SFU SIMON FRASER UNIVERSITY

[Company address]
City, Province, or State
Postal or Zip Code

Month Day, Year

Dr. John Shen, Director
Mechatronic Systems Engineering
Simon Fraser University
Surrey, BC, V5A 1S6

Dear Dr. Shen,

The enclosed written report titled as “Skytrain’s Vehicle on Board Computer(VOBC) Antenna Quality Check Device for Automated testing at British Columbia Rapid Transit Company (BCRTC)” is required for the successful completion of my first Co-op work term here at school of Mechatronic Systems Engineering. The report is written on the development of an automated device for the testing of antenna signals of Skytrain to replace the outdated technology.

British Columbia Rapid Transit Company(BCRTC) operates two of three SkyTrain lines in the lower mainland that are Expo Line and Millennium Line and the West Coast Express. The engineering department BCRTC is focused on Asset Management of Automatic Train Control, Rolling Stock and Power of Stations and Substations.

I was hired as an Electrical Engineering Co-op in the Electrical Engineering Department. I worked on four projects in total under the supervision of two Senior Electrical Engineers focused on Automatic Train Control (ATC) and Rolling Stock. My responsibilities aligned with that of a design engineer.

I cannot thank enough to BCRTC, [Name], Senior Electrical Engineer, [Name], Senior Electrical Engineer for their continuous mentoring, feedback, and support during the whole Co-op term. Thanks again to them for all the exposure to the engineering industry, procedures, and standards.

I hereby confirm that I have received no further help other than what is mentioned above in writing this report. I also confirm this report has not been previously submitted for academic credits at this or any other institution.
Sincerely,

(Signature)
Student Name,
ID 00000000

SFU SIMON FRASER UNIVERSITY

Skytrain's Vehicle on Board Computer(VOBC) Antenna Quality Check Device for Automated testing at British Columbia Rapid Transit Company (BCRTC)

Co-op Technical Report #1
Month Day, Year
Word Count: 1336

Prepared for:
Simon Fraser University
School of Mechatronic Systems Engineering
Co-op Program

Prepared by:
[Student Name]- [Student ID]

Abstract

This Project is focused on building an Automated, Compact, and technology aligned device to replace the traditional method of testing the quality of Antennas that are connected to the Vehicle on Board Computer of SkyTrains. Arduino is used to build the device as it can be programmed to work through the needs and can automate the process with minimal human interference and highest efficiency possible. The whole project involved building electronic circuits, electric schematics, PCB design, 3D design and documentation. The Programming of Arduino was also a crucial part to the project as it is the key feature to automate the process. Regular lab testing using lab equipment like oscilloscope, function generator and dc power supply was done to obtain results showing progress towards the objective. The testing on Skytrain is scheduled for August 11th to be performed under the supervision of Senior Electrical Engineer.

SFU SIMON FRASER UNIVERSITY

Table of Contents

Table of Figures

1.0. Introduction

1.0. About British Columbia Rapid Transit Company

British Columbia Rapid Transit Company, BCRTC in short is subsidiary of TransLink, that is operating Skytrain's Expo Line and Millennium Line in the Lower Mainland of the province of British Columbia in Canada [1]. Moreover, the West Coast Express is also maintained by the said company. The SkyTrain was constructed in 1985 and is fully automated. The SkyTrain while giving on-time service rating of 96.5% serves about 350000 passengers per weekday [1]. SkyTrain has Operations and Maintenance Centres for the maintenance of trains, Control Centre for trains, and offices for engineering and executive assistants. The Engineering department is classified into Engineering Asset Management, means prioritizing the maintenance of Rolling Stock, Automatic Train Control, and Vehicle Control Center.

1.1. Project Introduction and Objectives

During the full co-op term there were four projects in total that I have worked on. Those four projects include:

1. Transfer Switch Design for Propulsion Control Unit (PCU) shop to test different Auxiliary Power Units (APUs) of different series of trains.
2. Equipment replacement and automation of Antenna Quality Check of all series of trains.
3. Track switch monitoring to predict the failure before it happens.
4. Real time dump (RTD) reader using Internet of things (IoT) device to configure and store the RTD on Vehicle on Board Computer (VOBC).

