RESEARCH PROGRESS IN MECHANICAL AND MANUFACTURING ENGINEERING VOL. 4 NO. 2
(2023) 282-291

RPMME

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773 - 4765

Design and Development of a Human Height Measurement System for Sports Health Screening

Nurul Jannah M. Rodzi[1], Hanani Abd Wahab[1*]

[1]Faculty of Mechanical & Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2023.04.02.035
Received 1 Oct 2023; Accepted 15 Dec 2023; Available online 31 Dec 2023

Abstract: The rapid development of the Internet of Things (IoT) has enabled the creation of innovative and effective health monitoring systems. In the field of sports, height is an important physical characteristic that is important data in physical fitness standard tests and sports centre were taken during the screening session. However, traditional methods of measuring height can be time-consuming and extend the process flows. The development and design of a human height measurement system with IoT-based monitoring for sports health screening help to read the human height measurement from a distance. The circuit design consists of a NodeMCU ESP32 Wi-Fi Modules, HC-SR04 Ultrasonic Distance Sensor, LED Dot Matrix (MAX7219), and a cloud-based database. The height sensor as known as HC-SR04 Ultrasonic Distance Sensor at human height measurement prototype is mounted on a wall, and the ESP32 is connected to the computer via a USB serial connection and will be used as a gateway to retrieve data from the sensors and transfer the data to Arduino IDE (serial monitor) and Blynk which will be able to retrieve the data from that and display on the dashboard or gauge using a smartphone. The proposed system is a cost-effective and efficient way to measure height for sports health screening. The system is also scalable and can be easily adapted to different settings.

Keywords: Height Measurement, Ultrasonic Sensor, Monitoring System, Internet of Things (IoT)

1. Introduction

Metrology equipment has brought a revolutionary change from the past till the present day. In the study of metrology, the world has created various ways of measuring the human body. Designing advanced measuring equipment to capture a human height is more efficient now with the use of advanced complex data processing devices in the metrology family. Without an advanced system in place, there is a higher risk of errors in height measurements, which can compromise the integrity and reliability of athlete data. This can occur due to human error in manual measurements or the use of outdated measurement techniques, leading to inconsistent and unreliable results. Designing advanced

*Corresponding author: nani@uthm.edu.my

measuring equipment to capture a human height is more efficient now with the use of advanced complex data processing devices in the metrology family.

The past height measurement, a traditional physical measurement equipment device which is a retractable ruler system as known as a stadiometer were used in many fields focusing on sport health screening. The physical fitness standard test is related to sports health screening. A sports health screening is a medical examination done every year to determine whether a person is fit enough to take part in sports and determine the level of fitness by overviewing the score in the fitness test.

The height measurement system has a lot of potential to be coupled with the Blynk Application for the IoT system. The development of a height measurement system that can read the measurement in the Blynk App through a Mobile Phone from a distance where the display is located far away from the reader and designing a height measurement prototype through Solidwork software are the objective that needs to be achieved.

2. Literature Review

A human height measurement in various designs have been developed. From fixed to portable products to make the user easy to use over time. The technology that brings up into this era gives a lot of overviews on the design and development of the human height measurement system. The IoT-Based monitoring system has separated the type of human height measurement systems which are analogue and digital human height measurement.

3. Methodology

All the information required to produce the study's results is described in the methodology flowchart as shown in Figure 3.1. To be specific, the experimental setup contains all of the essential systems and components for the development of human height measurement.

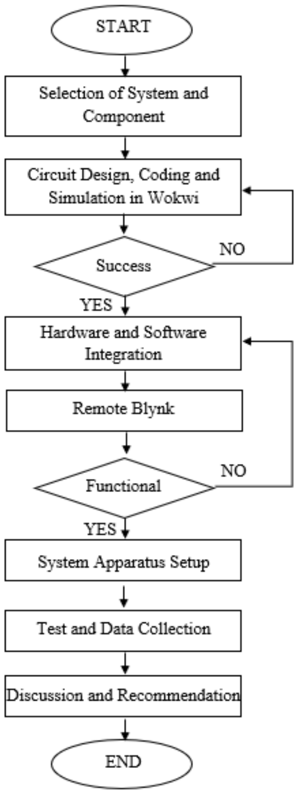

Figure 3.1: Flowchart of Methodology

3.1 Selection of System and Component

In this project, 3 components will be used: microcontroller, sensor, and display. The system can be controlled with Blynk. Figure 3.2 shows the module and sensor of the height measurement system integration can be described as the ESP32 is connected to the computer via a USB serial connection and will be used as a gateway to retrieve data from the sensors ESP32 and transfer it to Arduino IDE (serial monitor) and Blynk which will be able to retrieve the data and display it on the dashboard or gauge.

