Comsats University Islamabad
Abbottabad Campus

Real Time Embedded System
Lab Task # 5

Submitted by,

Aazan Ali Khan	FA20-EEE-026

Submitted to,

Dr. Syed Mashood Murtaza

Department of Electrical &
Computer Engineering

Msp430 32 bit

MSP432P4xx Series

1. **Core**: ARM Cortex-M4F.

2. **Clock Speed**: Up to 48 MHz.

3. **Memory**: Up to 256KB Flash, 64KB SRAM.

4. **Peripherals**:

    o   14-bit ADC

    o   Timers

    o   UART, SPI, I2C

    o   USB

5. **Low Power**: Multiple low-power modes, ultra-low power consumption.

6. **Development Tools**: Compatible with Code Composer Studio and IAR Embedded Workbench.

MSP432E4xx Series

1. **Core**: ARM Cortex-M4F.

2. **Clock Speed**: Up to 120 MHz.

3. **Memory**: Up to 1MB Flash, 256KB SRAM.

4. **Peripherals**:

    o   12-bit ADC

    o   Timers

    o   UART, SPI, I2C, CAN, Ethernet

5. **Security**: Advanced security features including AES256 encryption.

6. **Connectivity**: Integrated Ethernet and USB.

7. **Development Tools**: Compatible with Code Composer Studio and IAR Embedded Workbench.

MSP432I4xx Series

1. **Core**: ARM Cortex-M4F.

2. **Clock Speed**: Up to 80 MHz.

3. **Memory**: Up to 256KB Flash, 64KB SRAM.

4. **Peripherals**:

- o 24-bit sigma-delta ADC
- o Timers
- o UART, SPI, I2C

5. **Industrial Grade**: Designed for industrial applications with high-precision ADCs.

6. **Low Power**: Multiple low-power modes.

7. **Development Tools**: Compatible with Code Composer Studio and IAR Embedded Workbench.

MSP432P401R Specifics

1. **Core**: ARM Cortex-M4F.

2. **Clock Speed**: 48 MHz.

3. **Memory**: 256KB Flash, 64KB SRAM.

4. **Peripherals**:
   - o 14-bit ADC
   - o Timers
   - o UART, SPI, I2C

5. **Development Tools**: Compatible with Code Composer Studio and IAR Embedded Workbench.

6. **Low Power**: Ultra-low power modes for energy-efficient applications.

MSP432P4111 Specifics

1. **Core**: ARM Cortex-M4F.

2. **Clock Speed**: 48 MHz.

3. **Memory**: 256KB Flash, 64KB SRAM.

4. **Peripherals**:
   - o 14-bit ADC
   - o Timers
   - o UART, SPI, I2C

5. **Real-Time Clock**: Integrated RTC.

6. **Development Tools**: Compatible with Code Composer Studio and IAR Embedded Workbench.

7. **Low Power**: Ultra-low power consumption, ideal for battery-operated devices.

STM32

STM32F0 Series

- **Core**: ARM Cortex-M0

- **Performance**: Up to 48 MHz

- **Key Features**: Low power, low cost, basic features

- **Applications**: Basic control applications, home automation, industrial control

STM32F1 Series

- **Core**: ARM Cortex-M3

- **Performance**: Up to 72 MHz

- **Key Features**: Moderate performance, broad peripheral set, affordability

- **Applications**: Medical devices, consumer products, industrial control

STM32F2 Series

- **Core**: ARM Cortex-M3

- **Performance**: Up to 120 MHz

- **Key Features**: Higher performance than F1, more advanced peripherals, enhanced connectivity

- **Applications**: Advanced control applications, connectivity solutions

STM32F3 Series

- **Core**: ARM Cortex-M4

- **Performance**: Up to 72 MHz

- **Key Features**: DSP instructions, floating point unit, mixed-signal capabilities

- **Applications**: Motor control, sensor hubs, industrial automation

STM32F4 Series

- **Core**: ARM Cortex-M4

- **Performance**: Up to 180 MHz

- **Key Features**: High performance, DSP and FPU, rich set of peripherals

- **Applications**: High-performance applications, audio processing, embedded graphics

STM32F7 Series

- **Core**: ARM Cortex-M7
- **Performance**: Up to 216 MHz
- **Key Features**: Very high performance, advanced graphics, extensive peripheral set
- **Applications**: Complex industrial applications, advanced audio systems, consumer electronics

