NTNU

Institutt for elektrofag og fornybar energi

Bacheloroppgave

Oppgavens tittel: Colorophone – Et bærbart sensorisk substitusjons system **Project tittle:** Colorophone – A Wearable Sensory Substitution System	**Gitt dato:** 04.01.2016 **Innlevingsdato:** 31.05.2016 **Antall sider/bilag** 55 sider + 98 sider vedlegg
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Fritt tilgjengelig ☐

Tilgjengelig etter avtale med oppdragsgiver ☐

Rapporten frigitt etter ☐

Preface

This report was created to set a basis for completing the bachelor thesis Colorophone. Our employer is Dominik Osinski at the Norwegian University of Science and Technology (NTNU). Together we have come up with a task that should be manageable but at the same time challenging enough that we can test our academic knowledge.

The reason for this report is to enlighten our problem and show how the project was accomplished. The project goal is to make a system that is going to help blind people sense color through sound. We will also implement a proximity sensor that will help blind people estimate the distance to an object. The reason for this project is to create a basis for a continued research within this subject.

The language we decided to write this project in was English. The main reason for this was so that the group could practice writing reports in English. Since there are many engineering companies where the main language is English, writing this project in English would be a great practice for the group. Other reason for doing this rapport in English is so that if our employer want to show this report to anyone, the reader would not be in the need of a translator.

Our bachelor group consists of four industrial instrumentation students from NTNU: Jørgen Kopstad, Kawan Kandili, Sindre Bjørvik and Edwin de Pano. The project started 04.01.16 and was completed 31.05.16.

We would like to give a special thanks to Dominik Osinski for extraordinary help and guidance. This project would not have been possible if we did not have such an enthusiastic person and available 24/7. We would also thank Øystein Røysi for being our real blind test person.

Summary

This report creates a basis on the approach the group have taken to create a fully functional prototype of Colorophone. According to the projects guidelines we have created a functional sensory substitution system for the visually impaired. The prototype consists of a camera, ultrasonic proximity sensor and bone conducting headphones. The camera and the proximity sensor gather data that is processed and sent to the bone conducting headphones. We have ended up with two versions of Colorophone. One that uses a tablet, and another that uses myRIO.

The data from the camera we are interested in are the red, green and blue (RGB) values. In the program Colorophone, there are three signal generators, one for each RGB component. There is also one white noise generator which will fill in noise for the lowest RGB value. The RGB values will decide the intensity on each of the three waveforms that is generated and the noise level.

The data from the proximity sensor is a varied voltage. This data is converted in to frequency so the data can be picked up through the microphone input on the camera. To do this, we have built a small voltage to frequency converter (VFC). The proximity sensor has only been implemented on the tablet version of Colorophone, since we could not find a way to collect the data with a myRIO.

The system consists of several components which need to be powered in some way. These components are: camera, proximity sensor, VFC and bone conducting headphones. The camera is powered through a USB cable. The proximity sensor and the VFC is powered through the camera. The bone conducting headphones are powered on their own.

Oppsumering

Denne rapporten skal sette et grunnlag for hvordan gruppen har valgt å løse oppgaven. I følge rettningslinjene i prosjektet skal vi lage et funsjonelt sensor substitusjon system for synshemmede. Prototypen består av et kamera, ultrasonisk avstands sensor, og benledende hodetelefoner. Kameraet og avstands sensoren samler data som blir prossesert og sendt videre til de benledende hodetelefonene. Vi endte opp med to versjoner av Colorophone. En for tablet, og en annen for myRIO.

Dataene fra kameraet som vi er interessert i er de rød, grønn og blåe verdiene. I programmet Colorophone er det tre signal generatorer, en for hver RGB komponent. Det er også en hvit støy generator som fyller inn støy for den laveste RGB verdien. RGB verdiene will bestemme intensiteten for hvert av signalene som er generert og støy nivå.

Dataen fra avstands sensoren er en variert spenning. Denne dataen blir konvertert til frekvens slik at dataen kan bli tatt i mot gjennom mikrofon inngangen på kameraet. For å gjøre dette, har vi laget en liten spenning til frekvens konverterer (VFC). Avstands sensoren har bare blitt implementert på tablet versjonen av Colorophone, siden we fant ingen måte å samle dataen med myRIO.

Systemet består av flere komponenter som trenger strøm på en eller annen måte. Disse komponentene er: kamera, avstands sensor, VFC og benledende hodetelefoner. Kameraet får strøm gjennom USB-kabelen. Avstands sensoren og VFC får strøm gjennom kameraet. Benledende hodetelefonene har eget batteri.

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Abbreviations

ABS	=	Acrylonitrile butadiene styrene
DAQ	=	Data acquisition
ELVIS	=	Educational laboratory virtual instrumentation suite
FPGA	=	Field programmable gate array
NI	=	National instruments
PCB	=	Printed circuit board
PLA	=	Polylactic acid
RIO	=	Reconfigurable I/O (Input/Output)
VFC	=	Voltage to frequency converter

1 | Introduction

Background

In 2013, there were an estimate of 40 million blind people worldwide. Today, the number has grown to approximately 60 million. Many companies around the world are today trying to find new solutions to help blind people. The simplest and cheapest tool that can help blind people today is the white cane. Dogs are also very helpful but take a lot of time and money to train. In addition, the product that many companies makes can cost a lot of money and aim mostly towards shapes. Even though these are very helpful tools to a blind person there are still no effective tools that will help them to feel colors.

Sensing colors through sound have been a problem many scientists have tried to solve. "Isac Newton the creator of color theory" [1] says that even Sir Isaac Newton has his own theory of how to substitute colors with sound. Newton meant that there were five primary colors: red, yellow, green, blue and violet. Later he decided to add orange and indigo, so that it would match up with the numbers of musical notes. These notes would then be mathced up with the colors.

Assignment

Colorophone – A Wearable Real-Time Sensory Substitution System. The main assignment for the project is to create, design and test a prototype that will work as a sensory substitution system. The system will convert color to sound, which will make it possible for the blind to hear colors. A camera, ultrasonic proximity sensor and bone-conducting headphones will be the main components implemented to the system.

- Choose a designing software to 3D design the glasses that will be used, afterwards produce the design on a 3D printer. (First with PLA, and ABS in the end).
- Choose a camera that is suitable for the system.
- Design a proximity measuring system that will use little space and work great
- Design a program that is easy to use.

The goal for the bachelor group is to get experience with programming, system designing, 3D designing, prototype developing and cooperation. The group will end up with a better understanding of both pros and cons of working in groups. Also understand how important it is to have a favorable plan and follow up, which is good to bring out in the work life.

Report structure

This report consists of 6 main chapters along with several sub-chapters:

- Chapter 1 Introduction
- Chapter 2 Sources and methods
- Chapter 3 Hardware
- Chapter 4 Software
- Chapter 5 Results
- Chapter 6 Conclusion

The challange

Today there are many blind people in the world. Today there are many blind people in the world. The most accesible and affordable aid they have today is the white cane. Blind people have used canes for centuries, which means that there are still no effective technology-based aid to help them. We have taken the challenge to create a system to help them in a new way. The system we are going to make will help them do everyday tasks. It will help them in color identification and room orientation.

Project Goals

As a result from completing the project, the group will have at least one fully functional prototype. The prototype will also set a new basis for further research of sensing colors. Further the group would like to be able to enter the National Instrument student competition and show the world that this has a potential to become something big.

The goal for the bachelor group is to get experience within project development and cooperation. It is important that the group will see the pros and cons about being in a group and that planning is highly prioritized. The group will also gain some technical experience like programming in NI LabVIEW, system design, 3D-design and prototype development. These are all valuable experiences that the group can bring with them when they go out in the corporate world.

Objectives

- Create at least one functional prototype.
- Implement a proximity sensor to the prototype.
- Add our own code to the given Colorophone code.
- Test and analyze the prototype.

Results And Sub-goals / Assignment

Colorophone – A Wearable Real-Time Sensory Substitution System. Our main task is to create a functional prototype of Colorophone that will help blind people sense colors through sound. To create the system we will be using equipment like a proximity sensor and a camera that the university will provide us.

The system we are going to make is going to detect which color the camera is looking at. It is also going to determine the distance to an obstacle with the help of a proximity sensor.

Main tasks:

- Design and build at least one functional prototype of Colorophone.
- Decide which camera and proximity sensor suits the project best.
- Find a way to run the code through NI myRIO.
- Test and evaluate the system.
- Design a website for Colorophone
- End up with three prototype that the testers will use.

At the start of the project, the employer Dominik Osinski decided to give the group a small task. The task was to experience what it is like to be blind. The group found a blindfold and a “white cane” to start experiencing blindness. The first task was to walk from the top floor to the bottom floor and buy a soda from the soda machine. The second task was to go outside and do some daily activities like walking to the store.

Limitations

When the project started the group realized that the goals might have been set to high. To begin with, the group wanted to create at least one functional prototype with a camera and a proximity sensor. This part is very important, as it is the base of the whole project.

The goals in the preliminary were set too high. The goals that were set were to create a functional prototype within a month. The group also wanted to implement other functions like beacons and eye tracking. Both beacons and eye tracking was not possible to imply since there were no time left to start on these functions.

2 | Sources And Methods

This chapter will be about the sources and methods that was used during the whole project. This chapter will also describe what knowledge the group brought in to this project. At the end of this chapter, the group will describe the varied tools and test methods used to test the system.

2.1 Colorophone

2.1.1 Colors

There are two ways of mixing colors to get a more varied span of colors: Subtractive color and additive color. In the subtractive color system, the main colors are cyan, magenta and yellow (CMY). Additive also have three main colors, red, blue and green. Painters mainly use subtractive colors; they add colors together to get the color they want. As you add more and more colors, you will end up with black. While in the computer world, the main method to get a color is the same as in the subtractive method. However, the difference here is that instead of ending up with black, you end up with white as you add all the main colors.

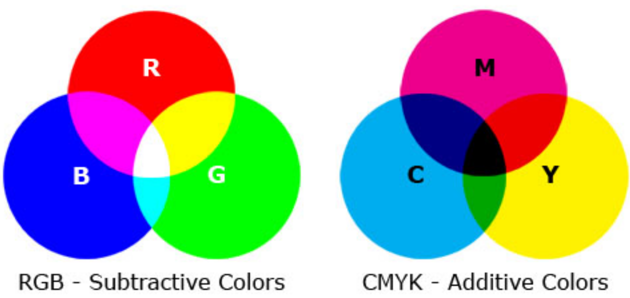

Figure 2.1: The RGB/CMYK colors

Before the project started, the group had no idea how the program Colorophone worked. Since Colorophone is something new that Dominik Osinski had come up with, the group had a short introduction of how the system worked. The way Colorophone works is that it generates three different frequencies. One for each color in the RGB system. The highest frequency is red, middle frequency is green and the lowest frequency is blue. This way, it is able to generate various numbers of color through sound.

2.1.2 Ultrasonic sensor

The only tool that blind people have today to determine the distance to an object is a white cane. While this is a great way to scan the road, it is a very limited way to determine the distance to an obstacle since it is only approximately one meter it can scan. The group would like to change that by implementing a proximity sensor.

To determine the distance to an object/obstacle, the group decided to implement an ultrasonic proximity sensor. This was something that the whole group had previous experience with, since it was a project in one of the earlier classes. The way that the ultrasonic proximity sensor works is that it sends out an ultrasonic sound, and when it hits an object, it sends it back to the sensor. When the sensor receives the echo, it produces a small voltage. This voltage varies depending on the distance to an object. The problem with this is that the output is a varied voltage. This voltage must be converted into a frequency before connecting it though the microphone.

2.1.3 Voltage-to-frequency converter

Voltage-to-frequency converter (VFC) consist of small chip (KA331) that converts voltage into frequency. To use this chip the group had to design a circuit board, since the chip is not able to work by its own. The reason a VFC was needed, was so that the data could be collected from the proximity sensor through the microphone input on the camera. The data that the proximity sensor provides is a varied voltage. This could not be handled by the microphone input, on the camera.

Before designing and milling a circuit board, testing it on a breadboard is always the best thing to do. The results from testing the circuit on the breadboard looked like it was missing a few peaks. The reason was that the sampling frequency was set too low. After changing the sampling frequency to the same sampling frequency as the standard computer have, which is 44000Hz, the signal started to look stable. After seeing that the signal looked stable, milling the circuit would be the next step.

Before connecting the VFC to the camera, it would be smart to use a voltmeter to measure the voltage on both the VFC and the camera. The reason we want to measure the voltage before connecting them together is to make sure that the camera can take the voltage from the VFC. Also before connecting the VFC to the camera, we soldered on an audio cable to the VFC to make sure that what comes out of the VFC looks good.

Figure 2.2, bottom graph shows the output data from the VFC. The bottom graph is the direct output from the VFC, while the graph over is a generated triangle pulse. The triangle pulse generated by a block in LabVIEW called “Simulate Signal”. The inputs to this block can either be a frequency, amplitude, phase or time. Since the output from the VFC is a varied frequency, we will use the frequency input on the “simulate Signal” block. The output on this block can either be a sine, square, triangle, sawtooth or noise. In figure 2.2, we can see that the simulated signal is a sawtooth signal. What we will hear on the audio output is ticking. The reason the group decided to choose a sawtooth signal, is that ticking interfere the least with the sound from colors.

Figure 2.2: Printscreen of VFC data and generated sawtooth signal

Table 2.1 shows what the tick frequency [ticks/min] will be, when changing the tick frequency scaling in the settings. Ticks/min 1, have a tick frequency scaling at 15. Ticks/min 2, have a tick frequency scaling at 14. Ticks/min 3, have a tick frequency scaling at -7.

The tick frequency scaling for ticks/min 3, was not a random test to see how it would sound. The tick frequency scaling was calculated by using a formula that the group came up with. See formula 2.1. The thought was that the ticks/min would be once every second at 1 meter. The group thought that this would be the most ideal tick frequency. However, from table 2.1 we are able to see that the tick frequency scaling was set too low, as it goes negative at a distance of 140 cm.

$$(14 + x + 3_{100cm}) * 6 = ticks/min \tag{2.1}$$

Where x equals the tick frequency scaling. 14 is a constant. The number 3 is also a constant but only at a distance of 100cm. This constant decreases with 3 for every 10cm. This means at 110cm, the constant would be zero, and at 90cm the constant would be 6.

Table 2.1: Tick frequency scaling

Distance [cm]	#found	Ticks/min 1	Ticks/min 2	Ticks/min 3
187	105	Starts ticking	Starts ticking	Starts ticking
180	100	48	42	-84
170	95	66	60	-66
160	90	84	78	-48
150	84	102	96	-30
140	78	120	114	-12
130	72	138	132	6
120	67	156	150	24
110	61	174	168	42
100	56	192	186	60
90	52	210	204	78
80	46	228	222	96
70	41	246	240	114
60	36	264	258	132
50	30	282	276	150
40	25	300	294	168
30	20	318	312	186
20	15	336	330	204
10	11	Stops ticking	Stops ticking	Stops ticking

By using formula 2.1 we are able to decide the ticks/min. If we want ticks/min to be 60 at a distance of 100cm, we can just set ticks/min equals 60 and do the calculations.

$$(14 + x + 3_{100cm}) * 6 = 60$$

$$x = \frac{60}{6} - 17$$

$$x = -7$$

If we set the tick frequency scaling to -7, we will get 60 ticks/min at 100cm.

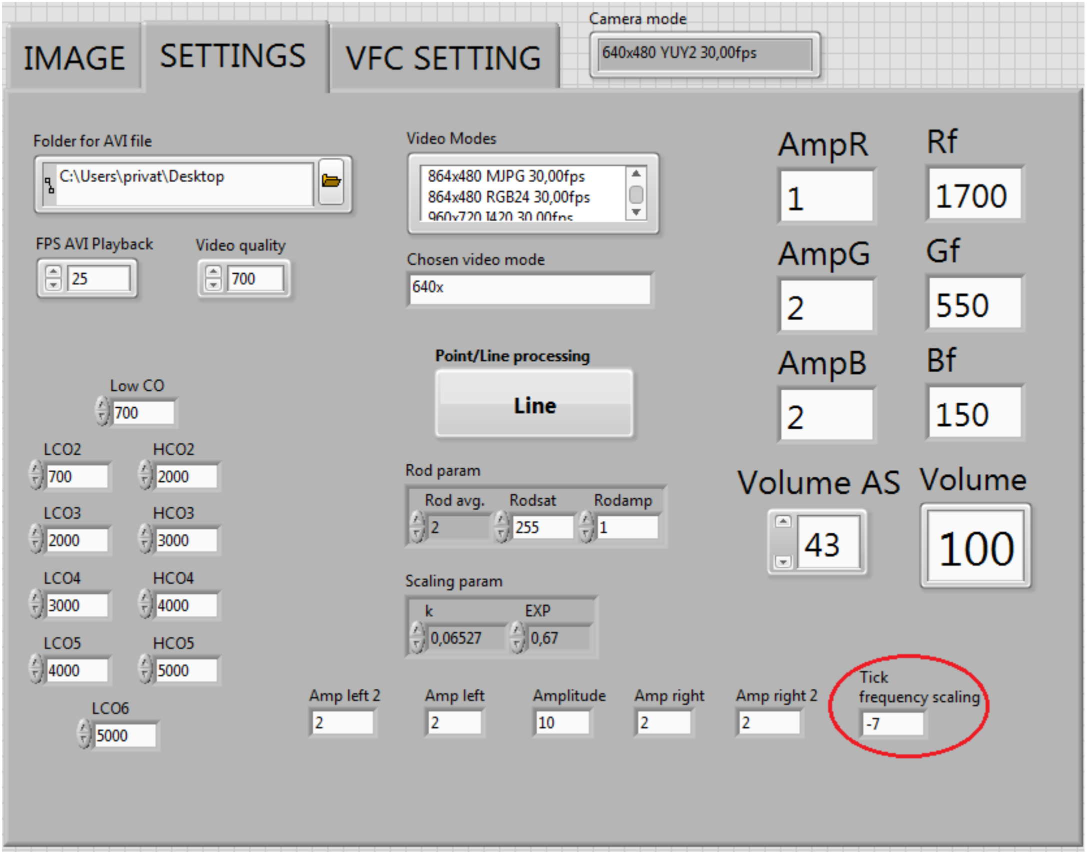

Figure 2.3: Colorophone v3.2 Settings

2.2 Software Tools

2.2.1 NI LabVIEW

The main software tool that the group used during this project was NI LabVIEW. LabVIEW is a platform-based program where you can do programming. Instead of the usual text based programming like in C++, java, python etc. LabVIEW programs by using graphical blocks. This makes programming much simpler since it enables the user to get a better overview of the program. Everyone on the group have taken C++ classes and done a little Arduino programming but everyone on the group agreed that programming in LabVIEW would be the easiest and best way to do this project.

2.2.2 SolidWorks

SOLIDWORKS is a computer assisted design program suited for creating 3D models. There was no one in the group with any knowledge about CAD programs before so some time was spent on researching which program to use. The assignment did not specify which 3D program to use. We chose SOLIDWOKRS because NTNU has a license, which meant we did not have to buy anything, and the program seemed easy to use. The person who got the 3D-design as his work package had to learn how the program worked. In addition, we had a 3D-printer at our disposal to bring the models to life. [2]

2.2.3 NI Multisim / Ultiboard

NI Multisim/Ultiboard is a program used to design circuit boards. The benefits of using this program is that it is easy to use and the group can easily get the program from NI's website or from any school computer at the university. All the members of the group have also a lot of experience on Multisim/Ultiboard from an earlier class, Applied Electronics. Compared to the amplifier everyone have designed, designing a circuit for VFC was no problem.

2.2.4 Weebly/ wix

Instead of creating the webpage for our project in HTML/PHP, Dominik said it would be fine to design the webpage on Weebly. Everyone on the group have experience in HTML/PHP from the first year. Since it has been a while since everyone have programmed in html/php it would be easiest if we used Weebly to create the webpage. Weebly and wix is easier to use if a basic website is good enough. That is the reason of changing from these programs to use real coding based website. www.colorophone.com

2.3 Hardware Evaluation

2.3.1 Battery for NI myRIO

At the start of the project, the code for Colorophone was running on a tablet. Instead of running the code through a tablet, we wanted to find a way to run the code through myRIO instead. There are many reasons for this. One of the reasons is so that all the equipment that run Colorophone is from NI. Another reason is so that the user is not obligated to carry a tablet everywhere they go.

To run a myRIO wireless, you will need a battery. Sadly, the myRIO does not have a battery included. Before ordering a battery for the myRIO, we will need to check the specifications for the myRIO. We cannot just order any battery. The battery that we ordered would also need a charger and a connector that fits the myRIO. Finding a charger for the myRIO was not a problem. Although finding the right connector to myRIO can be a small problem. Since no one on the group have any experience when it comes to power connectors, consulting an expert would be the best thing to do.

The last thing to think about is the capacity of the battery. How much capacity do we need? The capacity of the battery will determine how long the myRIO will live before it needs to be re-charged. Some simple calculations would be needed to decide how big the battery would need to be. Before we can start calculating, we will need to find out how much power the myRIO drains. This information is in the specifications for the myRIO.

myRIO specs. See attachment C.

- Max power consumption: 14.0 W
- Min power consumption: 2.6 W
- Power supply voltage range: 6 - 16 VDC

The power-supply-voltage-range varies between 6 and 16 VDC. The group decided to see what kind of battery other myRIO projects on the internet used to power the myRIO. 11.1 volt was the most used power supply voltage. [3]

Calculations for myRIO power-bank:

$$P = U * I \tag{2.2}$$

$$I = \frac{P}{U} \tag{2.3}$$

Battery capacity: 1400 mAh

Maximum power consumption:

$$\frac{14W}{11.1V} = 1.26A$$

Minimum power-consumption:

$$\frac{2.6W}{11.1V} = 0.234A$$

To determine how long the myRIO will live until it needs to be re-charged, we will just divide the battery capacity on the maxumim and minimum power-consumption.

Maximum power-consumption from myRIO will give:

$$\frac{1400mAh}{1260mA} = 1.11h$$

Minimum power-consumption from myRIO will give:

$$\frac{1400mAh}{0.234mA} = 5.98h$$

From the calculations above, we can see that the 1400mAh battery would not be good enough to run myRIO. Even if myRIO only consumed minimum power, myRIO would only live for 6 hours. To make sure that myRIO would live at least one whole day, finding a bigger battery would be best.

After a searching on the Internet for a battery with a bigger capacity, the group found a battery with a 5200mAh capacity. To make sure that this battery would be big enough, the group did the same calculations as above.

Battery capacity: 5200 mAh

The maximum and minimum power-consumption are constant and does not need to be calculated.

Maximum power-consumption: 1.26A

Minimum power-consumption: 0.234A

Again dividing the battery capacity on the maximum and minimum power-consumption:

Maximum power-consumption from myRIO will give:

$$\frac{5200mAh}{1260mA} = 4.12h$$

Minimum power-consumption from myRIO will give:

$$\frac{5200mAh}{0.234mA} = 22.2h$$

Even with a 5200mAh battery, myRIO would not last longer than 4.12 hours. This is only if myRIO consume maximum power. With a 5200mAh battery, it will also give approximately 22.22h with a minimum power consumption. Since it is not expected that myRIO would consume maximum power, a 5200mAh battery would be good enough. It would probably not consume minimum power either, but somewhere between, which should be good enough.

The group ended up with two different types of battery. Both are LiPo (Lithium-Polymer) batteries, but with different capacities. One of them are 5200mAh battery, and the other is a 2600mAh battery. It was ordered three of each type, since the goal is to end up with three functional prototypes. The reason a 2600mAh battery was ordered, was to see if it would last a day. If it did, then it would be a huge advantage to use of space. The 2600mAh battery is half the size of the 5600mAh.

2.3.2 Proximity Sensor

Choosing a proximity sensor for the system can be hard. There are many different types of proximity sensors. Since there are so many different types of sensors out there, we have decided to go with either an ultrasonic or an infrared sensor. From previous knowledge we can deduce that the infrared sensor does not meet our requirements.

2.4 How The System Was Assembled

Our goal is that the system would be a pair of glasses with a camera, speakers, proximity sensor and a voltage to frequency converter (VFC). To achieve that, the first thought was to give power to all the components. The camera would get the power from the tablet trough the USB cable. To power the other components, the plan was to attach a red and a black wire in the 4-pin input on the camera. The red wire would have the +5V input and the black wire would be ground, the attached wires would then be split, so the proximity sensor and the VFC would get one pair of black and red wires each.

When the system had granted power to all its components, it was time to set up the wiring for the signals. The proximity sensor would send a varied voltage to the VFC and then the VFC would convert the voltage to frequency and send the frequency values back to the microphone input on the camera. We used blue wires to connect the signal.

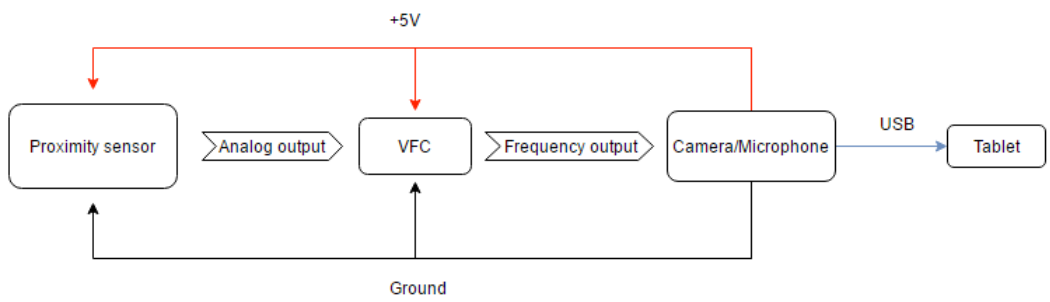

Figure 2.4: System overview

To get signal from the proximity sensor, one blue cable was soldered on the AN pin on the proximity sensor and then soldered to the AN pin on the VFC. To get the signal from the VFC to the tablet, the microphone inputs of the camera had to be used. One blue wire was soldered from the fout pin of the VFC to the microphone input pin, and another black wire was soldered from the ground of the VFC to the microphone ground. From the microphone input, the frequency signal would travel to the tablet through the USB cable.

When the camera, proximity sensor and the VFC was wired together, the system had to be tested. The first thing to test, was to see if the camera would connect to the computer. To see if the camera was connected, the standard Logitech driver program that was included was used. The next step was to start our LabVIEW program on the computer and check if any values from the camera and the proximity sensor could be monitored. If the values from the graphs of the LabVIEW program seemed reasonable, speakers were connected to the computer to see if the sound that came out made sense. When the group was pleased with the sound that came out, it was now time to assemble the system in the 3D printed glasses.

The 3D printed glasses had already a mounting rail for the camera and a hole to put the proximity sensor. The VFC did not have any mounting place, so the plan was to glue the VFC to the inside of the wall, silicon was used as glue. The wiring on the camera did not sit good enough, so zip-tie was used to release the wires from mechanical stress. When all the components and wires was placed inside of the glasses, the same test was done to see if the system was still functionable.

The last equipment to install to the glasses was the AfterShokz, see attachment H. The AfterShokz was
disassembled until it only was the speakers and the wires left of it. The speakers was mounted in place with mounting holes and some screws. The wiring was managed so it would go straight from one side to the other of the glasses, and the AUX cable would go out of the glasses with the USB cable from the camera to the tablet. Then the sound of the AfterShokz was tested with the system and calibrated if needed.

2.5 Testing the Colorophone

To be able to know where to take the project forward we had to run several tests to see what works and what can be improved upon. The testing was done by all the members of the group, with a slight change in setup so that the tests could not be done by memory. See attachment J+K, for test report with Øystein.

2.5.1 Equipment list

- Colorophone
- Blindfolds
- Tablet
- Trays with different colors

2.5.2 Color recognition test

The first test we did with the final product was a color test. The test person had four differently colored plates placed on a table and his observations about color were noted. The test was done several times, and the plates were moved between each test to remove the luck factor. See Table 2.2 for results.

With some tuning to the software the amplitude of the green frequency was amplified. The change seemed to work since there were only one error containing green. From the color red we only got the red value and some white noise, green gave a high green value but also some blue and white, yellow gave red and green values but the two sounds overlapped each other so it was hard to differentiate them, and finally white was mostly white noise.

Table 2.2: Color recognition test

Tester	Colors	Answers	Variation	Note
EP	G,W,Y,R	W,W,Y,R	G1	
EP	R,W,Y,G	R,W,Y,W	G4	
EP	R,G,Y,W	R,W,Y,W	G2	
EP	W,Y,R,G	W,Y,R,W	G4	
EP	Y,W,G,R	Y,W,G,R	None	Made green louder
EP	Y,G,W,R	Y,G,W,R	None	
EP	R,G,Y,W	R,G,Y,W	None	
EP	G,W,Y,R	G,W,Y,R	None	
JK	G,W,Y,R	G,W,R,R	R3	
JK	R,W,Y,G	R,W,Y,G	None	
JK	R,G,Y,W	R,G,Y,W	None	
JK	W,Y,R,G	W,Y,R,G	None	
SB	G,W,Y,R	G,W,R,R	R3	Added a light source
SB	R,W,Y,G	R,W,Y,G	None	
SB	R,G,Y,W	R,G,Y,W	None	
SB	W,Y,R,G	W,R,R,G	R4	
KK	R,Y,G,W	R,G,Y,W	G2 Y3	
KK	Y,G,R,W	R,G,R,W	R1	
KK	G,Y,W,R	G,Y,W,R	None	
KK	W,Y,R,G	W,Y,R,G	None	

2.5.3 Proximity sensor test

The second test was for the proximity sensor. The camera was shut off so the test person could not find the object by listening to the colors. The test involved an empty room with space to walk around.

The test person was guided into the middle of the room and had to find two other persons standing quietly somewhere in the room. They did not stay close to the wall so the test person couldn't just follow the wall.

The test went well after a few tries and the sweeping technique was developed. Since it was an open room and the cut of range of the proximity sensor is 180cm, it was possible to turn your head and scan around for any changes in the ticking frequency. The beam pattern of the sonar is too wide, the camera only uses a small part of the picture and having a beam pattern similar to that of the camera would help with obstacles like tables.

3 | Experiment / Hardware

This chapter will go into details about what components we chose and why. It will also go into detail about various changes made to the prototype as different techniques were used through out the process. In addition, it will go through the process with the VFC.

3.1 Data Acquisition

The main software development tool used during the whole project was LabVIEW. This software development tool has been perfect for the project, since it work perfect together with all the hardware integrations. The advantage of using LabVIEW is that it introduces many different types of modules like FPGA (Field programmable gate array), RT (Real-Time), power supply, oscilloscope etc.

The myDAQ is a data acquisition device that provides users two analog inputs/outputs. In addition, it also has an audio output/input. The device is also able to provide users +15V, -15V and 5V. This have been a huge advantage for the group, since both the VFC and the ultrasonic proximity sensor needs 5V to work. See attachment B, for full specification of myDAQ.

As mentioned, the myDAQ provides two analog outputs. This has also been an advantage, since the output of a proximity sensor is a voltage that varies between 0 and 1 volt. By using NI ELVIS (Educational Laboratory Virtual Instrumentation Suite), the group was able to simulate a varied voltage between 0 and 1 volt. It is possible to go up to 10 volts, but it is not necessary for this project. Being able to simulate the voltage, have saved the group a lot of time. For example after finishing the VFC, instead of soldering the proximity sensor to see if the VFC would work, it could just be connected to the myDAQ.

3.2 Component selection

The main challenge with selecting components is to choose the components that fits for the purpose as well as being affordable.

3.2.1 Ultrasonic sensor

For the proximity sensor the LV-MaxSensor Ez0 was chosen because of the team's previous experience with the sensor. With a measuring range from 6 to 254 inches (6,45m) and a wide beam pattern it would be hard for the user to miss an incoming object. Being able to use the product in any environment is important, but the non-protected environment sensors takes up to much space as we want the product to look and feel like normal glasses. [4]

With further testing the Ez0 struggled with finding door openings because of its wide beam pattern. The Ez2 is a good compromise between sensitivity and side object rejection. With a narrower beam pattern it is better suited as a proximity sensor for the Colorophone. See attachment F, for ultrasonic sensor datasheet.

3.2.2 Logitech c920

The group had to choose a camera that could film similar colors to real colors in the environment. The camera could not be too expensive and it could not be too heavy, the shape of the camera was also very important; it had to fit into the glasses. The camera also needed a microphone input for the voltage to frequency converter. The first step was to find if the camera had a microphone input, and see if the size, weight, price and shape was good enough. The last step was to watch several reviews of the selected cameras and try to judge which of them had the best color quality. The best-fitted camera for this project was the Logitech c920.

3.2.3 Components for VFC (STATEMENT)

All the components for the VFC were available for the group at the university. However, there were a couple of capacitors that the group could not find, so the group had to improvise and set the capacitors either in series or parallel to get the value they needed. [5]

3.3 Description of the prototypes

3.3.1 Prototype v1.0

With the first prototype we wanted to test several things. We wanted to see how the components would fit inside the casing, if there would be a need for more room or it could be made slimmer, and how to position the VFC to minimize the length of the wires. The AfterShokz will eventually be implemented onto the legs and head-straps are used as a replacement.

3.3.2 Prototype v2.0

With prototype 2.0 the lid was moved to the top instead of on the inside. The casing was made in two pieces so the wires could be pulled out through a hole between them, also the camera could be placed closer to the wall to save some space. The prototype has a different shape than the previous version which nullified the information about how much space was needed. Instead of having the nose support as a separate part it was created so it could fit all nose sizes and take up less space.

We had two things in mind when creating the casing besides its functionality, which were comfort and weight. We think that this prototype sets a good base for what can be improved on in the next prototype.

