

Module Code EE2601	Module title Computer Architecture and Interfacing	Module Leader Dr T Itagaki	Credit value 20	JACS Code G411 H651
Level 2	Pre-requisites EE1055, EE1082	Co-requisites	Additional Tutors	School(s) responsible for teaching Engineering and Design

Version No.	Date	Notes – Q&S USE ONLY	AO
1.0	Aug '10	New module from 2010/11 academic year	LMA

MAIN AIMS OF THE MODULE

- To present a comprehensive introduction to the design philosophies, fundamental constructs and operational principles of sequential computer architecture.
- To develop an understanding of computer architecture from an engineering perspective.
- To develop the underlying knowledge and skills appropriate to today's embedded systems and interfacing including the study of microcontroller system design, circuits and transducers to which the microcontroller must interface, and the embedded system programming in both Assembler and C.

LEARNING OUTCOMES FOR THE MODULE

The module provides opportunities for students to develop and demonstrate knowledge and understanding, qualities, skills and other attributes in the following areas:

(A) Knowledge and Understanding

1. Understanding of the fundamental principles of sequential computer design and implementation.
2. Understanding of microcontroller architecture, embedded system, hardware interfacing and sensors.
3. Appreciation of the use of microprocessors/microcontrollers in embedded systems.

(B) Cognitive (thinking) Skills

4. Explain the form and function of sequential computer system components.
5. Identify the factors that affect sequential computer performance.
6. Apply critical judgement in the assessment of the cost effectiveness of sequential computers.
7. Evaluate the requirements of an embedded application and design using appropriate microcontroller, electronic components, hardware interfacing and embedded programming model.

(C) Other Skills and Attributes (Practical/Professional/Transferable)

8. Competence in embedded systems design, I/O interfacing and embedded programming.

MAIN TOPICS OF STUDY:

COMPUTER ARCHITECTURE

INTRODUCTION

9. Role of the computer architect.
10. Virtual machine hierarchy.
11. Overview of the von Neumann computer architecture, processor, memory and I/O subsystem.

PROCESSOR

12. Review of the concepts of stored program control, Instruction Set Architecture (ISA), user-visible and control registers, data and instruction types and factors determining word size.
13. Instruction formats: operation repertoire, fetch-execute cycle, program control, 3/2/1/0-address instructions, absolute address and addressing modes (immediate, direct, indirect, relative, stack addressing), stack processing (dynamic storage allocation) and instruction format design factors.
14. Computer arithmetic: Algebraic expression evaluation: infix to postfix (reverse Polish) translation.
15. Review of fixed and floating-point numbers: unsigned, sign-magnitude, 1's and 2's complement plus little-, big- and bi-endian, and IEEE 754 floating-point representation
16. Fixed-point arithmetic: addition/subtraction (serial, parallel (ripple) and carry look ahead adders), multiplication (serial and serial-parallel, LUT and parallel (carry-save arrays plus Wallace and Dadda tree multipliers) plus Baugh & Wooley and (modified) Booth's correction algorithms algorithm).

- 17. Floating-point arithmetic: addition/subtraction, multiplication and division, precision and rounding.
- 18. Modern processor microarchitecture: CPI and MIPS. Instruction pipelining and overlapping, ISA evolution (CISC, RISC and CISC/RISC).
- 19. DSP and GPU – general purpose CPU vs. specialized processors

PARALLEL PROCESSOR ARCHITECTURE

- 20. Review of the concepts of Instruction Parallelism and Data Parallelism
- 21. Multi-core Processors and Distributed Parallel Processing

MEMORY

- Storage hierarchy: tape, CD-ROM, disk, main store, data cache and registers, locality of reference (time zones), primary/secondary storage and primary/secondary /tertiary data transfer.
- Storage classification: secondary and primary, non-volatile vs. volatile and static vs. dynamic plus sequential, random and associative access.

I/O SUB-SYSTEM

- Memory-mapped I/O.
- Programmed and interrupt-driven (prioritised, (non-)maskable & vectored interrupts) I/O plus DMA.
- Interconnection structures: local vs. remote communication, dedicated vs. shared links and priority control (daisy chaining, polling & independent requesting).
- Interfacing techniques: serial interfaces (UART & ACIA) and parallel interfaces (PICs & PIAs).
- Serial & parallel buses: handshaking and FIFO buffering plus bus control, arbitration and timing (PC bussing (ISA, EISA, USB and PCI) plus Firewire and Ethernet).

