AN3279

How to Use the SAMA5D2 PWM Under Linux

Introduction

This application note describes how to get started using the SAMA5D2 PWM under Linux.

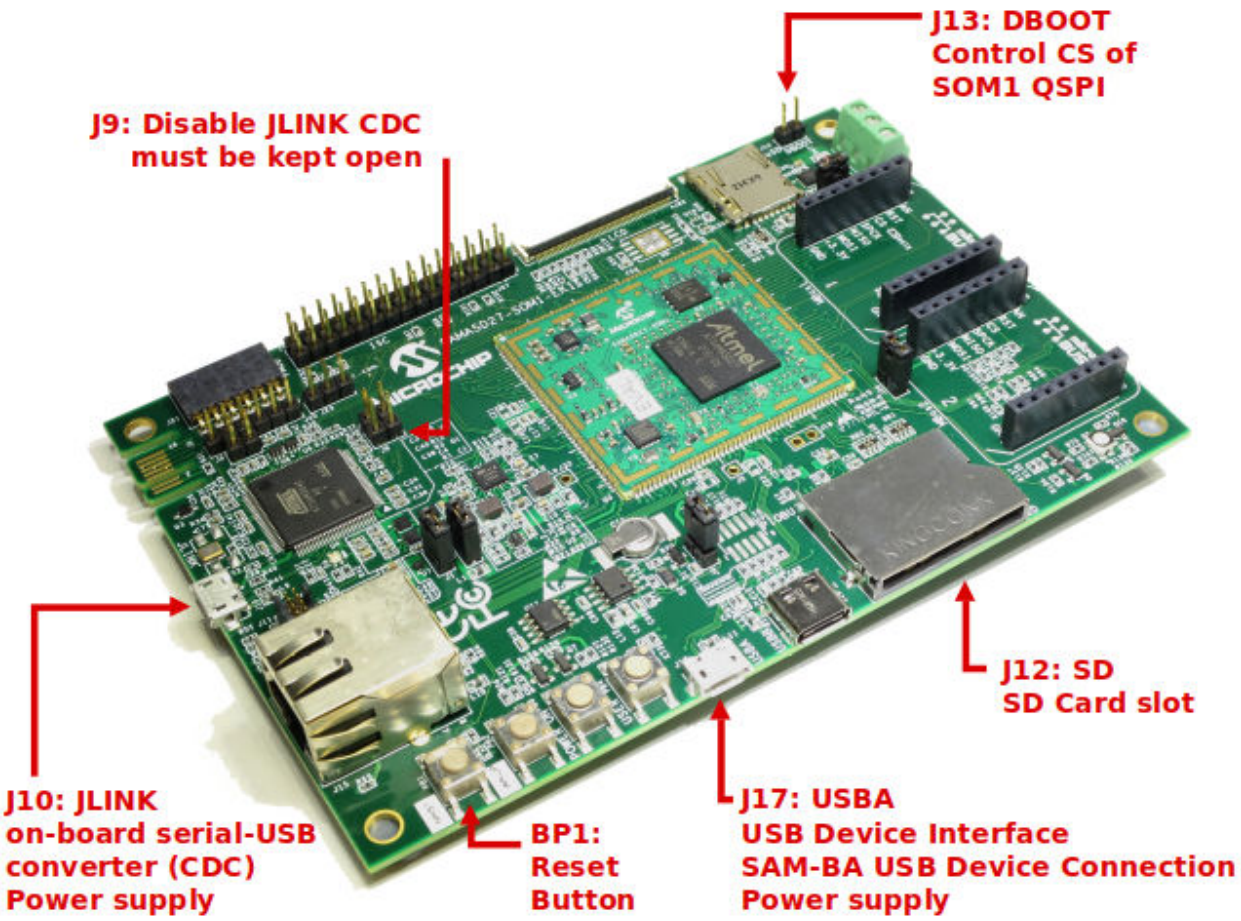
With the introduction of the generic PWM framework into the kernel, it is easy to implement the driver for a PWM device and access it in user space via sysfs. The device driver of the SAMA5D2 PWM has been released in the Microchip Linux BSP; however, with the default settings, the PWM device was not enabled in the Linux device tree. For more information, refer to the sections Device Tree and Hands-On.

Reference Documents

Title	Reference	Available
SAMA5D2 Series Datasheet	DS60001476	https://www.microchip.com/design-centers/32-bit-mpus
SAMA5D27 SOM1 Kit1 User Guide	DS50002667	https://www.microchip.com/DevelopmentTools/ProductDetails/PartNO/ATSAMA5D27-SOM1-EK1

Prerequisites

- Hardware
  - PC
  - SAMA5D27 SOM1 Evaluation Kit (Part Number: ATSAMA5D27-SOM1-EK1)
  - SDCard
- Software
  This demo runs on the AT91 Linux platform built by Buildroot. The first step is to set up the AT91 Buildroot development environment. Refer to the web site: http://www.at91.com/linux4sam/bin/view/Linux4SAM/BuildRoot


