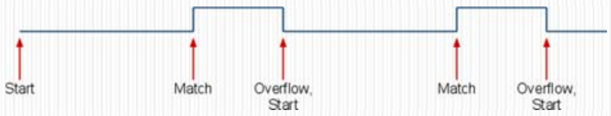
# 02-1 Pulse Width Modulation - bone

Controlling an output pin without using the CPU



## Outline

- Pin Mux
- PWM

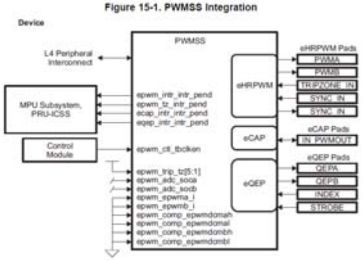
## Pulse Width Modulation

- Using the CPU to toggle an IO pin is a poor use of the CPU
- A 0.5 GHz processor can only toggle at about
  - 100 Hz using the shell, or
  - ______ using a C program
- Many applications could use such a signal
  - at a higher frequency
  - without using so much of the CPU
- Use PWM hardware

## PWM Hardware

- The AM335x has a Pulse Width Modulation SubSystem (PWMSS)
- Discussed in Section 17 of the TRM.
- 2 to 4 PWM signals can be produced.

Figure 15-1. PWMSS Integration

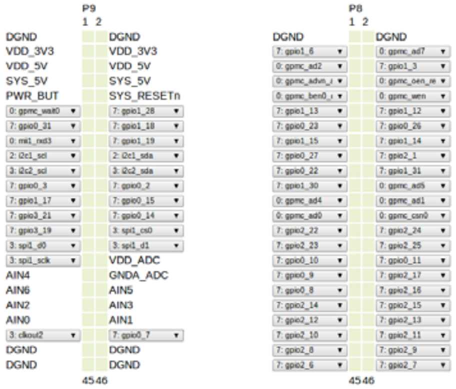


## Pin MUXing

- **Problem:** AM335x has more internal lines than hardware IO pins.
- **Solution:** IO pins run though a MUX which selects which internal lines appear on IO pins
- A pin can have 1 from as many as 8 lines assigned to it

## Bone default Mux Settings

(http://bone/pinMux.html)



P9

| | 1 | 2 | |
|---|---|---|---|
| DGND | | | DGND |
| VDD_3V3 | | | VDD_3V3 |
| VDD_5V | | | VDD_5V |
| SYS_5V | | | SYS_5V |
| PWR_BUT | | | SYS_RESETn |
| 0: gpmc_wait0 ▾ | | | 7: gpio1_28 ▾ |
| 7: gpio0_31 ▾ | | | 7: gpio1_18 ▾ |
| 0: mii1_rxd3 ▾ | | | 7: gpio1_19 ▾ |
| 2: i2c1_scl ▾ | | | 2: i2c1_sda ▾ |
| 3: i2c2_scl ▾ | | | 3: i2c2_sda ▾ |
| 7: gpio0_3 ▾ | | | 7: gpio0_2 ▾ |
| 7: gpio1_17 ▾ | | | 7: gpio0_15 ▾ |
| 7: gpio3_21 ▾ | | | 7: gpio0_14 ▾ |
| 7: gpio3_19 ▾ | | | 3: spi1_cs0 ▾ |
| 3: spi1_d0 ▾ | | | 3: spi1_d1 ▾ |
| 3: spi1_sclk ▾ | | | VDD_ADC |
| AIN4 | | | GNDA_ADC |
| AIN6 | | | AIN5 |
| AIN2 | | | AIN3 |
| AIN0 | | | AIN1 |
| 3: clkout2 ▾ | | | 7: gpio0_7 ▾ |
| DGND | | | DGND |
| DGND | | | DGND |
| | 45 | 46 | |

