02-2 Analog Out

Controlling the Brightness of and LED

b.analogWrite()

```
var b = require('bonescript');
var LED = 'P9_21';  // Pin to use
var brightness = 0.5;

b.pinMode(LED, b.ANALOG_OUTPUT);

b.analogWrite(LED, brightness);
```

PWM pins

P9

DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
GPIO_30	11	12	GPIO_60
GPIO_31	13	14	EHRPWM1A
GPIO_48	15	16	EHRPWM1B
GPIO_5	17	18	GPIO_4
I2C1_SCL	19	20	I2C1_SDA
EHRPWM0B	21	22	EHRPWM0A
GPIO_49	23	24	GPIO_15
GPIO_117	25	26	GPIO_14
GPIO_115	27	28	ECAPPWM2
EHRPWM0B	29	30	GPIO_122
EHRPWM0A	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	ECAPPWM0
DGND	43	44	DGND
DGND	45	46	DGND

P8

DGND	1	2	DGND
GPIO_38	3	4	GPIO_39
GPIO_34	5	6	GPIO_35
TIMER4	7	8	TIMER7
TIMER5	9	10	TIMER6
GPIO_45	11	12	GPIO_44
EHRPWM2B	13	14	GPIO_26
GPIO_47	15	16	GPIO_46
GPIO_27	17	18	GPIO_65
EHRPWM2A	19	20	GPIO_63
GPIO_62	21	22	GPIO_37
GPIO_36	23	24	GPIO_33
GPIO_32	25	26	GPIO_61
GPIO_86	27	28	GPIO_88
GPIO_87	29	30	GPIO_89
GPIO_10	31	32	GPIO_11
GPIO_9	33	34	EHRPWM1B
GPIO_8	35	36	EHRPWM1A
GPIO_78	37	38	GPIO_79
GPIO_76	39	40	GPIO_77
GPIO_74	41	42	GPIO_75
GPIO_72	43	44	GPIO_73
EHRPWM2A	45	46	EHRPWM2B

Up to 8 digital I/O pins can be configured with pulse-width modulators (PWM) to produce signals to control motors or create analog voltage levels, without taking up any extra CPU cycles.

Fading an LED

```
var b = require('bonescript');
var LED = 'P9_21';  // Pin to use
var step = 0.02,    // Step size
    min = 0.02,     // dimmest value
    max = 1,        // brightest value
    brightness = min; // Current brightness;

b.pinMode(LED, b.ANALOG_OUTPUT);

setInterval(fade, 20);      // Step every 20 ms

function fade() {
    b.analogWrite(LED, brightness);
    brightness += step;
    if(brightness >= max || brightness <= min) {
        step = -1 * step;
    }
}
```

02-2 Pulse Width Modulation

Controlling an output pin without using the CPU

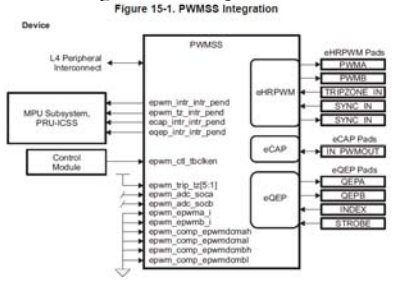
Pulse Width Modulation

- Using the CPU to toggle an IO pin is a poor use of the CPU
- A 1 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



Pulse Width Modulation

- The Bone has many standard interfaces
  - i2c, SPI, UART, etc.
- Let's play with the PWM

DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
GPIO_30	11	12	GPIO_60
GPIO_31	13	14	EHRPWM1A
GPIO_48	15	16	EHRPWM1B
GPIO_4	17	18	GPIO_5
I2C2_SCL	19	20	I2C2_SDA
EHRPWM0B	21	22	EHRPWM0A
GPIO_49	23	24	GPIO_15
GPIO_117	25	26	GPIO_14
GPIO_125	27	28	ECAPPWM2
EHRPWM0B	29	30	GPIO_122
EHRPWM0A	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	ECAPPWM0
DGND	43	44	DGND
DGND	45	46	DGND

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
- Handled through Device Tree Overlays

PWM

- Here's the 'magic' for PWM

```
$ SLOTS=/sys/devices/bone_capemgr.*/slots
$ echo am33xx_pwm     > $SLOTS
$ echo bone_pwm_P9_21 > $SLOTS
$ cd /sys/devices/ocp.*/pwm_test_P9_21.*
$ ls
driver duty  modalias  period  polarity
power  run  subsystem  uevent
```