J13: DBOOT
Control CS of
SOM1 QSPI
J9: Disable JLINK CDC
must be kept open
J12: SD
SD Card slot
J10: JLINK
on-board serial-USB
converter (CDC)
Power supply
BP1:
Reset
Button
J17: USBA
USB Device Interface
SAM-BA USB Device Connection
Power supply

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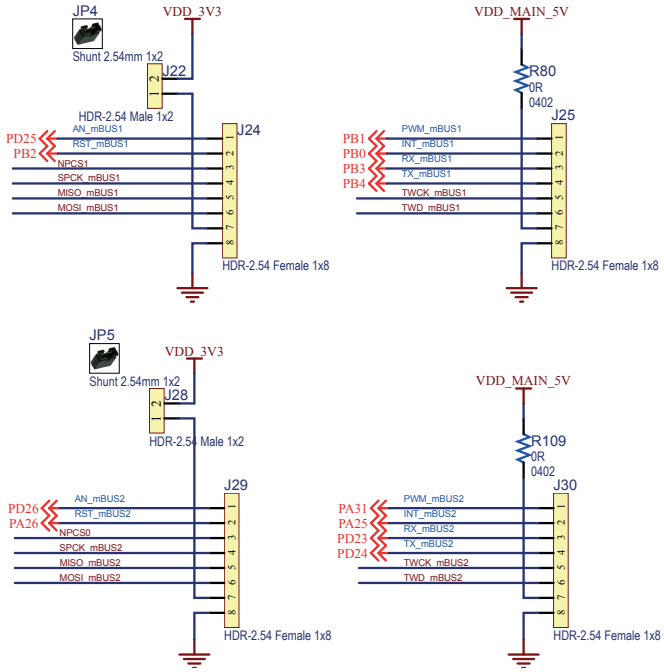
1. Hardware Design

1.1 Interface



The connectors mikroBUS1 and mikroBUS2 are used for easy testing and monitoring.

The PWM channel PWML0 is connected to the PWM_mBUS2 via GPIO PA31 on the SAMA5D27-SOM-EK1:

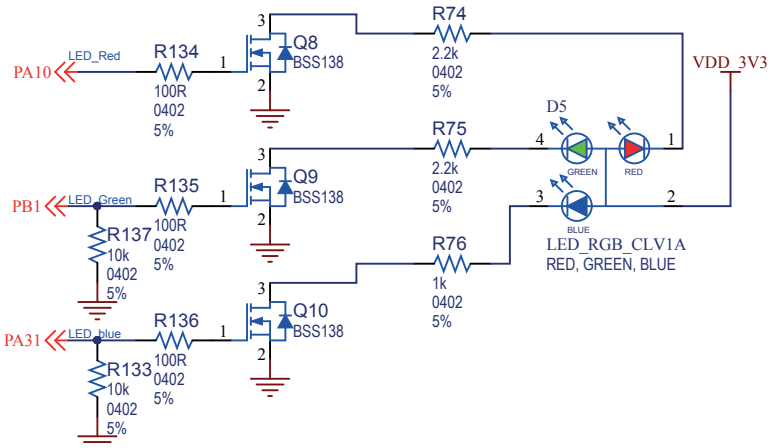
- PWML0 (PWM waveform output low for channel 0) → PA31 → PWM_mBUS2

The PWM channel PWML1 is connected to the PWM_mBUS1 via GPIO PB1 on SAMA5D27-SOM-EK1:

- PWML1 (PWM waveform output low for channel 1) → PB1 → PWM_mBUS1

For more details about the pin multiplexing of the SAMA5D2, refer to the table “Pin Description (all packages)” in the SAMA5D2 data sheet.

These PWM channels also connect to LED_Green and LED_blue, as illustrated below:



2. Software Design

The Microchip Linux platform was built using Buildroot with the following configuration:

atmel_sama5d27_som1_ek_mmc_dev_defconfig

A PWM driver has been selected in this configuration, but the PWM device was not enabled in the device tree. To enable the PWM function, the device tree must be modified.

2.1 Device Tree

- Action: need to change
  - Change 1:
    - With the default setting, the PWM device is disabled in the device tree. The bold font below shows how to enable the PWM in at91-sama5d27_som1_ek.dts.
  - Change 2:
    - There is a GPIO conflict between the PWM device and the LED device. As a result, the LED device must be disabled.
- Location: buildroot-at91/output/build/linux-linux4sam_6.0/arch/arm/boot/dts
- Sources:
  - sama5d2.dtsi
  - at91-sama5d27_som1_ek.dts

Device tree for PWM0 in sama5d2.dtsi:

```
pwm0: pwm@f802c000 {
    compatible = "atmel,sama5d2-pwm"; // specify which driver will be used for this PWM device
    reg = <0xf802c000 0x4000>; // PWM0 base address is 0xf802c000, size of register block is
                                    //0x4000
    interrupts = <38 IRQ_TYPE_LEVEL_HIGH 7>; // PID of PWM0 is 38, high level triggered,
                                              // priority is 7
    #pwm-cells = <3>;
    clocks = <&pwm_clk>; // definition for pwm0 clock source
};

pwm_clk: pwm_clk {
    #clock-cells = <0>;
    reg = <38>; // PID of PWM0 is 38, this definition of offset will be used to enable PWM0
                    // clock in PMC
    atmel,clk-output-range = <0 83000000>; // PWM0 input clock, max frequency is 83MHz
};
```