OPERATING SYSTEM

- Overview: resource management, scheduling, batch processing, multiprogramming and multitasking, Unix, Windows and Linux.
- Processes and process management: process creation and termination, exception handling (interrupts, traps and context switching) and multithreading.
- Memory management: logical and physical address mapping, static vs. dynamic memory allocation, memory utilisation and fragmentation, block replacement policies, memory paging and virtual memory.

INTERFACING

INTRODUCTION

- Introduction: Embedded system, interfacing to I/O peripherals and real-time applications.

EMBEDDED HARDWARE

PIC Microcontrollers: PIC16F88, PICF16F877

PIC Internal Peripherals: Internal clock, Timers, Comparators ADC, PWM, Interrupt, EEPROM, SPI, UART etc.

PIC Development Boards: on-board peripherals, system circuit.

Interfacing Circuitry, Peripherals and Protocols:

- Interfacing Circuitry: Analogue filter, op-amplifier
- I/O Peripherals: Switch, 7-segment display, Keypad, LCD, DC motor, Stepper motor, External memory (Static Memory)
- Sensors: Light Dependent Resistor (LDR), Temperature sensor (DS1820), Infra-red transceiver, Ultrasonic sensor
- Communication Protocol: UART, CAN, I²C

EMBEDDED PROGRAMMING

- Embedded Programming on PIC microcontrollers using C/ASM: Number system, operators, decisions, pointers/arrays, memory/register access,
- Real-time programming model: interrupts, multitasking (scheduling, concurrency)

INTERFACING CASE STUDY

- Case of various interfacing projects: Digital tape measure using ultrasonic transducer, serial communication using infrared transceiver, volt-meter, home security system etc.

TEACHING AND LEARNING METHODS/STRATEGIES USED TO ENABLE THE ACHIEVEMENT OF LEARNING OUTCOMES: these might include lectures, seminars, tutorials, practical, workshops, laboratories, distance learning, projects or other methods (*please specify*).

Lectures, Seminars, Labs

CONTACT HOURS: Please state the *indicative* distribution of learning hours across this module.

78 hrs contact (48 hours lectures, 24 hours seminars and 2*3 hours labs) plus 112 hrs of private study and assessment.

ASSESSMENT METHODS WHICH ENABLE STUDENT TO DEMONSTRATE THE LEARNING OUTCOMES FOR THE MODULE (please provide the length/duration of each assessment listed):

Test 1 (Computer Architecture)
 Test 2 (Interfacing)
 Lab (Interfacing) – 2 sessions
 3 hour written examination

WEIGHTING:

5%
 5%
 20%
 70%

INDICATIVE READING LIST:

COMPUTER ARCHITECTURE

1. ESSENTIAL READING [* Purchase advised]
 W. Stallings, Computer Organisation and Architecture (8th edition). Pearson Education 2009
2. RECOMMENDED READING
 A. Clements, The Principles of Computer Hardware (4th edition). Oxford 2006.
3. OTHER
 M D Ciletti, Advanced Digital Design with the Verilog HDL. Prentice Hall 2003.
 M M Mano and M D Ciletti, Digital Design (4th edition). Prentice Hall 2007.

INTERFACING

1. ESSENTIAL READING [* Purchase advised]
 Tim Wilmshurst, Design Embedded Systems with PIC Microcontrollers: Principles and Applications. Newnes, 2009
 Lucio Di Jasio, PIC Microcontrollers: Know It All. Newnes, 2007.
2. RECOMMENDED READING
 Martin P. Bates, Interfacing PIC Microcontrollers: Embedded Design by Interactive Simulation, Newnes, 2006, ISBN-10: 0750680288.
 S Katzen, The Quintessential PIC Microcontroller. Springer, 2001, ISBN: 1-85233-309-X
 M Predko, PICMicro Pocket Reference (Pocket Reference). McGraw-Hill, 2000, ISBN: 0071361758
 M Predko, Programming and Customizing the PICmicro (2nd edition). TAB Books Inc., 2000, ISBN: 0071361723
3. OTHER

The following information is required:

COMPULSORY module on the following programmes (please list):	BEng/MEng Computer Systems Engineering BEng Electronic and Electrical Engineering (Communication Systems) BEng Electronic and Microelectronic Engineering MEng Electronic and Computer Engineering
OPTION module on the following programmes (please list):	