq_switch/zbox/project-spec/meta-user/recipes-apps/router-co
nfig
INFO: Enabling created component...
INFO: sourcing bitbake
INFO: oldconfig rootfs
INFO: router-config has been enabled
iwin@ubuntu: ~/zynq_switch/zbox$

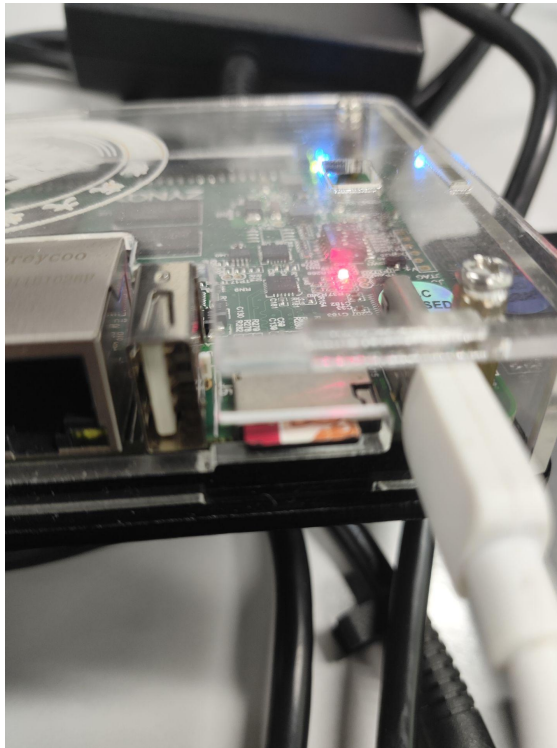
```

2.6 (第二次编译)在 zbox 工程路径下, 编译应用: petalinux-build -v

```
lwin@ubuntu: ~/zynq_switch/zbox
lwin@ubuntu:~/zynq_switch/zbox$ petalinux-create -t apps --template c --name router-config --enable
INFO: Create apps: router-config
INFO: New apps successfully created in /home/lwin/zynq_switch/zbox/project-spec/meta-user/recipes-apps/router-co
nfig
INFO: Enabling created component...
INFO: sourcing bitbake
INFO: oldconfig rootfs
INFO: router-config has been enabled
lwin@ubuntu:~/zynq_switch/zbox$ petalinux-build -v
[INFO] building project
[INFO] sourcing bitbake
INFO: bitbake petalinux-user-image
Loading cache: 100% |#####| Time: 0:00:02
Loaded 3257 entries from dependency cache.
Parsing recipes: 100% |#####| Time: 0:00:04
Parsing of 2468 .bb files complete (2434 cached, 34 parsed, 3261 targets, 226 skipped, 0 masked, 0 errors).
NOTE: Resolving any missing task queue dependencies
Initialising tasks: 100% |#####| Time: 0:00:09
Checking sstate mirror object availability: 100% |#####| Time: 0:00:02
NOTE: Executing SetScene Tasks
NOTE: Executing RunQueue Tasks
