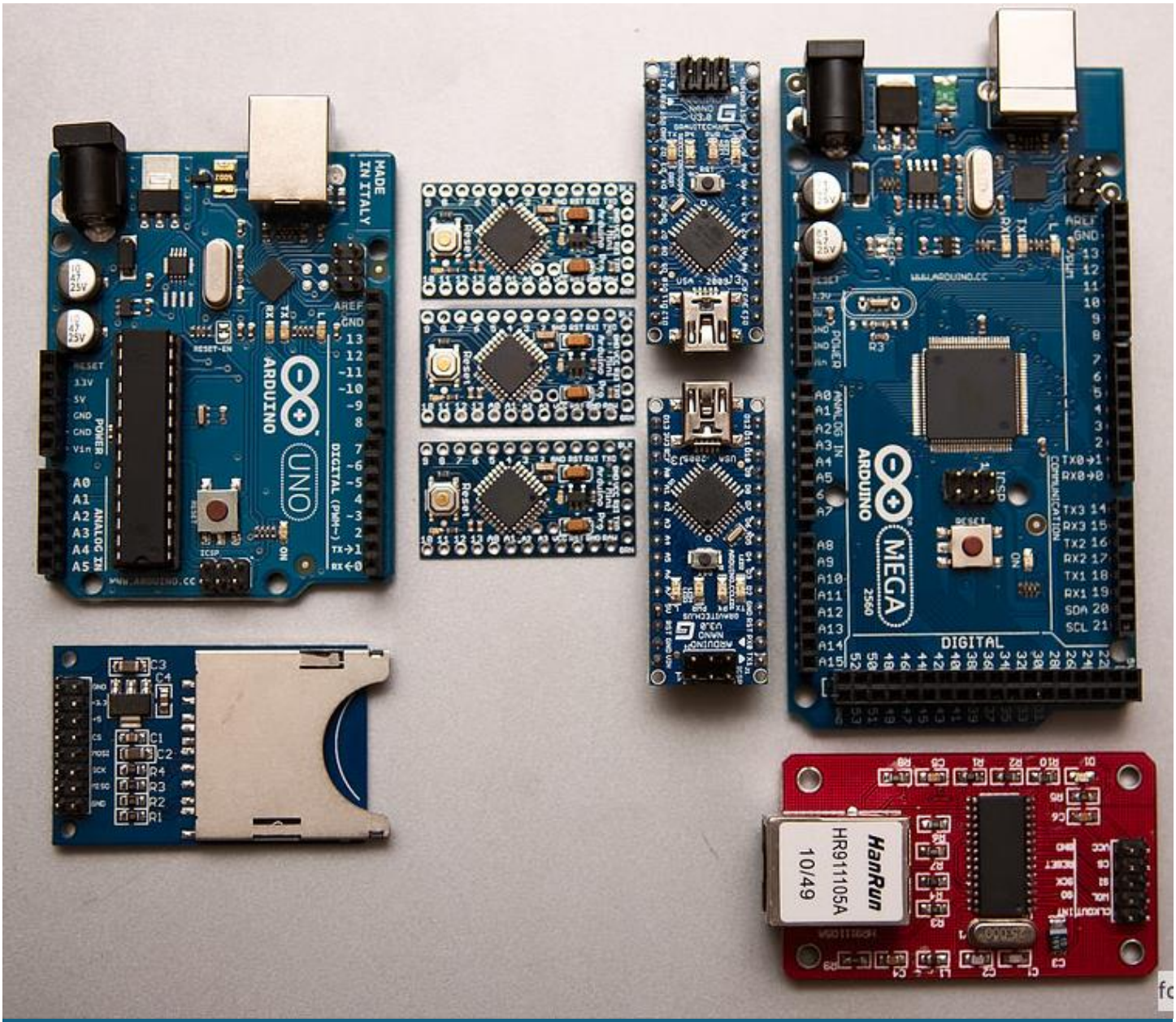

Microcontroller families

Technical Report

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Introduction to Microcontrollers

Microcontrollers are compact integrated circuits designed to do specific tasks within embedded systems. Often called the "brains" of electronic devices, they contains processor core, memory, and programmable input/output peripherals on a single chip. This integration allows microcontrollers to execute control functions, process data, and communicate with other devices efficiently.

