

Guideline for Integrated SmartAMP(TAS2563/TAS2781) Linux driver & Factory Tool

BeagleBone black/QCOM + Kernel-5.10-rt

Revision history

Ver	Date	Author	Description
1.0	2022/9/14		Initial
1.1	2022/9/20		1 st round Review & rework
1.2	2022/9/30		Add tinyalsa
1.3	2022/10/9		2 nd round Review & rework
1.4	2023/02/05		Add firmware compiling
1.5	2023/08/24		Update DTS setting
1.6	2023/09/02		Add Sound card register on QCOM
1.7	2023/09/04		Add Factory tool section
1.8	2023/10/8		Add direct register setting for screen rotation
1.9	2023/10/26		Add how to set i2c address in dts

Information

tasdevice Driver	TAS2563/TAS2781
7-bit I ² C Address	TAS2563: 0x4C ~ 0x4F
	TAS2781: 0x38 ~ 0x3F
Platform	Qualcomm/MTK/LSI/BeagleBone Black/AMBA
Architecture	ALSA/Tiny-ALSA
Bus type	I2C
Kernel Version	v5.10

Release Package II | Driver Package

Kconfig, Makefile	Config for compiling
.c, & .h,	Source code
ti,tas2781.yaml	Sample for dts setting
regbin folder	File to generate a sample register setting file with Regbin tool.
dspfw folder	File to generate a sample dsp firmware and acoustic params file with PPC3 tool.
Verification report	
.ftcfg file	Store speaker basic characterization params for speaker calibration
config_dir/.hybrid-config	Example of config file for compiling Linux kernel 5.10 for BeagleBone Black
hybrid-compile-kon-bbb.sh	Compiling script for compiling Linux kernel 5.10 for BeagleBone Black and integrated-tasdevice driver
hybrid-compile-on-bbb.sh	Compiling script for compiling Linux kernel 5.10 for BeagleBone Black

Release Package II | Tool Utility

FTC_tool	Source code for calibration
PPC3 tool	Tool for sample dsp firmware and acoustic params and ftcfg file
Non_Integrated_Bin_Tool_v1.3.6	Tool for regbin

Cross-compiler

- Deploy cross-compiler (shell command)

```
#sudo apt-get install gcc-arm-linux-  
gnueabi hf lzop
```

PS: If you found following installing log,
pls update apt-get first.



installing.log

```
#apt-get update
```

- Check the compiler version

```
#arm-linux-gnueabi hf-gcc -v
```

gcc version 7.5.0 (Ubuntu/Linaro 7.5.0-
3ubuntu1~18.04)

OR

gcc version 11.3.0 (Ubuntu 11.3.0-
1ubuntu1~22.04)

U-boot I

- Clone U-boot

```
$sudo -i
```

```
#git clone git://git.denx.de/u-boot.git u-boot
```

- Query the branch information

```
#git status
```

```
root@Tintin:/usr/local/BeagleBoneBlack/linux-4.19# cd u-boot/  
root@Tintin:/usr/local/BeagleBoneBlack/linux-4.19/u-boot# git status  
On branch master  
Your branch is up to date with 'origin/master'.  
  
nothing to commit, working tree clean
```

- Query all the tag information

```
#git tag
```



tag.txt

- Switch to specific tag

```
#cd u-boot
```

```
#git checkout v2017.03-rc2 -b tmp
```

```
root@Tintin:/usr/local/BeagleBoneBlack# cd u-boot/  
root@Tintin:/usr/local/BeagleBoneBlack/u-boot# ls  
Kbuild  Licenses  Makefile  api  board  common  configs  doc  dts  
Kconfig  MAINTAINERS  README  arch  cmd  config.mk  disk  drivers  env  
root@Tintin:/usr/local/BeagleBoneBlack/u-boot# git checkout v2017.03-rc2 -b tmp  
Checking out files: 100% (20757/20757), done.  
Switched to a new branch 'tmp'
```

- Check the difference between current tag and the specific tag

```
#git diff v2016.01
```

U-boot II

- Download the patch for BBB

```
# wget -c https://rcn-ee.com/repos/git/u-boot-patches/v2017.03-rc2/0001-am335x_evm-uEnv.txt-bootz-n-fixes.patch
```

```
# wget -c https://rcn-ee.com/repos/git/u-boot-patches/v2017.03-rc2/0002-U-Boot-BeagleBone-Cape-Manager.patch
```

```
# patch -p1 < 0001-am335x_evm-uEnv.txt-bootz-n-fixes.patch
```

```
# patch -p1 < 0002-U-Boot-BeagleBone-Cape-Manager.patch
```

Run above commands in the u-boot



0001-am335x_ev
Env.txt-bootz-n-fi



0002-U-Boot-Bea
ne-Cape-Manage

Linux kernel 5.10-rt Compiling

- Download kernel 5.10-rt([GitHub - beagleboard/linux at 5.10-rt](https://github.com/beagleboard/linux))

```
# git clone https://github.com/beagleboard/linux.git
```

- Uzip the kernel package

```
# sudo unzip linux-5.10-rt.zip
```

```
# cd linux-5.10-rt/
```

- Create compile_BBB-kernel.sh

```
#!/bin/bash
```

```
apt-get install gcc-arm-linux-gnueabi lzop 2>&1 | tee install.log
```

```
make clean 2>&1 | tee clean.log
```

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- bb.org_defconfig -j $(expr $(nproc) - 1) 2>&1 | tee config.log
```

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- -j $(expr $(nproc) - 1) 2>&1 | tee compile.log
```



- Compile the kernel

compile_BBB-kernel.sh

```
# chmod 777 compile_BBB-kernel.sh
```

```
# sudo ./compile_BBB-kernel.sh
```

Obtain root file system

- Download Debian11.4 :

```
# wget -c https://rcn-ee.com/rootfs/eewiki/minfs/debian-11.4-minimal-armhf-2022-07-11.tar.xz
```

```
# wget -c https://rcn-ee.com/rootfs/eewiki/minfs/debian-11.4-minimal-armhf-2022-07-11.tar.xz.sha256sum
```

- Verify sha256sum

```
#sha256sum debian-11.4-minimal-armhf-2022-07-11.tar.xz
```

```
luminlong@luminlong-mybox:~/Linux_new_kernel/debian_package/11.4$ sha256sum debian-11.4-minimal-armhf-2022-07-11.tar.xz
07257d00340fb097a1a9fba34d00b3e2a1224035e3c412a43d55d2356670366e  debian-11.4-minimal-armhf-2022-07-11.tar.xz
```

- Uncomprocessing

```
#tar -xf debian-11.4-minimal-armhf-2022-07-11.tar.xz debian11.4
```

```
# ls ./debian11.4
```

The debian11.4 direction shows following files:

```
an-11.4-minimal-armhf-2022-07-11$ ls
armhf-rootfs-debian-bullseye.tar  user_password.list
image-builder.project
```

- By the way, the user password.list stores the user name and password

```
an-11.4-minimal-armhf-2022-07-11$ cat user_password.list
debian:temppwd
```

Set up MicroSD card I

- Create partition in SD card
- Use fdisk command
 - #umount /dev/sdb*
 - #sudo fdisk /dev/sdb
- Input p, check the partitions, like this:

```
Command (m for help): p
Disk /dev/sdb: 7.5 GiB, 7994343424 bytes, 15613952 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0xd8ed8c21

Device      Boot  Start        End  Sectors  Size Id Type
/dev/sdb1   *      2048      411647   409600  200M  c W95 FAT32 (LBA)
/dev/sdb2           411648  15613951 15202304   7.3G  83 Linux

Filesystem/RAID signature on partition 1 will be wiped.
Filesystem/RAID signature on partition 2 will be wiped.
```

