Indoor monitoring system

PROIECT DE DIPLOMĂ

Autor: **Raul Velcherean**

Conducător științific: **Titlu.ing. Prenume NUME**

|  |  |
| --- | --- |
| DECAN  **Prof.dr.ing. Liviu MICLEA** | Vizat,  DIRECTOR DEPARTAMENT AUTOMATICĂ  **Prof.dr.ing. Honoriu VĂLEAN** |

Autor: **Prenume NUME**

Indoor monitoring system

1. **Enunţul temei:** *Provide the location of a TAG module in relation to the other ANCHOR modules, similar to the GPS system but on a smaller scale.*
2. **Conţinutul proiectului:** *(enumerarea părților componente) Pagina de prezentare, Declarație privind autenticitatea proiectului, Sinteza proiectului, Cuprins, Titlul capitolului 1, Titlul capitolului 2,… Titlul capitolului n, Bibliografie, Anexe.*
3. **Locul documentaţiei:** *Universitatea Tehnică din Cluj-Napoca, alte locuri dacă este cazul*
4. **Consultanţi:** *ing. Prenume Nume (dacă este cazul)*
5. **Data emiterii temei:**
6. **Data predării:**

Semnătura autorului

Semnătura conducătorului științific

**Declaraţie pe proprie răspundere privind**

**autenticitatea proiectului de diplomă**

Subsemnatul(a) **Prenume NUME**  , legitimat(ă) cu CI/BI seria nr. , CNP ,

autorul lucrării:

elaborată în vederea susţinerii examenului de finalizare a studiilor de licență la **Facultatea de Automatică și Calculatoare**, specializareaChoose an item.**,** din cadrul Universităţii Tehnice din Cluj-Napoca, sesiunea Choose an item. a anului universitar 2017-2018, declar pe proprie răspundere, că această lucrare este rezultatul propriei activităţi intelectuale, pe baza cercetărilor mele şi pe baza informaţiilor obţinute din surse care au fost citate, în textul lucrării, şi în bibliografie.

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In cazul constatării ulterioare a unor declaraţii false, voi suporta sancţiunile administrative, respectiv, *anularea examenului de licenţă*.

Data Prenume NUME

(semnătura)

**SINTEZA**

proiectului de diplomă cu titlul:

Titlul lucrării

Autor: **Prenume NUME**

Conducător științific: **Titlu.ing. Prenume NUME**

1. Cerinţele temei: pinpoint a location in a room which will be shown on a computer.

2. Soluţii alese: use of Atmel’s Atmega328p microcontroller as a host for Decawave’s DWM1000 transceiver module, which has the capabilities to communicate wirelessly with another module of the same kind.

3. Rezultate obţinute: display of location data on a PC

4. Testări şi verificări:

5. Contribuţii personale:

6. Surse de documentare:

Semnătura autorului

Semnătura conducătorului științific

Cuprins

[1 Introducere 2](#_Toc477457095)

[1.1 Context general 2](#_Toc477457096)

[1.2 Obiective 2](#_Toc477457097)

[1.3 Specificații 2](#_Toc477457098)

[2 Studiu bibliografic 3](#_Toc477457099)

[3 Analiză, proiectare, implementare 4](#_Toc477457100)

[4 Concluzii 5](#_Toc477457101)

[4.1 Rezultate obținute 5](#_Toc477457102)

[4.2 Direcții de dezvoltare 5](#_Toc477457103)

[5 Reguli de formatare 6](#_Toc477457104)

[5.1 Formatarea paginii 6](#_Toc477457105)

[5.2 Titluri și stiluri 6](#_Toc477457106)

[5.3 Figuri, tabele și ecuații 7](#_Toc477457107)

[5.3.1 Figuri 7](#_Toc477457108)

[5.4 Tabele 7](#_Toc477457109)

[5.5 Ecuații 7](#_Toc477457110)

[5.6 Referințe bibliografice 8](#_Toc477457111)

[6 Bibliografie 9](#_Toc477457112)

# Introducere

## Context general

In introducere familiarizați cititorul cu motivația lucrării, plasați lucrarea într-un context care să permită cititorului să înțeleagă obiectivele.

