How-To Guide: Electret Microphone Amplifier (MAX9814) - Setup for Audio
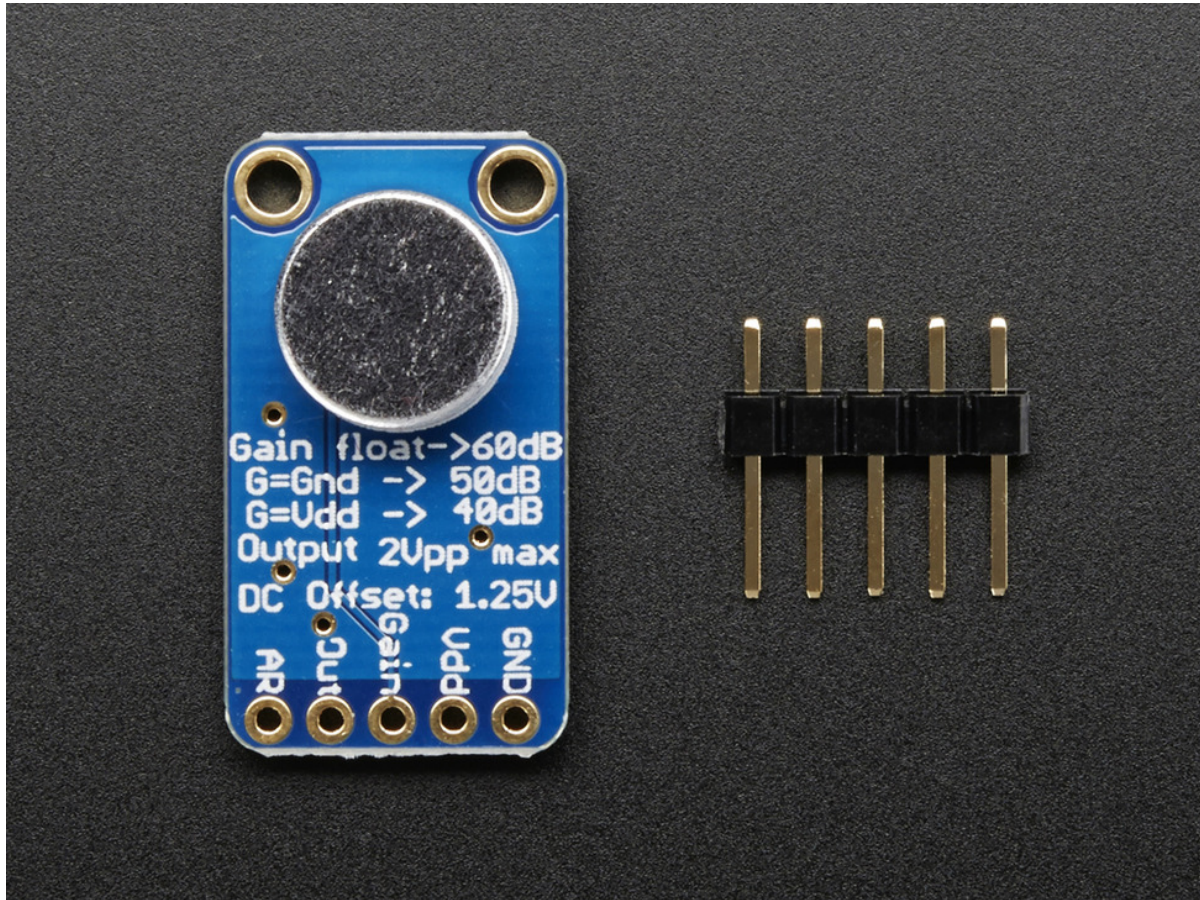

(image from Adafruit's product page, https://cdn-shop.adafruit.com/970x728/1713-00.jpg)

Introduction

This guide will help you with obtaining audio data that can be used for audio playback on the BeagleBone Green (BBG) using the Electret Microphone Amplifier (MAX9814). This guide will walk you through the wiring and BBG settings needed to have playable audio. By the end of this guide you will have audio data that can be used with Pulse-Code Modulation (PCM). Some prior knowledge from Brian Fraser's A2D and Audio guide is needed to complete this guide: https://opencoursehub.cs.sfu.ca/bfraser/grav-cms/cmpt433/guides/files/A2DGuide.pdf. https://opencoursehub.cs.sfu.ca/bfraser/grav-cms/cmpt433/guides/files/AudioGuide.pdf

This guide acts as an update to a previous group's Electret Microphone Amplifier guide here: https://opencoursehub.cs.sfu.ca/bfraser/grav-cms/cmpt433/links/files/2019-student-howtos/ElectretMicrophoneAmplifier.pdf