- Input d, Delete a Specified partition

```
Command (m for help): d
Partition number (1,2, default 2):

Partition 2 has been deleted.
```

Set up MicroSD card II

- Input n, create two new partitions
- Input t, then c, change partition 1's type from 'linux' to 'W95 FAT32(LBA)'
- Input a, enable bootable flag on partition1
- Input w, write the partition table to SD card, then exit from fdisk.

```
Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

- Format partitions

```
# sudo mkfs.vfat -F 32 -n boot /dev/sdb1
```

```
# sudo mkfs.ext4 -L rootfs /dev/sdb2
```

```
luminlong@luminlong-mybox:~$ sudo mkfs.vfat -F 32 -n boot /dev/sdb1
mkfs.fat 4.1 (2017-01-24)
mkfs.fat: warning - lowercase labels might not work properly with DOS or Windows
luminlong@luminlong-mybox:~$ sudo mkfs.ext4 -L rootfs /dev/sdb2
mke2fs 1.44.1 (24-Mar-2018)
Creating filesystem with 1900288 4k blocks and 475136 inodes
Filesystem UUID: 1e2b67e2-a9ec-46cb-8de0-a1f9902123a5
Superblock backups stored on blocks:
    32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632

Allocating group tables: done
Writing inode tables: done
Creating journal (16384 blocks): done
Writing superblocks and filesystem accounting information: done
```

- Mount /dev/sdb2 to /media/rootfs/

```
# sudo mkdir -p /media/rootfs/
```

```
# sudo mount /dev/sdb2 /media/rootfs/
```

Install & Backup U-Boot

Install Bootloader

```
# sudo dd if=./u-boot/MLO of=/dev/sdb1 count=2 seek=1  
bs=128k
```

```
# sudo dd if=./u-boot/u-boot-dtb.img of=/dev/sdb1 count=4  
seek=1 bs=384k
```

Backup Bootloader (optional)

```
# sudo mkdir -p /media/rootfs/opt/backup/uboot/
```

- **/media/rootfs/opt/backup/uboot/ is the folder mounted with BBB folder mentioned in previous page**

```
# sudo cp -v ./u-boot/MLO /media/rootfs/opt/backup/uboot/
```

```
# sudo cp -v ./u-boot/u-boot-dtb.img  
/media/rootfs/opt/backup/uboot/
```

Editing of uEnv.txt

- **Please Edit the uEnv.txt as follows:**

```
loadaddr=0x82000000
fdtaddr=0x88000000
rdaddr=0x88080000
initrd_high=0xffffffff
fdt_high=0xffffffff
#for single partitions:
mmcroot=/dev/mmcblk0p1
```

```
loadximage=load mmc 0:1 ${loadaddr} /boot/vmlinuz-${uname_r}
loadxfdt=load mmc 0:1 ${fdtaddr} /boot/dtbs/${uname_r}/${fdtfile}
loadxrd=load mmc 0:1 ${rdaddr} /boot/initrd.img-${uname_r}; setenv rdsiz ${filesize}
loaduEnvtxt=load mmc 0:1 ${loadaddr} /boot/uEnv.txt ; env import -t ${loadaddr} ${filesize};
loadall=run loaduEnvtxt; run loadximage; run loadxfdt;
mmccargs=setenv bootargs console=tty0 console=${console} ${optargs} ${cape_disable} ${cape_enable} root=${mmcroot}
rootfstype=${mmcrootfstype} ${cmdline}
```

```
uenvcmd=run loadall; run mmccargs; bootz ${loadaddr} - ${fdtaddr};
```

- **Copy uExt.txt to /media/rootfs/boot**

```
# sudo cp ./uExt.txt /media/rootfs/boot
```


Install Kernel and Root File System

- Add Kernel version into uEnv.txt

```
# export kernel_version=linux5.10.120-rt  
# sudo sh -c "echo 'uname_r=${kernel_version}' >>  
/media/rootfs/boot/uEnv.txt"
```

- Install root file system

```
# sudo tar xfvp ./denian/*-*-armhf-*/armhf-rootfs-*.tar -  
C /media/rootfs/  
  
# sync  
  
# sudo chown root:root /media/rootfs/  
  
# sudo chmod 755 /media/rootfs/
```

- Copy zImage & dtb

```
# sudo cp -v ./linux5.10-rt/arch/arm/boot/zImage  
/media/rootfs/boot/vmlinuz-${kernel_version}  
  
# sudo mkdir -p /media/rootfs/boot/dtbs/${kernel_version}/  
  
#sudo cp ./linux5.10-rt/arch/arm/boot/dts/am335x-  
boneblack.dtb /media/rootfs/boot/dtbs/${kernel_version}/
```

- Install kernel Modules (optional)

```
# cd ./linux5.10-rt/  
  
# sudo make ARCH=arm CROSS_COMPILE=arm-linux-  
gnueabihf- modules_install  
INSTALL_MOD_PATH=/media/rootfs -j16
```

- File system Table(/etc/fstab)

```
#sudo sh -c "echo '/dev/mmcblk0p1 / auto errors=remount-ro  
0 1' >> /media/rootfs/etc/fstab"
```

Network configuration (optional)

- Edit: /etc/network/interfaces

```
# sudo vi /media/rootfs/etc/network/interfaces
```

Add below:

```
#/etc/network/interfaces
```

```
auto lo
```

```
iface lo inet loopback
```

```
auto eth0
```

```
iface eth0 inet dhcp
```

- Enable eth0

```
# sudo vi /media/rootfs/etc/udev/rules.d/70-  
persistent-net.rules
```

Add below:

```
SUBSYSTEM=="net", ACTION=="add", DRIVERS=="?*",  
ATTR{dev_id}=="0x0", ATTR{type}=="1", KERNEL=="eth*",  
NAME="eth0"
```

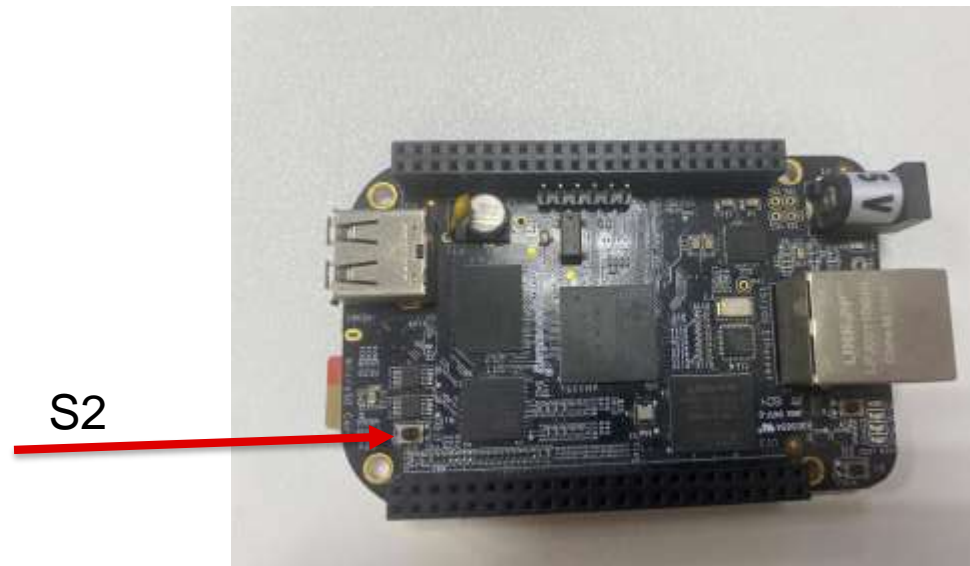

Remove microSD/SD card

- Remove microSD/SD card