Device tree for PWM0 in at91-sama5d27_som1_ek.dts:

```
pwm0: pwm@f802c000 {
    pinctrl-names = "default";
    pinctrl-0 = <&pinctrl_mikrobus1_pwm &pinctrl_mikrobus2_pwm>; // pin definition for PWM0
    status = "okay"; /* Conflict with leds. */ // This is change 1, set status of pwm0 to
                                                 // “okay”, enable pwm0 device
};

pinctrl_mikrobus1_pwm: mikrobus1_pwm {
    pinmux = <PIN_PB1__PWML1>; // the mux of PB1 will be switched to PWML1
    bias-disable; // pull up/down feature disabled
};
pinctrl_mikrobus2_pwm: mikrobus2_pwm {
    pinmux = <PIN_PA31__PWML0>; // the mux of PA31 will be switched to PWML0
    bias-disable; // pull up/down feature disabled
};
leds {
    compatible = "gpio-leds";
    pinctrl-names = "default";
    pinctrl-0 = <&pinctrl_led_gpio_default>;
    status = "disabled"; /* Conflict with pwm0. */ // This is change 2, set status of leds to
```

```
                                                    // “disabled”, disable leds device

    red {
        label = "red";
        gpios = <&pioA PIN_PA10 GPIO_ACTIVE_HIGH>;
    };

    green {
        label = "green";
        gpios = <&pioA PIN_PB1 GPIO_ACTIVE_HIGH>;
    };

    blue {
        label = "blue";
        gpios = <&pioA PIN_PA31 GPIO_ACTIVE_HIGH>;
        linux,default-trigger = "heartbeat";
    };
};
```

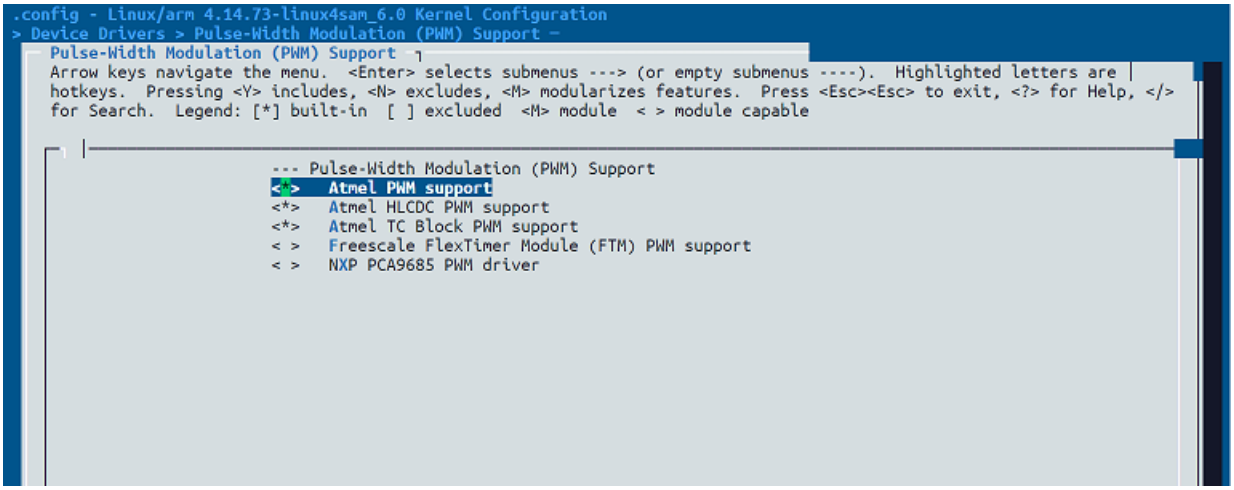
2.2 Kernel

- Action: no need to change
- Location: buildroot-at91/output/build/linux-linux4sam_6.0/
- Defconfig: sama5_defconfig
- Driver files: drivers/pwm/pwm-atmel.c

Check the kernel configuration for the PWM function:

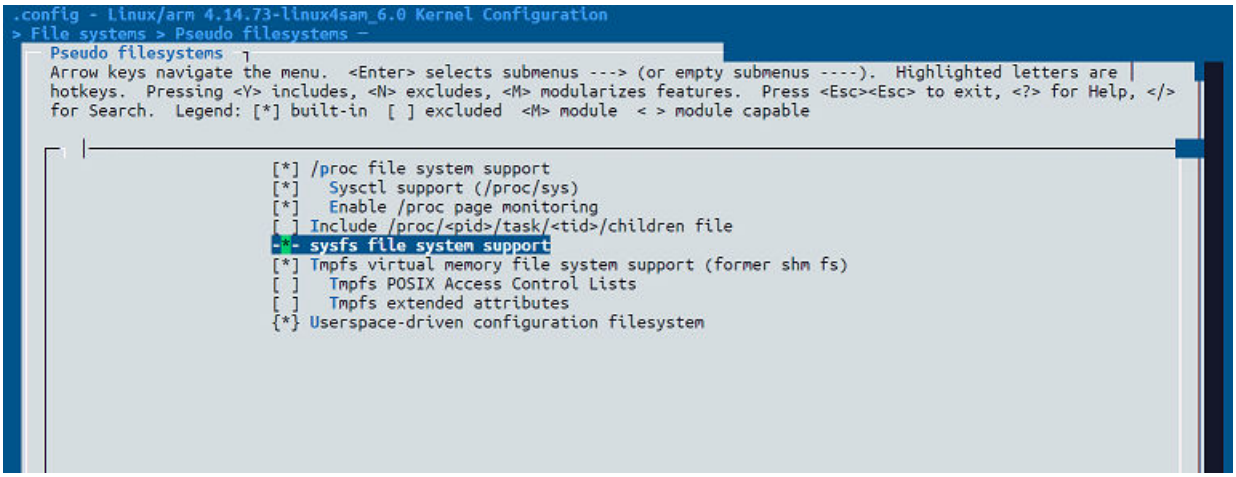
```
user@at91:~/buildroot-at91$ make linux-menuconfig
```

Device Drivers > Pulse-Width Modulation (PWM) Support >Atmel PWM support
With the default setting, the Atmel PWM driver has been selected.



File systems > Pseudo filesystems >sysfs file system support
With the default setting, the sysfs feature has been selected.

There is no device node file created for the PWM device. The PWM driver is accessed via sysfs in user space.



2.3 Rootfs

- Action: no need to change
- Location: buildroot-at91/output/images/rootfs.tar

The PWM driver can be accessed via the following sysfs path in user space:

- */sys/class/pwm*

Several files and sub-folders can be found in this path:

For more details on the PWM in Linux, see kernel_dir/documentation/pwm.txt.

- */sys/class/pwm/pwmchipN*
  - Each probed PWM controller/chip will be exported as pwmchipN, where N is the base of the PWM chip
- */sys/class/pwm/pwmchipN/npwm*
  - The number of PWM channels which this chip supports (read-only).
- */sys/class/pwm/pwmchipN/export*
  - Exports a PWM channel with sysfs (write-only).
  - The PWM channels are numbered using a per-chip index from 0 to npwm-1.
- */sys/class/pwm/pwmchipN/unexport*
  - Unexports a PWM channel from sysfs (write-only).

When a PWM channel is exported, a pwmX directory is created in the pwmchipN directory, where X is the number of the channel that was exported.

The following properties are available:

- */sys/class/pwm/pwmchipN/pwmX/period*
- – The total period of the PWM signal (read/write).
  - Value is in nanoseconds and is the sum of the active and inactive time of the PWM.
- */sys/class/pwm/pwmchipN/pwmX/duty_cycle*
- – The active time of the PWM signal (read/write).
  - Value is in nanoseconds and must be less than the period.
- */sys/class/pwm/pwmchipN/pwmX/polarity*
- – Change the polarity of the PWM signal (read/write).
  - This property only works if the PWM chip supports changing the polarity. The polarity can only be changed if the PWM is not enabled. Value is the string “normal” or “inversed”.
- */sys/class/pwm/pwmchipN/pwmX/enable*
  - Enable/disable the PWM signal (read/write).

