SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babes-Bolyai University**
1.2 Faculty	**Faculty of Physics**
1.3 Department	**Physics**
1.4 Field of study	**Physics**
1.5 Study cycle	**Master**
1.6 Study programme / Qualification	**Common semester of all master programs**

2. Information regarding the discipline

2.1 Name of the discipline	**Communication systems for embedded hardware**						
2.2 Course coordinator	**Arthur Robert Tunyagi**						
2.3 Seminar coordinator	**Arthur Robert Tunyagi**						
2.4. Year of study	**2**	2.5 Semester	**2**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**Speciality**

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					21
Additional documentation (in libraries, on electronic platforms, field documentation)					14
Preparation for seminars/labs, homework, papers, portfolios and essays					30
Tutorship					5
Evaluations					5
Other activities:					

3.7 Total individual study hours	75
3.8 Total hours per semester	125
3.9 Number of ECTS credits	5

4. Prerequisites (if necessary)

4.1. curriculum	• Basic electronics
4.2. competencies	• Programming skills with C and C++

5. Conditions (if necessary)

5.1. for the course	• Internet access, 1AC plug /student and blackboard, projector
5.2. for the seminar /lab activities	• Internet access, Ethernet and WiFi infrastructure, blackboard, projector, ESP32, ESP8266, NRF24L01+, WizNet5xxx, USR-K2,

	ZigBee/XBee, E18MS1, Bluetooth HC-05 and Arduino Uno platforms

6. Specific competencies acquired

Professional competencies	Skills for using the most common communication architectures available today for embedded hardware. Embedded system programming for real time applications. Development of hardware and software suitable for remote measurement and control systems .
Transversal competencies	Professional tasks effectively and responsibly with domain-specific ethics compliance under qualified assistance. Techniques are effective multidisciplinary team working on different hierarchical levels. Effective use of information sources and communication resources and training assistance, both in Romanian and in a foreign language

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• Familiarize the students with modern communications solutions used for embedded hardware.
7.2 Specific objective of the discipline	• During the course the students need to become familiar with: Analysis of a problem and optimal solution finding regarding hardware and software requirements for an embedded system. • Ability of mapping critical parameters taking into account the specific of the problem (time requirements (real time)), electric parameters, mechanical parameters (mechatronics)) • Choosing the right microcontroller and communication layer for the current problem. • Understanding key elements of various protocols in order to be able to make the best choice for an uncovered situation during the lectures.

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction into the Arduino framework, the VS-Code with PlatformIO plugin. Presentation of the hardware what will be used during the course. Overview of the most common protocols: Serial, RS232, RS485, SPI, I2C.	oral presentation and practical examples	2h
2. The Espressif microcontrollers, from GPIO to WiFi. Exploring the built in peripherals with examples. The non-standard communication protocols like the ESP-NOW and the ESP-MESH, part 1/3	oral presentation and practical examples	2h
3. The Espressif microcontrollers, from GPIO to WiFi. Exploring the built in peripherals with examples. The non-standard communication protocols like the ESP-NOW and the ESP-	oral presentation and practical examples	2h

MESH, part 2/3		
4. The Espressif microcontrollers, from GPIO to WiFi. Exploring the built in peripherals with examples. The non-standard communication protocols like the ESP-NOW and the ESP-MESH, part 3/3	oral presentation and practical examples	2h
5. Introduction into the 5-layer OSI model for Ethernet. From the Manchester encoding to the TCP socket.	oral presentation and practical examples	2h
6. How a web server works? Using the HTTP for embedded applications. Understanding the DOM in Web. Using Ajax and WebSocket. part 1/2	oral presentation and practical examples	2h
7. How a web server works? Using the HTTP for embedded applications. Understanding the DOM in Web. Using Ajax and WebSocket. part 2/2	oral presentation and practical examples	2h
8. Introduction into the MQTT protocol. Presenting the key features and characteristics of an MQTT system. Creating a local broker. Creating embedded MQTT clients. Using dedicated brokers (ThingSpeak and AdafruitIO). MQTT 5 and 3.1.1.	oral presentation and practical examples	2h
9. Other applications of the Ethernet infrastructure. Sending Emails, using data logging in databases, using NTP on embedded devices.	oral presentation and practical examples	2h
10. Introduction to Bluetooth 2.1 EDR the standard Bluetooth profiles. Using the SPP profile. The AT command set.	oral presentation and practical examples	2h
11. Introduction to Bluetooth 4.0 + and the BLE. The Generic Access Profile (GAP) and the Generic ATTribute (GATT).	oral presentation and practical examples	2h
12. Introduction to ZigBee.	oral presentation and practical examples	2h
13. Other RF based communication solutions using ISM frequencies. Discussion about several 315MHZ, 433MHZ, 866MHZ and 2.4GHZ transceivers. The modulation techniques AM, OFK, (G)FSK, the LoRa Chirp.	oral presentation and practical examples	2h
14. Security in communication. The AES, DES and RSA algorithms. The “https” versus the “http”.	oral presentation and practical examples	2h

