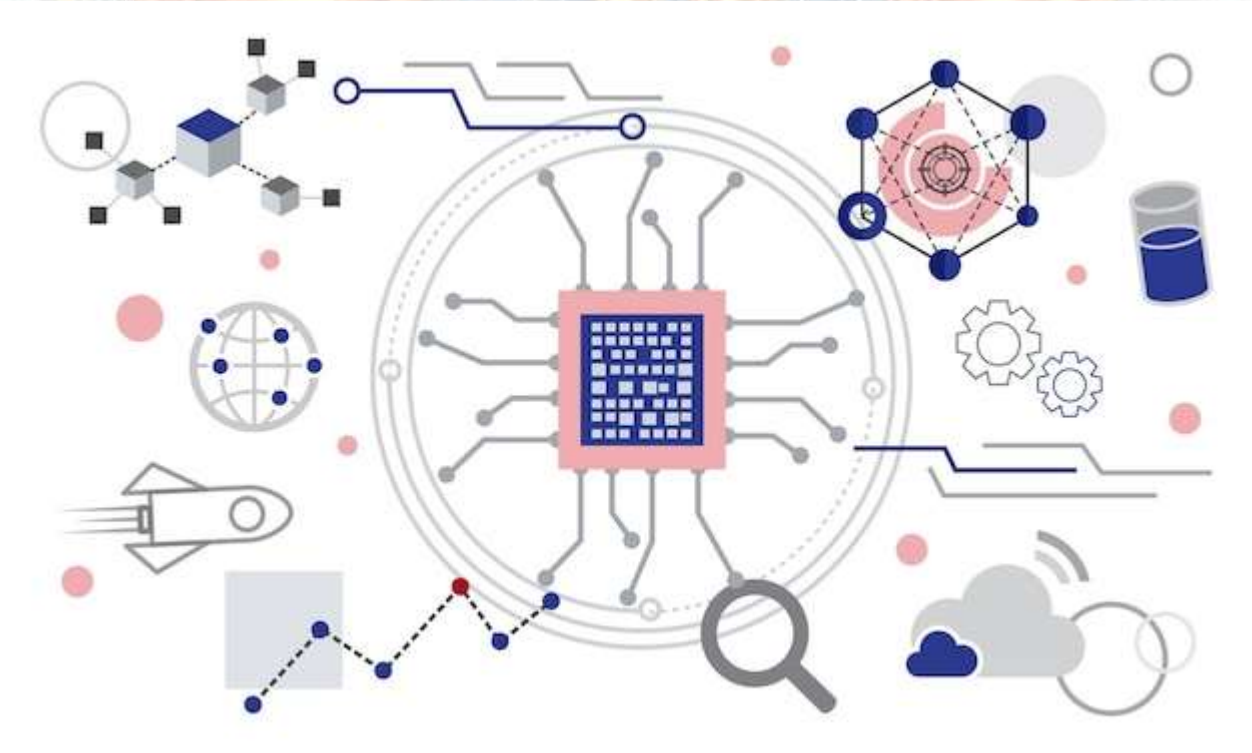
Alexandria University

Faculty of Engineering

Electrical Engineering Department

Communication Protocols

"Model_3_USART"