- 0: disabled
- 1: enabled

3. Hands-On

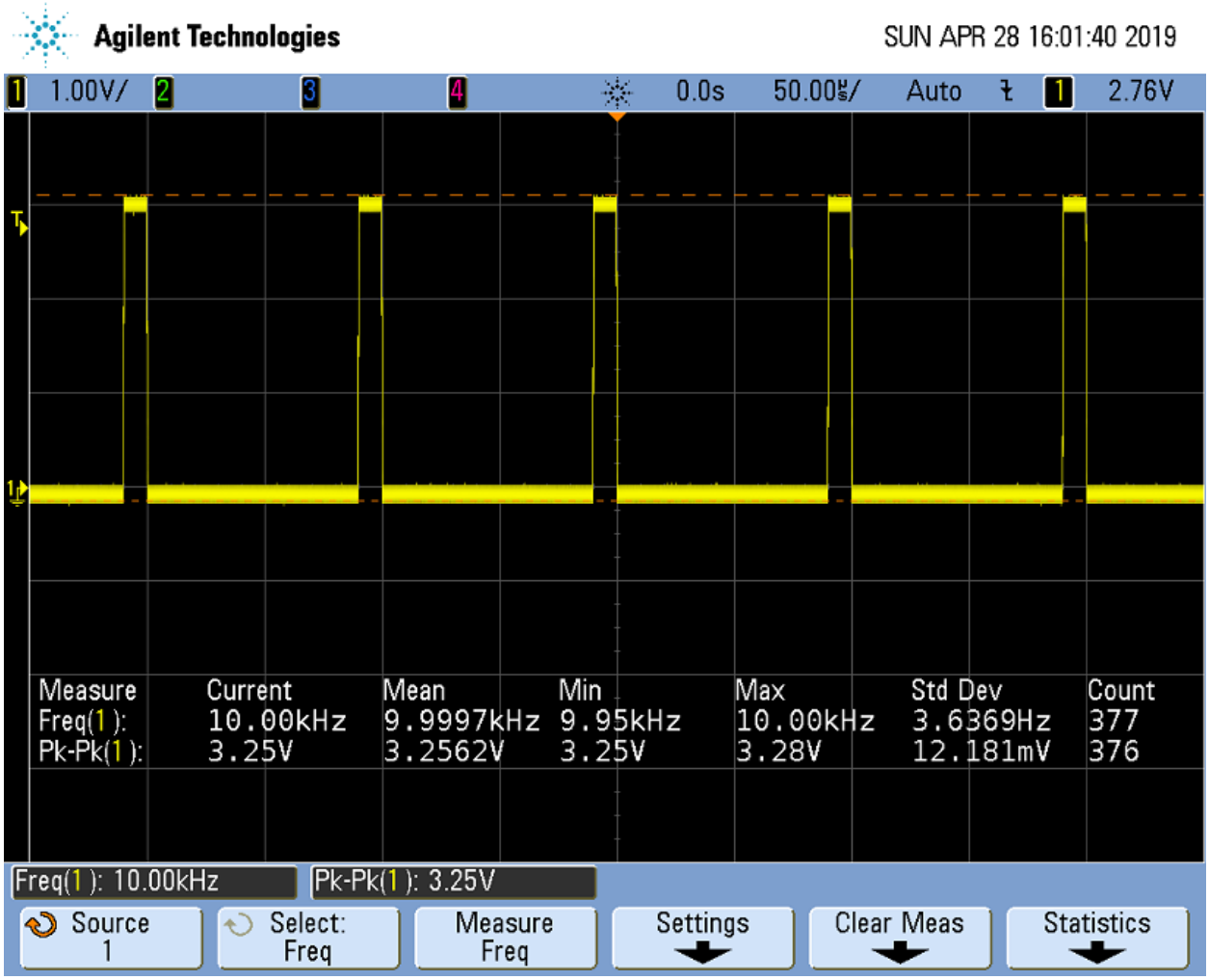
3.1 Hands-On with PWM_mBUS1

1. Reset the target board before the hands-on:

```
# reboot
```

2. Then set up a 10 kHz 90% duty cycle PWM output:

```
# cd /sys/class/pwm/
# ls
pwmchip0
# cd pwmchip0/
# echo 1 > export
# ls
device      npwm        pwm1        uevent
export      power       subsystem   unexport
# cd pwm1/
# ls
capture      enable       polarity     uevent
duty_cycle   period       power
# echo 100000 > period
# echo 90000 > duty_cycle
# echo 1 > enable
```



3.2 Hands-On with LED_Green

1. Reset the target board before the hands-on:

```
# reboot
```

2. Turn off the LED_Red:

```
# echo 10 > /sys/class/gpio/export
# echo out > /sys/class/gpio/PA10/direction
# echo 0 > /sys/class/gpio/PA10/value
```

3. Turn off the LED_Blue:

```
# echo 0 > /sys/class/pwm/pwmchip0/export
# echo 10000000 > /sys/class/pwm/pwmchip0/pwm0/period
# echo 10000000 > /sys/class/pwm/pwmchip0/pwm0/duty_cycle
# echo 1 > /sys/class/pwm/pwmchip0/pwm0/enable
```

4. Set up PWM channel 1 output:

```
# cd /sys/class/pwm/pwmchip0/
# echo 1 > export
# cd pwm1/
```

5. Adjust LED_Green brightness:

```
# echo 10000000 > period
# echo 10000000 > duty_cycle
# echo 1 > enable
# echo 9000000 > duty_cycle
# echo 8000000 > duty_cycle
# echo 7000000 > duty_cycle
# echo 6000000 > duty_cycle
# echo 5000000 > duty_cycle
# echo 4000000 > duty_cycle
# echo 3000000 > duty_cycle
# echo 2000000 > duty_cycle
# echo 1000000 > duty_cycle
```

6. Set the LED_Green to blink:

```
# echo 0 > enable
# echo 100000000 > period
# echo 50000000 > duty_cycle
# echo 1 > enable
```

3.3 Hands-On with Synchronous Channels

Some channels can be linked together as synchronous channels. For details about this feature, refer to the section “Synchronous Channels” in the SAMA5D2 data sheet .

In Linux, the current PWM device model does not support this feature. We can test this feature through a direct register setting via the devmem2 command.

Follow the sequence below to use PWM0 and PWM1 as synchronous channels.