There are plenty of reasons for the need of information regarding the location of certain things, as it can be clearly seen from our everyday use of the GPS. In its infancy, the GPS was used mostly by the military to coordinate troops, guide missiles and track targets, until it was cleared for public use.

Unfortunately the GPS doesn’t have a very high accuracy. The location that can be found using this system usually has an error of aproximately 5 meters. This average error is also the one we get when we have a clear view of the satellites used for geolocation. When inside a building, for example, the error increases.

To solve this accuracy problem

Descrieți importanța lucrării, de ce merita să o faceți, plasati ideile într-un context larg.

A solution to this accuracy problem is described in this paper. The main component of this solution is the DWM1000 module from Decawave, which boasts an error in the range of centimeters, more specifically, about 10 centimeters.

Sustineți studiul: de ce exact aceasta aplicație/implementare. Comentați asupra aspectelor teoretice sau practice care v-au facut să o alegeți.

In funcție de natura lucrării, ar putea fi necesar să prezentați informații de fond asupra domeniului în care se încadrează aplicația, mai ales dacă aveti o lucrare într-un domeniu multidisciplinar. In acest caz, puteți introduce terminologia pe care o utilizați în continuare.

Descrieti pe scurt lucrarea: ce conține fiecare capitol.

## Obiective

Enumerati și explicati obiectivele lucrării: ce v-ați propus să realizați în contextul prezentat anterior.

The main objective of this paper is to obtain a set of coordinates that describe the precise location in relation with a set coordinate frame. The set of coordinates will be reduced to a two-dimensional form for simplicity and so, come in the (X, Y) form, Z being omitted for now.

In order to achieve the set objective, the following steps are required to be fulfilled:

1. Achieve communication between a chosen host microcontroller and the DWM1000 module. This step consists of:
   1. Choosing a microcontroller
   2. Understanding the particularities of the chosen microcontroller
   3. The design of a PCB to physically connect the microcontroller with the DWM1000 module
   4. The software for communication

After this step is completed, the result will be a board which will henceforth be called a transceiver.

1. Wireless communication between 2 transceivers
   1. Having 2 transceivers completed
   2. Necessary software written on each
2. Wireless communication between 4 transceivers
3. Communication between one of the transceivers and a PC
4. Trilateration – calculating the coordinates based on the distances from 1 transceiver to the other 3. This is done on the PC.
5. Plotting the coordinates. Also done on the PC

Obiectivele pot fi prezentate sub formă de listă care să evidențieze precis orientarea lucrării, să identifice conceptele fundamentale pe care le studiati, să stabilească scopul aplicației pe care o realizați, sau enuntați întrebarile la care intentionați să răspundeți în lucrare.

## Specificații

In specificațiile lucrării detaliați cerințele. Descrieți ce intentionați să obtineți. Vă puteți referi la funcțiile aplicației, interfață, nivele de performanță, structuri de date, elemente, securitate, fiabilitate, calitate, limitări, etc.

For the first step the Atmega328P microcontroller was chosen due to familiarity and previous experience. The DWM1000 module uses the SPI protocol to communicate with its host microcontroller. This protocol requires 4 pins to operate. Other notable connections are the RESET and INTERRUPT pins of the module.

The connection of the 2 components is done via a PCB which was designed based on previous specifications. Software is uploaded on the board via SPCI programming.

After 2 boards have been completed for the second step, they will be tested to be able to wirelessly communicate with each other. One will transmit a packet of data, while the other will receive said packet. When the data has been correctly received, this step can be considered done.

The third step is similar to the second, the difference being the number of boards involved in the communication.

The fourth step involves serial communication between one of the boards, which has information about the distance to each of the other boards. This information will be sent to the PC for further processing. The program used to process the data on the PC is MATLAB.

The fifth step involves the calculation of the coordinates of one of the transceivers in a program of our choosing (MATLAB for this paper).

