Serial Communication Overview

Types of Data Transmission

Types of Serial Data Communication

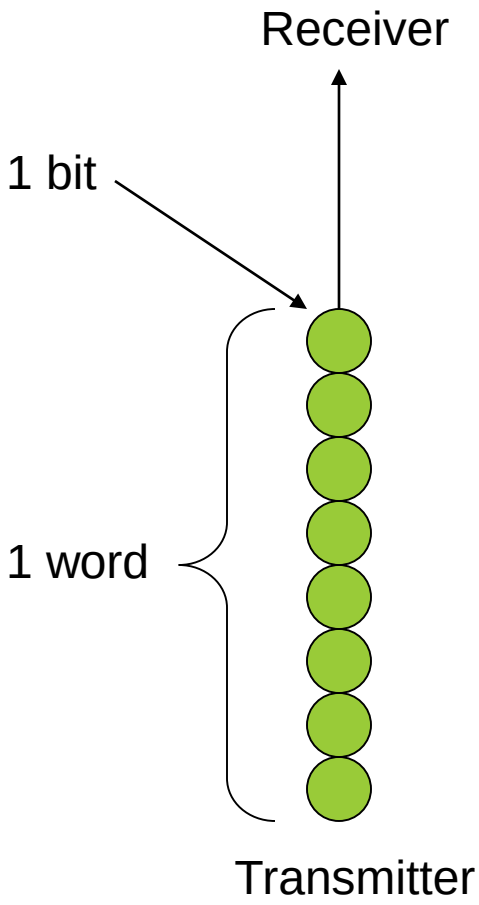
Asynchronous Data Transmission

Data Transmission Rates

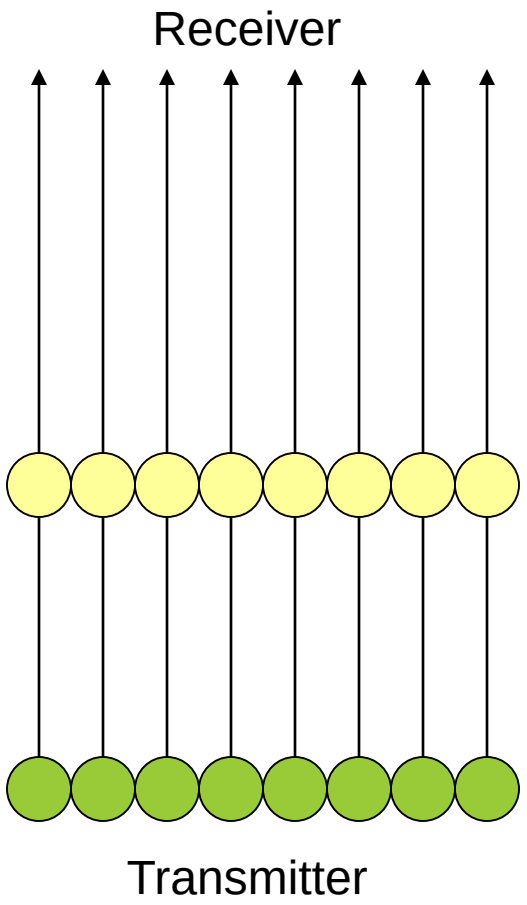
Examples of Data Transmission

Transmission Illustration

Serial



Parallel



Data Transmission

	Serial	Parallel
Cost	Cheap	Expensive
Speed	Slow	Fast
Transmission Amount	Single bit	8 bits (8 data lines) Transmitter & Receiver
Transmission Lines	One line to transmit one to receive	8 lines for simultaneous transmission
Transmission Distance	Long distance	Short distance (synchronization)
Example	Modem	Printer Connection

Serial Communications

Synchronous

- Synchronous Peripheral Interface (SPI)

Asynchronous

- Serial Communication Interface (SCI)

Synchrononous - SPI

Constant transmission of data

Clocks of Transmitter and Receiver must be synchronized

No safeguard against error or noise

Data rates depend on clock rates

Flexible to communication with peripheral devices

- LCD drivers, A/D converter, other microprocessors

Simultaneously transmits and receives data

- Transmission line, Receiving line, and Ground

Asynchronous - SCI

Transmission of data through “words”

Continuous transmission unnecessary

Built-in safeguards against noise and error

Transmitter and Receiver operate independently

Requires start and stop bit for each byte of data

- Sends constant ‘1’ for idle
- Sends a ‘0’ for start and “1” for stop bits

Very reliable data reception

Sending & Receiving

Set the Baud Rate of the Transmitter and Receiver (same value)

