

Teknik Antarmuka Komputer

#3 Antarmuka Komunikasi Serial

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Tujuan Kuliah

Setelah mengikuti perkuliahan ini, mahasiswa dapat:

1. Memahami pertimbangan pemilihan jenis komunikasi serial
2. Menjelaskan mekanisme pengiriman data secara serial
3. Mengetahui jenis-jenis protokol komunikasi serial
4. Memahami antarmuka komunikasi serial
5. Merancang dan menganalisis teknik antarmuka serial

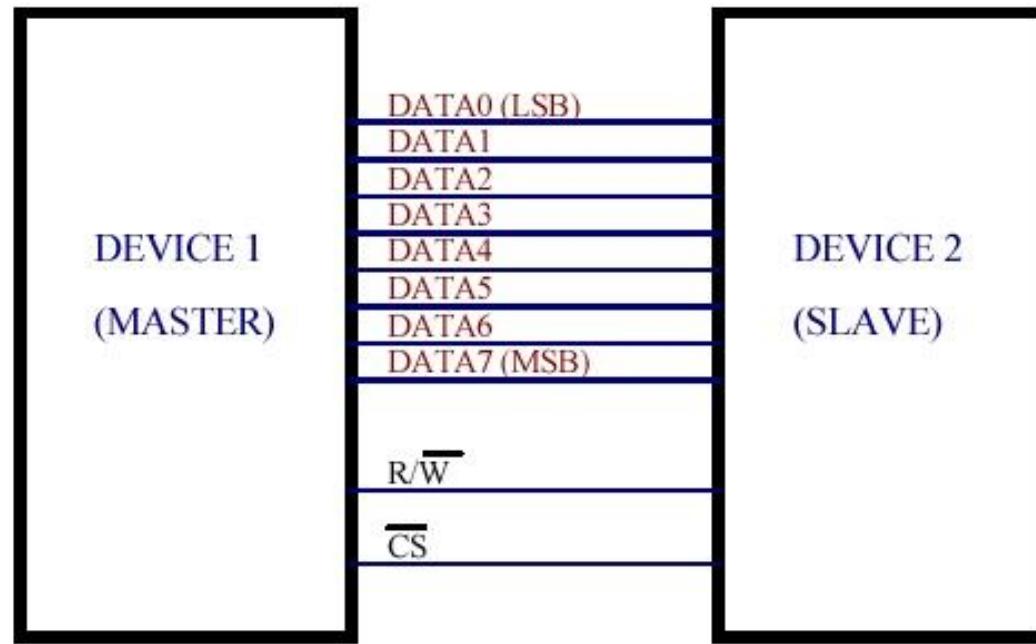
Outline Materi

- Pertimbangan Sistem Komunikasi Serial
- Parameter Komunikasi Serial
- Jenis Komunikasi Serial
- Komunikasi Asinkron/ Sinkron
- Teknik antarmuka serial
- Teknik pemrograman serial
- Aplikasi antarmuka serial
- Pengembangan antarmuka

Transmisi Paralel vs Serial

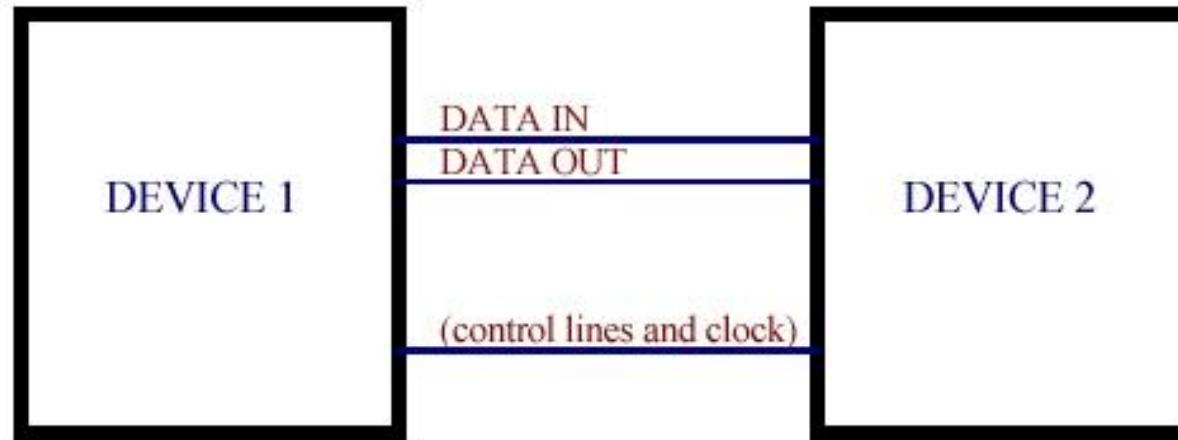
- Dua jenis komunikasi yang sering digunakan saat ini:
 - Transmisi Paralel (Banyak jalur)
 1. Data dikiring setiap satu pulsa clock (cepat)
 2. Biasanya digunakan untuk jarak dekat:
 - Bulky mahal (banyak jalur I/O).
 - Rentan terhadap refleksi dan dapat terinduksi oleh *noise*.
 - Banyaknya devais I/O tidak memiliki data rate yang cukup tinggi untuk mendukung transfer data secara parallel.
 - Serial
 1. Serial dengan pengiriman setiap bit (lambat)
 2. Setiap bit memerlukan satu pulsa clock
 3. Secara umum digunakan untuk jarak jauh
 4. Murah

Antarmuka Paralel



- Jalur data memungkinkan satu arah atau dua arah
- Lebar bus data biasanya ukuran **byte** (8 data bit).
- Sebuah byte penuh data ditransfer pada masing R/W siklus clock cycle.
- *Chip Select* (CS) memungkinkan beberapa perangkat untuk berbagi bus.

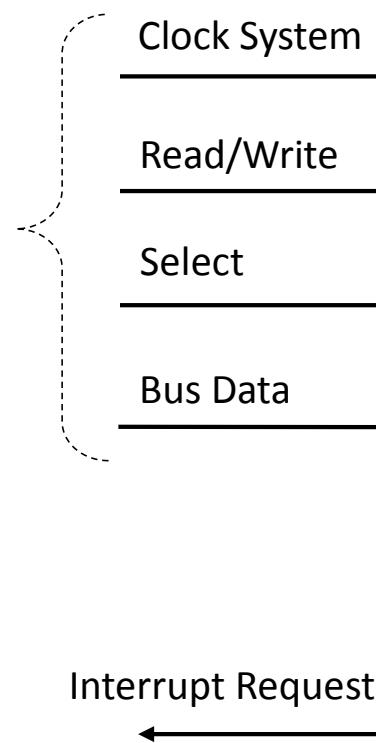
Antarmuka Serial



- Satu bit data ditransfer setiap satu pulsa clock (lambat tapi fleksibel).
- Serial Asinkron dapat diimplementasikan dengan jalur data saja.
 - Masing masing perangkat membangkitkan clock clock sendiri² (Baud Rate Generator).
 - Jalur handshaking dapat digunakan untuk status sinyal devais.
- Antarmukan serial sinkron memiliki jalur *clock* tersendiri.
 - Sinyal *Clock* dibangkitkan oleh devais master.

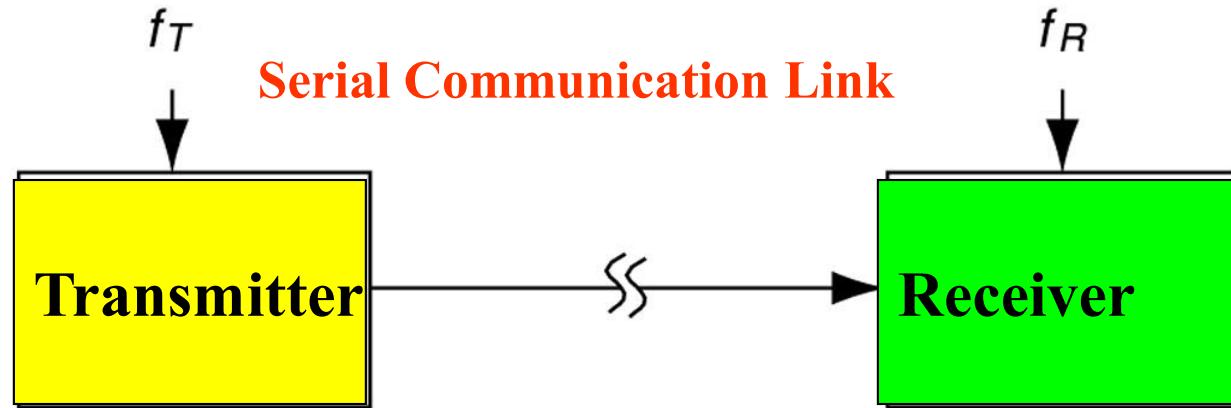
Tipical Stuktur Port I/O Serial

Antarmuka
sistem bus



- Port merupakan antarmuka bus dimana mikroprosesor mampu:
 1. Mengirim perintah ke port.
 2. Membaca status port
 3. Mengakses register data input/output port.
- Apa yang membedakan port ini dari struktur umum port I/O adalah konversi yang terjadi pada aliran (*stream*) data serial dan paralel.

Mekanisme I/O Serial



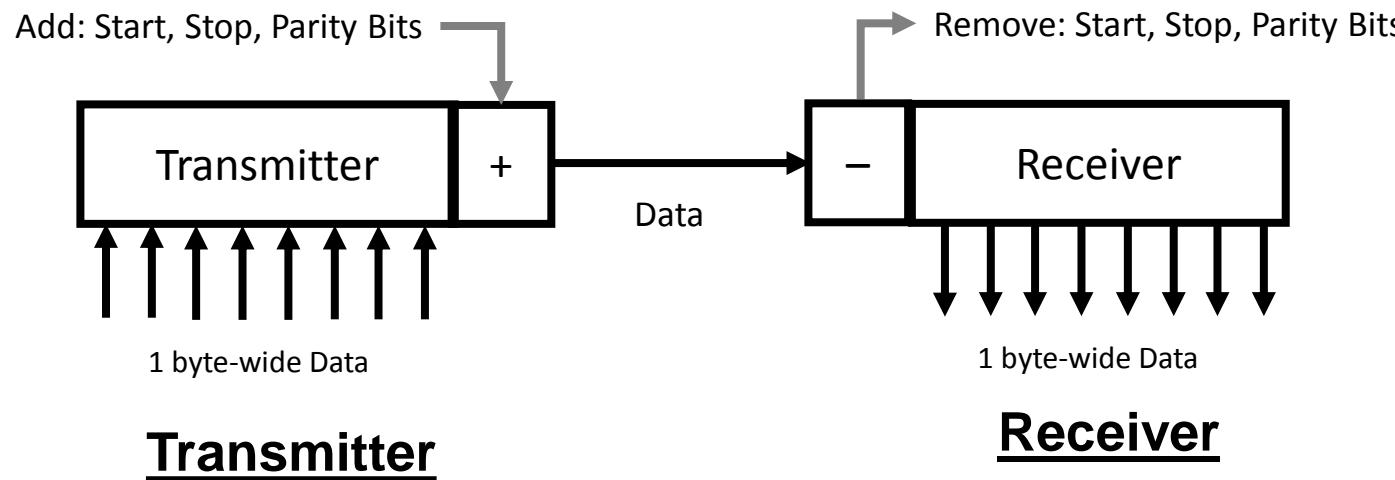
- Transmitter mengencode sinyal data data untuk dikirim ke receiver.
 - Timing sinyal data disasarkan pada clock f_T transmitter
- Receiver mencuplik sinyal serial signal untuk mendecode data.
 - Timing receiver sampling didasarkan pada clock f_R receiver
- Untuk menangkap setiap bit data, timing sampling receiver harus disinkronisasikan terhadap sinyal yang dikirim oleh transmitter.
 - Berdasarkan Teknik Sinkronisasi: (a) Sinkron (b) Asinkron

Sub Sistem Serial

- MCU memiliki dua sub sistem untuk antarmuka serial
 - I. Protokol komunikasi serial Asinkron :
 - ❑ Serial communication interface (SCI) dapat digunakan untuk menghubungkan terminal atau PC ke mikrokontroler.
 - II. Protokol Komunikasi Serial Sinkron:
 - ❑ Serial Peripheral Interface (**SPI**) dapat menyediakan komunikasi serial kecepatan tinggi terhadap perangkat atau to peripherals or other microcontroller units unit microcontroller lain.
 - ❑ Sistem ini diperkenalkan oleh Motorola untuk memfasilitasi mekanisme pengiriman data antara mikrokontroler dengan devais lain.
 - ❑ Protokol Sejenis: **I²C (Philips)**, Micro-wire (National Semi)

Komunikasi Serial Asinkron

- Pada Komunikasi Asinkron, transmitter dan receiver Tidak menggunakan clock bersama