$SLOTS is defined in my **.bashrc**

PWM

- Units are *ns*
- Try a 1Hz frequency with a 25% duty cycle

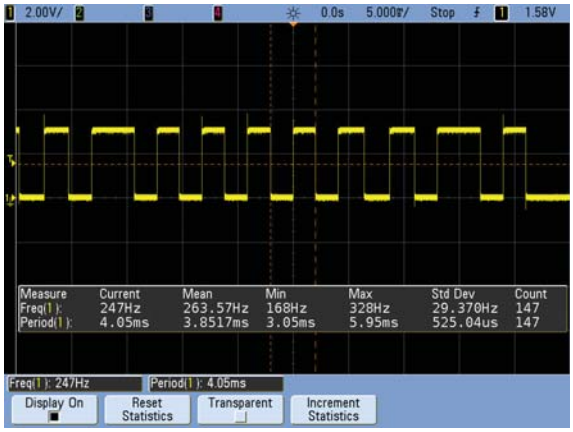
```
beagle$ echo 1000000000 > period
beagle $ echo  250000000 > duty
beagle $ echo 1 > run
```

- It should be blinking!

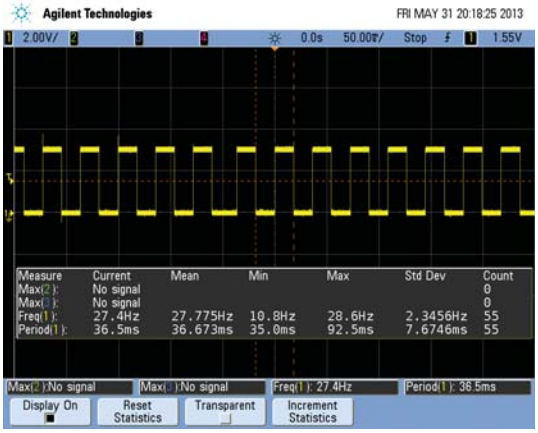
Performance

- How fast can the Bone handle I/O?
- I wrote a program to toggle a bit
  - BoneScript
  - Shell
  - C

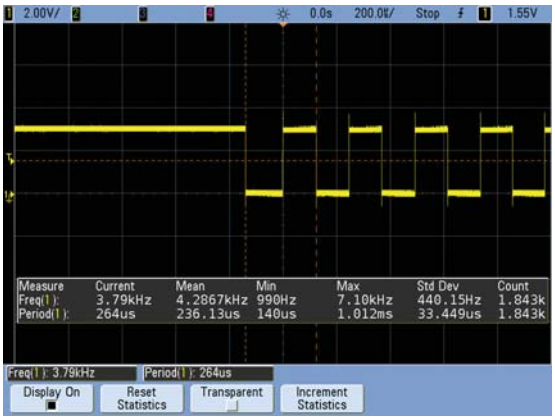
Performance - BoneScript



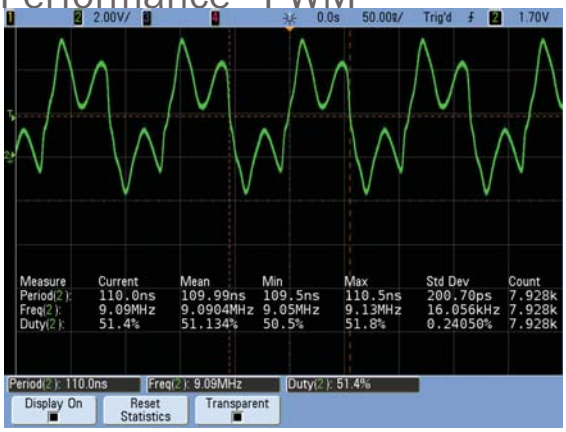
Performance - Shell



Performance - C



Performance - PWM



Performance - Summary

Language	CPU (%)	Mean (ms)	Min (ms)	Max (ms)
BoneScript	40	3.9	3.0	6.0
Shell	52	37	92	93
C	17	0.24	0.14	1.0
PWM	0	109.99 (ns)	109.5(ns)	110.5(ns)

Performance – gpio Through

- Read gpio7 and write to gpio60
- 30% cpu