```
# sync
```

```
# sudo umount /media/rootfs
```

- Insert the SD card on BBB
- Press and hold button on S2, and Power on the BBB



Device Tree | I2C - mono

- Configuration in DTS:

```
i2c2_pins: pinmux_i2c2_pins {
    pinctrl-single,pins = <
        AM33XX_PADCONF(AM335X_PIN_UART1_CTSN, PIN_INPUT_PULLUP, MUX_MODE3)
        AM33XX_PADCONF(AM335X_PIN_UART1_RTSN, PIN_INPUT_PULLUP, MUX_MODE3)
    >;
};
```

```
76 &i2c2 {
77     pinctrl-names = "default";
78     #address-cells = <1>;
79     #size-cells = <0>;
80     status = "okay";
81     clock-frequency = <400000>;
82     pinctrl-0 = <&i2c2_pins>;
83     tasdevice: tasdevice@38 {
84         status = "okay";
85         #sound-dai-cells = <0>;
86         compatible = "ti,tas2781";
87         reg = <0x38>;
88         reset-gpios = <&gpio1 10 GPIO_ACTIVE_HIGH>;
89     };
90 };
```

Two sides must be the
same i2c address

- How to check device

If the I2C is successfully registered, Check device through below commands, 2-0038 is the registered device. 0x38 is the i2c address for slave device.

```
# ls /sys/bus/i2c/device/
```

```
debian@beaglebone:~$ ls /sys/bus/i2c/devices/
0-0024 0-0050 2-0038 i2c-0 i2c-2
```

- DTS file

PS: This guideline only offer the interrupt setting for BeagleBone Black. For other platform, kindly consult the platform vendor.



am335x-bonebla
ck-hdmi.dtsi

Device Tree | I2C – multiple devices

- Configuration in DTS:

```
i2c2_pins: pinmux_i2c2_pins {
    pinctrl-single,pins = <
        AM33XX_PADCONF(AM335X_PIN_UART1_CTSN, PIN_INPUT_PULLUP, MUX_MODE3)
        AM33XX_PADCONF(AM335X_PIN_UART1_RTSN, PIN_INPUT_PULLUP, MUX_MODE3)
    >;
};
```

```
76 &i2c2 {
77     pinctrl-names = "default";
78     #address-cells = <1>;
79     #size-cells = <0>;
80     status = "okay";
81     clock-frequency = <400000>;
82     pinctrl-0 = <&i2c2_pins>;
83     tasdevice: tasdevice@38 {
84         status = "okay";
85         #sound-dai-cells = <0>;
86         compatible = "ti,tas2781";
87         reg = <0x38>, <0x3f>, <0x3b>;
88         reset-gpios = <&gpio1 10 GPIO_ACTIVE_HIGH>;
89     };
90 };
```

Two sides must be the
same i2c address

- How to check device

If the I2C is successfully registered, Check device through below commands, 2-0038 is the registered device. 0x38 is the i2c address for slave device.

```
# ls /sys/bus/i2c/device/
```

```
debian@beaglebone:~$ ls /sys/bus/i2c/devices/
0-0024 0-0050 2-0038 i2c-0 i2c-2
```

- DTS file

PS: This guideline only offer the interrupt setting for BeagleBone Black. For other platform, kindly consult the platform vendor.



am335x-boneblack-hdmi.dtsi

Device Tree | SPI

- Configuration in DTS:

```
bb_spi0_pins: pinmux_bb_spi0_pins {
    pinctrl-single,pins = <
        AM33XX_PADCONF(AM335X_PIN_SPI0_SCLK, PIN_INPUT, MUX_MODE0)
        AM33XX_PADCONF(AM335X_PIN_SPI0_D0, PIN_INPUT, MUX_MODE0)
        AM33XX_PADCONF(AM335X_PIN_SPI0_D1, PIN_INPUT, MUX_MODE0)
        AM33XX_PADCONF(AM335X_PIN_SPI0_CS0, PIN_INPUT, MUX_MODE0)
    >;
};
```

```
76 &spi0 {
77     #address-cells = <1>;
78     #size-cells = <0>;
79     pinctrl-names = "default";
80     pinctrl-0 = <&bb_spi0_pins>;
81     tasdevice:tasdevice@0 {
82         #sound-dai-cells = <0>;
83         compatible = "ti,tas2781";
84         symlink = "bone/spi/0.0";
85         reg = <0>;
86         reset-gpios = <&gpio1 10 GPIO_ACTIVE_HIGH>;
87         status = "okay";
88         spi-max-frequency = <400000>;
89     };
90 };
```

- How to check device.

If the SPI is successfully registered, Check device through below commands, spi0.0 is the registered device.

```
# ls /sys/bus/spi/device/
```

```
debian@beaglebone:~$ ls /sys/bus/spi/devices/
spi0.0
```

- DTS file

PS: This guideline only offer the interrupt setting for BeagleBone Black. For other platform, kindly consult the platform vendor.



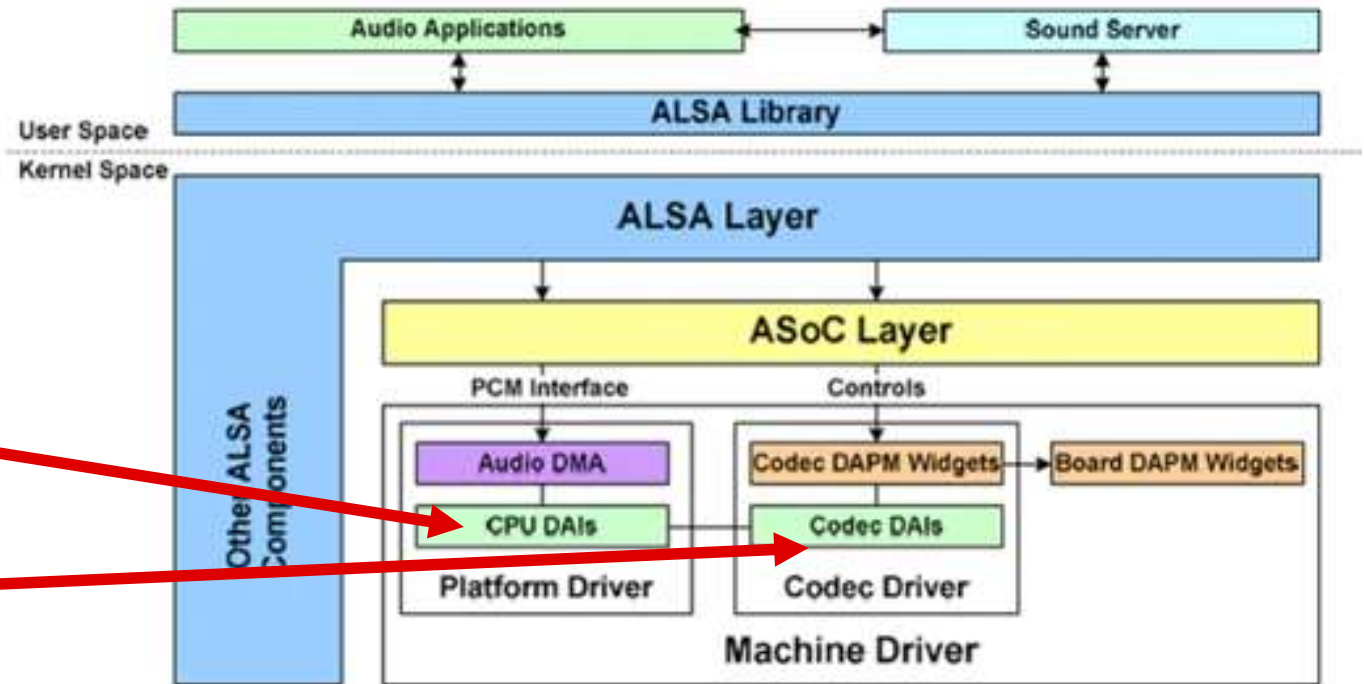
am335x-bonebla
ck-hdmi.dtsi

Device Tree | Sound card