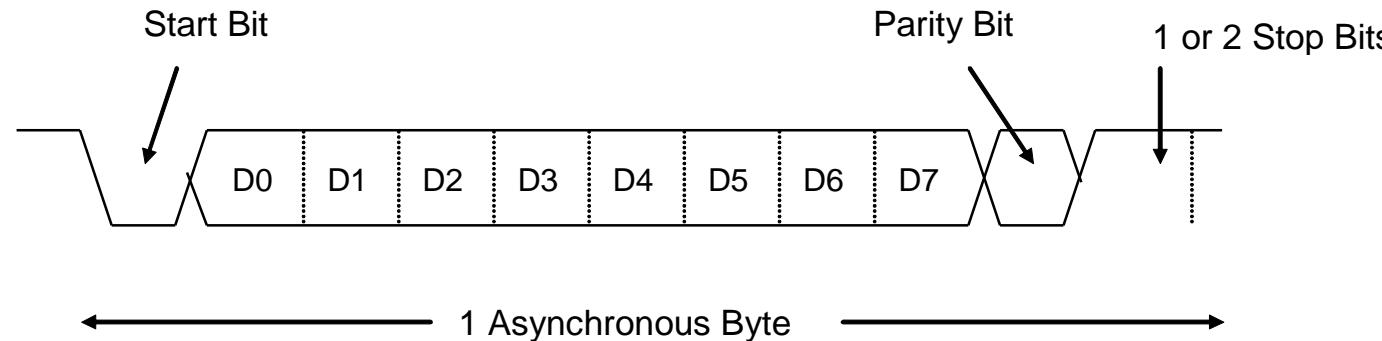
- ◆ Menggesert data data parallel ke jalur serial menggunakan clock-nya sendiri (internal)
- ◆ Menambahkan **start, stop** dan bit cek paritas

- ◆ Mengekstrak data menggunakan clock-nya sendiri (internal)
- ◆ Mengkonversi kembali data serial ke bentuk parallel setelah pemisahan **start, stop** dan **bit paritas**

Komunikasi Serial Asinkron

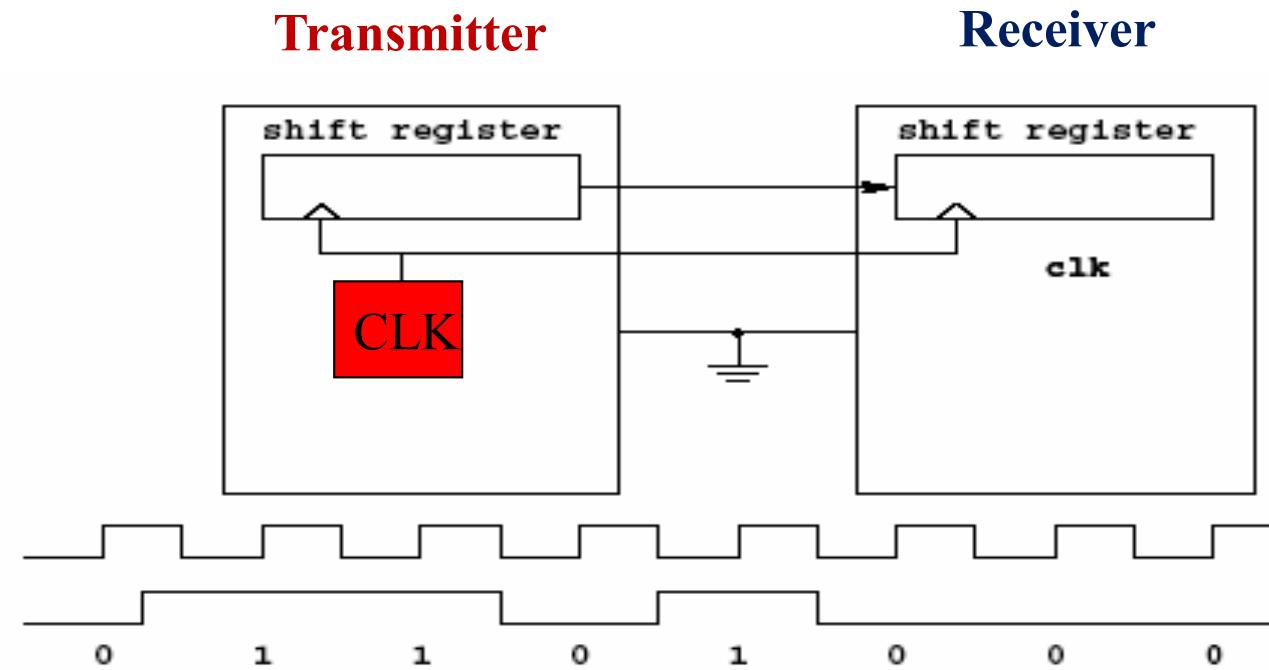
- ◆ Start bit → menandai awal dari data word
 - ◆ Stop → menandai akhir dari data word
 - ◆ Parity bit → ditambahkan untuk deteksi kesalahan (*opsional*)
 - ◆ Data bits → data aktual yang ditransmisikan
 - ◆ Baud rate → bit rate dari serial port (kecepatan transfer)
-
- **Throughput** → data aktual yang ditransmisikan per detik
(bit total yang ditransmisikan → overhead)
 - Contoh: 115200 baud = 115200 bits/sec
 - Jika menggunakan 8-bit data, 1 start, 1 stop, dan tanpa bit paritas,
throughput efektif: $115200 * 8 / 10 = 92160$ bits/sec

Komunikasi Serial Asinkron



- ◆ Transmisi asinkron mudah diimplementasikan namun memiliki efisiensi yang rendah → mensyaratkan 2 hingga 3 bit tambahan untuk setiap data 8 bit.
- ◆ Metode ini biasanya digunakan untuk transmisi volume data yang kecil.

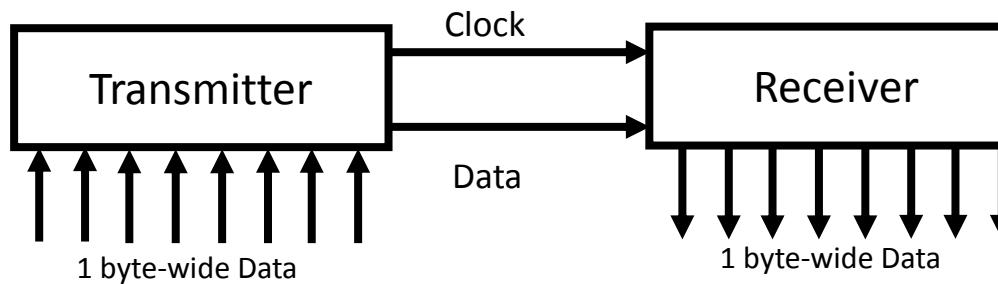
Komunikasi Serial Sinkron



- Sistem komunikasi sinkron **selalu mengirim sinyal clock** dengan data untuk mensinkronkan receiver untuk setiap waktu.
- Clock disediakan sebagai sinyal **clock tersendiri** atau dapat **dipadukan dengan sinyal data** itu sendiri.

Komunikasi Serial Sinkron

- ◆ Pada mode **sinkron**, transmitter dan receiver menggunakan clock bersama (sharing)
- ◆ Transmitter biasanya menyediakan sinyal clock tambahan yang terpisah dari data serial.



Transmitter

- ◆ Menggeser data paralel menuju jalur serial menggunakan *clocknya*.
- ◆ Menyediakan clock sebagai sinyal terpisah
- ◆ Tanpa start, stop, atau bit paritas tambahan

The Receiver

- ◆ Mengekstrak data menggunakan clock yang disediakan oleh transmitter
- ◆ Mengkonversi kembali data serial menjadi bentuk paralel.

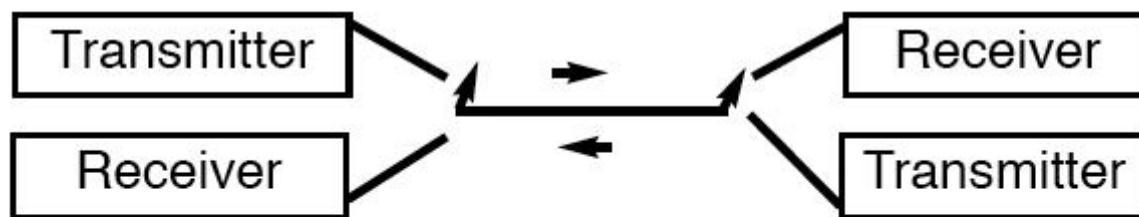
Berdasarkan Mode Operasi Kanal

Simplex



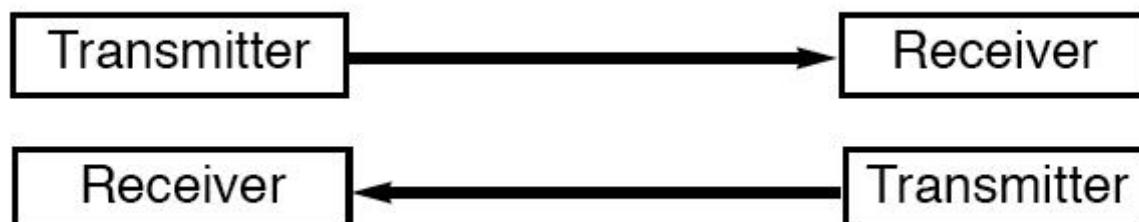
- Transmisi satu arah
- Biasanya disebut **receive only transmission**.
- Contoh: TV, Radio, PC → Printer

Half Duplex



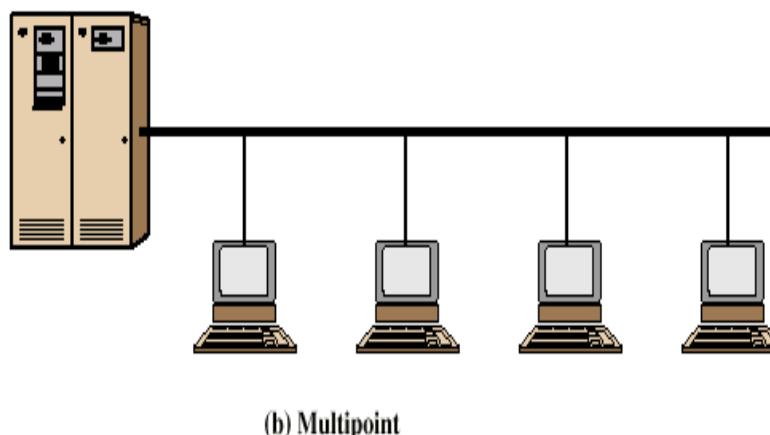
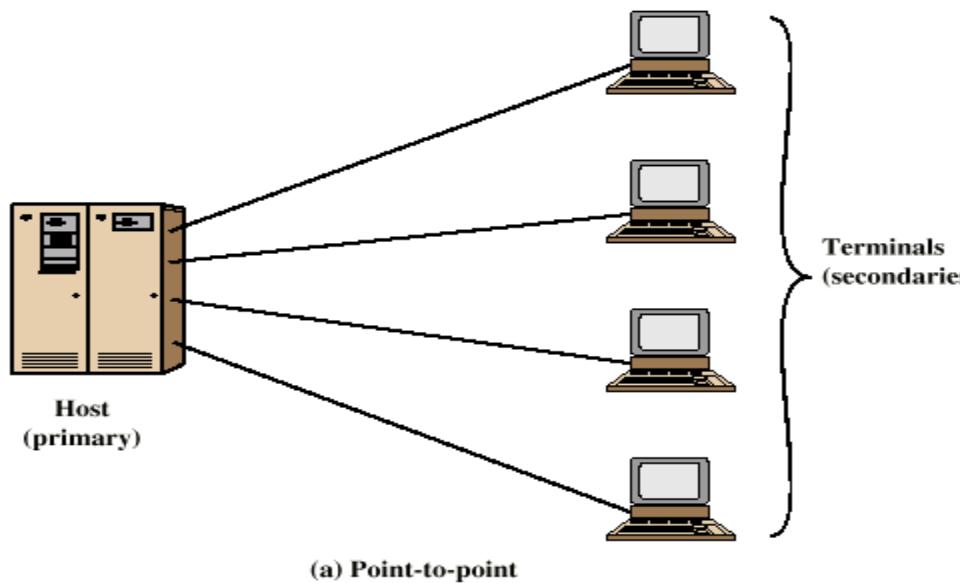
- Transmisi dimungkinkan dua arah, namun tidak dalam waktu yang bersamaan.
- Komunikasi manusia adalah half-duplex.
- contoh: Beberapa komputer terhubung bersama-sama

Full Duplex



- Full Duplex mengijinkan informasi (data) untuk ditransfer secara simultan secara dua arah dalam waktu bersamaan.
- Contoh: Telephone Standard .

