Serial Communication Interface

- Understand serial communication interface
- Distinguish between RS232 and RS485
- Study current loop and dial-up access

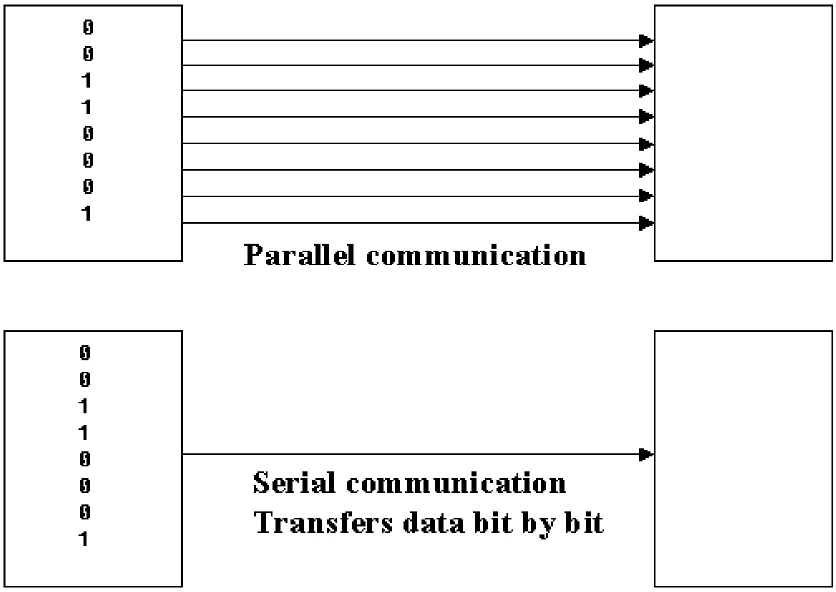
Reference:

•http://www.pccompci.com/Serial-Communication-Technology.html

•Networking and Integration of Facilities Automation Systems, Chapter 5

•http://www.bb-elec.com/technical_library.asp

Serial vs. Parallel Communications



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Serial Communications:

•Bits are assembled into bytes and transmitted in a single transmission path

•Slower throughput in comparison with parallel communications

•Long distance such that it is suitable for communications to remote locations

•Less communications path

•Practically, two-way (full duplex) communications require at least three separate wires - one to send, one to receive, and a common signal ground wire

Parallel Communications:

•Every bit is transmitted on its dedicated wire (transmission path) simultaneously

•High throughput

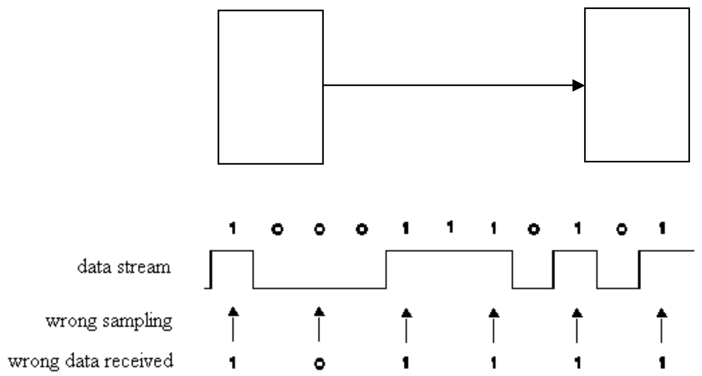
•Short distance

In automation industry, serial communications is one of the most popular means of data transmission. It is standardized and is defined by EIA or RS standards. The most frequently used standards for automation systems are EIA RS-232 and EIA RS-485.