We justify the need for this updated guide as we go over wiring a new version of the mic (MAX 9814), how to adjust the Gain for the mic, and how to obtain groups of samples with the mic.
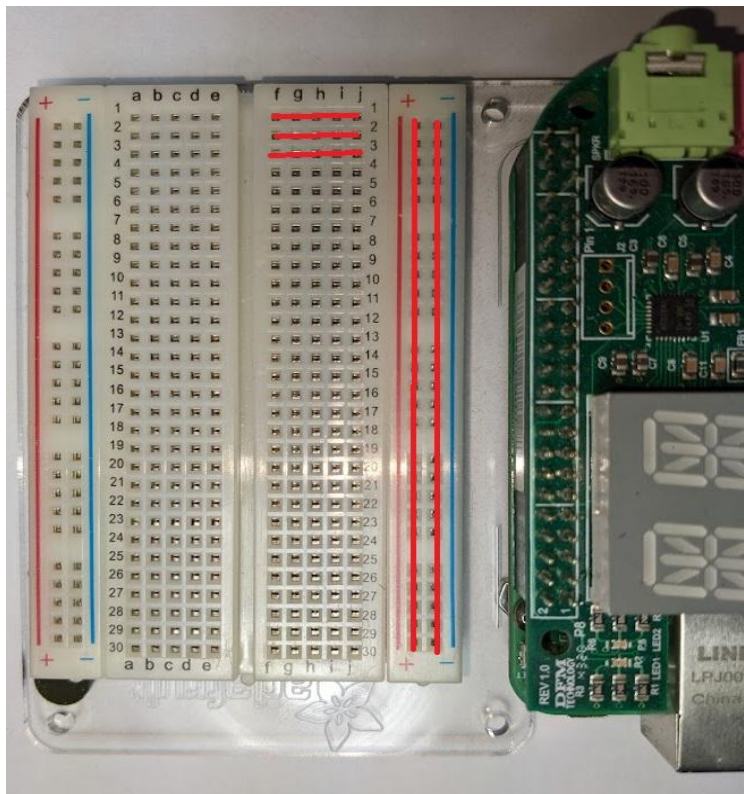
Wiring

You will need the following:

- 3 x Male/Male Breadboard Jumper Wires **(3rd wire is optional)**
- 3 x Female/Male Breadboard Jumper Wires
- MAX9814 Microphone
- BeagleBone Green
- Breadboard
- Zen Cape
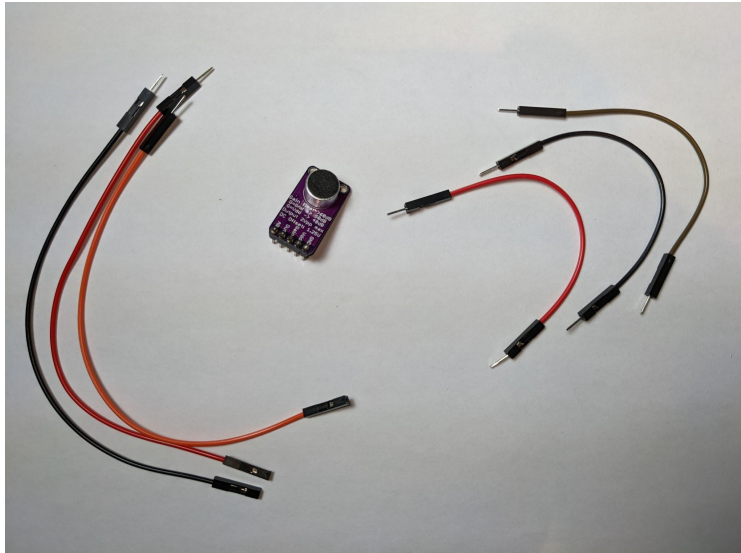
Note: Before doing any wiring please make sure the BBG is not plugged in and to ground yourself. The colours of the cables do not matter. Red is commonly used for power and black is commonly for ground. We will be referring to these colours for the wiring guide.


Note: On the left, the bright red lines indicate the direction of wiring for the breadboard. You can insert the microphone anywhere on the board within the 1-30 rows by the a-j columns. For this guide, the mic is placed at column f, rows 18-22 (see images below).