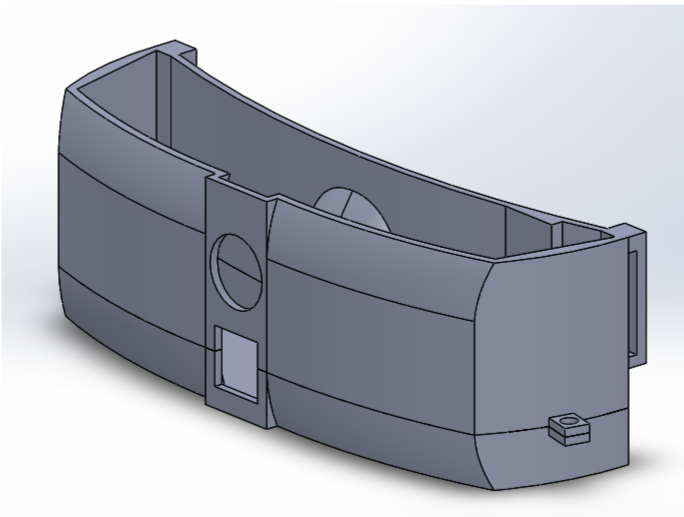

Figure 3.1: Prototype 2.0

3.3.3 Prototype v3.0

With 3.0 the focus was on the aesthetics and implementing the AfterShokz. The model has the same shape as 2.0 but is shorter, thinner and slimmer. With added leg support the AfterShokz are positioned at the temple with straps to keep it tight. We thought the legs would lack flexibility, but since the model is made out of two parts, the upper part moves slightly with the legs. The next step would be adding complete leg support which goes around the ears so the straps would not be needed.

3.3.4 Prototype v3.0.1

This prototype is a copy of 3.0. It goes back a version as there is no leg support for the AfterShokz, since the legs are not optimized and wearing a head-strap is more comfortable for longer tests.

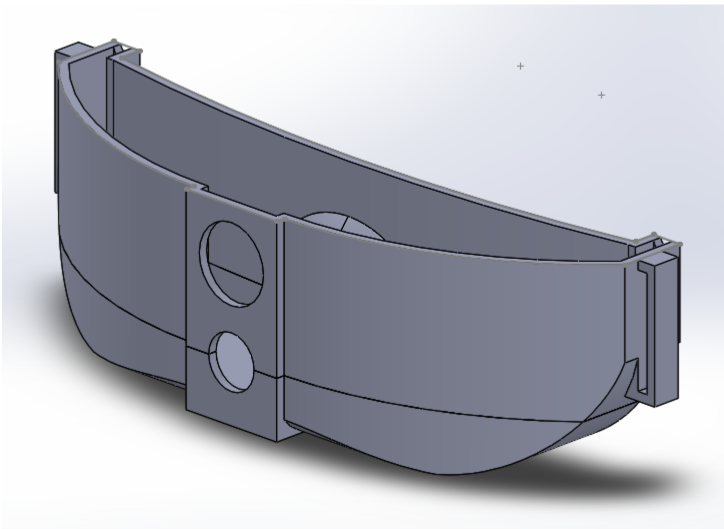

Figure 3.2: Prototype 3.0

3.3.5 Prototype v4.0

The prototype now consists of 3 different parts, down from 4. The AfterShokz are now part of the upper body and with an open roof solution, the wires can go out with the legs instead of a separate hole. The lid/roof also comes with legs that extend to the ears so a head-strap is no longer necessary. It shares some similarities with the 3.0, as the aesthetics, but is shorter, thinner and slimmer. Overall the prototype looks smoother and aesthetically pleasing.

3.3.6 Prototype v4.1

Prototype 4.1 was made to fix some minor problems with 4.0, for instance the legs for the AfterShokz did not extend far enough which resulted in some sound loss. The roof and legs were made slimmer to add some flexibility so they would fit more test persons.

Printing in PLA had its advantages, but as we printed the legs, we noticed the fact that parts that have been put under stress does not maintain their former solidness.

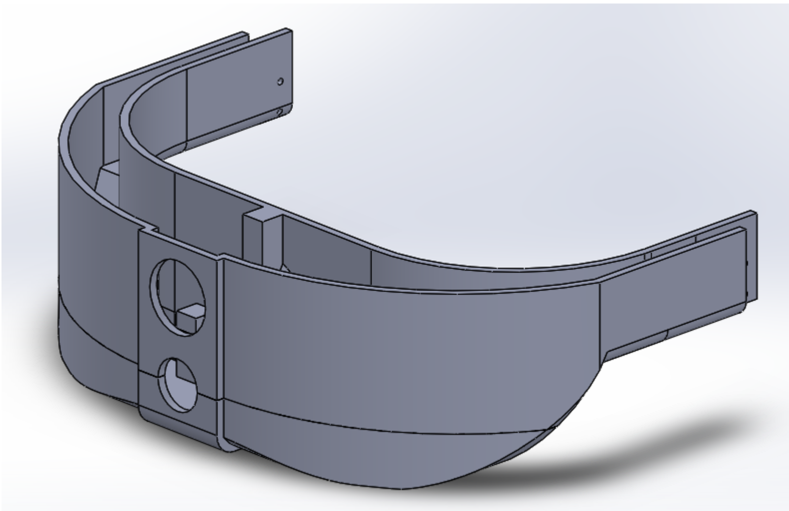

Figure 3.3: Prototype 4.1

3.4 VFC circuit schematic

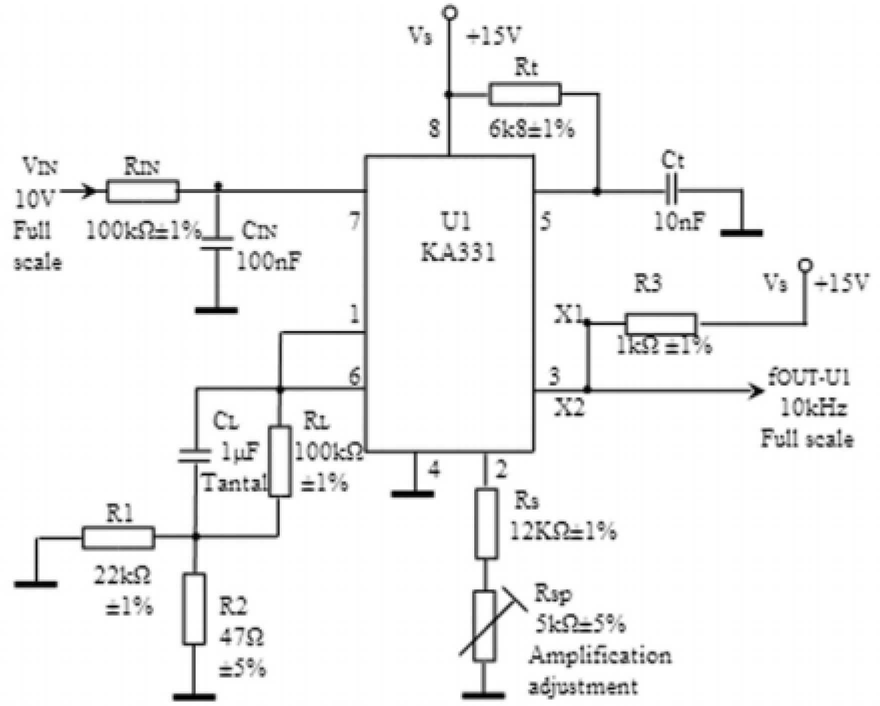

Figure 3.4: Voltage to frequency converter (VFC), obtained from the article "Voltage-frequency converter for laser welding control" [6].

In the datasheet for the KA331 voltage to frequency chip, there are several example circuit schematics, see attachment G. However, the group analyzed these schematics, and did not find them very useful. The VFC circuit schematic above were the one that the group ended up using. The group did a few tweaks, so it would suite the project better.

3.4.1 VFC v1.0

After testing the voltage-to-frequency converter (VFC) on the breadboard, producing the circuit board for it would be the next step. The first version of the VFC did not need to be perfect. There are four connectors on the VFC; +5 volt, ground, input from the proximity sensor and frequency output. After milling out the first version of the VFC, the group did not notice any problem with it, until testing. The VFC was missing a connector for the +5 volt. Instead of milling out a new circuit board, the +5 volt connector were just soldered directly on the circuit path.

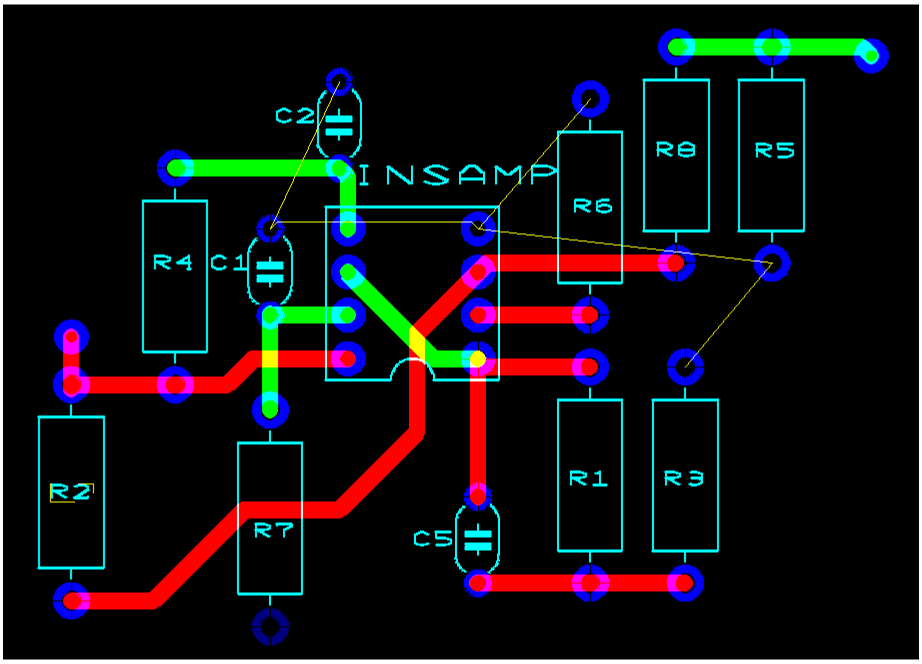

Figure 3.5: The first PCB layout (VFC v1.0)

After testing the VFC v1.0 through the analog input on the myDAQ, the next thing to do would be testing it through the audio input on the computer. To test the VFC through audio, the group would have to solder on a mini-jack plug to the VFC. The mini-jack plug requires two connectors, the frequency output and a ground. Since there is only one ground connector on the VFC, another ground connector had to be soldered on. This was not a problem since the VFC v1.0 was designed with a ground plane, so the ground connector could be soldered to the plane.

3.4.2 Surface-mount technology

Traditional through-hole components limits both cost, weight and size. Colorophone is a wearable tool and to decrease the weight and size we made the decision to replace the through-hole components to SMT components. On average the PCB (Printed Circuit Board) with SMT (Surface Mounted Technology) components can weight up to ten times less then PCB with through-hole components. [7]

3.4.3 VFCsmd v1.0

When the VFC PCB (Through-hole) did work as we wanted it to do, changing the components to SMT version means that the VFC PCB would give the benefits of smaller and lower weight. We had to change the Multisim design so we could use SMT components instead. The KA-331 (SMT version) was not implemented in Multisim, the only option was to create the component by our self. The only version of KA-331 we had available was the through-hole component, the KA-331 as it self are small, and wouldn't do so much difference if it was SMT version. This was the reason for changing all of the components beside of the KA-331 to SMT. Another notice is that there were no 1mF available, using two 470 microF in series makes ca. 1mF.

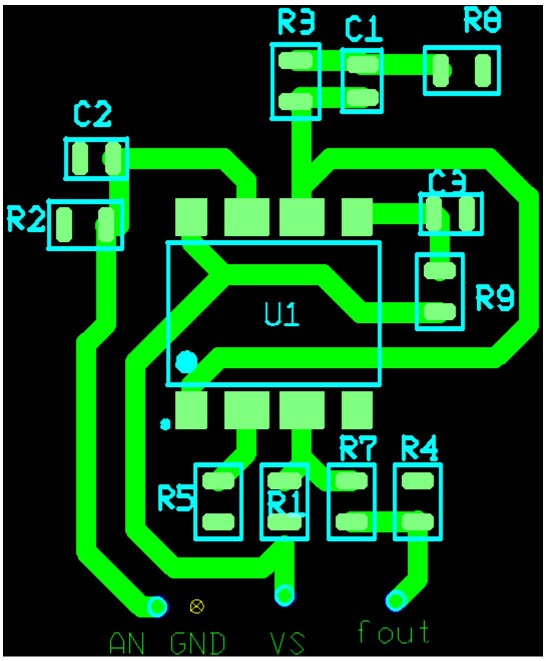

Figure 3.6: PCB layout of VFCsmd v1.0

3.4.4 VFCsmd v2.0

After milling and soldering the printed circuit board, there were an error, one of the resistors were not designed perfectly and the only option was to design a new PCB in Multisim, then milling and soldering the design. R1 was the resistor that was placed on the wrong place, R1 was in series with R4 and R7, but should be in series with R9. Replacing the R1 resistor should make the VFC PCB work again. [9]

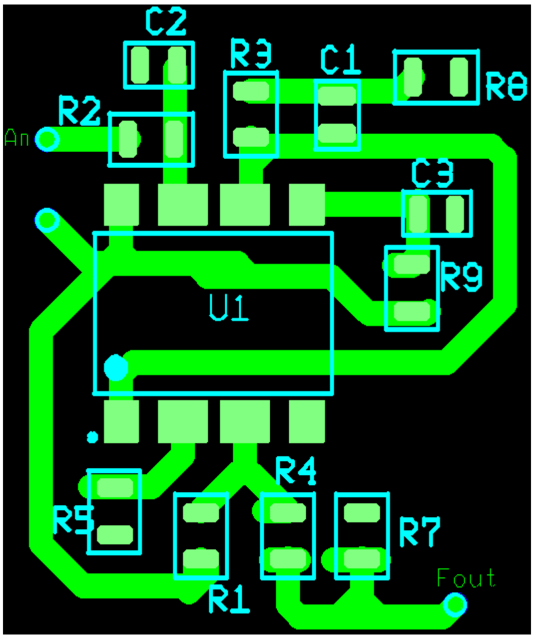

Figure 3.7: PCB layout of VFCsmd v2.0

3.4.5 VFCsmd v3.0

VFCsmd v2.0 did work as we wanted it to do, but there were still potentials to make it smaller. Milling and soldering the new VFCsmd v3.0 PCB made our final PCB, and we are still going to use the PCB layout to other Colorophone prototypes, because it works perfectly fine.

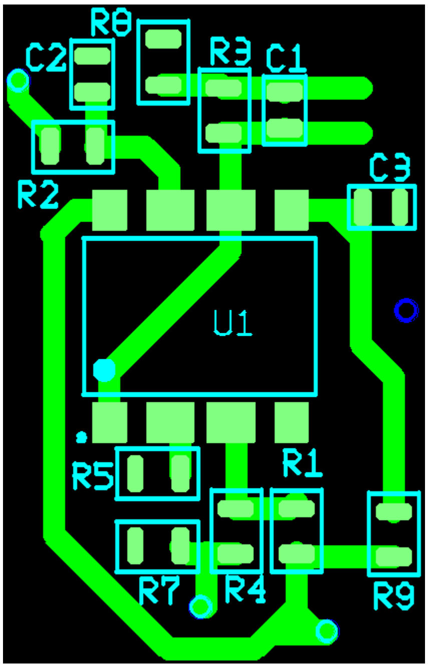

Figure 3.8: PCB layout of VFCsmd v3.0

3.5 myRIO casing

After making the myRIO wireless, it had a battery connected to it. This made it hard to carry the myRIO and battery together, since it was two separate parts. So the group were thinking designing a simple design to keep the battery and myRIO together.

3.6 VFC results

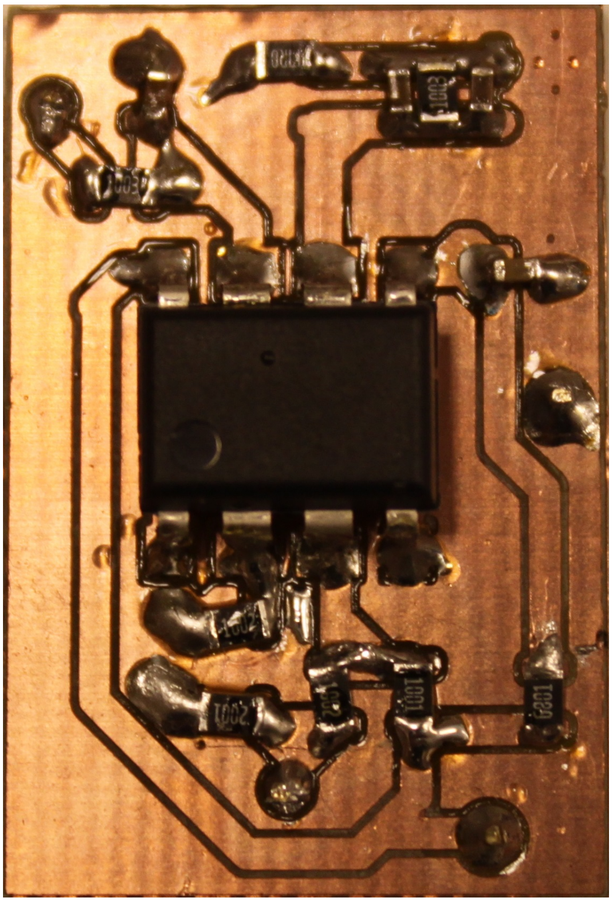

Figure 3.9: VFCsmd v3.0 result

See attachment I, for previous voltage to frequency converters.

4 | Software

This chapter will describe the different versions of the program Colorophone. As the project started the group were handed a LabVIEW code called Colorophone. The program
Colorophone is a very complicated LabVIEW code, but still understandable enough to continue working on. The program will not be described in detail, since there is much to describe, but several attachments will be included in the net-version of the report.

The assignment of the project specifies that NI LabVIEW is the main software development system that must be used. LabVIEW is a block-based program that makes programing easier. LabVIEW uses two main windows, a block diagram and a front panel. The front panel is what the end user of the program sees. The block diagram is where all the programing happens. The best part of using LabVIEW is that you do not need to write a lot of code. To get started you can just find the block you need and drag it in to the block diagram. This saves a lot of time, which is crucial for such a short period project.

The program Colorophone consists of several functions. It is collecting data from the camera so it can process the data and decide which color it is. Once the program have decided which color it is looking at, the program will generate a waveform that the program will send out through sound. The program will also collect data from the VFC. The data from the VFC will also be processed and sent out through sound.

At the start of the project, the group had no intention of creating their own version of Colorophone. However, since one of the tasks were to make the whole system as simple to use as possible, the group decided that implementing the code on myRIO would be best. This means that the group would have to create their own myRIO code, since there are no myRIO-versions of Colorophone.

4.1 Colorophone v1.0

Colorophone v1.0 was the very first program that the group got from Dominik. The first version of the program worked fine, but not optimized. This version of Colorophone do not have a way to acquire the data from the VFC. The only thing Colorophone v1.0 does is generate the sound for the color it is looking at. One problem with this version of Colorophone, is that it only have one while loop. When the whole code runs in one while loop, the program might drop frames. Since the system must run in real-time, losing frames is a big problem. The main usage of this version of the program is to fill in the group on how the whole idea worked.

4.2 Colorophone v2.0

After the group tested the first version of Colorophone, the group started to find out how to implement a proximity sensor to the code. Another good thing about LabVIEW is that it includes many examples of code. Luckily, LabVIEW have an example on how to acquire sound from the microphone input. Continues Sound Input.vi was the example code that was used. Before implementing this code to Colorophone v2.0, the group have to make a few changes in the code.

The example code only acquires the sound, but it will need it to do more than that. Since the only thing that comes in through the microphone in our case is a varied frequency, it will need to determine the frequency in real-time. To determine the frequency one can use either a tone measurement block or a peak detector block. If we use a tone measurement block, the unit that comes out is in hertz. This would be preferred, but since the tone measurement block is extremely unstable, the ideal block to use is the peak detector block. The unit that comes out of this block is "#found", depending on how wide the range is.

The reason for a stable measurement of the frequency is so that the "simulate signal" block can be used. The "simulate signal" block is a block that can simulate a sawtooth wave, which will sound like ticking.

4.3 Colorophone v3.0

Colorophone v3.0 is the latest version that the group got from Dominik. One of the big changes that was made were dividing the one while-loop into four parallel while-loops. The first loop consists of the color generator, the second loop is for the camera, third loop is for the audio, and the last one is for the proximity sensor.

There were also some unnecessary signal generators in the code that have been removed. When doing all of this and some other changes the code will get more optimized. The code will now run more or less in 25 frames per second.

4.4 Colorophone v3.1

On Colorophone v3.0, Dominik had his own way of acquiring the data from the proximity sensor. In this version of Colorophone, the group removed the whole while loop that Dominik used, and added the same code that was made in Colorophone v2.0.

The group also did more tests on this version of Colorophone, and noticed that the proximity sensor was unstable, when the distance got over 187 cm. Since it got more unstable when the system measured over 187 cm, the group added a threshold that made the ticking stop when the system measured over 180 cm.

4.5 Colorophone v3.2

Colorophone v3.2 is the latest version of Colorophone. It is practically the same version as the Colorophone 3.1, but with a few changes. The biggest change that was made is making the ticking stop when the user gets too close to an object. This way the user can focus on what the color is. To do this, a simple block called "In Range and Coerce" was used.

The way "In Range and Coerce" works is that it has an upper and a lower limit input. What comes out is a Boolean value, true or false. When the #found value gets under 110 and over 13, the output will be true and the ticking will be enabled. When the value gets out of range, the ticking is disabled.

The last changes that were made was cleaning up the front panel. A tab control for the VFC settings were made. In this tab control, the user is able to change value on where the ticking should be disabled. In this tab, the group will also see what comes in from the microphone input. This will not only make it easier for the users, but also to the group when testing the program. It makes the testing much simpler when the group have easier access to all the settings.

4.6 RT Colorophone v0.0

RT (Real-Time) Colorophone v0.0 was the first program that was developed on myRIO. This version of the program was developed for several reasons. First it was made to see if the myRIO was able to acquire the data from the VFC. This was not possible, as the group to do this for several weeks. After several attempts on acquiring data from the VFC, the group scratched the ide of implementing Colorophone to myRIO

After a week, the group had a small meeting with Dominik. At the meeting the discussion on implementing Colorophone to myRIO came up. Even though myRIO was not able to acquire the data from the VFC, it did not mean that Colorophone could not be implemented to the myRIO. Dominik suggested that the group should start with trying to generate the three frequencies on myRIO.

After several attempts on finding a way to generate the three frequencies, the group had finally generated the three frequencies. This was now RT Colorophone v0.0.

4.7 RT Colorophone v1.0

Until now, the group have only had the program running through either a computer or a tablet. It has been working perfectly fine, but can be a problem since it does not run in real-time. To run the program in real-time means that there are no delay in the system. The program will react within milliseconds. When running Colorophone on the tablet, there is a chance that a Windows update might come up. This might disrupt the program and cause some problems to the system. Since the target group are blind people, running Colorophone through a tablet might make it harder for them to use the system. It is very important to make the system as simple as possible to use.

All of the problems mentioned above can be solved with a NI myRIO. myRIO is an engineering hardware device that provides reconfigurable FPGA (Field Programmable Gate

Array) programming. Since Colorophone is a program that needs to run in real-time, programming in FPGA would be the best way to execute this project. In addition, NI myRIO is a small 14x9 cm box, which can fit in a pocket. This makes it easier to carry around.

Figure 4.1: NI myRIO

Since there are no versions of Colorophone that is compatible with myRIO, the group would have to program their own version of Colorophone. Programming our own version of Colorophone have been one of the toughest part of the project since no one on the group have any experience on programming the myRIO.

4.7.1 FPGA-target

The program Real-Time Colorophone will not be a finished program, but a start for further development. The main function of the program is generating the three frequencies for red, green and blue (RGB), and white noise. The frequencies lies on 1700Hz (red), 550 Hz (green) and 150 Hz (blue). These three frequencies are generated on the FPGA-target. To generate the three frequencies a simple "Sine Wave Generator" is used, and for the noise a White "Noise Generator".

The input on the frequency generators are frequency (periods/tick). Since the FPGA-target runs on a 40MHz clock, the frequency for each RGB component will be divided on the clock frequency before sending the value to the frequency generator block. After generating the three frequencies and white noise, everything will be streamed from FPGA-target to the RT-target.

4.7.2 RT-target

On the RT-target, we were able to do more complicated programming. This is where the RGB values will be acquired and decide the amplitude for frequencies red, green and blue. To acquire the frequencies generated on the FPGA-target, we must first open the FPGA target using an Open FPGA VI reference block. After acquiring the data from the FPGA-target, the data will be processed.

On the RT-target, we are able to use a Vision Acquisition VI. The Vision Acquisition block grabs the image from the camera, which is connected to an USB. After grabbing the image, we can now extract a pixel from the image by using an "IMAQ Color Image to Array VI". The data from the Color to Image Array will now be sent to a Color to RGB VI. This block gives the RGB values.

The RGB values will be the main data value that will decide the amplitude of each frequencies and the noise level. The RGB values varies between 0 and 255. The easiest way to describe what happens next is with examples.

Example 1: Color to RGB VI gives R=150, G=150 and B=10.

The lowest value of the three RGB component is 10 (blue). Since blue has the lowest value, this frequency will be replaced with white noise. In Addition, the entire RGB component will be subtracted by the lowest value. The lowest value will also decide the white noise level, which in this example is 10. We end up with R=140, G=140, B=zero and white noise with a value at 10. When we listen to this, we will hear the frequencies for red and green, and a little white noise. This is the sound of yellow.

Example 2: Color to RGB VI gives R=200, G=200 and B=200.

Here we can see that all of the components are equal. This will not have any effect on the code, the same will happen as in example 1. All the RGB components will be subtracted by the lowest value, which in this case is 200. The white noise level will be at 200, R=zero, G=zero, B=zero. When we listen to this, we will only hear noise. This is what white sounds like.

See attachment E, for RT Colorophone v1.0 code.

4.7.3 Audio output

Finally, all the processed data can be streamed back to the FPGA-target, where the frequencies will be played out through the audio output. To do this we will use a simple Audio Out block.

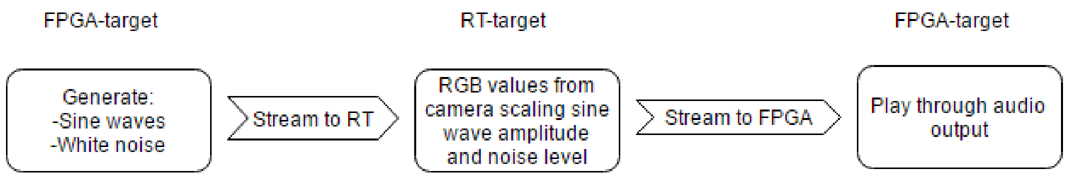

Figure 4.2: Overview of the program RT Colorophone v1.0

See attachment D, for more specific overview.

4.8 Concluding the software

The program RT Colorophone has been completed for the bachelor project. However, it is still missing the code for the proximity sensor. The reason for this was that a strange problem occurred. When using LabVIEW on a computer or a tablet, the data that was acquired looked fine. However, when using the myRIO to acquire the data, it did not give what we were looking for. After using a month trying to solve the problem, the group decided not to implement a proximity sensor on the RT Colorophone v1.0.

Even though RT Colorophone v1.0 do not have a proximity sensor included, the colorophone v3.2 does. This version of Colorophone is completed and there might not be any more versions. The only problem with this code is that it is only compatible with a computer or a tablet.

5 | Results

This chapter will give a short description of the result. We will describe what the system consists of. We will also give a description on the two versions of the program Colorophone v3.2 and RT Colorophone v1.0. In the end, we will name a couple of problems the group thinks the system have and how we can improve the system.

5.1 Hardware

In the end, the group have developed a final prototype that the group feels proud of. See figure 5.1. The latest version of the prototype consists of a Logitech c920 web camera, an ultrasonic proximity sensor, bone conducting headphones and a self-made voltage-to-frequency converter (VFC) using a small chip (KA331). The casing for all the components is a design that the group have designed on their own, using SOLIDWORKS. The web camera and the headphones were both disassembled so it could be mounted on to the design.

5.2 Software

This version of the system is compatible with both the programs, Colorophone v3.2 and RT Colorophone v1.0. Colorophone v3.2 uses all the components on the latest version of the system. Which means that it can identify color and determine the distance. However, the RT Colorophone v1.0 does not. RT Colorophone v1.0 does not acquire any data from the VFC, so it cannot determine the distance to an object. However, the benefit of using RT Colorophone is that it runs on a NI myRIO. When the system uses myRIO instead of a table, the system will run in real-time. This means no delay in the system.

Figure 5.1: Final result with myRIO

6 | Conclusion

In the preliminary, see attachment A, the assignment says that the group will design and produce a 3D model of glasses that will include a camera and a proximity sensor. The group will on their own, choose a camera that they think will suit the system. The group will use LabVIEW to implement their own code to use the proximity sensor. See attachment K, for an overview.

The system was mainly made to help blind people in the everyday life. Colorophone will help blind people identify color objects, which they have never been able to do. Colorophone will also be used for research on brain activity.

The group feel proud of their latest version of the prototype. However, there are always room for improvements. While doing a little bit of testing of the system, the group noted the problems that they meant occurred during testing of the system.

One of the problems the group noticed was that the proximity sensor had a little bit of delay. If a person waved their hand quickly in front of the system, the proximity sensor would have time to respond. This problem might get fixed if the data from the VFC could be obtained with myRIO.

Another problem is that the casing is not universal; the casing will not fit everybody. The human head comes in all shapes and sizes. This have caused many challenges for the designer. While the designer have made the system quite flexible, which helps on the wideness of the system. The system is still either a little bit too long or too short for some people.

6.1 Implementing other applications

At the start of the project it was mentioned that other applications might also be implemented to the system, if there would be time for it. There were mainly two other applications that was mentioned, a beacon and eye-tracking.

6.1.1 Comarch beacons

Comarch beacons are small blue-tooth beacons that can be placed around in cities. These beacons could then communicate with Colorophone and tell the user where he/she is. For example a beacon could be placed outside a supermarket. When a user is getting close to this supermarket, the user would then get a notification through Colorophone, which includes information about where the user is and what other possibilities are nearby.

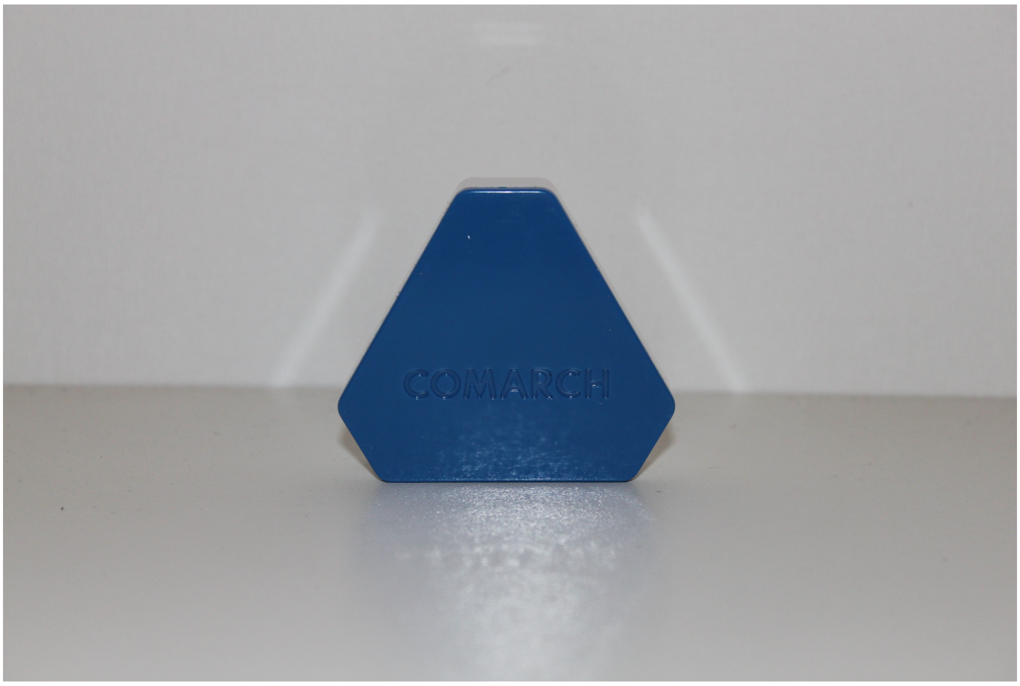

Figure 6.1: Comarch beacon

6.1.2 Eye-tracking

During this project the group have started researching the possibilities of implementing eye-tracking. One of the members of the group had a little bit of experience tracking objects using LabVIEW. To implement eye-tracking to the system, the group would have to find another camera. This camera does not need to be a high quality camera, but it would have to be a small camera to fit the system.

The idea of using eye-tracking, was so that the user would use their eye movements. This way the user would not need to move their head so much to see around, but instead move their eyes. Another idea was, when closing your eyes, it would mute all the sounds. Like taking a break.

6.2 What's the next step?

Since this bachelor project has been so original and new, it opens the door for many further problems. These problems would be; could we use other hardware than myRIO? Is there anything smaller than myRIO that the group could use? If so, could it fit in the glasses? Could we put everything in the glasses? Smaller camera? Smaller battery? Where lies the limit for too heavy glasses?