```
&mcasp0 {
    #sound-dai-cells = <0>;
    pinctrl-names = "default";
    pinctrl-0 = <&mcasp0_pins>;
    status = "okay";
    op-mode = <0>; /* MCASP_IIS_MODE */
    tdm-slots = <8>;
    serial-dir = < /* 0: INACTIVE, 1: TX, 2: RX */
        2 2 1 0
    >;
    tx-num-evt = <32>;
    rx-num-evt = <32>;
};

sound {
    compatible = "simple-audio-card";
    simple-audio-card,name = "TI BeagleBone Black";
    simple-audio-card,dai-link@0 {
        format = "dsp_a";
        bitclock-master = <&sound0_master>;
        frame-master = <&sound0_master>;
        sound0_master: cpu {
            sound-dai = <&mcasp0>;
            clocks = <&clk_mcasp0>;
        };

        codec {
            sound-dai = <&tasdevice>;
        };
    };
};
```



Kconfig & Makefile

Kconfig in sound/soc/codecs

```
99      imply SND_SOC_HDAC_HDA
100     imply SND_SOC_ICS43432
101     imply SND_SOC_INNO_RK3036
102     imply SND_SOC_INTEGRATED_TASDEVICE
103     imply SND_SOC_ISABELLE
104     imply SND_SOC_JZ4740_CODEC
105     imply SND_SOC_JZ4725B_CODEC

1788
1789 config SND_SOC_TPA6130A2
1790     tristate "Texas Instruments TPA6130A2 headphone amplifier"
1791     depends on I2C
1792
1793     comment "tas2563"
1794     source "sound/soc/codecs/tas2563/Kconfig"
1795 endmenu
1796
```

Makefile in sound/soc/codecs

```
611 # Amp
612 obj-$(CONFIG_SND_SOC_MAX9877) += snd-soc-max9877.o
613 obj-$(CONFIG_SND_SOC_MAX98504) += snd-soc-max98504.o
614 obj-$(CONFIG_SND_SOC_SIMPLE_AMPLIFIER) += snd-soc-simple-amplifier.o
615 obj-$(CONFIG_SND_SOC_TPA6130A2) += snd-soc-tpa6130a2.o
616 obj-$(CONFIG_SND_SOC_INTEGRATED_TASDEVICE) += tas2563/
```

Modification in defconfig for I2C interface

- Check whether following items have been enabled in arch/arm/configs/ti_sdk_am3x_release_defconfig, if not, enable them as following
 - CONFIG_I2C=y
 - CONFIG_I2C_GPIO=y
 - CONFIG_I2C_OMAP=y
 - CONFIG_I2C_MUX=y

Modification in defconfig for SPI interface

- Check whether following items have been enabled in arch/arm/configs/ti_sdk_am3x_release_defconfig, if not, enable them as following
 - CONFIG_SPI=y
 - CONFIG_SPI_GPIO=y
 - CONFIG_SPI_SPIDEV=y
 - CONFIG_SPI_MASTER=y

Modification in defconfig for Sound Card

- Add following items in arch/arm/configs/ti_sdk_am3x_release_defconfig.
 - CONFIG_SOUND=y
 - CONFIG_SND=y
 - CONFIG_SND_SOC=y
 - CONFIG_SND_SIMPLE_CARD=y
 - CONFIG_SND_SOC_INTEGRATED_TASDEVICE=y

Confirm where the firmware file store in the target device

- Below kernel 5.10
 - The path storing the bin file is defined in kernel/drivers/base/firmware_class.c

```
static const char * const fw_path[] = {
    fw_path_para,
    "/system/vendor/firmware", /*defined
only in Android system*/
    "/system/etc/firmware", /*defined only
in Android system*/
    "/lib/firmware/updates/"
    UTS_RELEASE,
    "/lib/firmware/updates",
    "/lib/firmware/" UTS_RELEASE,
    "/lib/firmware" };
```
- Above & including kernel 5.10
 - The default path storing the bin file is defined in kernel/drivers/base/firmware_loader/main.c.

```
static const char * const fw_path[] = {
    fw_path_para,
    "/lib/firmware/updates/"
    UTS_RELEASE,
    "/lib/firmware/updates",
    "/lib/firmware/" UTS_RELEASE,
    "/lib/firmware" };
```

Add bin file into zImage

- During debug, pushing the bin file into proper folder of the target device is more convenient than compiling into image.
- Detailed see [Firmware search paths — The Linux Kernel documentation](#).
- Other firmware paths can be defined in ueventd.rc

83 lines (70 sloc) | 3.09 KB

```
1 import /vendor/etc/ueventd.rc
2 import /odm/etc/ueventd.rc
3
4 firmware_directories /etc/firmware/ /odm/firmware/ /vendor/firmware/ /firmware/image/
5 uevent_socket_rcvbuf_size 16M
6
7 subsystem graphics
8     devname uevent_devpath
9     dirname /dev/graphics
```



ueventd.rc

Firmware Setting in defconfig

- Compile the bin file into image.
 - Add following settings into defconfig file

```
CONFIG_FW_LOADER=y
CONFIG_FW_LOADER_PAGED_BUF=y
CONFIG_EXTRA_FIRMWARE="tas2781-4amp-reg.bin tas2781-4amp-dsp.bin regulatory.db
regulatory.db.p7s am335x-pm-firmware.elf am335x-bone-scale-data.bin am335x-evm-scale-data.bin am43x-
evm-scale-data.bin"
CONFIG_EXTRA_FIRMWARE_DIR="firmware"
```

 - ❑ CONFIG_EXTRA_FIRMWARE_DIR is path where the bin file is stored into the kernel root. “firmware” is the relative path in the compiling base path.
 - ❑ CONFIG_EXTRA_FIRMWARE is the name of firmware name. if multiple bin files are required, input the file name format like **CONFIG_EXTRA_FIRMWARE = “a.bin b.bin c.bin”**
 - ✓ Do not forget copy the firmware file into “firmware” folder in the compiling base folder
 - ❑ If this method is enabled, the fw will be loaded during system bootup.
 - During debug, pushing the bin file into proper folder of the target device is more convenient than compiling into image. Once compiling into zImage, every time the bin file is changed, it should be recompiled into zImage instead of copied into the *fw_path*

PS: How to compile the firmware into Android, please refer to [Appendix V | Compile firmware into Android system](#)

Firmware & ftcfg file naming

file	File name	Remark
regbin	tas2781-1amp-reg.bin tas2563-4amp-reg.bin	Generated by regbin tool
Dsp firmware & params	tas2781-1amp-dsp.bin tas2563-4amp-dsp.bin	Generated by ppc3
ftcfg	tas2781-a.ftcfg tas2781-b.ftcfg tas2563-a.ftcfg tas2563-b.ftcfg tas2563-c.ftcfg tas2563-d.ftcfg ...	
Calibrated file	tas2781-a-cal.bin tas2781-b-cal.bin ...	Generated by ftc tool

Compile Image with tas2781 driver

- Generate .config
 - #sudo make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi-hf- ti_sdk_am3x_release_defconfig
- Compile the image
 - #sudo make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi-hf- zImage dtbs -j16

PS:

1. There's a config file with the name .hybrid_config in the [.hybrid-config « config_dir - tas2781-linux-drivers/tas2781-linux-driver - Unnamed repository; edit this file 'description' to name the repository.](#) It can be used directly for compiling without ,config generation.
2. [hybrid-compile-ko.sh](#) will compile the driver as a module, that is ko file.
3. [hybrid-compile.sh](#) will compile the kernel image without the driver.

Audio card registration

- BBB use mcasp0 to output the audio data. If the DTS was configured correctly, the driver will create sound card device and kcontrols, we can check below commands to confirm that.