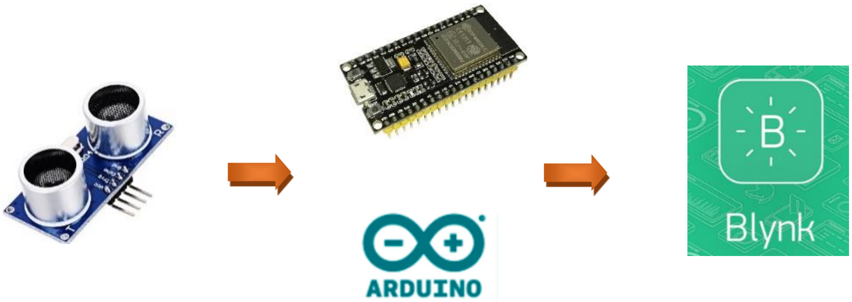

Figure 3.2: Module and sensor of the Height Measurement System

3.2 Circuit Design, Coding, and Simulation in Wokwi

The circuit that has been designed successfully achieved the functionality when matched with the coding that has been uploaded using the Wokwi Online Platform.

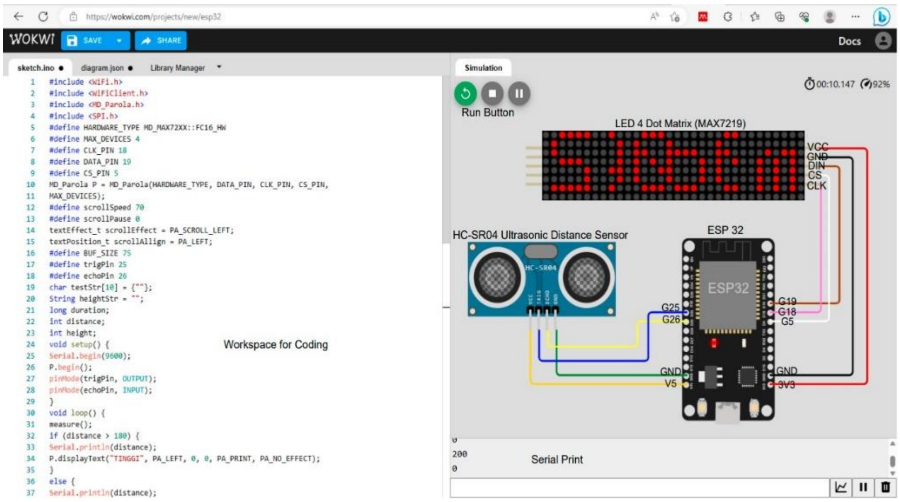

Figure 3.3: Simulation in Wokwi Online Platform

The complete simulation from Wokwi platform is done containing the circuit design, coding, and hardware for an electronic height measurement system. It is also completely functional when running the simulator. As a verification purpose, the LCD display screen 4 Dot Max7219 shows the 'HEIGHT' alphabet. This simulator gives a virtual scene through the coding that has been key in as in Figure 3.3. The program in reality must meet the functional criteria to show the coding work as expected. The schematic diagram of the height measurement design circuit gives a view or a good result to proceed to the next step in the integration of the system.

3.3 Hardware and Software Integration

In the system that was developed, the power bank with 2.1A serves as the power source. The block diagram in Figure 3.4 shows a sensor as an input connected by the microcontroller and then utilized the coding from Arduino to key in the data in it. Then, the output will go to display where the information is gathered and shown.

Figure 3.4: Block Diagram of Basic Height Measurement System

The real application was applied on the component where the hardware integration was made is shown in Figure 3.5. Each of the components was connected using jumper wire female to female with different colors. The jumper wire should be fit and cannot easily lose.