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[5] http://farside.ph.utexas.edu/teaching/302l/lectures/node46.html

[6] Victor Verbiţchi , Aurel-Valentin Bîrdeanu & Nicuşor-Alin Sîrbu (2013) Voltage–frequency converter for laser welding control, International Journal of Electronics, 100:8, s1093, DOI: 10.1080/00207217.2012.743065

[7] https://en.wikipedia.org/wiki/Surface-mount_technology

[8] http://www.ni.com/pdf/manuals/376047a.pdf

[9] http://www.electronics-tutorials.ws/resistor/res_3.html

Attachment A

Preliminary

NTNU
Institutt for elektrofag og fornybar energi

# Forprosjekt-E1625	
Oppgavens tittel: Colorphone Lukket Project tittel: Colorphone Classified	Oppgaven er gitt: 04.01.2016 Oppgaven skal leveres: 26.05.2016
Studieretning: Industriell Instrumentering Study: Industrial Instrumentation	Prosjektnummer: E1625 Project number: E1625
Forfattere/Authors: Kawan Kandili Edwin de Pano Sindre Bjørvik Jørgen Indergård Kopstad	
Oppdragsgiver: NTNU Veileder: Dominik Osinski Kontaktperson: Dominik Osinski dominik.osinski@hist.no Assigner: NTNU Supervisor: Dominik Osinski Contact: Dominik Osinski dominik.osinski@hist.no	

Sammendrag Bakgrunn

Blinde har vanskeligheter med å navigere i kjent og ukjent terreng. Vi vil lage en prototype, og ved hjelp av hørselen, gjøre det enklere for blinde å «se» hva som er framfor dem.

Oppgaven

Oppgaven går ut på å kombinere en avstandsmåler med et kamera, og med hjelp av litt koding få disse til å sende informasjon som farge og avstand til brukeren.

Hjelpemiddler

I løpet av prosjektet kommer vi til å bruke NI LabVIEW og komponenter som er på markedet fra før.

Mål

Vi har som mål at prosjektet leder til en eller flere prototyper som setter grunnlag for videre forskning på fargegjenkjenning og orientering for blinde.

Fremdriftsplan

Vi vil at planen skal følges slik at målene blir møtt innenfor tidsfristene. Det vil sikre at sluttresultatet blir det vi har planlagt.

Forord

Hensikten med denne forprosjektrapporten er at det skal legge et grunnlag for gjennomføring av bacheloroppgaven Colorophone. Colorophone er et system som skal hjelpe blinde med å høre farger. Sammen med vår veileder Dominik Osinski har vi kommet frem til en problemstilling som er gjennomførbar, men også utfordrende slik at vi kan trekke inn faglige kunnskaper for å gjennomføre oppgaven. I denne rapporten skal vi gi en klar definisjon på hva problemstillingen vår er og hvordan vi skal gjennomføre prosjektet.

Hovedmålet med prosjektet er å lage et system som skal få blinde og svaksynte personer til å høre farger og avstand til objekter de har foran seg. Om vi får mere tid skal vi også implementere noen andre funksjoner til systemet som skal gjøre dem enda mere orientert i sin hverdag. Disse funksjonene er blant annet, beacon og, «eye-tracking». Bachelorgruppen består av fire studenter fra industriell instrumentering på NTNU, Sindre Bjørvik, Kawan Kandili, Edwin de Pano og Jørgen Kopstad. Oppdragsgiver/veileder er Dominik Osinski ved NTNU.

Bakgrunn

Det er 40 millioner blinde mennesker i verden. Det er nesten ingen effektive hjelpemidler disse 40 millioner kan bruke. I dag er de enkleste hjelpemidlene en blindestokk eller en førerhund. Blindestokken kan bare gi brukeren en viss mengde informasjon av omgivelsene, og førerhundene trenger en grundig opplæring, noe som koster penger og tar tid. Det finnes også noen elektroniske produkter som skiller seg fra colophone ved måten de samler informasjon og sender til brukeren på. Disse produktene har en høy kostnad. Vi skal sette sammen et system som skal gjenkjenne farger og avstanden i den retningen den blinde personen «ser». Kostnadsmessig er poenget at Colorophone skal koste mye mindre enn tilbudene på markedet, slik at alle individer som ønsker å bruke produktet kan gjøre det.

En av gruppemedlemmene har vært hos Noca i sammenheng med prosjekt i bedrift. Der var oppgaven å lage et gjenkjenningsprogram som skulle finne kretskort som manglet komponenter i et samlebånd. Det faglige utbyttet fra det blir ført videre til dette prosjektet med tanke på programmering i labview.

Definisjoner

WC – Webcam

NI – National instruments

VFC – Voltage-to-frequency converter (Konverterer spenning til frekvens)

UPS – Ultrasonic proximity sensor

SW – Solidworks (program for å designe prototyper)

NI MS/UB – National instruments multisim/ultiboard (Program brukt til å designe kretskort)

Problemstilling

I dag finnes det over 40 millioner blinde mennesker rundt i verden. Det mest brukte hjelpemiddelet er en blindestokk. Blindestokken ble først introdusert etter 1. verdenskrig, av en fotograf ved navnet James Biggs. Biggs malte stokken sin hvit for å bli mer synlig for andre. Helt siden da har det ikke kommet veldig mange løsninger på å hjelpe blinde på.

I dag har det kommet flere hjelpemidler for de blinde når det kommer til avstander. Men det har enda ikke kommet noen løsninger når det kommer til farger. For å måle avstander og retninger finnes det flere metoder å gjøre dette på, men når det kommer til farger så er det litt vanskeligere å se for seg hvordan man skal takle problemet på. Metoden som blir brukt for å høre farger er at vi har registrert tre ulike frekvenser til fargemodellen RGB (rød, grønn og blå). Siden hvit og svart er litt spesielt, så er det kommet fram til at hvit er bare støy og svart er stillhet. Det vi konkret skal gjøre er å bygge dette systemet, og implementere en UPS.

Prosjektbeskrivelse

Kort forklart er produktet et par briller med et kamera, avstandsmåler og hodetelefoner som er koblet til et nettbrett. Nettbrettet har et labviewprogram som lager spesielle frekvenslyder for de forskjellige fargene kameraet ser, sånn at brukeren kan høre forskjell på farger. Avstandsmåleren skal enten sende et frekvenssignal som forandrer seg med avstanden til en gjenstand, eller så skal det festes en vibratormotor til brillene som endrer vibreringsgraden i.f.t avstanden til en gjenstand personen ser mot.

Brillene skal bli designet i solidworks og bli printet ut i en 3d printer. Det stilles ikke noe krav til hvordan brillene skal se ut i de første prototypene, da blir det mer tanke på funksjonaliteten. Når funksjonaliteten er «ferdig utviklet» er tanken at designen skal være så kompakt og praktisk som mulig.

Oppgavetekst

Hovedoppgaven for prosjektet er å lage, designe og teste en prototype som skal fungere som et lokaliseringssystem. Lokaliseringssystemet innebærer at farger/bilder blir omformet til lyd, slik at det skal bli mulig for blinde å «høre» farger. Det skal implementeres kamera, UPS, beinledende hodetelefoner.

Målet er at bachelorgruppen skal:

- Velge et designings verktøy til å 3D designe brillene som skal brukes, deretter produsere designet på en 3D skriver (PLA i førsteomgang, ABS til slutt) - Velge et kamera som er godt egnet for systemet.
- Designe et avstandsmålesystem som både skal bruke lite plass og fungere godt. - Programvareutvikling, som skal være enkelt å bruke.

Målet er at bachelorgruppen skal få erfaring fra programmering, systemdesign, 3D design, prototype utvikling og gruppearbeid. En annen erfaring er samarbeid, bachelorgruppen kommer til å forstå at det er både fordeler og ulemper med arbeid i gruppen, forstå hvor viktig det er med god planleggening og oppfølging, noe som er bra å ta med seg ut i arbeidslivet.

Prosjektmål

I løpet av de neste månedene med utvikling og testing skal vi ha kommet fram til flere fungerende prototyper. Den første prototypen skal være ferdig tidlig februar, og skal inneholde WC og UPS. Første prototypen skal legge et grunnlag for oss, slik at vi kan fortsette å videreutvikle Colorophone ved å implementere flere funksjoner. For at UPS skal fungere med WC, må vi lage et program i NI LabVIEW. Programmet for Colorophone fikk vi oppgitt av vår veileder Dominik Osinski. Vi må da finne en måte å få implementert LabVIEW koden fra UPS i Colorophone koden. Den første prototypen skal bli testet av først oss selv, men senere også blinde personer.

Delmål

- Prototype ○ Lage flere fungerende prototyper. ○ Software for UPS i NI LabVIEW. ○ Implementere flere funksjoner.
  - Software for implementerte funksjoner.
- Komponentvalg ○ Dimensjonering av komponentene for VFC skal være. ○ Finne ut hvor mye det koster å lage et kort.
  - Hvordan holde kostnaden til et minimum.
- Testing ○ Teste på oss selv. ○ Teste på blinde personer.
  - Feilsøking av problemer.

- Sluttrapport
    - Prosjektmøter med veileder annen hver uke.
    - Holde mest mulig oversikt.
    - Prøve å holde oss til prosjektplanen så mye som mulig.

Prosjektutbytte

Etter gjennomført prosjekt ønsker vi å ha utviklet vår kompetanse innen sensor- og instrumenteringsteknikk, anvendt instrumentering, elektronikk, design og testing av prototyper, forskningsmetoder og ikke minst prosjektstyring. Vi ønsker også å lage en prototype som er god nok slik at det kan bli videreutviklet av flere for å hjelpe blinde personer. Ut av prosjektet vil vi også stå igjen med en forbedret samarbeidsegenskap som vi kan ta med oss videre i arbeidslivet. Til slutt ønsker vi også selvsagt en god karakter slik at vi kan se tilbake på prosjektet og være stolte.

Problemområder

Oppgaven som er gitt er en oppgave som «tenker helt nytt» derfor forventes det at det dukker opp problemer. Dette vil si at vi må ta høyde for at vi må endre/ utsette oppgavene som foreligger i prosjektplanen.

Det er veldig viktig at alt av problemer som oppstår, selv om det er lite, blir dokumentert. Om løsningen på problemet blir rettet opp, må vi prøve å ta igjen tiden vi mistet på grunn av problemet. Om det ikke er mulig å ta igjen tiden, må vi endre på prosjektplanen.

Gruppa kommer til å lage flere prototyper, planen er at etter vi har produsert en prototype så kommer det til å bli mye enklere å løse problemene som kommer opp. Neste prototype kan allerede påbegynnes dersom problemet ansees som enkelt. Er problemet «umulig» å løse så skal det tenkes nytt, for så å implementeres inn i neste prototype.

Designet for prototypen skal være enkel, slik at det blir fokusert på at systemet skal virke optimalt. Senere i perioden kommer det til nytte at designet skal både se bra ut, og være praktisk.

Arbeidspakker/delprosjekt

Hensikten med arbeidspakker/delprosjekt er for å opprettholde et strukturert prosjektarbeid. Bachelorprosjektet er ganske stort, som kan føre til at vi lett kan minste oversikten. Arbeidspakkene har vi valgt å dele opp i to kategorier. Den ene kategorien er ulike delprosjekter som er obligatoriske og skal ha god tid til å gjøre. Den andre kategorien er ulike delprosjekter som vi skal gjøre om vi får tid.

Skal gjøres:

Hardware er noe som må gjøres. Dette består av alt som skal inn i prototypene. Til nå har vi kommet fram til at det er kun to ting som skal inn i den første prototypen, UPS som er koblet sammen med VFC og WC. Før man begynner å sette sammen en prototype er det viktig å teste ulike kretser på breadboard og se hvilke komponenter man trenger. Dette gjelder foreløpig kun UPS som er koblet sammen med VFC. For å teste VFC kretsen, setter man opp kretsen på breadboard, og sender inn en simulert spenning fra NI ELVISmx. Den simulerte spenningen bør være tilnærmet lik spenningen som kommer ut av UPS. Om alt ser ut til å funke kan man begynne å koble på en UPS. Til slutt om alt ser bra ut, kan man begynne å designe en enkel krets på NI MS/UB og frese ut kortet. Dette kortet trenger ikke å være minimalisert. Andre ting som går under hardware er WC. Denne trenger vi å finne ut om er god nok for prosjektet før det bestilles opp.

Software, også noe som skal gjøres. Denne delen består av for det meste NI LabVIEW koder for Colorophone og UPS koblet mot VFC. Koden for Colorophone fikk vi oppgitt av vår veileder Dominik Osinski, som vi skal prøve å få en forståelse over. I løpet av de første ukene skal vi også få en gjennomgang av Dominik om Colorophone koden. Koden for VFC skal vi lage selv. Denne koden skal klare å gjøre om den frekvensen vi får fra VFC til «tikker». Dette gjør vi ved hjelp av en funksjon inne i NI LabVIEW som kalles «signal simulator». Når koden for VFC er ferdig, skal man finne en måte å implementere denne koden inne i Colorophone koden.

Etter at både hardware og Software delene er ferdig og fungerer bra sammen, kan man begynne å sette sammen en fungerende **prototype**. Til å starte med trenger ikke prototypen å se perfekt ut, men bare inneholde de viktigste funksjonene som WC og UPS. Alle prototypene som skal lages blir designet i SW.

Til slutt skal vi **teste** systemet selv. Testingen vil bli slik at vi tar bind for øynene på oss selv, tar på oss systemet og «ser» hva som skjer. Vi skal da observere og sammenligne resultatet mot da vi bare hadde stokk som hjelpemiddel. Etter testing vil vi vurdere om noe gikk galt, eller om alt gikk som det skulle. Hvis det ble oppdaget noen feil i systemet, vil vi gå tilbake å se hvor feilen skjedde. Enten om det var på grunn av hardware eller software. Dersom alt gikk bra i systemet, kan man begynne å se på den neste kategorien i arbeidspakken/delprosjekt.

Gjennom prosjektet må vi også huske på å **dokumentere** så ofte som mulig. Alt arbeid som blir gjort (hardware, software, sammensetting av prototyper og testing) skal dokumenteres. Dette gjør vi for å ha flest mulig minner fra det som ble gjort, som skal gjøre det lettere å skrive en sluttrapport.

Tilleggsfunksjoner:

Om vi blir fort ferdige med de første prototypene og de fungerer som de skal, kan man begynne å introdusere andre funksjoner til systemet. Den første funksjonen som skal bli implementert da er **beacon**. Beacon kan bli plassert rundt ulike plasser i byen som for eksempel en butikk. Når en blind person står utenfor eller er i nærheten av denne butikken, kan personen få en indikasjon om at han/hun er der. Dette er da tanken bak beacon.

Den siste funksjonen som har blitt snakket om er «**eye-tracking**». Om vi helt til slutt enda har tid igjen kan vi begynne å implementere «eye-tracking». Denne funksjonen kan vi sette inn i systemet for å prøve å ta i bruk øyet til brukerne. Om man får til dette trenger ikke brukerne å bevege alt for mye på hodet, men heller bruke øynene. Siden «eye-tracking» er veldig komplisert, og krever veldig mye koding i NI LabVIEW så er det en veldig liten sannsynlighet at vi kommer til å bli ferdig med denne funksjonen. Vi kommer da mest sannsynlig til å bare skrive kort om hvordan vi hadde tenkt å takle denne oppgaven.

Kvalitetssikring

For å kvalitetssikre prototypene har det blitt planlagt å teste de ut på testpersoner og få tilbakemeding på hva som kan forbedres og hva som er bra.

Prosjektleveranse

Etter gjennomført prosjekt skal vi ende opp ferdiglaget:

- Prototyper
- Toukersrapporter
- Prosjektrapport

Bachelorprosjektdeltakere

Kawan Kandili:

22 år gammel, kommer fra Trondheim.

Jeg gikk allmennfag på Tiller videregående skolen, hvor jeg tok realfagene kjemi, fysikk, matte og biologi. Etter endt videregående utdanning, ble jeg et år i hæren, hvor jeg var ingeniørsoldat hos Ingeniørbataljonen, med spesialisering innenfor CBRN. Gjennom alle år har jeg enten jobbet som deltidsarbeider eller sommervikar. Etter dimittering, begynte jeg på elektroingeniør linjen ved HIST (NTNU), hvor jeg ble interessert i, og senere valgte industriell instrumentering. I tillegg til skole jobber jeg som deltidsarbeider hos varelageret til COOP NORGE.

Sindre Bjørvik:

22 år gammel, kommer fra Trondheim.

Gikk allmennfag på Tiller VGS, hvor jeg tok realfagene, fysikk, matte og biologi. Etter endt videregående utdannelse jobbet jeg et år i varelageret til COOP NORGE. I 2013 startet jeg på elektroingeniør linjen ved HIST (NTNU), hvor jeg senere valgte industriell instrumentering. Jeg jobber fortsatt hos COOP siden jeg begynte på HIST, men jobber deltid.

Edwin de Pano:

21 år gammel, kommer fra Trondheim.

Gikk allmennfag på Tiller videregående skole, hvor jeg tok realfagene, fysikk, matte og biologi. Etter endt videregående utdannelse startet jeg rett på elektroingeniørlinjen ved HiST (NTNU), hvor jeg senere valgte industriell instrumentering. Samtidig som jeg jobber med bachelor oppgaven, jobber jeg som studentassistent i faget anvendt instrumentering. Jeg er for det meste studentassistent i Dominik Osinski sin del av faget, som er kun om LabVIEW programmering.

Jørgen Kopstad:

22 år gammel, kommer fra Trondheim.

Gikk studiespesialisering ved Tiller videregående skole. Der tok jeg realfagene matte, fysikk, kjemi og biologi. Gikk et år på materialteknologi ved HiST før jeg begynte på elektro på HiST (NTNU), her valgte jeg å gå industriell instrumentering fordi det virket mest interessant. Det faget jeg likte best var sensor og instrumenteringsteknikk.

Ulike rammer

Ressurser: NTNU	Stille med bachelor-rom Ulike programmering/design programmer

Penger: NTNU	• Beinledende hodetelefoner (Aftershokz Sport M3) 49.95 $ • Digitalt WC (Logitech C920) 770 kr • UPS (Ultrasonic proximity sensor) 29.95 $ • 720p HD Polarized sunglasess camera 600 kr • HP 608 tablet 10 000 kr • Sugru 99 kr
Utstyr: NTNU	• 3D-Printer • Beinledende hodetelefoner • HP Tablet • Fresemaskin • Loddeutstyr • Breadboard • NI Labview • Elektroniske komponenter (resistanser, kondensatorer etc) • Skole PC • Boremaskin • NI myDAQ • SW • Makerbot Desktop • NI MS/UB • Multimeter og LCR multimeter Vision Enginering microskop
Tid: Deltagere	Det er satt av 500 timer pr person, som tilsvarer 2000 timer sammenlagt på gruppa
Spesielle behov: NTNU og deltagere	Vi kommer til å trenge ulike testpersoner som vi kan teste produktet på Dette kan både være frivillige studenter, og frivillige blinde personer.

Oppgaver før bachelorprosjekt

Før vi skulle starte med bachelorprosjektet hadde vi får en oppgave av Dominik Osinski. Denne oppgaven gikk ut på å oppleve hvor vanskelig det er å være blind. Alle i gruppen fikk utgitt et ark hvor dette var skrevet:

Colorophone – bacheloroppgave

Hva slags utfordringer møter blinde personer i hverdagen?

Dere skal sjekke det personlig ved å bruke sovemaske og gjennomføre enkle, vanlig oppgave – men denne gangen uten å bruke synssansen. Husk å observere og lære mest mulig både når du har sovemasken på selv eller når kollegaene dine har masken på.

NB. Når du har masken på lukk øynene for å ha et helt svart bilde foran øynene.

En testperson bør ha masken på, en annen person skal være til hjelp og to andre bør ikke påvirke prosessen.

1. *Oppgave for alle. Den første oppgaven blir å starte på 5te etasje og komme ned til Colaautomat og prøve å kjøpe en Colaflaske.*

2. *Kawan – start ved siden av Colaautomat og gå på garderobe på Vitenskapsmuseet og etterpå gå ut av bygget.*

3. *Sindre – Start foran Vitenskapsmuseet og gå til butikken Rimi Leuthenhaven finn en panteautomat, og sett inn en tom flaske og hent lappen fra automaten. Deretter gå ut av butikken-*

4. *Edwin – Start utenfor Rimi og går til en skobutikk på Torget og prøv på et par vintersko.*

5. *Jørgen – Start på en skobutikk på Torget og så til Servicesenteret på HiST og hent en brosjyre om studier.*

Generelle merknader:

Den forrige «blinde» personen bør bære en hjelper til den neste «blinde» personen. Lag notater eller ta bilder på veien. Dette blir en del av bachelorrapporten deres så prøv å dokumentere det.

Prøv å stille spørsmål om hva er utfordringene og hvordan kan de løses.

Colorophone

SAMARBEIDSAVTALE

mellom:

1. Jørgen Kopstad
2. Kawan Kandili
3. Sindre Bjørvik
4. Edwin de Pano

Målet for samarbeidet

Målet for samarbeidet i vår gruppe er jobbing og innlevering av en felles prosjektoppgave. Tittel for prosjektoppgaven er Colorophone. I gruppen ønsker vi å fremme læring, samhold og trivsel mellom de enkelte medlemmene. Gjennom gruppen ønskes det også å utvikle samarbeidsevnen, slik at vi kan ta det med videre i arbeidslivet.

Vi er enige om at rettferdig arbeidsfordeling i gruppen er svært viktig for å oppnå dette målet. Rettferdig arbeidsfordeling er en forutsetning for gruppens arbeid fordi gruppen skal få en felles karakter på prosjektoppgaven. Gjennom denne avtalen ønsker vi å sette opp et samarbeid slik at det kan fungere etter hensikten.

Betydning av denne avtalen

En av betydningene av denne avtalen er å danne et rammeverk for levering av prosjektrapporten. Alle gruppemedlemmene må lese godt gjennom avtalen før personen kan underskrive.

Møtetidspunkt - og sted

Vi er enige om å møtes kontinuerlig i prosjektperioden. Vi forplikter oss til å møtes som det framgår av møteplanen nedenfor. Møtene skal foregå hver dag mellom 10:00 og 16:00 i masterlabben. I starten av prosjektet vil mandag, tirsdag og onsdag bli satt av til faget ingeniørfaglig systemtenkning.

Oppmøte

- Oppmøte skal være presist. Vi er enige om at hvis en av gruppemedlemmene er 30 minutters forsinket uten forvarsel, skal dette noteres.

- Det blir definert som hyppig forsinkelse om forsinkelsen vedvarer 2 eller flere dager etter hverandre. Det er også regnet som hyppig forsinkelse om deltageren kommer ofte forsinket i en kort tidsperiode, dette er for at prosjektet skal gjennomføres på

en profesjonell måte. Dette skal også hjelpe oss med å få en bedre oversikt over antall timer som hver enkelt gruppemedlem har brukt.
- Dersom man kommer for sent pga. omstendigheter man ikke kan gjøres ansvarlig for (sykdom, legebesøk etc.), aksepteres dette, men skal varsles så fort som mulig.

Fravær

- Ved eventuell fravær, så må dette meldes til minst en deltaker i gruppen. Det bør også meldes ifra minst en dag i forveien.
- Det settes en nulltoleranse for ugyldig fravær.
- Fravær pga. omstendigheter man ikke kan gjøres ansvarlig for (sykdom, dødsfall etc.), aksepteres.

Gruppens ledelse

Som gruppe har vi nå avtalt at i dette prosjektet har vi ingen behov for noen gruppeleder. Oppgavene blir fordelt med hensyn til at gruppen er enige om hvordan oppgaven skal være.

Møteprotokoll

Vi er enige om at det skal skrives en kort protokoll i løpet av hvert gruppemøte. Denne inneholder a) møtetidspunkt, b) for sent fremmøte og fravær c) kort beskrivelse av møtets innhold.

Mulige komplikasjoner i samarbeidet

Vi er enige om at gruppen tar en beslutning som ordner opp i forholdene.

Eventuelle tiltak ved mislighold

Vi er enige om at hyppige forsinkelser eller ugyldig fravær er ødeleggende for gruppens samarbeidsevne, det vil derfor bli satt opp følgende tiltak:

- Et gruppemedlem som får ugyldig fravær vil bli sendt til skolens styre for å fastsette en egen karakter til den gjeldende.
- Ved hyppig forsinkelse, vil det bli satt opp et krisemøte, for å finne en løsning til saken. Men hvis dette fortsatt er et problem, så vil det få samme konsekvenser som for ugyldig fravær.

Varighet, gyldighet og reformulering

Denne avtalen er gyldig fra og med underskriftsdato inntil innlevering av bachelorprosjektet.

Gruppen er enig om at vi kan bruke elektronisk underskrift.

Trondheim, dato:

28.01.2016

Underskrifter:

Sindre Langen Bjørvik

Kawan Kandili

Jørgen Kopstad

Edwin de Pano

Attachment B

myDAQ specification

SPECIFICATIONS

NI myDAQ

Français	Deutsch	日本語	한국어	简体中文

ni.com/manuals

Analog Input

Number of channels..2 differential or 1 stereo audio input

ADC resolution...16 bits

Maximum sampling rate..................................200 kS/s

Timing accuracy ....100 ppm of sample rate

Timing resolution..10 ns

Range

Analog input ....±10 V, ±2 V, DC-coupled

Audio input...±2 V, AC-coupled

Passband (-3 dB)

Analog input ....DC to 400 kHz

Audio input...1.5 Hz to 400 kHz

Connector type

Analog input ....Screw terminals

Audio input...3.5 mm stereo jack

Input type (audio input) ....Line-in or microphone

Microphone excitation (audio input) ....5.25 V through 10 kΩ

Absolute accuracy

Nominal Range		Typical at 23 °C (mV)	Maximum (18 to 28 °C) (mV)
Positive Full Scale	**Negative Full Scale**		
10	-10	22.8	38.9
2	-2	4.9	8.6

Figure 1. Settling Time (10 V Range) versus Different Source Impedance

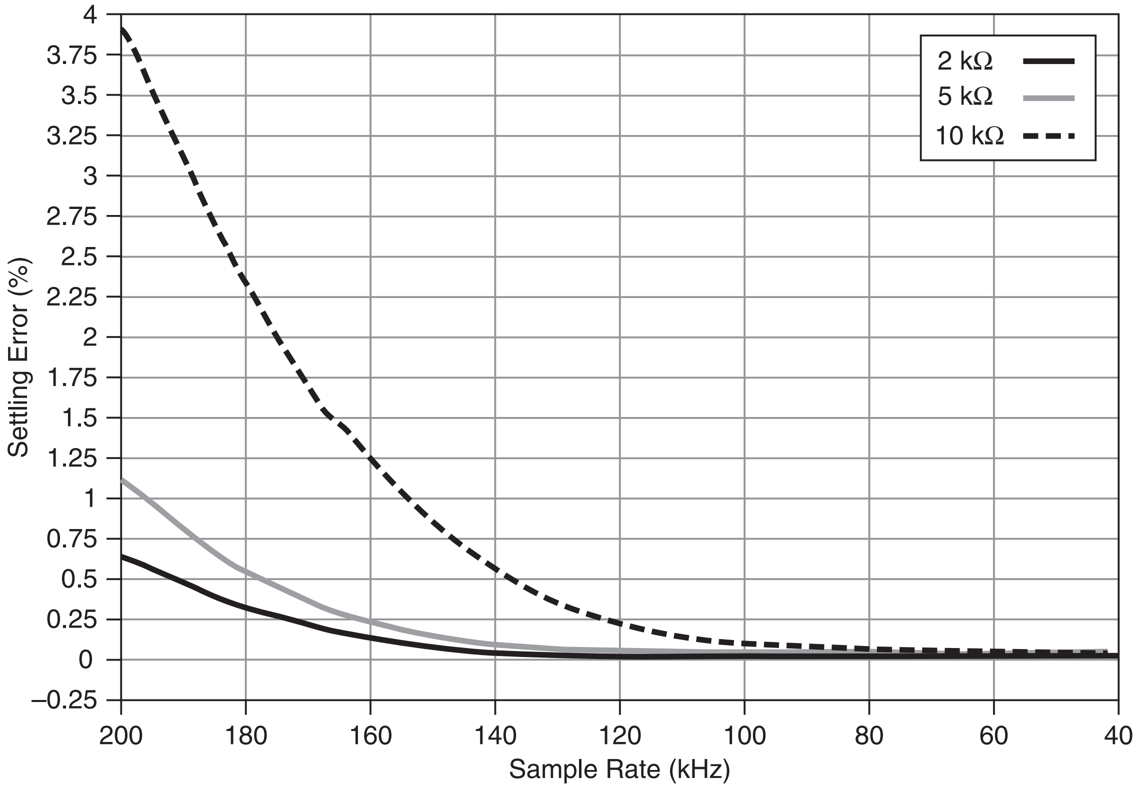
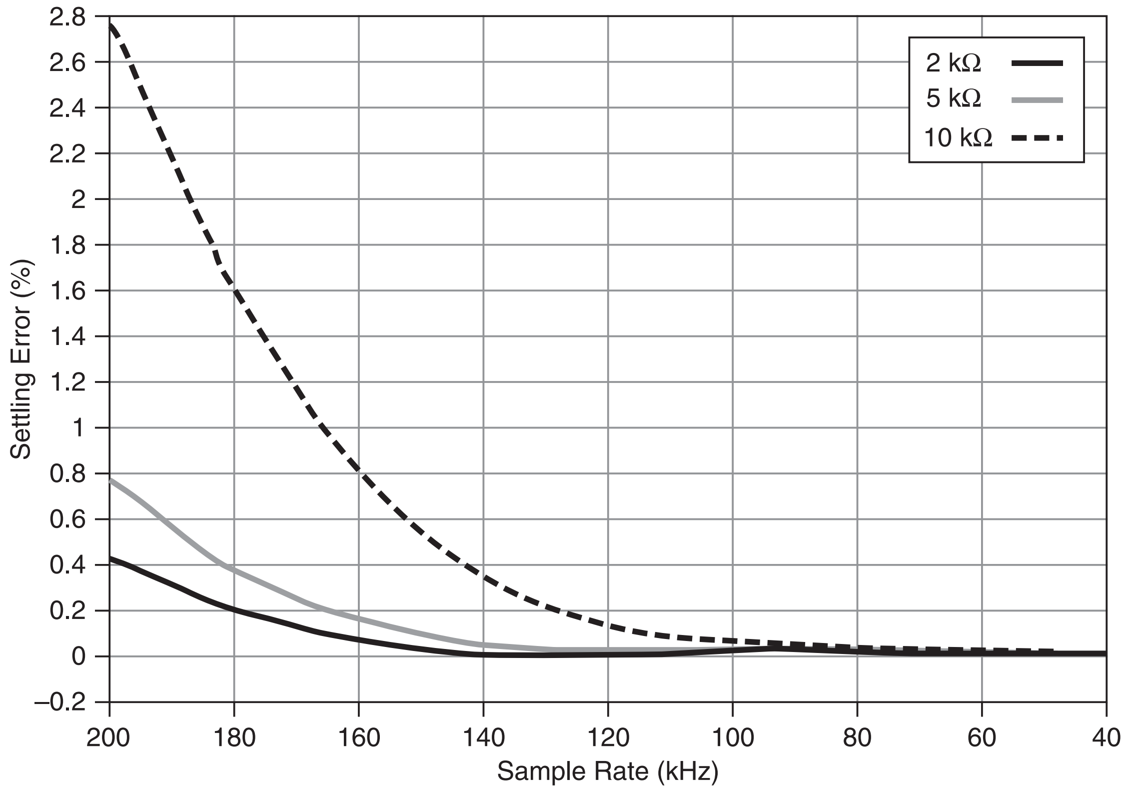


Figure 2. Settling Time (2 V Range) versus Different Source Impedance



Input FIFO size .... 4,095 samples, shared among channels used

Maximum working voltage for analog
inputs (signal + common mode) .... ±10.5 V to AGND

Common-mode rejection
ratio (CMRR) (DC to 60 Hz)........................... 70 dB

Input impedance

Device on

AI+ or AI- to AGND .... >10 GΩ || 100 pF

AI+ to AI- .... >10 GΩ || 100 pF

Device off

AI+ or AI- to AGND .... 5 kΩ

AI+ to AI- .... 10 kΩ

Anti-aliasing filter.. None

Overvoltage protection
AI+ or AI - to AGND .... ±16 V

Overvoltage protection
(audio input left and right)............................... None

Analog Output

Number of channels... 2 ground-referenced or 1 stereo audio output

DAC resolution .... 16 bits

Maximum update rate .... 200 kS/s

Range

Analog output .... ±10 V, ±2 V, DC-coupled

Audio output .... ±2 V, AC-coupled

Maximum output current
(analog output)[1] .... 2 mA

Output impedance

Analog output .... 1 Ω

Audio output .... 120 Ω

Minimum load impedance
(audio output) .... 8 Ω

[1] The total power available for the power supplies, analog outputs, and digital outputs is limited to 500 mW (typical)/100 mW (minimum). Refer to the *Calculating Power Consumption* section for information on calculating the total power consumption of the components of your system.

Connector type

Analog output .... Screw terminals

Audio output .... 3.5 mm stereo jack

AC-coupling high-pass frequency
(audio output with 32 Ω load).......................... 48 Hz

Absolute accuracy

Nominal Range			
Positive Full Scale	Negative Full Scale	Typical at 23 °C (mV)	Maximum (18 to 28 °C) (mV)
10	-10	19.6	42.8
2	-2	5.4	8.8

Slew rate .... 4 V/µs

Timing accuracy... 100 ppm of sample rate

Timing resolution... 10 ns

Overdrive protection .... ±16 V to AGND

Maximum power-on voltage[1] .... ±110 mV

Output FIFO size .... 8,191 samples, shared among channels used

Digital I/O

Number of lines .... 8; DIO <0..7>

Direction control .... Each line individually programmable as input or output

Update mode .... Software-timed

Pull-down resistor .... 75 kΩ

Logic level .... 5 V compatible LVTTL input; 3.3 V LVTTL output

V_{IH} min .... 2.0 V

V_{IL} max .... 0.8 V

Maximum output current per line[2].................... 4 mA

[1] When powered on, the analog output signal is not defined until after USB configuration is complete.