```
# ls /dev/snd
```

```
# ls /sys/bus/i2c/devices/2-0038
```

```
# cat /proc/asound/pcm
```

```
# cat /proc/asound/cards
```

```
debian@beaglebone:~$ ls /dev/snd/
by-path  controlC0  pcmC0D0c  pcmC0D0p  timer
debian@beaglebone:~$ ls /sys/bus/i2c/devices/2-0038
act_addr  driver      fwload     of_node   regbininfo_list  subsystem
dev_addr  dspfw_config  modalias  power     regcfg_list      uevent
devinfo   dspfwinfo_list  name      reg       regdump
debian@beaglebone:~$ cat /proc/asound/pcm
00-00: davinci-mcasp.0-tasdevice_codec tasdevice-codec.2-0038-0 : davinci-mcasp.0-tasdevice_codec tasdevice-codec.2-0038-0 : playback 1 : capture 1
debian@beaglebone:~$ cat /proc/asound/cards
 0 [Black          ]: TI_BeagleBone_B - TI BeagleBone Black
                          TI BeagleBone Black
```

Driver nodes I | Introduction

- In order to debug driver freely, several driver nodes have been defined,

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ ls
act_addr  driver      fwload      of_node     regbininfo_list  subsystem
dev_addr  dspfw_config  modalias    power       regcfg_list      uevent
devinfo   dspfwinfo_list  name        reg         regdump
```

- Check below path to access above driver nodes
 - /sys/bus/i2c/devices/2-0038
 - /sys/class/i2c-adapter/i2c-2/2-0038
 - /sys/class/i2c-dev/i2c-2/device/2-0038

Driver nodes II | fwload/i2caddr/devinfo

- #echo > fwload

Illustration: Use for debug if firmware has not been compiled into rootfs.

```
root@an335x-evm:/sys/bus/i2c/devices/2-0048# echo>fwload
root@an335x-evm:/sys/bus/i2c/devices/2-0048# [ 192.697698] pcmdevice-codec 2-0048: fwload: count = 1
[ 192.719134] pcmdevice-codec 2-0048: pcmdev: regbin_ready start
[ 192.719184] pcmdevice-codec 2-0048: nconfig = 1
[ 192.719214] pcmdevice-codec 2-0048: img_sz = 436 total_config_sz = 144 offset = 292
[ 192.719336] pcmdevice-codec 2-0048: Firmware init complete
```

- #amixer contents

```
debian@beaglebone:/sys/class/i2c-dev/i2c-2/device/2-0038$ amixer contents
numid=3,iface=MIXER,name='Configuration'
; type=INTEGER,access=rw-----,values=1,min=0,max=0,step=0
[ 7044.116010] tasdevice-codec 2-0038: tasdevice_info_dsp: max program num = 1
: values=0
numid=1,iface=MIXER,name='Program'
; type=INTEGER,access=rw-----,values=1,min=0,max=255,step=0
: values=1
numid=2,iface=MIXER,name='TASDEVICE Profile id'
; type=INTEGE[ 7044.116046] tasdevice-codec 2-0038: tasdevice_info_dsp: max configuration num = 2
R,access=rw-----,values=1,min=0,max=6,step=0
: values=0
```

- #cat dev_addr

Illustration: show the active i2c address

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat dev_addr
ndev:1
addr0:38
```

- #cat devinfo

Illustration: Get the basic information of audio device on the board

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat devinfo
No.      DevTyp  Addr
0        audev  0x38
```

Driver nodes II | reg

- `#echo chn 0xBK 0xPG 0xRG 0xXX > reg`

Illustration: Write a value to a certain register

- chn is channel no, must be 1-digital
- BK, PG, RG & XX must be 2-digital HEX
- eg: `0 0x00 0x00 0x05 0x07 > reg`

- `#cat reg`

Illustration: Read back the value from the register which have been echoed before

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ echo 0 0x00 0x00 0x05 0x07 > reg
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat reg
i2c - addr: 0x38
Chn0B0x00P0x00R0x05:0x07
```

Driver nodes III | regdump

- `#echo chn 0xBK 0xPG > regdump`

Illustration: the command dump all the registers of the specific page

- chn is channel no, must be 1-digital
- BK & PG must be 2-digital HEX

- `#cat regdump`

Illustration: run the echo command, show the 7-bit i2c address of the chip and dump the registers



Driver nodes IV | regbininfo_list &

- #cat regbininfo_list

Illustration: list the regbin version and dump the name of all the audio cases from regbin file, If wanted detailed info from specific audio case, kindly use the drive node **regcfg_list**

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat regbininfo_list
Regbin File Version: 0x0105
conf 00: I2S-16bit-echoreference-slot0
conf 01: I2S-16bit-echoreference-slot2
conf 02: I2S-16bit-IV-slot0
conf 03: TDM-16bit-echoreference-slot0
conf 04: dsp-16bit-slot0
conf 05: echo-ref
```

- #cat dspfwinfo_list

Illustration: list the detail of fwdsp bin file and dump the program name and configuration name.

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat dspfwinfo_list
tas2781_dsp.bin
Git format
Generated by PPC3V0x14200

ndev: 1
mnPrograms: 1
  ProgramName:   Tuning Mode
mnConfigurations: 2
  nConfig:0
    ConfigName:configuration_audio_Tuning Mode_48 KHz_s1_0  Program:0x00
  nConfig:1
    ConfigName:calibration_Tuning Mode_48 KHz_s1_0  Program:0x00
```

Driver nodes V | regcfg_list

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ echo 00 >regcfg_list
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ [ 8108.293276] tasdevice-codec 2-0038: regcfg: count = 3
[ 8108.293320] tasdevice-codec 2-0038: [regcfg_list]cfg= 0, cnt=3

debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat regcfg_list
Conf 00: I2S-16bit-echo-reference-slot0
block type:PRE_POWER_UP device idx = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x00 REG0x0e VALUE = 0xc4
        BOOK0x00 PAGE0x00 REG0x0f VALUE = 0x40
        BOOK0x00 PAGE0x00 REG0x5c VALUE = 0xd9
        BOOK0x00 PAGE0x00 REG0x0d VALUE = 0x01
        BOOK0x00 PAGE0x00 REG0x10 VALUE = 0x04
        BOOK0x00 PAGE0x00 REG0x16 VALUE = 0x40
        BOOK0x00 PAGE0x01 REG0x17 VALUE = 0xc8
    BURST:
        BOOK0x00 PAGE0x04
        REG0x30 = 0x00 REG0x31 = 0x00 REG0x32 = 0x00 REG0x33 = 0x01
    BURST:
        BOOK0x00 PAGE0x08
        REG0x18 = 0x00 REG0x19 = 0x00 REG0x1a = 0x00 REG0x1b = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x08 REG0x1c VALUE = 0x00
    BURST:
        BOOK0x00 PAGE0x08
        REG0x28 = 0x40 REG0x29 = 0x00 REG0x2a = 0x00 REG0x2b = 0x00
    BURST:
        BOOK0x00 PAGE0x0a
        REG0x48 = 0x00 REG0x49 = 0x00 REG0x4a = 0x00 REG0x4b = 0x00
    BURST:
        BOOK0x00 PAGE0x0a
        REG0x58 = 0x40 REG0x59 = 0x00 REG0x5a = 0x00 REG0x5b = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x00 REG0x02 VALUE = 0x00
block type:PRE_SHUTDOWN device idx = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x00 REG0x02 VALUE = 0x02
```

