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Directed Research Final Report

Goal

To characterize the waveform of the received ultrasonic signal using the OpenMote's ADC at different bit resolutions and intersampling times using Time Difference of Arrival (TDoA) scheme.

Capacitor on the Rx side

The capacitor value used on the experiments (Rx side) was a 22 nF ceramic capacitor. The following website was used as a reference for the values of ceramic capacitors according to their numbering: http://grathio.com/assets/capacitor_tags.pdf

If we want to have a better performance, we should use a small size capacitor because it will discharge faster. Another reason a small capacitor will match better with the circuit is because SoC used needs low power. If a bigger capacitor was used, then it will discharge more power and a high power SoC will be needed.

TDoA Implementation

From the experiments, it was observed that the noise floor was constant from 10us to 500us intersampling time for all the resolutions. We tested different intersampling times to see if the noise floor was influenced by the time constant of the capacitor of the ADC input. Furthermore, the noise floor did not change from 0.5 to 1.5 meters, which were the distances measured in the experiments. The following results show the minimum intersampling time possible (10us) and varying the ADC resolution. The screenshots of the terminal indicate the bump curves when the Rx received an ultrasonic signal.

Resolution of ADC 7 bit using the intersample time of 10 us and distance of 1.5 meters:

```
8 8 8 8 8 9 10 13 15 15 15 13 11 10 10 9 9 8 8 8 9 8 8 8 8 8
```

```
8 8 8 8 8 8 8 10 13 14 17 17 15 13 11 10 9 9 8 8 8 8 8 8 8 8
```

```
8 8 8 8 9 8 8 8 8 8 9 12 14 16 17 15 13 11 10 10 9 9 8 8 8 8 8 8 8 8 8 8
```

```
8 8 8 8 8 8 9 11 13 15 17 16 14 12 11 10 9 9 8 8 8 8 8 8 8 8
```

```
8 8 8 8 8 8 9 11 13 14 16 15 14 11 10 10 9 9 8 8 8 8 8 8
```

Resolution of ADC 9 bit using the intersample time of 10 us and distance of 1.5 meters:

```
35 34 33 33 35 36 44 54 57 56 55 50 42 40 39 37 33 35 33 35 35 35 34
```

```
35 34 34 34 34 35 35 39 46 57 56 55 49 45 41 38 37 35 36 34 35 34 34 34 35 35
```

```
33 34 36 34 34 34 35 41 50 56 60 58 52 48 42 37 37 35 35 36 35 33
```

```
34 34 34 33 34 35 38 46 55 59 55 52 46 41 40 35 34 32 33 34 33 34
```

```
33 34 36 34 34 34 33 35 40 48 56 57 53 48 44 38 38 37 35 35 34 35 35
```

Resolution of ADC 10 bit using the intersample time of 10 us and distance of 1.5 meters:

```
70 70 70 70 66 66 67 66 64 65 78 95 108 114 108 98 85 79 73 75 69 69 66 70 65 67
```

```
68 69 70 68 70 73 84 98 119 123 116 102 93 85 78 76 70 72 69 70 68
```

```
68 67 70 69 68 69 68 70 76 90 104 116 105 97 85 81 76 73 72 69 70 69
```

```
68 70 69 69 69 70 70 73 85 100 117 113 107 93 86 79 76 73 70 71 68 69
```

```
69 69 66 68 69 68 69 65 69 82 100 113 124 124 110 94 86 78 79 75 73 70 68
```

Resolution of ADC 12 bit using the intersample time of 10 us and distance of 1.5 meters:

```
269 268 274 267 272 276 296 383 435 469 260 281 272 272 276 279 271 271 277 269 271
```

```
281 280 273 277 279 306 381 434 479 266 280 273 280 279 269 262 288
```

```
284 279 273 273 277 288 326 365 362 262 280 274 280 279 269 261
```

```
278 281 279 279 273 282 276 309 360 380 266 278 277 280 279 269 261
```

```
266 269 278 280 310 386 447 477 447 268 278 258 269 276 279 278 273 289 268
```

<u>Thresholds</u>

If looking to calculate the TDoA, the following thresholds are recommended from previous testing:

- 7 bit resolution: 13

- 9 bit resolution: 53 to 60
- 10 bit resolution: 110 to 118
- 12 bit resolution: 465 to 496

<u>Noise Floor</u>

The noise floor has a pattern of a sinusoid; however is not a clear sine wave. Multiple sine waves together can be the reason the noise floor is not a clear sine wave. This can be due to interference from other equipment or echo from the sound wave bouncing from other locations into the Rx.

Sequence of noise at ADC 10 bit resolution using intersample time of 10us:

```
67 70 68 67 66 66 70 69 70 67 65 65 70 70 66 71 69 70 65 67 66 68 68 70 71 68 71 71 68 71 68 69 70 70 70 67 68 68 67 69 68 69 68 70 67 67 63 67
```

```
68 65 69 66 67 64 66 68 70 68 67 68 69 66 68 68 67 68 68 69 66 67 69 66 68 67
```

Sequence of noise at ADC 12 bit resolution using intersample time of 10us:

```
268 257 271 273 269 273 267 270 264 267 269 282 277 264 274 269 272 272 275 263 280
```

```
269 279 277 279 269 270 279 280 266 279 283 273 268 278 270 265 267 276 273 275 280
```

<u>To get up and running in Mac OS</u>

Install pip for Mac before installing python-serial:
sudo easy_install pip

Then, to install python-serial:
sudo pip install pyserial

Install homebrew for Mac:
/usr/bin/ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"

Install gcc-arm for Mac:
brew tap PX4/homebrew-px4
brew update
brew install gcc-arm-none-eabi

<u>Issues with BSL script using Mac OS</u>

This is to fix the way the BSL script uses the lines that are connected to the OpenMote. We have to invert the usual order of the lines (DTR and RTS). Also, the baud rate is reduced.

Change boards/openmote-cc2538/Makefile.include export FFLAGS = -p "$(PORT)" -e --bootloader-invert-lines -w -v -b 450000 $(HEXFILE)

List USB devices on Mac OS on terminal
Usually you will have to press tab once or twice.

ls /dev/tty.usbserial[press tab until the devices appear]

Getting into bootloader using Mac
To get into the bootloader, you need to set physically the ON/SLEEP pin to the GND pin on OpenMote. Mac hardware does not support getting into bootloader.

Side Notes
The output voltage of a MacBook Pro is 5V, therefore the performance of the circuit might change when using batteries. Mac OS has python pre-installed.