All four of the projects took about equal time's share of the Co-op term. In detail, Equipment replacement and automation of Antenna Quality Check project is to be explained. The Scope of this project is to create an automated process to check the quality of the transmitter and receiver antenna mounted on the SkyTrain that is used for communication between Vehicle on Board Computers (VOBC) of two cars in the same train so they can coordinate with each other. The current procedure used to check the antenna quality:

1. Is outdated almost by a couple decades.
2. Takes a lot of time for the Equipment setup.
3. Is technical Labor Intensive.
4. Has a huge margin of error because of outdated technology.

The current process requires use of portable oscilloscope and a signal generator to test the antennas by emitting signal into Receiver antenna and reading it through oscilloscope from VOBC. Similarly, the signal generator transmits signal into VOBC, and oscilloscope is used to measure it from the Receiver antenna. The objectives of this project were to:

1. Create an automated process to make quality antenna check quick and efficient with minimal labor required.
2. To build a device that is compact with good user interface reflecting ease of use for shop technicians.
3. Replace the currently used equipment with current technology intensive alternatives.

The new automated project will be, as said by Senior Electrical Engineer, and I quote “a new milestone”, for the SkyTrain Electrical Engineering Department.

2.0. Detailed Analysis

2.0. Approach

Following the objectives, the approach is considered to use an electronic microcontroller device to automate this process with use of an Integrated Development Environment (IDE). Because of the previous experience and skillset learnt from Electric and Electronic circuits courses, the way to go was with Arduino.

2.1. Equipment and Software

This project would replace a signal generator and an oscilloscope to a small handheld device. Electronic circuits were the way to go. The Board used is Arduino UNO R3. It runs on Arduino IDE that use C++ to compile and upload the code to the Arduino Board over a serial port (COM4 in my case). A voltage divider is used to step down the voltage from 25V range to 5V range as the maximum input for Arduino is only 5V. In contrast, an Op-amp is used to step up the voltage to 25V range from 5V range as maximum output is also 5V only. Despite of being an excellent microcontroller device, the only way to produce a perfect sine wave is to use Pulse-Width Modulation (PWM), but it has limitation of maximum frequency of about 50Hz only. But we are talking about 1000 times more. Fortunately, Arduino can be equipped with different modules and to serve the purpose AD9850 Signal Generator module is used. Combine all the different parts together a full schematic[Figure 1] is generated that works as a function generator as well as oscilloscope and can automatically detect if the signal transmitted and received lies in the tolerance for the acceptable values. In addition to this, 16x2 LCD is used to display the results if the test is passed or not. The device is connected to the antenna and VOBC using the coaxial cable. A case[Figure 2] for the device is designed and manufactured using 3D printing.

