Hedwig

A-Level Coursework by
Vagif Aliyev
D'Overbroeck's Collage
2014 / 2015

Chapter 1

Definition, Investigation and Analysis

1.1 Definition - nature of the program to be investigated

1.1.1 About the Organisation

The firm, on behalf whom this project is being undertaken, is a small organisation who specializes in software development. They provide the client with a custom-made solution to meet their needs. They have experience in a wide array of fields ranging from iPhone applications to micro-controllers. John Thomas, my client, considers their organisation to be more of a 'lifestyle' company, they all enjoy their work and constantly have lots of projects underway. Their clients are diverse and they usually suggest project that appeals to A-level students.

The current project is a robot which needs to detect the location of the sound source and feed information to micro-controller to rotate the motor towards the sound source.

1.1.2 About the End User

The end user will be members of the organisation and potentially their guest who would love to own one. Therefore, anybody with the intention of having the machinery must contact the Company if they are interested in purchasing the product.

No requirements are needed to use this device since all parts will be assembled before hand. Connecting the device to a power socket is the only possible requirement.

The ideal end user would be someone who is interested in robotics or people who would like to use the video & audio recording of the device in conference to contain a first person view of the conference.

1.1.3 Areas of Development

The two major areas of development are:

- Audio Object Localization

The core of the application is the Audio Object Localization module. This will determine the location of the source of the sound and then data can be fetched. The location will be determined by comparing the incoming sound amplitudes.

1.1.4 About the Data

The sound data in its raw format will be fetched from the sound sensors. This method will provide micro controller with values from sound sensors which will need to be processed in order to find the location of the source. After doing some calculations using the values from sensor, the motor will moved at the right speed and direction until the sound source is faced.

Other data, concerning Audio and Video will be derived from the attached camera

1.2 Investigation and Analysis

This section covers the pre-production communication with he the client, Peter Thomas, in order to establish the project, determine it feasibility and arrive at a requirement specification that both parties agree upon.

1.2.1 System Analysis and Communication

To understand the project clearly, my client and i exchanged emails and met at various occasions. An out-take of conversation is documented below.

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Dear John,

I received your email from Alan Milosevic ,who is one of my mentors , regarding the course project. I hope you can provide a project for me to produce for you. I am willing to take up a challenging project, especially one involving motors and sensors.

Best Regards,

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Hi Vagif

I've had a chat to Alan about you and apparently you're intending to apply to university to study engineering. For the past four or five years or so we've worked with Alan's students on a varied collection of projects which have ranged from iOS applications to automated train systems to writing in the air. Without exception every project has been a real success, so much so that this year again we're happy to suggest a range of projects that we and/or our clients would like to see.

You mention that you'd like something involving motors and sensors. Many. many years ago some friends and I built a really interesting project that involved a stuffed owl, a bunch of discrete electronics and software. The owl has long since disappeared but I've often wondered about building it again. So, if you're up for it, this is it in a nutshell.

Take one large owl (stuffed or a toy)
Put some means of sensing sound in each ear.
Place motors in its neck
Put some electronics in its head
Write the appropriate software so that the head of the owl will rotate so as to equalise the pressure of any sound - i.e. move the head so as to point in the direction of the sound.

This was a great party piece - people found it hilarious as the owl moved to follow a conversation.

I'd love to see it work again.

It should be a very satisfying project - there will be a lot of trial and error working with the sensors and motors but with the introduction of the arduino board and the raspberry pi (and other controller boards that you should take a look at) you should be able to get something interesting up and running fairly rapidly I would hope.

If that isn't enough for you, I can think of plenty of extensions :-)

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Hello Mr.Thomas,

It sounds really interesting and i would love to design such a machine. There are many available micro-controllers, sensors and motors. It would be great if we could meet and decide on few to purchase. After I test them and give you a feedback, you could decide on which ones you would like to be used in the project.
Regards

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Hi Vagif

Good to hear from you. I suggest that you pop across to see us sometime in the next couple of weeks. Your teacher will give you directions to our offices. I suggest that you make it after 5:30 - Tuesdays or Thursdays are best.

Look forward to hearing from you

Cheers

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

How about next week Thursday (November 21st 2014) at 18:00 ?

Cheers

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

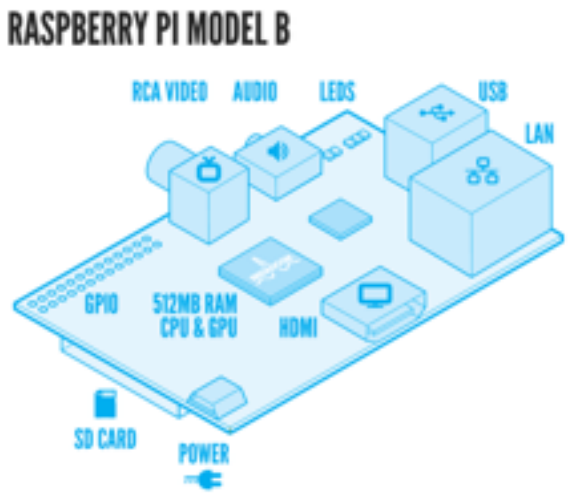
Hi Vagif

That sounds fine.

cheers

Meeting 1

These were the chosen micro-controllers:



The Raspberry Pi 2 Model B is the second generation Raspberry Pi.

Specifications:

•A 900MHz quad-core ARM Cortex-A7 CPU

•1GB RAM

•4 USB ports

•40 GPIO pins

•Full HDMI port

•Ethernet port

•Micro SD card slot

Although Raspberry Pi is a powerful machine, it requires a tv screen with HDMI output and a keyboard to program on it which is a hassle.

Arduino Due

The Due has a 32-bit ARM core that can outperform typical 8-bit micro-controller boards.

Specifications:

•A 32-bit core, that allows operations on 4 bytes wide data within a single CPU clock.

•CPU Clock at 84Mhz.

•96 KBytes of SRAM.

•512 KBytes of Flash memory for code.

• a DMA controller, that can relieve the CPU from doing memory intensive tasks.

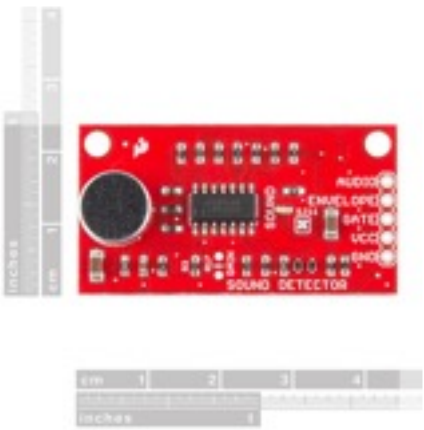
• 54 Digital I/O Pins (of which 12 provide PWM output)

These were the chosen <u>sound sensors</u>:

<u>Electret Microphone Amplifier - MAX9814 with Auto Gain Control</u>

This fully assembled and tested board comes with a 20-20KHz electret microphone soldered on. For the amplification, they use the Maxim MAX9814, a specialty chip that is designed for amplifying electret microphones in situations where the loudness of the audio isn't predictable.

The AGC in the amplifier means that nearby 'loud' sounds will be quieted so they don't overwhelm & 'clip' the amplifier, and even quiet, far-away sounds will be amplified.



<u>SparkFun Sound Detector - SEN-12642 ROHS</u>

The SparkFun Sound Detector is a small and very easy to use audio sensing board with three different outputs. The Sound Detector not only provides an audio output, but also a binary indication of the presence of sound, and an analog representation of its amplitude. The 3 outputs are simultaneous and independent, so you can use as many or as few as you want at once.

The envelope output allows you to easily read amplitude of sound by simply measuring the analog voltage. Gain can be adjusted with a through-hole resistor, to change the threshold of the binary (gate) output pin as well.

These were the chosen <u>motors</u>:

<u>Stepper Motor with Cable - ROB-09238</u>

This is a simple, but very powerful stepper motor with a 4-wire cable attached.

This is a Bipolar Motor.

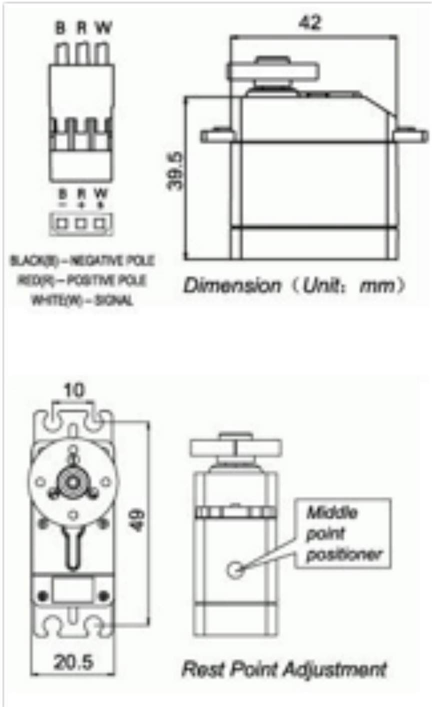
Features:

• Step Angle (degrees) :1.8

• Rated Voltage : 12V

- Rated Current : 0.33A
- Holding Torque : 2.3kg*cm

Servo - Generic High Torque Full Rotation - ROB-09347



This is a simple, high quality continuous full-rotation servo motor. This servo is able to take in 6 volts and deliver 66.7 oz-in. of maximum torque at 70 r/min.

A standard 3-pin power and control cable is attached.

Features:

- Voltage: 4.8-6.0 Volts
- Torque: 45.8/66.7 oz-in. (4.8/6.0V)
- Speed: 60/70 r/min (4.8/6.0V)
- Rotation: 360°
- Dual Ball Bearing

After narrowing down the hardware to these options, Mr.Thomas told me to purchase each of these and play around with it. He game the full responsibility to use any hardware i wanted out of the ones we selected together.