EIA – Electronic Industries Association

RS – Recommended standard

Synchronization



Control Network: Serial Communications

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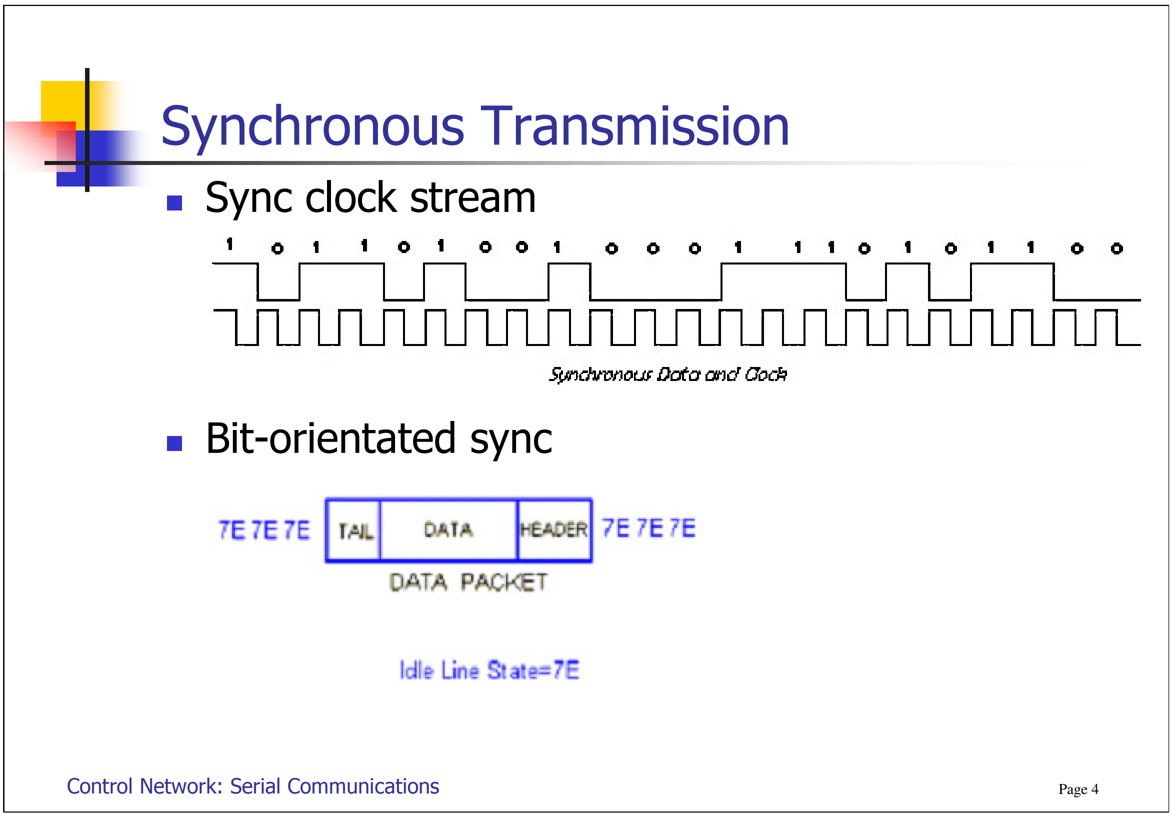
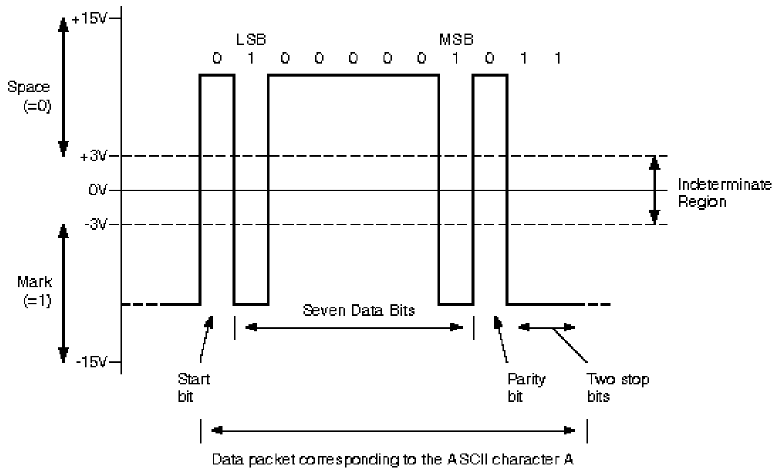
- Serial data transfers depend on accurate timing in order to differentiate bits in the data stream
- Communication require synchronization between the sender and receiver
- Two ways to cope with this timing issue:
    1. Synchronous transmission
    2. Asynchronous transmission



Synchronous Communications:

- The clock rate used for synchronization is sent together with data
  1. by additional channel
  2. By additional bit stream
     - The receiving device adjusts its internal clock rate according to the clock signal
- Error detection is usually provided by the use of several bits at the end of blocks of data (i.e., CRC)

Asynchronous Transmission



Asynchronous Communications:

•Data is enclosed by a start and stop bit (0s and 1s). The start bit indicates when the data byte is about to begin and the stop bit signals when it ends.