fsbl-2017.4-g1tAU101NC-77448ae629-r0 do_compile: NOTE: fsbl: compiling from external source tree /opt/pkg/petali
nux/tools/hsm/data/embeddedsw
NOTE: Tasks Summary: Attempted 2472 tasks of which 2377 didn't need to be rerun and all succeeded.
INFO: Copying Images from deploy to images
NOTE: Failed to copy built images to tftp dir: /tftpboot
[INFO] successfully built project
lwin@ubuntu:~/zynq_switch/zbox$
```

3. 交换机功能验证

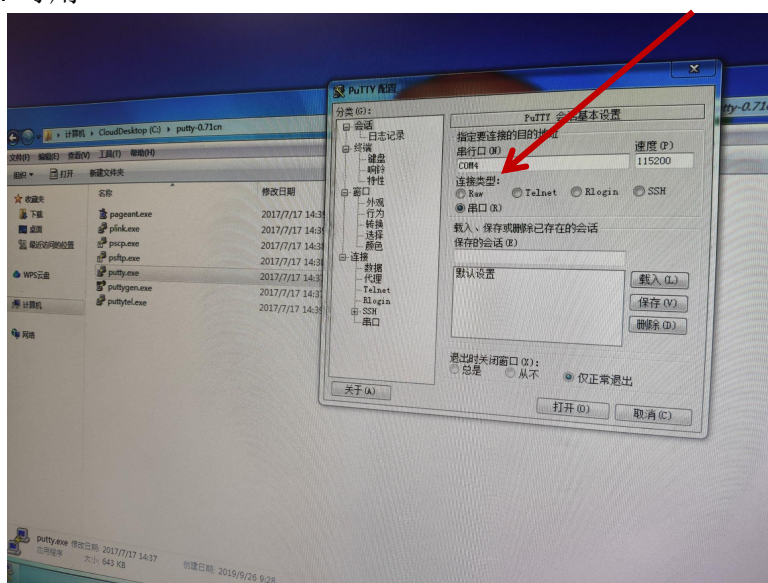
3.1 连接主机，指示灯亮且正常：



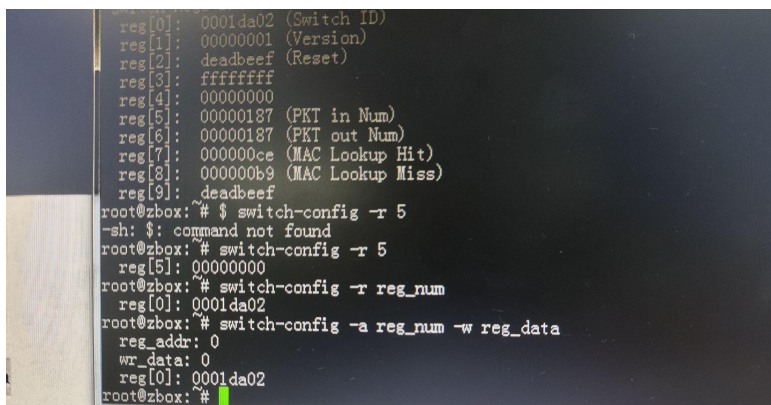
3.2 配置两台主机的 IP：本实验中主机 IP 分别为 192.168.189.103 和 192.168.189.104



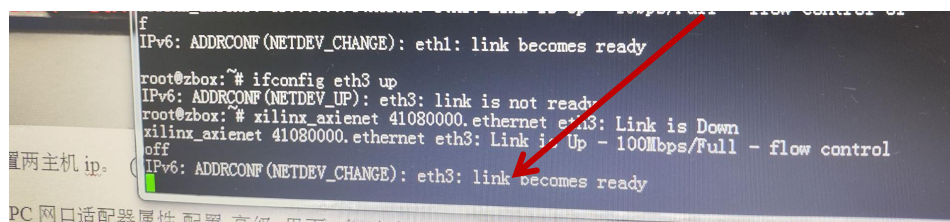
3.3 打开 Putty: 经查看验证, 串行口包括 COM3 和 COM4, 经测试, 只有 COM4 可用



3.4 查看和配置交换机查找表

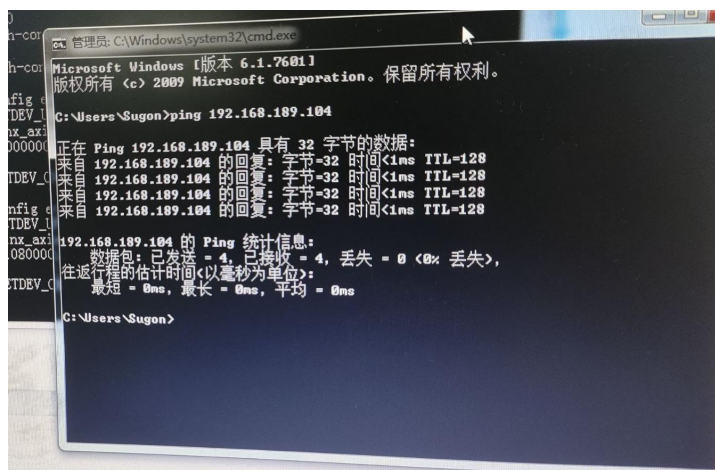


3.5 启动交换机 eth1 和 eth3 端口



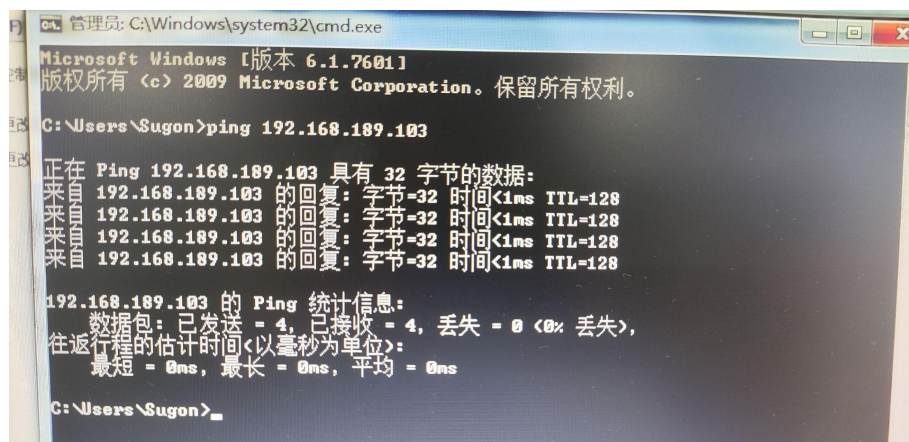
四、实验结果及分析和（或）源程序调试过程

1. 主机 A(192.168.189.103) ping 主机 B(192.168.189.104)



由图可知，消息收发成功，可以 ping 通

2. 主机 B(192.168.189.104) ping 主机 A(192.168.189.103)



由图可知，消息收发成功，可以 ping 通

五、实验心得与体会

通过这次实验，我对 ARM 处理器模块、MAC 模块、DMA 模块、AXI 互联模块以及交换机功能模块有了更深入的理解，了解了如何将这些模块集成在一起，实现完整的交换机功能。

ARM 处理器模块是整个系统的核心，它负责处理各种指令和数据，协调各个模块的工作。MAC 模块和 DMA 模块是实现网络数据传输的关键，MAC 模块负责数据的接收和发送，而 DMA 模块则负责在 MAC 模块和存储器之间进行数据交换。AXI 互联模块是系统中不同模块之间通信的桥梁。通过它，我们可以实现不同 Ethernet 端口间的通信互联，使整个系统的各个模块能够紧密地连接在一起。

在实验过程中，第一次操作的时候生成 bit 流的时候产生了错误，大概是因为导入 23 个文件模块时没有及时更新，导致后面出现了问题，通过重做得以解决。不得不说，实验过程等待时间确实很长，而且一不注意就容易产生问题。