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Hello Mr.Thomas,

It has been a week and a half since i got my orders delivered. After using everything finally I came to the conclusion of using Arduino micro-controller for the project. For the motor Servo seems more flexible so i will go with that. For the sound sensor i couldn't choose between the two so probably i will use Electret Microphone Amplifier - MAX9814 with Auto Gain Control to create the LED display we were talking about and the other sound sensor for the project. Please let me know if you have any complaint or suggestions.

Cheers,

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Dear Vagif

The Arduino is a safe bet - which board are you planning on using? I suggest that you a fairly powerful one, the algorithms you'll no doubt have to employ will obviously work better with a faster board. Re the electret microphone you suggest, I've taken a look at the specifications and two of those should do the job with the necessary software, which clearly you'll have to write. I suggest that you look into using some form of PID controller (http://en.wikipedia.org/wiki/PID_controller and http://www.csimn.com/CSI_pages/PIDforDummies.html) to try to make the movement of the head as smooth as possible.

Cheers

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Hi John

I am planning on using the Arduino Due board since it seems to be the strongest one on the market so far. With the help of the meetings and emails, I have made a summary on what we have agreed on.

1- The direction of the sound will be calculated by using the values from the sensors.

2- If the difference of the values is not great the motor will not move.

3- If it is greater than threshold value the motor will keep rotating until the value in amplitude difference is less then the threshold

Anything to add to it?

Regards,

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Sounds sensible - how are you planning on calculating the direction of the sound I wonder ? Looking for phase differences or absolute sound level ? The second might prove difficult in anything other than a totally silent environment and in any case the microphones might not be sufficiently sensitive. You're going to have to do a lot of experimentation on this one.

cheers

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

I think it will be much better if we had a new meeting and describe how to approach this project and the requirement specification. How does December 11 at 16:00 sounds to you ?

Cheers

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Hi Vagif

I'm afraid that I can't make the meeting at 4 o'clock but I can make it later at say 6 o'clock. Unless I hear to the contrary, I'll assume that I'll see you then.

Cheers

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Hello John,

6 o'clock is suitable for me, i will see you next Thursday then.

Cheers,

Meeting 2

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

After having a meeting with you, we agreed to produce several prototypes for the functions below:

1. A program that able to graph the sensor values (amplitude)

2. A program that will enable the user to move the motor in any direction desired with a keyboard/mouse.

3. A program which will be able to read multiple sensors and display their difference and values.

4. (optional) Using LEDs to display the amplitude in real time.

As you suggested before diving into the code, i will go through the libraries and make sure i know how each function behaves.

I will make sure to experiment with different values for the sensor offset and the threshold amplitude to use the sensors as efficient as possible.

We also agreed that i will be looking at the phase difference of the sensors to locate the direction of the sound sensor.

Also, the last addition to the code will be the PID controller which will make the movement of the head as smooth as possible.

Please let me know if there is anything i missed from the meeting or if you have new ideas or request to make.

Cheers,

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Hi Vagif

This sounds like a pretty complete summary of the meeting - I look forward to seeing progress. In the meantime you should write up a draft requirement specification that I can take a look at.

cheers

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Dear John,

This is still a draft, please let me know if you are unhappy about any part or would like addition.

User Requirements:

User should be able to produce a sound.
User should be able to connect the micro-controller to the power socket to turn the device on.
User should have enough space to place the device which dimensions will be roughly 25cm x15cm x10cm.

Design Requirement:

The device should have an appearance of an Owl.

Hardware Requirements:

Arduino Due SparkFun Sound Detector - SEN-12642 ROHS
Electret Microphone Amplifier - MAX9814 with Auto Gain Control Servo
Generic High Torque Full Rotation - ROB-09347
Power battery

Software Requirement:

C++ code installed on micro-controller.
The micro-controller will have everything already complied on the Arduino e.g storage of libraries and code.

Sound Localisation Requirements:

Micro-controller should use software to calculate the location of the sound source using phase difference of the sound sensors.
Micro-controller should identify the sound source position and pass the information to the motor.

Motor Requirements:

Drive the servo appropriately to move the device into an appropriate position.
The Nose of the owl should be constantly facing the sound source as it moves or stays still.
Should be able to turn through out 360°.
Should have enough power to turn with the device on the top.

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

Hi Vagif

This looks good - it's in line with what we're looking for. How much space in total does this take up ?

cheers

From: Vagif R. Aliyev vagif.r.aliyev@gmail.com
Subject:
To: John Peter Thomas john.peter.thomas@gmail.com

Hello Petter,

Like i mentioned in the draft the dimensions will be roughly 25cm x15cm x10cm.

I would also want to remind you that i will be responsible for the hardware and software part of the project. You will have to Victoria Stanway for the design of the Owl, i will provide the contact information below:

Victoria Stanway Artist

Contact:

07789 186759
www.victoriastanwayart.com
mail@victoriastanwayart.com
www.facebook.com/victoriastanwayart

Cheers,

From: John Peter Thomas john.peter.thomas@gmail.com
Subject:
To: Vagif R. Aliyev vagif.r.aliyev@gmail.com

OK - that's fine - I should have read it a little more carefully :-)

cheers

1.2.2 Requirement Specification

User Requirements:

- User should be able to produce a sound.
- User should be able to connect the micro-controller to the power socket to turn the device on.
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- Drive the servo appropriately to move the device into an appropriate position.
- The Nose of the owl should be constantly facing the sound source as it moves or stays still.
- Should be able to turn through out 360º.
- Should have enough power to turn with the device on the top.

1.2.3 Client’s confirmation to the Requirement Specification

By signing this document, both parties agree that the requirement specification is satisfactory and pleases the client’s vision to the application design and that the final product will be close to that described.

Developer’s Signature

Client’s Signature

Date: ____/____/_______

Chapter 2

Design

2.1 Nature of the solution

2.1.1 Objectives and Limitations

Objective :

- The program should accurately locate the sound of the source
- The program must rotate the servo to the sound source

Limitations :

- The accuracy can be increased greatly by purchasing a better sound sensor and motor
- The motor has a limited accuracy, pointing exactly at the sound source might be not possible in some situations

2.1.2 Hardware

Prototyping board

The design processes began with choosing the board to use, i choose the Arduino Due, depicted on the left side.

This particular model is the most efficient model of Arduino series in the market. It is more efficient than the other boards but a bit more expensive.

The purpose of getting a Arduino board over Raspberry Pi is that it can be easily programmed to control multiple hardware (with the addition of the motor shield even more can be controlled)

It also has digital inputs which can receive information about the sensor values and en information to the servo. Arduino uses an easily grasp language and writing environment based on processing which was a beginners language at MIT.I have used Processing multiple times with the Arduino software to create test my hardware and control them manually.

Arduino New Products

Arduino DUE

The Arduino Due is the newcomer microcontroller board in the Arduino boards family. It's the first board based on a 32 bit processor (Atmel SAM3X8E ARM Cortex-M3 MCU), which improves all the standard Arduino functionalities and adds many new features.

The arduino DUE offers 54 digital input/output pins (of which 16 can be used as PWM outputs, with selectable resolution), 12 analog inputs with 12 bits of resolution, 4 UARTs (hardware serial ports), two DAC (digital to analog converter) outputs, an 84 MHz crystal oscillator, two USB connections, a power jack, an ICSP header, a JTAG header, and a reset button.

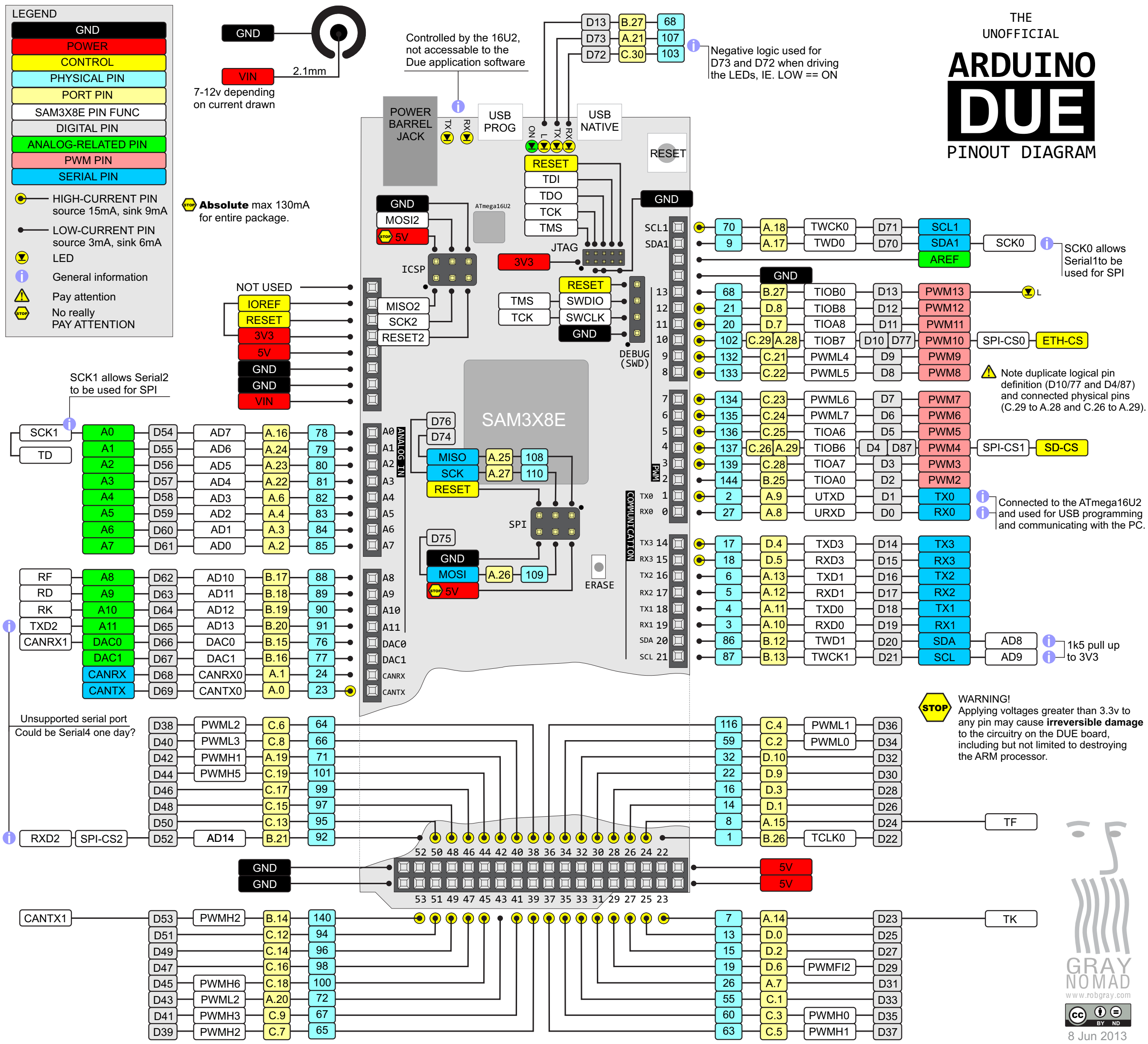
The Due has two micro USB connectors: one intended for debugging purposes and a second one capable of acting as a USB host, allowing external USB peripherals such as mouse, keyboards, smartphones, etc. to be connected to the Arduino Due.
More information will be soon on line at the page http://arduino.cc/ArduinoDUE