•Start and stop bits are called synchronizing signals.

•The receiving device recognizes the start bit and reads the incoming data at a fixed time interval

•Re-synchronizing its internal timing with each bit and at each start bit

•Transmission errors may be detected by parity bits at the end of each byte

- •Odd parity – total number of "1" bits is an odd number
- •Even parity – total number of "1" bits is an even number

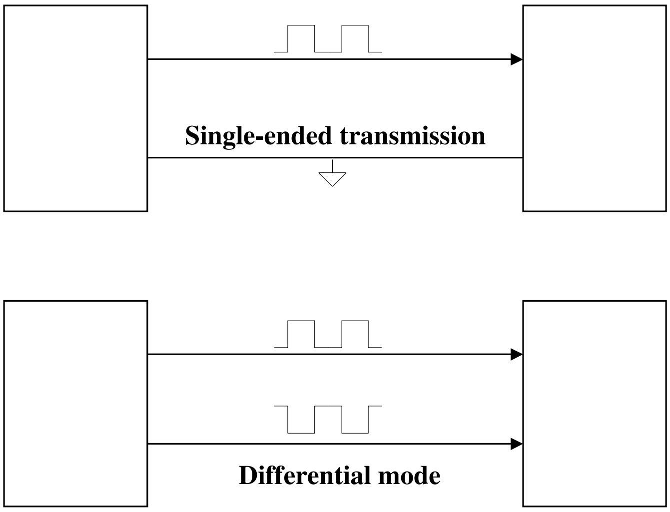
Sync vs. Async

- Speed
- Complexity
- Processor requirement

•Synchronous communications allows faster data transfer rates than asynchronous methods, because additional bits to mark the beginning and end of each data byte are not required

•the advantage that the processor under async does not have to deal with the additional idle characters and easy to implement

Balanced and Unbalanced Data Transmission



•Single-ended mode is also called unbalanced mode; differential mode is also called balanced mode.

•The single-ended signals are represented by voltage levels with respect to a system common (power / logic ground). The "idle" state (MARK) has the signal level negative with respect to common, and the "active" state (SPACE) has the signal level positive with respect to common.

•When communicating at high data rates, or over long distances in real world environments, single-ended methods are often inadequate. Differential data transmission (balanced differential signal) offers superior performance in most applications. Differential signals can help nullify the effects of ground shifts and induced noise signals that can appear as common mode voltages on a network.

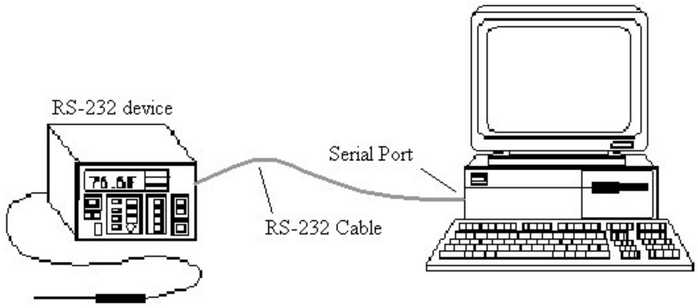
RS232 Standard

- Point-to-point topology
- 1 driver/1 receiver per channel
- Unbalanced mode of operation
- Max 50 feet cable length
- Max 20 kbps data rate (256 kbps for new standard)

•It is also called Universal Asynchronous Receiver/Transmitter (UART) when asynchronous transmission is used.

•Due to the nature of the unbalanced circuit and relatively high voltage, RS232 transmission is susceptible to noise and crosstalk. It is also susceptible to ground loops as a result of possible voltage differences at different points of the line, caused by different ground potentials.

UART Data Format



- **Baud rate -- bits per second**
- **Data bits -- inverted logic and LSB first**
- **Start bit – "0" at data start**
- **Stop bits -- 1, 1.5, or 2 inverted bits at data end**
- **Parity -- optional error-checking bit**
- **Flow control -- hardware and software handshaking options**

•**Baud rate**—How many bits per second are transferred on the serial cable (say 4800baud, 9600baud)

•**Data bits**—How many bits represent a data value (5,6,7 or 8). Almost all devices transmit data using either 7 or 8 data bits.