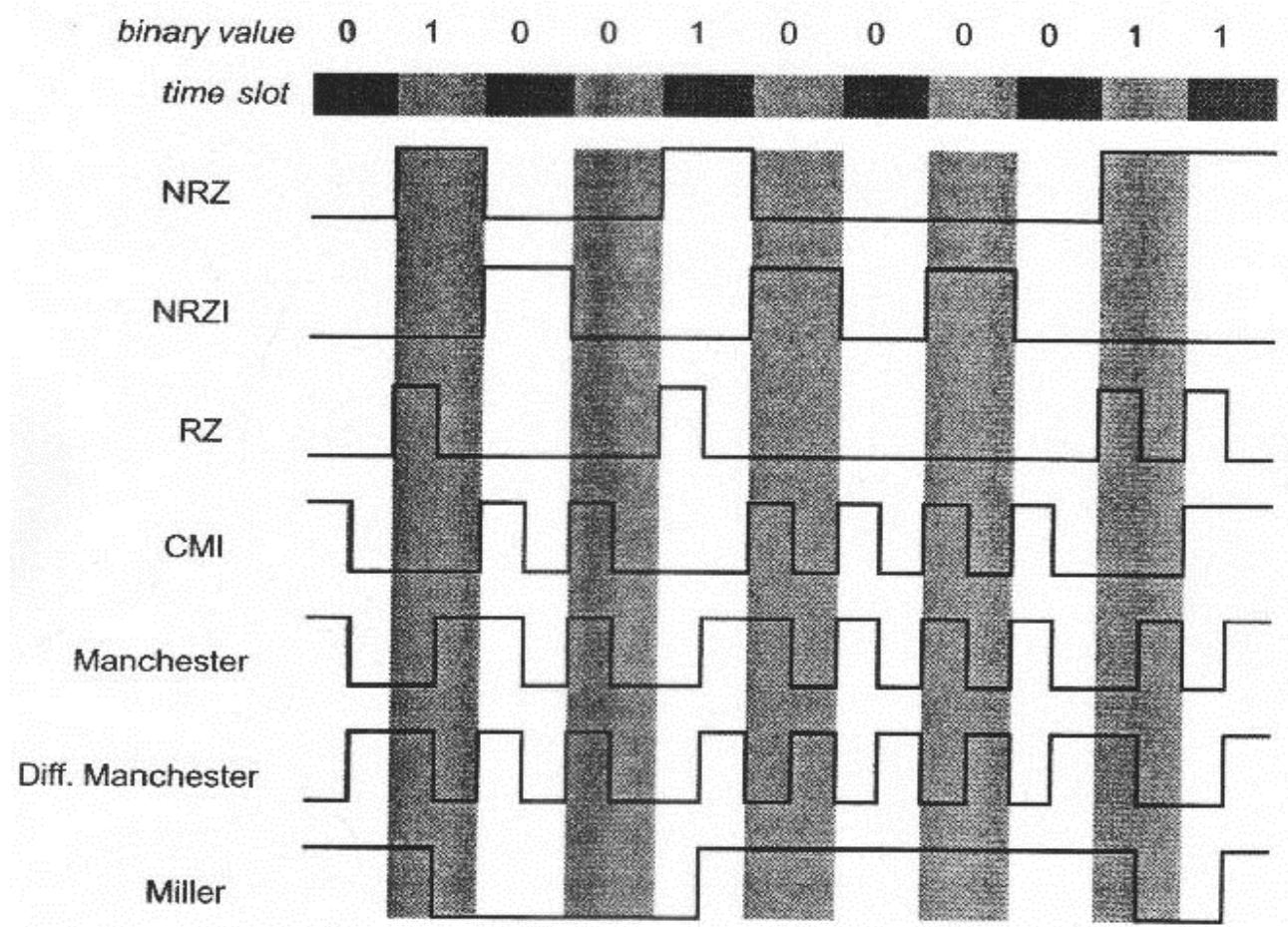
Konfigurasi Tradisional



- Host communicates with the terminals using a dedicated link.
- Terminals can communicate with each other via host only.

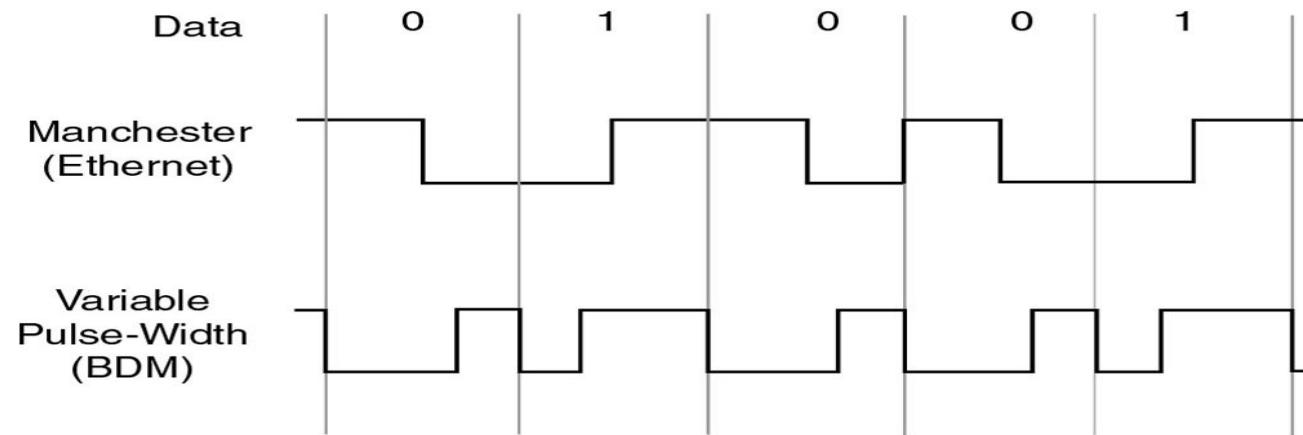
- Host communicates with the terminals using a shared connection.
 - Terminals have to identify if data is intended to them (address)
- **Other Topologies?**
 - Star, Mesh, Ring

Prinsip Kode Biner Serial



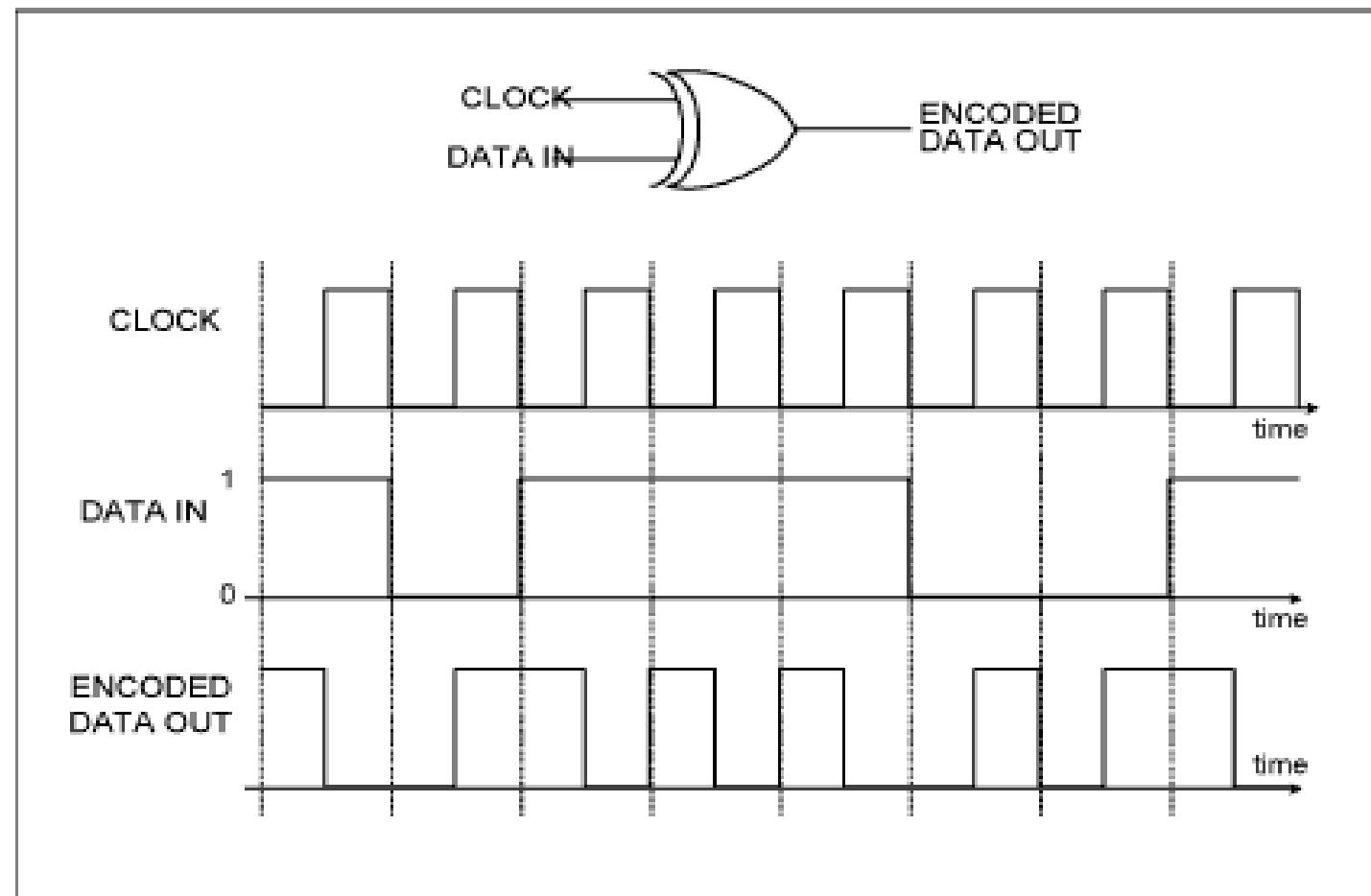
- Beberapa cara untuk identifikasi data (ex: menandai *mark* (1) dan *spaces* (0)).
 1. NRZ
 2. NRZI
 3. RZ
 4. CMI (*Code Mark Inversion*)
 5. Manchester
 6. Diff Manchester
- Teknik ini disebut dengan **Tipe coding** atau format modulasi.

Komunikasi Serial Sinkron

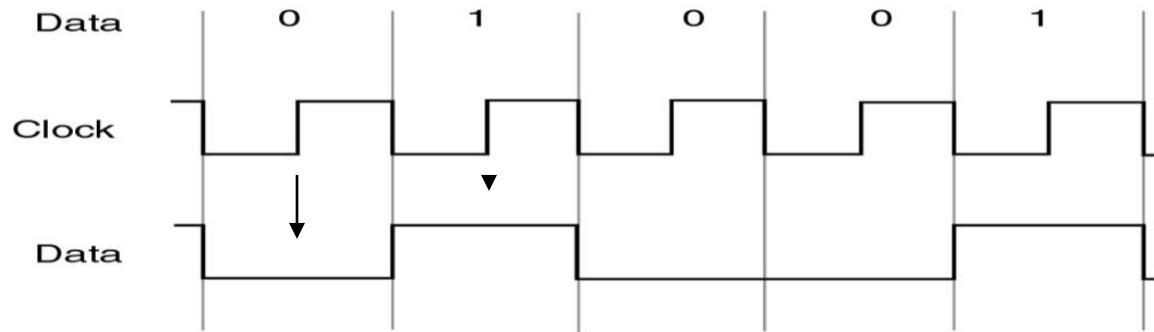


- Clock dapat disediakan terpisah atau dipadukan dengan data.
 - Dua cara yang umum untuk memadukan clock ke dalam sinyal data dapat digunakan : (i) Manchester atau (ii) sinyal lebar pulsa variable.
 - Catatan: **Sinyal Berubah pada pertengahan** setiap bit → digunakan oleh receiver untuk sinkronisasi proses sampling.