1. Reset the target board before the hands-on:

```
# reboot
```

2. Commands to initialize the PWM channels:
   2.1. Enable PWM0 and PWM1 SYNC feature:

```
# devmem2 0xF802C020 w 0x3
# cd /sys/class/pwm/pwmchip0/
# echo 0 > export
# echo 1 > export
# echo 10000000 > pwm1/period
# echo 9000000 > pwm1/duty_cycle
```

2.2. This is dummy enabling for PWM1, used for writing duty cycle configurations:

```
# echo 1 > pwm1/enable
```

2.3. Since the SYNC feature of PWM1 has been enabled, all SYNC channels are enabled together by enabling the channel 0:

```
# echo 10000000 > pwm0/period
# echo 2000000 > pwm0/duty_cycle
```

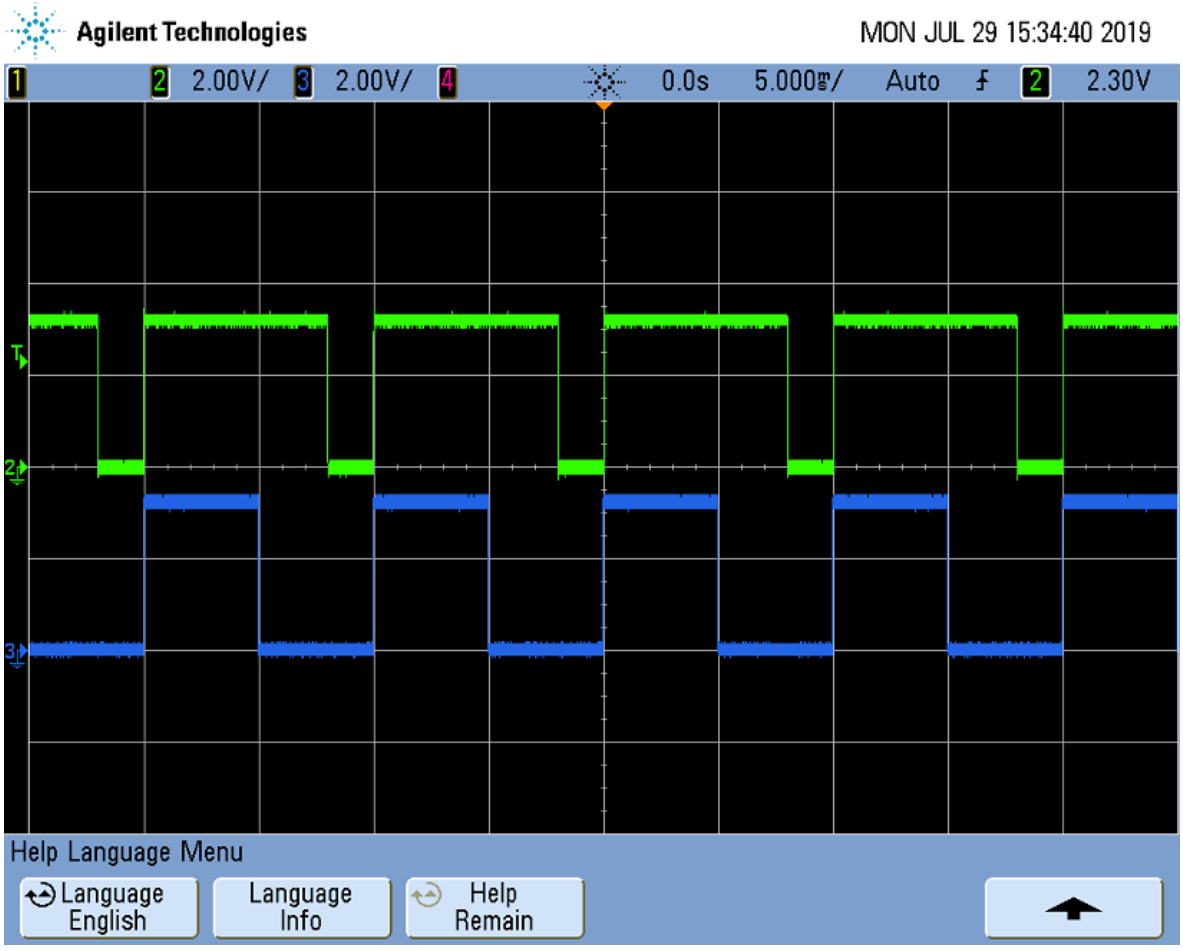
2.4. Here the output of PWM0 and PWM1 is enabled together:

```
# echo 1 > pwm0/enable
```

3. Command to update the channel configuration:

3.1. Write the bit UPDULOCK in PWM_SCUC after adjusting the configuration of the PWM channel.

```
# devmem2 0xF802C028 w 1
```



4. Microchip Peripheral I/O Python® (MPIO)

The Microchip Peripheral I/O (MPIO) Python package provides easy access to various hardware peripherals found on Microchip MPU processors and evaluation boards running Linux. The API is clean, consistent, flexible, documented, and well tested. It makes navigating and exercising even the most complex hardware peripherals a trivial task.

For more information, see https://github.com/linux4sam/mpio. Code examples showing how to work with the MPIO interface modules are provided in the folder mpio/examples.