Set the ‘M’ bit of SCCR1 for 8 or 9 bit data for Transmitter/Receiver

Set ‘TE’ bit of SCCR2 to high to enable Transmitter (‘RE’ for Receiver)

Load data into SCDR, RDRF bit set when data has been entered into SCSR

TDRE bit of SCSR goes high to allow another data character into SCDR

Sending & Receiving

Data is read from the RDR and stored

Error check is performed

TC bit of SCSR goes high and clears the transmit buffer

Transmitter resumes idle

Asynchronous Serial Transmission

Start Bit

Data Bit

Stop Bit

Parity Bit

Noise

SCI Registers

Bit Types

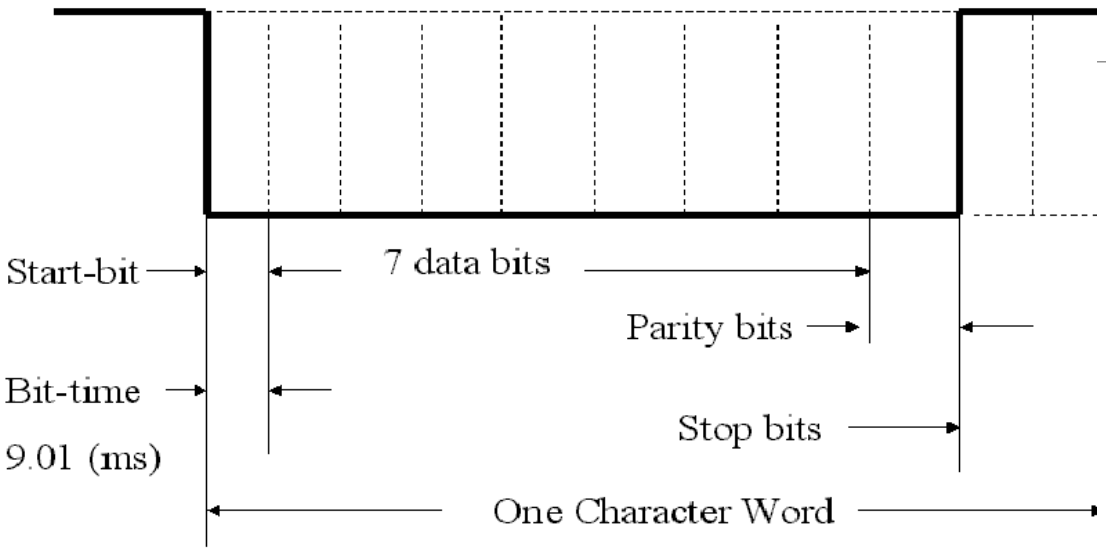


Figure 1. Role of stop, start and parity bits.

Start Bit –

- Signals the transmission of a word.
- Transition from “1” to “0”. (“Mark-to-space”)
- First bit to be transmitted.

Bit Types (Cont)

Stop Bits –

- Bit at the end of a data word.
- Bit set to high “1”.
- Indicates the end of a word.

Data bits –

- Data bits to be transmitted.
- Sender and receiver have to agree in the number of data bits. (Usually 8 or 9)
- Least significant bit is sent first.
- Can be low or high.

Bit Types (Cont)

Parity bit –

- Works as an error check.
- There are two types: *odd* and *even*
  - Even: if number of 1's in the data word is even.
  - Odd: if number of 1's in the data word is odd.
- Bit after the data bits and before the stop bit.
- Can prevent single noise signal, but does not recognize when two bits are altered by noise.
- Used to prevent noise.

Noise

Noise is an interference in the line, which causes a word to be misinterpreted.

Noise Detection by HC11:

- Noise detected if three samples taken near the middle of the bit time do not agree.
- When start bit is detected, 4 additional samples are taken during the first half of the bit time for start bit verification.
- If noise is detected noise flag (NF) is set.

SCI Registers

BAUD Register: Sets the bit rate for the SCI system

Address: $102B

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	0	0	SCP1	SCP0	0	SCR2	SCR1	SCR0
Write:	TCLR				RCKB			
Reset:	0	0	0	0	0	U	U	U

U = Unaffected

SCP bits: Pre-scale select bits.

SCR bits: Baud rate selects.

Other bits set for factory tests.

