Level: Undergraduate

# **SYLLABUS**

- 1. Course name: Embedded Systems Lab
- **2. Course code:** ESPR427064
- **3.** Credits: 2 credits (0/2/4) (0 theoretical credits, 2 practical credit). *Duration*: 15 weeks (6 main periods and 12 self-study periods)/week).

## 4. Instructors:

- *a.* Primary instructor: Le Minh Thanh, M.Eng.
- b. Secondary instructors:
  - Truong Quang Phuc, M.Eng.
  - Truong Ngoc Ha, M.Eng.

## 5. Course conditions:

- a. Prerequisites: N/A.
- b. Corequisites: Embedded Systems.

## 6. Course Description:

In this class, the fundamentals of embedded system hardware and firmware design will be explored. Issues such as embedded processor selection, hardware/firmware partitioning, glue logic, circuit design, circuit layout, circuit debugging, development tools, firmware architecture, firmware design, and firmware debugging will be discussed. The STM32F4, a very popular microcontroller family, will be studied. The architecture and instruction set of the microcontroller will be discussed, and a wirewrapped microcontroller board will be built and debugged by each student. The course will culminate with a significant final project which will extend the concepts covered earlier in the course. Learning may be supplemented with periodic guest lectures by embedded systems engineers from industry. Depending on the interests of the students, other topics may be covered.

## 7. Course Goals

Goals	<b>Goal description</b> This course provides students:	ELOs
G1	Surveying embedded development tools (IDEs), Win CE, Python, Tkinter, Raspberry Pi	01(M), 02(M)
G2	Analysis of hardware design on embedded systems.	03 (H)
G3	Application programming on embedded systems using Keil C, CubeMX programming language.	08 (M), 09(L)
<b>G4</b>	Ability to communicate in technical environment, teamwork and read communication documents.	06 (H)
G5	Ability to perform steps to design a embedded system.	07 (M)
G6	Ability to measure, test, analyze, calculate, design and assembly embedded systems.	10 (H), 11 (M)

\* Note: H: High; M: Medium; L: Low

#### 8. Course Learning Outcomes - CLOs:

CLOs	Description	ELOs
CLOS	After completing this course, students can have:	ELUS

C1	G1.1	Know how to use the STM32F4 kits, Ras Pi kits.	01	
G1	G1.2	Ability to present block diagrams of STM32F4 kits,. Ras Pi kits	01	
C	G2.1 Ability to analyze and fix errors in a STM32F4 kits, Ras Pi kits .		02	
G2	G2.2	Ability to analyze and fix errors when connecting blocks in a system.	02	
G3	G3.1	Ability to use Keil, CubeMX softwares to programming STM32F4 kits, Ras Pi kits		
	G4.1	Ability to perform operation of the experimental kits.	08, 09	
<b>G4</b>	G4.2	Ability to solve the system' problem.	06, 06	
	G4.3	Reading digital datasheet.	07	
G5	G5.1	Ability to perform steps to design a communication system.		
<b>G6</b>	G6.1	Ability to design and assembly UART communication, SPI communication, TIM, interup	10,11	

## 9. Study materials:

- a. Textbooks:
  - [1]. STM32F4 Labs.
- b. References:

[2]. Datasheets stm32f4 discovery

## **10. Student Assessments:**

- a. Grading points: 10
- b. Planning for students assessment is followed:

Туре	Contents	Line time	Assessment techniques	CLOs	Rates (%)
	Report				50
Р	Embedded Operating System.	Week 6	Report by individual / group	G1, G4, G5	10
Р	Embedded software Programming in Python	Week 10	Report by individual / group	G1, G4, G5	20
Р	Ras. Pi based-Embedded system prototyping	Week 14	Report by individual / group	G1, G4, G5	20
	Test 1				50
М	Paper: Win CE, Gui Python, Raspberry PI.	Week 15	Individual students.	G2, G6	20
Test 2					30
М	Lab: Win CE, Gui Python, Raspberry PI.	Week 15	Assembling, measuring.	G2, G6	30

\* Note: Q: Quiz; H: Homework; P: Project; M: Midterm Exam; F: Final Exam;