4.1 MPIO in buildroot

In order to benefit from MPIO in your buildroot configuration, follow the steps below:

1. Enable Python

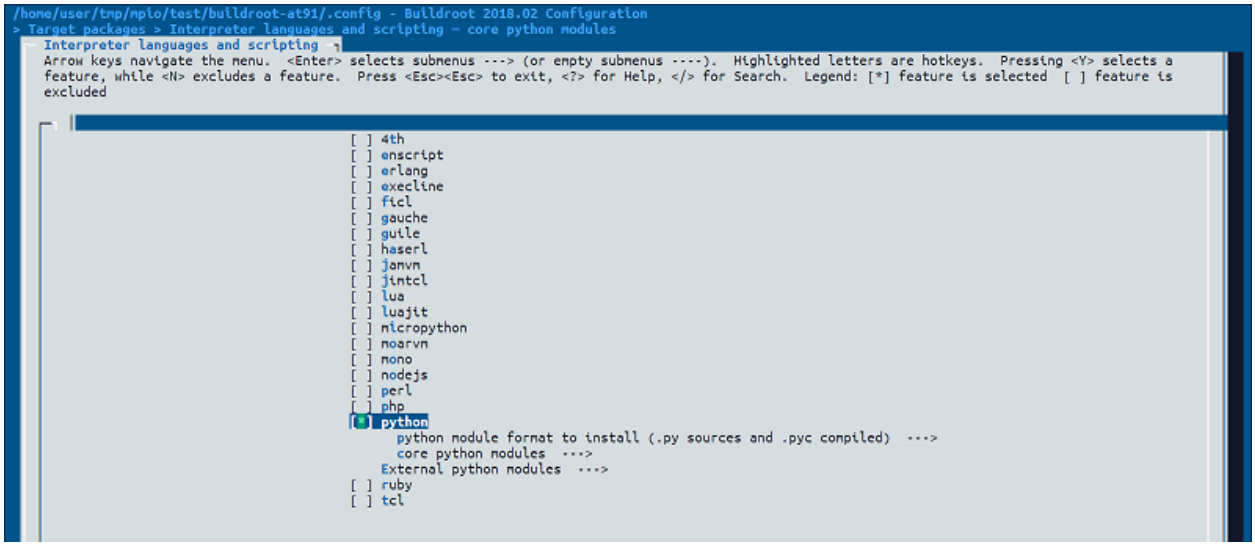
```
user@at91:~/buildroot-at91$ make menuconfig
```

Select “**python**” to enable python support:

- Target packages > Interpreter languages and scripting > [*] **python**

Then enter “**python module format to install**” and select “**.py sources and .pyc compiled**”.

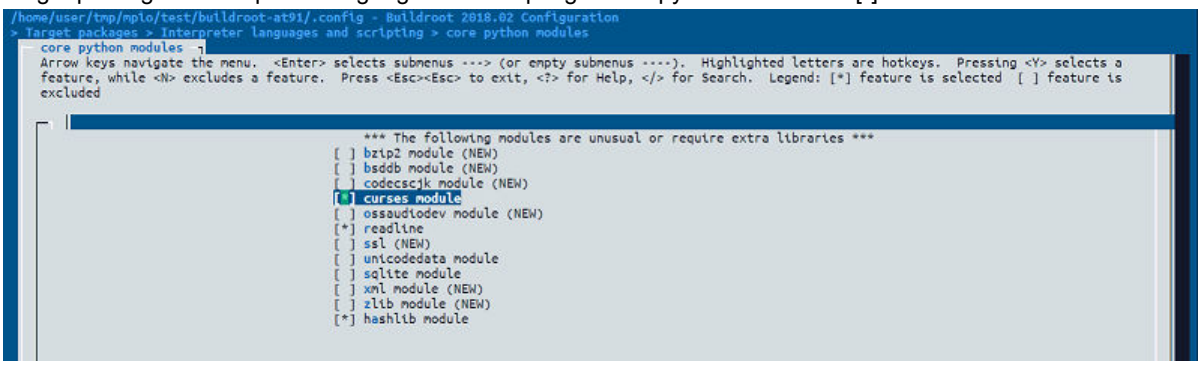
- Target packages > Interpreter languages and scripting > python > python module format to install > **.py sources and .pyc compiled**



Some additional python modules must be selected. Enter “**core python modules**” and select “**curses module**”, “**readline**” and “**hashlib module**”.

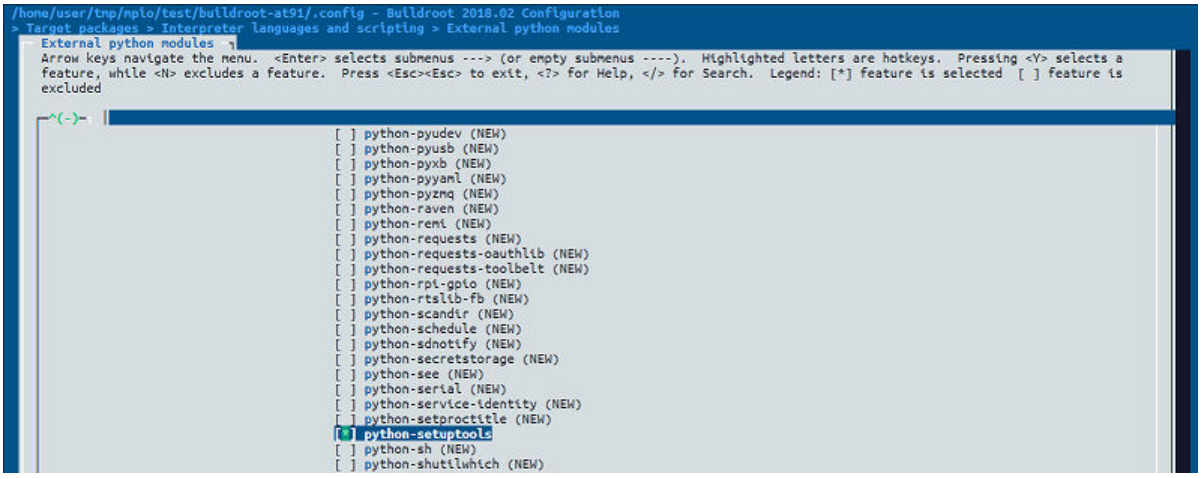
- Target packages > Interpreter languages and scripting > core python modules > [*] **curses module**
- Target packages > Interpreter languages and scripting > core python modules > [*] **readline**