Microcontrollers are present in modern technology, found in everyday items such as household appliances, automotive systems, medical devices, and consumer electronics. Their ability to be adapted to many different functions enables them to handle tasks ranging from simple operations, like turning on a light bulb, to complex functions, such as managing the engine control systems in vehicles.

The architecture of microcontrollers typically includes a central processing unit (CPU), random access memory (RAM), read-only memory (ROM), and various interfaces for communication. They can be programmed using high-level languages such as C or assembly language, making them accessible to engineers and hobbyists alike.

As the demand for smart and connected devices continues to grow, microcontrollers play an important role in the development of the Internet of Things (IoT), enabling seamless interaction between devices and the cloud. Their ability to operate in low-power environments and perform real-time processing makes them an essential component in advancing technology across multiple industries.

Introduction to the main characteristics of different types of microcontrollers

PIC Microcontroller: manufactured by Microchip Technology, used in electronics design, computer robotics and similar devices, a PIC (Peripheral Interface Controller) includes an integrated memory, data bus together with a dedicated microprocessor for all I/O purposes and methods. The flexibility and efficiency of PIC microcontrollers make them a staple in hobbyist projects and professional applications alike.

-Device families:

- PIC10 and PIC12
- PIC16
- PIC17
- PIC18
- PIC24 and dsPIC
- PIC32M MIPS-based line

- PIC32MX
- PIC32MZ
- PIC32MM
- PIC32MK
- PIC32C Arm-based line
- PIC64

ARM (Advanced RISC Machine) Microcontroller: is highly popular in the industrial sector due to its balance of quality, performance, and cost. Its advantages include not only a small size with high performance, but also an energy efficiency. ARM's architecture is renowned for its low power consumption and high-speed processing capabilities, making it a favorite among developers focusing on portable devices.

- Arm processor families

Cortex-A series (Application)

• High performance processors capable of full Operating System

(OS) support

• Applications include smartphones, digital TV, smart books

Cortex-R series (Real-time)

• High performance and reliability for real-time applications;

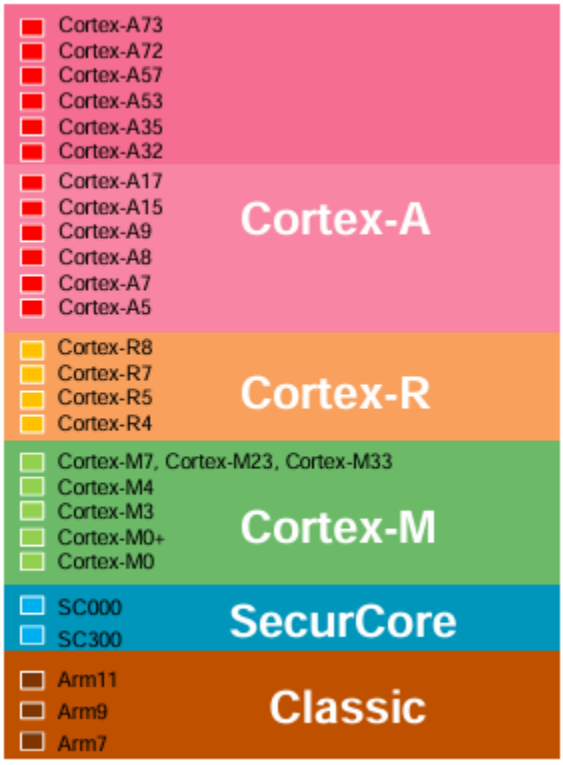
• Applications include automotive braking system, powertrains

Cortex-M series (Microcontroller)

• Cost-sensitive solutions for deterministic microcontroller

applications

• Applications include microcontrollers, smart sensors



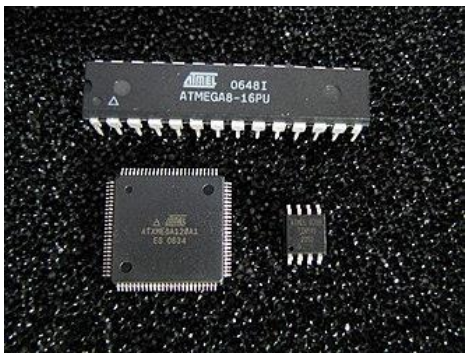
SecurCore series for high security applications

Earlier classic processors including Arm7, Arm9, Arm11 families

8051 Microcontroller: was created by Intel in the 1980s. It is an 8-bit microcontroller capable of processing 8 bits of data at a time. It finds application in various embedded systems including robotics, remote controls, automotive, medical devices, telecommunication applications, power tools, and consumer appliances. Its enduring popularity underscores the 8051's reliability and ease of use in a wide range of applications.