SCI Registers

SCCR1 Register: Sets control bits for the 9-bit character format and the receiver wake up feature

Address: $102C

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	R8	T8	0	M	WAKE	0	0	0
Write:								
Reset:	U	U	0	0	0	0	0	0

U = Unaffected

R8- Receive Data bit 8

T8: Transmit Data Bit 8

WAKE:Wake up Method Select Bit

- "0" for idle. Detection of at least a fill character time of idle time gets the receiver to wake up
- "1"for address mark. "1" in the MSB gets the receiver to wake up.

M: SCI Character Length Bit

- "0" for 8 data bits, "1" for 9 data bits.

SCI Registers

SCCR2 Register: Main control register for the SCI system.

Address: $102D

	Bit 7	6	5	4	3	2	1	Bit 0
Read: Write:	TIE	TCIE	RIE	ILIE	TE	RE	RWU	SBK
Reset:	0	0	0	0	0	0	0	0

U = Unaffected

TIE: Transmit Interrupt Enable Bit

- "0" TDRE interrupts disabled, "1" SCI interrupt requested when TDRE is "1".

TCIE: Transmit Complete Interrupt Enable Bit

- "0" TC interrupts disabled, "1" SCI interrupt requested when TC is "1".

RIE: Receive Interrupt Enable Bit

- "0" RDRF and OR interrupts disabled, "1" SCI interrupt requested when either RDRF or OR is "1".

SCI Registers

SCCR2 Register (Cont.)

ILIE: Idle-Line Interrupt Enable Bit.

- "0" IDLE interrupts disabled, "1" SCI interrupt requested when IDLE is "1".

TE: Transmit Enable

- "0" SCI transmitter disabled, "1" SCI transmitter enabled.

RE: Receive Enable Bit

- "0" SCI receiver disabled, "1" SCI receiver enabled.

RWU: Receiver Wakeup Bit

- "0" Normal SCI receiver operation (Wake up feature not enabled), "1" Places SCI in standby mode (receiver related interrupts are inhibited).

SBK: Send break Bit

- "0" Normal SCI Transmitter operation, "1" Enable transmitter to send synchronous break characters.

SCI Registers

SCSR Register: Generated hardware interrupts and indicate errors.

Address: $102D

	Bit 7	6	5	4	3	2	1	Bit 0
Read: Write:	TIE	TCIE	RIE	ILIE	TE	RE	RWU	SBK
Reset:	0	0	0	0	0	0	0	0

U = Unaffected

TDRE: Transmit Data Register Empty Bit

- "0" Not empty, "1" New character can be written to the SCDR.

TC: Transmit Complete Bit

- "0" Transmitter busy sending character, "1"Transmitter completed sending character and is in idle state.

RDRF: Receive Data Register Full Bit

- "0" Not full (Nothing received since last reading of SCDR, "1" Character received and transferred from receive shift register to parallel SCDR.

SCI Registers

SCSR Register (Cont.)

IDLE: Idle-Line Detect Bit

- "0"RxD line is active or never used, "1" RxD line is idle.

OR: Overrun Error Bit

- "0" No error, "1"Another character was serially received and ready to be transferred to SCDR, but the previously received character was not yet read.

NF: Noise Flag

- "0" No noise detected.

FE: Framing Error bit

- "0" No Framing error, "1" Framing error detected for the character in the SCDR.

SCI Registers

SCDR Register: It contains the data to and from the MCU.

Address: $102F

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	R7	R6	R5	R4	R3	R2	R1	R0
Write:	T7	T6	T5	T4	T3	T2	T1	T0
Reset:	Unaffected by rest							

U = Unaffected

SCDR is two separate registers:

When SCDR is read, read only RDR is accessed

When SCDR is written, the write only TDR is accessed.