- #echo CG > regcfg_list
 - CG is conf NO, it should be 2-digital decimal
 - eg: echo 00 > regcfg_list
- #cat regcfg_list
 - Illustration: dump the register setting of the audio case specified by echo command

Driver nodes VI | force_fw_load_chip

```
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ echo 00 >regcfg_list
debian@beaglebone:/sys/bus/i2c/devices/2-0038$ [ 8108.293276] tasdevice-codec 2-0038: regcfg: count = 3
[ 8108.293320] tasdevice-codec 2-0038: [regcfg_list]cfg= 0, cnt=3

debian@beaglebone:/sys/bus/i2c/devices/2-0038$ cat regcfg_list
Conf 00: I2S-16bit-echo-reference-slot0
block type:PRE_POWER_UP device idx = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x00 REG0x0e VALUE = 0xc4
        BOOK0x00 PAGE0x00 REG0x0f VALUE = 0x40
        BOOK0x00 PAGE0x00 REG0x5c VALUE = 0xd9
        BOOK0x00 PAGE0x00 REG0x0d VALUE = 0x01
        BOOK0x00 PAGE0x00 REG0x10 VALUE = 0x04
        BOOK0x00 PAGE0x00 REG0x16 VALUE = 0x40
        BOOK0x00 PAGE0x01 REG0x17 VALUE = 0xc8
    BURST:
        BOOK0x00 PAGE0x04
        REG0x30 = 0x00 REG0x31 = 0x00 REG0x32 = 0x00 REG0x33 = 0x01
    BURST:
        BOOK0x00 PAGE0x08
        REG0x18 = 0x00 REG0x19 = 0x00 REG0x1a = 0x00 REG0x1b = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x08 REG0x1c VALUE = 0x00
    BURST:
        BOOK0x00 PAGE0x08
        REG0x28 = 0x40 REG0x29 = 0x00 REG0x2a = 0x00 REG0x2b = 0x00
    BURST:
        BOOK0x00 PAGE0x0a
        REG0x48 = 0x00 REG0x49 = 0x00 REG0x4a = 0x00 REG0x4b = 0x00
    BURST:
        BOOK0x00 PAGE0x0a
        REG0x58 = 0x40 REG0x59 = 0x00 REG0x5a = 0x00 REG0x5b = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x00 REG0x02 VALUE = 0x00
block type:PRE_SHUTDOWN device idx = 0x00
    SINGLE BYTE:
        BOOK0x00 PAGE0x00 REG0x02 VALUE = 0x02
```

- `#echo > force_fw_load_chip`
 - Illustration: Force to redownload the dsp firmware next playback
- `#cat force_fw_load_chip`
 - Illustration: get the dsp firmware downloading information

Bypass mode

- Write a shell script to test bypass mode. Use **#amixer contents** to check the kcontrol list, then set the parameters we used. “Program” is 0 when only use tuning mode.
 - PS: For details about regbin configuration, please see the appendix. If set bypass mode, Setting Configuration is unnecessary.

Shell script with Alsa

```
#!/bin/bash
amixer cset numid=1,iface=MIXER,name="Program" 1
amixer cset numid=2,iface=MIXER,name='TASDEVICE Profile id' 0
aplay --device="hw:0,0" test.wav &
sleep 1
amixer cset numid=2,iface=MIXER,name='TASDEVICE Profile id' 5
arecord -c 2 -f S16_LE -r 48000 -d 15 --device="hw:0,0" 16bit-echoref.wav &
```

Shell script with Tinyalsa

```
#!/bin/bash
tinymix set "Program" 1
tinymix set "TASDEVICE Profile id" 0
tinyplay test.wav &
sleep 1
tinymix set 'TASDEVICE Profile id' 5
tinyap 16bit-echoref.wav &
```

Tuning mode

- Write a shell script to test tuning mode. “Program” is 1 when use tuning mode, then select the configuration number.
 - PS: For details about fwdsp bin file, please use “**cat dspfwinfo_list**”.

Shell script with Alsa


















































```
#!/bin/bash
amixer cset numid=1,iface=MIXER,name="Program" 0
amixer cset numid=3,iface=MIXER,name="Configuration" 0
amixer cset numid=2,iface=MIXER,name='TASDEVICE Profile id' 4
aplay --device="hw:0,0" test.wav &
sleep 1
amixer cset numid=2,iface=MIXER,name='TASDEVICE Profile id' 5
arecord -c 2 -f S16_LE -r 48000 -d 15 --device="hw:0,0" 16bit-echoref.wav &
```

Shell script with Tinyalsa

```
#!/bin/bash
tinymix set "Program" 0
tinymix set "Configuration" 0
tinymix set "TASDEVICE Profile id" 4
tinyplay test.wav &
sleep 1
tinymix set 'TASDEVICE Profile id' 5
tinycap 16bit-echoref.wav &
```


Example of Regbin file I

- In jsn/regbin, there's tas2563-4amp-reg.json.
 - It defines 13 audio cases in Configuration column and 4 pieces of tas2563 in blocks.
 - The order of device is define in devicetree. See ti,tas2781.yaml for details
 - Sometimes there's difference the audio configs(or audio cases) in between regbin file and dsp file, so audio_hal will maintain a mapping table to connect both.

Configurations		Blocks	
Music degree 0	  	PRE_SHUTDOWN - Common	 
calibration	  	PRE_POWER_UP - Dev 1	 
voice call	  	PRE_POWER_UP - Dev 3	 
ringtone	  	PRE_POWER_UP - Dev 2	 
attach	  	PRE_POWER_UP - Dev 4	 
spk1 bypass	  		
spk2 bypass	  		
spk3 bypass	  		
spk4 bypass	  		
Music degree 90	  		
Music degree 180	  		
Music degree 270	  		
bypass	  		

Example of Regbin file II | Mapping Table I

No.	Audio Cases	Regbin No.	Program No. in dsp firmware	Configure No. in dsp firmware
0	Music - default, degree 0° (dev1 & dev2 - left; dev3 & dev4 - right)	0	0	0
1	Calibration	1	0	1
2	Voice call	2	0	2
3	ringtone	3	0	3
4	Attach	4	0	4
5	SPK1-only (bypass for electrical test)	5	1	NA
6	SPK2-only (bypass for electrical test)	6	1	NA
7	SPK3-only (bypass for electrical test)	7	1	NA
8	SPK4-only (bypass for electrical test)	8	1	NA
9	Music - default, degree 90° (dev2 & dev3 - left; dev4 & dev1 - right)	9	0	0
10	Music - default, degree 180° (dev3 & dev4 - left; dev1 & dev2 - right)	10	0	0
11	Music - default, degree 270° (dev4 & dev1 –left; dev2 & dev3 - right)	11	0	0
12	Bypass (4amps)	12	1	NA

Example of Regbin file III | Mapping Table II

- How to directly set for screen rotaion.
 - Use kcontrol “TASDEVICE Rotation id” to set one of the four directions.