Steps

1. Insert the microphone into the breadboard (here it is column f, rows 18-22)
2. Use a Male/Male breadboard jumper wire and connect it to one of the two minus (-) columns. Connect the other end of the wire to the GND row of the MAX9814 Microphone on the breadboard (here it is column j, row 18)
3. Use a Male/Male breadboard jumper wire and connect it to one of the two plus (+) columns. Connect the other end of the wire to the Vdd row of the MAX9814 Microphone on the breadboard (here it is column j, row 19).
4. Use a Female/Male breadboard jumper wire and connect the female end on pin 40 on the zen cape P9 header and the male end on the Out row of the MAX9814 Microphone on the breadboard (here it is column j, row 21)
5. Use a Female/Male breadboard jumper wire and connect the female end on pin 1 on the zen cape P9 header and the male end anywhere on the minus (-) column from step 2
6. Use a Female/Male breadboard jumper wire and connect the female end on pin 3 on the zen cape P9 header and male end anywhere on the plus (+) column from step 3

The wiring should look something like this:
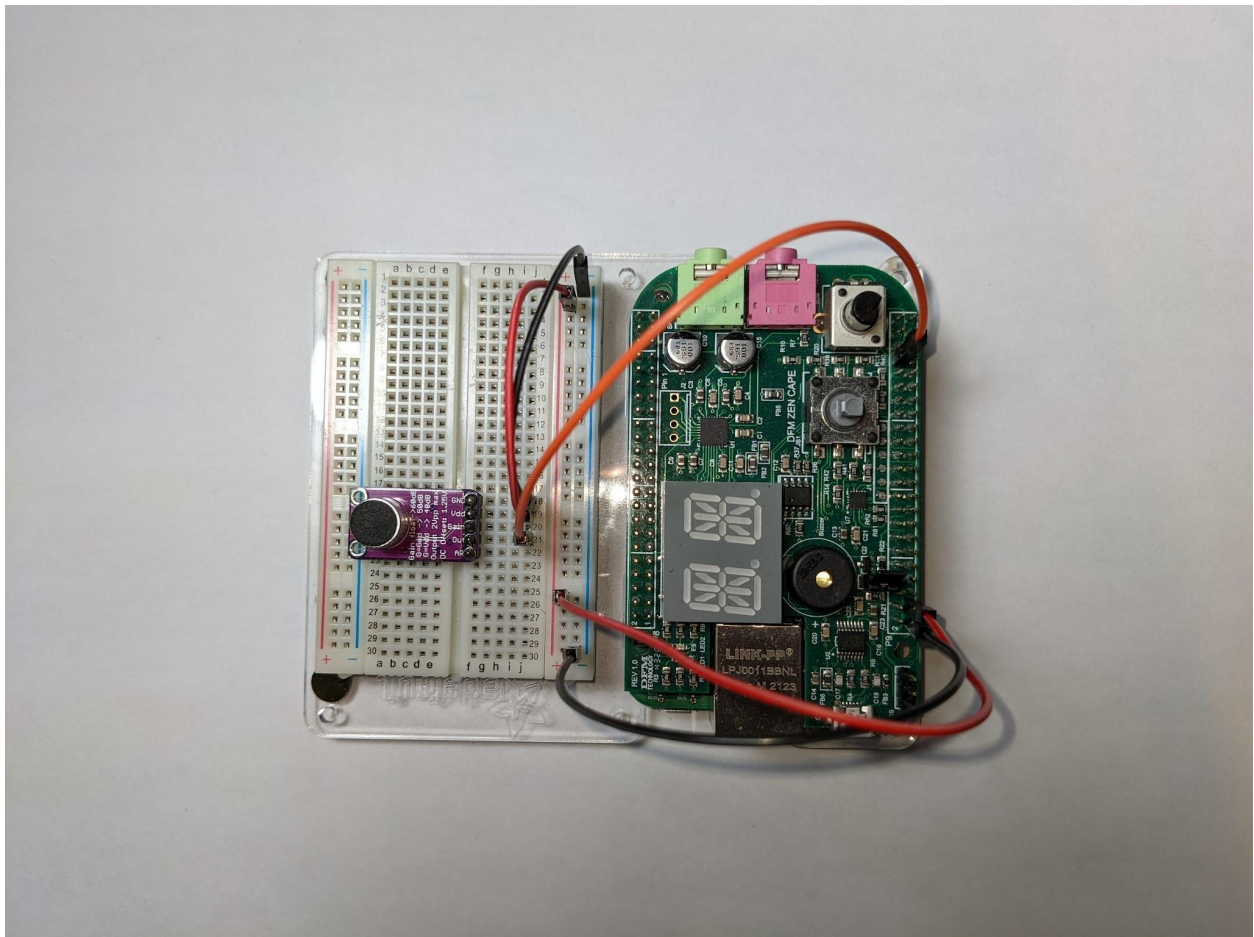
The reason for this wiring is because on the MAX9814 Microphone you may control the gain by connecting the "Gain" on the microphone to GND or Vdd. Use the optional wire to connect "Gain" (column j, row 20) to any part of the plus (+) column or minus (-). More information can be found on the data sheet.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Gain	A	GAIN = V_{DD}	39.5	40	40.5	dB
		GAIN = GND	49.5	50	50.6	
		GAIN = unconnected	59.5	60	60.5	
Minimum Gain		GAIN = V_{DD}	18.7	20	20.5	dB
		GAIN = GND	29.0	30	30.8	
		GAIN = unconnected	38.7	40	40.5	