•**Start bit**—Send a bit "0" at the beginning of data transfer

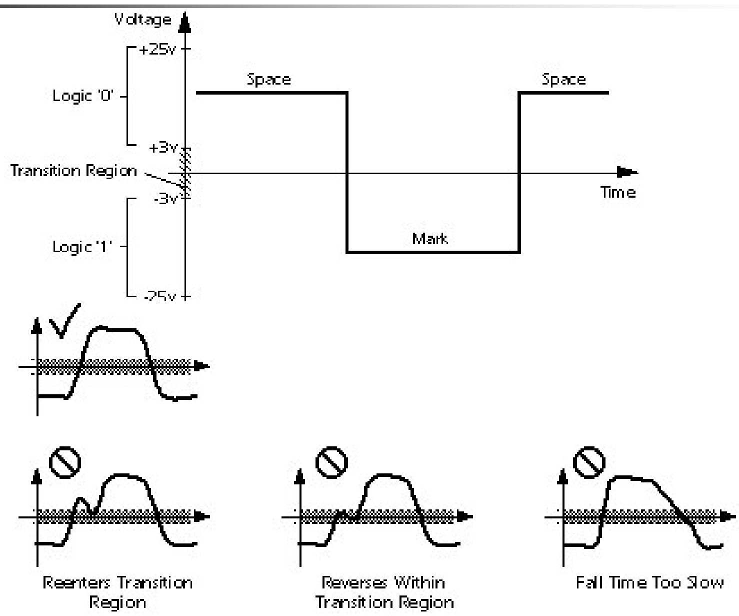
•**Stop bits**—Certain number of bits added to the end of each data transfer (1, 1.5 or 2)

•Start bit/Stop bits are used for synchronization.

•**Parity**—Optional error checking bit that is added to the data (even or odd parity), e.g., the 8 bits data: 10110100, the even parity bit will be 0 and the odd parity bit will be 1

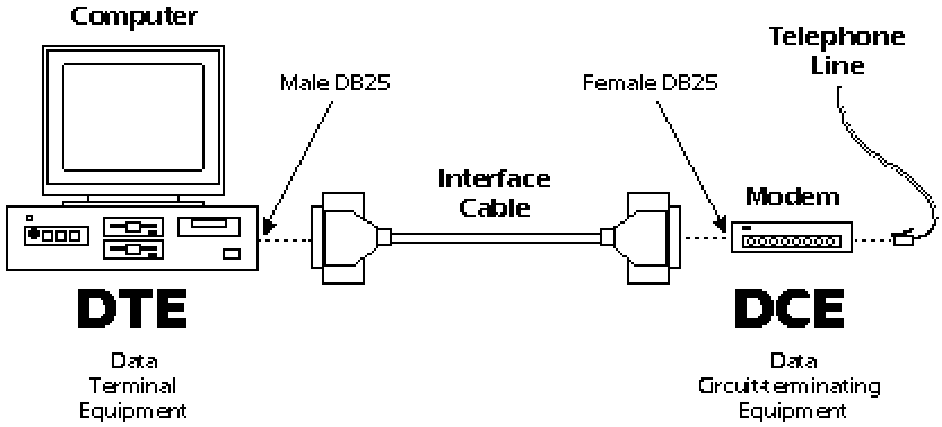
•**Flow control**—Optional hardware or software handshaking parameters for communicating with a device.
(The method of exchanging signals for data flow control between computers and data sets is called handshaking. The most popular and most often used handshaking variant is called XON/XOFF; it's done by software, while other methods are hardware-based.)

RS232 Signal Definition



- *Signal State Voltage Assignments*: Voltages of -3v to -25v with respect to signal ground (pin 7) are considered logic '1' (the marking condition), whereas voltages of +3v to +25v are considered logic '0' (the spacing condition). The range of voltages between -3v and +3v is considered a transition region for which a signal state is not assigned
- *Changes in signal state from logic '1' to logic '0' or vice versa must abide by following requirements*:
    1. Signals that enter the transition region during a change of state must move through the transition region to the opposite signal state without reversing direction or reentering.
    2. For control signals, the transit time through the transition region should be less than 1ms.
    3. For Data and Timing signals, the transit time through the transition region should be
        - less than 1ms for bit periods greater than 25ms,
        - 4% of the bit period for bit periods between 25ms and 125µs,
        - less than 5µs for bit periods less than 125µs.
          The rise and fall times of data and timing signals ideally should be equal, but in any case vary by no more than a factor of three.
    4. The slope of the rising and falling edges of a transition should not exceed 30v/µS. Rates higher than this may induce crosstalk in adjacent conductors of a cable.