Encoding Data “Manchester”

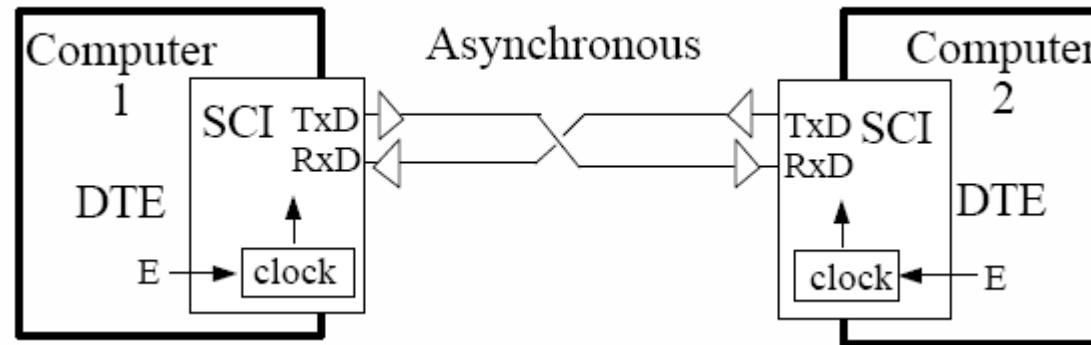


Serial Sinkron: Pemisahan sinyal Clock



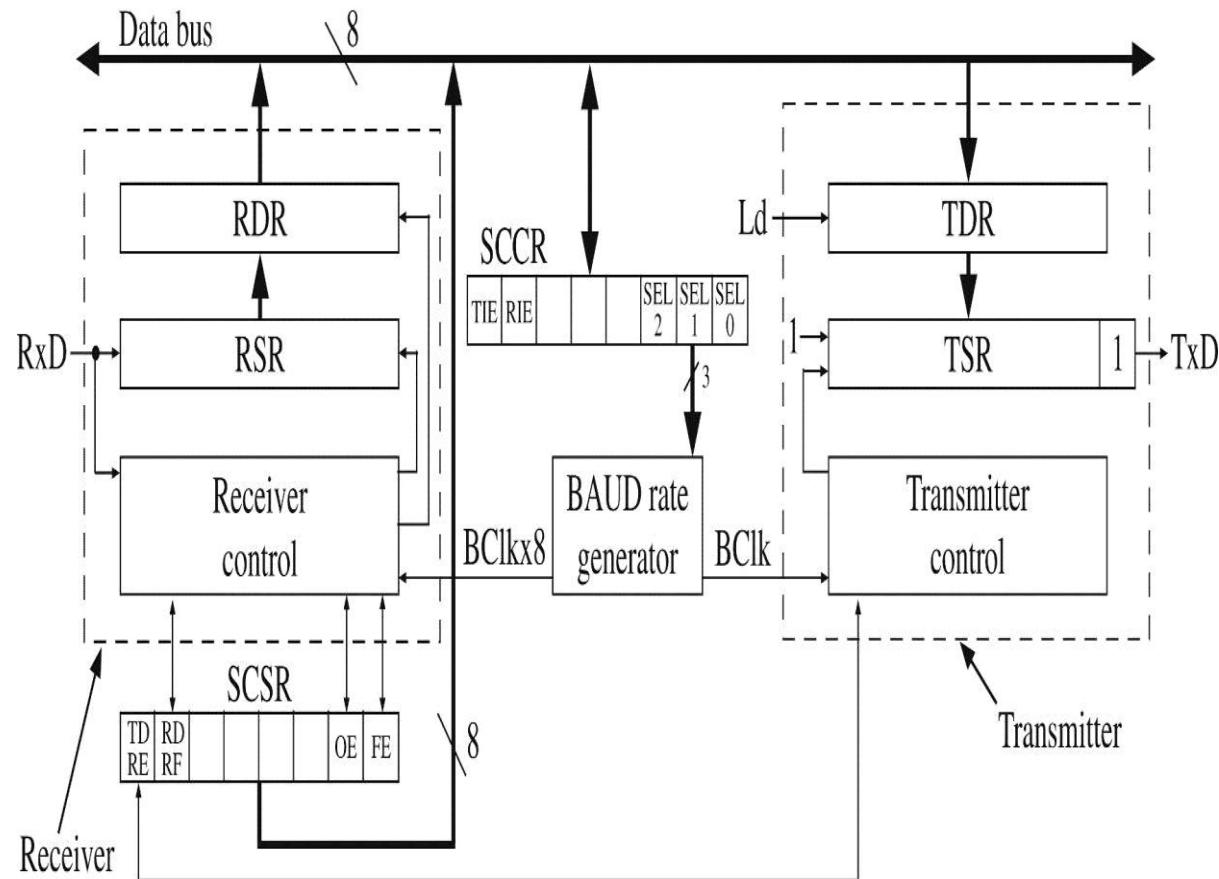
- Other synchronous serial communication systems send the synchronization clock as a separate clock signal.
 - The clock's rising edge always falls in the center of the data bit time.
 - Examples: Motorola SPI, Phillips I²C, National MicroWire.
- The advantage of using a separate clock:
 1. Circuit Simplicity (rising edge triggered shift register)
 2. Data rate does not have to be fixed
- The disadvantage?
 1. A Separate clock signal is required (long distance, expensive, reliability!)

Serial Komunikasi Asinkron



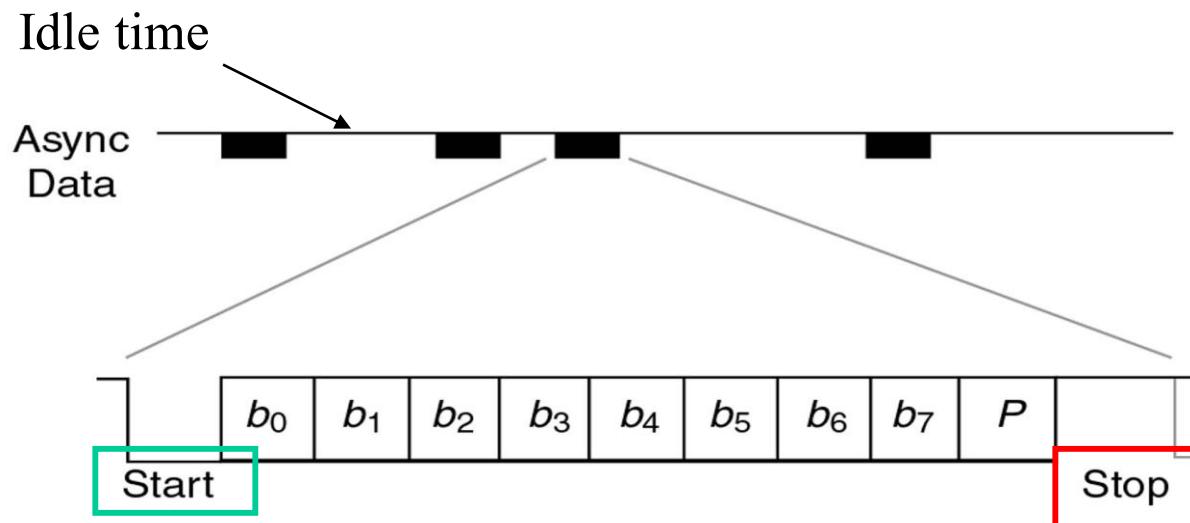
- Each device uses its *own clock*.
 - The *clocks must run at the same rate* but do not need to be synchronized.
 - The receiver clock must be *within 4%* of the transmitter clock.

UART : Universal Asynchronous Receiver Transmitter



- The UART is the interface chip that implements serial data transmission.
- Also known as (ACIA) asynchronous communication interface adapter.
- If you need more serial ports you would use an UART to interface with your MCU.
- Six major components:
 1. Chip select & read/write cont
 2. Data bus buffers
 3. Transmit data Register
 4. Receive data Register
 5. Status Register
 6. Control Register

Frame Data Asinkron

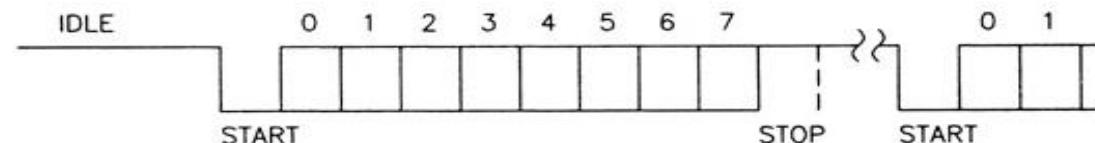


- The **basic unit of information** is the character or data frame
 - A **Frame** is a complete and non divisible packet of bits.
 - It includes both information (data) and overhead (extra bits)
- Synchronization is achieved using Start-Stop bits.
 - i.e. the receiver needs to know when a character starts and when it stops => character is framed by **start** and **stop** bits

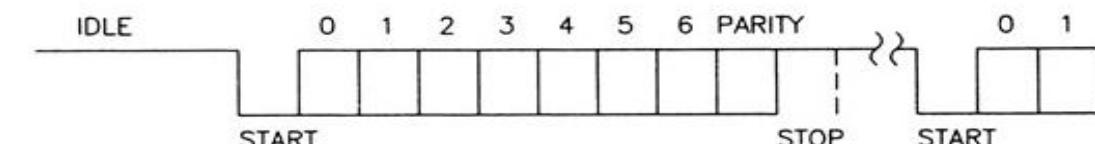
Start and Stop Framing. Parity

- **The transmitter** can send characters at any rate, so there may be delays between the transmission of each character
- **The receiver** detects the falling edge of the start bit and then attempts to sample in the center of each bit time.
- **Parity** is used to detect single bit errors
 - type: even or odd
 - the quantity of 1 bits in the data determine the parity bit
- **The receiver also needs to know** (i) number of data bits in each character, (ii) type of parity used if any, (iii) number of stop bits.