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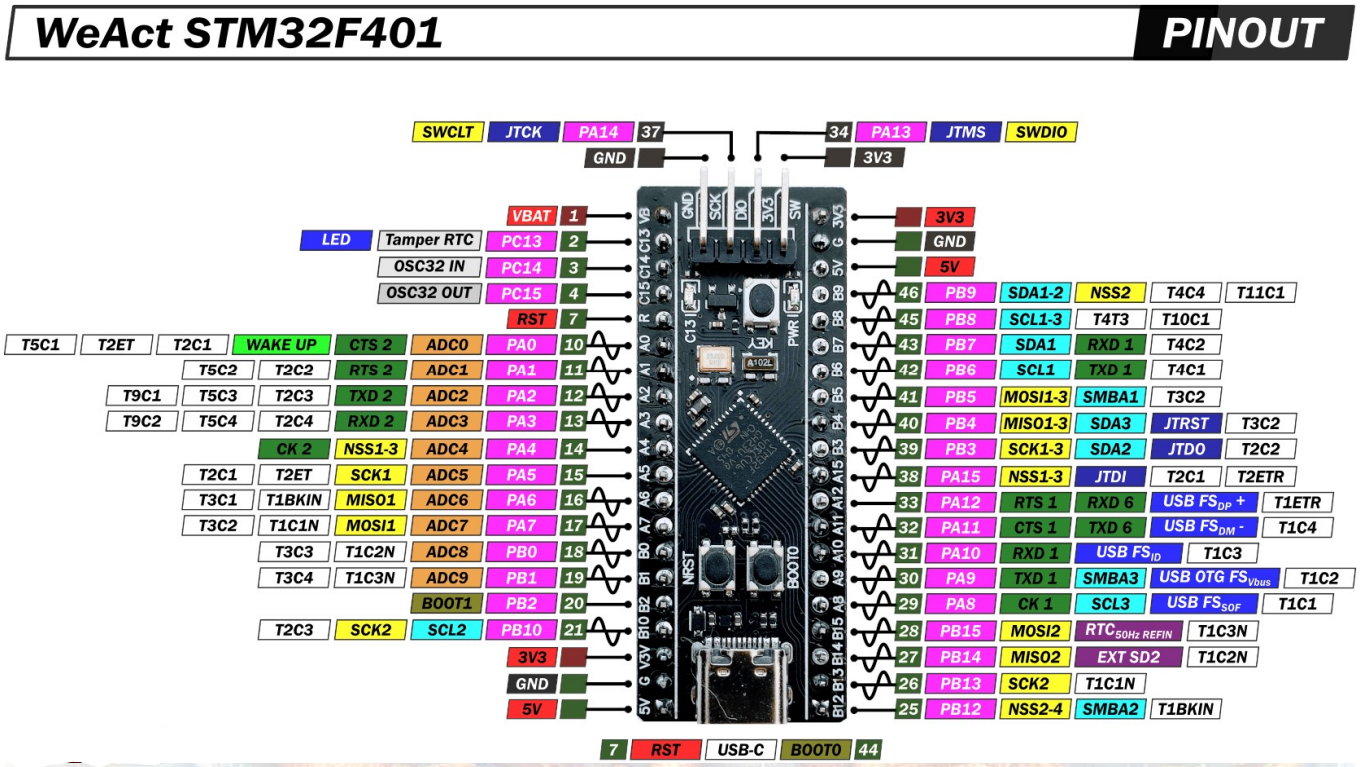
Chapter_1_Introduction

In our project we will discuss interfacing one of the most popular and modern microcontrollers into embedded systems STM32F401CC (Black Seed).



Theory of USART Communication:

A USART (universal synchronous/asynchronous receiver/transmitter) is hardware that enables a device to communicate using serial protocols. It can function in a slower asynchronous mode, like a universal asynchronous receiver/transmitter (UART), or in a faster synchronous mode with a clock signal. USARTs are no longer common in consumer PCs but are still used in industrial equipment and embedded systems.

USART vs. UART

A UART device can use asynchronous communication protocols. A USART device can use both asynchronous and synchronous communication protocols. Therefore, a USART can do anything a UART can do and more. Because a USART requires more complex circuitry and more communication lines to fully implement, many devices may only implement a UART to save on cost, complexity or power usage.

Asynchronous and synchronous serial communication

In serial communication, each bit of data is sent one at a time on a transmit wire. This is a serial communications interface. If the sender and the receiver don't agree on how the data is sent, such as the order and length of time of each bit, then the data becomes garbled, and they won't understand each other. Asynchronous and synchronous are two different ways to standardize how serial data is sent.

Standardization:

The Universal Synchronous Asynchronous Receiver Transmitter (USART) is a widely used communication protocol, and its specifications are often standardized.

Standardization ensures compatibility across devices and allows for interoperability in various applications.