Technical Specifications

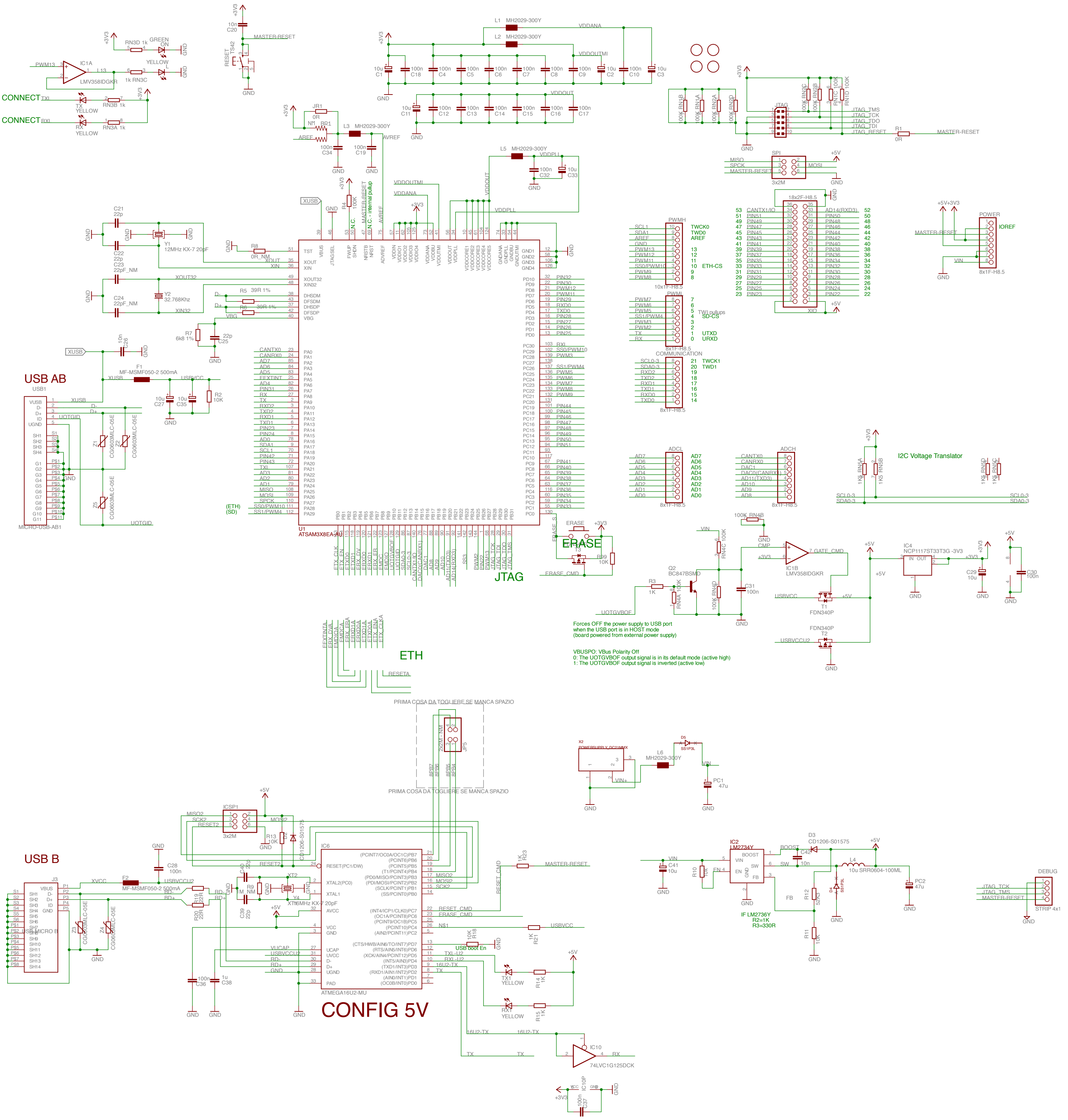
Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 16 provide PWMoutput)
Analog Input Pins	12
Analog Outputs Pins	2 (DAC)
Total DC Output Current on all I/O lines	130mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	theoretical 1A, realistic 800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (64 + 32 KB)
DataFlash	2 Mbit (250 KB)
Clock Speed	84 MHz

ARDUINO

Pin Out Diagram



Schematics

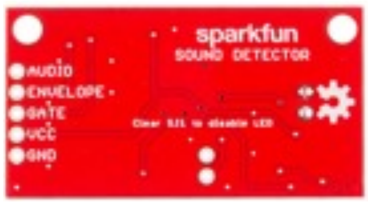


CONNECT
CONNECT
USB AB
USB B
ERASE
JTAG
ETH
CONFIG 5V
I2C Voltage Translator

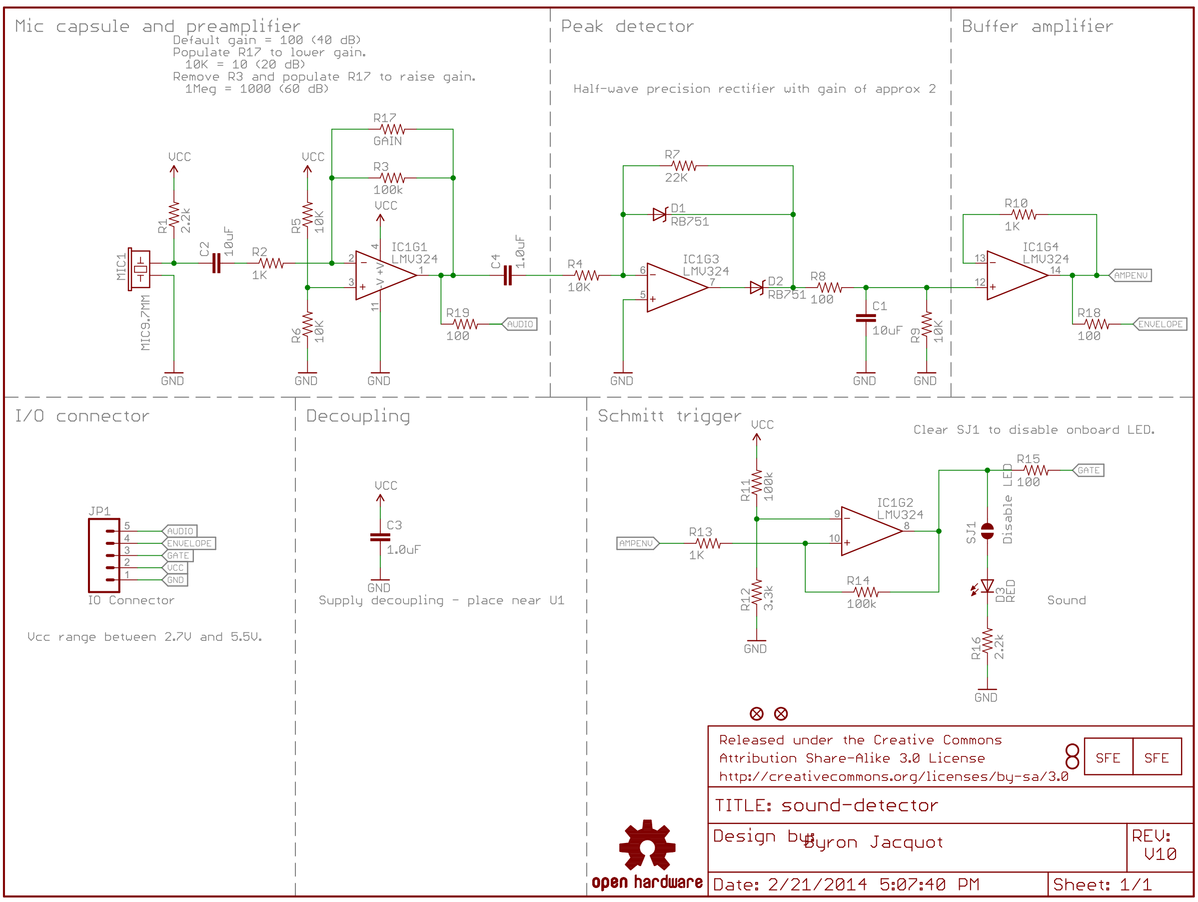
Sound Sensor(s)

The SparkFun Sound Detector is a small and very easy to use audio sensing board with three different outputs. The Sound Detector not only provides an audio output, but also a binary indication of the presence of sound, and an analog representation of its amplitude. The 3 outputs are simultaneous and independent, so you can use as many or as few as you want at once.