DTE and DCE



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•DTE stands for Data Terminal Equipment, and DCE stands for Data Communications Equipment.

•These terms are used to indicate the pin-out for the connectors on a device and the direction of the signals on the pins.

•Your computer is a DTE device, while most other devices are usually DCE devices, or simply called remote devices.

Pin Assignment

DB-25 Pin#	DB-9 Pin#	Description
1	-	Protective Ground/Frame Ground
2	3	Transmitted Data (TD) (from DTE to DCE)
3	2	Received Data (RD)
4	7	Request To Send (RTS)
5	8	Clear To Send (CTS)
6	6	Data Set Ready (DSR)
7	5	Signal Ground
8	1	Date Carrier Detect (DCD)
20	4	Data Terminal Ready (DTR)
22	9	Ring Indicator (RI)

•*Signal ground:* This is the logical ground, which is used as a point of reference for all signals received or transmitted. This signal is very important and must be present for all communications.

•*Transmitted data (TD):* This line is used to transmit data from the DTE to the DCE. It is maintained at a logical 1 state when nothing is transmitted.

•*Received data (RD):* This circuit is used to receive data from the DCE to the DTE.

•*Request To Send (RTS)*: On this line, the DTE will send a signal when it wants to receive data from the DCE.

•*Clear To Send (CTS):* Here the DCE will send a signal when it's ready to receive data from the DTE. (Example: When your local modem connects to another modem via telephone lines).

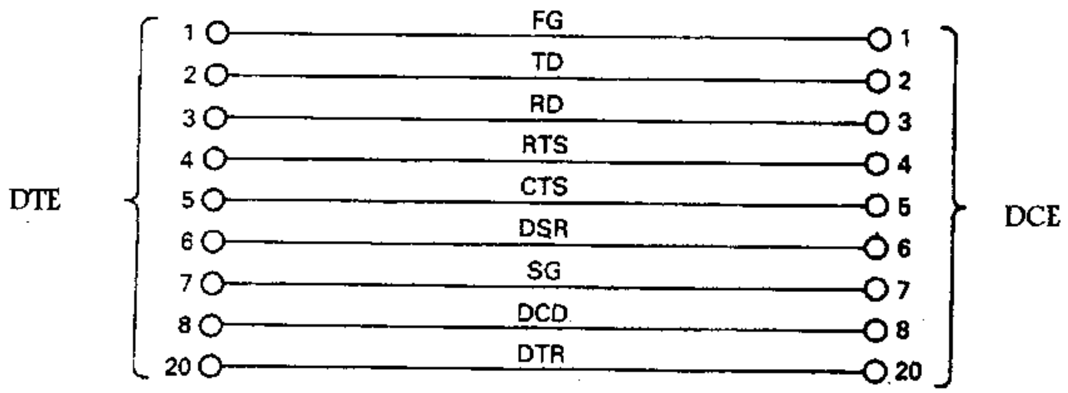
•*Data Set Ready (DSR):* At a logical level of 1, this line indicates to the DTE that the DCE is ready to send data. (Ex. When a modem has established a connection with a remote modem and is in transmission mode).

•*Data Terminal Ready (DTR):* When a logical level 1 is sent from the DTE the DCE can start to send and receive data. When this line passes to logical level 0 the DCE will stop all communications. (Ex. A modem would stop all communications and would disconnect from the line, you will often see "DROP DTR" in communication programs).

•*Data Carrier Detect (DCD):* On this line the DCE indicates to the DTE that it has established a carrier with a remote device.