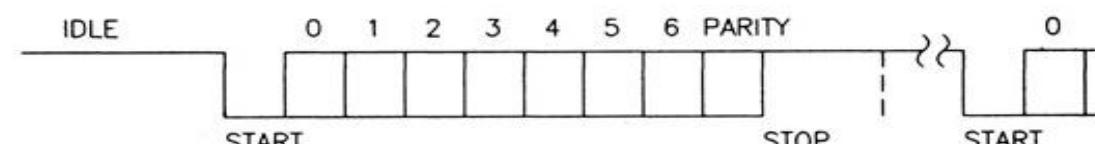
Start, Stop and Parity Bits



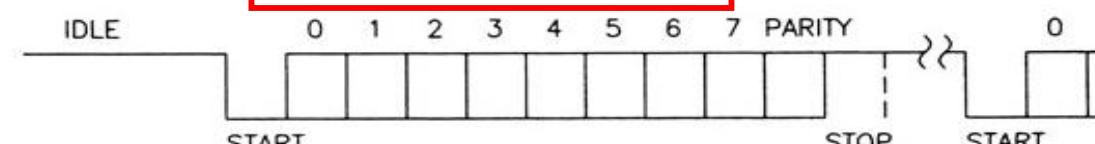
(a) 8 Bits + 1 Stop Bit



(b) 7 Bits + Parity + 1 Stop Bit



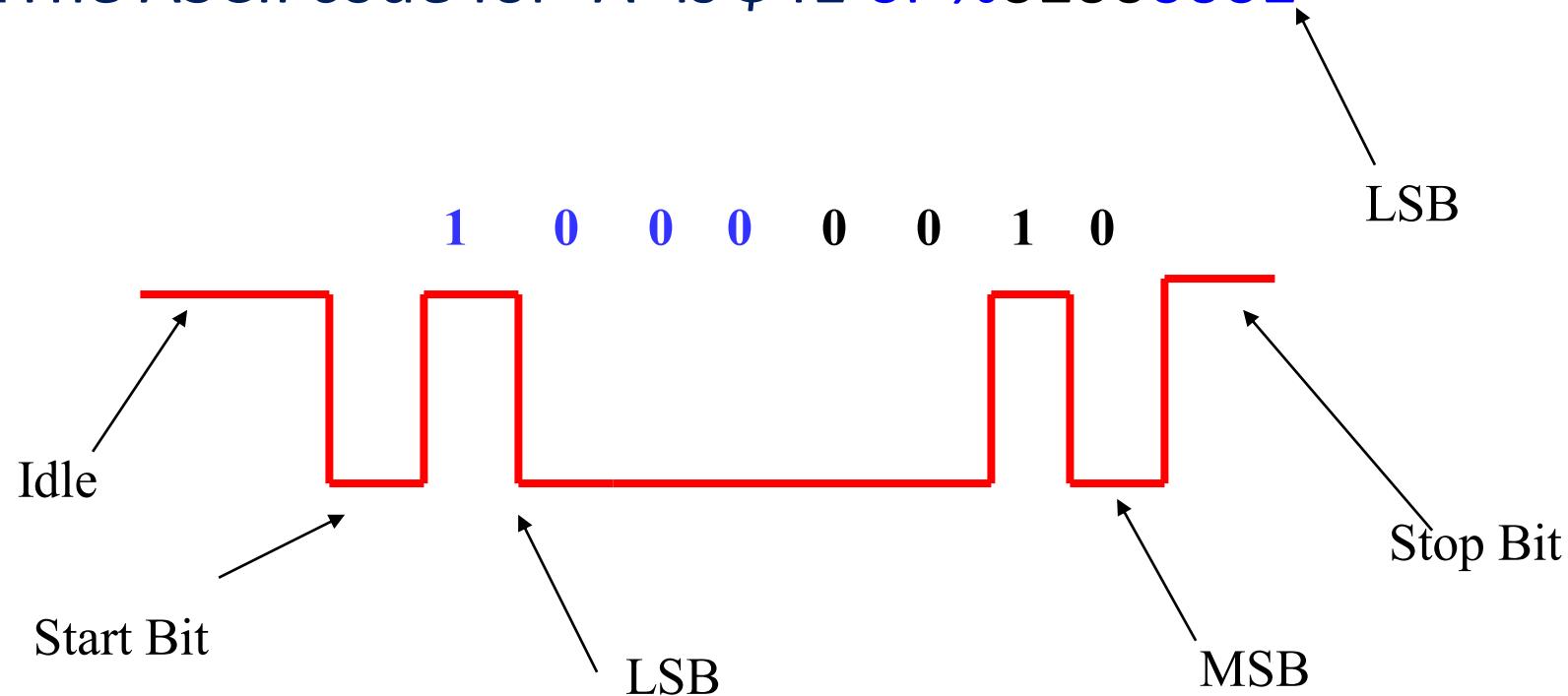
(c) 7 Bits + Parity + 2 Stop Bits



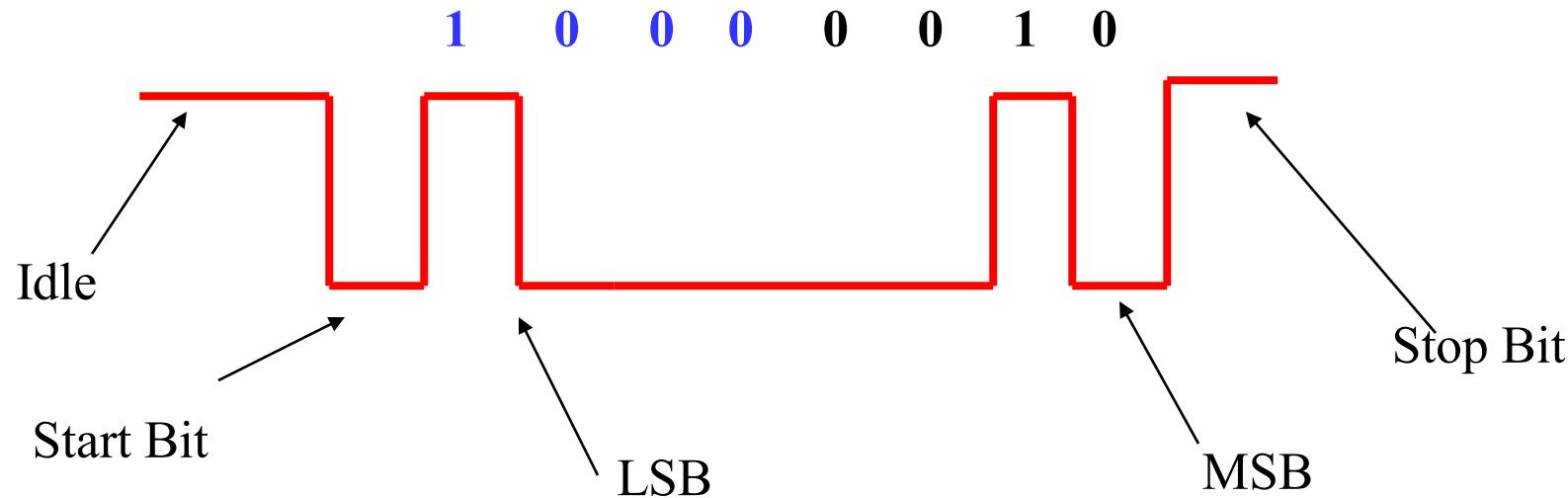
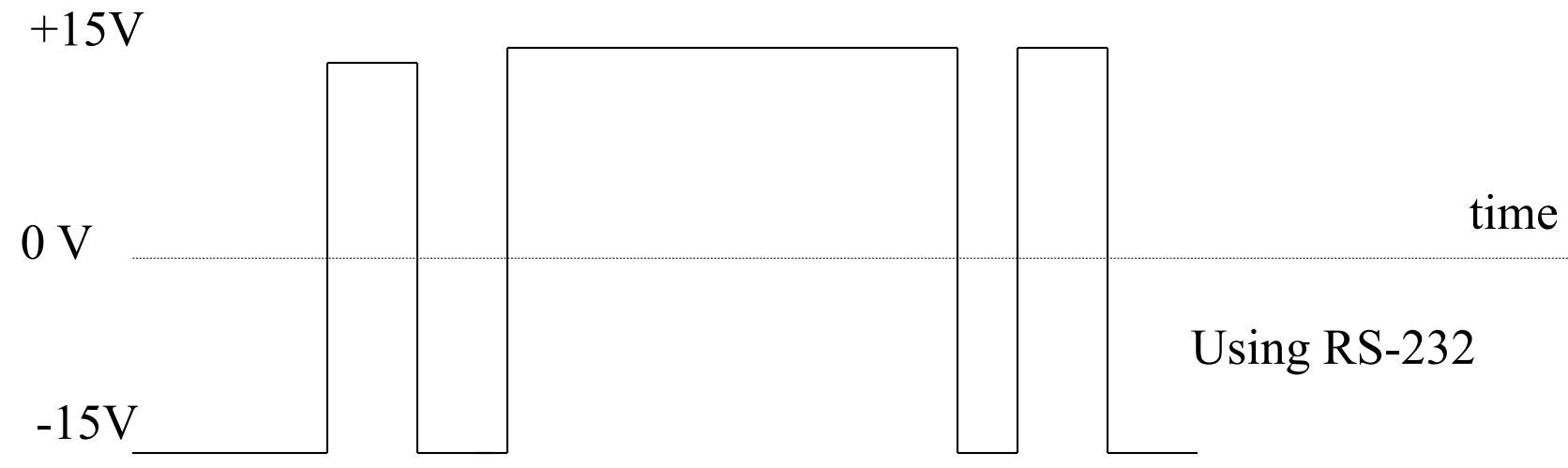
(d) 8 Bits + Parity + 1 Stop Bit

Contoh

- The letter 'A' is to be transmitted in the format with (i) 8 data bits (ii) no parity (iii) one stop bit Sketch the output
 - The ASCII code for 'A` is \$41 or %01000001

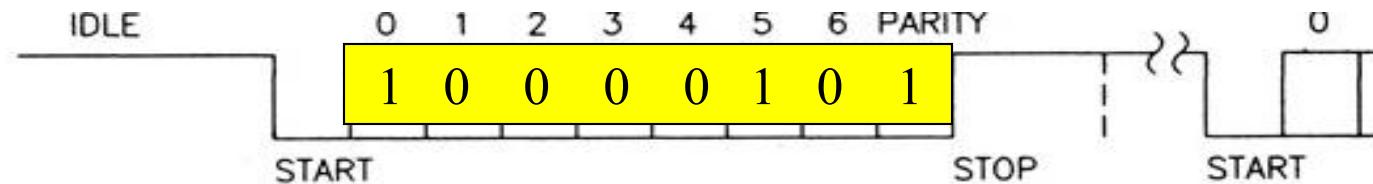


Contoh: menggunakan RS232



Contoh

- Show the framing bits when the char B (21_{16}) is sent at 7 data bits, 2 stop bits, odd parity:
- Solution:
 1. start bit: 0
 2. data bits: 0100001
 3. parity bit: 1
 4. stop bits: 11



Data Speed dan Baud

- ***Two units of speed are employed in data transmission.***
 1. # of data bits transmitted per second (BPS)
 2. Baud : the rate at which the signal changes
- For a binary two-level signal, a data rate of one bit per second is equivalent to one Baud.
 - if a data transmission system uses signals with 16 possible discrete level, each signal can have $16 = 2^4$ different values (i.e., signal element encodes 4 bits)
 - Example: If the 16-level signals are transmitted at 1,200 Baud, the data rate is $4 \times 1,200 = 4,800$ bps.
- Effective BPS = (nr of data bits)/(nr of frame bits) x baud

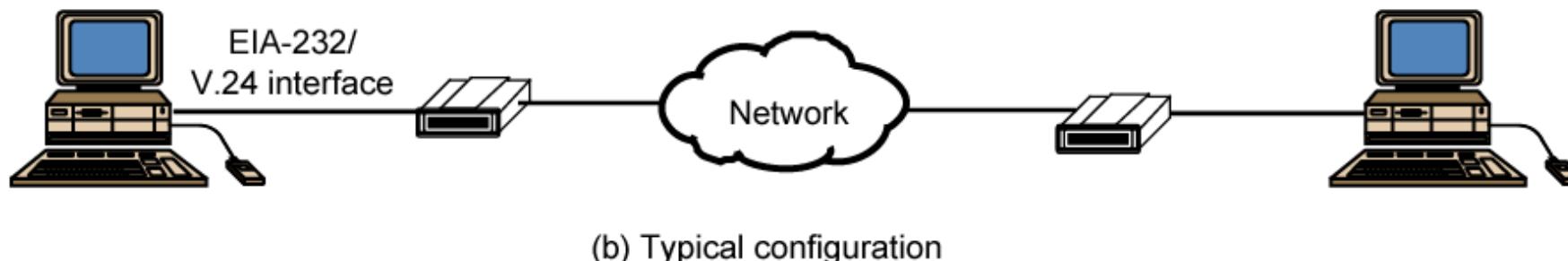
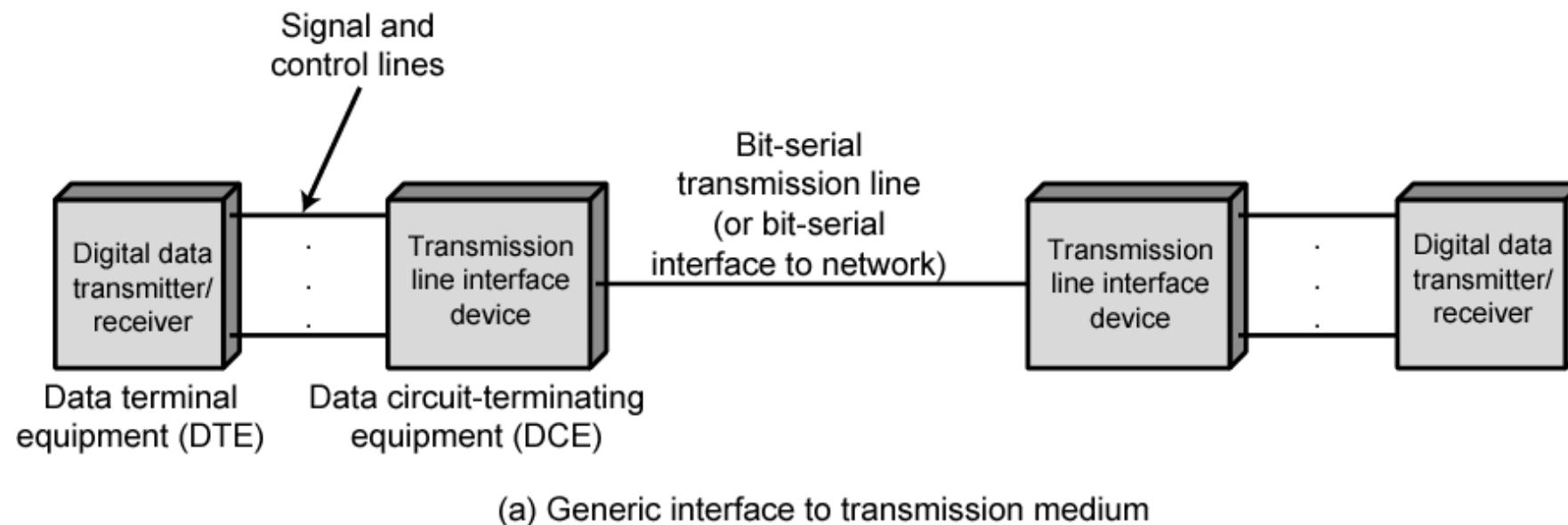
Contoh

- **How long does it take to transmit one character** at a speed of 9600 bauds? Each character is transmitted using a format of seven data bits, even parity, one stop bits.
- **Solution:**
 1. Each character consists of 10 bits (1 start, 1 stop, 1 parity, 7 data)
1. Effective Data bit rate: $7/10 \times 9600 = 6720$ Bps
 2. Each bit requires 104 us = $(1/9600)$
 3. Thus each character will require : 10×104 us = 1.04 ms

Standard RS-232

- The RS-232 standard was established in 1960 by the **Electronic Industry Association (EIA)** for interfacing between a **computer and a modem**.
 - The standard is referred to as either
 - ❖ RS-232 or
 - ❖ EIA-232
 - In data communication terms, both computers and terminals are called **data terminal equipment (DTE)**.
 - Modems and routers are called **Data Communication Equipment (DCE)**