The envelope output allows you to easily read amplitude of sound by simply measuring the analog voltage. Gain can be adjusted with a through-hole resistor, to change the threshold of the binary (gate) output pin as well.



Schematic



LMV321, LMV358, LMV324

General Purpose, Low Voltage, Rail-to-Rail Output Amplifiers

Features at +2.7V

- 80µA supply current per channel
- 1.2MHz gain bandwidth product
- Output voltage range: 0.01V to 2.69V
- Input voltage range: -0.25V to +1.5V
- 1.5V/µs slew rate
- LMV321 directly replaces other industry standard LMV321 amplifiers; available in SC70-5 and SOT23-5 packages
- LMV358 directly replaces other industry standard LMV358 amplifiers; available in MSOP-8 and SOIC-8 packages
- LMV324 directly replaces other industry standard LMV324 amplifiers; available in SOIC-14 package
- Fully specified at +2.7V and +5V supplies
- Operating temperature range: -40°C to +125°C

Applications

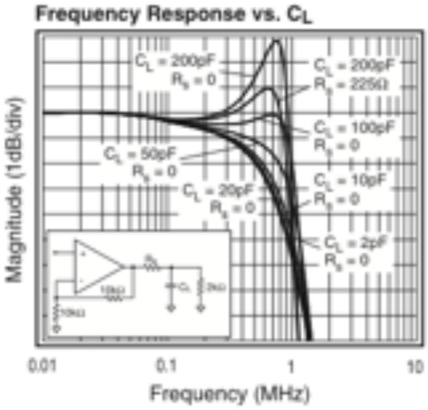
- Low cost general purpose applications
- Cellular phones
- Personal data assistants
- A/D buffer
- DSP interface
- Smart card readers
- Portable test instruments
- Keyless entry
- Infrared receivers for remote controls
- Telephone systems
- Audio applications
- Digital still cameras
- Hard disk drives
- MP3 players

Description

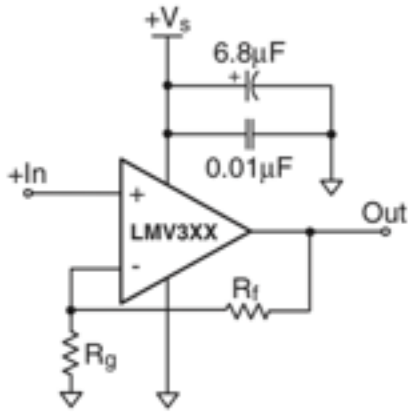
The LMV321 (single), LMV358 (dual), and LMV324 (quad) are a low cost, voltage feedback amplifiers that consume only 80µA of supply current per amplifier. The LMV3XX family is designed to operate from 2.7V (±1.35V) to 5.5V (±2.75V) supplies. The common mode voltage range extends below the negative rail and the output provides rail-to-rail performance.

The LMV3XX family is designed on a CMOS process and provides 1.2MHz of bandwidth and 1.5V/µs of slew rate at a low supply voltage of 2.7V. The combination of low power, rail-to-rail performance, low voltage operation, and tiny package options make the LMV3XX family well suited for use in personal electronics equipment such as cellular handsets, pagers, PDAs, and other battery powered applications.

Frequency Response vs. C_L



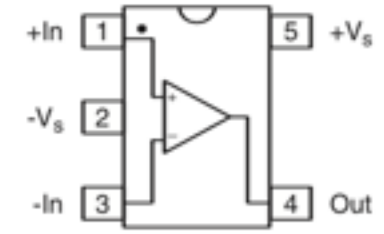
Typical Application



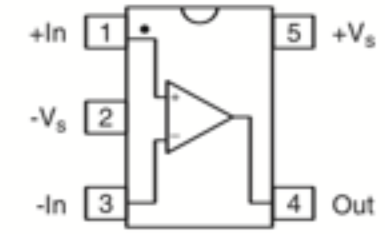
Pin Assignments

LMV321

SOT23-5

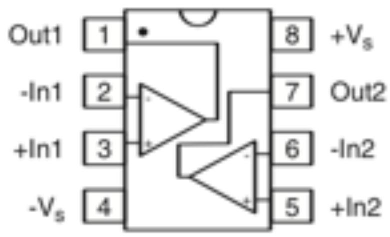


SC70-5

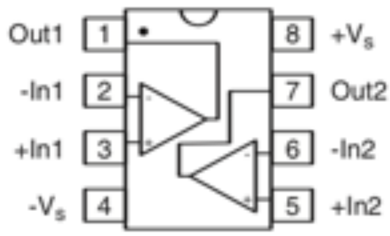


LMV358

SOIC-8

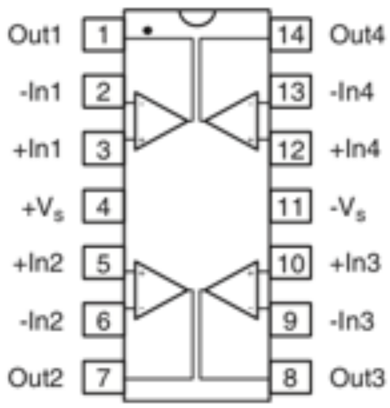


MSOP-8

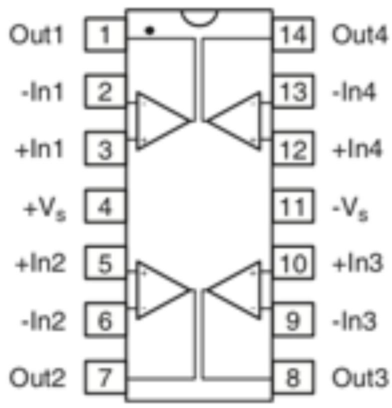


LMV324

TSSOP-14



SOIC-14



Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Supply Voltages	0	+6	V
Maximum Junction Temperature	–	+175	°C
Storage Temperature Range	-65	+150	°C
Lead Temperature, 10 seconds	–	+260	°C
Input Voltage Range	$-V_S$ -0.5	$+V_S$ +0.5	V

Recommended Operating Conditions

Parameter	Min.	Max.	Unit
Operating Temperature Range	-40	+125	°C
Power Supply Operating Range	2.5	5.5	V

Electrical Specifications

(T_C = 25°C, V_S = +2.7V, G = 2, R_L = 10kΩ to V_S/2, R_f = 10kΩ, $V_{o\ (DC)}$ = V_{CC}/2; unless otherwise noted)

Parameter	Conditions	Min.	Typ.	Max.	Unit
AC Performance					
Gain Bandwidth Product	C_L = 50pF, R_L = 2kΩ to V_S/2		1.2		MHz
Phase Margin			52		deg
Gain Margin			17		dB
Slew Rate	V_O = 1V_{pp}		1.5		V/µs
Input Voltage Noise	>50kHz		36		nV/√Hz
Crosstalk: LMV358	100kHz		91		dB
LMV324	100kHz		80		dB
DC Performance					
Input Offset Voltage[1]			1.7	7	mV
Average Drift			8		µV/°C
Input Bias Current[2]			<1		nA
Input Offset Current[2]			<1		nA
Power Supply Rejection Ratio[1]	DC	50	65		dB
Supply Current (Per Channel)[1]			80	120	µA
Input Characteristics					
Input Common Mode Voltage Range[1]	LO	0	-0.25		V
	HI		1.5	1.3	V
Common Mode Rejection Ratio[1]		50	70		dB
Output Characteristics					
Output Voltage Swing	R_L = 10kΩ to V_S/2; LO[1]	0.1	0.01		V
	R_L = 10kΩ to V_S/2; HI[1]		2.69	2.6	V

Min/max ratings are based on product characterization and simulation. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

Notes:
1. Guaranteed by testing or statistical analysis at +25°C.
2. +IN and -IN are gates to CMOS transistors with typical input bias current of <1nA. CMOS leakage is too small to practically measure.

Electrical Specifications

(T_C = 25°C, V_S = +5V, G = 2, R_L = 10kΩ to V_S/2, R_f = 10kΩ, $V_{O\ (DC)}$ = V_{CC}/2; unless otherwise noted)

Parameter	Conditions	Min.	Typ.	Max.	Unit
AC Performance					
Gain Bandwidth Product	C_L = 50pF, R_L = 2kΩ to V_S/2		1.4		MHz
Phase Margin			73		deg
Gain Margin			12		dB
Slew Rate			1.5		V/µs
Input Voltage Noise	>50kHz		33		nV/√Hz
Crosstalk: LMV358	100kHz		91		dB
LMV324	100kHz		80		dB
DC Performance					
Input Offset Voltage[1]			1	7	mV
Average Drift			6		µV/°C
Input Bias Current[2]			<1		nA
Input Offset Current[2]			<1		nA
Power Supply Rejection Ratio[1]	DC	50	65		dB
Open Loop Gain[1]		50	70		dB
Supply Current (Per Channel)[1]			100	150	µA
Input Characteristics					
Input Common Mode Voltage Range[1]	LO	0	-0.4		V
	HI		3.8	3.6	V
Common Mode Rejection Ratio[1]		50	75		dB
Output Characteristics					
Output Voltage Swing	R_L = 2kΩ to V_S/2; LO/HI		0.036 to 4.95		V
	R_L = 10kΩ to V_S/2; LO[1]	0.1	0.013		V
	R_L = 10kΩ to V_S/2; HI[1]		4.98	4.9	V
Short Circuit Output Current[1]	sourcing; V_O = 0V	5	+34		mA
	sinking; V_O = 5V	10	-23		mA

Min/max ratings are based on product characterization and simulation. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

Notes:

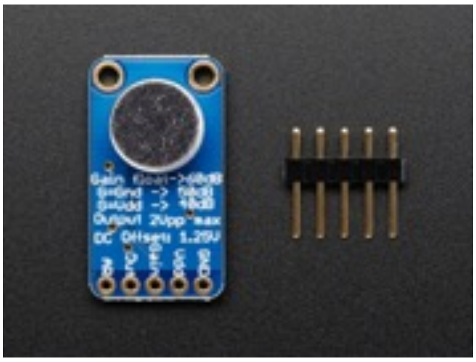
1. Guaranteed by testing or statistical analysis at +25°C.
2. +IN and -IN are gates to CMOS transistors with typical input bias current of <1nA. CMOS leakage is too small to practically measure.