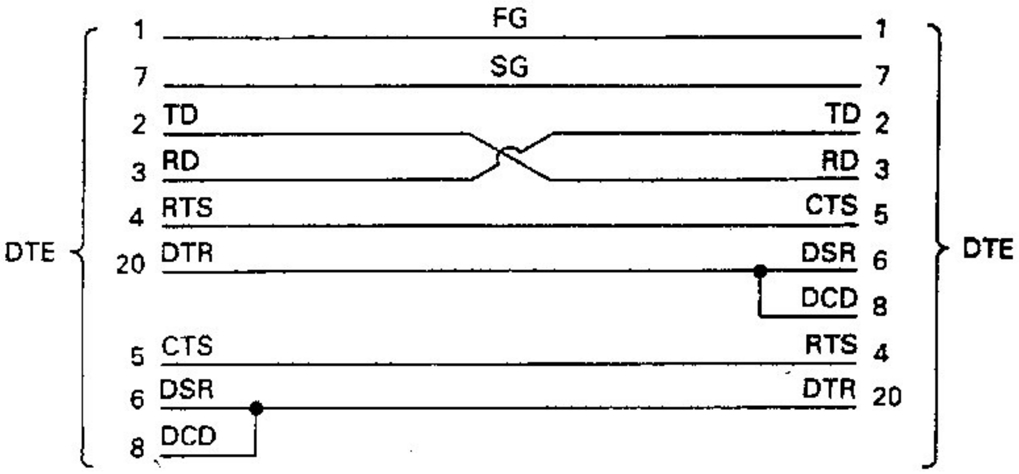
•*Ring Indicator (RI):* This line is used mostly by communications software when the modem is not in "auto answer" mode and will indicate to the software that a remote device is calling. This is signal is optional when not using software that will answer a phone call automatically.

Direct Connection



- For software handshaking, only signal ground, TD and RD are required.
- The Data Terminal Ready and Data Set Ready signals of the serial port can be used for handshaking purposes, too. Their names express what they do: the computer signals with DTR that it's ready to send and receive data, while the data set sets DSR. With most modems, the meaning of these signals is slightly different: DTR is ignored or causes the modem to hang up if it is dropped, while DSR signals that a connection has been established.
- While DTR and DSR is mostly used to establish a connection, RTS and CTS have been specially designed for data flow control. The computer signals with RTS Request To Send that it wishes to send data to the data set, while the data set (modem) sets CTS Clear To Send when it's ready to do one part of its job: to send data through the phone wires.

Cross-Connection



Cable Length vs. Baud Rate

Baud Rate	Max Distance	Max Distance
	Shielded Cable	Unshielded Cable
110	5000ft	3000ft
300	5000ft	3000ft
1200	3000ft	3000ft
2400	1000ft	500ft
4800	1000ft	250ft
9600	250ft	250ft

The RS-232C standard imposes a cable length limit of 50 feet. You can usually ignore this "standard", since a cable can be as long as 10000 feet at baud rates up to 19200 if you use a high quality well shielded cable. The external environment has a large effect on lengths for unshielded cables. In electrically noisy environments, even very short cables can pick up stray signals. The chart above offers some reasonable guidelines for 24-gauge wire under typical conditions. You can greatly extend the cable length by using additional devices like optical isolators and signal boosters. Optical isolators use LEDs and Photo Diodes to isolate each line in a serial cable including the signal ground. Any electrical noise affects all lines in the optically isolated cable equally - including the signal ground line. This causes the voltages on the signal lines relative to the signal ground line to reflect the true voltage of the signal and thus canceling out the effect of any noise signals

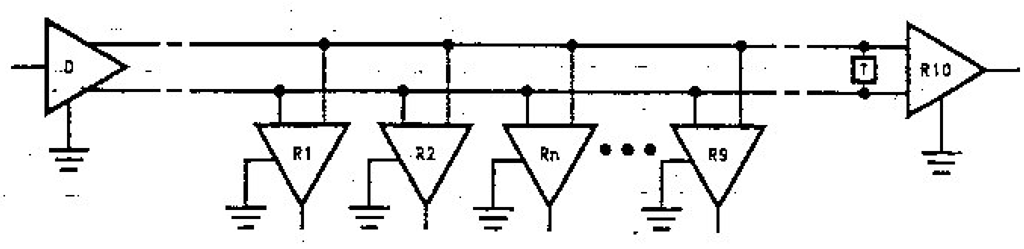
RS422 Standard

- Bus topology
- 1 driver/32 receiver per channel
- Balanced mode of operation
- Max 4000 feet cable length
- Max 10 Mbps data rate

•RS-422 was developed in the 1970s to improve the limitations of the RS-232 standard

•The main improvements are related to the communication speed, interference, and cable length