P8

| | 1 | 2 | |
|---|---|---|---|
| DGND | | | DGND |
| 7: gpio1_6 ▾ | | | 0: gpmc_ad7 ▾ |
| 0: gpmc_ad2 ▾ | | | 7: gpio1_3 ▾ |
| 0: gpmc_advn_ ▾ | | | 0: gpmc_oen_re ▾ |
| 0: gpmc_ben0_ ▾ | | | 0: gpmc_wen ▾ |
| 7: gpio1_13 ▾ | | | 7: gpio1_12 ▾ |
| 7: gpio0_23 ▾ | | | 7: gpio0_26 ▾ |
| 7: gpio1_15 ▾ | | | 7: gpio1_14 ▾ |
| 7: gpio0_27 ▾ | | | 7: gpio2_1 ▾ |
| 7: gpio0_22 ▾ | | | 7: gpio1_31 ▾ |
| 7: gpio1_30 ▾ | | | 0: gpmc_ad5 ▾ |
| 0: gpmc_ad4 ▾ | | | 0: gpmc_ad1 ▾ |
| 0: gpmc_ad0 ▾ | | | 0: gpmc_csn0 ▾ |
| 7: gpio2_22 ▾ | | | 7: gpio2_24 ▾ |
| 7: gpio2_23 ▾ | | | 7: gpio2_25 ▾ |
| 7: gpio0_10 ▾ | | | 7: gpio0_11 ▾ |
| 7: gpio0_9 ▾ | | | 7: gpio2_17 ▾ |
| 7: gpio0_8 ▾ | | | 7: gpio2_16 ▾ |
| 7: gpio2_14 ▾ | | | 7: gpio2_15 ▾ |
| 7: gpio2_12 ▾ | | | 7: gpio2_13 ▾ |
| 7: gpio2_10 ▾ | | | 7: gpio2_11 ▾ |
| 7: gpio2_8 ▾ | | | 7: gpio2_9 ▾ |
| 7: gpio2_6 ▾ | | | 7: gpio2_7 ▾ |
| | 45 | 46 | |

## Controlling the Mux

- Currently there is no clean way to control the mux from user space
- However there is a debug interface

```
beagle$ cd /sys/kernel/debug/omap_mux
beagle$ ls
ain0            gpmc_ad2      lcd_data3    mii1_txd2
ain1            gpmc_ad3      lcd_data4    mii1_txd3
ain2            gpmc_ad4      lcd_data5    mii1_txen
ain3            gpmc_ad5      lcd_data6    mmc0_clk
ain4            gpmc_ad6      lcd_data7    mmc0_cmd
ain5            gpmc_ad7      lcd_data8    mmc0_dat0
ain6            gpmc_ad8      lcd_data9    mmc0_dat1
ain7            gpmc_ad9      lcd_hsync    mmc0_dat2
…
```

```
beagle$ mkdir debugfs
beagle$ mount -t debugfs none debugfs
```

## Where's PWM

```
beagle$ grep ehrpwm *
gpmc_a0:signals: gpmc_a0 | gmii2_txen | rgmii2_tctl |
rmii2_txen | gpmc_a16 | pr1_mii_mt1_clk |
ehrpwm1_tripzone_input | gpio1_16
gpmc_a1:signals: gpmc_a1 | gmii2_rxdv | rgmii2_rctl |
mmc2_dat0 | gpmc_a17 | pr1_mii1_txd3 | ehrpwm0_synco |
gpio1_17
gpmc_a2:signals: gpmc_a2 | gmii2_txd3 | rgmii2_td3 |
mmc2_dat1 | gpmc_a18 | pr1_mii1_txd2 | ehrpwm1A | gpio1_18
```

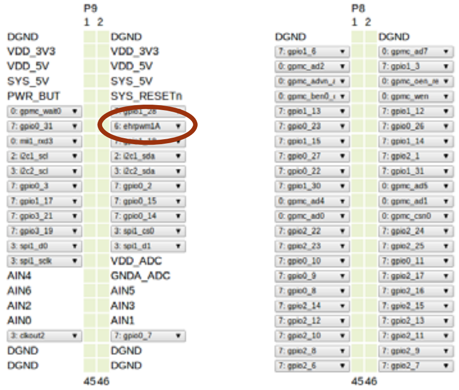
- **`ehrpwm1A`** shows up in the file **`gpmc_a2`**

```
beagle$ cat gpmc_a2
name: gpmc_a2.gpio1_18 (0x44e10848/0x848 = 0x0027), b NA, t NA
mode: OMAP_PIN_INPUT_PULLDOWN | OMAP_MUX_MODE7
signals: gpmc_a2 | gmii2_txd3 | rgmii2_td3 | mmc2_dat1 |
gpmc_a18 | pr1_mii1_txd2 | ehrpwm1A | gpio1_18
```

## Switch to PWM

```
beagle$ echo 6 > gpmc_a2
beagle$ cat gpmc_a2
name: gpmc_a2.ehrpwm1A (0x44e10848/0x848 = 0x0006), b NA, t NA
mode: OMAP_PIN_OUTPUT | OMAP_MUX_MODE6
signals: gpmc_a2 | gmii2_txd3 | rgmii2_td3 | mmc2_dat1 |
gpmc_a18 | pr1_mii1_txd2 | ehrpwm1A | gpio1_18
```