Package Thermal Resistance

Package	θ_{JA}
5 lead SC70	331.4°C/W
5 lead SOT23	256°C/W
8 lead SOIC	152°C/W
8 lead MSOP	206°C/W
14 lead SOIC	88°C/W

Electret Microphone Amplifier - MAX9814 with Auto Gain Control

Board comes with a 20-20KHz electret microphone soldered on. For the amplification, they use the Maxim MAX9814, a specialty chip that is designed for amplifying electret microphones in situations where the loudness of the audio isn't predictable.



The AGC in the amplifier means that nearby 'loud' sounds will be quieted so they don't overwhelm & 'clip' the amplifier, and even quiet, far-away sounds will be amplified. This amplifier is great for when you want to record or detect audio in a setting where levels change and you don't want to have to tweak the amplifier gain all the time.

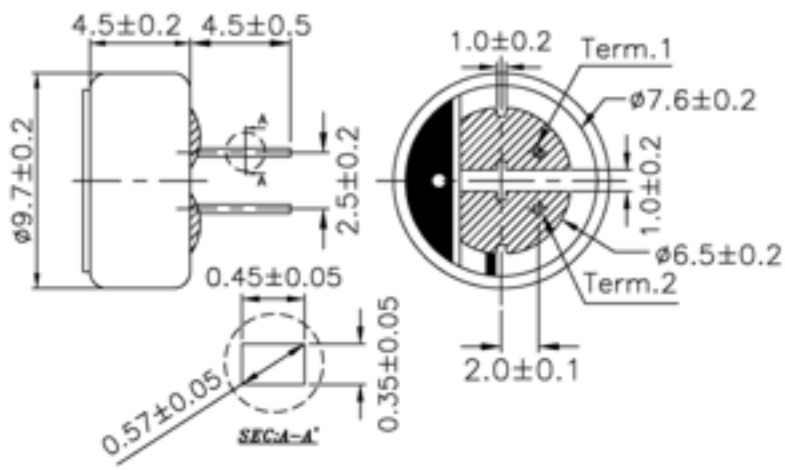
PART NUMBER: CMA-4544PF-W **DESCRIPTION:** electret condenser microphone

SPECIFICATIONS

directivity	omnidirectional	
sensitivity (S)	-44 ±2 dB	f = 1KHz, 1Pa 0dB = 1V/Pa
sensitivity reduction (ΔS-Vs)	-3 dB	f = 1KHz, 1Pa Vs = 3.0 ~ 2.0 V dc
operating voltage	3 V dc (standard), 10 V dc (max.)	
output impedance (Zout)	2.2 KΩ	f = 1KHz, 1Pa
operating frequency (f)	20 ~ 20,000 Hz	
current consumption (IDSS)	0.5 mA max.	Vs = 3.0 V dc RL = 2.2KΩ
signal to noise ratio (S/N)	60 dBA	f = 1KHz, 1Pa A-weighted
operating temperature	-20 ~ +70° C	
storage temperature	-20 ~ +70° C	
dimensions	ø9.7 x 4.5 mm	
weight	0.80 g max.	
material	Al	
terminal	pin type (hand soldering only)	
RoHS	yes	

note: We use the "Pascal (Pa)" indication of sensitivity as per the recomendation of I.E.C. (International Electrotechnical Commission). The sensitivity of "Pa" will increase 20dB compared to the "ubar" indication. Example: -60dB (0dB = 1V/ubar) = -40dB (1V/Pa)

APPEARANCE DRAWING



EVALUATION KIT AVAILABLE

MAX9814

Microphone Amplifier with AGC and Low-Noise Microphone Bias

General Description

The MAX9814 is a low-cost, high-quality microphone amplifier with automatic gain control (AGC) and low-noise microphone bias. The device features a low-noise preamplifier, variable gain amplifier (VGA), output amplifier, microphone-bias-voltage generator and AGC control circuitry.

The low-noise preamplifier has a fixed 12dB gain, while the VGA gain automatically adjusts from 20dB to 0dB, depending on the output voltage and the AGC threshold. The output amplifier offers selectable gains of 8dB, 18dB, and 28dB. With no compression, the cascade of the amplifiers results in an overall gain of 40dB, 50dB, or 60dB. A trilevel digital input programs the output amplifier gain. An external resistive divider controls the AGC threshold and a single capacitor programs the attack/release times. A trilevel digital input programs the ratio of attack-to-release time. The hold time of the AGC is fixed at 30ms. The low-noise microphone-bias-voltage generator can bias most electret microphones.

The MAX9814 is available in the space-saving, 14-pin TDFN package. This device is specified over the -40°C to +85°C extended temperature range.

Applications

- Digital Still Cameras
- Digital Video Cameras
- PDAs
- Bluetooth Headsets
- Entertainment Systems (e.g., Karaoke)
- Two-Way Communicators
- High-Quality Portable Recorders
- IP Phones/Telephone Conferencing

Features

- ♦ Automatic Gain Control (AGC)
- ♦ Three Gain Settings (40dB, 50dB, 60dB)
- ♦ Programmable Attack Time
- ♦ Programmable Attack and Release Ratio
- ♦ 2.7V to 5.5V Supply Voltage Range
- ♦ Low Input-Referred Noise Density of $30nV/\sqrt{Hz}$
- ♦ Low THD: 0.04% (typ)
- ♦ Low-Power Shutdown Mode
- ♦ Internal Low-Noise Microphone Bias, 2V
- ♦ Available in the Space-Saving, 14-Pin TDFN (3mm x 3mm) Package
- ♦ -40°C to +85°C Extended Temperature Range

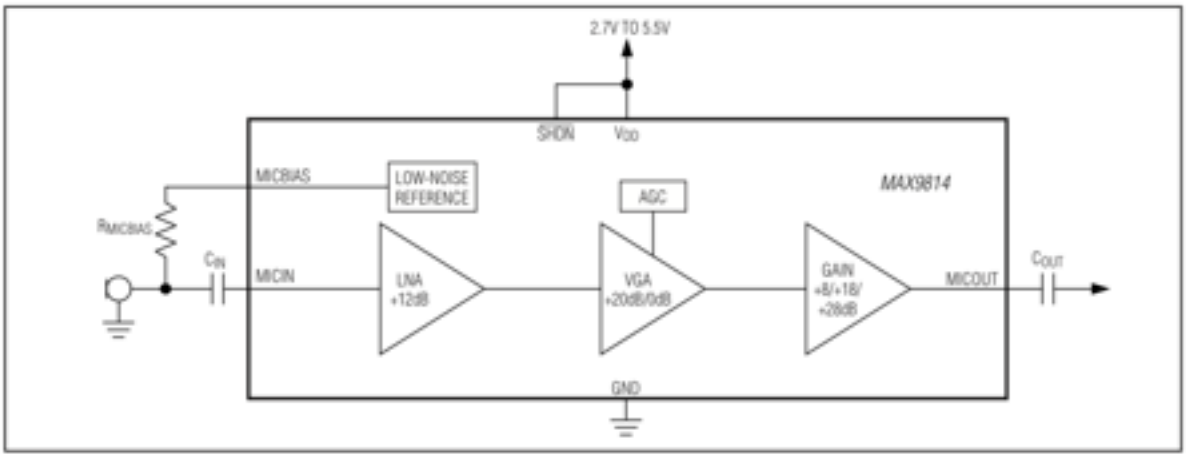
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX9814ETD+T	-40°C to +85°C	14 TDFN-EP*

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.
**EP = Exposed pad.*

Pin Configurations appear at end of data sheet.