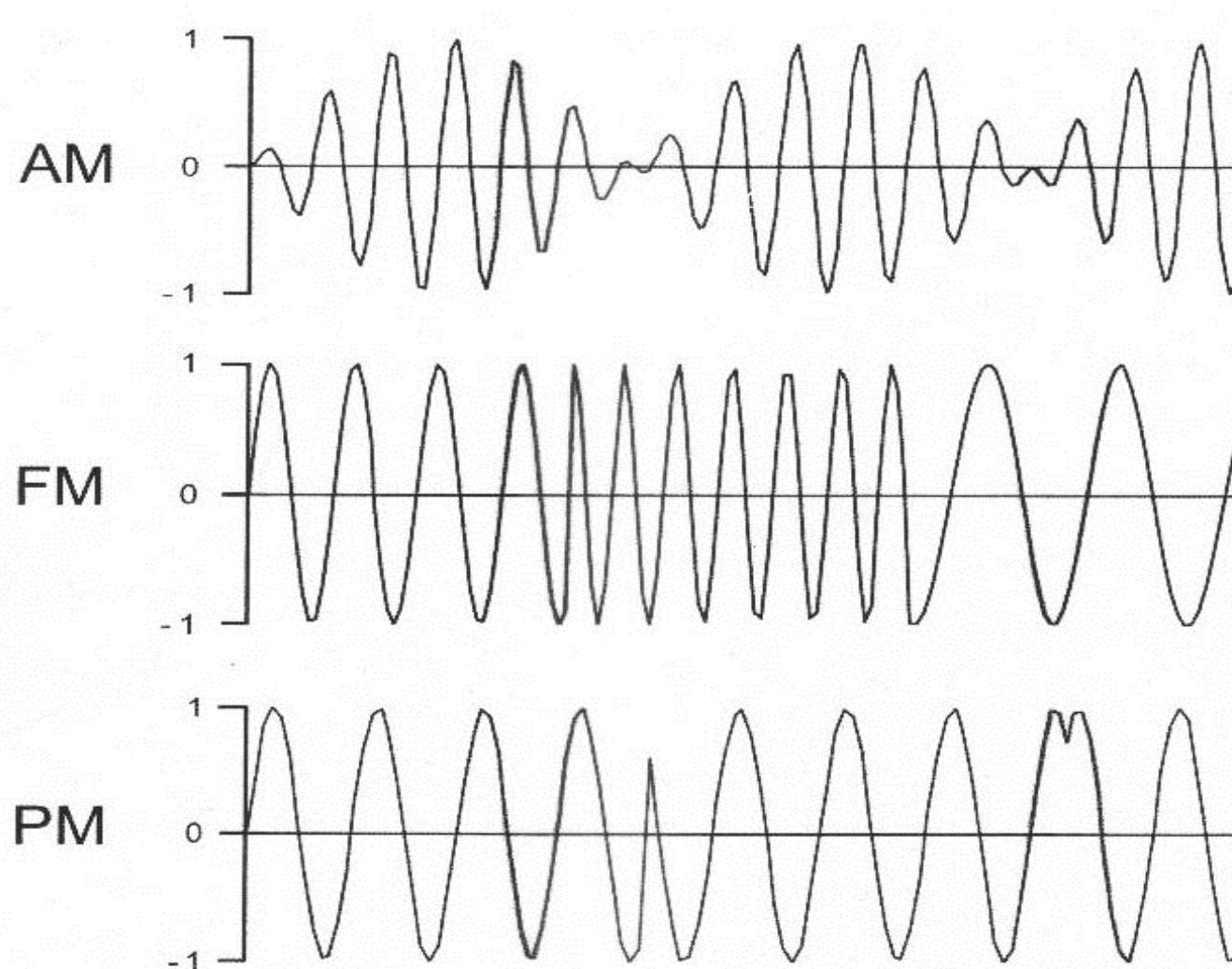
Antarmukan Komunikasi Data



MODEM

- Modems is a contraction of modulator-demodulator
- Modem is used to **send and receive serial digital data** over a telephone line
- **Basics of modems**
- Modem is connected to a serial port
 - dedicated circuit
- the serial port, the RS-232 data terminal equipment (DTE) -> connected to a modem, a data communication equipment (DCE) -> to a telephone line
- Transmission ...
- Receiving ...
- The audio signal is known as the carrier signal
- Tech: PSK; DPSK; QAM

Modulasi Carrier (Analog)



Modulasi Carrier (Digital)

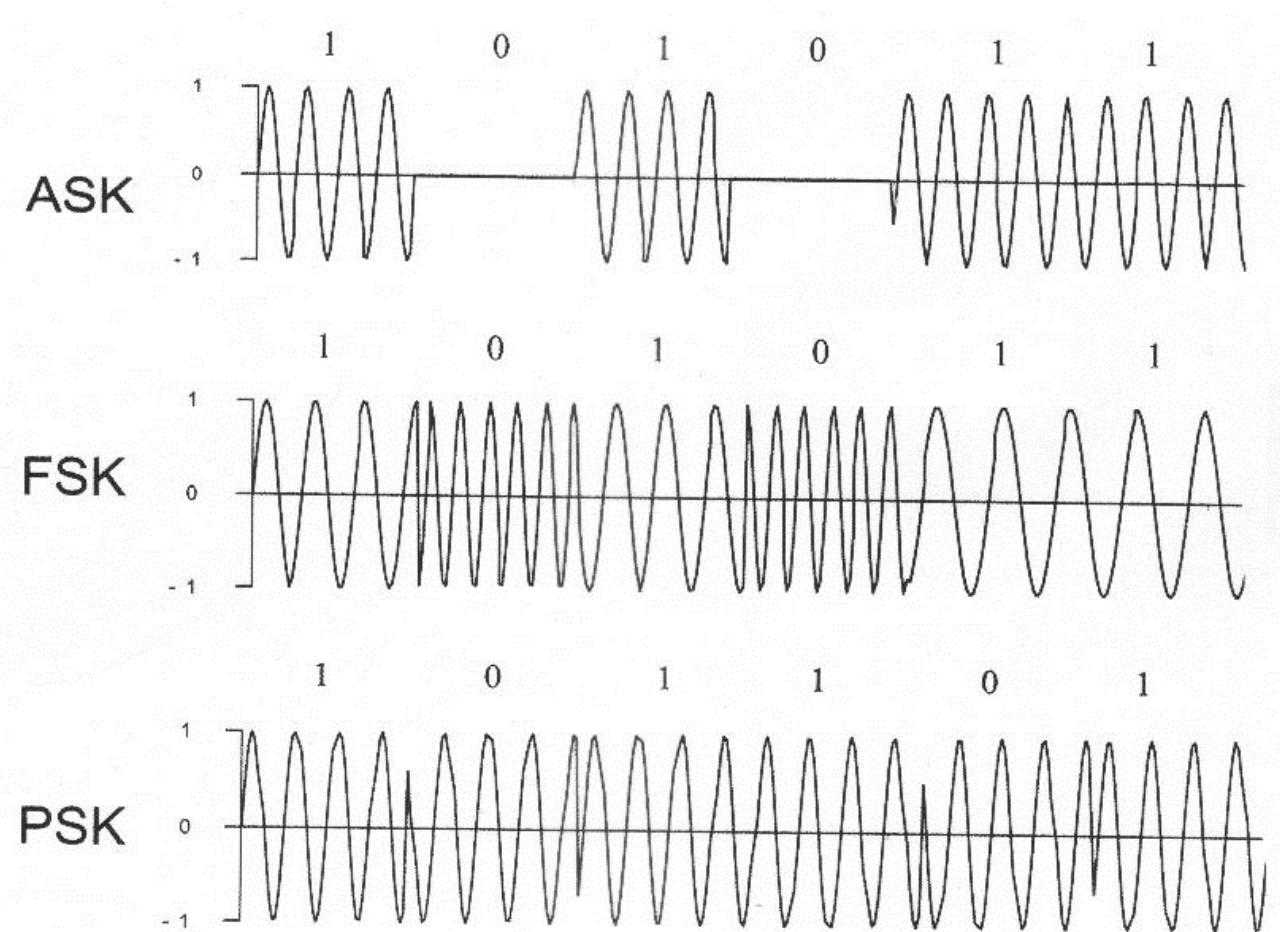
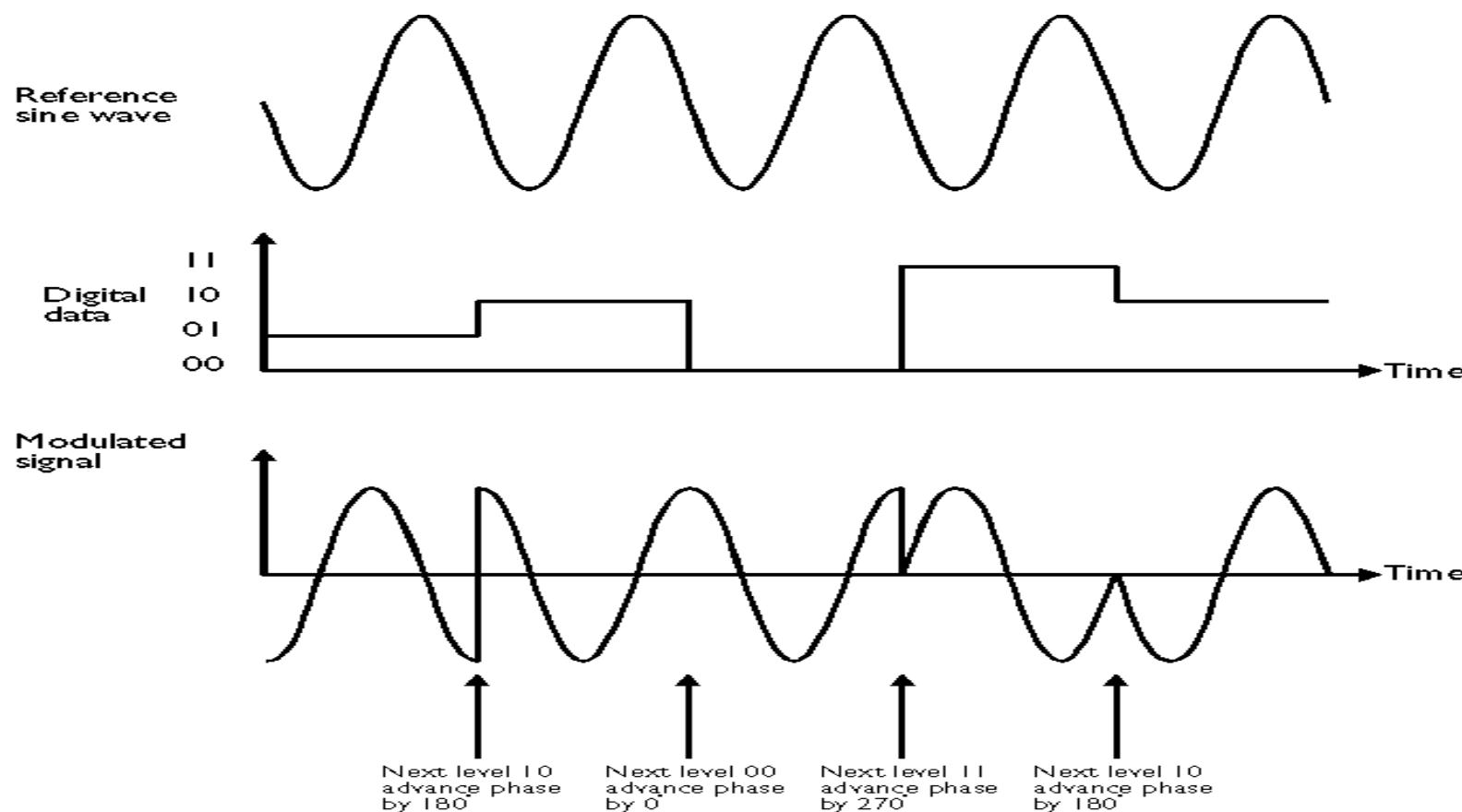


FIGURE 1.11 Three types of waveform modulation with binary coding: unipolar amplitude (ASK), frequency (FSK) and phase (PSK) shift keying.

Modulasi Fase Diferensial

- Phase is shifted by multiples of 90, therefore two bits at a time can be transmitted.