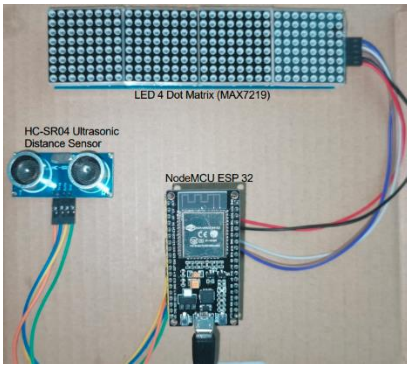

Figure 3.5: Hardware Integration

Software Integration was added with the Blynk IoT platform. Blynk IoT is to receive the data from its measuring gadget wirelessly, and appears as an accurate height measurement in real-time. The development of the system is shown in Figure 3.6.

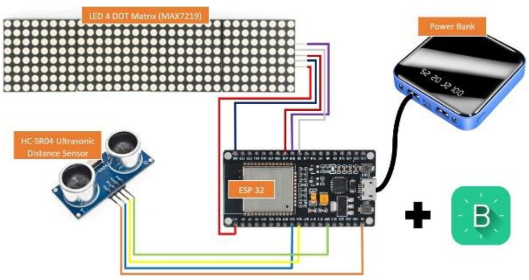

Figure 3.6: Software Integration

Solidwork software was included in this project to achieve the objective of a final product where design of the human height measurement prototype with the development of a circuit system through hardware integration and complete software integration. The material used for the development of the prototype is PTEG Filament using 3D Printing.

3.4 Remote Blynk

The general procedure to use the Human Height Measurement is listed below in Figure 3.7:

i ii iii

Figure 3.7: The general procedure for measuring height

i. Take off your shoes
ii. Make sure the body standing straight near to the mark at the floor
iii. The face looks forward and ready to take the reading

The Blynk procedure to use the Human Height Measurement is listed below:

i. Turn on the Wi-Fi.
ii. Make sure the display appears in “HEIGHT” sentences.
iii. Open the Blynk App on the Mobile.
iv. Read the measurement on the Mobile screen

3.5 System Apparatus Setup

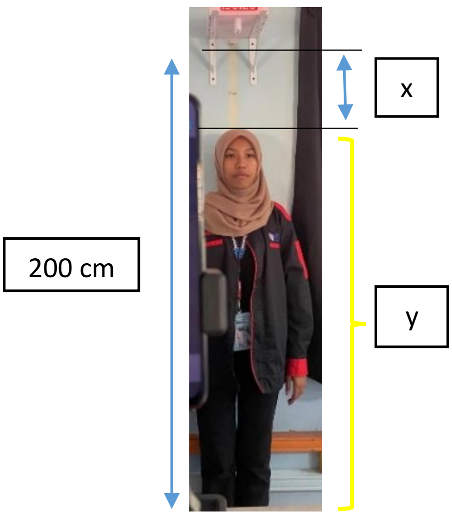

Figure 3.8: The Height Measurement System

Figure 3.8 shows the height measurement prototype which was fixed and placed 200 cm from the floor. The person standing straight under the sensor where has a mark on the floor means the person can easily spot the position to stand. It is required to take off the shoes before screening. The reading will appear on the display and also gauge in the Blynk App using Mobile. The height of the person can be determined by the height of the sensor placement to the person standing state as y and will minus to the unknown distance.

4. Results and Discussions

4.1 Analysis of The Circuit Design Troubleshoot

Analysis of the design of the circuit involves testing the electronic circuit in the model. The creator analyzed the functionality of the electrical circuits. Troubleshooting will occur in case the electrical circuit does not work properly. Troubleshooting requires the creator to revise the electronic circuit and find the source of faulty from the electronics circuit.

4.1.1 Analysis of The Microcontroller Functionality Pins

NodeMCU ESP32 Wi-Fi module is the main controlling component of the entire operation of the Height Human Measurement System Prototype. NodeMCU ESP32 Wi-Fi Module was pre-programmed using Arduino IDE. The NodeMCU Wi-Fi module needs to be tested first to get the value voltage for each pin used in the Height Human Measurement System as shown in Figure 4.1 and Table 4.1.