The sixth and final step consists of plotting the data that was calculated in the previous step. Here, we use MATLAB as well because of its capabilities.

# Studiu bibliografic

Conține o analiză a ceea ce s-a realizat/studiat anterior. Arătați că ați studiat materiale bibliografice și că ați înteles ceea ce ați citit.

Puteti include diferite puncte de vedere asupra problemei pe care o rezolvați în lucrare.

Nu uitați să citați corespunzător autorii oricărei idei extrase dintr-o sursă bibliografică.

## The Decawave DWM1000 module

Transceiver, data rate, radio, spi, form factor, time

The main component that this paper makes use of, and around which the whole implementation revolves around is the Decawave DWM1000 transceiver module. As the name implies, the transceiver is able to transmit and receive data. This is done wirelessly via radio waves. It can use up to 4 radio frequency bands bounded by the 3.5 GHz and 6.5 GHz. This method of data transmission is a must because of the well known properties of radio waves.

RADIO WAVES

Radio waves are characterized by the frequency range which they occupy in the electromagnetic radiation spectrum (radio being a type of electromagnetic radiation), this being lower bounded by 30Hz and upper bounded by 300GHz. A radio wave is basically an oscillation which occurs at a frequency in the afore mentioned range, of electric and magnetic fields that constantly create one another. The speed at which this happens is the speed of light, a well known constant, having a value of 299,792,458 metres per second.

Radio waves can occur naturally, being emitted by various weather phenomena, most notably lightning, astronomical objects, which are the main source of radio waves through stars. But, radio waves can also be generated artificially. By having a certain signal of electric current that is amplified and passed through an antenna, electromagnetic radiation will be generated with the antenna as a source and it will start propagating in space, usually omnidirectionally, but that can also be changed by the design of the antenna.

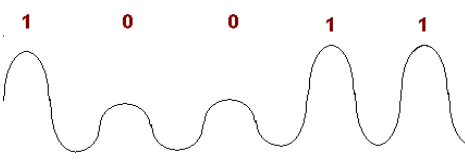
An antenna is also used on the receiving end of the signal. The antenna captures the signal which is passed through a circuit for further processing.

DATA TRANSIMISSION THROUGH RADIO WAVES

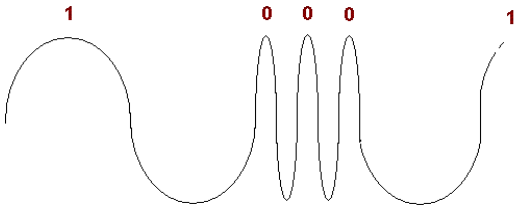
Using the process described above, we can send data from point A to point B wirelessly. The main properties of the signal sent are its amplitude and frequency. And thus we can send bits of data by changing those properties. This is done by modulating the signal that is sent along the air.

There are 2 main methods for modulating a signal based on the 2 properties mentioned above, but there are also other possibilities.

Amplitude modulation is the process of encoding information using the amplitude of the radio wave. For binary data, we can impose that an amplitude denotes the value 0 and another amplitude the value 1. And so, choosing 2 Volts for 0 and 5 Volts for 1, when the amplitude of the wave in the current period hits a maximum of 5V, it is interpreted as a 1, the process being similar for 0.



Frequency modulation is the process of encoding information using the frequency of the radio wave. The process for modulation is very similar to the previous case, but instead of amplitude we modify the value of the frequency.



Another type of modulation is the phase modulation, which is the process of encoding information using the phase of the radio wave. For example, a 0 signal will be represented by a 0° change in phase, while a 1 will be represented by a 180° change in phase.

Those 3 types of modulation are the basic ones when it comes to this process. Modern wi-fi signals use something a bit more complex, mainly, Quadrature Phase Shift Keying. It is similar to the Phase Shift Modulation method, the difference being the number of states the wave can be in. If we increase the number of states, we increase the number of symbols sent. In this case we send 4 symbols, which are 00, 01, 10 and 11. Those are represented by a difference of 90° change. So, starting with an offset of 45°, we have 45° to represent 00, 135° to represent 01, 225° to represent 10 and 315° to represent 11.