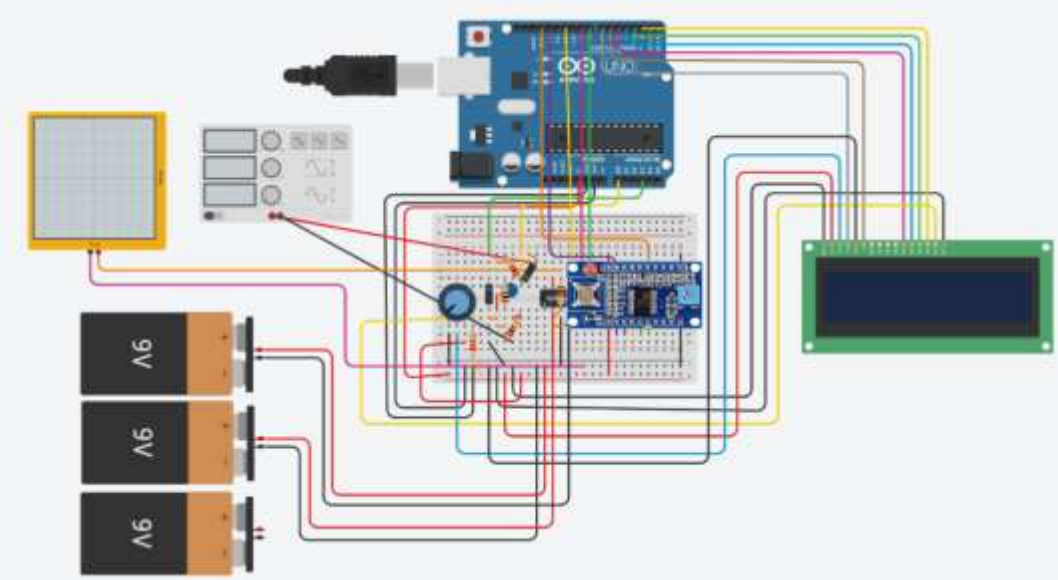

Figure1: Arduino Schematics [2].

Figure 2 and 3: 3D Enclosure Box.

2.2. Experiments

The Experiments were performed in engineering labs to test if Arduino can generate and measure the signal. After numerous attempts and redesigning of the signal generator module and amplifier the signal to match the requirements was obtained [Figure 4]. In similar way, the required signal was supplied to Arduino through signal generator in lab and displayed on the LCD [Figure 5]. The real test on actual train is schedule for August 11th to be done.

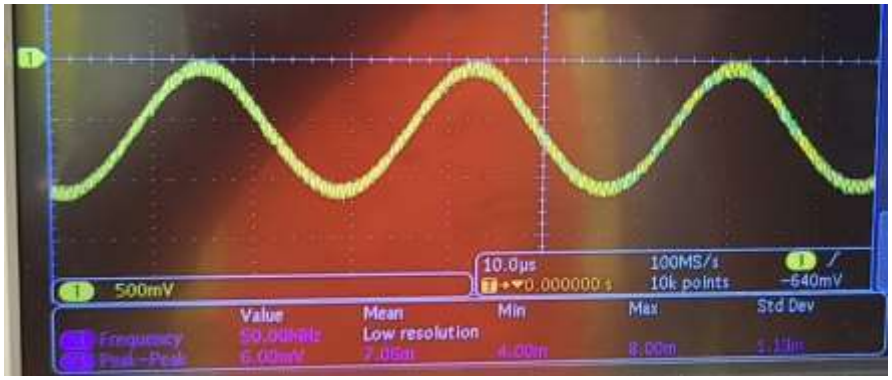

Figure 4: Generated Oscilloscope Signal

Figure 5: Measured Signal

2.3. Analyses and Results

The enclosure was 3D printed and the circuit was wired to obtain the real-life device[Figure 6 and 7]. The device is compact, and user can obtain quick results if antenna has passed the test or not in the lab environment.