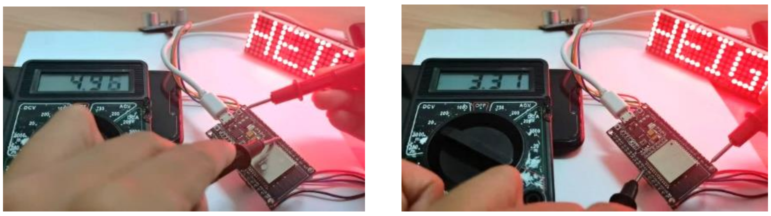

Figure 4.1: Testing the Microcontroller Pins Voltage

Table 4.1: Microcontroller Voltage Output Reading

Pin used in Wi-Fi Module Node MCU ESP32	Voltage Output Reading, (V)
G25	4.96
G26	4.96
G5	3.31
G18	3.31
G19	3.31

4.1.2 Analysis of The Microcontroller Functionality Pins

The HC-SR04 Ultrasonic Distance Sensor is known as the input for this model. Every data received by the HC-SR04 Ultrasonic Distance Sensor is sent to the Wi-Fi Module Node MCU ESP32 for processing for the next operation. After the HC-SR04 Ultrasonic Distance Sensor measures a person's height, the microcontroller will receive the data and send the data to the server. Then, this server will inform the user about the height reading as shown in Figure 4.2 and Table 4.2.

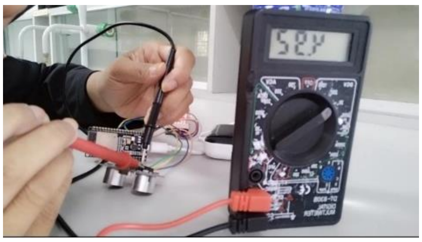

Figure 4.2: Testing the Sensor Pins Voltage

Table 4.2: Sensor Voltage Output Reading

Pin at HC-SR04 Ultrasonic Distance Sensor	Voltage Output Reading, (V)
echoPin	4.95
trigPin	4.95

4.1.3 Analysis of The Display Functionality Pins

This prototype's LED Dot Matrix (MAX7219) is equipped with an SPI (Serial Peripheral Interface) module to communicate with a microcontroller or a host device. Furthermore, it also has five pins namely the Power pin, Ground pin, Clock, and CS, DIN. The output from the LED Dot Matrix (MAX7219) is the output for the Height Human Measurement System. This is because the LED Dot Matrix (MAX7219) will measure a person's height (Figure 4.3 and Table 4.3).

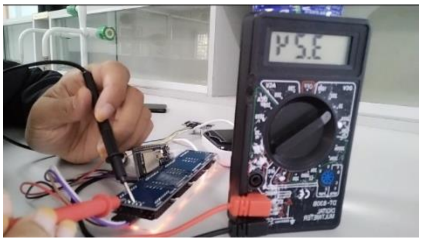

Figure 4.3: Testing the Display Pin's Voltage

Table 4.3: Display Voltage Output Reading

Pin at LED Dot Matrix (MAX7219) Display	Voltage Output Reading, (V)
DIN (Data In)	3.54
CS (Chip Select)	0.06
CLK (Clock)	3.54

4.2 Analysis of HC-SR04 Ultrasonic Distance Sensor Angle

Figure 4.4 shows the non-detection area and range detection of the HC-SR04 Ultrasonic Distance Sensor. The object under the sensor gives a reading as it's in the detection area.