The DWM1000 uses Binary Phase-Shift Keying.

THE BANDS/FREQ USED -> DATA RATES

The DWM1000 module transmits data with frequencies between 3.5Ghz and 6.5Ghz on 4 different radio frequency bands. Those 4 channels are 1, 2, 3 and 5 and they have a bandwidth of 500MHz. The centre frequencies for those channels are the following: 3494.4MHz for channel 1, 3993.6 MHz for channel 2, 4492.8 for channel 3 and 6489.6 for channel 5.

The data rate is the amount of data that is sent per unit of time, and in our case is equivalent with the number of bits that are sent in a second since we only have 2 states, hence 1 symbol equals 1 bit. The DWM1000 module supports 3 different data rates. Those are: 110 kbps(kilo-bits per second), 850 kbps and 6.8 Mbps(mega-bits per second).

RANGING USING TIME -> THE CLOCK

One of the main features of the DWM1000 module that allows it to be used for the purpose of our paper is the sampling clock that is used for ranging. This clock works at 63.8976 GHz which means it has a time period of 15.65 picoseconds. This clock is what allows us to calculate the distance between 2 transceivers with such a high accuracy. Since we know the speed at which light travels and of course, radio waves, we know that in a picosecond, the distance that has been traveled is about 0.3 millimeters. Multiplying that with our value of 15.65 we get 4.695. This number represents in millimeters the minimum error in millimeters that we can have in our system when we measure distance. The error is further increased to the range of centimeters because of other factors in the circuit, such as the antenna delay and the processing of the microcontroller.

## The Atmega328P microcontroller

Spi, code, idk

Even though our module is quite powerful, it cannot do the job we want it to alone. It is capable of sending messages through radio waves, but it can’t do so by itself, it needs a brain to control it. This problem is solved with the help of a microcontroller.

A microcontroller is very similar to a computer: it has a processor, memory (ROM and RAM), Input/Output pins that let it interact with various peripherals like our module, and all of this comes on a single chip of very small size which makes it perfect for our embedded application.

To make use of a microntroller, first we must upload code unto it. The code is stored in its ROM memory (usually Flash). When the microcontroller boots, the CPU, which comes in options as simple as 4-bit to more complex such as 32-bit or 64-bit, fetches the instructions stored in memory and starts executing them. This behaviour makes microntrollers suitable for a certain task that it does over and over again. Tasks such as awaiting data from sensors and doing something based on the received data, periodic tasks, simple robots, and of course controlling peripherals.

The microcontroller that we choose has the task telling our DWM1000 module to send data and listening for the data that the module sends back. The data involved in this process will then be processed and sent further to a PC.

The microcontroller that was chosen for this project is Atmel’s Atmega328p. This is a high performance 8-bit from the AVR family of microntrollers. It is based on the RISC (Reduced Instruction Set Computing) architecture, which as the name implies uses a reduced number of instructions that total 131 and the execution time is of a single clock cycle for most of them. This makes it capable of achieving 16 MIPS (million instructions per second) at 16 MHz. It has 32 x 8 general purpose registers.

It has 32 Kbytes of flash memory that is used to store the program data, an additional 1Kbyte of EEPROM memory for data and 2 Kbytes of internal SRAM. The flash memory supports up to 10,000 writing and erasing cycles, while the EEPROM up to 100,000 cycles. The locking of a certain section of the memory for the purpose of a boot sector is also possible.

Regarding peripherals, it has two 8-bit Timer/Counters and one 16-bit Timer/Counter. Six PWM channels and an 8 channel 10-bit ADC that can be used to interpret analogue sensors.

The operating voltage for the ATmega328P is between the 2.7V and 5.5V range. This is very important since the DWM1000 module operates at the 3.3V level, which is included in the above mentioned range. The small physical size of the microntroller (34.5mm x 8mm) is also useful for the final implementation of the project.