Simplified Block Diagram



MAX9814

Microphone Amplifier with AGC and Low-Noise Microphone Bias

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND ....-0.3V to +6V
All Other Pins to GND ....-0.3V to (V_{DD} + 0.3V)
Output Short-Circuit Duration ....Continuous
Continuous Current (MICOUT, MICBIAS) ....±100mA
All Other Pins ....±20mA

Continuous Power Dissipation (T_A = +70°C)
14-Pin TDFN-EP
(derate 16.7mW/°C above +70°C) 1481.5mW
Operating Temperature Range ....-40°C to +85°C
Junction Temperature ....+150°C
Lead Temperature (soldering, 10s) ....+300°C
Bump Temperature (soldering) Reflow ....+235°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{DD} = 3.3V, $\overline{SHDN}$ = V_{DD}, C_{CT} = 470nF, C_{CG} = 2µF, GAIN = V_{DD}, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
GENERAL						
Operating Voltage	V_{DD}	Guaranteed by PSRR test	2.7		5.5	V
Supply Current	I_{DD}			3.1	6	mA
Shutdown Supply Current	$I_{\overline{SHDN}}$			0.01	1	µA
Input-Referred Noise Density	e_n	BW = 20kHz, all gain settings		30		nV/√Hz
Output Noise		BW = 20kHz		430		µV$_{RMS}$
Signal-to-Noise Ratio	SNR	BW = 22Hz to 22kHz (500mV$_{RMS}$ output signal)		61		dB
		A-weighted		64		
Dynamic Range	DR	(Note 2)		60		dB
Total Harmonic Distortion Plus Noise	THD+N	f_{IN} = 1kHz, BW = 20Hz to 20kHz, R_L = 10kΩ, V_{TH} = 1V (threshold = 2V_{P-P}), V_{IN} = 0.5mV$_{RMS}$, V_{CT} = 0V		0.04		%
		f_{IN} = 1kHz, BW = 20Hz to 20kHz, R_L = 10kΩ, V_{TH} = 0.1V (threshold = 200mV$_{P-P}$), V_{IN} = 30mV$_{RMS}$, V_{CT} = 2V		0.2		
Amplifier Input BIAS	V_{IN}		1.14	1.23	1.32	V
Maximum Input Voltage	V_{IN_MAX}	1% THD		100		mV$_{P-P}$
Input Impedance	Z_{IN}			100		kΩ
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	
Maximum Output Level	V_{OUT_RMS}	1% THD+N, V_{TH} = MICBIAS		0.707		V_{RMS}
Regulated Output Level		AGC enabled, V_{TH} = 0.7V	1.26	1.40	1.54	V_{P-P}
AGC Attack Time	t_{ATTACK}	C_{CT} = 470nF (Note 3)		1.1		ms
Attack/Release Ratio	A/R	A/R = GND		1:500		ms/ms
		A/R = V_{DD}		1:2000		
		A/R = unconnected		1:4000		

ELECTRICAL CHARACTERISTICS (continued)

(V_{DD} = 3.3V, $\overline{SHDN}$ = V_{DD}, C_{CT} = 470nF, C_{CG} = 2µF, GAIN = V_{DD}, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
MICOUT High Output Voltage	V_{OH}	I_{OUT} sourcing 1mA		2.45		V
MICOUT Low Output Voltage	V_{OL}	I_{OUT} sinking 1mA		3		mV
MICOUT Bias		MICOUT unconnected	1.14	1.23	1.32	V
Output Impedance	Z_{OUT}			50		Ω
Minimum Resistive Load	R_{LOAD_MIN}			5		kΩ
Maximum Capacitive Drive	C_{LOAD_MAX}			200		pF
Maximum Output Current	I_{OUT_MAX}	1% THD, R_L = 500Ω		1	2	mA
Output Short-Circuit Current	I_{SC}		3	8		mA
Power-Supply Rejection Ratio	PSRR	AGC mode; V_{DD} = 2.7V to 5.5V (Note 4)	35	50		dB
		f = 217Hz, V_{RIPPLE} = 100mV_{P-P} (Note 5)		55		
		f = 1kHz, V_{RIPPLE} = 100mV_{P-P} (Note 5)		52.5		
		f = 10kHz, V_{RIPPLE} = 100mV_{P-P} (Note 5)		43		
MICROPHONE BIAS						
Microphone Bias Voltage	$V_{MICBIAS}$	$I_{MICBIAS}$ = 0.5mA	1.84	2.0	2.18	V
Output Resistance	$R_{MICBIAS}$	$I_{MICBIAS}$ = 1mA		1		Ω
Output Noise Voltage	$V_{MICBIAS\_NOISE}$	$I_{MICBIAS}$ = 0.5mA, BW = 22Hz to 22kHz		5.5		µV_{RMS}
Power-Supply Rejection Ratio	PSRR	DC, V_{DD} = 2.7V to 5.5V	70	80		dB
		$I_{MICBIAS}$ = 0.5mA, V_{RIPPLE} = 100mV_{P-P}, f_{IN} = 1kHz		71		
TRILEVEL INPUTS (A/R, GAIN)						
Tri-Level Input Leakage Current		A/R or GAIN = V_{DD}	0.5V_{DD} / 180kΩ	0.5V_{DD} / 100kΩ	0.5V_{DD} / 50kΩ	mA
		A/R or GAIN = GND	0.5V_{DD} / 180kΩ	0.5V_{DD} / 100kΩ	0.5V_{DD} / 50kΩ	
Input High Voltage	V_{IH}		V_{DD} x 0.7			V
Input Low Voltage	V_{IL}				V_{DD} x 0.3	V
Shutdown Enable Time	t_{ON}			60		ms
Shutdown Disable Time	t_{OFF}			40		ms
DIGITAL INPUT ($\overline{SHDN}$)						
$\overline{SHDN}$ Input Leakage Current			-1		+1	µA
Input High Voltage	V_{IH}		1.3			V
Input Low Voltage	V_{IL}				0.5	V
AGC THRESHOLD INPUT (TH)						
TH Input Leakage Current			-1		+1	µA

Note 1: Devices are production tested at T_A = +25°C. Limits over temperature are guaranteed by design.
Note 2: Dynamic range is calculated using the EIAJ method. The input is applied at -60dBFS (0.707µV_{RMS}), f_{IN} = 1kHz.
Note 3: Attack time measured as time from AGC trigger to gain reaching 90% of its final value.
Note 4: CG is connected to an external DC voltage source, and adjusted until V_{MICOUT} = 1.23V.
Note 5: CG connected to GND with 2.2µF.

Motor

Servo - Generic High Torque Full Rotation
ROB-09347 is able to take in 6 volts and deliver 66.7 oz-in. of maximum torque at 70 r/min.

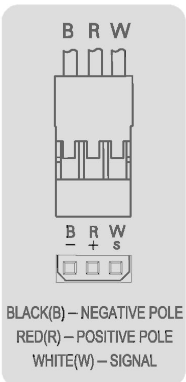
A standard 3-pin power and control cable is attached.

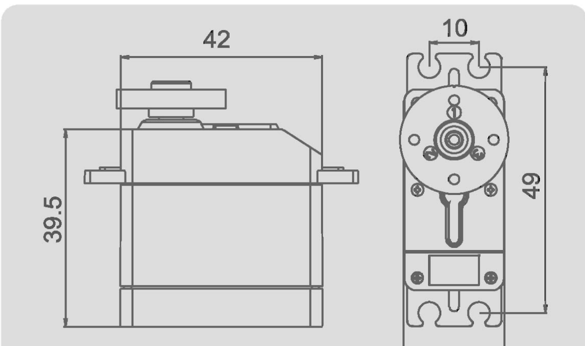
43R Servo(360° Rotation) Specification

Thank you for choosing Spring Model's product

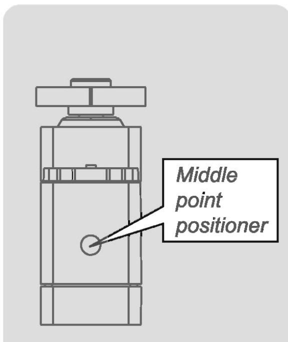
MODEL	TYPE	WEIGHT		4.8V			6V			DESCRIPTION	
		g	oz	SPEED r/min	TORQUE kg.cm	TORQUE oz.in	SPEED r/min	TORQUE kg.cm	TORQUE oz.in	GEAR	BEARING
SM-S4303R	Analog	44	1.55	60	3.3	45.8	70	4.8	66.7	1Metal Gear+ 4Plastic Gear	2
SM-S4306R		44	1.55	60	5.0	69.4	50	6.2	86.1	1Metal Gear+ 4Plastic Gear	2
SM-S4309R		60	2.12	58	7.9	109.7	49	8.7	120.8	Metal Gear	2
SM-S4315R		60	2.12	62	14.5	201.4	53	15.4	213.9	Metal Gear	2

▲ 43R Robot series servo controled via analog signal(PWM),stopped via middle point positiner.
▲ Standard interface(like JR)with 30cm wire.
▲ Rotation and Rest Point Adjustment:when analog signal inputs,servo chooses orientation according to impulse width.when intermediatevalue of impluse width is above 1.5ms, servo is clockwise rotation,conversely,anticlockwise.Rest point need use slotted screwdriver to adjust the positioner carefully.Servo stopped rotation when the input signal is equivalent to impluse width.
▲ Please choose correct model for your application.
Caution: Torque over-loaded will damage the servo's mechanism.
▲ Keep the servo clean and away from dust, corrosive gas and humid air.
▲ Without further notification when some parameters slightly amend for improving quality.