RS422 Connection



- A terminator is used to
    1. Reduce wave reflection
    2. Load matching

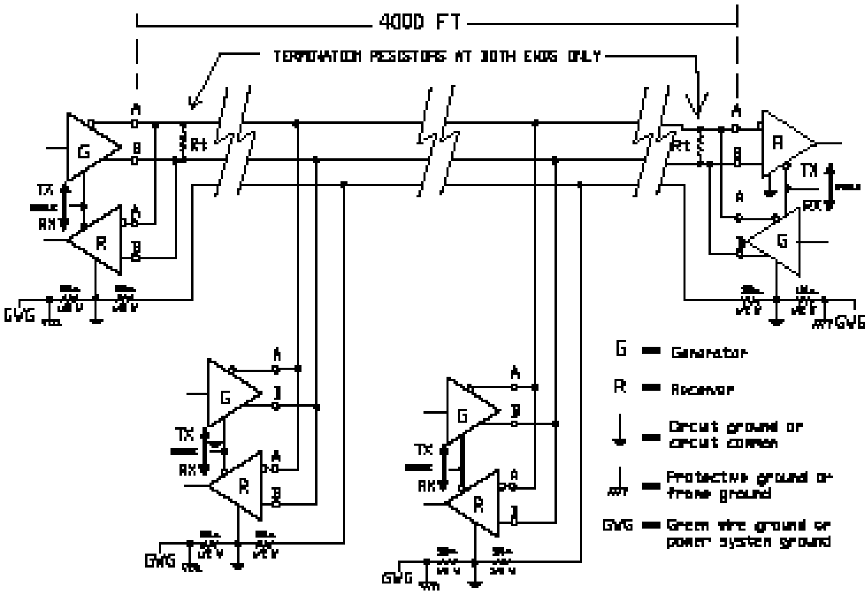
RS485 Standard

- Bus topology
- 32 driver/32 receiver per channel
- Balanced mode of operation
- Max 4000 feet cable length
- Max 10 Mbps data rate

•The RS-485 standard is widely used for automation system connections

•The significant improvement is that up to 32 (128 for some driver IC) pairs of transmitters and receivers can coexist on the RS-485 network

RS-485 Two-wire Multidrop Network

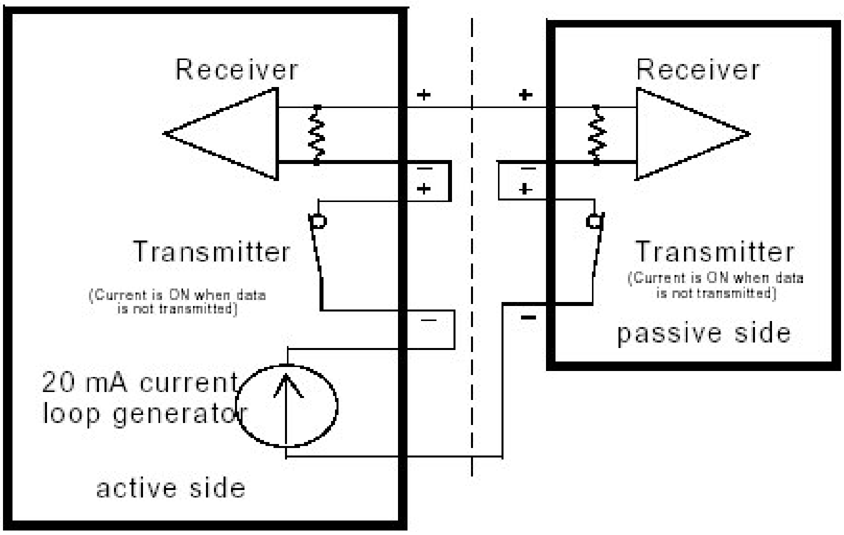


•The RS-485 serial communication is used by many direct digital controller (DDC) and automation systems.

•Low cost, high expansion and promising performance of this simple data transmission method made it a preferred choice for protocols designers, integrators, and end users.