[2] The total power available for the power supplies, analog outputs, and digital outputs is limited to 500 mW (typical)/100 mW (minimum). Refer to the *Calculating Power Consumption* section for information on calculating the total power consumption of the components of your system.

General Purpose Counter/Timer

Number of counter/timers 1

Resolution .... 32 bits

Internal base clocks .... 100 MHz

Base clock accuracy .... 100 ppm

Maximum counting and pulse
generation update rate .... 1 MS/s

Default routing

- CTR 0 SOURCE .... PFI 0 routed through DIO 0
- CTR 0 GATE .... PFI 1 routed through DIO 1
- CTR 0 AUX .... PFI 2 routed through DIO 2
- CTR 0 OUT .... PFI 3 routed through DIO 3
- FREQ OUT .... PFI 4 routed through DIO 4

Data transfers .... Programmed I/O

Update mode .... Software-timed

Digital Multimeter

Functions[1] .... DC voltage, AC voltage, DC current, AC current, resistance, diode, continuity

Isolation level .... 60 VDC/20 V_{rms}, Measurement Category I

Caution Do *not* use this device for connection to signals or for measurements within Measurement Categories II, III, or IV. For more information on Measurement Categories, refer to the *Safety Voltages* section.

Connectivity .... Banana jacks

Resolution .... 3.5 digits

Input coupling .... DC (DC Voltage, DC Current, Resistance, Diode, Continuity);
AC (AC Voltage, AC Current)

Voltage Measurement

DC ranges .... 200 mV, 2 V, 20 V, 60 V

AC ranges .... 200 mV_{rms}, 2 V_{rms}, 20 V_{rms}

[1] All AC specifications are based on sine wave RMS.

Note All AC voltage accuracy specifications apply to signal amplitudes greater than 5% of range.

Accuracy

Function	Range	Resolution	Accuracy ± ([% of Reading] + Offset)	
DC Volts	200.0 mV	0.1 mV	0.5% + 0.2 mV	
	2.000 V	0.001 V	0.5% + 2 mV	
	20.00 V	0.01 V	0.5% + 20 mV	
	60.0 V	0.1 V	0.5% + 200 mV	
			40 to 400 Hz	**400 to 2,000 Hz**
AC Volts	200.0 mV	0.1 mV	1.4% + 0.6 mV*	—
	2.000 V	0.001 V	1.4% + 0.005 V	5.4% + 0.005 V
	20.00 V	0.01 V	1.5% + 0.05 V	5.5% + 0.05 V

* The accuracy for AC Volts 200.0 mV range is in the frequency range of 40 Hz to 100 Hz. For example, for a 10 V using the DC Volts function in the 20.00 V range, calculate the accuracy using the following equation:

$$10\ V \times 0.5\% + 20\ mV = 0.07\ V$$

Input impedance..10 MΩ

Current Measurement

DC ranges ....20 mA, 200 mA, 1 A

AC ranges ....20 mA_{rms}, 200 mA_{rms}, 1 A_{rms}

Note All AC accuracy specifications within 20 mA and 200 mA ranges apply to signal amplitudes greater than 5% of range. All AC accuracy specifications within the 1 A range apply to signal amplitudes greater than 10% of range.

Accuracy

Function	Range	Resolution	Accuracy ± ([% of Reading] + Offset)	
DC Amps	20.00 mA	0.01 mA	0.5% + 0.03 mA	
	200.0 mA	0.1 mA	0.5% + 0.3 mA	
	1.000 A	0.001 A	0.5% + 3 mA	
			40 to 400 Hz	**400 to 2,000 Hz**
AC Amps	20.00 mA	0.01 mA	1.4% + 0.06 mA	5% + 0.06 mA
	200.0 mA	0.1 mA	1.5% + 0.8 mA	5% + 0.8 mA
	1.000 A	0.001 A	1.6% + 6 mA	5% + 6 mA

Input protection.. Internal ceramic fuse, 1.25 A 250 V, fast-acting, 5 × 20 mm, F 1.25A H 250V (Littelfuse part number 02161.25)

Resistance Measurement

Ranges .... 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ, 20 MΩ

Accuracy

Function	Range	Resolution	Accuracy ± ([% of Reading] + Offset)
Ω	200.0 Ω	0.1 Ω	0.8% + 0.3 Ω*
	2.000 kΩ	0.001 kΩ	0.8% + 3 Ω
	20.00 kΩ	0.01 kΩ	0.8% + 30 Ω
	200.0 kΩ	0.1 kΩ	0.8% + 300 Ω
	2.000 MΩ	0.001 MΩ	0.8% + 3 kΩ
	20.00 MΩ	0.01 MΩ	1.5% + 50 kΩ

* Exclusive of lead wire resistance

Diode Measurement

Range... 2 V

Power Supplies

Caution Do *not* mix power from NI myDAQ with power from external power sources. When using external power, remove any connections to the power supply terminals on NI myDAQ.

+15V Supply

Output voltage

- Typical (no load) .... 15.0 V
- Maximum voltage with no load .... 15.3 V
- Minimum voltage with full load .... 14.0 V

Maximum output current[1] .... 32 mA

Maximum load capacitance .... 470 µF

-15V Supply

Output voltage

- Typical (no load) .... -15.0 V
- Maximum voltage with no load .... -15.3 V
- Minimum voltage with full load .... -14.0 V

Maximum output current[1] .... 32 mA

Maximum load capacitance .... 470 µF

+5V Supply

Output voltage

- Typical (no load) .... 4.9 V
- Maximum voltage with no load .... 5.2 V
- Minimum voltage with full load .... 4.0 V

Maximum output current[1] .... 100 mA

Maximum load capacitance .... 33 µF

Calculating Power Consumption

The total power available for the power supplies, analog outputs, and digital outputs is limited to 500 mW (typical)/100 mW (minimum). To calculate the total power consumption of the power supplies, multiply the output voltage by the load current for each voltage rail and sum them together. For digital output power consumption, multiply 3.3 V by the load current. For

[1] The total power available for the power supplies, analog outputs, and digital outputs is limited to 500 mW (typical)/100 mW (minimum). Refer to the *Calculating Power Consumption* section for information on calculating the total power consumption of the components of your system.

analog output power consumption, multiply 15 V by the load current. Using audio output subtracts 100 mW from the total power budget.

For example, if you use 50 mA on +5 V, 2 mA on +15 V, 1 mA on -15 V, use four DIO lines to drive LEDs at 3 mA each, and have a 1 mA load on each AO channel, the total output power consumption is:

$5 \text{ V} \times 50 \text{ mA} = 250 \text{ mW}$

$|+15 \text{ V}| \times 2 \text{ mA} = 30 \text{ mW}$

$|-15 \text{ V}| \times 1 \text{ mA} = 15 \text{ mW}$

$3.3 \text{ V} \times 3 \text{ mA} \times 4 = 39.6 \text{ mW}$

$15 \text{ V} \times 1 \text{ mA} \times 2 = 30 \text{ mW}$

Total output power consumption = 250 mW + 30 mW + 15 mW + 39.6 mW + 30 mW = 364.6 mW

Communication

Bus interface .... USB 2.0 Hi-Speed

Physical Characteristics

Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.

Dimensions (without screw terminal connector)

NI myDAQ device part number 195509D-01L and earlier .... 14.6 cm × 8.7 cm × 2.2 cm (5.75 in. × 3.43 in. × 0.87 in.)

NI myDAQ device part number 195509E-01L and later .... 13.6 cm × 8.8 cm × 2.4 cm (5.36 in. × 3.48 in. × 0.95 in.)

Weight

NI myDAQ device part number 195509D-01L and earlier .... 175.0 g (6.1 oz)

NI myDAQ device part number 195509E-01L and later .... 164.0 g (5.8 oz)

Note NI myDAQ device part number (*P/N: 195509*x*-01L*) is located on the product label on the bottom of the device.

Screw-terminal wiring .... 16 to 26 AWG

Torque for screw terminals .... 0.22-0.25 N · m (2.0-2.2 lb · in.)

Environmental

Operating temperature
(IEC 60068-2-1 and IEC 60068-2-2)................0 to 45 °C

Storage temperature
(IEC 60068-2-1 and IEC 60068-2-2)................-20 to 70 °C

Operating humidity
(IEC 60068-2-56)..10 to 90% RH, noncondensing

Storage humidity
(IEC 60068-2-56)..10 to 90% RH, noncondensing

Maximum altitude..2,000 m (at 25 °C ambient temperature)

Pollution Degree (IEC 60664) 2

Indoor use only.

Safety

Safety Voltages

Measurement Category I[1] is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not use this module for connection to signals or for measurements within Measurement Categories II, III, or IV.

Safety Standards

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Caution Using the NI myDAQ in a manner not described in this document may impair the protection the NI myDAQ provides.

[1] Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Hazardous Locations

The NI myDAQ device is not certified for use in hazardous locations.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class B emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class B emissions
- EN 55022 (CISPR 22): Class B emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class B emissions
- AS/NZS CISPR 22: Class B emissions
- FCC 47 CFR Part 15B: Class B emissions
- ICES-001: Class B emissions

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Online Product Certification

To obtain product certifications and the Declaration of Conformity (DoC) for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at `ni.com/environment`. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers This symbol indicates that waste products must be disposed of separately from municipal household waste, according to Directive 2002/96/EC of the European Parliament and the Council on waste electrical and electronic equipment (WEEE). All products at the end of their life cycle must be sent to a WEEE collection and recycling center. Proper WEEE disposal reduces environmental impact and the risk to human health due to potentially hazardous substances used in such equipment. Your cooperation in proper WEEE disposal will contribute to the effective usage of natural resources. For information about the available collection and recycling scheme in a particular country, go to `ni.com/citizenship/weee`.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Worldwide Support and Services

The National Instruments website is your complete resource for technical support. At `ni.com/support` you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit `ni.com/services` for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit `ni.com/register` to register your National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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373061F-01 Aug14

Attachment C

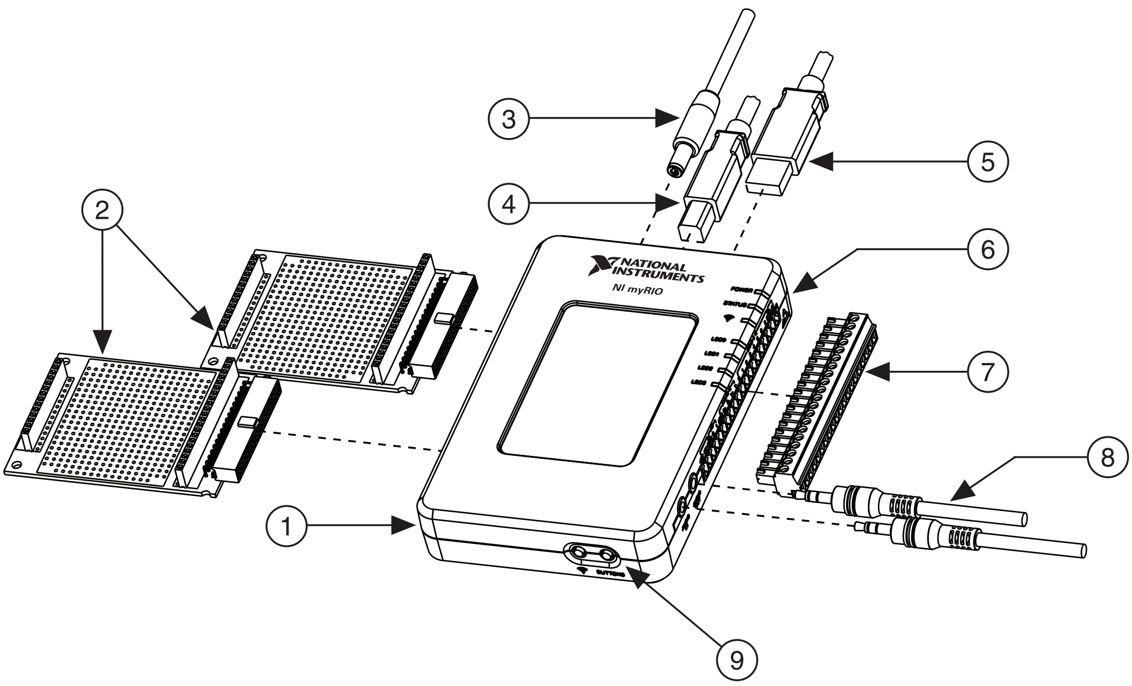
myRIO specification

USER GUIDE AND SPECIFICATIONS

NI myRIO-1900

The National Instruments myRIO-1900 is a portable reconfigurable I/O (RIO) device that students can use to design control, robotics, and mechatronics systems. This document contains pinouts, connectivity information, dimensions, mounting instructions, and specifications for the NI myRIO-1900.

Figure 1. NI myRIO-1900



1	NI myRIO-1900	6	LEDs
2	myRIO Expansion Port (MXP) Breakouts (One Included in Kit)	7	Mini System Port (MSP) Screw-Terminal Connector
3	Power Input Cable	8	Audio In/Out Cables (One Included in Kit)
4	USB Device Cable	9	Button0
5	USB Host Cable (Not Included in Kit)		

Safety Information

Caution Do not operate the hardware in a manner not specified in this document and in the user documentation. Misuse of the hardware can result in a hazard. You can compromise the safety protection if the hardware is damaged in any way. If the hardware is damaged, return it to National Instruments for repair.

Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in commercial locations. There is no guarantee that harmful interference will not occur in a particular installation or when the product is connected to a test object. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Caution This product was tested for EMC compliance using myRIO application software. The maximum length for USB cables is 2.0 m (6.6 ft), and the maximum length for signal wires is 30.0 cm (11.8 in.).

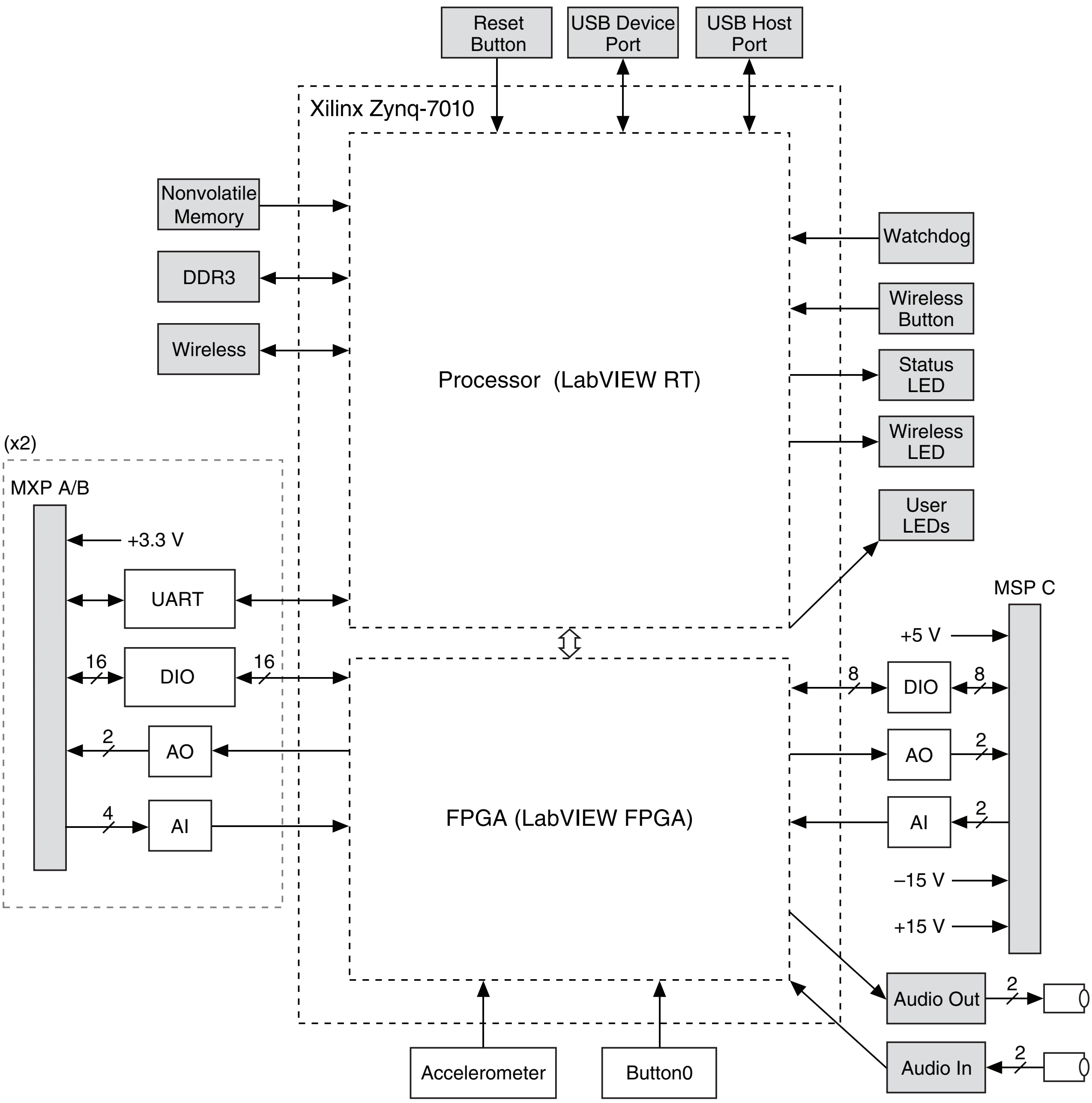
Caution The mounting keyholes on the back of the NI myRIO-1900 are sensitive to electrostatic discharge (ESD). When handling the device, be careful not to touch inside the keyholes.

Hardware Overview

The NI myRIO-1900 provides analog input (AI), analog output (AO), digital input and output (DIO), audio, and power output in a compact embedded device. The NI myRIO-1900 connects to a host computer over USB and wireless 802.11b,g,n.

The following figure shows the arrangement and functions of NI myRIO-1900 components.

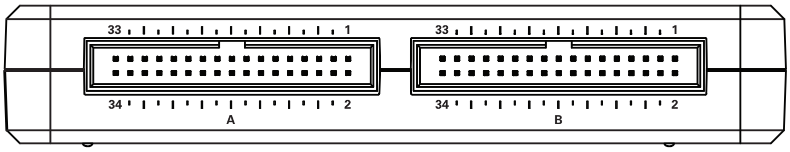
Figure 2. NI myRIO-1900 Hardware Block Diagram



Connector Pinouts

NI myRIO-1900 Expansion Port (MXP) connectors A and B carry identical sets of signals. The signals are distinguished in software by the connector name, as in `ConnectorA/DIO1` and `ConnectorB/DIO1`. Refer to the software documentation for information about configuring and using signals. The following figure and table show the signals on MXP connectors A and B. Note that some pins carry secondary functions as well as primary functions.

Figure 3. Primary/Secondary Signals on MXP Connectors A and B



+3.3 V	DIO10 / PWM2	DIO9 / PWM1	DIO8 / PWM0	DIO7 / SPI.MOSI	DIO6 / SPI.MISO	DIO5 / SPI.CLK	DIO4	DIO3	DIO2	DIO1	DIO0	AI3	AI2	AI1	AI0	+5V
33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2
DIO15 / I2C.SDA	DIO14 / I2C.SCL	DGND	DGND	DIO13	DGND	DIO12 / ENC.B	DGND	DIO11 / ENC.A	DGND	UART.TX	DGND	UART.RX	DGND	AGND	AO1	AO0

Table 1. Descriptions of Signals on MXP Connectors A and B

Signal Name	Reference	Direction	Description
+5V	DGND	Output	+5 V power output.
AI <0..3>	AGND	Input	0-5 V, referenced, single-ended analog input channels. Refer to the *Analog Input Channels* section for more information.
AO <0..1>	AGND	Output	0-5 V referenced, single-ended analog output. Refer to the *Analog Output Channels* section for more information.
AGND	N/A	N/A	Reference for analog input and output.
+3.3V	DGND	Output	+3.3 V power output.
DIO <0..15>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the *DIO Lines* section for more information.
UART.RX	DGND	Input	UART receive input. UART lines are electrically identical to DIO lines.
UART.TX	DGND	Output	UART transmit output. UART lines are electrically identical to DIO lines.
DGND	N/A	N/A	Reference for digital signals, +5 V, and +3.3 V.

The following figure and table show the signals on Mini System Port (MSP) connector C. Note that some pins carry secondary functions as well as primary functions.

Figure 4. Primary/Secondary Signals on MSP Connector C

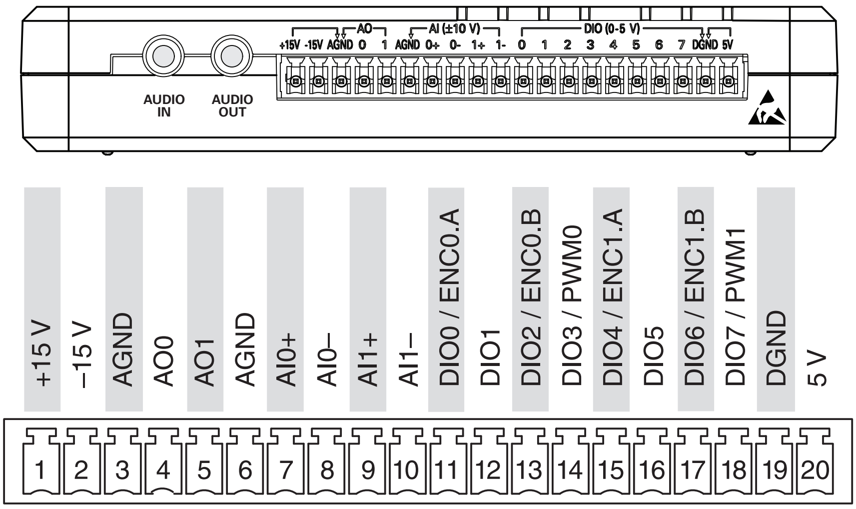


Table 2. Descriptions of Signals on MSP Connector C

Signal Name	Reference	Direction	Description
+15V/-15V	AGND	Output	+15 V/-15 V power output.
AI0+/AI0-; AI1+/AI1-	AGND	Input	±10 V, differential analog input channels. Refer to the *Analog Input Channels* section for more information.
AO <0..1>	AGND	Output	±10 V referenced, single-ended analog output channels. Refer to the *Analog Output Channels* section for more information.
AGND	N/A	N/A	Reference for analog input and output and +15 V/-15 V power output.
+5V	DGND	Output	+5 V power output.
DIO <0..7>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the *DIO Lines* section for more information.
DGND	N/A	N/A	Reference for digital lines and +5 V power output.

Table 3. Descriptions of Signals on Audio Connectors

Signal Name	Reference	Direction	Description
AUDIO IN	N/A	Input	Left and right audio inputs on stereo connector.
AUDIO OUT	N/A	Output	Left and right audio outputs on stereo connector.

Analog Input Channels

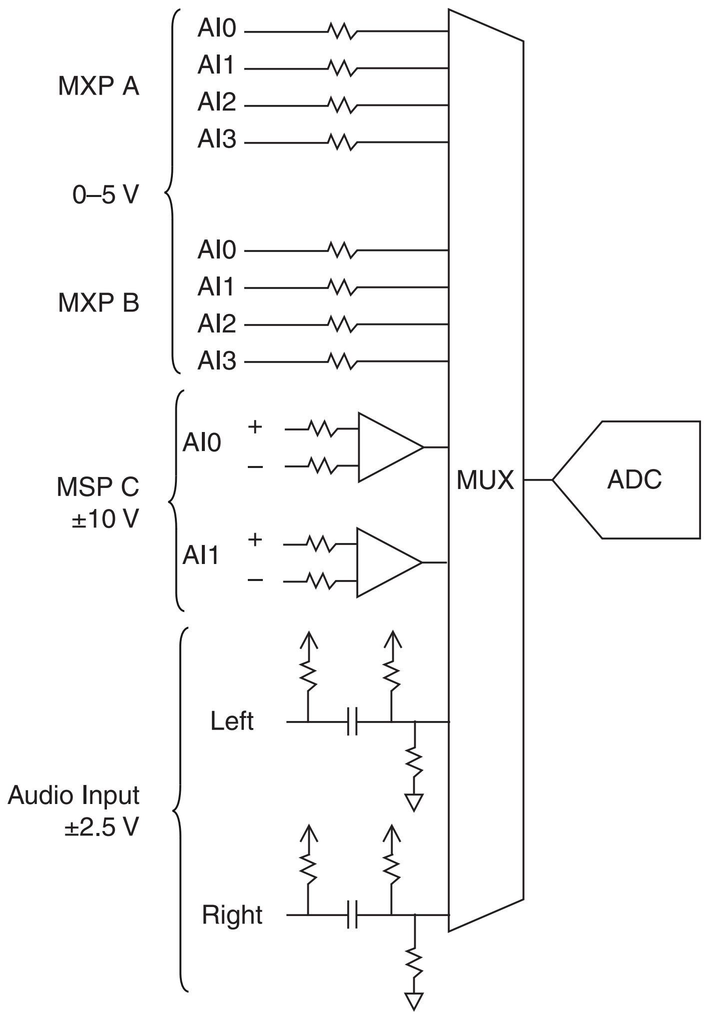
The NI myRIO-1900 has analog input channels on myRIO Expansion Port (MXP) connectors A and B, Mini System Port (MSP) connector C, and a stereo audio input connector. The analog inputs are multiplexed to a single analog-to-digital converter (ADC) that samples all channels.

MXP connectors A and B have four single-ended analog input channels per connector, AI0-AI3, which you can use to measure 0-5 V signals. MSP connector C has two high-impedance, differential analog input channels, AI0 and AI1, which you can use to measure signals up to ±10 V. The audio inputs are left and right stereo line-level inputs with a ±2.5 V full-scale range.

Note For important information about improving measurement accuracy by reducing noise, go to `ni.com/info` and enter the Info Code `analogwiring`.

Figure 5 shows the analog input topology of the NI myRIO-1900.

Figure 5. NI myRIO-1900 Analog Input Circuitry



Analog Output Channels

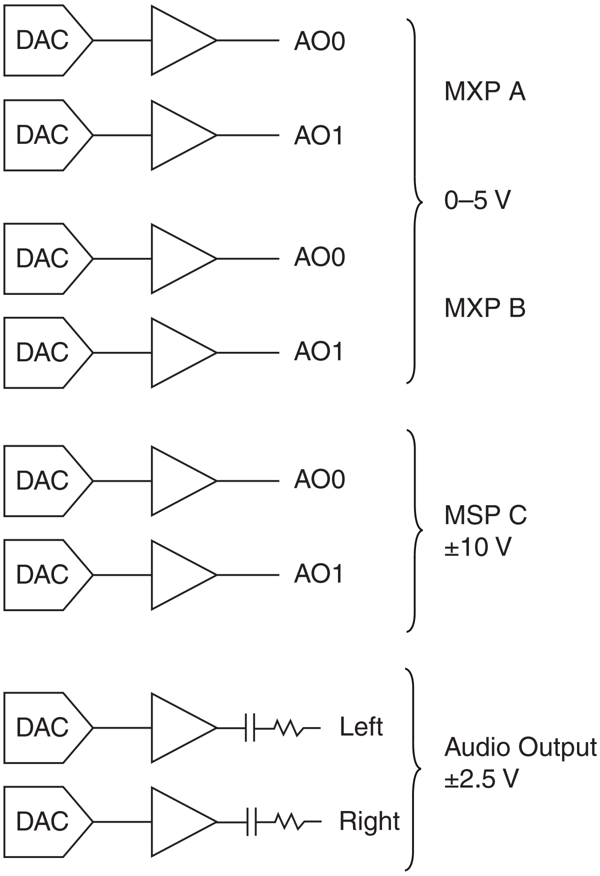
The NI myRIO-1900 has analog output channels on myRIO Expansion Port (MXP) connectors A and B, Mini System Port (MSP) connector C, and a stereo audio output connector. Each analog output channel has a dedicated digital-to-analog converter (DAC), so they can all update simultaneously. The DACs for the analog output channels are controlled by two serial communication buses from the FPGA. MXP connectors A and B share one bus, and MSP connector C and the audio outputs share a second bus. Therefore, the maximum update rate is specified as an aggregate figure in the *Analog Output* section of the *Specifications*.

MXP connectors A and B have two analog output channels per connector, AO0 and AO1, which you can use to generate 0-5 V signals. MSP connector C has two analog output channels, AO0 and AO1, which you can use to generate signals up to ±10 V. The audio outputs are left and right stereo line-level outputs capable of driving headphones.

Caution Before using headphones to listen to the audio output of the NI myRIO-1900, ensure that the audio output is at a safe level. Listening to audio signals at a high volume may result in permanent hearing loss.

Figure 6 shows the analog output topology of the NI myRIO-1900.

Figure 6. NI myRIO-1900 Analog Output Circuitry



Accelerometer

The NI myRIO-1900 contains a three-axis accelerometer. The accelerometer samples each axis continuously and updates a readable register with the result. Refer to the *Accelerometer* section of the *Specifications* for the accelerometer sample rates.

Converting Raw Data Values to Voltage

You can use the following equations to convert raw data values to volts:

$$V = Raw\ Data\ Value * LSB\ Weight$$

$$LSB\ Weight = Nominal\ Range \div 2^{ADC\ Resolution}$$

where *Raw Data Value* is the value returned by the FPGA I/O Node,

LSB Weight is the value in volts of the increment between data values,

Nominal Range is the absolute value in volts of the full, peak-to-peak nominal range of the channel,

and *ADC Resolution* is the resolution of the ADC in bits. (*ADC Resolution* = 12.)

- For AI and AO channels on the MXP connectors,

$$LSB\ Weight = 5\ \text{V} \div 2^{12} = 1.221\ \text{mV}$$

$$Maximum\ reading = 4095 * 1.221\ \text{mV} = 4.999\ \text{V}$$

- For AI and AO channels on the MSP connectors,

$$LSB\ Weight = 20\ \text{V} \div 2^{12} = 4.883\ \text{mV}$$

$$Maximum\ Positive\ Reading = +2047 * 4.883\ \text{mV} = 9.995\ \text{V}$$

$$Maximum\ Negative\ Reading = -2048 * 4.883\ \text{mV} = -10.000\ \text{V}$$

- For Audio In/Out,

$$LSB\ Weight = 5\ \text{V} \div 2^{12} = 1.221\ \text{mV}$$

$$Maximum\ Positive\ Reading = +2047 * 1.221\ \text{mV} = 2.499\ \text{V}$$

$$Maximum\ Negative\ Reading = -2048 * 1.221\ \text{mV} = -2.500\ \text{V}$$

- For the accelerometer,

$$LSB\ Weight = 16\ \text{g} \div 2^{12} = 3.906\ \text{mg}$$

$$Maximum\ Positive\ Reading = +2047 * 3.906\ \text{mg} = +7.996\ \text{g}$$

$$Maximum\ Negative\ Reading = -2048 * 3.906\ \text{mg} = -8.000\ \text{g}$$

DIO Lines

The NI myRIO-1900 has 3.3 V general-purpose DIO lines on the MXP and MSP connectors. MXP connectors A and B have 16 DIO lines per connector. On the MXP connectors, each DIO line from 0 to 13 has a 40 kΩ pullup resistor to 3.3 V, and DIO lines 14 and 15 have 2.2 kΩ pullup resistors to 3.3 V. MSP connector C has eight DIO lines. Each MSP DIO line has a 40 kΩ pulldown resistor to ground. DGND is the reference for all the DIO lines. You can program all the lines individually as inputs or outputs. Secondary digital functions include Serial Peripheral

Interface Bus (SPI), I2C, pulse-width modulation (PWM), and quadrature encoder input. Refer to the NI myRIO software documentation for information about configuring the DIO lines.

Figure 7. DIO Lines <13..0> on MXP Connector A or B

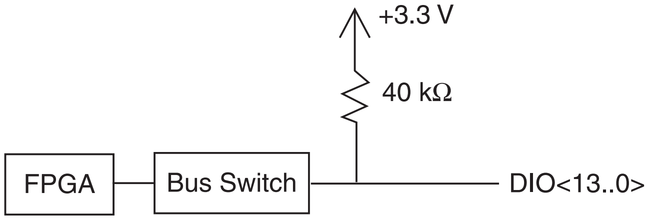


Figure 8. DIO Lines <15..14> on MXP Connector A or B

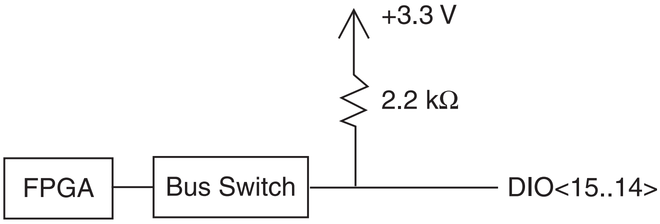
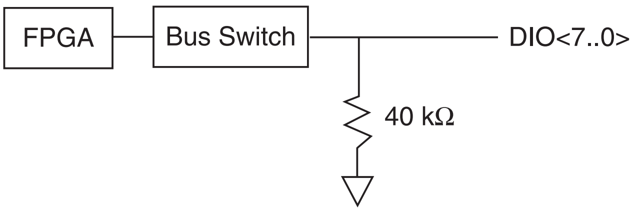


Figure 9. DIO Lines <7..0> on MSP Connector C



When a DIO line is floating, it floats in the direction of the pull resistor. A DIO line may be floating in any of the following conditions:

- when the myRIO device is starting up
- when the line is configured as an input
- when the myRIO device is powering down

You can add a stronger resistor to a DIO line to cause it to float in the opposite direction.

UART Lines

The NI myRIO-1900 has one UART receive input line and one UART transmit ouput line on each MXP connector. The UART lines are electrically identical to DIO lines 0 to 13 on the MXP connectors. Like those lines, UART.RX and UART.TX have 40 kΩ pullup resistors to 3.3 V. Use LabVIEW Real-Time to read and write over the UART lines.