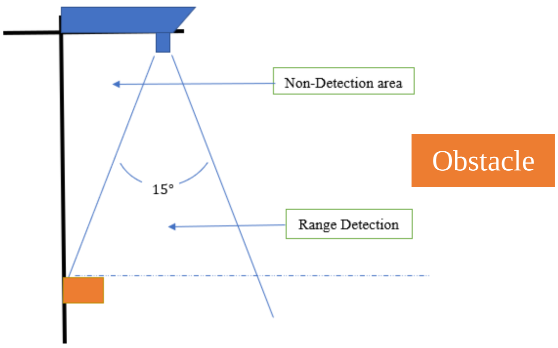

Figure 4.4: Range Detection

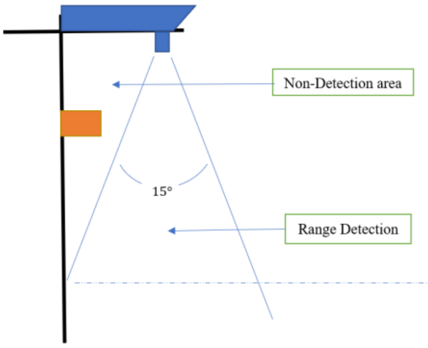

Figure 4.5: Area of Detection

The pulse of HC-SR04 Ultrasonic Distance Sensor emitted with a high-frequency sound wave that is typically generated by an onboard ultrasonic transducer, the conversion of electrical energy into ultrasonic sound waves. The trigger pins will receive a high-level pulse of around 10 microseconds when the sensor is triggered. An object under the sensor will be poured with a pulse that propagates through the air and travels in the detection range. However, if the object is not under the pulse range as shown in Figure 4.5, the reading will not appear on the display as the object did not in the detection range. As a result, the reading will remain constant like there is no object under the sensor. The reading will read as 0 cm.

4.3 Analysis of Height System

The various colour of the histogram stated as sensor distance from 200 cm to 203 cm shown in Figure 4.6. The histogram shows the percentage height of all four distance sensors has a percentage accuracy of more than 90% from the three different heights. The comparison sensor distance of 200 cm, 201 cm, 202 cm and 203 cm for height between 60 cm, 120 cm and 200 cm. Its shows that the sensor distance of 203 cm got the highest percentage of accuracy compare to sensor distance of 200 cm, 201 cm and 202 cm.

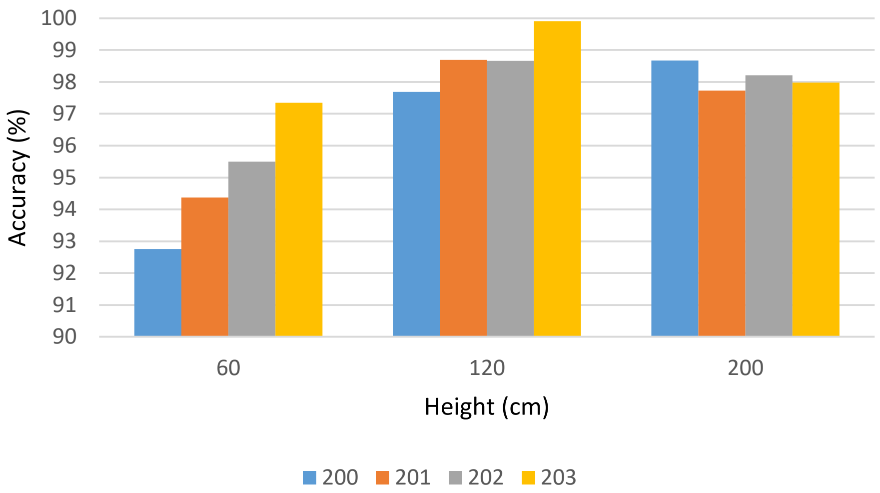

Figure 4.6: The Percentage Accuracy of Sensor Distance

The validation of the highest percentage accuracy focused on sensor distance of 203 cm for height 120 cm has the highest percentage accuracy which 99.91% followed by the distance sensor of 201 cm for height 120 is 98.67% and the distance sensor of 202 cm for height 120 is 98.66%. Unfortunately, a distance sensor of 200 cm contributes the lowest accuracy for 120 cm height which the percentage accuracy is 97.69%. Also, the average percentage error for a distance sensor of 203 cm for 120 cm height is the lowest (0.09%) compare to distance sensors of 200 cm, 201 cm, and 202 cm for 60 cm, 120 cm, and 200 cm which the percentage error start from 7.25% until 1.33%. The accuracy of the height system depends on the value of percentage error where the lowest value of percentage error, is the highest value for accuracy. That being the case, it can be concluded that an ultrasonic sensor type HC-SR04 can give an accurate reading at 203 cm compared to the other three distance sensors stated.

As a result, the analysis of the height system using the HC-SR04 Ultrasonic Distance Sensor based on the percentage accuracy can be stated that this sensor cannot reliably measure the height that is closer than this minimum height. For future research, the alternative sensor can be used such as infrared (IR) distance sensors or time-of-flight ToF sensors, which give more precise measurements at close distances. It is also important to know the range of distance that need to use based on the datasheet and its application.