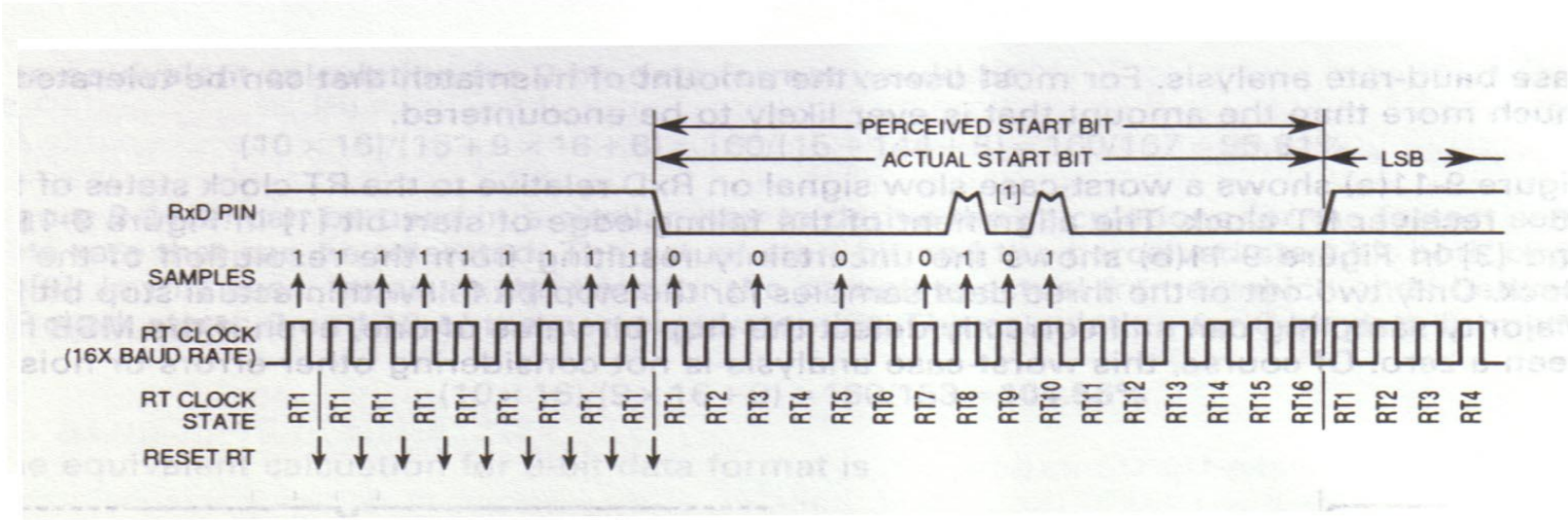
Ancillary Registers

PORTD- $1008
- Input/Output Port D

DDRD- $1009
- Data Direction Register for Port D

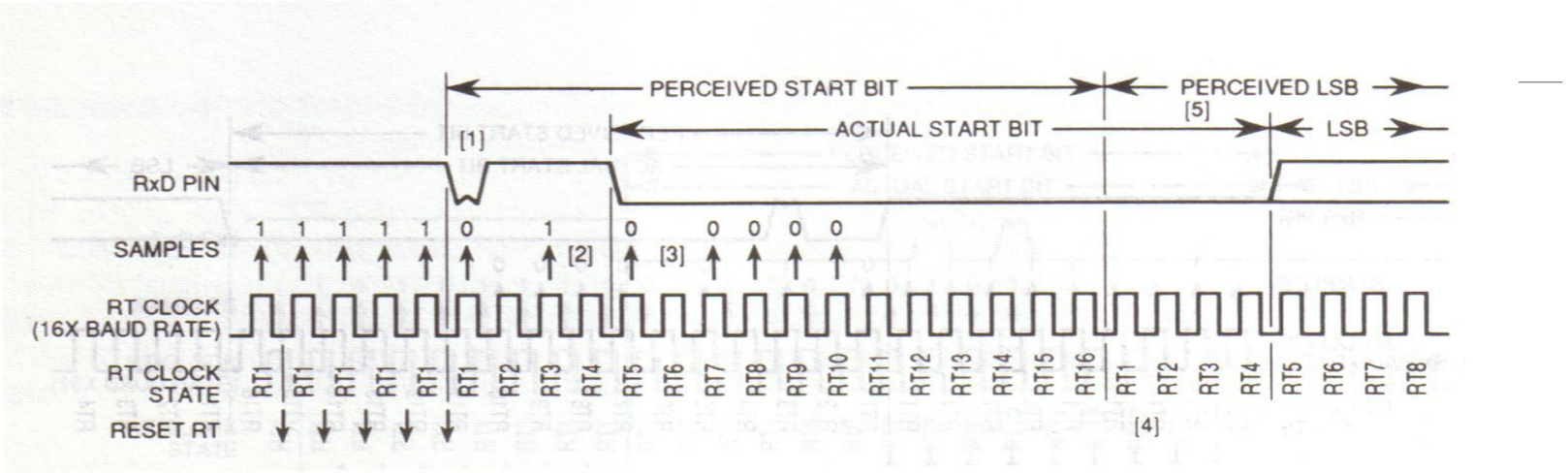
SPCR- $1028
- SPI Control Register

Noise



- Receiving clock is sampling at 12x the transmitting clock, so each bit can be tested 12 times
- Start bit is detected properly
- Since RT8 and RT10 are ‘1’, the noise flag is set
- Since the majority of the start bit was detected as ‘0’, the bit will be accepted as the start bit