Using the Reset Button

Pressing and releasing the Reset button restarts the processor and the FPGA.

Pressing and holding the Reset button for 5 seconds, then releasing it, restarts the processor and the FPGA and forces the NI myRIO-1900 into safe mode. In safe mode, the NI myRIO-1900 launches only the services necessary for updating configuration and installing software.

When the NI myRIO-1900 is in safe mode, you can communicate with it by using the UART lines on MXP connector A. You need the following items to communicate with the myRIO device over UART:

- USB-to-TTL serial UART converter cable (for example, part number TTL-232RG-VSW3V3-WE from FTD Chip)
- Serial-port terminal program configured with the following settings:
  - 115,200 bits per second
  - Eight data bits
  - No parity
  - One stop bit
  - No flow control

Using the Wireless Button and LED

For information about using the Wireless button, go to `ni.com/info` and enter the Info Code `myriowirelessbutton`.

For information about using the Wireless LED, go to `ni.com/info` and enter the Info Code `myriowirelessled`.

Using Button0

Button0 produces a logic TRUE when depressed and a logic FALSE when not depressed. Button0 is not debounced.

Understanding LED Indications

Power LED

The Power LED is lit while the NI myRIO-1900 is powered on. This LED indicates that the power supply connected to the device is adequate.

Status LED

The Status LED is off during normal operation. The NI myRIO-1900 runs a power-on self test (POST) when you apply power to the device. During the POST, the Power and Status LEDs turn on. When the Status LED turns off, the POST is complete. The NI myRIO-1900 indicates specific error conditions by flashing the Status LED a certain number of times every few seconds, as shown in Table 4.

Table 4. Status LED Indications

Number of Flashes Every Few Seconds	Indication
2	The device has detected an error in its software. This usually occurs when an attempt to upgrade the software is interrupted. Reinstall software on the device.
3	The device is in safe mode.
4	The software has crashed twice without rebooting or cycling power between crashes. This usually occurs when the device runs out of memory. Review your RT VI and check the memory usage. Modify the VI as necessary to solve the memory usage issue.
Continuously flashing or solid	The device has detected an unrecoverable error. Contact National Instruments.

LEDs 0-3

You can use LEDs 0-3 to help debug your application or easily retrieve application status. Logic TRUE turns an LED on and logic FALSE turns an LED off.

Using the USB Host Port

The NI myRIO-1900 USB host port supports Web cameras that conform to the USB Video Device Class (UVC) protocol as well as machine vision cameras that conform to the USB3 Vision standard and are USB 2.0 backward compatible. The NI myRIO-1900 USB host port also supports Basler ace USB3 cameras.

The NI myRIO-1900 USB host port also supports USB Flash drives and USB-to-IDE adapters formatted with FAT16 and FAT32 file systems. LabVIEW usually maps USB devices to the `/U`, `/V`, `/W`, or `/X` drive, starting with the `/U` drive if it is available.

NI myRIO-1900 Physical Dimensions

Figure 10. NI myRIO-1900 Dimensions, Front

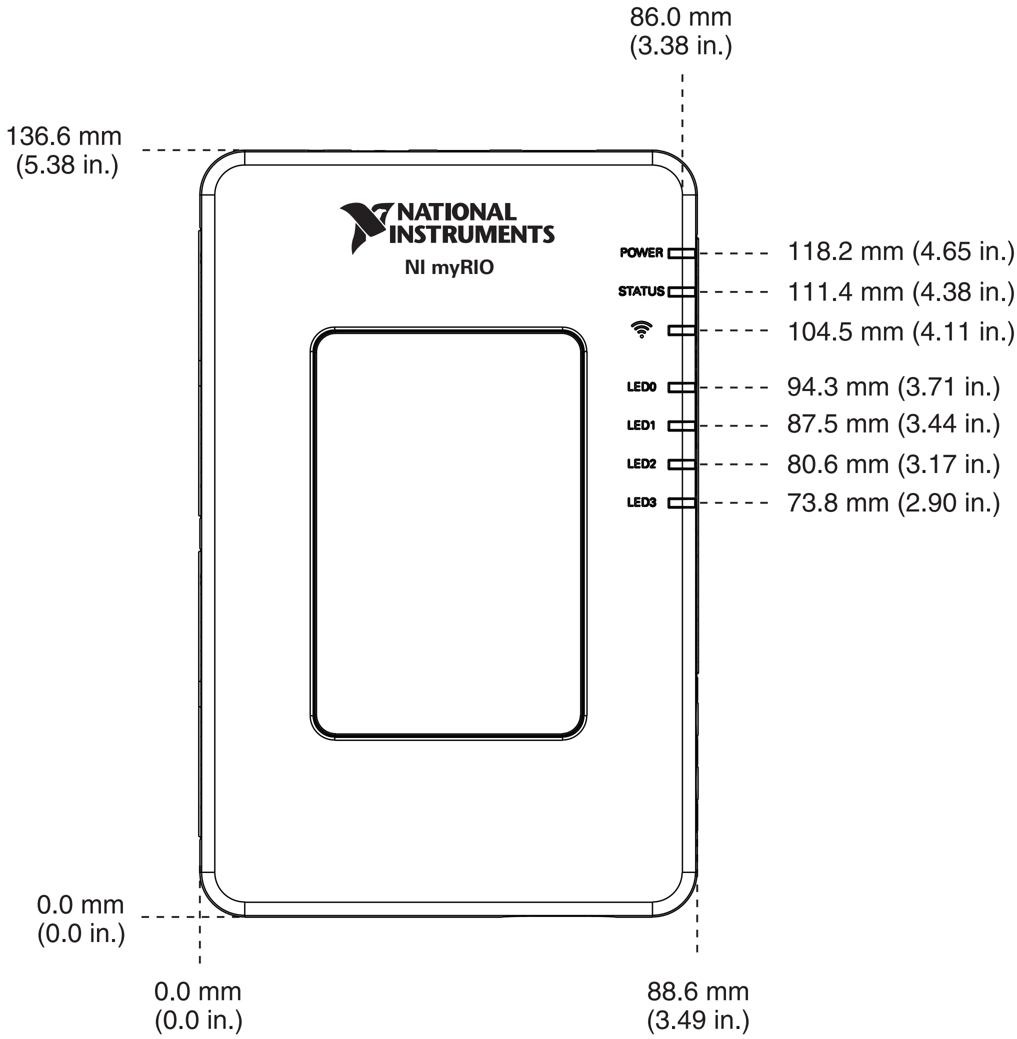


Figure 11. NI myRIO-1900 Dimensions, Back

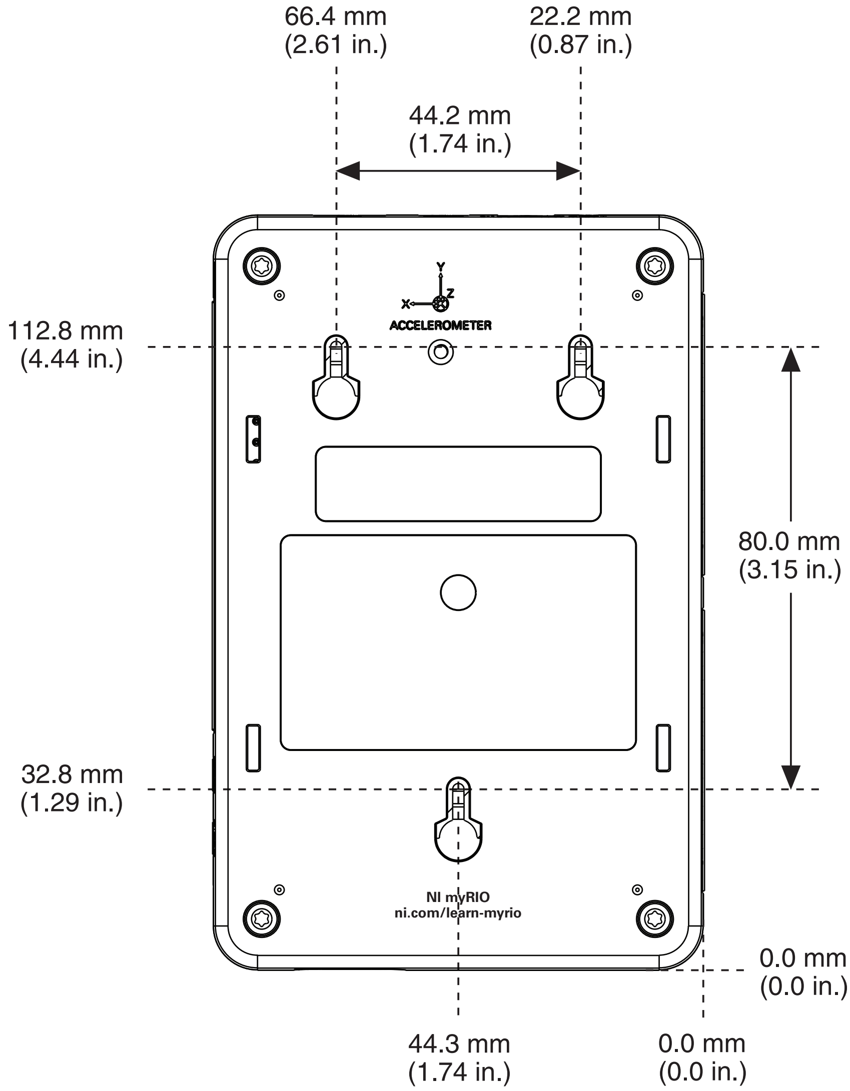
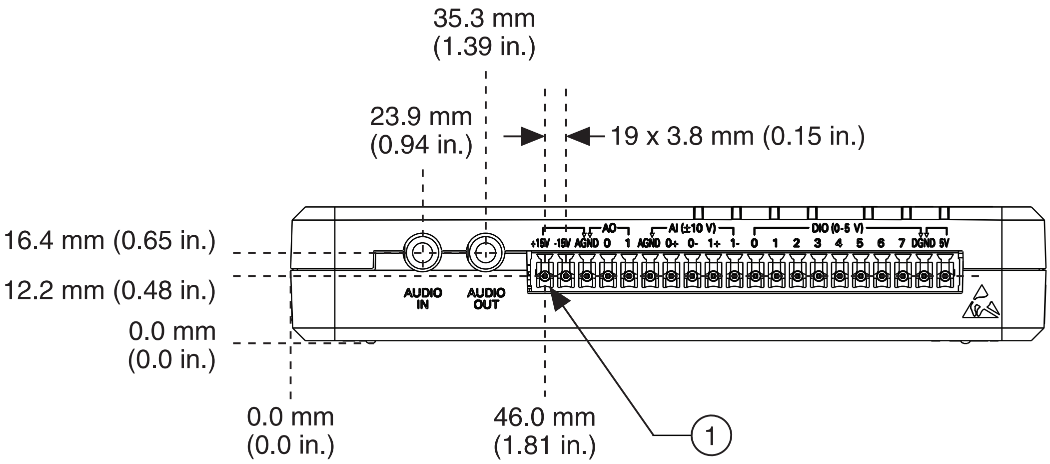
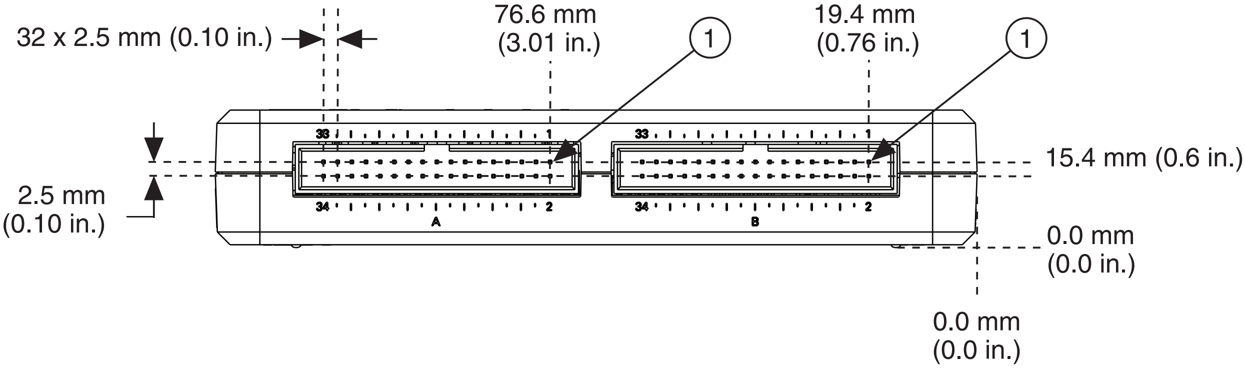


Figure 12. NI myRIO-1900 Dimensions, MSP Side



1 Pin 1

Figure 13. NI myRIO-1900 Dimensions, MXP Side



1 Pin 1

Figure 14. NI myRIO-1900 Dimensions, I/O End

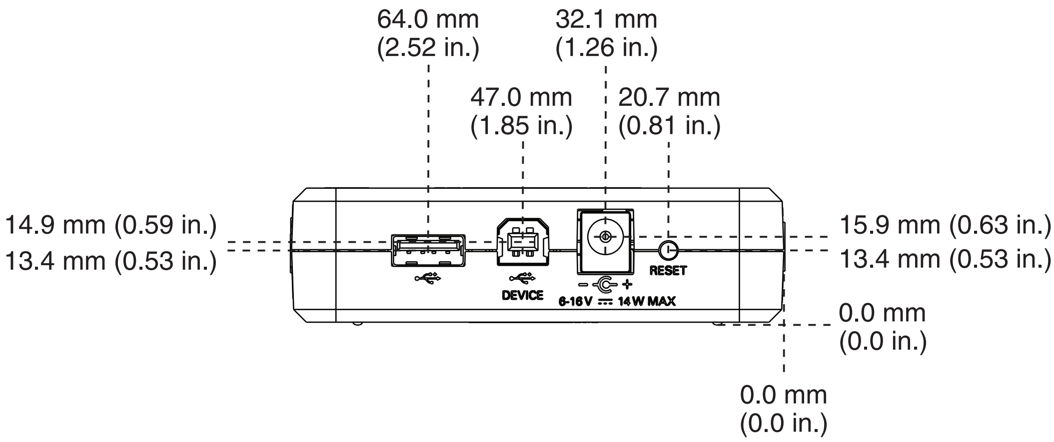
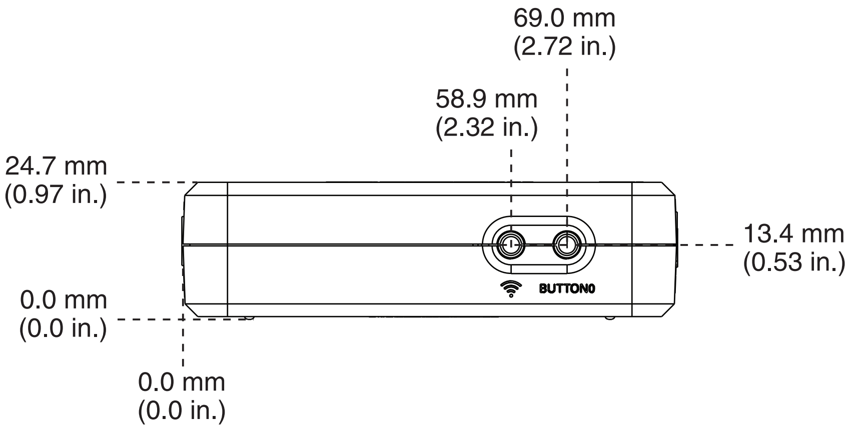


Figure 15. NI myRIO-1900 Dimensions, User End

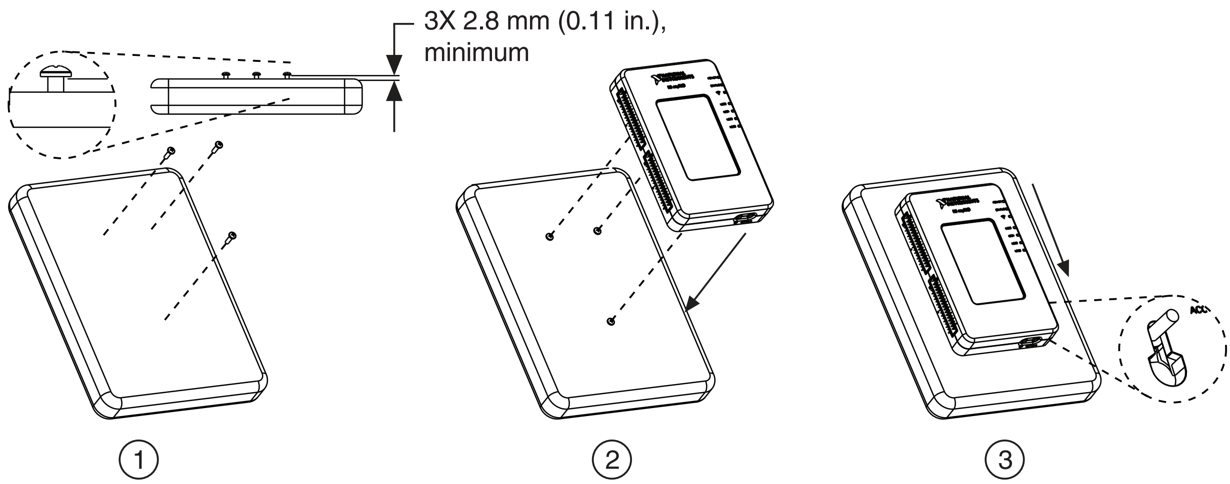


Mounting the NI myRIO-1900

Mounting the NI myRIO-1900 Using the Key Holes

You can use the provided key holes on NI myRIO-1900 to mount the device on a flat surface. Install the NI myRIO-1900 as shown in Figure 16. Use Unified #4 or ISO M3 screws to mount the NI myRIO-1900 using the key holes. Panhead screws are suitable for use with the NI myRIO-1900 key holes.

Figure 16. Mounting the NI myRIO-1900 Using the Key Holes

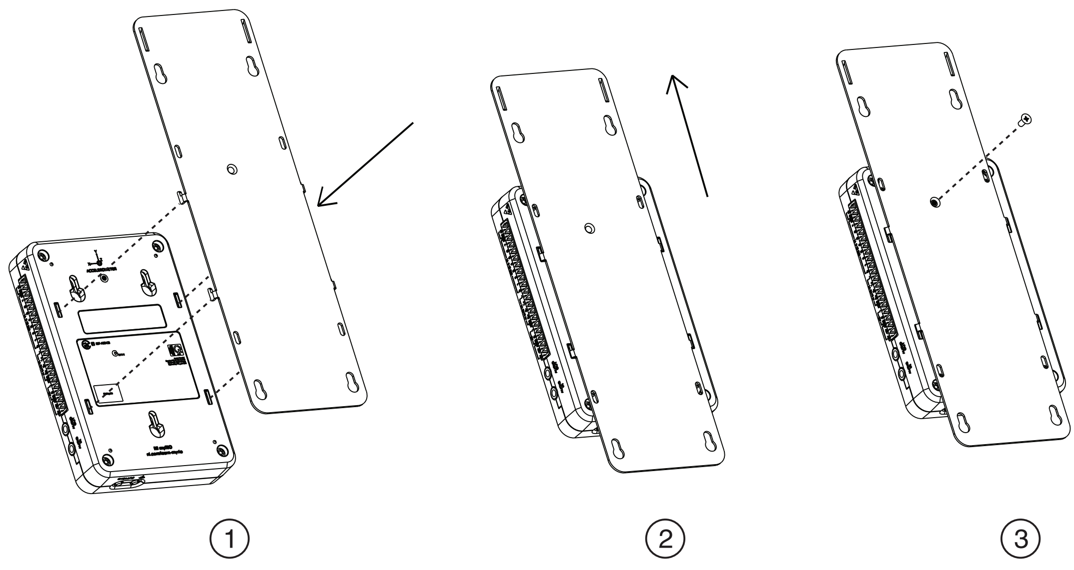


1 Install three Unified #4 or M3 screws in the flat surface using the key hole dimensions of the NI myRIO-1900 as a guide. Refer to Figure 11 for NI myRIO-1900 key hole dimensions. Leave a minimum spacing of 2.8 mm (0.11 in.) between the flat surface and the screw heads.
2 Place the NI myRIO-1900 on the screw heads.
3 Slide the NI myRIO-1900 down to secure the key holes on the screw heads.

Mounting the NI myRIO-1900 Using the Panel Mounting Kit

You can use the Panel Mounting Kit for NI myRIO-1900 to mount the device on a flat surface such as a panel or wall. Install the panel mounting kit on the NI myRIO-1900 as shown in Figure 17.

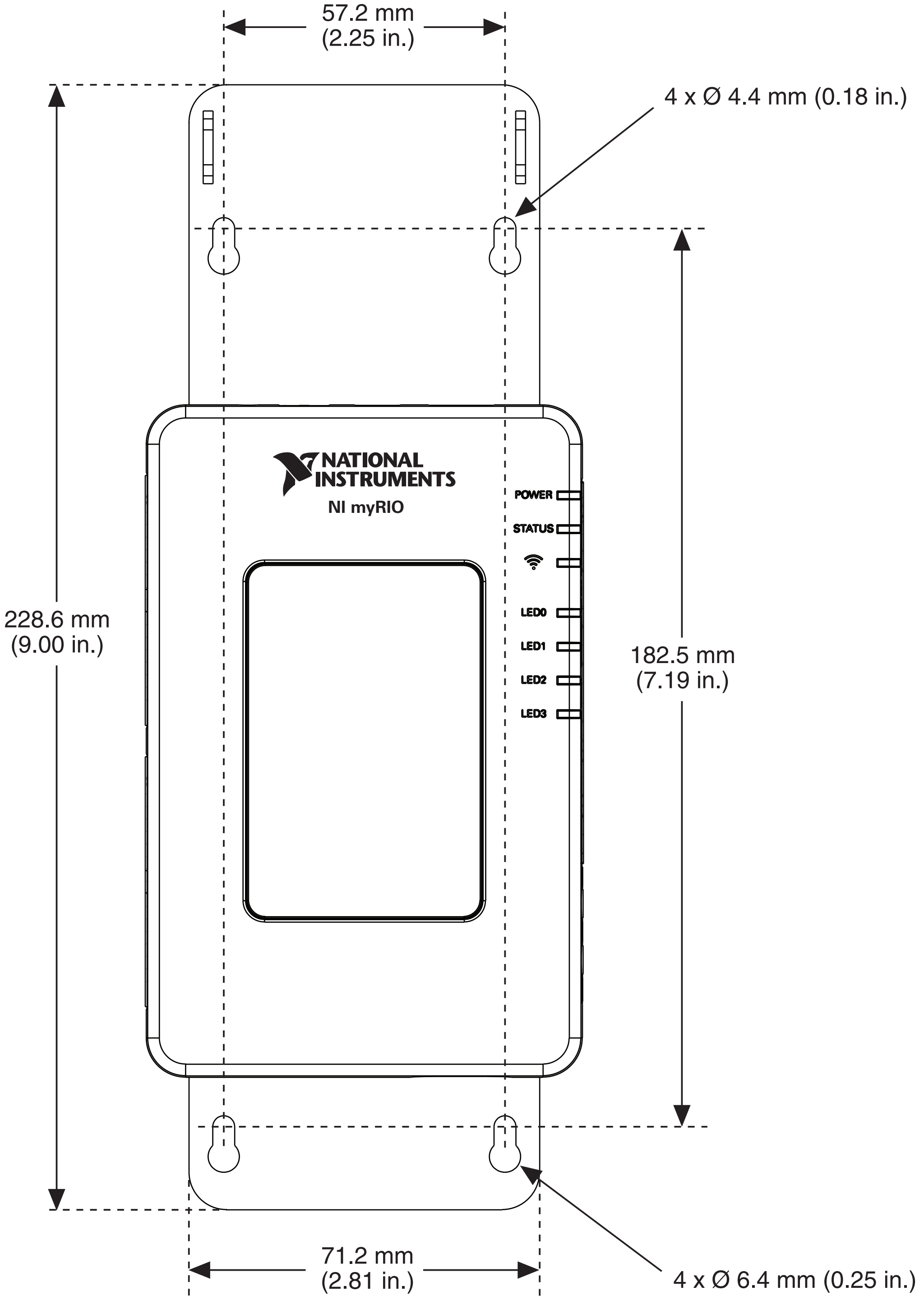
Figure 17. Installing the Panel Mounting Kit on the NI myRIO-1900



1 Place the panel on the back of the NI myRIO-1900
2 Slide the panel up to line up the screw holes on the panel and the NI myRIO-1900.
3 Secure the panel to the NI myRIO-1900. You must use the included 4-40 × 1/4 in. screw to attach the panel mounting kit to the NI myRIO-1900. Tighten the screw to 0.76 N · m (6.7 lb · in.) of torque. Do not exceed 0.87 N · m (7.7 lb · in.) of torque.

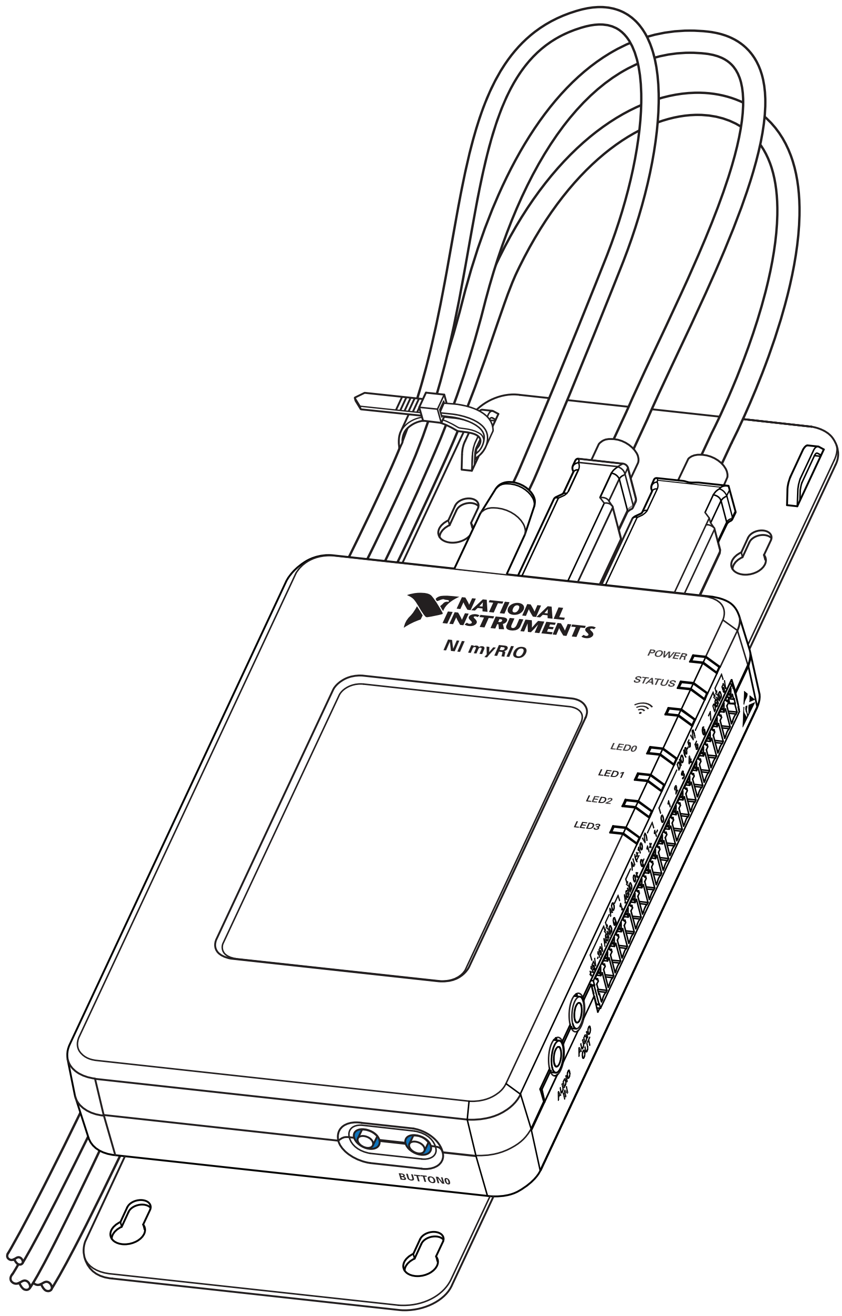
Fasten the panel mounting kit to the panel or wall using screws appropriate for the surface. The following figure shows the dimensions of the NI myRIO-1900 with the panel mounting kit installed.

Figure 18. Dimensions of NI myRIO-1900 with Panel Mounting Kit



Use a cable tie to secure the power and USB cables to the panel mounting kit as shown in Figure 19.

Figure 19. Securing the Power and USB Cables to the Panel Mounting Kit



Cables and Accessories

Table 5. Accessories Available from NI

Accessory	Description	NI Part Number
Power supply	Power supply for NI myRIO-1900	723403-01
MXP breakouts	Set of five MXP breakout boards for NI myRIO-1900	782696-01
MSP connector	MSP replacement connector plug for NI myRIO-1900	765788-01
Panel mounting kit	Panel mounting kit for NI myRIO-1900	783091-01

Specifications

The following specifications are typical for the 0 to 40 °C operating tempreature range unless otherwise noted.

Processor

Processor type ....Xilinx Z-7010

Processor speed..667 MHz

Processor cores 2

Memory

Nonvolatile memory ....256 MB

DDR3 memory..512 MB

  DDR3 clock frequency ....533 MHz

  DDR3 data bus width...............................16 bits

For information about the lifespan of the nonvolatile memory and about best practices for using nonvolatile memory, go to `ni.com/info` and enter the Info Code `SSDBP`.

FPGA

FPGA type ....Xilinx Z-7010

Wireless Characteristics

Radio mode ....IEEE 802.11 b,g,n

Frequency band..ISM 2.4 GHz

Channel width ....20 MHz

Channels	USA 1-11, International 1-13
TX power	+10 dBm max (10 mW)
Outdoor range	Up to 150 m (line of sight)
Antenna directivity	Omnidirectional
Security	WPA, WPA2, WPA2-Enterprise

USB Ports

USB host port	USB 2.0 Hi-Speed
USB device port	USB 2.0 Hi-Speed

Analog Input

Aggregate sample rate	500 kS/s
Resolution	12 bits
Overvoltage protection	±16 V
MXP connectors	
Configuration	Four single-ended channels per connector
Input impedance	>500 kΩ acquiring at 500 kS/s 1 MΩ powered on and idle 4.7 kΩ powered off
Recommended source impedance	3 kΩ or less
Nominal range	0 V to +5 V
Absolute accuracy	±50 mV
Bandwidth	>300 kHz
MSP connector	
Configuration	Two differential channels
Input impedance	Up to 100 nA leakage powered on; 4.7 kΩ powered off
Nominal range	±10 V
Working voltage (signal + common mode)	±10 V of AGND
Absolute accuracy	±200 mV
Bandwidth	20 kHz minimum, >50 kHz typical
Audio input	
Configuration	One stereo input consisting of two AC-coupled, single-ended channels
Input impedance	10 kΩ at DC
Nominal range	±2.5 V
Bandwidth	2 Hz to >20 kHz

Analog Output

Aggregate maximum update rates

All AO channels on MXP connectors....... 345 kS/s

All AO channels on MSP connector and audio output channels........................ 345 kS/s

Resolution .... 12 bits

Overload protection .... ±16 V

Startup voltage .... 0 V after FPGA initialization

MXP connectors

Configuration .... Two single-ended channels per connector

Range .... 0 V to +5 V

Absolute accuracy.................................... 50 mV

Current drive .... 3 mA

Slew rate .... 0.3 V/µs

MSP connector

Configuration .... Two single-ended channels

Range .... ±10 V

Absolute accuracy.................................... ±200 mV

Current drive .... 2 mA

Slew rate .... 2 V/µs

Audio output

Configuration .... One stereo output consisting of two AC-coupled, single-ended channels

Output impedance .... 100 Ω in series with 22 µF

Bandwidth... 70 Hz to >50 kHz into 32 Ω load; 2 Hz to >50 kHz into high-impedance load

Digital I/O

Number of lines

MXP connectors .... 2 ports of 16 DIO lines (one port per connector); one UART.RX and one UART.TX line per connector

MSP connector.. 1 port of 8 DIO lines

Direction control .... Each DIO line individually programmable as input or output

Logic level .... 5 V compatible LVTTL input; 3.3 V LVTTL output

Input logic levels

- Input low voltage, V_{IL} .... 0 V min; 0.8 V max
- Input high voltage, V_{IH} .... 2.0 V min; 5.25 V max

Output logic levels

- Output high voltage, V_{OH} sourcing 4 mA .... 2.4 V min; 3.465 V max
- Output low voltage, V_{OL} sinking 4 mA .... 0 V min; 0.4 V max

Minimum pulse width...................................... 20 ns

Maximum frequencies for secondary digital functions

- SPI .... 4 MHz
- PWM... 100 kHz
- Quadrature encoder input .... 100 kHz
- I^2C.. 400 kHz

UART lines

- Maximum baud rate................................. 230,400 bps
- Data bits... 5, 6, 7, 8
- Stop bits 1, 2
- Parity... Odd, Even, Mark, Space
- Flow control.. XON/XOFF

Accelerometer

Number of axes.. 3

Range.. ±8 g

Resolution... 12 bits

Sample rate .... 800 S/s

Noise... 3.9 mg_{rms} typical at 25 °C

Power Output

+5 V power output

- Output voltage .... 4.75 V to 5.25 V
- Maximum current on each connector .... 100 mA

+3.3 V power output

- Output voltage .... 3.0 V to 3.6 V
- Maximum current on each connector .... 150 mA

+15 power output

Output voltage.......................................+15 V to +16 V

Maximum current ....32 mA (16 mA during startup)

-15 V power output

Output voltage.......................................-15 V to -16 V

Maximum current ....32 mA (16 mA during startup)

Maximum combined power from +15 V and -15 V power output ....500 mW

Power Requirements

NI myRIO-1900 requires a power supply connected to the power connector.