Consequently, based on the datasheet HC-SR04 Ultrasonic Distance Sensor, the maximum range detection is 400 cm. This experimental height system can verify that the range detection for the HC-SR04 Ultrasonic Sensor cannot reach 400 cm. It is because the analysis that has been conducted shows that the theoretical and experimental measurements are minus 2 cm to 3 cm. The validation of the datasheet from the manufacturer for the maximum 400 cm can be considered that the blind region of the sensor included

5. Conclusion

A prototype of the Human Height Measurement using an IoT-Based Monitoring system has been successfully developed according to the set period and meets the objectives of the study. The first objective that has been achieved is a prototype of Human Height Measurement that can be designed and developed for measuring height using a Mobile App. Prototypes can solve problems that happen on the screening test day to avoid time-consuming. This is because objectively have used 3 electronic hardware and 4 software to achieve the designs that are ready to be done to develop this prototype. Hence, the design that uses Solidwork software is very successful in this project. Next, the objective that has been achieved is that this prototype can analyze functionality and develop a monitoring system for human height as a tool to help screening tests can be monitored automatically for a distance. This is because doing analysis in terms of technology can know the lack of prototypes and can improve for the future. The suggestions suggested by the supervisor may help future researchers produce a Prototype version of an efficient Human Height Measurement using an IoT-Based Monitoring system and better.

Acknowledgment

The authors would also like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for its support in giving the permission to make installment of the human height measurement prototype at Block E12.

References

[1] B. Klaus and P. Horn, Robot Vision. Cambridge, MA: MIT Press, 1986. (Example citation for books)

[2] L. Stein, “Random patterns,” in Computers and You, J. S. Brake, Ed. New York: Wiley, 1994, pp. 55-70. (Example for a chapter in a book)

[3] L. Bass, P. Clements, and R. Kazman, Software Architecture in Practice, 2nd ed. Reading, MA: Addison Wesley, 2003. [E-book] Available: Safari e-book. (Example for e-books)

[4] J. U. Duncombe, "Infrared navigation - Part I: An assessment of feasibility," IEEE Trans. Electron. Devices, vol. ED-11, pp. 34-39, Jan. 1959. (Example for a journal article)

[5] H. K. Edwards and V. Sridhar, "Analysis of software requirements engineering exercises in global virtual team setup," Journal of Global Information Management, vol. 13, no. 2, p. 21+, April-June 2005. [Online]. Available: Academic OneFile, http://find.galegroup.com. [Accessed May 31, 2005]. (Example for an e-journal article extracted from a database)

[6] A. Altun, "Understanding hypertext in the context of reading on the web: Language learners' experience," Current Issues in Education, vol. 6, no. 12, July 2003. [Online]. Available: http://cie.ed.asu.edu/volume6/number12/. [Accessed Dec. 2, 2004]. (Example for an e-journal article extracted from the internet)

[7] L. Liu and H. Miao, "A specification-based approach to testing polymorphic attributes," in Formal Methods and Software Engineering: Proceedings of the 6th International Conference on Formal Engineering Methods, ICFEM 2004, Seattle, WA, USA, November 8-12, 2004, J. Davies, W. Schulte, M. Barnett, Eds. Berlin: Springer, 2004. pp. 306-19. (Example for a conference paper)

[8] T. J. van Weert and R. K. Munro, Eds., Informatics and the Digital Society: Social, ethical and cognitive issues: IFIP TC3/WG3.1&3.2 Open Conference on Social, Ethical and Cognitive Issues of Informatics and ICT, July 22-26, 2002, Dortmund, Germany. Boston: Kluwer Academic, 2003. (Example for conference proceedings)

[9] J. Riley, "Call for a new look at skilled migrants," The Australian, p. 35, May 31, 2005. [Online]. Available: Factiva, http://global.factiva.com. [Accessed May 31, 2005]. (Example for newspaper article)

[10] J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987. (Example for technical report)

[11] J. P. Wilkinson, “Nonlinear resonant circuit devices,” U.S. Patent 3 624 125, July 16, 1990. (Example for a patent)

[12] IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969. (Example for a standard)

[13] J. O. Williams, “Narrow-band analyzer,” PhD dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993. (Example for a thesis)