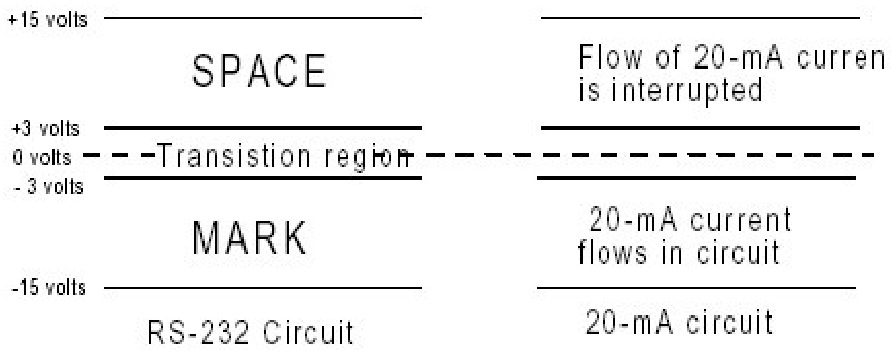
Digital 20mA Current Loop

- 2000 feet at data rates up to 19.2k baud



- Current loop interfaces were very popular throughout the 60’s, 70’s, and early 80’s because they offered the most cost effective approach to long distance, noise immune data transmission
- Suitable for distances to 2000 feet at data rates up to 19.2k baud *with careful attention to interface design*
- Current loop diminished rapidly because of EIA RS485 standard
- Fundamental elements: current source, current switch and current detector
- Transmitter is the current switch and the receiver is the current detector
- The interface with the current source is the active unit and all other units without current source is the passive units
- Principle:
  1. In idle mode, the switch is closed and 20mA current flows
  2. Only one transmitter sends data by switching the current switch on and off at a time

Signal levels comparison with RS232

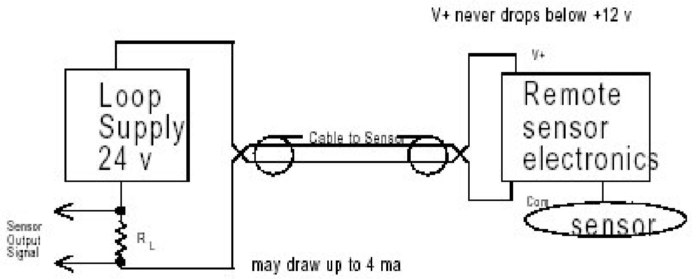


Problem of Digital 20mA Current Loop

- No mechanical or electrical standard defined for this interface
- Low connectivity

4 to 20mA Analog Current Loop

- Used to transmit the signal from an analog sensor over some distance in the form of current signal



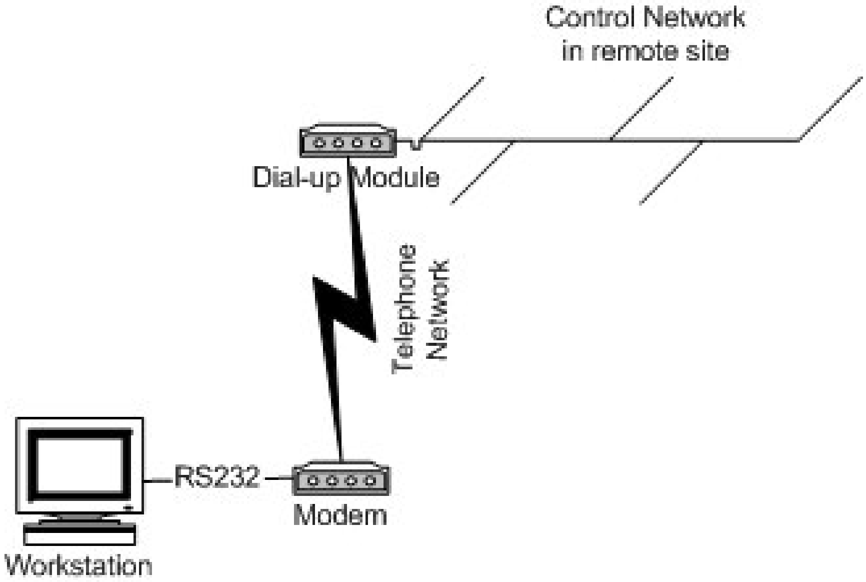
•Used to transmit the signal from an analog sensor over some distance in the form of current signal

•Only two wires and a supply power are required

•The remote sensor regulates the loop current such that the loop current represents the value of the parameter being measured by the sensor

•A series resistor at loop power supply converts the current to a voltage that is used by processor

Dial-up Access



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•Make use of Public Switched Telephone Network (PSTN) or dedicated line (lease line) to implement remote monitoring and control