Caution You must use either the power supply provided in the shipping kit, or another UL Listed ITE power supply marked *LPS*, with the NI myRIO-1900.

Power supply voltage range.............................6-16 VDC

Maximum power consumption.........................14 W

Typical idle power consumption......................2.6 W

Environmental

To meet these specifications, you must operate the NI myRIO-1900 with the window facing away from the mounting surface and ensure that there is at least 1 in. of clearance in front of the window during use.

Ambient temperature near device (IEC 60068-2-1, IEC 600682-2)......................0 to 40 °C

Storage temperature (IEC 60068-2-1, IEC 600682-2)......................-20 to 70 °C

Operating humidity (IEC 60068-2-56) ....10 to 90% RH, noncondensing

Storage humidity (IEC 60068-2-56)................10 to 90% RH, noncondensing

Maximum altitude..2,000 m

Pollution Degree (IEC 60664) 2

Indoor use only.

Physical Characteristics

Weight...193 g (6.8 oz)

Safety

Safety Standards

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Caution Using the NI myRIO-1900 in a manner not described in this document may impair the protection the NI myRIO-1900 provides.

Hazardous Locations

The NI myRIO-1900 is not certified for use in hazardous locations.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity
- EN 55022 (CISPR 22): Group 1, Class A emissions
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note For EMC declarations and certifications, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)
- 1999/5/EC; Radio and Telecommunications Terminal Equipment Directive (R&TTE)

Online Product Certification

To obtain product certifications and the Declaration of Conformity (DoC) for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at `ni.com/environment`. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste and Electronic Equipment, visit `ni.com/environment/weee`.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Regulatory Information

United States

FCC Radio Exposure

The radiated output power of this device is below the FCC radio frequency exposure limits. Nevertheless, this device should be used in such a manner that the potential for human contact during normal operation is minimized. This device has been evaluated for and shown compliant with the FCC RF Exposure limits under mobile exposure conditions (antennas are greater than 20 cm from a person's body). This device cannot be co-located with any other transmitter unless approved by FCC.

This product does not contain any user serviceable components. Any unauthorized product changes or modifications will invalidate the warranty and all applicable regulatory certifications and approvals.

FCC Interference Statement

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the manufacturer's instruction manual, may cause interference with radio and television reception. This equipment has been tested and found to comply with the limits for a Class B digital device pursuant to Part 15 of the FCC Rules.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

This wireless adapter generates, uses, and can radiate radio frequency energy. If the wireless adapter is not installed and used in accordance with the instructions, the wireless adapter may cause harmful interference to radio communications. There is no guarantee, however, that such interference will not occur in a particular installation. If this wireless adapter does cause harmful interference to radio or television reception (which can be determined by turning the equipment off and on), the user is encouraged to try to correct the interference by taking one or more of the following measures:

- Reorient or relocate the receiving antenna of the equipment experiencing the interference.
- Increase the distance between the wireless adapter and the equipment experiencing the interference.
- Connect the equipment to an outlet on a circuit different from which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canada

Industry Canada (IC) Notices

This product complies with Industry Canada RSS-210.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Under Industry Canada regulations, the radio transmitter(s) in this device may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Avis d’Industry Canada (IC)

Cet appareil est conforme aux norme RSS210 d’Industrie Canada.

Cet appareil est conforme aux normes d'exemption de licence RSS d’Industry Canada. Son fonctionnement est soumis aux deux conditions suivantes : (1) cet appareil ne doit pas causer d’interférence et (2) cet appareil doit accepter toute interférence, notamment les interférences qui peuvent affecter son fonctionnement.

Conformément aux réglementations d'Industry Canada, les émetteurs radio de cet appareil ne peuvent fonctionner qu’à l’aide d'une antenne dont le type et le gain maximal (ou minimal) pour ces émetteurs – transmetteurs sont approuvés par Industry Canada. Pour réduire le risque d’interférence éventuelle pour les autres utilisateurs, le type et le gain de l’antenne doivent être choisis de manière à ce que la puissance isotrope rayonnée équivalente (p.i.r.e.) minimale nécessaire à une bonne communication soit fournie.

EU Regulatory Statements

cs	Česky [Czech]	*National Instruments* tímto prohlašuje, _e tento NI myRIO-1900 je ve shodě se základními po_adavky a dalšími příslušnými ustanoveními směrnice 1999/5/ES.
da	Dansk [Danish]	Undertegnede *National Instruments* erklćrer herved, at fřlgende udstyr NI cDAQ-9191 overholder de vćsentlige krav og řvrige relevante krav i direktiv 1999/5/EF.
de	Deutsch [German]	Hiermit erklärt *National Instruments*, dass sich das Gerät NI myRIO-1900 in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 1999/5/EG befindet.
et	Eesti [Estonian]	Käesolevaga kinnitab*National Instruments* seadme NI myRIO-1900 vastavust direktiivi 1999/5/EÜ põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele.
en	English	Hereby, *National Instruments*, declares that this NI myRIO-1900 is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
es	Español [Spanish]	Por medio de la presente *National Instruments* declara que el NI myRIO-1900 cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 1999/5/CE.
el	Ελληνική [Greek]	ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ *National Instruments* ΔΗΛΩΝΕΙ ΟΤΙ NI myRIO-1900 ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 1999/5/ΕΚ.
fr	Français [French]	Par la présente *National Instruments* déclare que l'appareil NI myRIO-1900 est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 1999/5/CE.
it	Italiano [Italian]	Con la presente *National Instruments* dichiara che questo NI myRIO-1900 è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 1999/5/CE.
lv	Latviski [Latvian]	Ar šo *National Instruments* deklarē, ka NI myRIO-1900 atbilst Direktīvas 1999/5/EK būtiskajām prasībām un citiem ar to saistītajiem noteikumiem.
lt	Lietuvių [Lithuanian]	Šiuo *National Instruments* deklaruoja, kad šis NI myRIO-1900 atitinka esminius reikalavimus ir kitas 1999/5/EB Direktyvos nuostatas.
nl	Nederlands [Dutch]	Hierbij verklaart *National Instruments* dat het toestel NI myRIO-1900 in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 1999/5/EG.
mt	Malti [Maltese]	Hawnhekk, *National Instruments*, jiddikjara li dan NI myRIO-1900 jikkonforma mal-htigijiet essenzjali u ma provvedimenti ohrajn relevanti li hemm fid-Dirrettiva 1999/5/EC.
hu	Magyar [Hungarian]	Alulírott, *National Instruments* nyilatkozom, hogy a NI myRIO-1900 megfelel a vonatkozó alapvetõ követelményeknek és az 1999/5/EC irányelv egyéb elõírásainak.

pl	Polski [Polish]	Niniejszym *National Instruments*. oświadcza, że NI myRIO-1900 jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 1999/5/EC.
pt	Português [Portuguese]	*National Instruments* declara que este NI myRIO-1900 está conforme com os requisitos essenciais e outras disposições da Directiva 1999/5/CE.
sl	Slovensko [Slovenian]	*National Instruments* izjavlja, da je ta NI myRIO-1900 v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 1999/5/ES.
sk	Slovensky [Slovak]	*National Instruments* týmto vyhlasuje, _e NI myRIO-1900 spĺňa základné po_iadavky a všetky príslušné ustanovenia Smernice 1999/5/ES.
fi	Suomi [Finnish]	*National Instruments* vakuuttaa täten että NI myRIO-1900 tyyppinen laite on direktiivin 1999/5/EY oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen.
sv	Svenska [Swedish]	Härmed intygar *National Instruments* att denna NI myRIO-1900 står I överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 1999/5/EG.
	Íslenska [Icelandic]	Hér með lýsir *National Instruments* yfir því að NI myRIO-1900 er í samræmi við grunnkröfur og aðrar kröfur, sem gerðar eru í tilskipun 1999/5/EC.
no	Norsk [Norwegian]	*National Instruments* erklærer herved at utstyret NI myRIO-1900 er i samsvar med de grunnleggende krav og øvrige relevante krav i direktiv 1999/5/EF.

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Singapore

Complies with IDA Standards DA105692

Taiwan R.O.C.

低功率電波輻性電機管理辦法
第十二條經型式認證合格之低功率射頻電機，非經許可，公司、商號或使
用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。
第十四條低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發
現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。
前項合法通信，指依電信規定作業之無線電信。低功率射頻電機須忍受合法通信
或工業、科學及醫療用電波輻射性電機設備之干擾。

Mexico

La operación de este equipo está sujeta a las siguientes dos condiciones:
1) es posible que este equipo o dispositivo no cause interferencia perjudicial y
2) este equipo debe aceptar cualquier interferencia, incluyendo la que pueda causar su propia operación no deseada.

Brazil

ANATEL 2078-13-9228

(01)07898909336299

Brasil-Aviso da Anatel

Este equipamento opera em caráter secundário, isto é, não tem direito a proteção contra interferência prejudicial, mesmo de estações do mesmo tipo, e não pode causar interferência a sistemas operando em caráter primário.

Warranty

For customers other than private individual users in the EU: The NI myRIO-1900 is warranted against defects in materials and workmanship for a period of one year from the date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

For private individual users in the EU: Based on your statutory rights, National Instruments will—through its distributor—cure defects in materials and workmanship within two years from delivery.

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting ni.com/certification. If your product supports calibration, you can obtain the calibration certificate for your product at ni.com/calibration.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at ni.com/support and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, visit the Worldwide Offices section of ni.com/niglobal to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

376047A-01 Aug13

Attachment D

myRIO overview

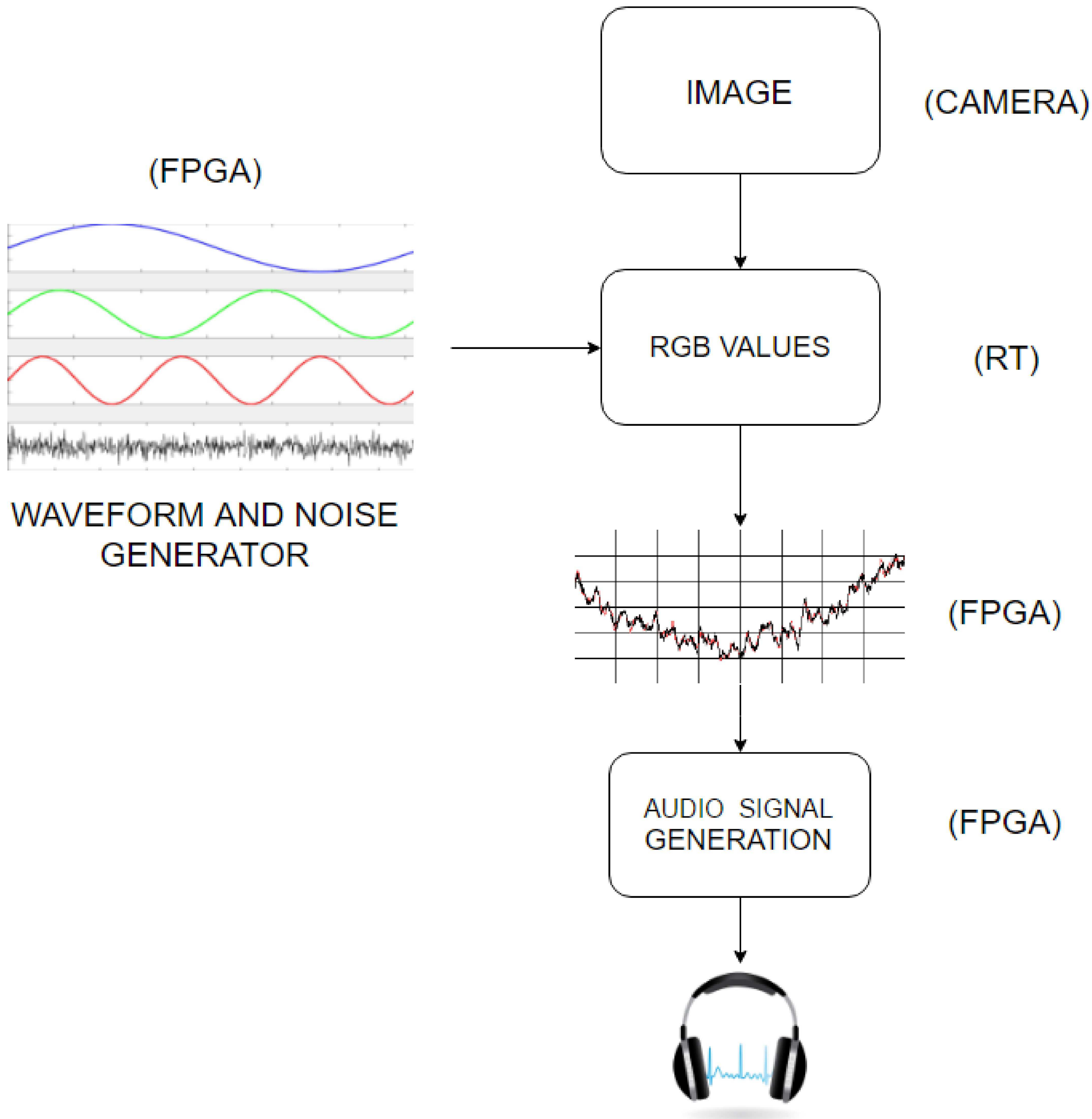
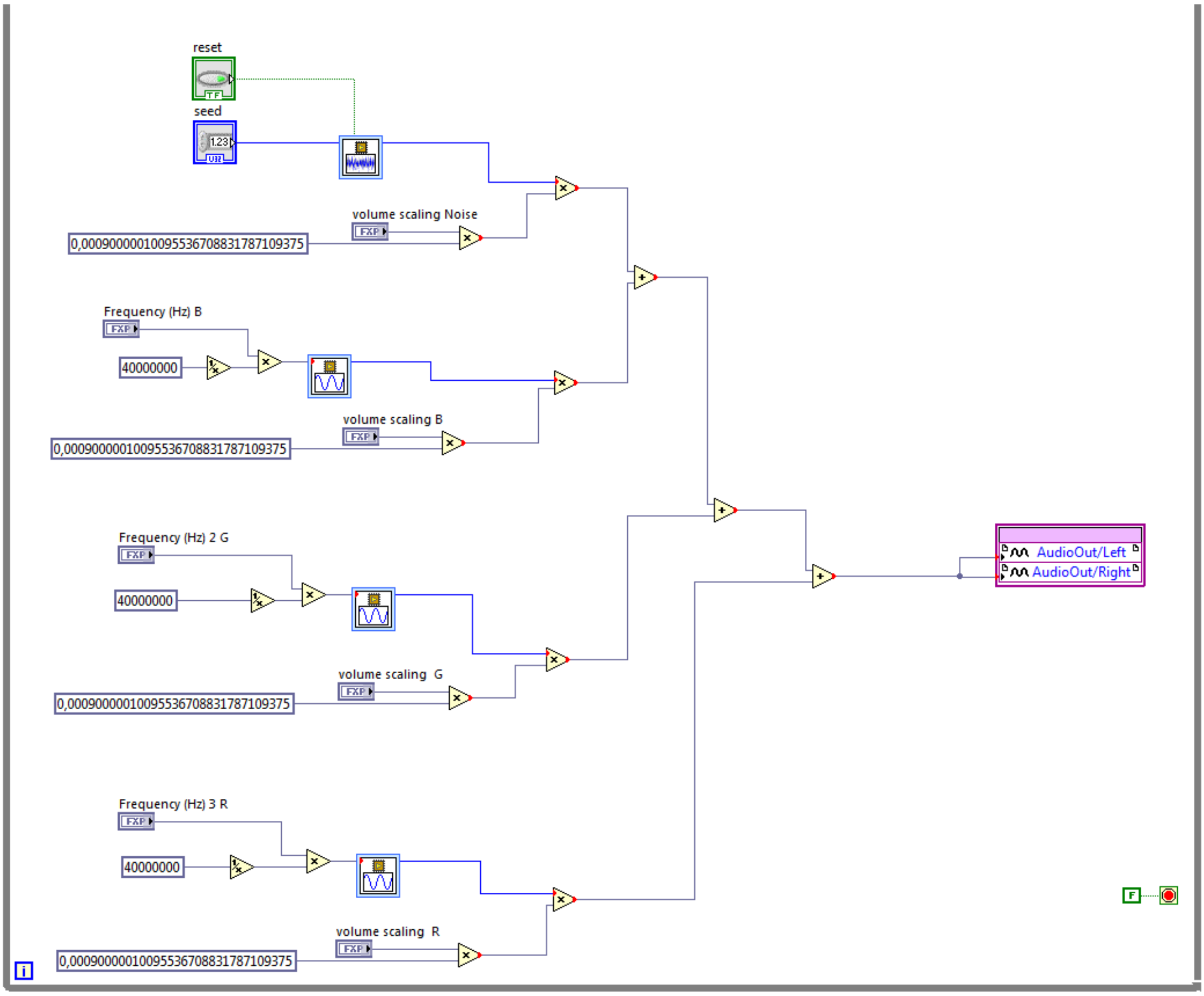


IMAGE
(CAMERA)
(FPGA)
RGB VALUES
(RT)
WAVEFORM AND NOISE
GENERATOR
(FPGA)
AUDIO SIGNAL
GENERATION
(FPGA)

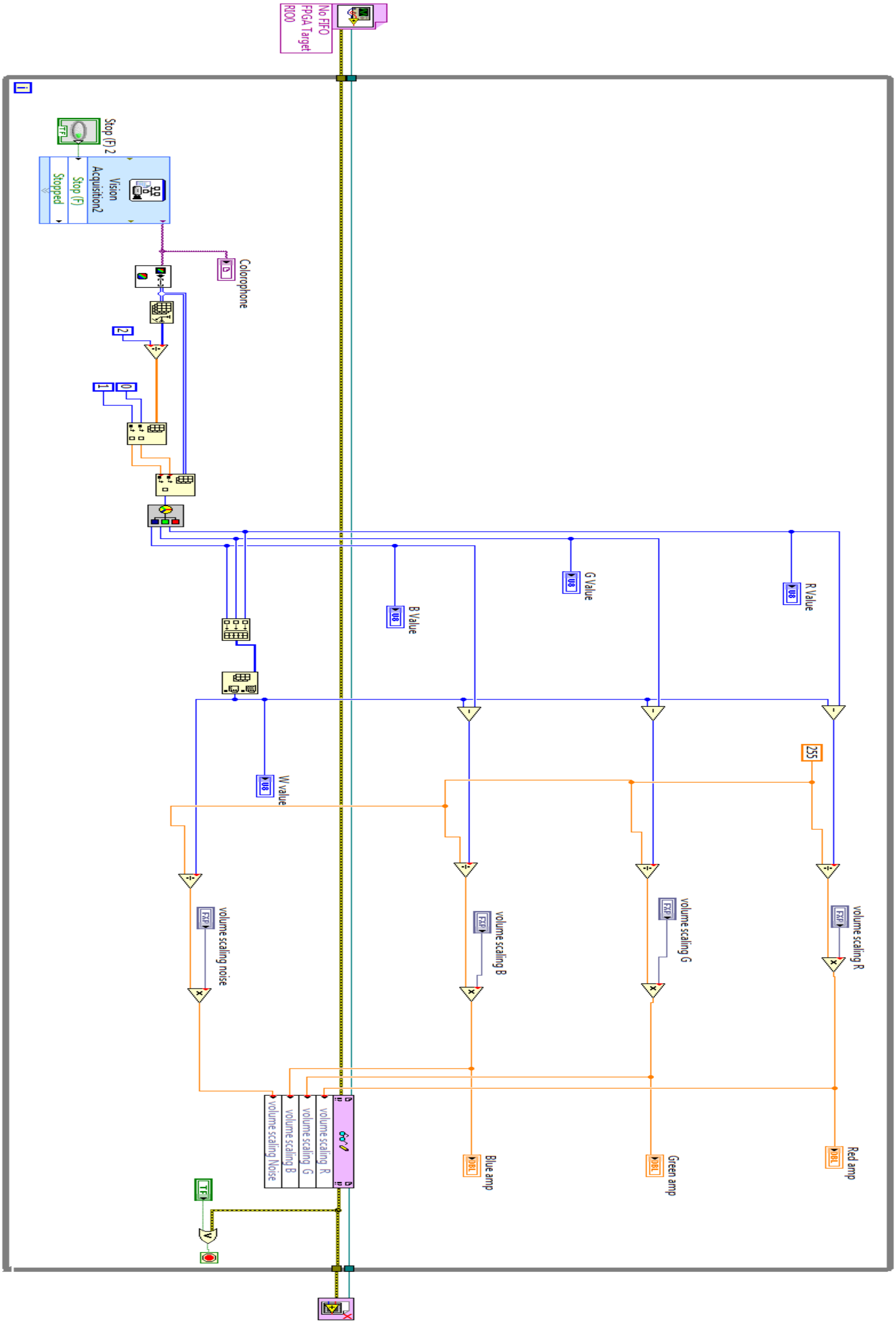
Attachment E

RT Colorophone code

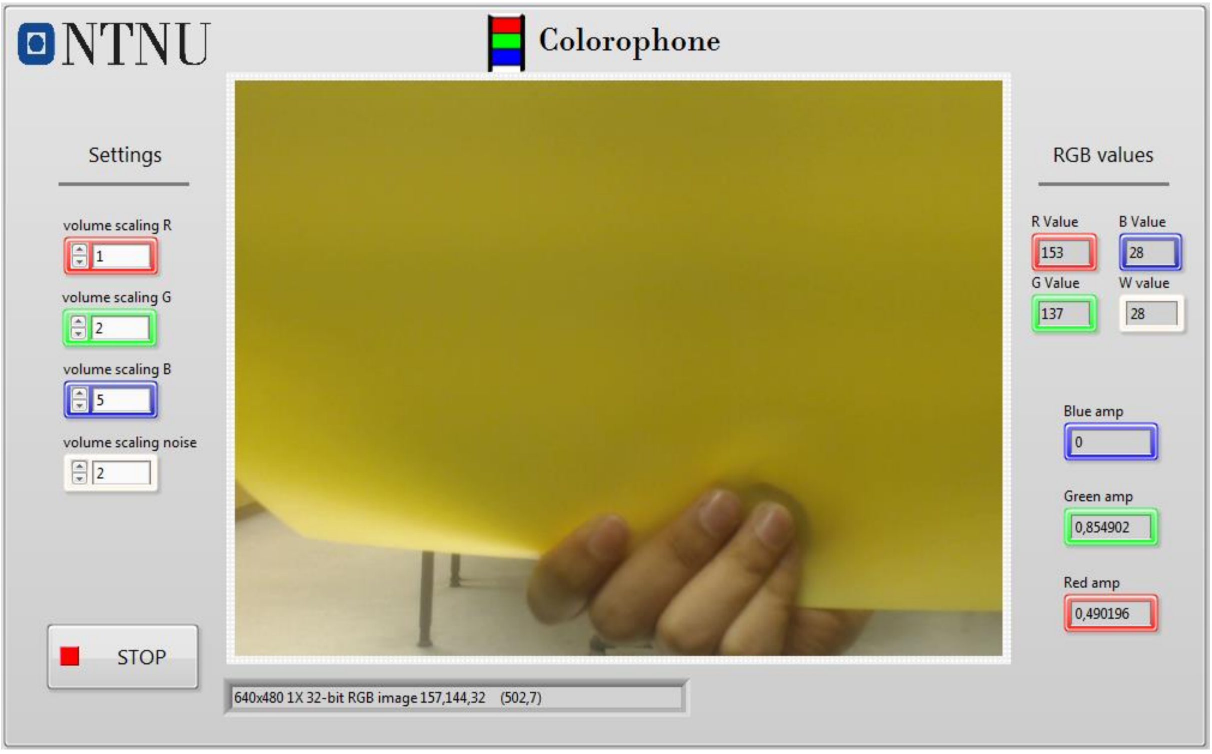
RT Colorophone v1.0 (FPGA – target code)



RT Colorophone v1.0 (RT– target code)



RT Colorophone v1.0 (front panel)



Attachment F

Ultrasonic proximity sensor datasheet

LV-MaxSonar®-EZ™ Series

High Performance Sonar Range Finder

MB1000, MB1010, MB1020, MB1030, MB1040

With 2.5V - 5.5V power the LV-MaxSonar-EZ provides very short to long-range detection and ranging in a very small package. The LV-MaxSonar-EZ detects objects from 0-inches to 254-inches (6.45-meters) and provides sonar range information from 6-inches out to 254-inches with 1-inch resolution. Objects from 0-inches to 6-inches typically range as 6-inches[1]. The interface output formats included are pulse width output, analog voltage output, and RS232 serial output. Factory calibration and testing is completed with a flat object. [1]***See Close Range Operation***

Features

- Continuously variable gain for control and side lobe suppression
- Object detection to zero range objects
- 2.5V to 5.5V supply with 2mA typical current draw
- Readings can occur up to every 50mS, (20-Hz rate)
- Free run operation can continually measure and output range information
- Triggered operation provides the range reading as desired
- Interfaces are active simultaneously
- Serial, 0 to Vcc, 9600 Baud, 81N
- Analog, (Vcc/512) / inch
- Pulse width, (147uS/inch)
- Learns ringdown pattern when commanded to start ranging
- Designed for protected indoor environments
- Sensor operates at 42KHz
- High output square wave sensor drive (double Vcc)

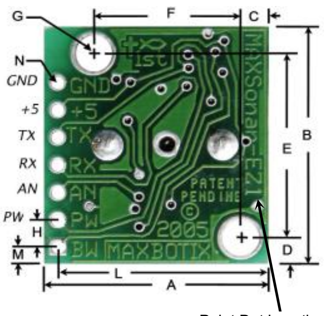
Benefits

- Very low cost ultrasonic rangefinder
- Reliable and stable range data
- Quality beam characteristics
- Mounting holes provided on the circuit board
- Very low power ranger, excellent for multiple sensor or battery-based systems
- Fast measurement cycles
- Sensor reports the range reading directly and frees up user processor
- Choose one of three sensor outputs
- Triggered externally or internally

Applications and Uses

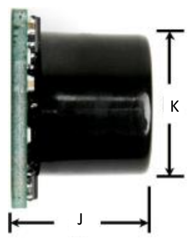
- UAV blimps, micro planes and some helicopters
- Bin level measurement
- Proximity zone detection
- People detection
- Robot ranging sensor
- Autonomous navigation
- Multi-sensor arrays
- Distance measuring
- Long range object detection
- Wide beam sensitivity

LV-MaxSonar-EZ Mechanical Dimensions



A	0.785"	19.9 mm	H	0.100"	2.54 mm
B	0.870"	22.1 mm	J	0.610"	15.5 mm
C	0.100"	2.54 mm	K	0.645"	16.4 mm
D	0.100"	2.54 mm	L	0.735"	18.7 mm
E	0.670"	17.0 mm	M	0.065"	1.7 mm
F	0.510"	12.6 mm	N	0.038" dia.	1.0 mm dia.
G	0.124" dia.	3.1 mm dia.	weight, 4.3 grams		

Part Number	MB1000	MB1010	MB1020	MB1030	MB1040
Paint Dot Color	Black	Brown	Red	Orange	Yellow



Close Range Operation

Applications requiring 100% reading-to-reading reliability should not use MaxSonar sensors at a distance closer than 6 inches. Although most users find MaxSonar sensors to work reliably from 0 to 6 inches for detecting objects in many applications, MaxBotix® Inc. does not guarantee operational reliability for objects closer than the minimum reported distance. Because of ultrasonic physics, these sensors are unable to achieve 100% reliability at close distances.

Warning: Personal Safety Applications

We do not recommend or endorse this product be used as a component in any personal safety applications. This product is not designed, intended or authorized for such use. These sensors and controls do not include the self-checking redundant circuitry needed for such use. Such unauthorized use may create a failure of the MaxBotix® Inc. product which may result in personal injury or death. MaxBotix® Inc. will not be held liable for unauthorized use of this component.

About Ultrasonic Sensors

Our ultrasonic sensors are in air, non-contact object detection and ranging sensors that detect objects within an area. These sensors are not affected by the color or other visual characteristics of the detected object. Ultrasonic sensors use high frequency sound to detect and localize objects in a variety of environments. Ultrasonic sensors measure the time of flight for sound that has been transmitted to and reflected back from nearby objects. Based upon the time of flight, the sensor then outputs a range reading.

Pin Out Description

Pin 1-BW-*Leave open or hold low for serial output on the TX output. When BW pin is held high the TX output sends a pulse (instead of serial data), suitable for low noise chaining.

Pin 2-PW- This pin outputs a pulse width representation of range. The distance can be calculated using the scale factor of 147uS per inch.

Pin 3-AN- Outputs analog voltage with a scaling factor of (Vcc/512) per inch. A supply of 5V yields ~9.8mV/in. and 3.3V yields ~6.4mV/in. The output is buffered and corresponds to the most recent range data.

Pin 4-RX– This pin is internally pulled high. The LV-MaxSonar-EZ will continually measure range and output if RX data is left unconnected or held high. If held low the sensor will stop ranging. Bring high for 20uS or more to command a range reading.

Pin 5-TX- When the *BW is open or held low, the TX output delivers asynchronous serial with an RS232 format, except voltages are 0-Vcc. The output is an ASCII capital “R”, followed by three ASCII character digits representing the range in inches up to a maximum of 255, followed by a carriage return (ASCII 13). The baud rate is 9600, 8 bits, no parity, with one stop bit. Although the voltage of 0-Vcc is outside the RS232 standard, most RS232 devices have sufficient margin to read 0-Vcc serial data. If standard voltage level RS232 is desired, invert, and connect an RS232 converter such as a MAX232. When BW pin is held high the TX output sends a single pulse, suitable for low noise chaining. (no serial data)

Pin 6-+5V- Vcc – Operates on 2.5V - 5.5V. Recommended current capability of 3mA for 5V, and 2mA for 3V.

Pin 7-GND- Return for the DC power supply. GND (& Vcc) must be ripple and noise free for best operation.

Range “0” Location

The LV-MaxSonar-EZ reports the range to distant targets starting from the front of the sensor as shown in the diagram below.

The range is measured from the front of the transducer.

In general, the LV-MaxSonar-EZ will report the range to the leading edge of the closest detectable object. Target detection has been characterized in the sensor beam patterns.

Sensor Minimum Distance

The sensor minimum reported distance is 6-inches (15.2 cm). However, the LV-MaxSonar-EZ will range and report targets to the front sensor face. Large targets closer than 6-inches will typically range as 6-inches.

Sensor Operation from 6-inches to 20-inches

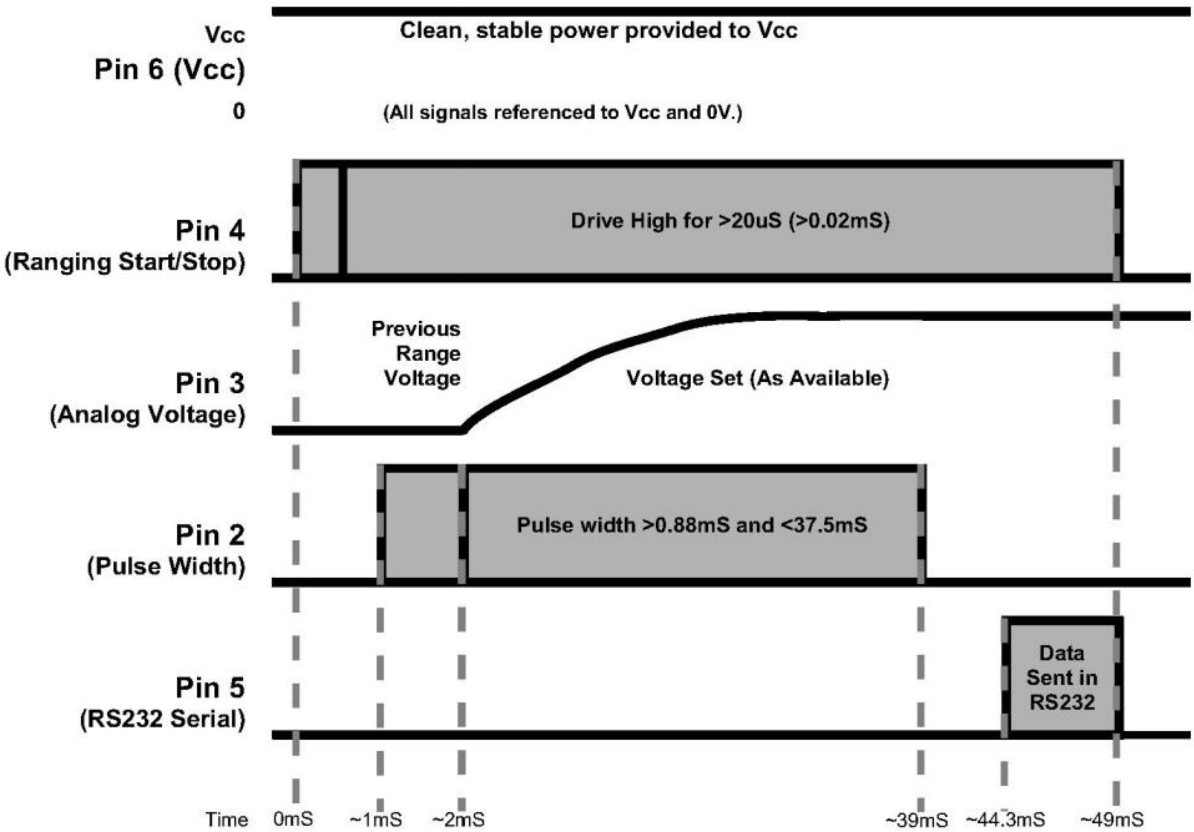
Because of acoustic phase effects in the near field, objects between 6-inches and 20-inches may experience acoustic phase cancellation of the returning waveform resulting in inaccuracies of up to 2-inches. These effects become less prevalent as the target distance increases, and has not been observed past 20-inches.