Noise



- Noise on RxD pin causes the start bit to be detected too soon
- Since the majority of the samples are zero, start bit is accepted
- the noise flag is also set since ones were detected
- if a ‘1’ is not detected where the stop bit should be, a framing error will be detected

Baud Rate vs. Bit Rate

Baud rate: number of total information bits transmitted per second (includes start, data, parity and stop bits)

Bit rate: number of data bits only transmitted per second

So for us, Baud rate > Bit rate

Note: in modems, multiple transmission voltage levels are used, so multiple bits are encoded with each signal, meaning bit rates can be greater than baud rates

Baud Rate vs. Bit Rate

For the HC11, there is always either 10 or 11 total information bits per word

If the M bit is 0, there are 10 (8 data bits, 1 start, 1 stop)

If the M bit is 1, there are 11 (8 data bits, 1 start, 1 stop, and one additional ‘data’ bit)

The additional bit can be an extra stop bit or a parity bit (from the T8 bit of SCCR1)

Using a parity bit takes more computation time

Baud Rate Example

What is the bit rate for a 2400 baud rate using a parity bit and two stop bits per data word?

$$\text{bit rate} = \text{baud rate} \frac{8 \text{ data bits/word}}{12 \text{ total bits/word}}$$

$$\text{bit rate} = 2400(2/3) = 1600 \text{ bps}$$

For HC11 with one start, 8 data, and one stop:

$$\text{bit rate} = \text{baud rate} \frac{8 \text{ data bits/word}}{10 \text{ total bits/word}}$$

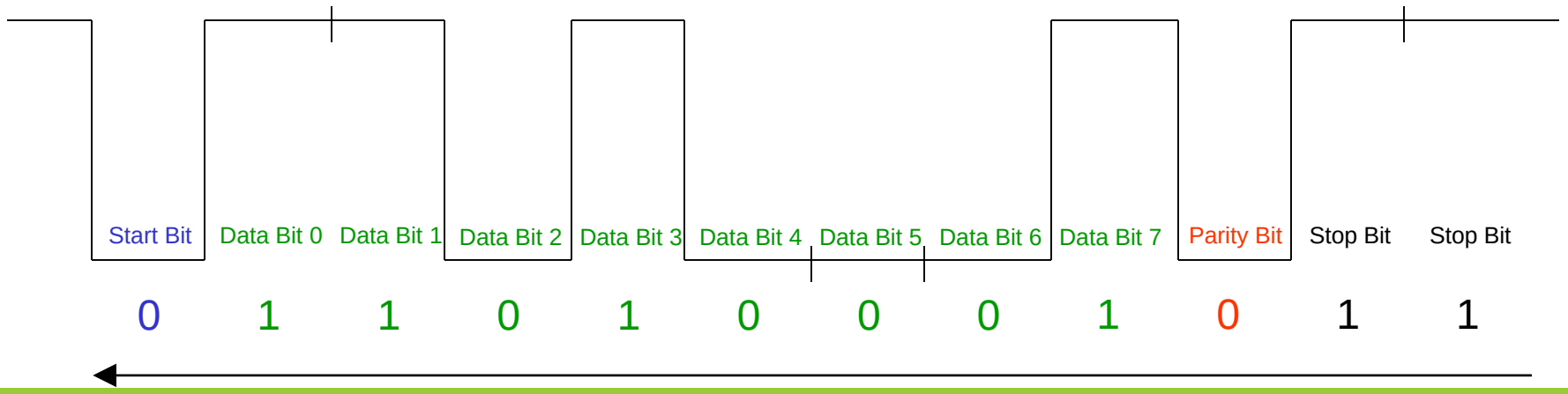
$$\text{bit rate} = 2400(4/5) = 1920 \text{ bps}$$

Asynchronous Transmission

Example 1:

Send $8B_{16}$ with one start bit, 8 data bits, even parity, and two stop bits.

