UART Protocol summary

I. Introduce

UART, or universal asynchronous receiver-transmitter, is one of the most used device-to-device communication protocols. UARTs transmit data asynchronously, which means there is no clock signal to synchronize the output of bits from the transmitting UART to the sampling of bits by the receiving UART. When the receiving UART detects a start bit, it starts to read the incoming bits at a specific frequency known as the baud rate.

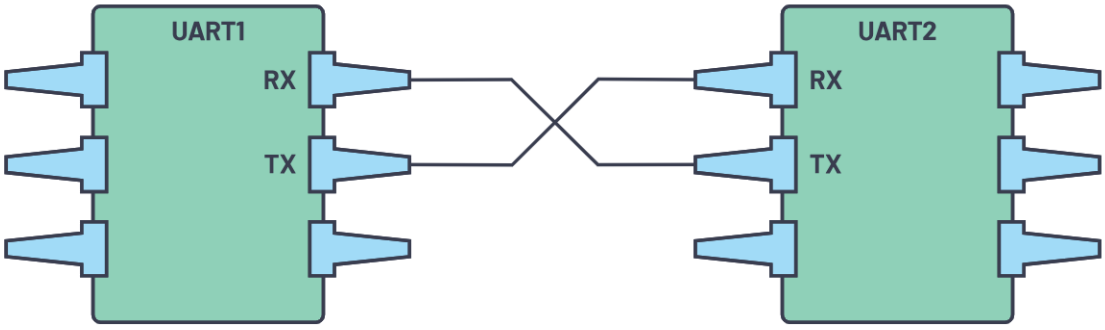
Baud rate is a measure of the speed of data transfer, expressed in bits per second (bps). Both UARTs must operate at about the same baud rate.

Common baud rate: 4800, 9600, 19200, 57600 and 115200

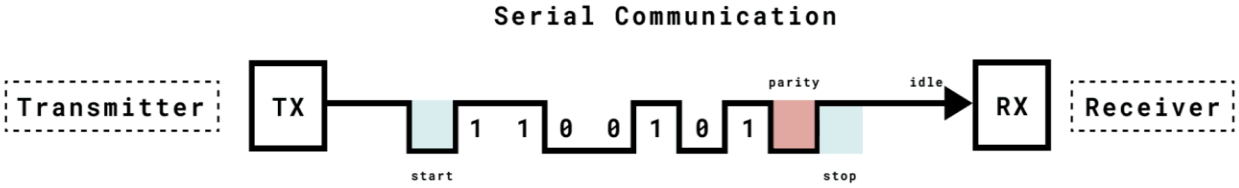
Example:

- 9600 baud rate -> 9600 Hz
- 9600 bits per second (bps)
- Each bit transmit/receive take 1/(9600 Hz) = 104.17 us

UART have two wires TX (transmit and RX (receive, can be simplex, half-duplex or full-duplex



II. UART data frame



Start bit

Start Bit The UART data transmission line is normally held at a high voltage level when it's not transmitting data. To start the transfer of data, the transmitting UART pulls the transmission line from high to low. When the receiving UART detects the high to low voltage transition, it begins reading the bits in the data frame at the frequency of the baud rate.

Data Frame

The data frame contains the actual data being transferred. It can be 5 bits up to 8 bits long if a parity bit is used. If no parity bit is used, the data frame can be 9 bits long. In most cases, the data is sent with the least significant bit first

Parity Bit

describes the evenness or oddness of a number. The parity bit is a way for the receiving UART to tell if any data has changed during transmission. Bits can be changed by electromagnetic radiation, mismatched baud rates, or long distance data transfers. After the receiving UART reads the data frame, it counts the number of bits with a value of 1 and checks if the total is an even or odd number. If the parity bit is a 0 (even parity), the 1 bits in the data frame should total to an even number. If the parity bit is a 1 (odd parity), the 1 bits in the data frame should total to an odd number. When the parity bit matches the data, the UART knows that the transmission was free of errors. But if the parity bit is a 0, and the total is odd; or the parity bit is a 1, and the total is even, the UART knows that bits in the data frame have changed.

7 bits of data	(count of 1-bits)	8 bits including parity	
		even	odd
0000000	0	00000000	00000001
1010001	3	10100011	10100010
1101001	4	11010010	11010011
1111111	7	11111111	11111110

Example for Parity Bit

Stop Bits

To signal the end of the data packet, the sending UART drives the data transmission line from a low voltage to a high voltage for at least two bit durations

III. Summary

- UART TX is high when idle
- **Start Bit**: Signals the beginning of data transmission, usually a single low bit.
- **Data Bits**: Typically 5 to 9 bits representing the actual data.
- **Parity Bit** (optional): Error-checking bit to detect single-bit errors.
- **Stop Bit(s)**: Indicates the end of data transmission, typically one or two high bits.
- **Baud Rate**: Defines the rate of data transmission in bits per second (bps) and needs to match on both transmitting and receiving UART. Common baud rate: 4800, 9600, 19200, 57600 and 115200