Features:

The USART (Universal Synchronous Asynchronous Receiver Transmitter) boasts a range of features that make it a versatile communication protocol. Here's a brief overview of its main features:

- **Full Duplex, Asynchronous Communications:** USART supports simultaneous transmission and reception of data, making it suitable for bidirectional communication.
- **NRZ Standard Format (Mark/Space):** Non-Return-to-Zero encoding is employed, utilizing Mark and Space levels for binary representation.
- **Configurable Oversampling:** The oversampling method is adjustable, offering flexibility between speed and clock tolerance. It can be configured by 16 or by 8.
- **Fractional Baud Rate Generator:** The system includes a fractional baud rate generator, allowing for common programmable transmit and receive baud rates.
- **Programmable Data Word Length:** Data word length can be programmed to 8 or 9 bits, adapting to the specific requirements of the communication.
- **Configurable Stop Bits:** Supports the use of 1 or 2 stop bits, providing options for framing data within the communication protocol.
- **LIN (Local Interconnect Network) Capabilities:** Features LIN Master Synchronous Break send capability and LIN slave break detection capability. It supports 13-bit break generation and 10/11 bit break detection when configured for LIN.
- **Transmitter Clock Output:** For synchronous transmission, the USART provides a transmitter clock output.
- **IrDA SIR Encoder Decoder:** Supports Infrared Data Association (IrDA) SIR encoding and decoding, including 3/16 bit duration for normal mode.
- **Smartcard Emulation Capability**: The USART can emulate Smartcard interfaces as per ISO 7816-3 standards, supporting 0.5, 1.5 stop bits for Smartcard operations.
- **Single-Wire Half-Duplex Communication:** Facilitates communication over a single wire in half-duplex mode.
- **Configurable Multibuffer Communication using DMA:** Allows for buffering of received/transmitted bytes in reserved SRAM using centralized Direct Memory Access (DMA).

- **Separate Enable Bits for Transmitter and Receiver:** The USART provides separate enable bits for transmitter and receiver, allowing independent control of these functions.
- **Baud Rate:** Determines the speed of data transmission, with common rates such as 9600, 19200, and 115200 bits per second (bps).

Throughput:

Throughput in USART communication is influenced by factors like baud rate, data frame size, and additional control bits. It represents the actual data transfer rate and is crucial for assessing the efficiency of communication.

Hardware vs. Software Flow Controls:

Hardware Flow Control: Involves dedicated hardware lines (e.g., RTS/CTS) to manage data flow between devices, enhancing reliability.

Software Flow Control: Uses special control characters within the data stream for flow management, offering a more flexible but potentially less robust solution.

Oversampling Techniques:

Oversampling is a technique employed to enhance the accuracy of sampled data. USART often uses oversampling to improve reliability. By sampling the received signal at a rate higher than the Nyquist rate, errors can be minimized, contributing to more accurate data reception.

Overrun Condition:

An overrun condition occurs when the USART receiver is unable to process incoming data at the rate it is being received. This can lead to data loss, and addressing this condition is crucial for maintaining data integrity.

Message Frame and Packets:

Message Frame: A complete unit of data transmission, including start and stop bits, parity, and the actual data payload.

Packets: In USART, data is organized into packets, consisting of a header (containing control information) and a payload (the actual data). This structured approach facilitates efficient communication and data interpretation.

Common USART Applications:

Embedded Systems:

USART is integral in microcontroller-based systems for communication with peripherals and external devices. It provides a reliable means for information exchange within embedded applications.

PC-Peripheral Communication:

Devices such as printers, scanners, and modems use USART for communication with computers. This enables seamless connectivity and interaction between various peripherals and the central processing unit.

Industrial Automation:

USART plays a vital role in industrial automation by facilitating communication between controllers, sensors, and other components. It forms the backbone of data exchange in automated systems, contributing to efficient and synchronized operations.

Wireless Communication Modules:

USART is employed in modules that enable wireless communication, serving as a bridge between wired and wireless networks. This application is crucial for the proliferation of wireless technologies in various industries.

Serial Communication between Microcontrollers:

(Which we will explain a simple example about it)

Interconnecting microcontrollers in a network for information exchange is a common application of USART. This is prevalent in scenarios where multiple microcontrollers need to work together, sharing data and coordinating tasks.