No.	Audio Cases	Regbin No.	Program No. in dsp firmware	Configure No. in dsp firmware
13	Direct rotation degree 0° (dev1 & dev2 - left; dev3 & dev4 - right)	13	NA	NA
14	Direct rotation degree 90° (dev2 & dev3 - left; dev4 & dev1 - right)	14	NA	NA
15	Direct rotation degree 180° (dev3 & dev4 - left; dev1 & dev2 - right)	15	NA	NA
16	Direct rotation degree 270° (dev4 & dev1 –left; dev2 & dev3 - right)	16	NA	NA
17	SPK1-only (dsp for acoustic test)	17	0	0
18	SPK2-only (dsp for acoustic test)	18	0	0
19	SPK3-only (dsp for acoustic test)	19	0	0
20	SPK4-only (dsp for acoustic test)	20	0	0

Factory Tool

FTC tool I

- ftcfg file, is the file to store the spk basic params for speaker calibration
 - File name style:
[chip name]-[chip number].ftcfg
 - a is first chip, b is second chip,
 - all the letter in the file name is lowercase
 - For example, tas2781-a.ftcfg, tas2563-a.ftcfg, tas2781-b.ftcfg
 - the file name is defined in tasdevice.c, see, the right column

```
static const char *ftcfg[] = {  
    "%s-a.ftcfg",  
    "%s-b.ftcfg",  
    "%s-c.ftcfg",  
    "%s-d.ftcfg"  
};
```

- Put ftcfg file (Generated by ppc3) into directory:
 - Linux: /lib/firmware
 - Android: /mnt/vendor/persist/audio/PS: the macro
TASDEVICE_CAL_CFG_PATH in
tasdevice-rtc.h ought to match the Operating
System.

FTC tool II

- Run FTC tool with root permission
 - # sudo ./tasdevice-fts
- After the calibration process finished, the results save into /home/audio/ti/tasdevice-cal.txt

```
debian@beaglebone:~$ cat /home/audio/ti/tas2781_cal.txt
Ambient temperature = 20.00

Dev[0] Re = 13.41
Dev[0] rms_pow  = 0x00000000
Dev[0] t_limit  = 0x00000000
Dev[0] Result = 0x1
```

Calibration

- It's necessary to enable IV sense in PPC3.
- Write a shell script to test calibration. Select the **calibration_tuning_mode** in “configuration”.
- Playing silence during calibration
- If calibration is successful, tas2563-0x4c-cal.bin/tas2563-0x4d-cal.bin/tas2563-0x4e-cal.bin /tas2781-0x3c-cal.bin/tas2781-0x3f-cal.bin, etc will be saved into
 - Andoird: /system/vendor/firmware/
 - Linux: /lib/firmware/

PS: the macro TASDEVICE_CAL_BIN_PATH in tasdevice-ftc.h ought to match the Operating System.

Shell script with Alsa

```
#!/bin/bash
amixer cset numid=1,iface=MIXER,name="Program" 0
amixer cset numid=3,iface=MIXER,name="Configuration" 1
amixer cset numid=2,iface=MIXER,name='TASDEVICE Profile id' 1
aplay --device="hw:0,0" silence.wav &
sleep 15
./tasdevice_ftc
```

Shell script with Tinyalsa

```
#!/bin/bash
tinymix set "Program" 0
tinymix set "Configuration" 1
tinymix set "TASDEVICE Profile id" 1
tinyplay silence.wav &
sleep 15
./tasdevice_ftc
```

Appendix

Appendix I | Download Kernel 5.10-rt for BBB from...

- <https://github.com/beagleboard/linux/tree/5.10-rt>

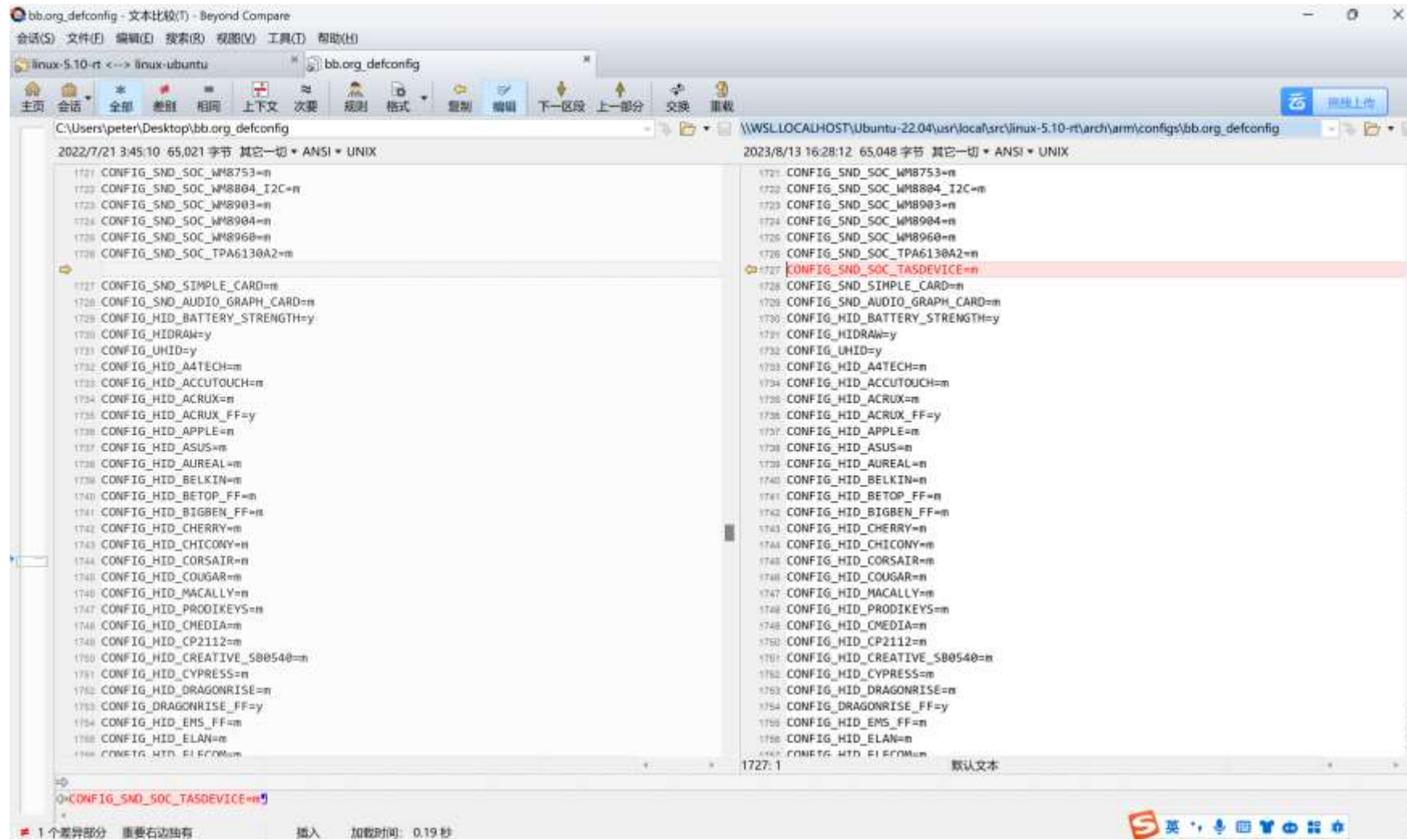
Appendix II | Porting Tinyalsa I

- Reference link:
[Tinyalsa - Tiny library to interface with ALSA in the Linux kernel - \(tinyalsa\) \(opensourcelibs.com\)](#)
- Download link:
[GitHub - tinyalsa/tinyalsa: Tiny library to interface with ALSA in the Linux kernel](#)
- Move driver code into BBB's local direction.