#### 11. Course details:

**CLOs** 

	<i>Lab 1.</i> Introduction (0/6/12)	
	Teaching contents: (6)	
1	1.1. Course overview, expectations, logistics, processes, syllabus, FAQ, and prerequisite material.	
	1.2. Embedded systems descriptions, definitions, and vocabulary. Design Engineer's notebook.	
	1.3. Design considerations and requirements, processor selection and tradeoffs	G1.1
	1.4. Overview of board development process, wire wrapping vs. soldering.	G1.2
	<b>Teaching methods:</b> + Theoretical lectures.	
	<ul> <li>+ Theorem a fectures.</li> <li>+ Previous operation.</li> </ul>	
	Self-study contents: (12)	
	+ Review relevant knowledge.	
	<i>Lab 2.</i> Configure GPIO for LED toggling (0/6/12)	
	<b>Teaching contents:</b> (6)	
	2.1 Learn how to setup pin and GPIO port in CubeMX	
	<ul><li>2.2 Configure GPIO pin in CubeMX and Generate Code</li><li>2.3 Add in to project HAL_Delay function and HAL_GPIO_Toggle</li></ul>	G1.2
2	function.	G3.1
2	Teaching methods:	G3.2
	+ Theoretical lectures.	G5.1
	+ Previous operation.	G6.1
	Self-study contents: (12)	
	2.4 Verify the correct functionality on toggling LED.	
	Lab 3 Configure EXTI which turns on LED. (0/6/12)	
	<b>Teaching contents:</b> (6)	
	3.1.Configure GPIO and EXTI pin in CubeMX and Generate Code 3.2.Add into project Callback function and function which turn on led.	G1.2
3	Teaching methods:	G3.1
5	+ Theoretical lectures.	G3.2
	+ Previous operation.	G5.1
	Self-study contents: (12)	G6.1
	Verify the correct functionality by pressing button which turns on LED	
	Lab 4. Use SLEEP mode with EXTI (0/6/12)	
4	<b>Teaching contents:</b> (6)	
	<ul><li>4.1. Use project from EXTI lab</li><li>4.2. Learn how to setup the SLEEP in HAL, and which events can wake up MCU.</li></ul>	G1.2 G2.1 G4.1,
	Teaching methods:	G4.2
	+ Theoretical lectures.	G5.1 G6.1
	+ Previous operation.	00.1
	Self-study contents: (12)	G3.1
	+ Verify the correct functionality by measuring consumption .	G5.1 G6.1

	Lab 5. Data transfer over DMA (0/6/12)		
	<b>Teaching contents:</b> (6)		
5	<ul> <li>5.1 Use CubeMX and Generate Code with DMA</li> <li>5.2 Learn how to setup the DMA in HAL</li> <li>5.3 Verify the correct functionality by comparing transferred buffers.</li> </ul>		
	Teaching methods:	G4.1 G6.2	
	+ Theoretical lectures.	00.2	
	+ Previous operation.		
	Self-study contents: (12)	G4.3	
	+ Data transfer over DMA with interrupt.	G5.1 G6.2	
	Lab 6. Creating a Project with Windows CE (0/6/12)	00.2	
	<b>Teaching contents:</b> (6)		
	6.1. Applications for Microsoft Foundation Classes (MFC) for Windows CE		
	6.2. Objects for the MFC Component Object Model (COM)		
6	Teaching methods:	G1,G4, G5	
	+ Theoretical lectures.	05	
	+ Previous operation.	-	
	Self-study contents: (12)		
	COM projects for the Active Template Library (ATL) for Windows CE.		
7	REPORT 1	G2, G6	
	<i>Lab 7.</i> Simple UART communication (0/6/12)		
	<ul> <li>Teaching contents: (6)</li> <li>7.1 Configure UART in CubeMX and Generate Code</li> <li>7.2 Learn how to send and receive data over UART without interrupts</li> <li>7.3 Verify the correct functionality.</li> </ul>	G2.2 G3.1	
8	Teaching methods:	G4.1	
Ũ	+ Theoretical lectures.	G6.2	
	+ Previous operation.		
	Self-study contents: (12) + Use UART with interrupt	G3.1 G4.3	
		G6.2	
	Lab 8. GUI IN PYTHON (0/6/12)		
	<b>Teaching contents:</b> (6)		
	Teaching contents: (6)         8.1. Import the <i>Tkinter</i> module.		
0		G2.2	
9	8.1. Import the <i>Tkinter</i> module.	G3.1	
9	<ul><li>8.1. Import the <i>Tkinter</i> module.</li><li>8.2. Create the GUI application main window.</li></ul>	G3.1 G4.1	
9	<ul> <li>8.1. Import the <i>Tkinter</i> module.</li> <li>8.2. Create the GUI application main window.</li> <li>8.3. Add one or more of the above-mentioned widgets to the GUI</li> </ul>	G3.1	
9	<ul> <li>8.1. Import the <i>Tkinter</i> module.</li> <li>8.2. Create the GUI application main window.</li> <li>8.3. Add one or more of the above-mentioned widgets to the GUI application.</li> </ul>	G3.1 G4.1	