- **$8B_{16}=10001011_2$**

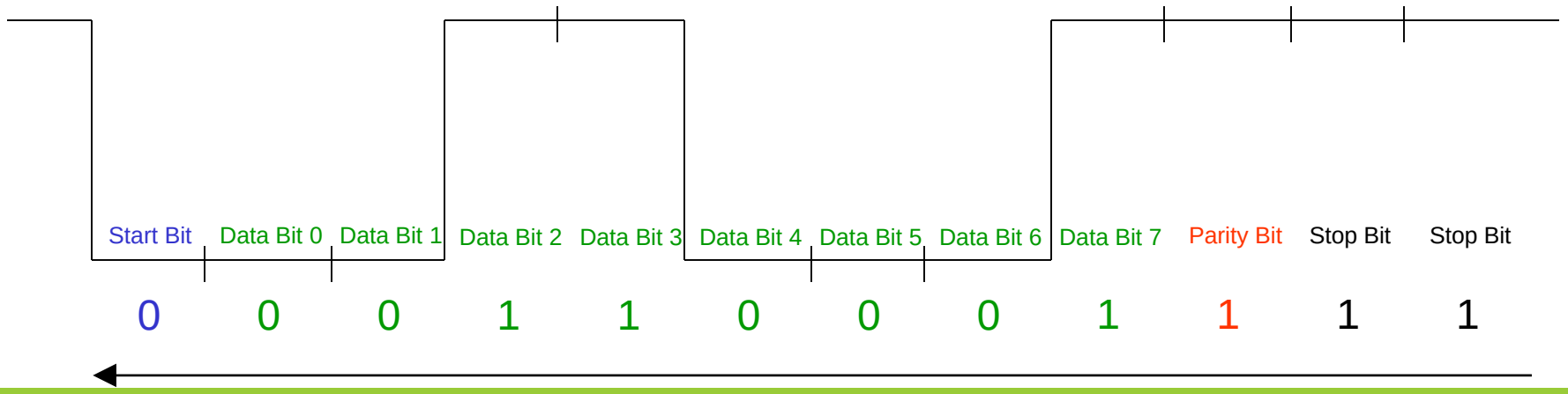


Asynchronous Transmission

Example 2:

Send $8C_{16}$ with one start bit, 8 data bits, even parity, and two stop bits.

- **$8C_{16}=10001100_2$**

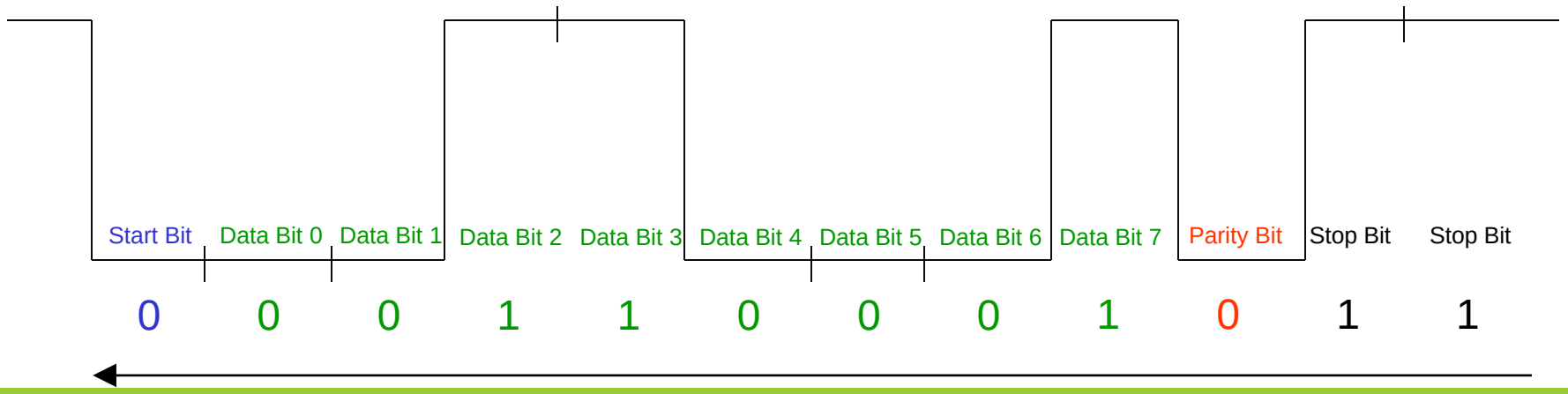


Asynchronous Transmission

Example 3:

Send $8C_{16}$ with one start bit, 8 data bits, *odd* parity, and two stop bits.

- **$8C_{16}=10001100_2$**



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Questions