This page is translated from the original by using the Google translator.

RS-232 Recommended Standard .
Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

Author: Electron18
www.softelectro.ru
2009
electron18@softelectro.ru

Contents:

§1.Introduction

RS-232 (Recommended Standard 232) - standard describes an interface for serial bi-directional data transfer between the terminal (DTE, Data Terminal Equipment) and end-device (DCE, Data Circuit-Terminating Equipment). This legendary standard, which appeared in the 60's the 20 th century and became the basis for all subsequent serial interfaces for data exchange. RS-232C interface has been applied in the first personal computers from IBM and to this day is a part of any PC in hardware or software form.

Decisions which are incorporated in this standard are used almost everywhere. It is impossible to consider themselves industrial programmer did not know this standard

Interface RS-232 is fully hardware implemented on personal computers in the form of chips and connectors. In the PC it is called the COM-port (Communication port). Hardware implementation means that it always works, no matter which operating system is installed on the PC (it works without OS). Programs can communicate with the COM ports all available means: a direct source microprocessor, hardware interrupts, functions, BIOS, operating system tools, components of high-level languages COM port is implemented on standard RS-232-universal. He made it work with PC peripherals (what is now busy with USB), the interaction with the local network via a modem (Ethernet), the exchange of data between the PC and industrial equipment (ModBus, etc.) to understand how these protocols need to understand what function the COM port they have undertaken.

§2.Description of the standard RS-232

2.1 Developers and editorial standards RS-232

Designation Standard:
RS-232(Recommended Standard 232).*Recommended Standard 232.*

Title:
Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

Developers:
Electronics Industries Association (EIA). until 1997. *Association of Industrial Electronics.*
Electronics Industries Alliance (EIA).. after 1997. *Alliance of industrial electronics industries.*
Telecommunications Industry Association (TIA). joint EIA c 1988. *Association of the telecommunications industry.*

Revision of the standard:
RS-232A (Recommended Standard 232 Edition: A) 1962.
RS-232B (Recommended Standard 232 Edition: B) ????.
RS-232C (Recommended Standard 232 Edition: C) 1969.
EIA 232-D (RS-232D - not officially) 1986.
TIA/EIA 232-E (RS-232E - not officially) 1991.
TIA/EIA 232-F (RS-232F - not officially) 1997.

2.2 Brief History

In the 60 years of last century began the rapid development of telecommunication technologies. Numerous firms in the USA and other countries, producing communications equipment, used their own standards for data transmission. Using this equipment does cause problems of their compatibility. Connectors, electrical characteristics of signals, service alerts, synchronization mechanisms were different in different firms. Some protocols coded symbols four bits, the other 5 bits, etc. to 8 bits. The absence of an international standard for serial transmission of data hindered the development of the telecommunications industry.

In 1962, the Electronics Industries Association (EIA) has developed recommendations for equipment manufacturers, calling them "Recommended Standard 232. RS-232 interface has been designed as universal as possible, allowing many producers can easily convert their equipment to this standard. Encode characters allowed from 5 to 8 bits, the voltage signal could be from ± 3 to ± 25 V, etc. It consists of 16 service signals, whose use was not mandatory. Allowed to work, as in synchronous and asynchronous data transmission. Such loyalty to the standard suit manufacturers of telecommunications equipment.

In 1969, the EIA released edition of the standard RS-232C, which has been accounted for seven-year experience of the standard RS-232A / B. The final was legalized 25 pin DB25 and electrical characteristics of the signal .. This edition has become the primary interface for serial data communication channels for many years to come. International and national standards were to include part of the standard RS-232C in its structure.
In 1983, the company released the IBM PC IBM XT and IBM AT in 1984 with built-in universal transceiver UART. UART designed for standard RS-232C, it supports data transmission only in asynchronous mode. IBM XT supports up to 4 independent UART, which are called COM-ports (Communication port). Originally connectors COM ports comply with standard RS-232C, ie a 25 pin connector DB25p. Most of the service signals RS-232C in the UART is not used. Therefore, a company IBM started using computers in their 9-pin connectors DE9p, which used six service signals of the standard RS-232C. To legitimize the use of this connector TIA has released a new standard TIA-574. Standard TIA-574 allowed to use the 9 pin connector in the telecommunications equipment operating on standard RS-232C.