General Power-Up Instruction

Each time the LV-MaxSonar-EZ is powered up, it will calibrate during its first read cycle. The sensor uses this stored information to range a close object. It is important that objects not be close to the sensor during this calibration cycle. The best sensitivity is obtained when the detection area is clear for fourteen inches, but good results are common when clear for at least seven inches. If an object is too close during the calibration cycle, the sensor may ignore objects at that distance.

The LV-MaxSonar-EZ does not use the calibration data to temperature compensate for range, but instead to compensate for the sensor ringdown pattern. If the temperature, humidity, or applied voltage changes during operation, the sensor may require recalibration to reacquire the ringdown pattern. Unless recalibrated, if the temperature increases, the sensor is more likely to have false close readings. If the temperature decreases, the sensor is more likely to have reduced up close sensitivity. To recalibrate the LV-MaxSonar-EZ, cycle power, then command a read cycle.

Timing Diagram



Timing Description

250mS after power-up, the LV-MaxSonar-EZ is ready to accept the RX command. If the RX pin is left open or held high, the sensor will first run a calibration cycle (49mS), and then it will take a range reading (49mS). After the power up delay, the first reading will take an additional ~100mS. Subsequent readings will take 49mS. The LV-MaxSonar-EZ checks the RX pin at the end of every cycle. Range data can be acquired once every 49mS.

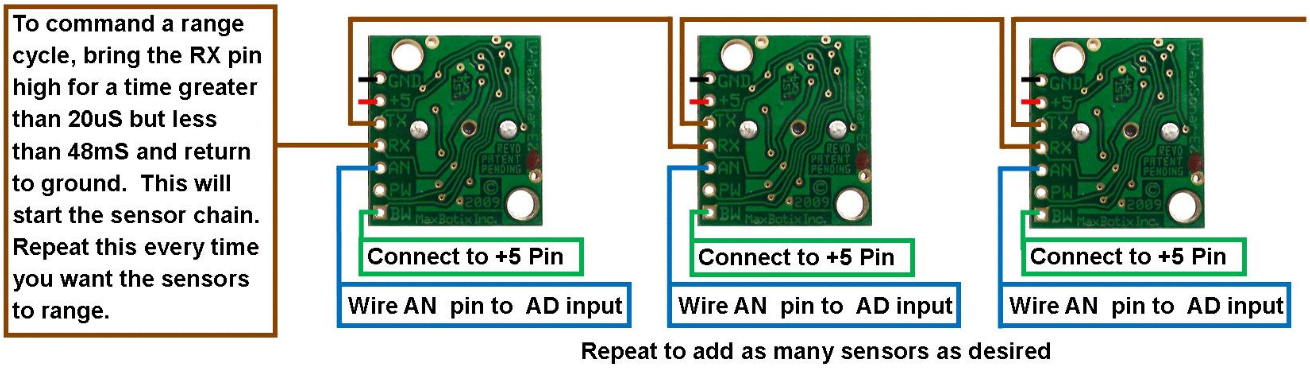
Each 49mS period starts by the RX being high or open, after which the LV-MaxSonar-EZ sends the transmit burst, after which the pulse width pin (PW) is set high. When a target is detected the PW pin is pulled low. The PW pin is high for up to 37.5mS if no target is detected. The remainder of the 49mS time (less 4.7mS) is spent adjusting the analog voltage to the correct level. When a long distance is measured immediately after a short distance reading, the analog voltage may not reach the exact level within one read cycle. During the last 4.7mS, the serial data is sent.

The LV-MaxSonar-EZ timing is factory calibrated to one percent at five volts, and in use is better than two percent. In addition, operation at 3.3V typically causes the objects range, to be reported, one to two percent further than actual.

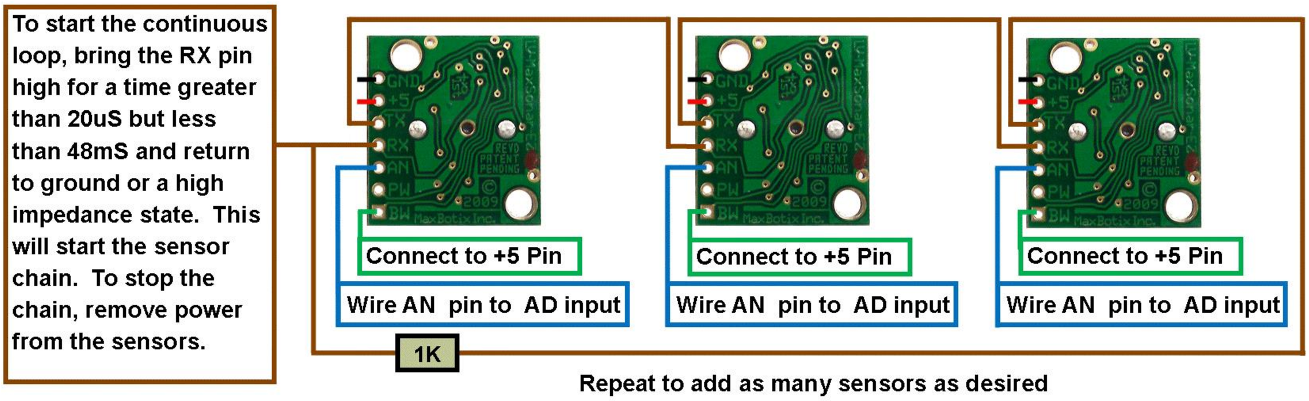
Using Multiple Sensors in a single system

When using multiple ultrasonic sensors in a single system, there can be interference (cross-talk) from the other sensors. MaxBotix Inc., has engineered and supplied a solution to this problem for the LV-MaxSonar-EZ sensors. The solution is referred to as chaining. We have 3 methods of chaining that work well to avoid the issue of cross-talk.

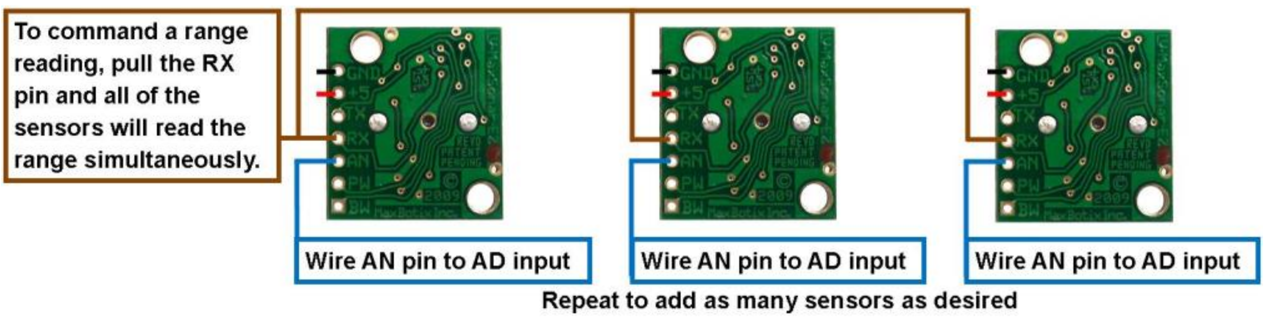
The first method is AN Output Commanded Loop. The first sensor will range, then trigger the next sensor to range and so on for all the sensor in the array. Once the last sensor has ranged, the array stops until the first sensor is triggered to range again. Below is a diagram on how to set this up.



The next method is AN Output Constantly Looping. The first sensor will range, then trigger the next sensor to range and so on for all the sensor in the array. Once the last sensor has ranged, it will trigger the first sensor in the array to range again and will continue this loop indefinitely. Below is a diagram on how to set this up.



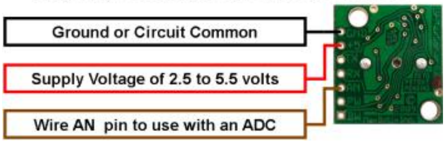
The final method is AN Output Simultaneous Operation. This method does not work in all applications and is sensitive to how the other sensors in the array are positioned in comparison to each other. Testing is recommend to verify this method will work for your application. All the sensors RX pins are conned together and triggered at the same time causing all the sensor to take a range reading at the same time. Once the range reading is complete, the sensors stop ranging until triggered next time. Below is a diagram on how to set this up.



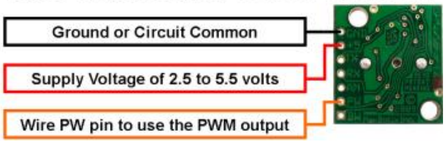
Independent Sensor Operation

The LV-MaxSonar-EZ sensors have the capability to operate independently when the user desires. When using the LV-MaxSonar-EZ sensors in single or independent sensor operation, it is easiest to allow the sensor to free-run. Free-run is the default mode of operation for all of the MaxBotix Inc., sensors. The LV-MaxSonar-EZ sensors have three separate outputs that update the range data simultaneously: Analog Voltage, Pulse Width, and RS232 Serial. Below are diagrams on how to connect the sensor for each of the three outputs when operating in a single or independent sensor operating environment.

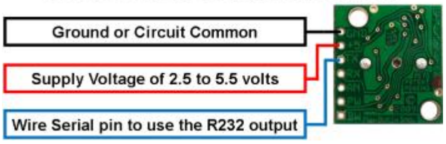
Analog Output Sensor Operation



Pulse Width Output Sensor Operation



Serial Output Sensor Operation



Selecting an LV-MaxSonar-EZ

Different applications require different sensors. The LV-MaxSonar-EZ product line offers varied sensitivity to allow you to select the best sensor to meet your needs.

The LV-MaxSonar-EZ Sensors At a Glance

People Detection Wide Beam High Sensitivity		Best Balance		Large Targets Narrow Beam Noise Tolerance
MB1000	MB1010	MB1020	MB1030	MB1040

The diagram above shows how each product balances sensitivity and noise tolerance. This does not effect the maximum range, pin outputs, or other operations of the sensor. To view how each sensor will function to different sized targets reference the LV-MaxSonar-EZ Beam Patterns.

Background Information Regarding our Beam Patterns

Each LV-MaxSonar-EZ sensor has a calibrated beam pattern. Each sensor is matched to provide the approximate detection pattern shown in this datasheet. This allows end users to select the part number that matches their given sensing application. Each part number has a consistent field of detection so additional units of the same part number will have similar beam patterns. The beam plots are provided to help identify an estimated detection zone for an application based on the acoustic properties of a target versus the plotted beam patterns.

Each beam pattern is a 2D representation of the detection area of the sensor. The beam pattern is actually shaped like a 3D cone (having the same detection pattern both vertically and horizontally). Detection patterns for dowels are used to show the beam pattern of each sensor. Dowels are long cylindered targets of a given diameter. The dowels provide consistent target detection characteristics for a given size target which allows easy comparison of one MaxSonar sensor to another MaxSonar sensor.

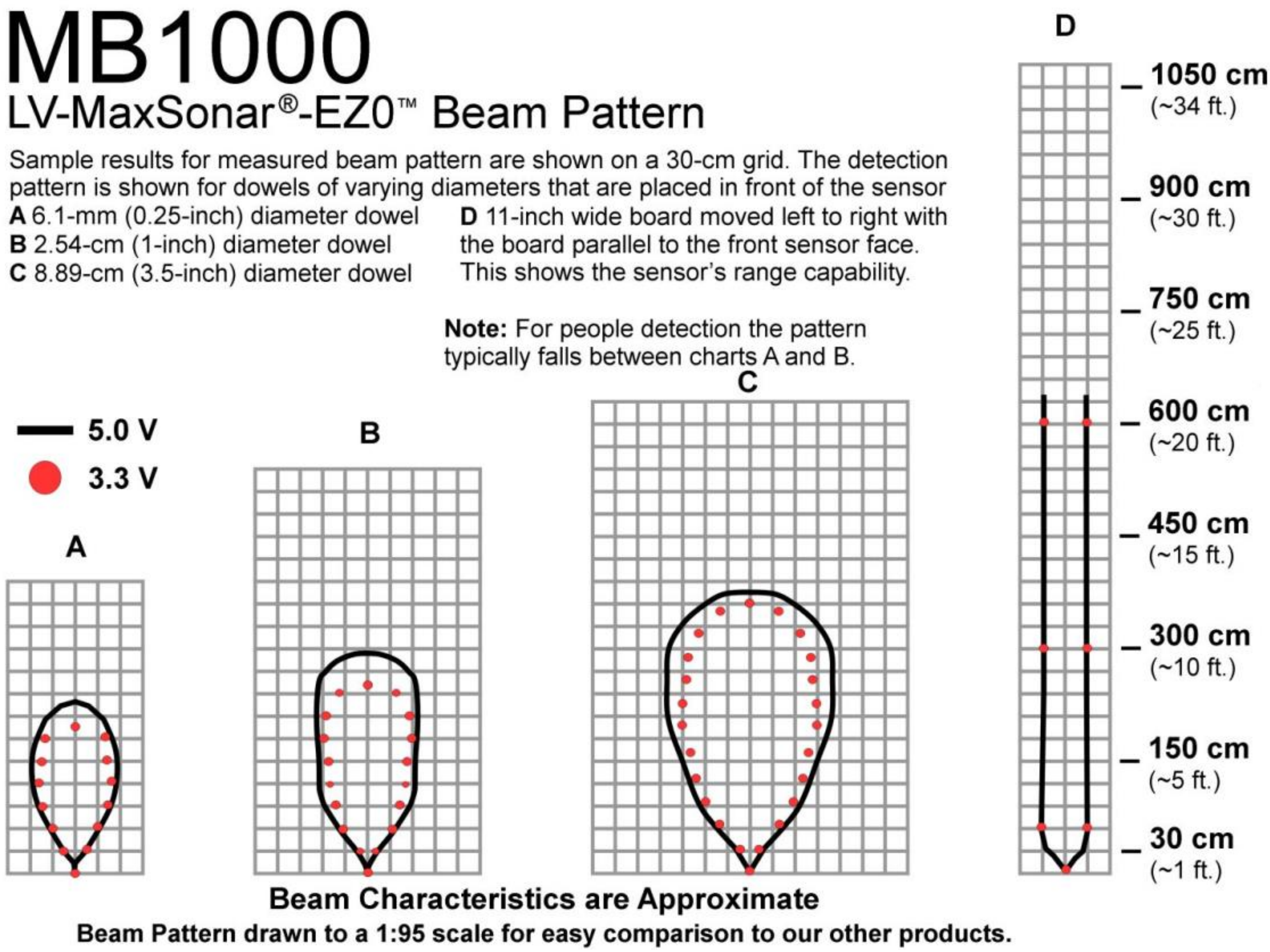
People Sensing: For users that desire to detect people, the detection area to the 1-inch diameter dowel, in general, represents the area that the sensor will reliably detect people.

For each part number, the four patterns (A, B, C, and D) represent the detection zone for a given target size. Each beam pattern shown is determined by the sensor's part number and target size.

The actual beam angle changes over the full range. Use the beam pattern for a specific target at any given distance to calculate the beam angle for that target at the specific distance. Generally, smaller targets are detected over a narrower beam angle and a shorter distance. Larger targets are detected over a wider beam angle and a longer range.

MB1000 LV-MaxSonar-EZ0

The LV-MaxSonar-EZ0 is the highest sensitivity and widest beam sensor of the LV-MaxSonar-EZ sensor series. The wide beam makes this sensor ideal for a variety of applications including people detection, autonomous navigation, and wide beam applications.



MB1000 Features and Benefits

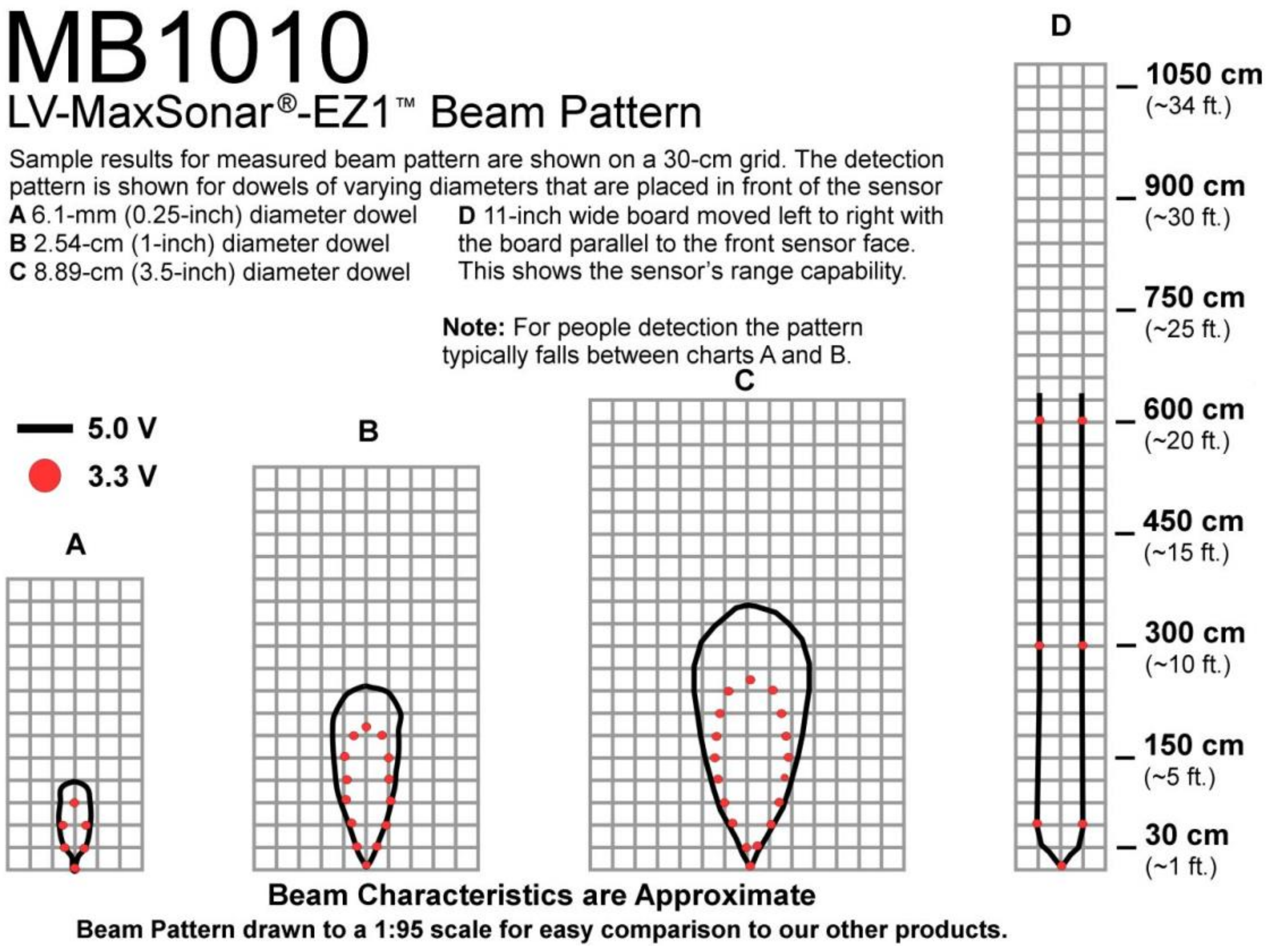
- Widest and most sensitive beam pattern in LV-MaxSonar-EZ line
- Low power consumption
- Easy to use interface
- Will pick up the most noise clutter when compared to other sensors in the LV-MaxSonar-EZ line
- Detects smaller objects
- Best sensor to detect soft object in LV-MaxSonar-EZ line
- Requires use of less sensors to cover a given area
- Can be powered by many different types of power sources
- Can detect people up to approximately 10 feet

MB1000 Applications and Uses

- Great for people detection
- Security
- Motion detection
- Used with battery power
- Autonomous navigation
- Educational and hobby robotics
- Collision avoidance

MB1010 LV-MaxSonar-EZ1

The LV-MaxSonar-EZ1 is the original MaxSonar product. This is our most popular indoor ultrasonic sensor and is a great low-cost general-purpose sensor for a customer not sure of which LV-MaxSonar-EZ sensor to use.



MB1010 Features and Benefits

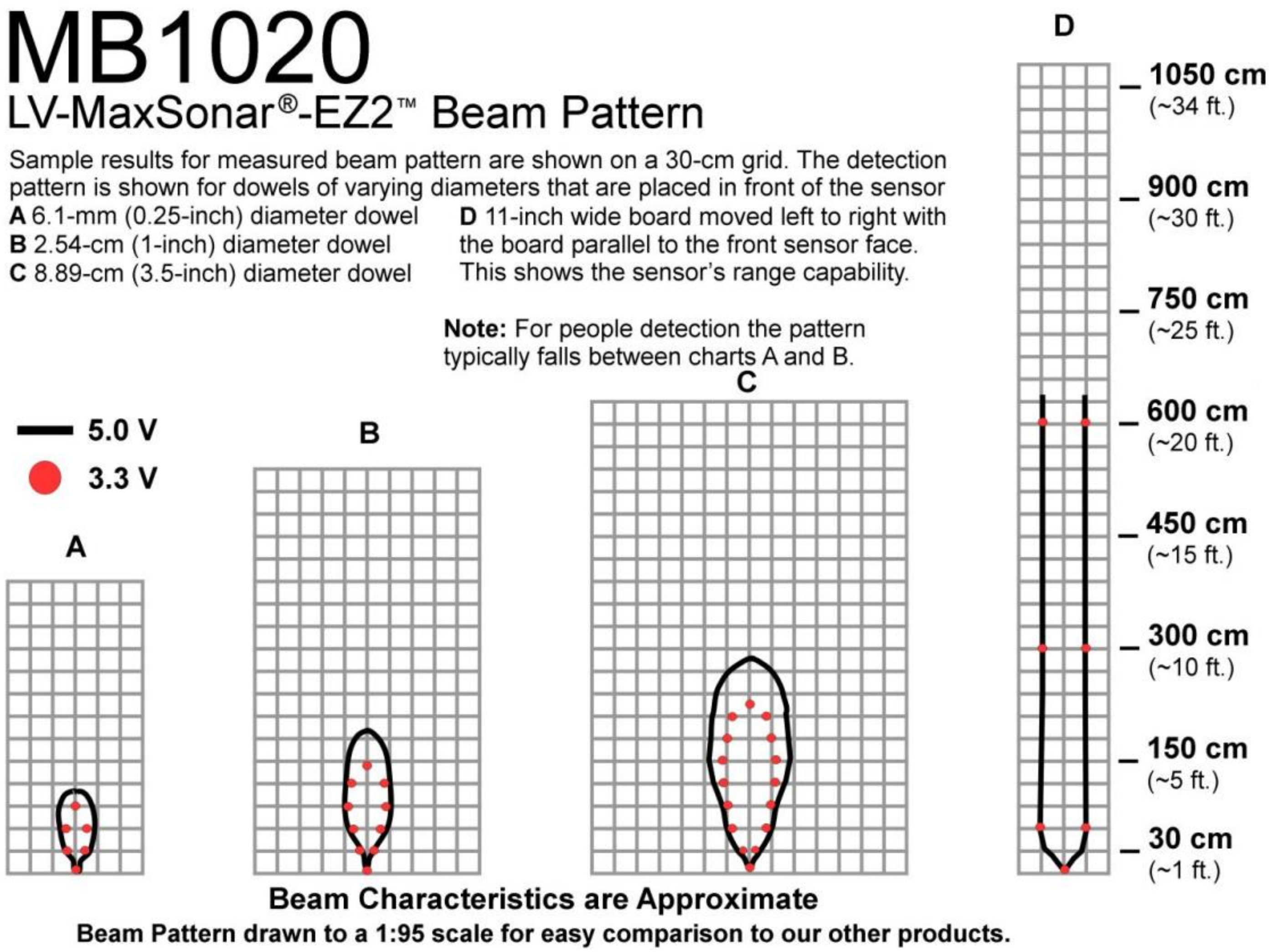
- Most popular ultrasonic sensor
- Low power consumption
- Easy to use interface
- Can detect people to 8 feet
- Great balance between sensitivity and object rejection
- Can be powered by many different types of power sources

MB1010 Applications and Uses

- Great for people detection
- Security
- Motion detection
- Used with battery power
- Autonomous navigation
- Educational and hobby robotics
- Collision avoidance

MB1020 LV-MaxSonar-EZ2

The LV-MaxSonar-EZ2 is a good compromise between sensitivity and side object rejection. The LV-MaxSonar-EZ2 is an excellent choice for applications that require slightly less side object detection and sensitivity than the MB1010 LV-MaxSonar-EZ1.



MB1020 Features and Benefits

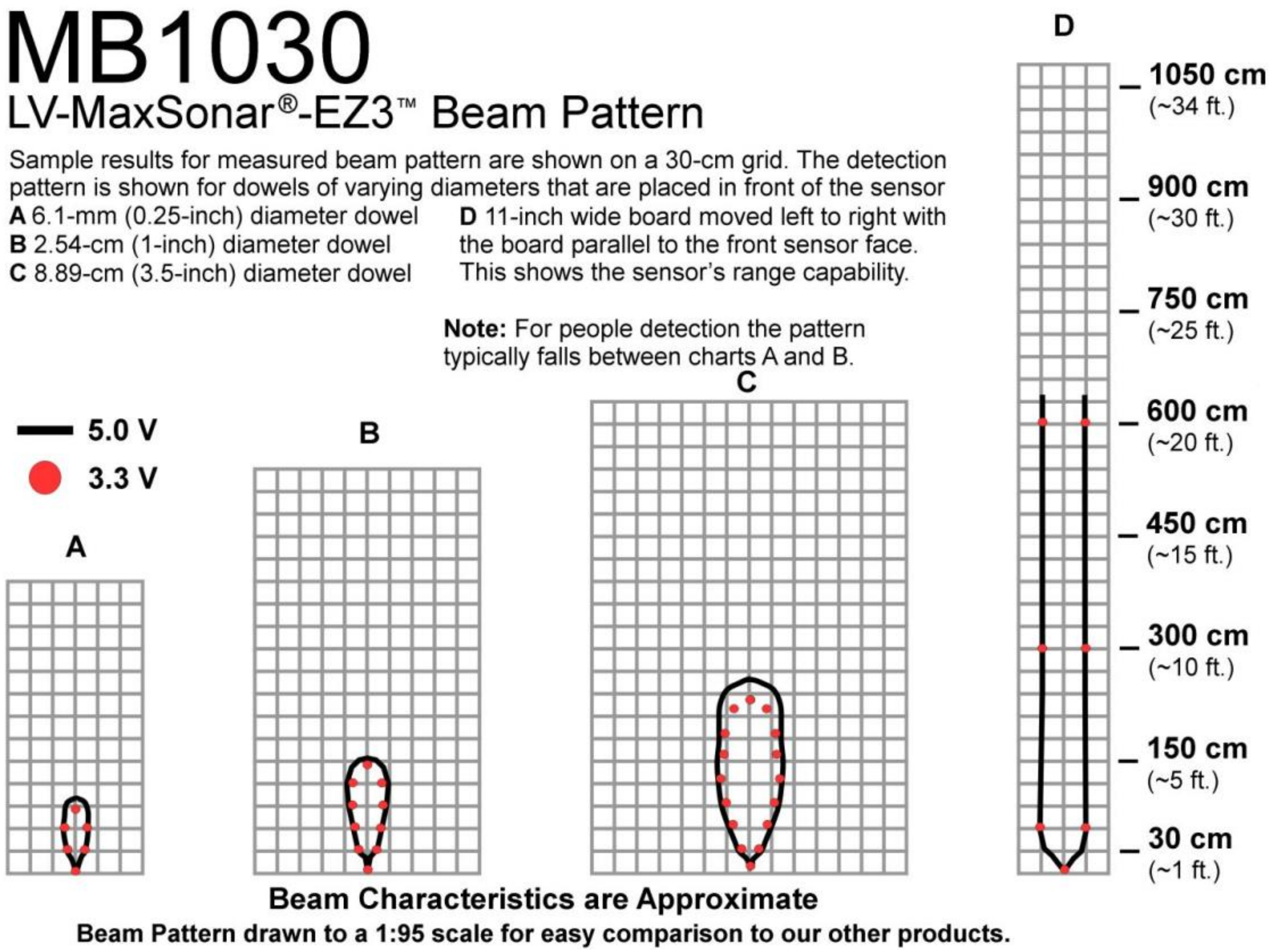
- Great for applications where the MB1010 is too sensitive.
- Excellent side object rejection
- Can be powered by many different types of power sources
- Can detect people up to approximately 6 feet

MB1020 Applications and Uses

- Landing flying objects
- Used with battery power
- Autonomous navigation
- Educational and hobby robotics
- Large object detection

MB1030 LV-MaxSonar-EZ3

The LV-MaxSonar-EZ3 is a narrow beam sensor with good side object rejection. The LV-MaxSonar-EZ3 has slightly wider beam width than theMB1040 LV-MaxSonar-EZ4 which makes it a good choice for when the LV-MaxSonar-EZ4 does not have enough sensitivity for the application.



MB1030 Features and Benefits

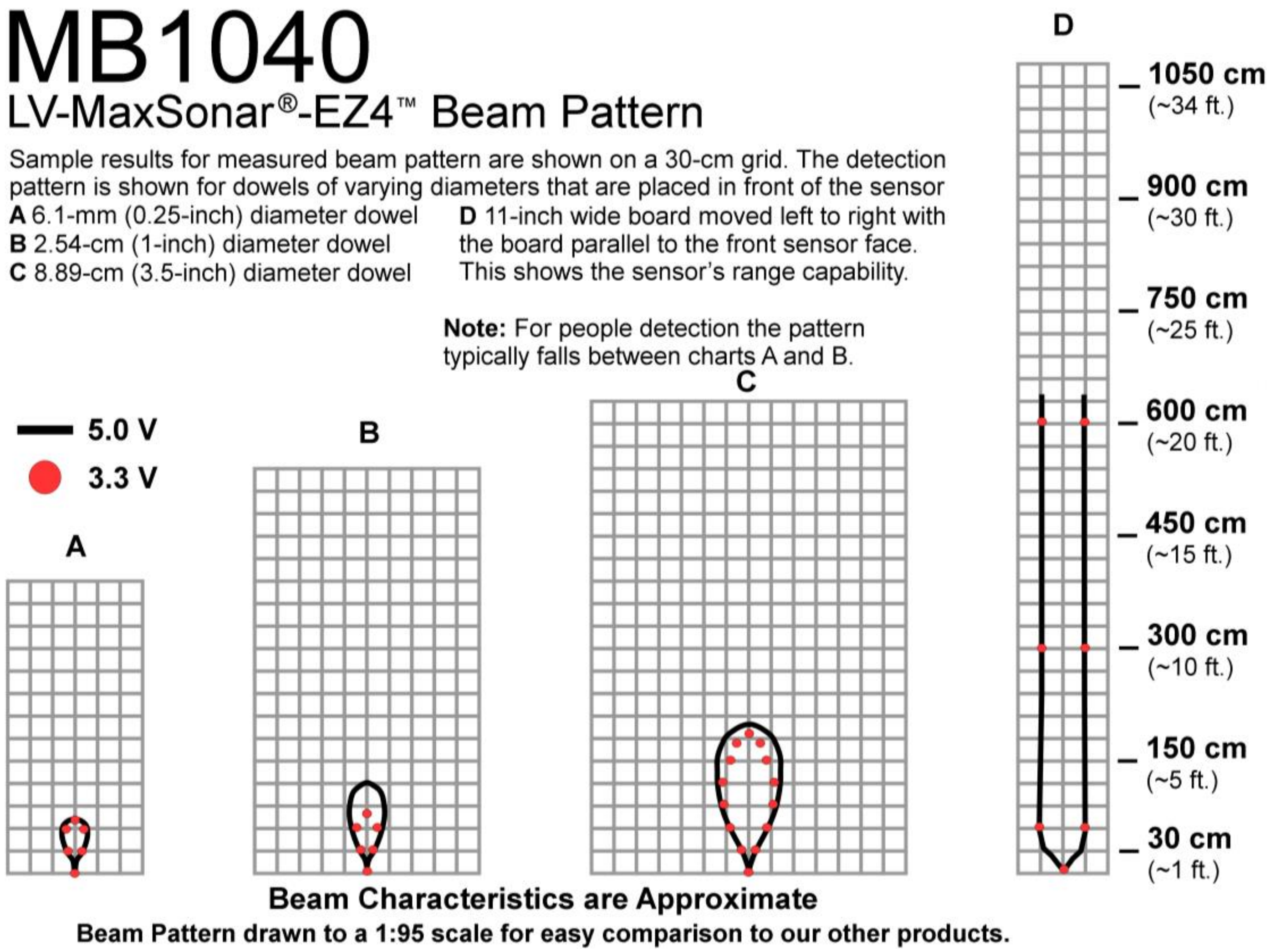
- Excellent side object rejection
- Low power consumption
- Easy to use interface
- Great for when MB1040 is not sensitive enough
- Large object detection
- Can be powered by many different types of power sources
- Can detect people up to approximately 5 feet

MB1030 Applications and Uses

- Landing flying objects
- Used with battery power
- Autonomous navigation
- Educational and hobby robotics

MB1040 LV-MaxSonar-EZ4

The LV-MaxSonar-EZ4 is the narrowest beam width sensor that is also the least sensitive to side objects offered in the LV-MaxSonar-EZ sensor line. The LV-MaxSonar-EZ4 is an excellent choice when only larger objects need to be detected.



MB1040 Features and Benefits

- Best side object rejection in the LV-MaxSonar-EZ sensor line
- Low power consumption
- Easy to use interface
- Best for large object detection
- Can be powered by many different types of power sources
- Can detect people up to approximately 4 feet

MB1040 Applications and Uses

- Landing flying objects
- Used with battery power
- Autonomous navigation
- Educational and hobby robotics
- Collision avoidance

Have the right sensor for your application?
Select from this product list for Protected and Non-Protected Environments.