(Image from MAX9814 data sheet: https://cdn-shop.adafruit.com/datasheets/MAX9814.pdf)

You can wire the pins directly to the microphone if you do not need to adjust Gain. Here is a simplified table on the wiring from the MAX9814 Microphone to the BeagleBone Green:

MAX9814	BBG (on the P9 Header)
GND	Pin 1 (GND)
Vdd	Pin 3 (DC_3.3V)
Gain	n/a
Out	Pin 40 (AIN1)
AR	n/a

Troubleshooting

1. If the BBG LEDs flashes once and it does not boot, check your wiring. You may have wired the ground and power wrong. Fix the wiring and try again.

BeagleBone Setup/Reading Samples

1. Make sure the wiring is correct, then power on the BBG
2. We need to set the analog setting to continuous mode and change the sample rate. Copy and run the following commands:

```
sudo chmod 0666 "/sys/bus/iio/devices/iio:device0/scan_elements/in_voltage1_en"
echo 1 > "/sys/bus/iio/devices/iio:device0/scan_elements/in_voltage1_en"
sudo chmod 0666 "/sys/bus/iio/devices/iio:device0/buffer/length"
echo 4000 > "/sys/bus/iio/devices/iio:device0/buffer/length"
sudo chmod 0666 "/sys/bus/iio/devices/iio:device0/buffer/enable"
echo 1 > "/sys/bus/iio/devices/iio:device0/buffer/enable"
sudo chmod 0666 /dev/iio:device0
```

We are using sudo chmod 0666 to allow us to be able to read and write to the file. This may not be ideal in a production setting. Changing the number inside "/sys/bus/iio/devices/iio:device0/buffer/length" adjusts the amount of samples it can hold at a given time. You will need to run these commands every time on boot if you want to sample audio. Thus, it's best to put these commands into a script file to run in the future.

3. Compile and run the following sample code to start sampling:

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <fcntl.h>
#include <unistd.h>
#include "stdint.h"
#include <time.h>
#include <errno.h>

short sound[16000];
#define arrSize 16000
// millisecond sleep
int msleep(long msec)
{
    struct timespec ts;
    int res;

    if (msec < 0)
    {
        errno = EINVAL;
        return -1;
    }
```

```c
    ts.tv_sec = msec / 1000;
    ts.tv_nsec = (msec % 1000) * 1000000;

    do
    {
        res = nanosleep(&ts, &ts);
    } while (res && errno == EINTR);

    return res;
}

int main() {
    // copy sampled values to array
    int size = 200;
    uint16_t buf[200];
    int fd = open("/dev/iio:device0", O_RDONLY | O_NONBLOCK);
    if (fd == -1)
    {
        printf("error\n");
        exit(1);
    }


    int count = 0;
    while (1)
    {
        read(fd, buf, size * sizeof(uint16_t));
        for (int i = 0; i < size; i++)
        {
            if (count > arrSize)
            {
                count = 0;
            }


            sound[count] = buf[i];

            printf("%d\n", sound[count]);

            count++;
        }
        msleep(25); //waits so we can get more than 1 sample at time
    }
}
```

4. Now main.c should be printing the audio sample on a loop. You can run a separate thread to read the sound array and play it using PCM. We did not include the audio playing section code because that section of the code is very similar to a Brian Fraser CMPT 433 assignment. You can refer to Brian's audio guide to get audio playback working on the zen cape:
   https://opencoursehub.cs.sfu.ca/bfraser/grav-cms/cmpt433/guides/files/AudioGuide.pdf
5. When you want to stop your program and do other things please run the following commands to disable continuous reading so it doesn't use up system resources.

```
echo 0 > "/sys/bus/iio/devices/iio:device0/buffer/enable"
echo 0 > "/sys/bus/iio/devices/iio:device0/scan_elements/in_voltage1_en"
```

Troubleshooting

1. If there is an error message regarding GPIO, then it means you do not have permissions to open the analog files. Try re-running the commands on step 2 again.
2. If samping audio with the code does not work, check your wiring. Fixing any loose or faulty cables is likely the issue.

References

An older guide for a different Beaglebone and microphone combo setup. Used as a reference to create this guide for the MAX9814 on the Beaglebone Green:
https://elinux.org/EBC_Exercise_10a_Analog_In

Electret Microphone Amplifier - MAX9814 Store Page:
https://www.adafruit.com/product/1713

Electret Microphone Amplifier - MAX9814 Data Sheet:
https://cdn-shop.adafruit.com/datasheets/MAX9814.pdf

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