STM32H7 Series

- **Core**: ARM Cortex-M7 (with dual-core Cortex-M7 and Cortex-M4 options)
- **Performance**: Up to 480 MHz
- **Key Features**: Highest performance, dual-core options, advanced graphics and connectivity
- **Applications**: High-end industrial control, advanced graphics, high-speed connectivity

STM32L0 Series

- **Core**: ARM Cortex-M0+
- **Performance**: Up to 32 MHz
- **Key Features**: Ultra-low power, basic features
- **Applications**: Energy-sensitive applications, wearable devices, sensors

STM32L1 Series

- **Core**: ARM Cortex-M3
- **Performance**: Up to 32 MHz
- **Key Features**: Low power, more advanced peripherals than L0
- **Applications**: Medical applications, low-power industrial applications

STM32L4 Series

- **Core**: ARM Cortex-M4
- **Performance**: Up to 80 MHz
- **Key Features**: Ultra-low power, high performance, rich peripherals
- **Applications**: Wearables, portable medical devices, IoT applications

STM32L5 Series

- **Core**: ARM Cortex-M33
- **Performance**: Up to 110 MHz
- **Key Features**: Ultra-low power, enhanced security features
- **Applications**: Secure IoT applications, energy-sensitive devices, advanced wearables

STM32G0 Series

- **Core**: ARM Cortex-M0+
- **Performance**: Up to 64 MHz
- **Key Features**: Efficient power consumption, essential peripheral set
- **Applications**: Entry-level and cost-sensitive applications

STM32G4 Series

- **Core**: ARM Cortex-M4
- **Performance**: Up to 170 MHz
- **Key Features**: Mixed-signal processing, advanced analog features
- **Applications**: Industrial drives, digital power supplies, motor control

STM32WB Series

- **Core**: ARM Cortex-M4 and Cortex-M0+
- **Performance**: Up to 64 MHz (M4) and 32 MHz (M0+)
- **Key Features**: Wireless connectivity (Bluetooth, Zigbee), dual-core architecture
- **Applications**: IoT, wireless sensor networks, smart home devices

BBC micro

v1

- **Microcontroller**: Nordic nRF51822 (ARM Cortex-M0)
- **Performance**: 16 MHz
- **Memory**: 16 KB RAM, 256 KB Flash
- **Key Features**:
    - 5x5 LED matrix display

- o Two programmable buttons
- o Built-in accelerometer and magnetometer
- o Bluetooth Low Energy (BLE) support
- o Edge connector for expansion
- o USB interface for power and programming
- **Applications**: Basic coding and electronics education, simple projects and experiments

BBC micro

v2

- **Microcontroller**: Nordic nRF52833 (ARM Cortex-M4)
- **Performance**: 64 MHz
- **Memory**: 128 KB RAM, 512 KB Flash
- **Key Features**:
  - o Improved 5x5 LED matrix display
  - o Two programmable buttons
  - o Built-in accelerometer, magnetometer, and temperature sensor
  - o Built-in speaker and microphone
  - o Bluetooth Low Energy (BLE) support
  - o Edge connector for expansion
  - o USB interface for power and programming
  - o Touch-sensitive logo
- **Applications**: Enhanced educational projects, interactive and multimedia projects, more complex programming and electronics experiments

BBC micro

v2.2

- **Microcontroller**: Nordic nRF52833 (ARM Cortex-M4)
- **Performance**: 64 MHz (same as v2)
- **Memory**: 128 KB RAM, 512 KB Flash (same as v2)
- **Key Features**:
  - o Same features as micro

v2 with minor hardware updates for manufacturing improvements

- **Applications**: Same as micro

v2 with the same educational and project possibilities

Key Differences Between Versions

- **Performance**: v2 and v2.2 have a more powerful microcontroller (ARM Cortex-M4) compared to v1's ARM Cortex-M0.

- **Memory**: v2 and v2.2 have significantly more RAM and Flash memory.

- **Features**: v2 and v2.2 include additional sensors (temperature sensor, microphone, speaker) and a touch-sensitive logo, which are not present in v1.

- **Usability**: v2 and v2.2 offer more advanced capabilities and are better suited for more complex projects and interactive applications.

Common Uses Across All Versions

- **Educational Tools**: Widely used in classrooms to teach programming and electronics basics.

- **DIY Projects**: Popular in maker communities for creating interactive devices, robots, and simple games.

- **Prototyping**: Used by hobbyists and professionals to quickly prototype ideas and test concepts.