- Target packages > Interpreter languages and scripting > core python modules > [*] **hashlib module**



Enter “**External python modules**” and select “**python-setuptools**”.

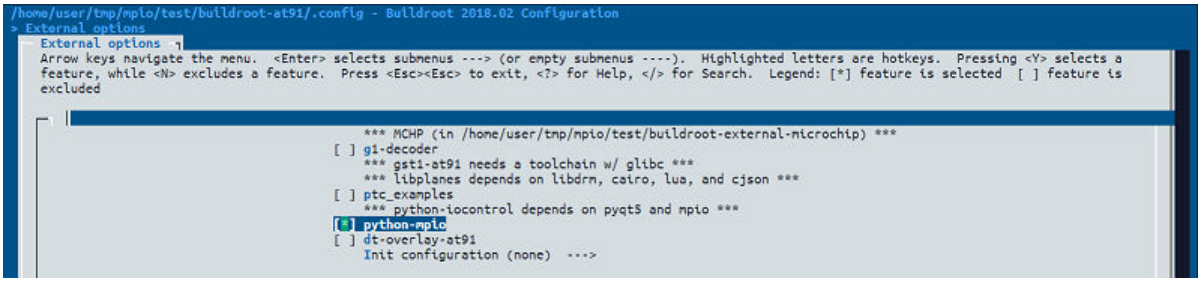
- Target packages > Interpreter languages and scripting > External python modules > **[*] python-setuptools**



2. Enable the MPIO Module

Enter “**External options**” and select “**python-mpio**”.

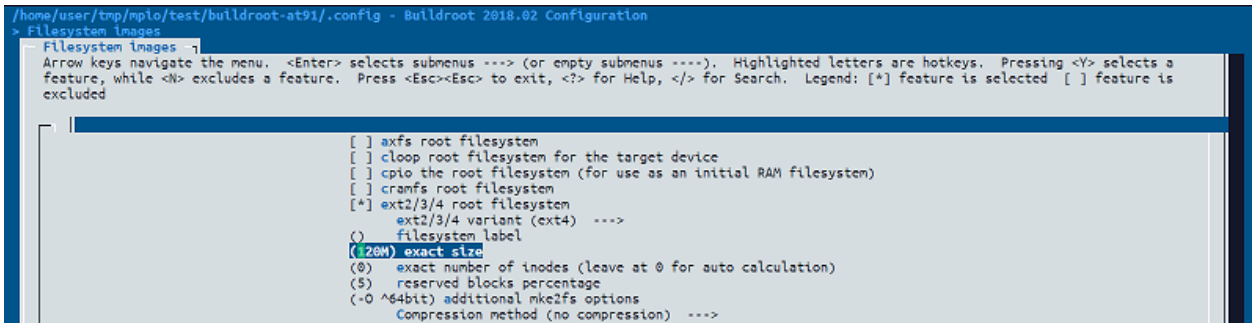
- External options > **[*] python-mpio**



3. Finish the buildroot Configuration and Build

Enter “**Filesystem images**” and set the exact size of rootfs to 120MB.

- Filesystem images > **(120M) exact size**



After saving, the following new settings are added to the configuration file of buildroot:

……

BR2_PACKAGE_PYTHON=y

BR2_PACKAGE_PYTHON_PY_PYC=y

BR2_PACKAGE_PYTHON_CURSES=y

BR2_PACKAGE_PYTHON_READLINE=y

BR2_PACKAGE_PYTHON_HASHLIB=y

BR2_PACKAGE_PYTHON_SETUPTOOLS=y

BR2_PACKAGE_PYTHON_MPIO=y

BR2_TARGET_ROOTFS_EXT2_SIZE="120M"

……

Then re-configure and build buildroot:

user@at91:~/buildroot-at91$ **make atmel_sama5d27_som1_ek_mmc_dev_defconfig**

user@at91:~/buildroot-at91$ **make**

4.2 Examples

After building successfully, burn your SD card with buildroot-at91/output/images/**sdcard.img**.

Execute the python codes on the target board, for example:

./adc2.py DEVICE

./gpio1.py PIN

./pwm_led.py DEVICE CHANNEL

……

Note: The python example code can be found in https://github.com/linux4sam/mpio/examples

5. Revision History

5.1 Rev. A - 10/2019

First issue.

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