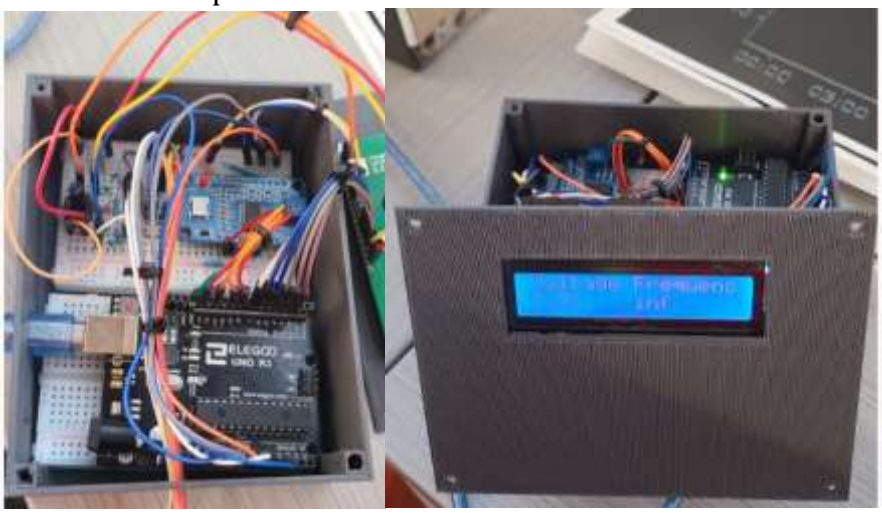

Figure 6 and 7: Assembled Device

The Objective was to create an automated device that can measure and generate signal while comparing the values to acceptable values. This device under the lab capacity is capable to do that. The final decision of this device being able to work will be obtained from the real train test. The Resulted signal [Figure 8] has met the expectations of what signal this device needs to generate. During the real test on August 10th the same signal will be fed to the train and get the desired output on VOBC.

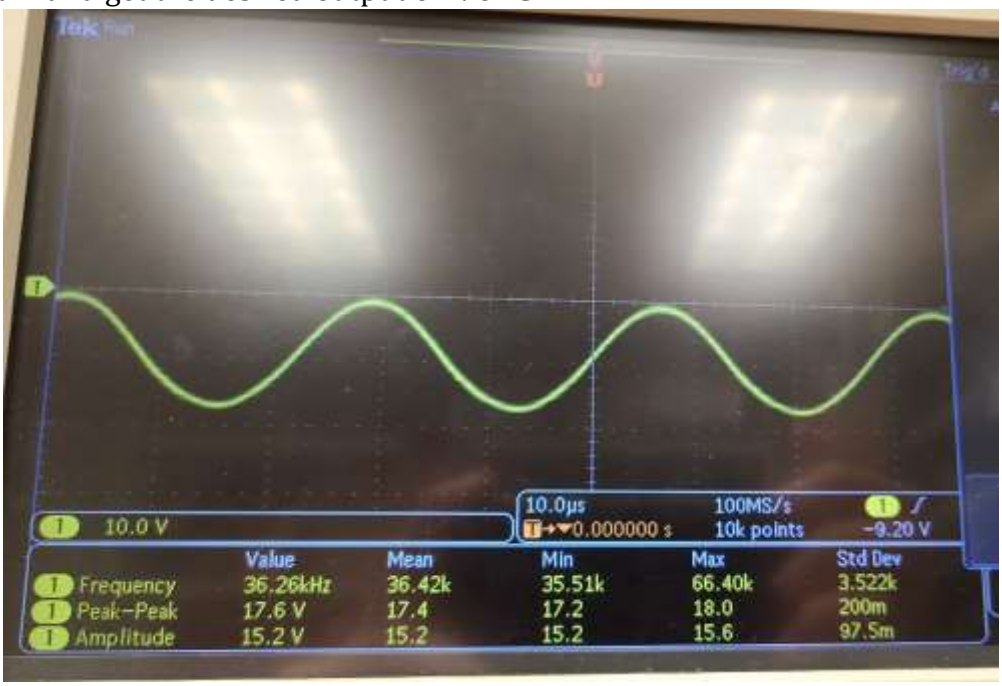

Figure 8: The final signal 17 Volts Peak to Peak

2.4. Discussion

Looking at the planned objectives, the project so far has gone well. The remarkable goal of using a microcontroller device like Arduino as a Function Generator and an Oscilloscope is accomplished. During the whole project there were other major components to it apart from building the actual product and that included tons of documentation. At the start of this project a Scope of work was written, and a timeline was established. During the project the supporting documents for the C++ code in Arduino IDE, the wiring diagrams, and the PCB layout for future use[Figure 9] were constructed. And on the successful first test on the train Technical Change Instructions, Maintenance Procedures, and User Manual are to be fabricated so this device can be reproduced and upgraded by other fellow engineers.