+ Enter the main event loop to take action against each event triggered by the userG4. G6.10REPORT 2G2. C11Lab 9. Simple SPI communication ( $0/6/12$ )G2.Teaching contents: (6) 9.1. Configure SPI in CubeMX and Generate Code 9.2. Learn how to send and receive data over SPI without interrupts Verify the correct functionality. Teaching methods: + Theoretical lectures. + Previous operation.G2.Self-study contents: (12) + Use SPI with interrupt.G5.Teaching contents: (6) 10.1. Configure TIM in CubeMX and Generate Code 10.3. Verify the correct functionality.12Teaching contents: (6) 10.1. Configure TIM in CubeMX and Generate Code 10.3. Verify the correct functionality. Teaching methods: + Theoretical lectures. + Previous operation.G2.12Lab 10. TIM with interrupt ( $0/6/12$ )G2.14Lab 11. RASPBERRY PI 3 ( $0/6/12$ )G3.15Self-study contents: (6) 11.1. Introduction to the Raspberry Pi and the gear you will need to get started 11.2. How the GPIO pins are configured on the Raspberry Pi 3.G1. G4.13Teaching methods: + Theoretical lectures. + Previous operation.G1. G4.14REPORT 3G2.		Self-study contents: (12)	
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11       Teaching contents: (6)       9.1. Configure SPI in CubeMX and Generate Code       9.2. Learn how to send and receive data over SPI without interrupts       G2.:         9.1. Configure SPI in CubeMX and Generate Code       9.2. Learn how to send and receive data over SPI without interrupts       G4.         11       Teaching methods:       64.         12       Teaching methods:       65.         12       Self-study contents: (12)       65.         14       Teaching contents: (6)       61.         15       Teaching contents: (6)       61.         16       10.1. Configure TIM in CubeMX and Generate Code       62.         17       Teaching contents: (6)       61.         18       Teaching methods:       64.         19.2. Learn how start timer and handle interrupt       66.         10.3. Verify the correct functionality.       64.         10.4.       10.         10.5.       11.         10.6       11.         10.7       Teaching methods:         11.       11.         12       Theoretical lectures.	10	REPORT 2	G2, G6
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Teaching contents: (6)         11.1. Introduction to the Raspberry Pi and the gear you will need to get started         11.2. How the GPIO pins are configured on the Raspberry Pi 3.         13         Teaching methods:         + Theoretical lectures.         + Previous operation.         Self-study contents: (12)         + How to control two LEDs from two push buttons using Python. This requires us to use GPIO pins as inputs and outputs.         14       REPORT 3			
started       11.2. How the GPIO pins are configured on the Raspberry Pi 3.       G1,         13       Teaching methods:       .         + Theoretical lectures.       .       .         + Previous operation.       Self-study contents: (12)       .         + How to control two LEDs from two push buttons using Python. This requires us to use GPIO pins as inputs and outputs.       G2, C         14       REPORT 3       G2, C			
13       Teaching methods: + Theoretical lectures. + Previous operation.       G1, G4, G         Self-study contents: (12) + How to control two LEDs from two push buttons using Python. This requires us to use GPIO pins as inputs and outputs.       G1, G4, G         14       REPORT 3       G2, G		started	
+ Theoretical lectures.       G4,	13		G1
Self-study contents: (12)         + How to control two LEDs from two push buttons using Python. This requires us to use GPIO pins as inputs and outputs.         14       REPORT 3       G2, G		+ Theoretical lectures.	G1, G4, G5
+ How to control two LEDs from two push buttons using Python. This requires us to use GPIO pins as inputs and outputs.       14       REPORT 3       G2, G			
requires us to use GPIO pins as inputs and outputs.       Image: Comparison of the second secon		Self-study contents: (12)	
		· · ·	
15 <b>TEST</b> G2, G	14	REPORT 3	G2, G6
	15	TEST	G2, G6

12. Learning ethics:

- Home assignments and projects must be done by the students themselves. Plagiarism found in the assessments will get zero point.
- Students who attend less than 80% or do not complete 80% of homework will be banned.

# **13. First approved date:** 01/01/2012

14. Approval level

Department Instructor	1	Dean
Department Instr	1	Dean

Nguyen Minh Tam, Ph.D Nguyen Ngo Lam, M.Eng

## 15. Syllabus updated process:

1 <sup>st</sup> time: Updated content dated: 15/01/2014 <i>Contents:</i>	Instructor:
	Head of demontry on the Wark Huar, Dh.D.
<b>2<sup>nd</sup> time:</b> Updated content dated: 15/01/2016	Head of department: Vo Minh Huan, Ph.D Instructor:
Contents:	
	Head of department: Phan Van Ca, Ph.D
<b>3<sup>rd</sup> time:</b> Updated content dated: 06/05/2017 <i>Contents:</i>	Instructor: Le Minh Thanh, M.Eng
	Head of department: Phan Van Ca, Ph.D