Advanced Embedded System Design
Course Code: EE-821

Course Description

This graduate level course on Advanced Embedded Systems covers the Modeling, Design and Analysis of embedded systems and cyber physical systems. The course is about a principled approach to designing and implementing such systems. Key focus of this course is on the usage of Real-time Operating System (RTOS) for embedded applications so that resource management, and deadline-driven design, based on a multi-tasking or multicore computing system, can be correctly ensured..

Text Book:

1. Introduction to Embedded Systems (IES), A Cyber-Physical Systems Approach, by Edward A. Lee and Sanjit A. Seshia, 2nd Edition, 2017.

Reference Book:

1. Embedded System Design (ESD): Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things by Peter Marwedel, 4th ed. 2021 Edition
2. The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, 3rd Edition (2021) (GAC) by Joseph Yiu2.

Prerequisites

nil

ASSESSMENT SYSTEM

Quizzes	10%
Assignments	10%
Mid Terms	30%
Project	10%
ESE	40%

Teaching Plan

Week No	Topics	Learning Outcomes
1	Introduction	Introduction to Embedded Systems (ES) Embedded Applications and Benchmarks, ES Case Studies
2-5	Real-time Operating System (RTOS)	Embedded Software Flow Interrupt Driven Processing vs Multitasking Real-time Operating System (RTOS), RTOS Task Management, RTOS Task States, Task Creation in FreeRTOS

6-8	Scheduling , Memory and Queue Management in an RTOS	Basics of Scheduling, Pre-emptive and Non pre-emptive Scheduling, Periodic Scheduling Algorithms Context Switching in an RTOS, Memory Management in FreeRTOS, Use of Queues in FreeRTOS Queue Management in FreeRTOS, Passing Data-structures via Queues , Gate-Keeper Tasks in FreeRTOS, Multiprocessor Scheduling Multiprocessor Scheduling Anomalies Best-Effort Round Robin Scheduling
	MID TERM IN WEEK 9	
10-11	Mutex and Semaphores	Inter Process/Task Communication Mutual-Exclusion (Mutex) Binary and Counting Semaphores for Resource Management, Binary Semaphores Used for Synchronization Counting Semaphores Used for Event Management
12-13	Pitfalls in Embedded Software	Problems in Embedded Software: Deadlock Priority Inversion Priority Inheritance Protocol, Priority Ceiling Protocol
14-15	Use of Interrupts within an RTOS based embedded system	Exception Handling in ARM architecture Interrupt Management Deferred Interrupt Processing, Interrupt Nesting
16-17	Use of Direct Memory Access and Tightly Coupled Memory in ES	Direct Memory Access (DMA), Types of DMA Configuration of 1D and 2D DMA in Blackfin Embedded Processor, Double-Buffer-Mode using DMA in Blackfin Embedded Processor Tightly Coupled Memory – Why is it needed in ES? Tightly Coupled Memory in ARM Cortex M microcontrollers
18	**End Semester Exams**	