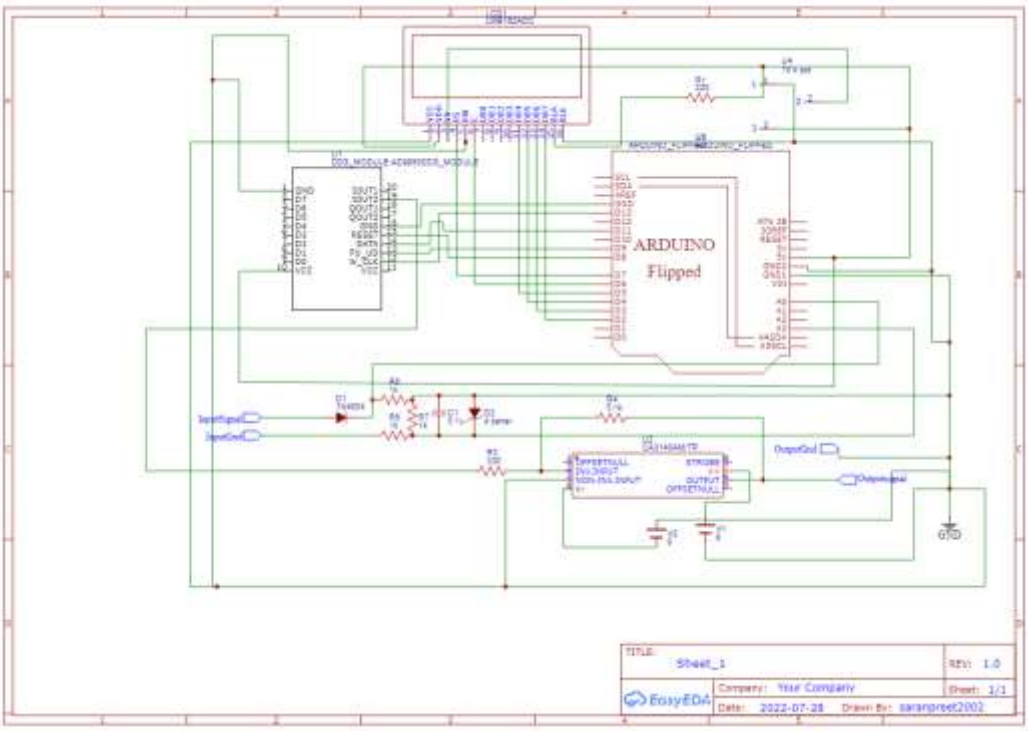

Figure 9 : Future PCB Board Schematic First Draft [3].

3.0. Conclusion and Recommendations

This Project, at least by me, would be considered as one of the major projects in my engineering career. There were many roadblocks encountered which include failed tests[Figure 10], unfamiliarity with combination of complex electric circuits, and inexperience in engineering industry. However, the key to get over these roadblocks is continuous learning and giving the 100 percent to even minor and least important parts of the job. The next steps for this project are:

1. Making the device more compact preferably on to a PCB by finalizing the Schematics [Figure 9] and manufacturing the board itself.
2. Making redesigned enclosure to house five 9V batteries to provide Supply voltage to Arduino as well as Operational amplifier to amplify the produced signal.
3. Adding a keypad to increase ease of use to choose between different test modes like Receiver antenna or transmitter antenna.
4. Mounting a storage device to extract the reading data for analysing the recorded values later in time in context to further testing.

References

[1] Translink, "British Columbia Rapid Transit Company," 10 08 2022. [Online]. Available: https://www.translink.ca/about-us/about-translink/operating-companies/british-columbia-rapid-transit-company.

[2] Tinkercad, "Tinkercad," Autodesk, [Online]. Available: https://www.tinkercad.com/dashboard?type=circuits&collection=designs. [Accessed 03 08 2022].

[3] Easy EDA, "Easy EDA," [Online]. Available: https://easyeda.com/. [Accessed 01 08 2022].