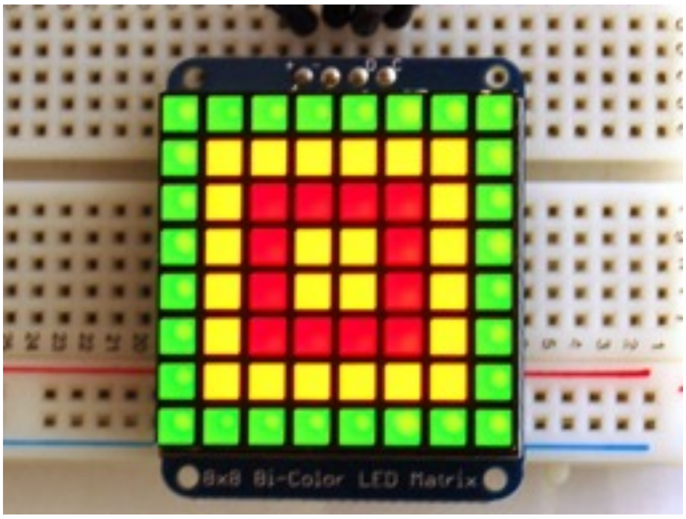


Dimension（Unit：mm）



Rest Point Adjustment

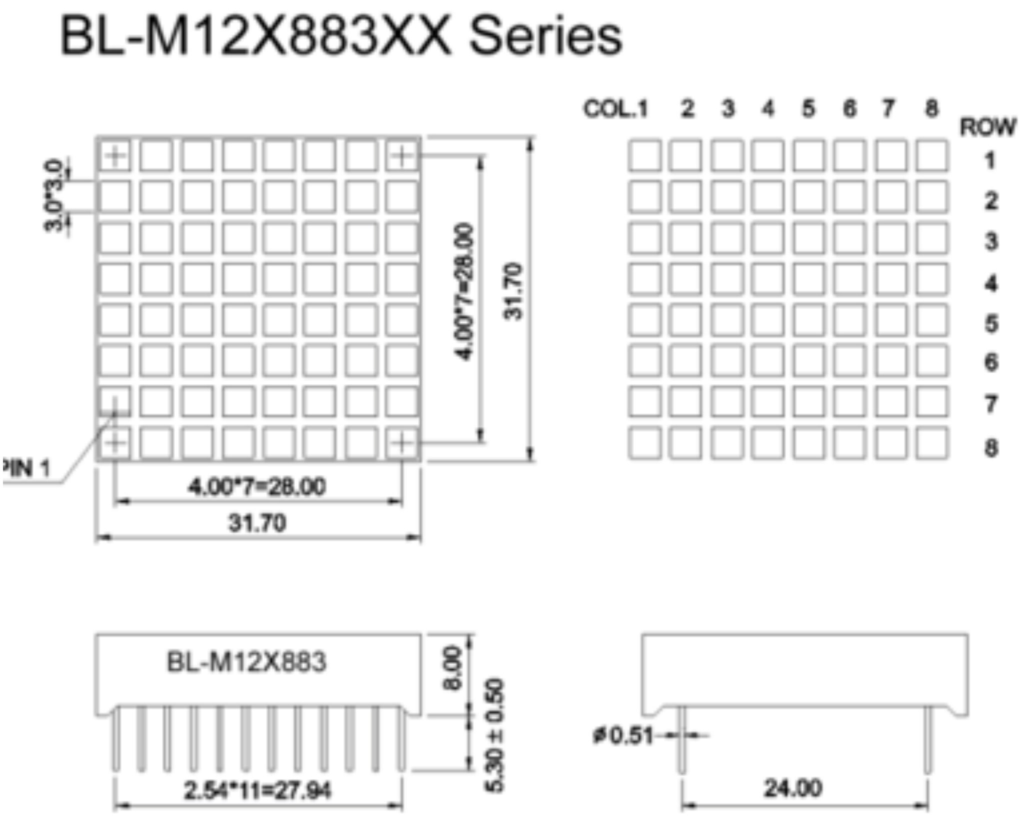
LED



The matrices use a driver chip that does all the heavy lifting for me : They have a built in clock so they multiplex the display.

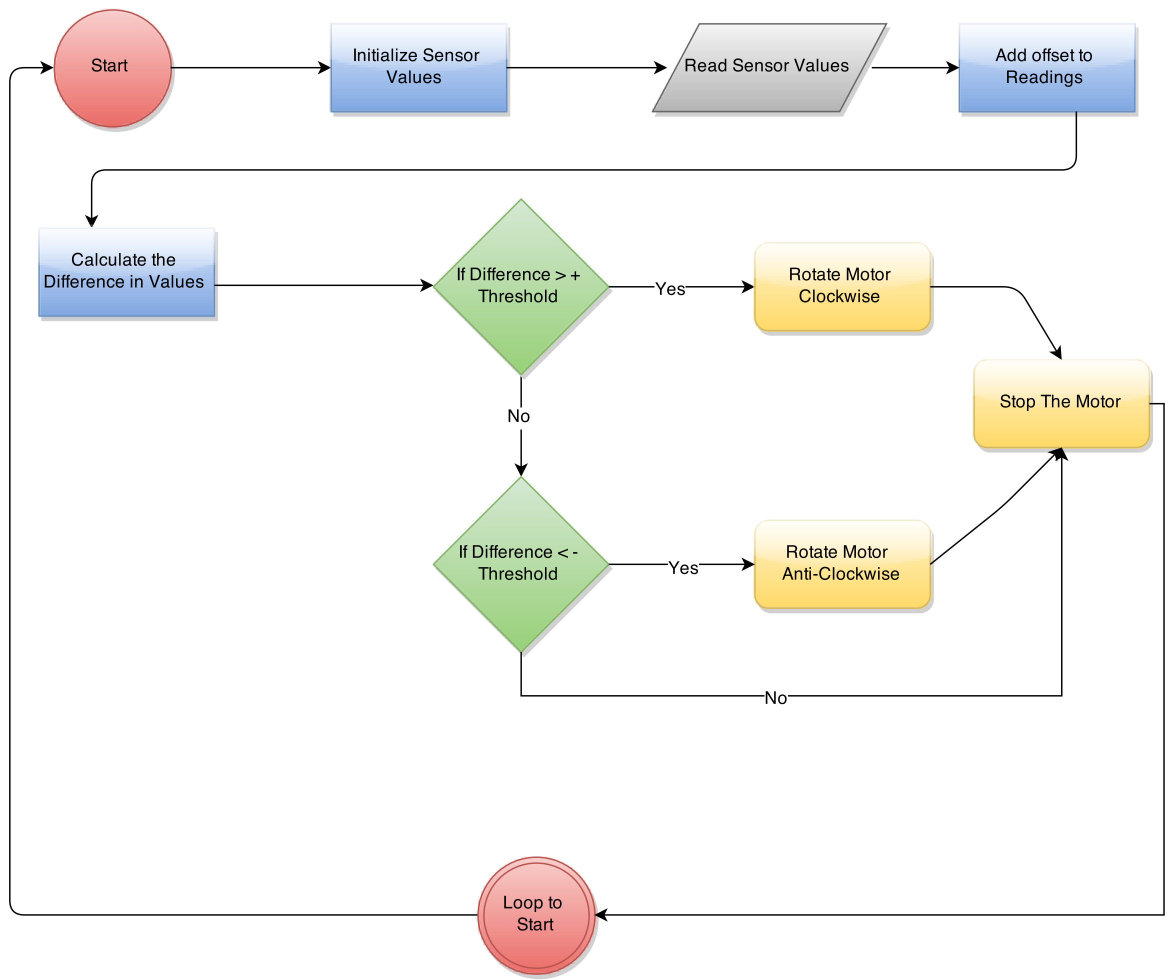
They use constant-current drivers for ultra-bright, consistent color, 1/16 step display dimming, all via a simple I2C interface.

The backpacks come with address-selection jumpers so i can connect up to four mini 8x8's or eight 7-segments/bicolor on a single I2C bus.



2.2 Algorithms

2.2.1 Main Program

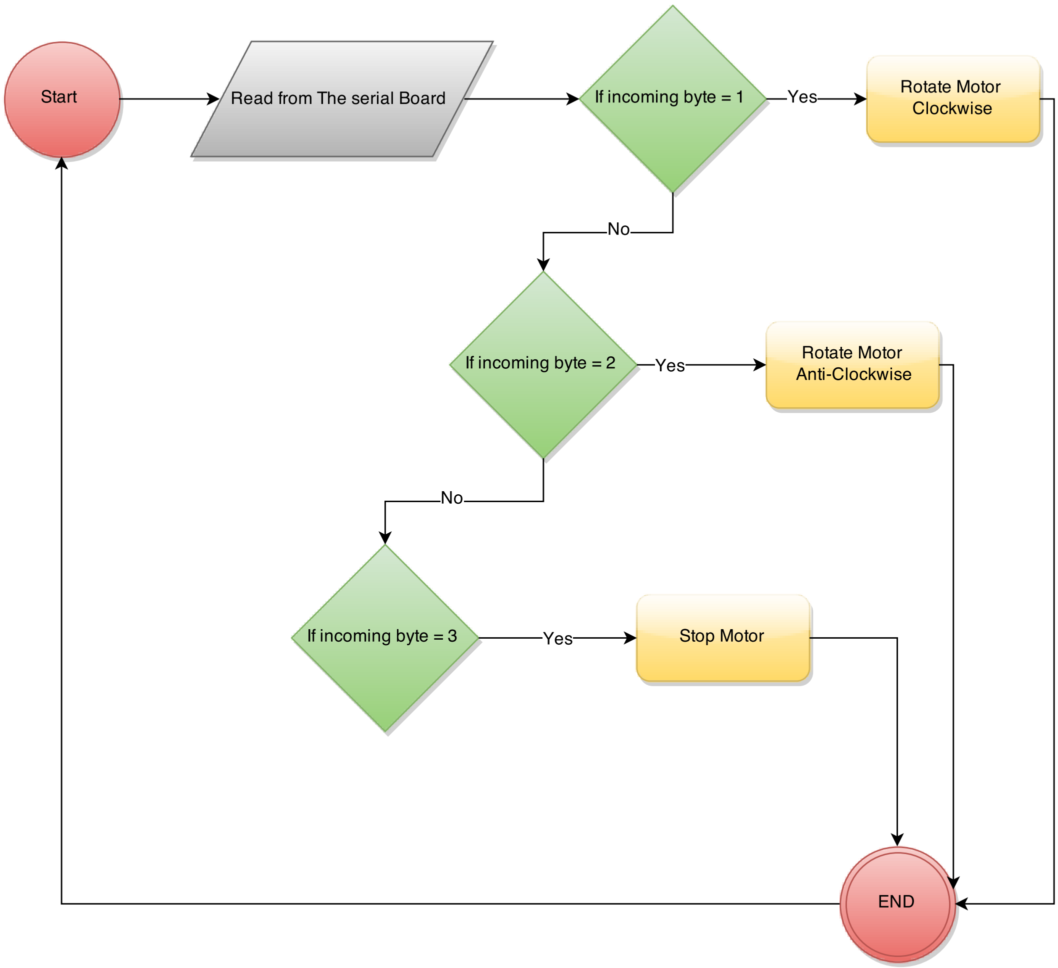


Description:

- First off, initialize the sensor values, then read the values from the sensors and add the offset which was determined during experimenting.
- Calculate the difference in two values.
- If difference larger than positive threshold amplitude rotate the motor clock wise then stop the motor.
- Else if difference is smaller than the negative threshold amplitude rotate the motor anti-clockwise the stop the motor.
- Else stop the motor.
- Loop back to start.