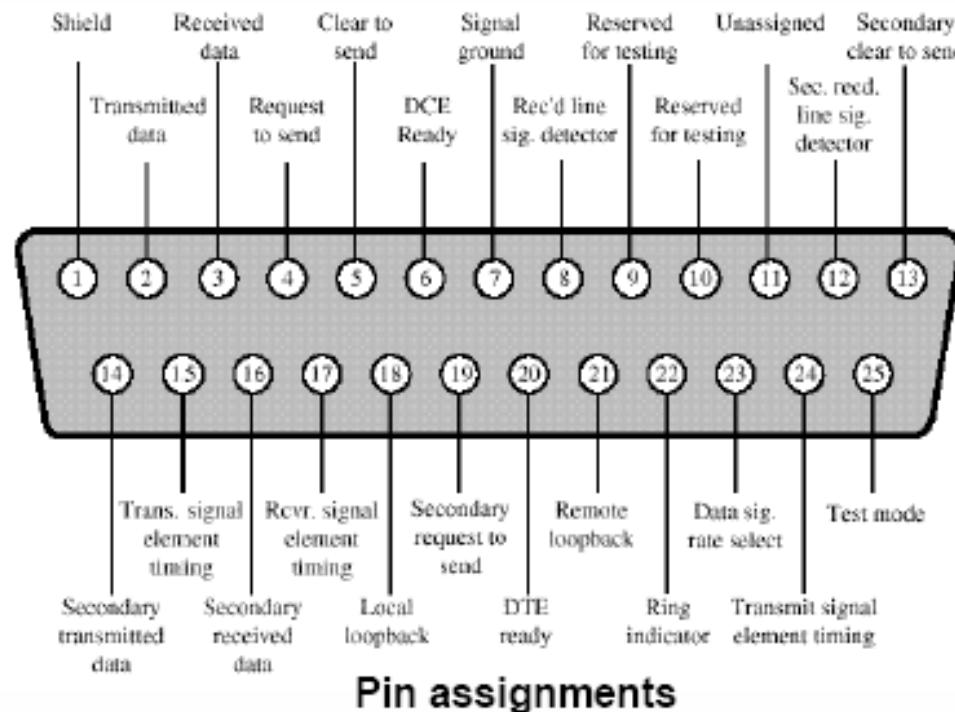
The RS-232 Standard

- There are four aspects to the EIA-232 standard
 1. **Electrical specifications** -- specifies the voltage level, data rates, distance of communication
 2. **Mechanical Specifications** – specify the number of pins and the shape and dimensions of the connectors.
 3. **Functional Specifications** – specify the function of each signal.
 4. **Procedural Specifications** – specifies the sequence of events for transmitting data

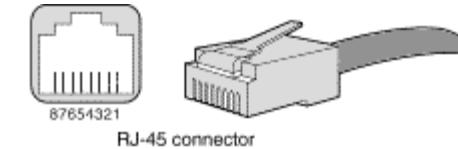
(1) The EIA-232 Electrical Specs

- The interface is rated at a signal rate less than 20 KBPS. With good design, however, we can achieve a higher data rate.
- The signal can transfer correctly within 15 meters. Greater distance can be achieved with good design.
- Driver maximum output voltage is -25V to +25V
 - A voltage more negative than **-3V** at the receiver's input is interpreted as logic one.
 - A voltage more positive than **+3V** at the receiver's input is interpreted as logic zero.

(2) The EIA-232 Mechanical Specs



V.24/RS-232 DB25 Pin Connector

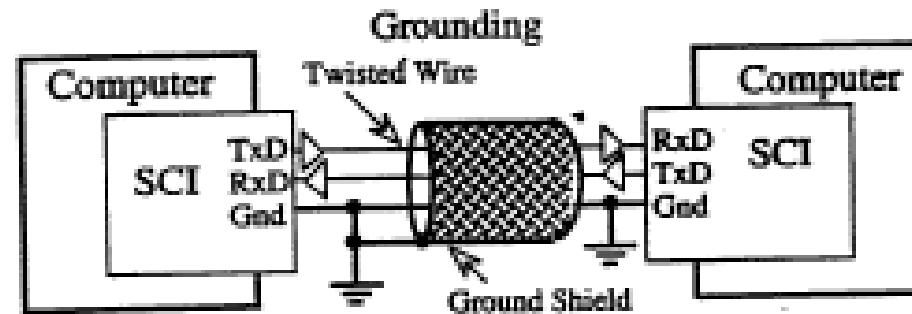


RJ45 (EIA-561) Connector



DB9 (EIA574) Connector

Mechanical: The EIA-232 Cable

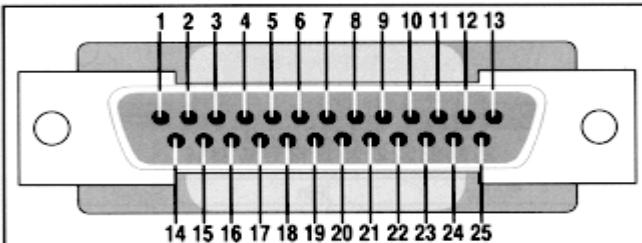


- The simplest RS232 cable uses just :
 - TXD,
 - RXD and
 - Ground with optional ground shield.
 - ❖ The shield provides protection from electric field interference.

(3) Functional Specs

RS-232 Interface

RS-232 (EIA Std.) applicable to the 25 pin interconnection of Data Terminal Equipment (DTE) and Data Communications Equipment (DCE) using serial binary data



Pin Description	EIA CKT	From DCE	To DCE
1 Frame Ground	AA		
2 Transmitted Data	BA		D (Data)
3 Received Data	BB	D	
4 Request to Send	CA		C (Control)
5 Clear to Send	CB	C	
6 Data Set Ready	CC	C	
7 Signal Gnd/Common Return	AB		
8 Rcvd. Line Signal Detector	CF	C	
11 Undefined			
12 Secondary Rcvd. Line Sig. Detector	SCF	C	
13 Secondary Clear to Send	SCB	C	
14 Secondary Transmitted Data	SBA		D
15 Transmitter Sig. Element Timing	DB	T (Timing)	
16 Secondary Received Data	SBB	D	
17 Receiver Sig. Element Timing	DD	T	
18 Undefined			
19 Secondary Request to Send	SCA		C
20 Data Terminal Ready	CD		C
21 Sig. Quality Detector	CG		C
22 Ring Indicator	CE	C	
23 Data Sig. Rate Selector (DCE)	CI	C	
23 Data Sig. Rate Selector (DTE)	CH		C
24 Transmitter Sig. Element Timing	DA		T
25 Undefined			

- I. DTR (Data Terminal Ready) (DTE)
- II. DSR (Data Set Ready) (DCE)
- III. RTS (Request to Send) (DTE)
- IV. CLS (Clear to Send) (DCE)
- V. RI (Ring Indicator) (DCE)
- VI. TX (Transmit)
- VII. RX (Receive)
- VIII.

Cont ... Functional Specs

TABLE 10.2 MODEM CONTROL SIGNALS^a

Signal name	DTE (port)	DCE (modem)	Function	Pin/EIA circuit label
RTS	Output	Input	<i>Request to send</i> tells the DCE that the DTE wishes to transmit.	4/CA
$\overline{\text{CTS}}$	Input	Output	<i>Clear to send</i> tells the DTE that the DCE is ready to receive; DCE transmits any data sent by DTE.	5/CB
$\overline{\text{DTR}}$	Output	Input	<i>Data terminal ready</i> prepares the DCE for connection to the communications channel.	20/CD
$\overline{\text{DSR}}$	Input	Output	<i>Data set ready</i> indicates that the DCE is ready to operate the communications channel.	6/CC
$\overline{\text{RI}}$	Input	Output	<i>Ring indicator</i> indicates that the DCE received a ring signal on the communications channel.	22/CE

^a Control signals are active low when converted to HCMOS levels.

Procedural Specification

- E.g. Asynchronous private line modem (Point-to-Point Link “Not over the phone line”)
- The modem will require only the following signals to operate:
 1. GND,
 2. Tx, Rx,
 3. RTS, (Request to Send)
 4. CTS, (Clear to Send)
 5. DSR, (Data Set Ready)
 6. DCD (Data Carrier Detect)

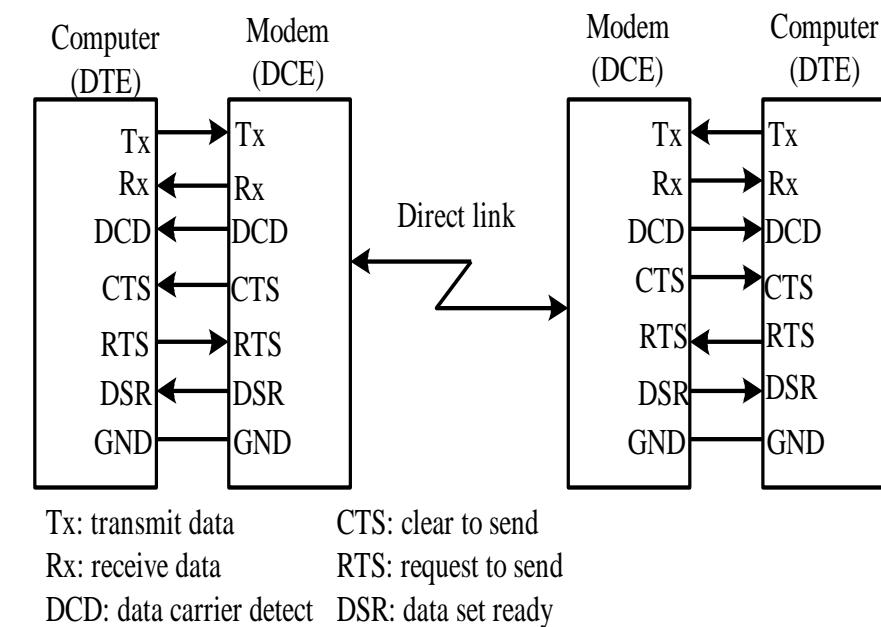
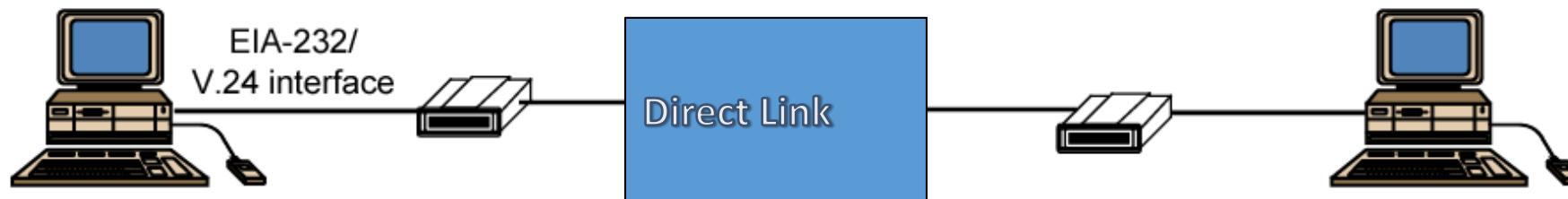