Regarding communication peripherals, the ATmega328P has a couple to choose from. The I2C which stands for inter integrated circuit, also pronounced as I squared C, is a serial communication protocol which uses a master/slave implementation, where the master sends data to a slave on a common bus using an addressing format.

The UART, which stands for Universal Asynchronous Receiver-Transmitter, is a simple serial communication protocol, having only two pins, the Rx and Tx, used to transmit and receive serial data. This is the protocol that we use with our PC with the help of a simple USB to UART converter.

The most important peripheral feature that this microntroller has and we need for our project is the Master/Slave SPI serial interface that is used to communicate with the DWM1000 module. The microntroller acts as a master while the module is a slave in this exchange of data.

## The SPI protocol

Communication involves messages sent in two direction with the involved parties playing the role of receiver and transmitter, one sending data and the other receiving said data and vice-versa. The SPI (Serial Peripheral Interface) is a synchronous serial data protocol that facilitates the communication between the two involved parties. The relationship established between the 2 devices that are communicating is a master/slave one, meaning that the master is the device that sends instructions to the slave, while the slave executes said instructions. Also one master is able to control more than one slave, and can choose which slave to control.

The physical layer of the SPI protocol consists of the 4 wires that are used to connect the devices and looks something like this:

PIC SPI

* MOSI (Master Ouptup/Slave Input) – the wire on which the master sends data to the slave
* MISO (Master Input/Slave Output) – the wire on which the slave sends data to the master
* SCLK (Clock) – the wire on which the clock signal used for synchronizing is sent
* SS (Slave Select) – the wire on which the signal for selecting the slave is sent

SPI works by first selecting the slave chip that the master wants to communicate with. After this, the clock signal is started by the master which means that data is about to be sent. This signal also synchronizes the data since bits will be sampled according to the clock signal. The speed of the transfer is also dictated by the frequency of the clock. Higher frequency meaning higher speeds and lower frequencies lower speeds.

After the clock signal, data starts to stream from the master through the MOSI line one bit at a time and the slave reads those bits as they are received. Data sampling starts with the first edge of the clock signal. Then, if a response is needed from the slave, it will be received on the MISO line in a similar way to the process of sending data from master to slave.

After the transfer is complete the clock signal is stopped, meaning that the data transfer is over for now.

## Serial communication

Basic stuff

## PCB

From uc to pc

## Trilateration

Algorithm

# Analiză, proiectare, implementare

Aceasta parte a lucrării este flexibilă și depinde foarte mult de natura lucrării, poate fi organizată în mai multe capitole și conține contribuțiile personale ale autorului.

Includeți:

* + Detalii referitoare la analiză și proiectare:
    - descrierea metodelor pe care le-ați aplicat pentru rezolvarea problemei,
    - descrierea materialelor, procedurilor
    - calcule, tehnici, descrierea echipamentelor
    - metodologia de proiectare
    - informațiile necesare pentru ca cineva să poata reface lucrarea
  + Implementare :
    - Descrieti detaliile tehnice ale implementarii aplicatiei: mediul de implementare, modul de prezentare, modul de utilizare al aplicatiei, etc.
  + Testare si validare :
    - Descrieți metodologia de testare a aplicației și rezultatele
    - Includeți experimentele pe care le-ați realizat, analiza rezultatelor pe care le-ați obținut.

# Concluzii

## Rezultate obținute

Evidentiați toate rezultatele pe care le-ați obtinut și trageți concluzii din ele. Puteți prezenta o analiză critică a ceea ce ați realizat comparativ cu alte lucrări/studii anterioare.

Includeți o listă a contribuțiilor pe care le-ați avut în domeniul temei abordate.

## Direcții de dezvoltare

Descrieți direcțiile posibile de dezvoltare.