NodeMCU

- **Description**: An open-source IoT platform based on the ESP8266 Wi-Fi module.

- **Core**: ESP8266 (Tensilica L106 32-bit RISC processor)

- **Clock Speed**: 80 MHz (can be overclocked to 160 MHz)

- **Memory**: 64 KB of instruction RAM, 96 KB of data RAM, 4MB Flash memory

- **Key Features**:

    o Integrated Wi-Fi connectivity (802.11 b/g/n)

    o GPIO, PWM, I2C, SPI, ADC, and UART interfaces

    o Lua scripting support via the NodeMCU firmware

- **Applications**: IoT applications, home automation, sensor networks, prototyping

ESP32

- **Description**: A powerful, low-cost, low-power system on a chip (SoC) with integrated Wi-Fi and Bluetooth.

- **Core**: Dual-core Tensilica Xtensa LX6 microprocessor

- **Clock Speed**: Up to 240 MHz

- **Memory**: 520 KB SRAM, 448 KB ROM, up to 16MB Flash memory (varies by model)

- **Key Features**:

    o Wi-Fi (802.11 b/g/n) and Bluetooth 4.2 (including BLE)

    o Rich set of peripherals: GPIO, ADC, DAC, UART, SPI, I2C, PWM, touch sensors, and more

    o Low power consumption with various power-saving modes

- **Applications**: Advanced IoT applications, wearable electronics, industrial automation, smart home devices

Raspberry Pi Pico

- **Description**: A microcontroller board based on the RP2040 chip, designed by Raspberry Pi.

- **Core**: Dual-core ARM Cortex-M0+

- **Clock Speed**: Up to 133 MHz

- **Memory**: 264 KB SRAM, 2MB Flash memory

- **Key Features**:

    o 26 multifunction GPIO pins, including ADC, UART, SPI, I2C, PWM

    o USB 1.1 Host/Device support

    o Programmable I/O (PIO) for custom peripheral support

- **Applications**: Embedded systems, educational projects, hobby electronics, prototyping

Single-Board Computers (SBCs)

SBCs are complete computers built on a single circuit board. Here are some popular SBCs:

Raspberry Pi Series

- **Description**: Popular SBCs known for their versatility and wide range of uses.

- **Examples**:

  - **Raspberry Pi 4 Model B**: Quad-core ARM Cortex-A72 CPU, up to 8GB RAM, multiple USB ports, HDMI outputs, and Ethernet.

  - **Raspberry Pi Zero W**: Smaller form factor, single-core ARM11 CPU, 512MB RAM, integrated Wi-Fi and Bluetooth.

- **Applications**: Education, DIY projects, media centers, web servers, IoT applications.

BeagleBone Series

- **Description**: Open-source SBCs known for their real-time capabilities and extensive I/O options.

- **Examples**:

  - **BeagleBone Black**: ARM Cortex-A8 processor, 512MB RAM, extensive GPIO, PRUs for real-time tasks.

- **Applications**: Industrial automation, robotics, real-time processing, prototyping.

Arduino

- **Description**: While not strictly an SBC, Arduino boards are widely used microcontroller platforms.

- **Examples**:

  - **Arduino Uno**: Based on the ATmega328P microcontroller, 14 digital I/O pins, 6 analog inputs.

- **Applications**: DIY electronics, educational projects, embedded systems.

Odroid Series

- **Description**: Powerful SBCs with high-performance processors.

- **Examples**:

  - **Odroid XU4**: Samsung Exynos5422 Cortex-A15 2GHz and Cortex-A7 Octa-core CPUs, 2GB RAM, USB 3.0, Gigabit Ethernet.

- **Applications**: Gaming, media centers, development platforms, AI projects.

Jetson Nano

- **Description**: SBC designed for AI and machine learning applications.

- **Processor**: Quad-core ARM Cortex-A57 CPU, 128-core NVIDIA Maxwell GPU.

- **Memory**: 4GB LPDDR4 RAM

- **Key Features**: GPIO, USB 3.0, HDMI, Gigabit Ethernet.

- **Applications**: AI projects, robotics, computer vision, machine learning.

Orange Pi Series

- **Description**: Low-cost SBCs with various configurations.

- **Examples**:

  - **Orange Pi 4**: Rockchip RK3399 processor, 4GB RAM, USB 3.0, HDMI, and Gigabit Ethernet.

- **Applications**: DIY projects, educational purposes, media centers, and more.