Figure 9.2 Point-to-point asynchronous connection

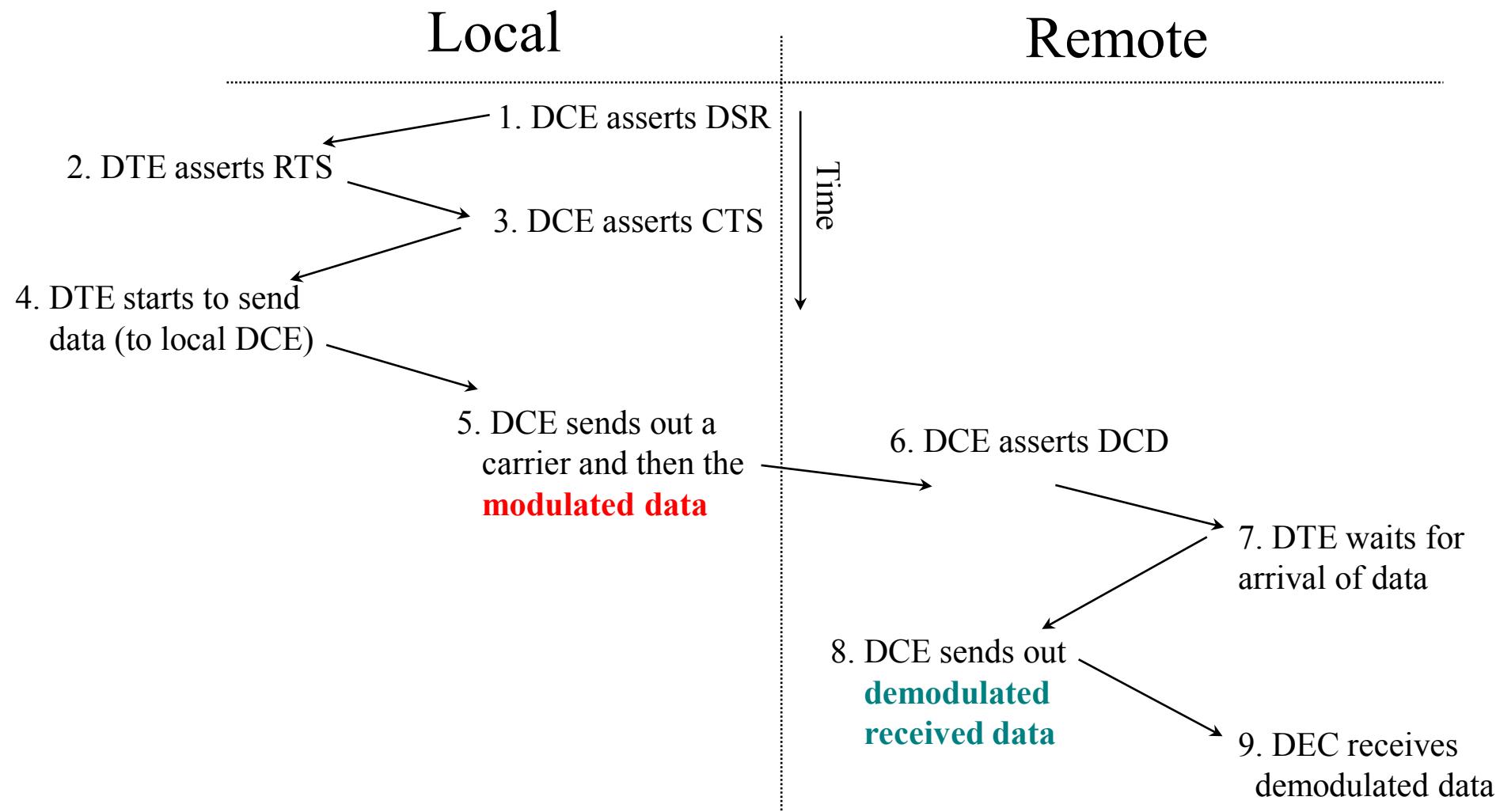
(2) Functional/Procedural Specs

- I. DSR (Data Set Ready) → From DCE (i.e., Modem is ready)
- II. RTS (Request to Send) → DTE to DCE (i.e., DTE Wants to send info)
- III. CLS (Clear to Send) → ACK from DCE (i.e., Data may be transmitted now)
- IV. Local Computer (i.e., DTE) sends data serially to modem.
- V. Local Modem (i.e., DCE) modulates signal but before that sends a carrier signal to remote modem.
- VI. Remote Modem detects the carrier signal ring and asserts DCD to inform remote DTE that a call arrived.
- VII. DCD (Data Carrier Detect) → Remote Modem (i.e., DCE) indicates that a carrier frequency has been established.
- VIII. Remote Modem (i.e., DCE) receives modulated data, demodulates it and sends it to remote DTE.



(b) Typical configuration

Sequence of events occurred during data transmission over dedicated link



Procedural Specification

- Over the telephone line the modems will have to go through the following phases:
 1. Phase 1: Establishing the Connection
 2. Phase 2: Data Transmission
 3. Phase 3: Disconnection
- The modem will require more signals to operate: GND, Tx, Rx, RTS, CTS, DSR, DCD,

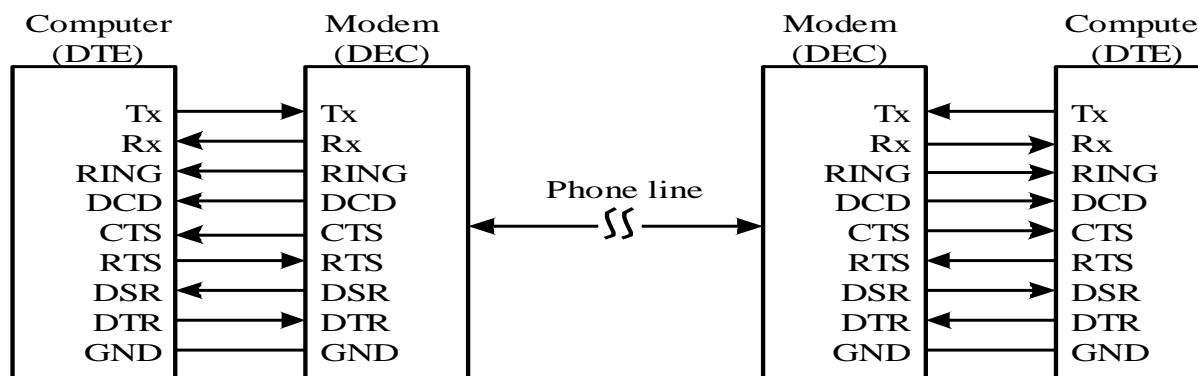
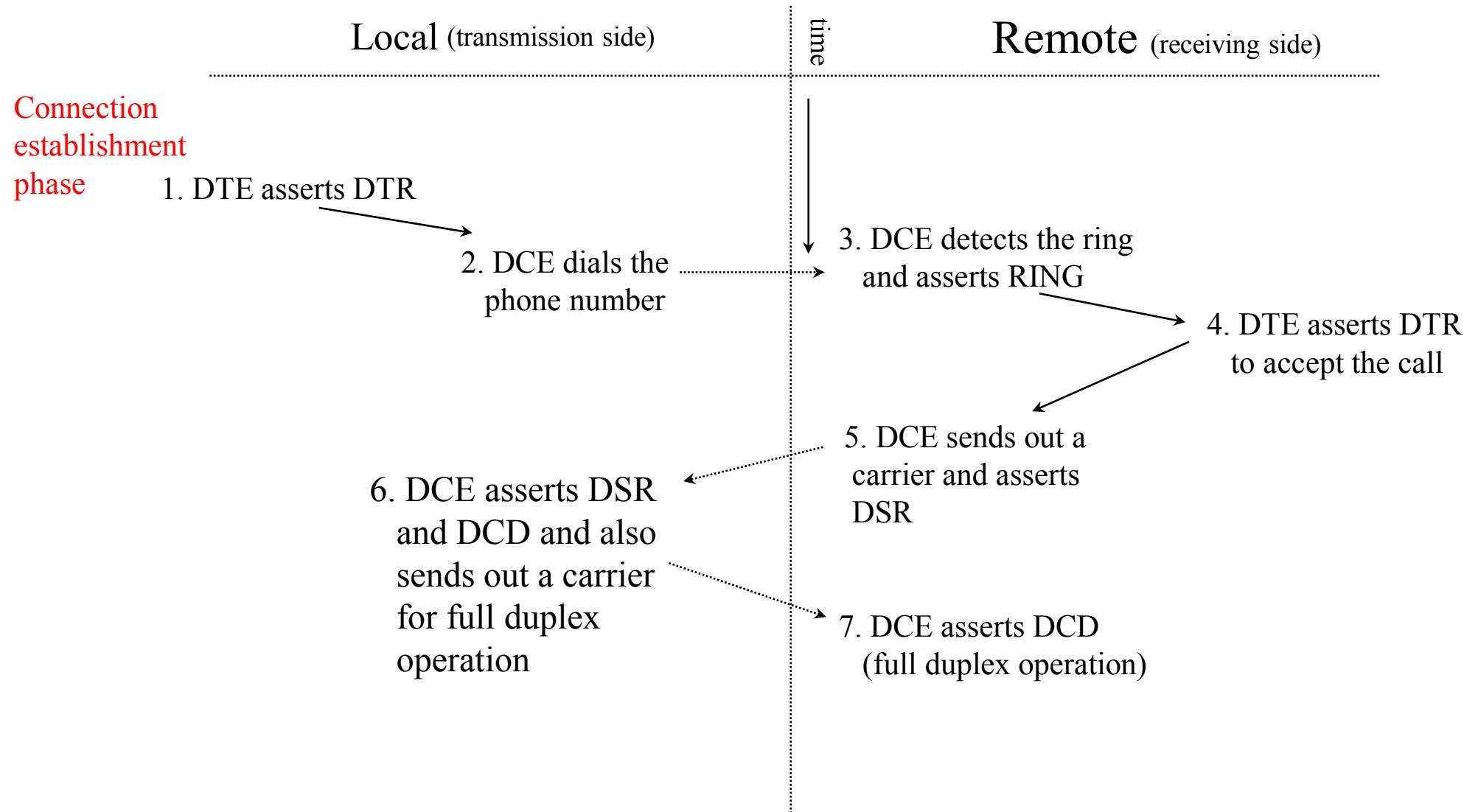
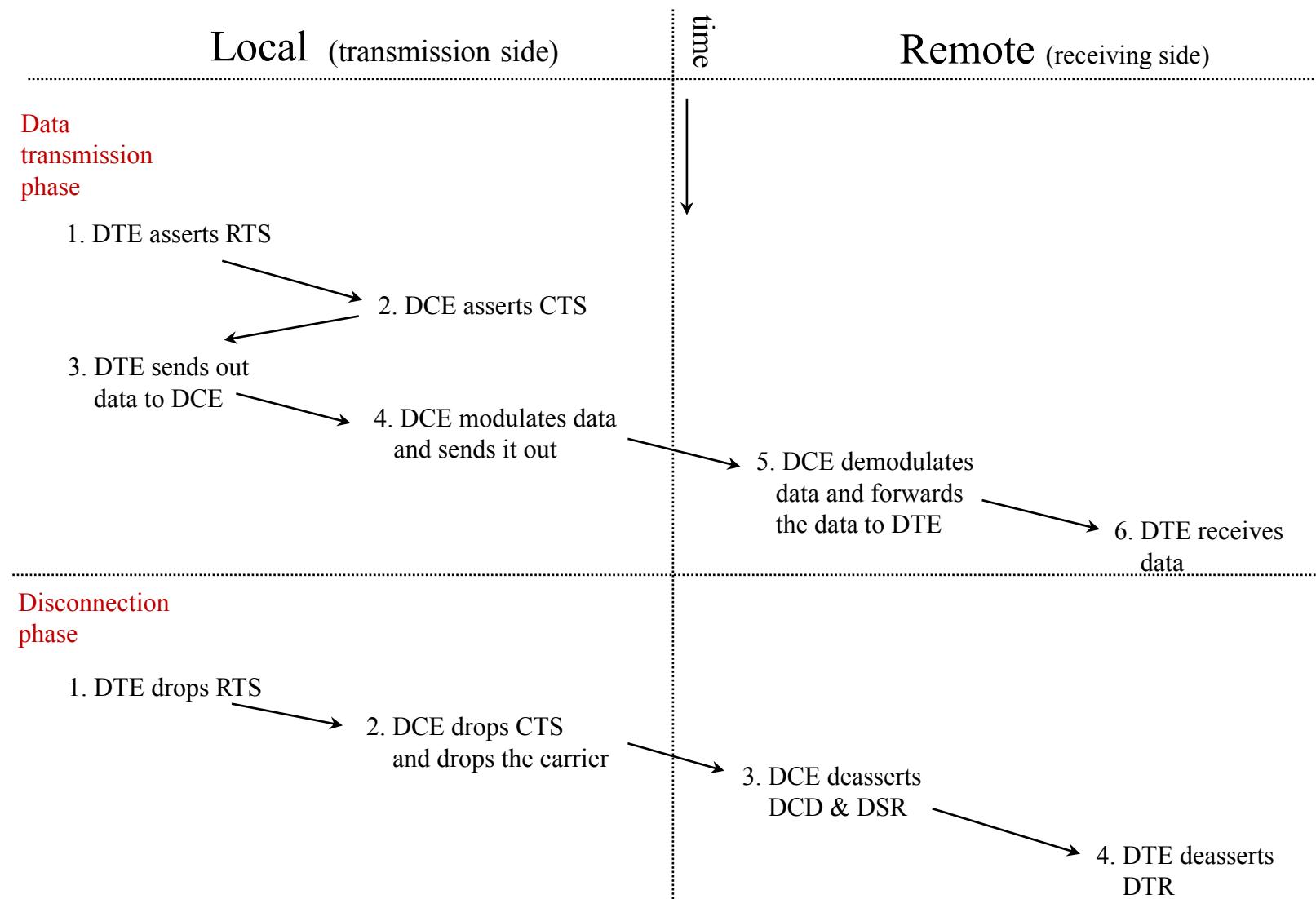


Figure 9.3 Asynchronous connection over public phone line

Sequence of events occur during data transmission over public phone line



Sequence of events occur during data transmission (continued)



RS-232 Interface Standard: Summary

- Equipment using asynchronous serial com. normally use the RS-232 interface
- The logic levels used for RS-232 signals are:
 - +12 V for logic 0;
 - -12 V for logic 1
- This is to allow signals to be transmitted over greater distances
- This is a bipolar form of NRZ format
- The standard defines 25 different signals
- Many signals are not used => serial ports also use a DB-9 connector
- Common signals:
 - Transmit data: TxD or TD
 - Receive data: RxD or RD
 - Request to send: TSR
 - Clear to send: CTS
 - Data set ready: DSR
 - Signal ground: SG
 - Data carrier detect: DCD
 - Data terminal ready: DTR
 - Ring indicator: RI
- From normal HCMOS and TTL levels we need to use special driver chips for
 - ...

Komunikasi Serial

Sampai ketemu minggu berikutnya ...