# Reguli de formatare

## Formatarea paginii

* + Dimensiunea paginii: A4
  + Margini: 2.5 cm (sus, jos, stânga, dreapta)
  + Antet și subsol: 1.27 cm de la marginea paginii
  + În antetul paginii (header): titlul capitolului, centrat, stil: Header\_style
  + În subsolul paginii: numărul paginii, centrat

## Titluri și stiluri

Titlurile capitolelor și subcapitolelor se marchează cu stilurile Heading 1 – 4, conform documentului model anexat în format Word. Descrierea stilurilor utilizate în document este prezentată în Tabelul 5 .1.

Tabelul 5.1. Stiluri utilizate în acest document

| **Nr.** | **Stil** | **Utilizat pentru** | **Format** |
| --- | --- | --- | --- |
| **1** | Normal | Text normal | Font: (Default) Cambria, 12 pt, Justified, Line spacing: Multiple 1.1 li, Space After: 6 pt |
| **2** | Titlu | Titlul proiectului, prima pagină | Font: 24 pt, Small caps, Centered Line spacing: single, Space Before: 126pt, After: 0 pt, |
| **3** | Titlu2 | Titlul proiectului, pagina de prezentare | Font:14pt, Bold, Centered |
| **4** | Heading 1 | Titlurile capitolelor (nivel 1) | Font: 24 pt, Indent: Left: 0 cm Hanging: 0.76 cm, Space Before: 24pt, After: 12pt |
| **5** | Heading 2 | Titlurile subcapitolelor (nivel 2) | Font: 14 pt, Bold, Indent: Left: 0 cm  Hanging: 1.02 cm, Space Before: 18pt, After: 12pt |
| **6** | Heading 3 | Titlurile secțiunilor (nivel 3) | Font: Bold, Indent: Left: 0 cm Hanging: 1.27 cm, Space Before: 6 pt, After: 6pt |
| **7** | Heading 4 | Titlurile secțiunilor (nivel 4) | Font: Italic, Indent: Left: 0 cm Hanging: 1.52 cm, Space Before: 2 pt, After: 0 pt |
| **8** | Caption | Legenda figurilor și tabelelor | Font: Italic, Font color: Text 1, Line spacing: single, Space After: 10 pt, |
| **9** | Header\_style | Antetul paginii | Font: 10 pt, Italic, Centered, Border: Bottom: (Single solid line, Background 1, 0.5 pt Line width) |

## Figuri, tabele și ecuații

### Figuri

Figurile se inserează în text centrate, cu etichetă de numerotare și legendă (Caption) în partea de jos a figurii. Numărul figurii include și numărul capitolului, după exemplul prezentat în Figura 5 .1.



Figura 5.1. Figură exemplu, stil: Caption

## Tabele

Tabelele se inserează în text centrate, cu etichetă și legendă (Caption) în partea de sus a tabelului, aliniată la stânga. Numărul tabelului include și numărul capitolului, după cum este prezentat, de exemplu, în Tabelul 5 .1.

## Ecuații

Ecuațiile se inserează în text centrate, cu numerotare în partea dreaptă. Numărul ecuației include și numărul capitolului, conform exemplului din relația (5.1).

|  |  |
| --- | --- |
|  | (5.1) |

## Referințe bibliografice

Se recomandă ca citarea referințelor bibliografice să fie făcută în formatul IEEE.

În secțiunea Bibliografie sunt prezentate exemple pentru: o citare a unui capitol dintr-o carte [1], un articol publicat într-o revistă [2] și un articol publicat la o conferință [3].

Detalii cu privire la formatul citării diverselor tipuri de referințe pot fi găsite în [4] sau [5].

Referințele bibliografice se pot insera în text utilizând facilitățile Word de a adăuga surse și bibliografie unui document (References -> Citations & Bibliography). Dacă formatul IEEE pentru bibliografie nu este instalat implicit în Word, se poate descărca gratuit de la:

<https://bibword.codeplex.com/wikipage?title=Styles&referringTitle=Home>

Instrucțiunile de instalare pentru diferite versiuni de Word se pot obține de la aceeași adresă.

# Bibliografie

|  |  |
| --- | --- |
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