Bibliography:

1) https://www.arduino.cc

2) http://esp32.net/

3) https://microchipdeveloper.com/xwiki/bin/view/applications/tcp-ip/

4) ESP8266, ESP32, Atmega328p datasheets

5) https://www.espressif.com/

6) https://microchipdeveloper.com/xwiki/bin/view/applications/tcp-ip/

7) J. Ganssle, The Art of Designing Embedded Systems, second edition

8) Michael J. Donahoo, TCP/IP Socket In C

9) Beej's Guides , TCP/IP, http://beej.us/guide/

10) http://www.beyondlogic.org/usbnutshell/usb-in-a-nutshell.pdf

11) Fred Eady, Implementing 802.11 with microcontrollers: Wireless Networking for Embedded Systems Designers

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Introduction to Arduino. The VS-Code & PlatformIO environment, the basic program structure of an Arduino sketch.	Oral presentation / lab exercise	1h
2. Exploring the ESP32 peripherals. Applications using the ESP-NOW and ESP-MESH	Oral presentation / lab exercise	1h
3. Exploring basic TCP various communication using the ESP32.	Oral presentation / lab exercise	1h
4. Examples using the AsyncTCP library.	Oral presentation / lab exercise	1h
5. Basic webserver examples using the ESP32. understanding the hidden part of a webpage.	Oral presentation / lab exercise	1h
6. More advanced webserver applications on ESP32. Updating the page using Ajax.	Oral presentation / lab exercise	1h
7. MQTT application on local broker. The mosquito broker.	Oral presentation / lab exercise	1h
8. MQTT on AdafruitIO. Phone application for MQTT dashboard.	Oral presentation / lab exercise	1h
9. Using RTC disciplined by NTP. Sending Email with the ESP32.	Oral presentation / lab exercise	1h
10. Creating a Bluetooth connection between Arduino Uno using the HC-05 and the ESP32 in EDR mode.	Oral presentation / lab exercise	1h
11. Exploring the Bluetooth Low Energy (BLE). BLE beacon and custom BLE device with BLE notification service.	Oral presentation / lab exercise	1h
12. Application with E18MS1.	Oral presentation / lab exercise	1h
13. Wired Ethernet solutions with Wiz5100 and USR-K2 hardware.	Oral presentation / lab exercise	1h
14. Application using the cryptographic engine of the ESP32.	Oral presentation / lab exercise	1h

Bibliography

1) https://www.arduino.cc

2) http://esp32.net/

3) https://microchipdeveloper.com/xwiki/bin/view/applications/tcp-ip/

4) ESP8266, ESP32, Atmega328p datasheets

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6) https://microchipdeveloper.com/xwiki/bin/view/applications/tcp-ip/

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8) Michael J. Donahoo, TCP/IP Socket In C

9) Beej's Guides , TCP/IP, http://beej.us/guide/

10) http://www.beyondlogic.org/usbnutshell/usb-in-a-nutshell.pdf

11) Fred Eady, Implementing 802.11 with microcontrollers: Wireless Networking for Embedded Systems Designers

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- Course content is consistent with other universities like USA ECE4760 Cornell University or Massachusetts Institute of Technology, USA 6002.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Presence of minimum 12 courses is required	Oral exam	60 %
10.5 Seminar/lab activities	Presence of minimum 12 laboratory's is required	Laboratory activity	40%
10.6 Minimum performance standards			
➢ Basic understanding of the covered material during the lectures and the lab.			

Date

....01.05.2025.....

Signature of course coordinator

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Signature of seminar coordinator

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Date of approval

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Signature of the head of department

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