Intel P8051 microcontroller

AVR Microcontroller (Alf and Vegard's RISC Processor): it was among the pioneering microcontroller families to use internal flash memory to store program content. It allows the program memory to be erased and rewritten with a new version. Furthermore, it is not necessary to remove the microcontroller from the board on which it is mounted. AVR microcontrollers are celebrated for their user-friendly nature, offering a seamless experience for both beginners and seasoned developers.



Various older AVR microcontrollers

MSP Microcontroller (Mixed Signal Processor): it is a type of a microcontroller specifically designed for low-cost and low-power dissipation in embedded applications. MSPs are 16-bit mixed-signal processors for ultra-low-power RISC-based systems. Their unique blend of analog and digital capabilities opens up a world of possibilities for innovative embedded system designs.

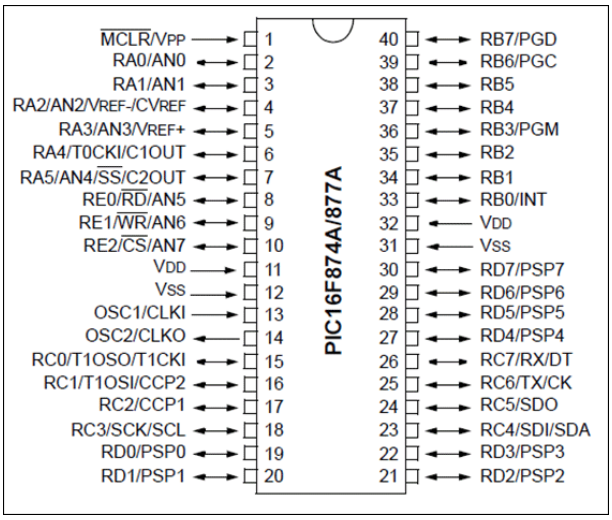
STM32 microcontroller is a family of 32-bit are that is produced by STMicroelectronics , based on the ARM Cortex-M 32-bit processor core. They offer a large number of serial and parallelcommunica□on peripherals . it has many types : STM32F0 (MainStream) , STM32U5 , STM32L5 , STM32L4+ (Ultra-low-power). they are used in a wide range of applications, including industrial automation, consumer electronics, and IoT Applications. They are known for their high performance, low power consumption, and extensive range of peripherals.

STM32F103C8T6 Basic ARM development board DIP Module

A Comparative Analysis of the PIC16F87XA and Tiva C TM4C123GH6PM Microcontrollers

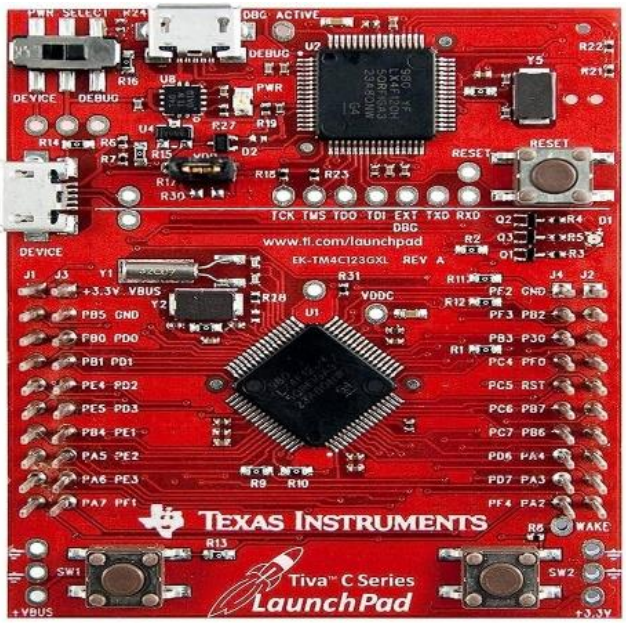
Architectural Design

The PIC16F87XA series, developed by Microchip Technology, operates on an 8-bit architecture. It features a 14-bit instruction set architecture (ISA), which affords it a compact and efficient means of executing commands. The microcontroller supports various instruction types, including arithmetic, logic, and control instructions, making it suitable for a wide range of applications. With a maximum clock speed of 20 MHz, the PIC16F87XA can handle basic tasks efficiently, but it may fall short when faced with more complex computational requirements.