Appendix II | Porting Tinyalsa II | Steps of installation

1. Modify cross compile, add below statements into top of Makefile.
export ARCH = arm
export CROSS_COMPILE = arm-linux-gnueabi-
export CC = \$(CROSS_COMPILE)gcc
2. Assign permissions to scripts in tinyalsa package
#chmod 777 script
3. To build and install with Make, run the commands:
sudo make
sudo make install
sudo ldconfig
4. Once installed, the man pages are available via:
man tinyplay
man tinycap
man tinymix
man tinypcm_info

Appendix III | Add new module to be compiled



Appendix IV | DTS in QCOM Platform and Sound card register I

We provide reference DTS for Beagle Bone Black. For i2c setting for pcmdevice, DTS on QCOM platform is same as DTS on BBB. Only difference is the sound card register. Here offer an example on how to register the sound card. You may as well consult Qualcomm on this part for detail.

- `SND_SOC_DAILINK_DEFS(quat_tdm_tx_0,
DAILINK_COMP_ARRAY(COMP_CPU("msm-dai-q6tdm.36913")),
DAILINK_COMP_ARRAY(COMP_CODEC("tasdevice-codec.x-00yy", "tasdevice-codec")),
DAILINK_COMP_ARRAY(COMP_PLATFORM("msm-pcm-routing")));`
 - x is the i2c bus No. where tasdevice connected
 - yy is the 7-bit i2c address in HEX style, the letter ought to be lowercase

e.g:

```
SND_SOC_DAILINK_DEFS(pri_mi2s_rx,  
DAILINK_COMP_ARRAY(COMP_CPU("snd-soc-dummy-dai")),  
DAILINK_COMP_ARRAY(COMP_CODEC("tasdevice-codec.x-00yy", "tasdevice-codec")),  
DAILINK_COMP_ARRAY(COMP_PLATFORM("snd-soc-dummy")));  
SND_SOC_DAILINK_DEFS(pri_mi2s_tx,  
DAILINK_COMP_ARRAY(COMP_CPU("snd-soc-dummy-dai")),  
DAILINK_COMP_ARRAY(COMP_CODEC("tasdevice-codec.x-00yy", "tasdevice-codec")),  
DAILINK_COMP_ARRAY(COMP_PLATFORM("snd-soc-dummy")));
```

Appendix IV | DTS in QCOM Platform and Sound card register II

```
gem_row_wifi:/ # cat proc/asound/pcm
00-00: CODEC_DMA-LPAIF_RXTX-RX-0 multicodec-0 : : playback 1
00-01: CODEC_DMA-LPAIF_RXTX-RX-1 multicodec-1 : : playback 1
00-02: CODEC_DMA-LPAIF_RXTX-RX-2 multicodec-2 : : playback 1
00-03: CODEC_DMA-LPAIF_RXTX-RX-3 multicodec-3 : : playback 1
00-04: CODEC_DMA-LPAIF_RXTX-RX-5 multicodec-4 : : playback 1
00-05: CODEC_DMA-LPAIF_RXTX-RX-6 rx_macro_rx6-5 : : playback 1
00-06: CODEC_DMA-LPAIF_RXTX-TX-3 multicodec-6 : : capture 1
00-07: CODEC_DMA-LPAIF_RXTX-TX-4 multicodec-7 : : capture 1
00-08: CODEC_DMA-LPAIF_VA-TX-0 va_macro_tx1-8 : : capture 1
00-09: CODEC_DMA-LPAIF_VA-TX-1 va_macro_tx2-9 : : capture 1
00-10: CODEC_DMA-LPAIF_VA-TX-2 va_macro_tx3-10 : : capture 1
00-11: PCM_RT_PROXY-TX-1 snd-soc-dummy-dai-11 : : capture 1
00-12: PCM_RT_PROXY-RX-1 snd-soc-dummy-dai-12 : : playback 1
00-13: USB_AUDIO-RX snd-soc-dummy-dai-13 : : playback 1
00-14: USB_AUDIO-TX snd-soc-dummy-dai-14 : : capture 1
00-15: MI2S-LPAIF-RX-PRIMARY tasdevice-codec.3-004c-15 : : playback 1
00-16: MI2S-LPAIF-TX-PRIMARY tasdevice-codec.3-004c-16 : : capture 1
00-17: MI2S-LPAIF_AUD-RX-PRIMARY msm-stub-rx-17 : : playback 1
00-18: MI2S-LPAIF_AUD-TX-PRIMARY msm-stub-tx-18 : : capture 1
00-19: MI2S-LPAIF-RX-TERTIARY msm-stub-rx-19 : : playback 1
00-20: MI2S-LPAIF-TX-TERTIARY msm-stub-tx-20 : : capture 1
00-21: MI2S-LPAIF_RXTX-RX-PRIMARY msm-stub-rx-21 : : playback 1
00-22: MI2S-LPAIF_RXTX-TX-PRIMARY msm-stub-tx-22 : : capture 1
00-23: MI2S-LPAIF_VA-RX-PRIMARY msm-stub-rx-23 : : playback 1
00-24: MI2S-LPAIF_VA-TX-PRIMARY msm-stub-tx-24 : : capture 1
00-25: MI2S-LPAIF_WSA-RX-PRIMARY msm-stub-rx-25 : : playback 1
00-26: MI2S-LPAIF_WSA-TX-PRIMARY msm-stub-tx-26 : : capture 1
00-27: DISPLAY_PORT-RX msm_dp_audio_codec_rx_dai-27 : : playback 1
00-28: SLIM-DEV1-RX-7 btfm_bt_sco_a2dp_slim_rx-28 : : playback 1
00-29: SLIM-DEV1-TX-7 btfm_bt_sco_slim_tx-29 : : capture 1
gem_row_wifi:/ #
```

Appendix V | Compile firmware into Android system

- Add following into mk file

```
#Add backend_conf.xml for agmtool
PRODUCT_COPY_FILES += \
    vendor/qcom/opensource/audio-hal/primary-hal/configs/taro/audio_param/backend_conf.xml:${TARGET_COPY_OUT_VENDOR}/etc/backend_conf.xml \
    vendor/qcom/opensource/audio-hal/primary-hal/configs/taro/audio_param/tas2563-4amp-reg.bin:${TARGET_COPY_OUT_VENDOR}/firmware/tas2563-4amp-
reg.bin \
    vendor/qcom/opensource/audio-hal/primary-hal/configs/taro/audio_param/tas2563-4amp-dsp.bin:${TARGET_COPY_OUT_VENDOR}/firmware/tas2563-4amp-
dsp.bin
# Audio configuration xml's related to Waipio
```

THANKS!