Protected Environments

1 mm Resolution
HRLV-MaxSonar-EZ

1 in Resolution
LV-MaxSonar-EZ
LV-ProxSonar-EZ

1 cm Resolution
XL-MaxSonar-EZ
XL-MaxSonar-AE
XL-MaxSonar-EZL
XL-MaxSonar-AEL

1 mm Resolution
HRUSB-MaxSonar-EZ

1 in Resolution
USB-ProxSonar-EZ

Non-Protected Environments

1 mm Resolution
HRXL-MaxSonar-WR
HRXL-MaxSonar-WRS
HRXL-MaxSonar-WRT
HRXL-MaxSonar-WRM
HRXL-MaxSonar-WRMT
HRXL-MaxSonar-WRL
HRXL-MaxSonar-WRLT
HRXL-MaxSonar-WRLS
HRXL-MaxSonar-WRLST
SCXL-MaxSonar-WR
SCXL-MaxSonar-WRS
SCXL-MaxSonar-WRT
SCXL-MaxSonar-WRM
SCXL-MaxSonar-WRMT
SCXL-MaxSonar-WRL
SCXL-MaxSonar-WRLT
SCXL-MaxSonar-WRLS
SCXL-MaxSonar-WRLST
4-20HR-MaxSonar-WR

1 cm Resolution
XL-MaxSonar-WR
XL-MaxSonar-WRL
XL-MaxSonar-WRA
XL-MaxSonar-WRLA
I2CXL-MaxSonar-WR

1 mm Resolution
HRXL-MaxSonar-WRC
HRXL-MaxSonar-WRCT

1 cm Resolution
XL-MaxSonar-WRC
XL-MaxSonar-WRCA
I2CXL-MaxSonar-WRC

1 cm Resolution
UCXL-MaxSonar-WR
UCXL-MaxSonar-WRC
I2C-UCXL-MaxSonar-WR

Chemical Shield

F-Option. Available for WR models except UCXL. For additional protection when necessary in hazardous chemical environments.

Accessories — More information is online.

MB7954 — Shielded Cable

The MaxSonar Connection Wire is used to reduce interference caused by electrical noise on the lines. This cable is a great solution to use when running the sensors at a long distance or in an area with a lot of EMI and electrical noise.

MB7950 — XL-MaxSonar-WR Mounting Hardware

The MB7950 Mounting Hardware is selected for use with our outdoor ultrasonic sensors. The mounting hardware includes a steel lock nut and two O-ring (Buna-N and Neoprene) each optimal for different applications.

MB7955 / MB7956 / MB7957 / MB7958 / MB7972 — HR-MaxTemp

The HR-MaxTemp is an optional accessory for the HR-MaxSonar. The HR-MaxTemp connects to the HR-MaxSonar for automatic temperature compensation without self heating.

MB7961 — Power Supply Filter

The power supply filter is recommended for applications with unclean power or electrical noise.

MB7962 / MB7963 / MB7964 / MB7965 — Micro-B USB Connection Cable

The MB7962, MB7963, MB7964 and MB7965 Micro-B USB cables are USB 2.0 compliant and backwards compatible with USB 1.0 standards. Varying lengths.

MB7973 — CE Lightning/Surge Protector

The MB7973 adds protection required to meet the Lightning/Surge IEC61000-4-5 specification.

Attachment G

KA331 datasheet

www.fairchildsemi.com

KA331

V-F Converter

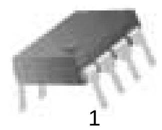
Features

- Guaranteed linearity: 0.01% max.
- Low power dissipation: 15mW at 5V
- Wide range of full scale frequency: 1Hz to 100KHz
- Pulse output compatible with all logic forms
- Wide dynamic range: 100dB min at 10KHz full scale frequency

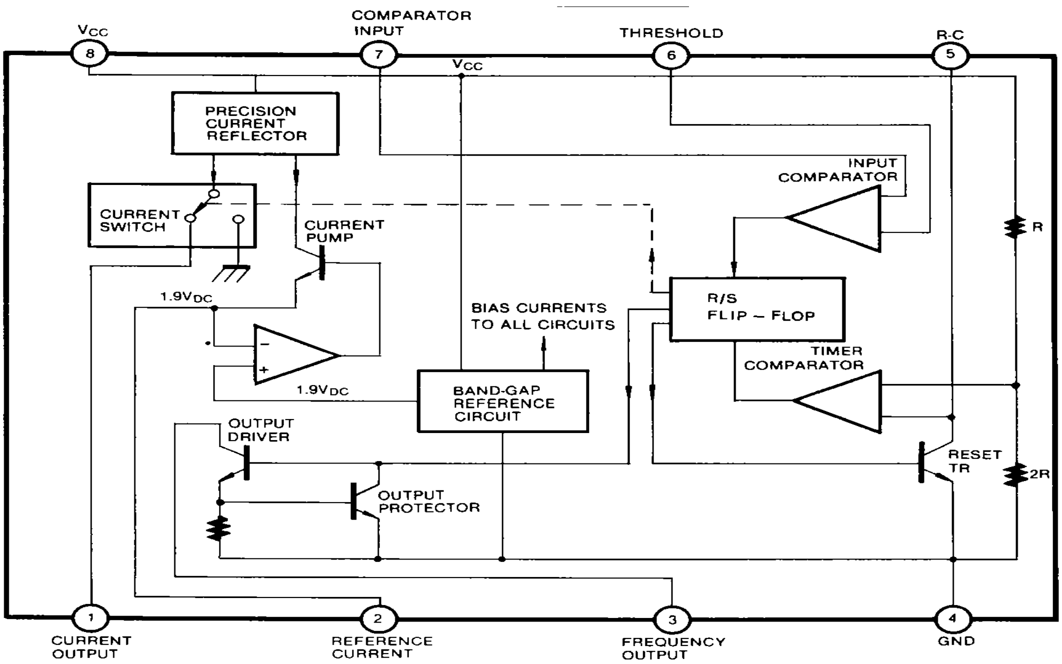
Description

This voltage to frequency converter provides the output pulse train at a frequency precisely proportional to the applied input voltage. The KA331 can operate at power supplies as low as 4.0V and be changed output frequency from 1Hz to 100KHz. It is ideally suited for use in simple low-cost circuit for analog-to digital conversion, long term integration, linear frequency modulation or demodulation, frequency-to-voltage conversion, and many other functions.

8-DIP



Internal Block Diagram



Rev. 1.0.0

Absolute Maximum Ratings (T_A = 25°C)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	40	V
Input Voltage	V_I	-0.2 ~ + V_{CC}	V
Operating Temperature Range	T_{OPR}	0 ~ +70	°C
Power Dissipation	P_D	500	mW

Electrical Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
VFC Non-Linearity	VFCNL	4.5 ≤ V_{CC} ≤ 20V	-	±0.003	±0.01	% Full-Scale
Conversion Accuracy Scale Factor	ACCUR	V_I = -10V, R_S = 14KΩ	0.90	1.00	1.10	KHz/V
Chang Of Gain With V_{CC}	V_{CC}ΔG/V_{CC}	4.5V ≤ V_{CC} ≤ 10V	-	0.01	0.1	%/V
		10V ≤ V_{CC} ≤ 40V	-	0.006	0.06	
Rated Full - Scale Frequency	f	V_I = -10V	10.0	-	-	KHz
INPUT COMPARATOR						
Offset Voltage	V_{IO}	0°C ≤ T_A ≤ +70°C	-	±3	±10	mV
Bias Current	I_{BIAS}	-	-	-80	-300	nA
Offset Current	I_{IO}	-	-	±8	±100	nA
Common-Mode Range	V_{CM}	0°C ≤ T_A ≤ +70°C	-0.2	-	V_{CC}-2.0	V
TIMER (PIN 5)						
Timer Threshold Voltage	V_{TH}	-	0.63	0.667	0.701	×V_{CC}
Input Bias Current	I_{BIAS}	V_{CC} = 15V, 0V ≤ V_5 ≤ 9.9V	-	±10	±100	nA
		V_5 = 10V	-	200	1000	nA
Saturation Voltage	V_{SAT}	I = 5mA	-	0.22	0.5	V
CURRENT SOURCE (PIN 1)						
Output Current	I_O	R_S = 14KΩ, V_1 = 0V	116	136	156	µA
Change with Voltage	ΔI_O/ΔV_1	0V ≤ V_1≤ 10V	-	0.2	1.0	µA
Current Source Off Leakage	I_{LKG}	-	-	0.02	10.0	nA
REFERENCE VOLTAGE (PIN 2)						
Reference Voltage	V_{REF}	-	1.70	1.89	2.08	V_{DC}
Stability vs Temperature	ST_T	-	-	±60	-	ppm/°C
Stability vs Time, 1000Hours	ST_T	-	-	±0.1	-	%
LOGIC OUTPUT (Pin 3)						
Saturation Voltage	V_{SAT}	I = 5mA	-	0.15	0.50	V
		I = 3.2mA	-	0.10	0.40	
Off Leakage	I_{LKG}	-	-	±0.05	1.0	µA
SUPPLY CURRENT						
Supply Current	I_{CC}	V_{CC} = 5V	1.5	3.0	6.0	mA
		V_{CC} = 40V	2.0	4.0	8.0	

Typical Applications

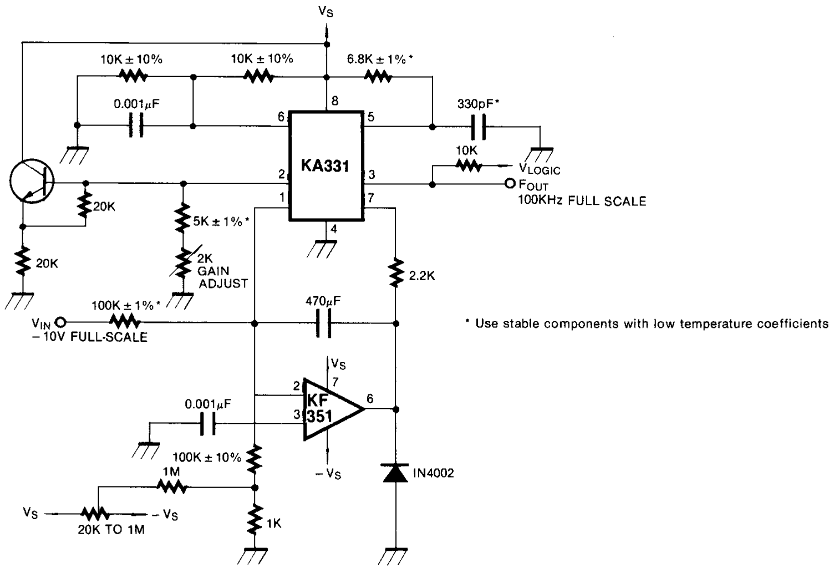


Figure 1. Precision Voltage-to-Frequency Converter, 100KHz Full-Scale

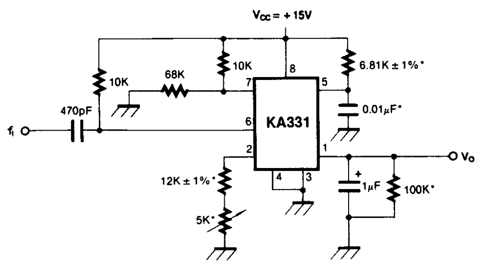


Figure 2. Simple Frequency-to-Voltage Converter, 10KHz Full-Scale

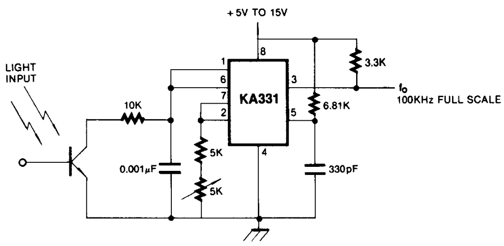
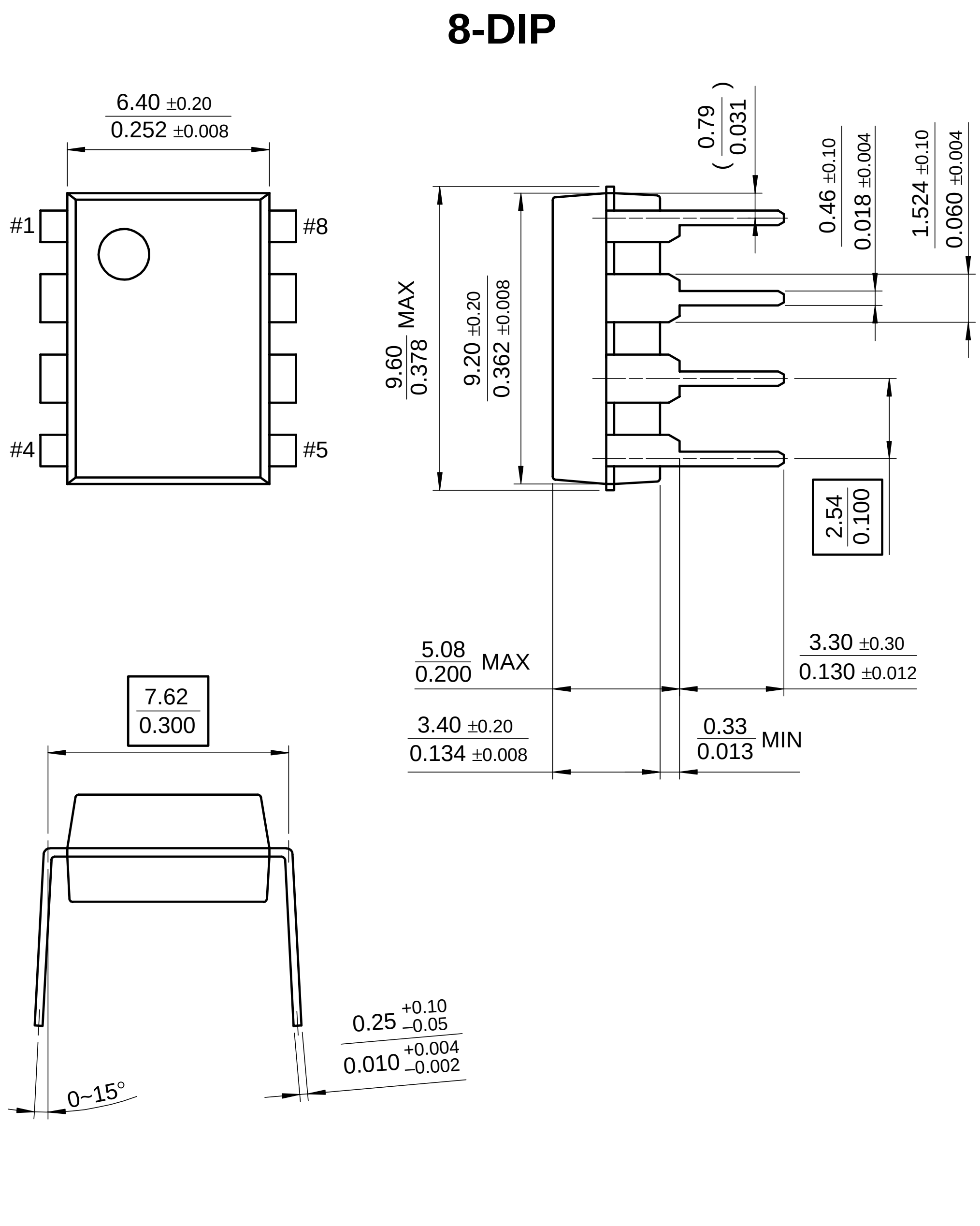


Figure 3. Light Intensity to Frequency Converter

Mechanical Dimensions

Package

Dimensions in millimeters



Ordering Information

Product Number	Package	Operating Temperature
KA331	8-DIP	0 ~ + 70°C

DISCLAIMER

LIFE SUPPORT POLICY

5/22/01 0.0m 001
Stock#DSxxxxxxxx

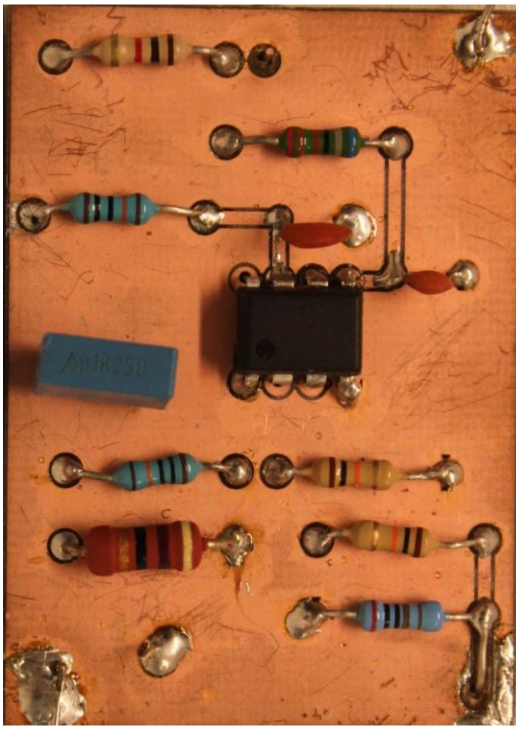
Attachment H

AfterShokz specification

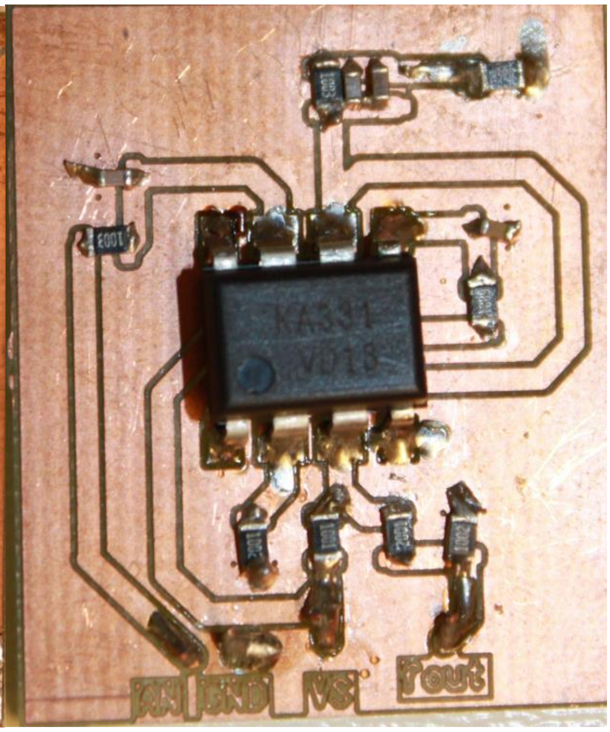
- Speaker type: bone conduction transducers
- Frequency response: 20Hz~20KHz
- Sensitivity: 100 ± 3dB
- Microphone: -40dB ± 3dB
- Compatible profiles: A2DP, AVRCP, HSP, HFP
- Wireless range: 33 ft (10m)
- Battery: rechargeable lithium ion
- Continuous play: 12 hours
- Standby time: 10 days
- Charge in: 2 hours
- Weight: 1.60 oz (41g)
- Cable length: 51 in (130cm

Attachment I

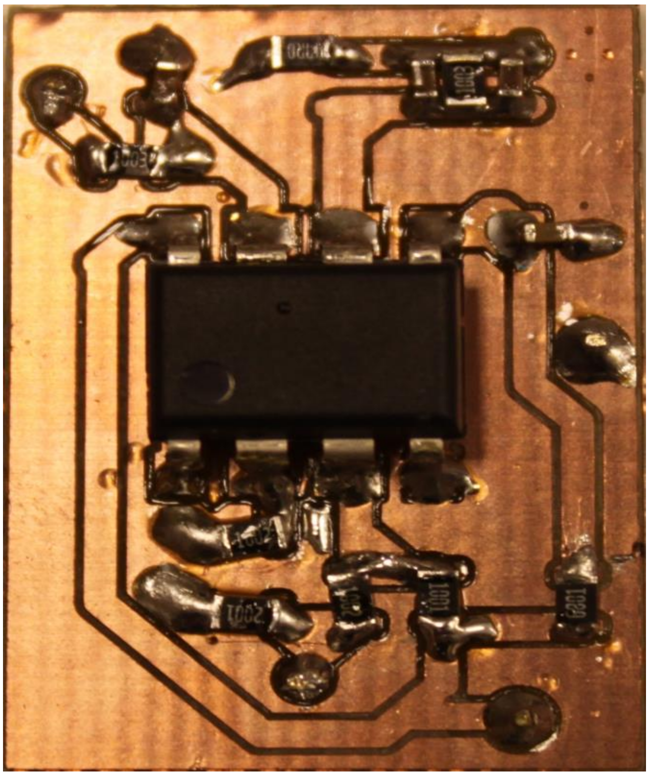
Voltage to frequency converters



The VFC v1.0



The VFCsmd v1.0



The VFCsmd v3.0

Attachment J

Meeting report

NTNU
Norwegian University of Science and Technology

Møtereferat

Kawan Kandili, Sindre Bjørvik
Veileder: Dominik Osinski

22 Feb 2016

Åpning av møtet

Vi møtte Øystein utenfor han leilighet hvor han skulle lufte hunden (Kato), vi dro deretter opp til han leilighet hvor vi ble introdusert til Øystein, om hva vi skulle teste osv.

Introduksjon

Det ble introdusert til Øystein om hvordan colorophone var og hva som var meningen med prosjektet.

Testing

Etter at utstyret var festet og koblet opp på testpersonen (Øystein Røysi), fikk han vite og leke seg med utstyret, hvor han fikk høre hvilken frekvens er hvilken farge. Vi tenkte at dette kunne ta litt tid før brukeren ble vant og forstod frekvensene, men Øystein var veldig flink og mestret "opplæringen" veldig raskt, slik at vi kunne starte med å teste.

Utstyr:

- Tablet
- Avstandssensor
- Kamera
- Beinledenede hodetelefoner
- Rød , gul, grønn og blå permer
- Rød, grønn og blå brusflasker
- Lilla, blå og rød yoghurt

Test 1, Enkel farge gjenkjenning

Startet enkelt med å finne farger på permer, vi hadde ulike farger på permene. Testpersonen tok fargene foran kameraet og fant veldig fort og nøyaktig hvilken farge som var på permene.

Test 2, Avstandssensor

Avstandssensoren ble testet ved at testpersonen orienterte seg rundt om i leiligheten. Objekter ble satt foran sensorer for å teste avstandssensoren og avklare hvordan den fungerte.

Test 3, Brusflasker og youghurt

Testpersonen prøvde å holde opp brusflasker og yoghurt bokser foran kamera for å finne ut hvilken farge de hadde, dette var litt mere utfordrende enn det vi så for oss, siden det var mye skrift på flaskene noe som gjorde at det ble en del hvit støy inn i bildet, men testpersonen klarte likevel å finne ut hvilken farge de hadde.

Test 4, Garderobe

Testpersonen ville gjerne teste ut hvordan han kunne skille skortene sine. Han ble veldig glad siden han med engang fant ut hvilken farge de hadde og syntes at dette var kult. Han merket også om det var stripete.

Kommentarer

- Testene og møtet gikk overaskende bra, vi hadde satt av en god stund til å lære testeren om fargene og frekvensene, men han overgikk våre forventninger.
- Viktig med en fin og enkelt system, både app og tablet
- Trenger nesten ikke noe opplæring
- Produktet er fram til nå bare et "Vil ha/vil være nyttig" produkt.

Attachment K

Meeting report

NTNU
Norwegian University of Science and Technology

Møtereferat

Edwin de Pano, Jørgen kopstad
Veileder: Dominik Osinski

24 Feb 2016

Åpning av møtet

Vi møtte Øystein utenfor leiligheten han, hvor vi da ringte på og spurte om han kunne slippe oss inn. I stedet for å bare slippe oss inn sa han at skulle komme ned for å hente oss i stedet. Han kom da ned aleine for å hente oss. Da vi kom inn i leiligheten hans ble, Jørgen og Edwin introdusert til Øystein.

Intoduksjon

Igjen samme som sist møte de hadde fikk Øystein igjen bli kjent med Colorophone. Videre diskuterte vi om den ene testen vi skulle ha med Øystein. Denne gangen hadde vi kun en test ettersom at de fleste testene ble gjort noen dager siden uten problem. Men i dag skulle det også filmes, slik at man ikke bare har skriftlig dokumentasjon om hvordan testen gikk, men også video dokumentasjon. I video dokumentasjonen skulle vi også spørre han om fordeler og ulemper med Colorophone.

Testing

Før testing startet fikk vi litt problemer med å få startet programmet på nettbrettet og innså med en gang at det hadde lønnet seg med å ha hele programmet i NI myRIO i stedet. Etter å ha startet nettbrettet på nytt fungerte programmet og vi kunne da fortsette med testingen. Forsøket gikk som sist gang, men denne gangen hadde vi med ulike frukt. I tillegg hadde vi tre ulike typer epler. Vi et gult, grønt og rødt eple som han skulle prøve å gjenkjenne. Øystein klarte da enkelt å kjenne igjen hvilken farge eplet hadde. Noe som overasket oss alle var da Øystein skulle gjenkjenne hvilken farge appelsinen hadde. Han merket da at det var noe blått i appelsinen! Dette var da den lille klistremerkelappen som var festet til appelsinen.

Utstyr

- Nettbrett
- Avstandssensor
- Kamera til Colorophone
- Beinledende hodetelefoner
- Frukt
- Kamera til dokumentasjon

Spørsmål og svar

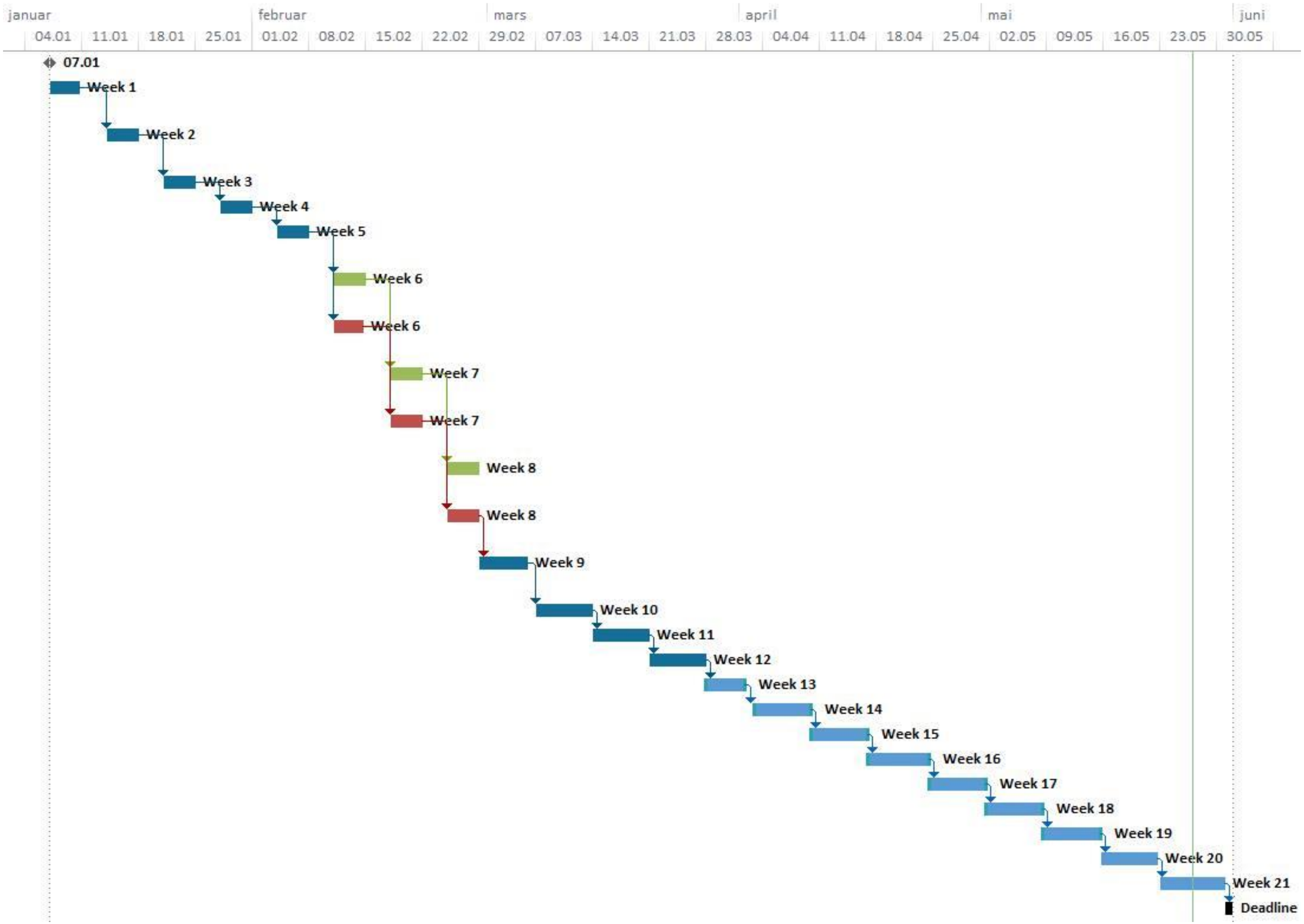
Spørsmål: Synes du at det blir for mye informasjon gjennom øret?
Svar: Nei jeg synes ikke at det var for mye informasjon gjennom øret.
Spørsmål: Liker du produktet?
Jeg synes dette produktet virker meget interessant og har potensialet til å bli noe stort.

Kommentarer

- Testen i dag gikk også veldig bra.
- Viktig med en fin og enkelt system, både app og tablet.
- Trengte ingen opplæring denne gangen.
- Produktet er fram til nå bare et "Vil ha / vil være nytting" produkt.
- Hadde vært bra om vi hadde fått programmet til å kjøre gjennom myRIO.
- I videodokumentasjonen snakker vi på engelsk siden filmen kan vises til internasjonale grupper.

Attachment K

Gantt chart


januar
februar
mars
april
mai
juni
04.01
11.01
18.01
25.01
01.02
08.02
15.02
22.02
29.02
07.03
14.03
21.03
28.03
04.04
11.04
18.04
25.04
02.05
09.05
16.05
23.05
30.05
07.01
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 6
Week 7
Week 7
Week 8
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Week 15
Week 16
Week 17
Week 18
Week 19
Week 20
Week 21
Deadline

Aktivitetsnavn	Start
Introduction	to 07.01.16
Week 1 : Introduction, test of equipment (glasses, tablet, bone conduction headphones), disassemble glasses, learn Solidworks.	to 07.01.16
Week 2 : Try to design a prototype on solidworks, design a curcuit for rangefinder (VFC, voltage-to-frequency converter), find a camera with good color feature, and also order one.	to 14.01.16
Week 3 : Disassemble webcam, complete the rangefinder (circuit design, soldering, testing), find a way to put webcam and ultrasonic together, program the ultrasonic to LabVIEW to measurement the distance.	to 21.01.16
Week 4 : Try to make webcam and ultrasonic sensor to work together, 3D print the first prototype (prototype1), Put all the components in the first prototype, complete the distance program on LabVIEW.	to 28.01.16
Week 5 : Test the first prototype, toubleshooting the first prototype, try to come up with a solution for potentoal problems.	to 04.02.16
Week 6 : Working prototype = come up with a better design (better/smaller circuit), suggestions for the second prototype.	to 11.02.16
Week 6 : Not working prototype = try to come up with any solutions for the prototype.	to 11.02.16
Week 7 : Working prototype = What can we improve?, implementing other applications (beacon, bluetooth, etc.)	to 18.02.16
Week 7 : Not working prototype = continue to solve any problems that were found during week 5 or 6, start on next prototype?	to 18.02.16
Week 8 : working prototype = continue implementing of other applications, improve design.	to 25.02.16
Week 8 : Not working prototype = Problems solved!, continue on [Week 6 = better design, design a smaller/better circut for the rangefinder], generally improve the first/second prototype .	to 25.02.16
Week 9 : Solve any problems with the second prototype.	ma 29.02.16
Week 10 : Continue on fixing any problems on the second prototype, third prototype?	ma 07.03.16
Week 11 : Test the product on blind people , try to complete the third prototype.	ma 14.03.16
Week 12 : Continue on testing the prodct (the third prototype)	ma 21.03.16
Week 13: Continue on the third prototype, begining with the 3.1 prototype.	ma 28.03.16
Week 14: Meeting, making 3 new PCB's with the VFC circuit, ordering batterypacks, programming on LabVIEW.	sø 03.04.16
Week 15 : FPGA, research on eyetracking, website, meeting, NI-competition, website.	sø 10.04.16
Week 16: writing on the Bachelor manual, 3D-design,FPGA, website, meeting,NI-competition.	sø 17.04.16
Week 17: NI-competition, FPGA, Bachelor manual, website, cleaning, 3D-Design.	sø 24.04.16
Week 18: Colorophone the movie, meeting Erik, The bachelor manual, website, NI-competition.	sø 01.05.16
Week 19: website, Bachelor maual, NI- competition, Colorophone the movie.	sø 08.05.16
Week 20: website, Bachelor maual, NI- competition, Colorophone the movie.	sø 15.05.16
Week 21 : Final week.	ma 23.05.16
DEADLINE	ti 31.05.16

Attachment M

Timesheet

Date	Hours
07.01.16 – 25.01.16	**288**
25.01.16 – 05.02.16	**159**
08.02.16 – 19.02.16	**152**
22.02.16 – 04.03.16	**100**
07.03.16 – 18.03.16	**172**
21.03.16 – 01.04.16	**156**
04.04.16 – 15.04.16	**276**
15.04.16 – 29.04.16	**312**
29.04.16 – 13.05.16	**240**
13.05.16 – 27.05.16	**240**
Total =	**2095**