PIC16F874A/877A

The Tiva C TM4C123GH6PM, produced by Texas Instruments, utilizes a 32-bit architecture based on the ARM Cortex-M4 core. This modern architecture allows for more powerful computations, improved floating-point operations, and extensive support for digital signal processing. The TM4C123GH6PM also supports a range of clock frequencies, up to 80 MHz, which enhances its performance in handling multiple tasks simultaneously and processing data at much greater speeds. The 32-bit architecture and higher clock speed position the Tiva C as a more sophisticated solution for complex embedded applications, making it particularly adept at real-time processing and multitasking.



Tiva c tm4c123gh6pm

Performance

-The PIC16F87XA offers up to 368 bytes of SRAM and 256 bytes of Electrically Erasable Programmable Read-Only Memory (EEPROM), alongside programmable Flash memory options ranging from 1KB to 14KB. While this configuration is adequate for many basic tasks, it may result in limitations for projects requiring higher data storage or more complex software algorithms.

-The Tiva C TM4C123GH6PM has a larger memory architecture, with 256KB of Flash memory, 32KB of SRAM, and support external memory interfacing. This allows for storing of larger programs and extensive data, which is useful in applications such as data logging, automation, and multimedia processing. Furthermore, the Tiva C microcontroller's processing power enables it to perform operations with greater speed and greater efficiency, facilitating the execution of more complex algorithms and enhancing the overall user experience.

Connectivity Options

-The PIC16F87XA Limited I/O ports (up to 33 I/O pins), equipped with a variety of communication interfaces, including Universal Asynchronous Receiver-Transmitter (UART), Serial Peripheral Interface (SPI), and Inter-Integrated Circuit (I2C). While these interfaces cover basic connectivity needs, they may not support the advanced connectivity requirements of modern applications, such as wireless communication or high-speed data transfer.

-The Tiva C TM4C123GH6PM excels in connectivity options. It has a total of 64 pins , with six GPIO (General Purpose Input/Output) ports (PORTA, PORTB, PORTC, PORTD, and PORTE), it also provides an impressive suite of protocols, including Ethernet, USB, UART, SPI, and I2C, along with advanced connectivity features like CAN (Controller Area Network. The inclusion of Ethernet connectivity is particularly noteworthy, allowing for seamless integration into Internet of Things (IoT) applications and enabling developers to implement remote monitoring and control functionalities.

Power Characteristics

-The PIC16F87XA consumes minimal power during operation and featuring several sleep modes to extend battery life. This makes it suitable for applications where power availability may be limited, such as in portable devices or remote sensors.

-The Tiva C TM4C123GH6PM is also optimized for low power consumption but offers a broader range of operational modes to adapt to various application needs. Its advanced power management features include multiple sleep modes (ex.: deep sleep mode) and the ability to configure specific peripherals to operate in low-power modes independently. Consequently, the Tiva C microcontroller can maintain operational efficiency while minimizing energy consumption, which is critical for IoT devices and long-lasting applications.

Development Environment

-PIC16F87XA

Development typically done using MPLAB X IDE and XC8 Compiler, But we used mikroC PRO for PIC in our summer training.

-Tiva C TM4C123GH6PM

Development using TivaWare or Keil MDK (currently using in this course) with support for ARM development tools.

Application Domains

-The PIC16F87XA is often employed in basic control applications such as home appliances, simple robotics, and educational projects. Its simplicity, low cost, and ease of use make it an ideal choice for beginners and less demanding applications.

-The Tiva C TM4C123GH6PM finds its place in more advanced applications such as industrial automation, medical devices, and IoT implementations. Its powerful processing capabilities, extensive memory, and advanced connectivity options empower developers to create complex and interactive systems that can analyze data in real-time, communicate over networks, and integrate seamlessly with cloud-based services.

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