



**Comsats University Islamabad
Abbottabad Campus**

**Real Time Embedded System
Lab Task # 6**

Submitted by,

Aazan Ali Khan	FA20-EEE-026
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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:**
 - 14-bit ADC
 - Timers
 - UART, SPI, I2C
 - 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:**
 - 12-bit ADC
 - Timers
 - 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:**

- 24-bit sigma-delta ADC
 - Timers
 - 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:**
 - 14-bit ADC
 - Timers
 - 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:**
 - 14-bit ADC
 - Timers
 - 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

- Two programmable buttons
- Built-in accelerometer and magnetometer
- Bluetooth Low Energy (BLE) support
- Edge connector for expansion
- 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:**
 - Improved 5x5 LED matrix display
 - Two programmable buttons
 - Built-in accelerometer, magnetometer, and temperature sensor
 - Built-in speaker and microphone
 - Bluetooth Low Energy (BLE) support
 - Edge connector for expansion
 - USB interface for power and programming
 - 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:**
 - 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:**
 - Integrated Wi-Fi connectivity (802.11 b/g/n)
 - GPIO, PWM, I2C, SPI, ADC, and UART interfaces
 - 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:**
 - Wi-Fi (802.11 b/g/n) and Bluetooth 4.2 (including BLE)
 - Rich set of peripherals: GPIO, ADC, DAC, UART, SPI, I2C, PWM, touch sensors, and more
 - 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:**
 - 26 multifunction GPIO pins, including ADC, UART, SPI, I2C, PWM
 - USB 1.1 Host/Device support
 - 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.