## Refresh bone:pinMux.html



P9

| | 1 | 2 | |
|---|---|---|---|
| DGND | | | DGND |
| VDD_3V3 | | | VDD_3V3 |
| VDD_5V | | | VDD_5V |
| SYS_5V | | | SYS_5V |
| PWR_BUT | | | SYS_RESETn |
| 0: gpmc_wait0 ▾ | | | 7: gpio1_28 ▾ |
| 7: gpio0_31 ▾ | | | 6: ehrpwm1A ▾ |
| 0: mii1_rxd3 ▾ | | | 7: [illegible] ▾ |
| 2: i2c1_scl ▾ | | | 2: i2c1_sda ▾ |
| 3: i2c2_scl ▾ | | | 3: i2c2_sda ▾ |
| 7: gpio0_3 ▾ | | | 7: gpio0_2 ▾ |
| 7: gpio1_17 ▾ | | | 7: gpio0_15 ▾ |
| 7: gpio3_21 ▾ | | | 7: gpio0_14 ▾ |
| 7: gpio3_19 ▾ | | | 3: spi1_cs0 ▾ |
| 3: spi1_d0 ▾ | | | 3: spi1_d1 ▾ |
| 3: spi1_sclk ▾ | | | VDD_ADC |
| AIN4 | | | GNDA_ADC |
| AIN6 | | | AIN5 |
| AIN2 | | | AIN3 |
| AIN0 | | | AIN1 |
| 3: clkout2 ▾ | | | 7: gpio0_7 ▾ |
| DGND | | | DGND |
| DGND | | | DGND |
| | 45 | 46 | |

P8

| | 1 | 2 | |
|---|---|---|---|
| DGND | | | DGND |
| 7: gpio1_6 ▾ | | | 0: gpmc_ad7 ▾ |
| 0: gpmc_ad2 ▾ | | | 7: gpio1_3 ▾ |
| 0: gpmc_advn_ ▾ | | | 0: gpmc_oen_re ▾ |
| 0: gpmc_ben0_ ▾ | | | 0: gpmc_wen ▾ |
| 7: gpio1_13 ▾ | | | 7: gpio1_12 ▾ |
| 7: gpio0_23 ▾ | | | 7: gpio0_26 ▾ |
| 7: gpio1_15 ▾ | | | 7: gpio1_14 ▾ |
| 7: gpio0_27 ▾ | | | 7: gpio2_1 ▾ |
| 7: gpio0_22 ▾ | | | 7: gpio1_31 ▾ |
| 7: gpio1_30 ▾ | | | 0: gpmc_ad5 ▾ |
| 0: gpmc_ad4 ▾ | | | 0: gpmc_ad1 ▾ |
| 0: gpmc_ad0 ▾ | | | 0: gpmc_csn0 ▾ |
| 7: gpio2_22 ▾ | | | 7: gpio2_24 ▾ |
| 7: gpio2_23 ▾ | | | 7: gpio2_25 ▾ |
| 7: gpio0_10 ▾ | | | 7: gpio0_11 ▾ |
| 7: gpio0_9 ▾ | | | 7: gpio2_17 ▾ |
| 7: gpio0_8 ▾ | | | 7: gpio2_16 ▾ |
| 7: gpio2_14 ▾ | | | 7: gpio2_15 ▾ |
| 7: gpio2_12 ▾ | | | 7: gpio2_13 ▾ |
| 7: gpio2_10 ▾ | | | 7: gpio2_11 ▾ |
| 7: gpio2_8 ▾ | | | 7: gpio2_9 ▾ |
| 7: gpio2_6 ▾ | | | 7: gpio2_7 ▾ |
| | 45 | 46 | |

## Turn on the PWM

- PWM is controlled from /sys/class/pwm

```
beagle$ cd /sys/class/pwm
beagle$ ls -F
ecap.0@  ecap.2@      ehrpwm.0:1@  ehrpwm.1:1@  ehrpwm.2:1@
ecap.1@  ehrpwm.0:0@  ehrpwm.1:0@  ehrpwm.2:0@
```

- We are using ehrpwm1A which maps to ehrpwm.1:0

```
beagle$ cd /sys/class/pwm/ehrpwm.1\:0
beagle$ ls
device   duty_percent  period_ns  power    run        tick_hz
duty_ns  period_freq   polarity   request  subsystem  uevent
beagle$ echo 1 > request
beagle$ echo 1 > run
beagle$ echo 10 > period_freq
beagle$ echo 25 > duty_percent
```

## Exercise 13

- Do the PWM exercise
- Plan some time to come to lab and use the 'scope to measure how fast the PWM can run