2.2.2 Processing and Arduino Communication to Control Servo

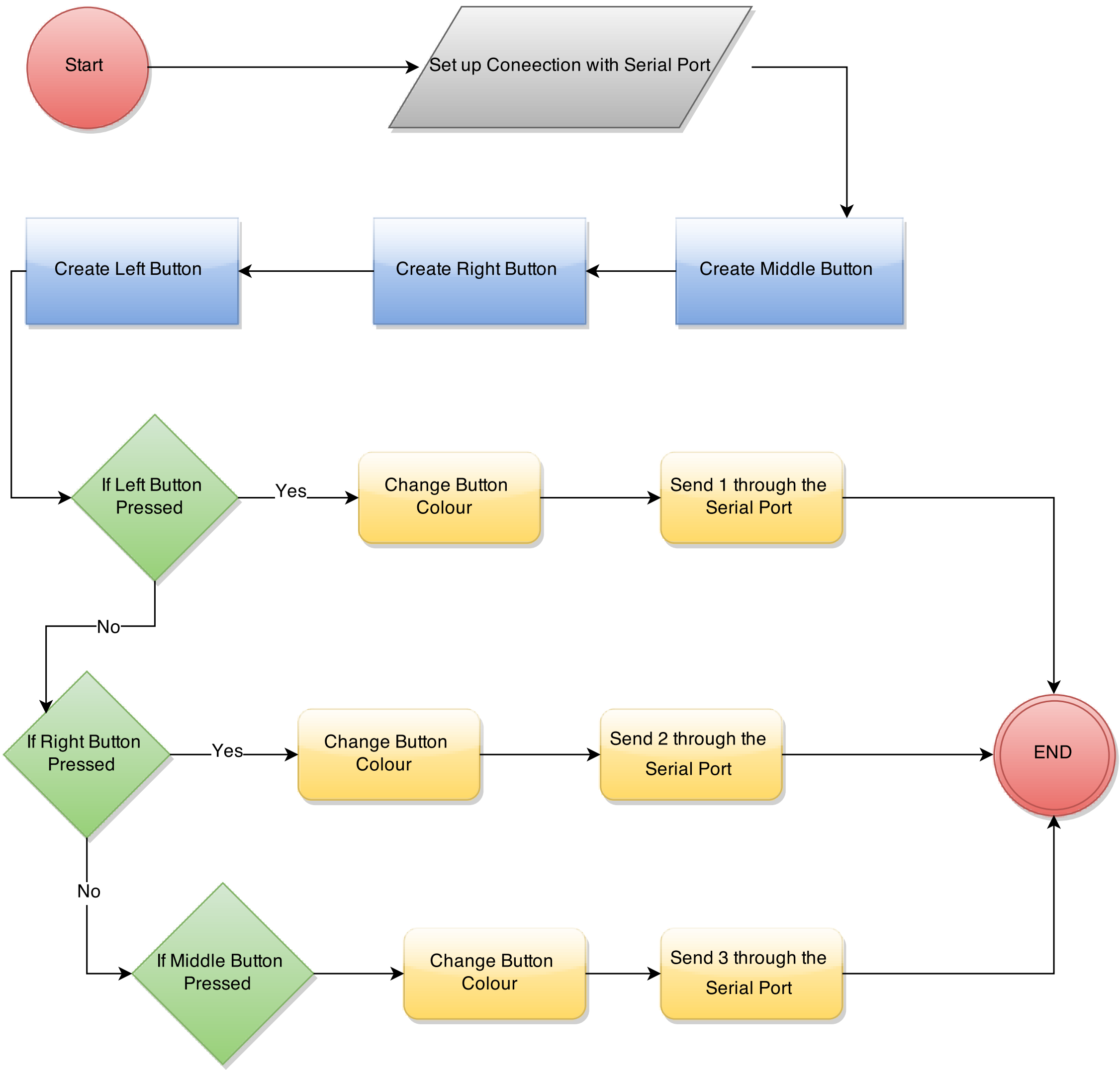
Arduino



Description:

- Read the Byte that is being send from processing through serial port.
- If the byte is 1, rotate the motor Clockwise.
- Else if the byte incoming is 2 rotate the motor Anti-Clockwise.
- Else if the byte incoming is 3 stop the motor.

Processing

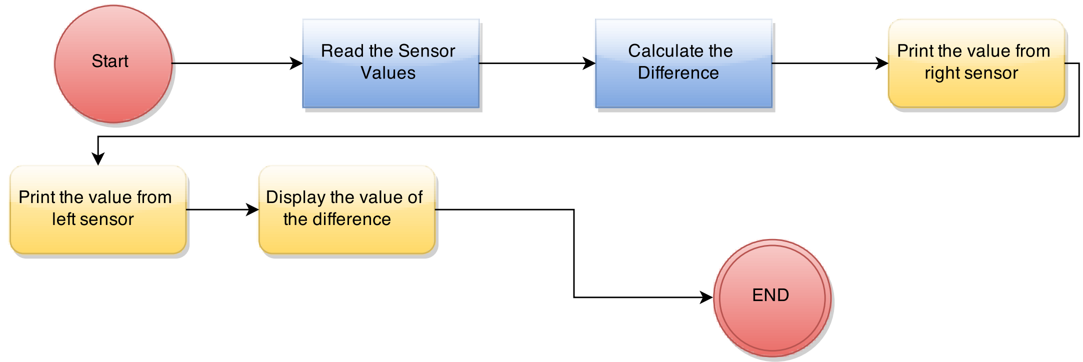


Description:

- Set up the connection with the proper serial port.
- Create a middle Button.
- Create a right Button.
- Create a left Button.
- If left button pressed,change the colour of the button to indicate that it was pressed , send 1 through the Serial Port.
- If right button pressed,change the colour of the button to indicate that it was pressed , send 2 through the Serial Port.
- If middle button pressed,change the colour of the button to indicate that it was pressed , send 3 through the Serial Port.

2.2.3 Processing Graphing for Sound Sensor(s)

2.2.4 Displaying sensor values and their Difference



Description:

- Read the values of right sensor and left.
- Calculate their difference.
- Print the value from the right sensor
- Print the value from the left sensor
- Print the difference of the values.

2.3 Test Strategy

Hedwig has three interfaces that need to be tested, one of them is the graphing interface, the other the servo control through processing and lastly the sound localisation.

Interface Testing

The interface must be tested to ensure that it can be correctly navigated by the end user and that each option it presents, when selected, does as it says.

2.3.1 Main Program

This testing is to ensure that the user can interact with the OWL as intended. When performing these tests the tester must move in all possible directions and distances.

Statement	Expected Result	Result Met
Sound source is being faced	Motor not moving	
Sound source is on the left side	Motor rotates Clockwise	
Sound source is on the right side	Motor rotates Anti-clockwise	
Sound source far away	The motor will not move	

2.3.2 Arduino and Processing Servo Control

This testing ensured that when the button is pressed the selected function is activated if it is intended to and nothing happens if not. If it was intended to perform a function then i t must perform the correct function

Statement	Expected Result	Result Met
When Right box pressed	The servo moves Clockwise	
When Left box pressed	The servo moves Anti-Clockwise	
When Middle box pressed	The servo Stops	
At the start of the program	The servo Stops.	

2.3.3 Processing Graphing

Statement	Expected Result	Result Met
Silence	The graph is a straight horizontal line	
Clap	The Graphs peak should increase rapidly and then decrease	
Continuous loud sound	The graph is a unsteady horizontal line	
Speaking	The graph should change unsteadily	

2.3.4 Arduino Sensor LED

Statement	Expected Result	Result Met
Silence	none of the LEDs lit	
Clap	LEDs should reach the middle	
Speaking	LEDs must alternate between yellow and green	
Very Loud	The peak should reach the RED LEDs	

2.3.5 User Acceptance Testing

The user acceptance testing is performed by questionnaire style where the person performing the questionnaire circles a number from one to five showing how strongly they agree to the statement.

They are then asked to answer some general questions about how they rate the product.

Rating the End Product

Statement	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
Hedwig performs to my expectations.	1	2	3	4	5
I am happy to use Hedwig in the setting that i intended it.	1	2	3	4	5
Hedwig is aesthetically pleasing	1	2	3	4	5
Hedwig meets the Design specification	1	2	3	4	5
Hedwig meets the Requirement specification	1	2	3	4	5
I found Hedwig easy to use.	1	2	3	4	5
I was amused by Hedwig.	1	2	3	4	5

General Questions

What pleases you about Hedwig ?

What displeases you about Hedwig ?

Did Hedwig fail to meet any of your expectations and if so, which ones?

What pleases you about Hedwig ?

Chapter 3

Software Development and Testing

3.1 Alpha Testing

3.2 Source Code

3.3 Testing

Chapter 4

Evaluation

4.1 Meeting the Objectives

4.1.1 User Requirements

4.1.2 Hardware Requirement

4.2 Software Requirement

4.3 Desirable Extensions