With the development of international and national standards in the field of telecommunications, the role of EIA began to diminish. In 1986, for maintaining the EIA for its image has replaced the name of standards with RS on EIA. The role of the association has continued to decline and its duties transferred to the related Association TIA. The Association TIA has released two version of the standard RS-232C with the name of TIA / EIA 232-E (1991) and TIA / EIA 232-F (1997). Nothing new in the serial data, these standards are not brought, they are almost exactly like a standard RS-232C. In 1997, the EIA Association ceased to exist, its successor has become an alliance of industrial electronics. Today, EIA and TIA trade organizations.

2.3 International and national standards, based on the RS-232.

Standards comprised of RS-232 standard large amount.
Below are some of these standards:

ITU-T v.24. *(2000 acting)*
Publisher: TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU
Title: LIST OF DEFINITIONS FOR INTERCHANGE CIRCUITS BETWEEN DATA TERMINAL EQUIPMENT (DTE) AND DATA CIRCUIT-TERMINATING EQUIPMENT (DCE)
Oldest Received:
ITU-T v.24. *(1996 not valid)*
ITU-T v.24. *(1993 not valid)*
CCIT v.24. *(1988 not valid)*

ITU-T v.28 . *(1993 acting)*
Publisher: TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU
*Title:*ELECTRICAL CHARACTERISTICS FOR UNBALANCED DOUBLE-CURRENT INTERCHANGE CIRCUITS.
Oldest Received:
CCIT v.28 *(1988 not valid)*

GOST 23675-79 *(1979)*
Publisher: USSR. State Committee on Standards.
*Title:*Chains joint C2 system of data transmission.

GOST 18145-81 *(1981)*
Publisher: USSR. State Committee on Standards.
*Title:*Chains at the junction of C2 equipment data with terminal equipment for serial input-output data.

GOST R 50668-94 *(1994)*
Publisher: National Standard RF
*Title:*Chains joint C2 system of data transmission.

ANSI/TIA/EIA-232-F *(1997)*
Publisher: USA. American National Standards Institute.
Title: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

2.4 Extension of the standard RS-232. [1]

Links to some standards that enhance the content of the standard RS-232:

- **EIA/TIA-334-B**,
  Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission.
- **EIA-363**,
  Standard for Specifying Signal Quality for Transmitting and Receiving Data Processing Terminal Equipment Using Serial Data Transmission at the Interface with Non-Synchronous Communication Equipment.
- **EIA-366-A**,
  Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communication.
- **EIA/TIA-404-A**,
  Standard for Start-Stop Signal Quality for Non-Synchronous Data Communication Equipment.
- **EIA/TIA-422-B**,
  Electrical Characteristics of Balanced Voltage Digital Interface Circuits.
- **EIA/TIA-530-A**,
  High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment, Including Alternative 26-Postion Connector.
- **EIA/TIA-561**,
  Simple 8-Position Non-Synchronous Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
- **EIA/TIA-574**,
  9-Position Non-Synchronous Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
- **TIA/EIA-602**,
  Data Transmission Systems and Equipment - Serial Asynchronous Automatic Dialing and Control.
- **TIA/EIA-687**,
  Medium Speed Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment.
- **ITU-T V.24**,
  List Of Definitions For Interchange Circuits Between Data Terminal Equipment (DTE) And Data Circuit-Terminating Equipment (DCE).
- **ITU-T V.28**,
  Electrical Characteristics For Unbalanced Double-Current Interchange Circuits.
- **ISO/IEC2110**,
  25-pole DTE/DCE Interface Connector and Contact Number Assignments.
- **ISO/IEC11560**,
  Information Technology - Telecommunications and information exchange between systems - 26 pole interface connector mateability dimensions and contact number assignments.

2.5 The content of the standard RS-232 .

Standard RS-232 is recommended to use the relationship user terminal equipment (DTE) equipment and terminal devices (DCE) using serial communication of binary data

Standard RS-232 contains sections:
1. Scope.
2. Signal characteristics.
3. Interface mechanical characteristics.
4. The functional description of interchange circuits.
5. Standard interfaces for selected communication system configurations.
6. Recommendations and explanatory notes.

2.5.1 Scope RS-232. [1]

This standart is applicable to the interconnection of data terminal equipment (DTE) and data circuit-terminating equipment (DCE) employing serial binary data interchange.

This standart includes thirteen specific interface configurations intended to meet the needs of fifteen defined system applications/ These configurations are identified by type, using alphabetic characters A through M. In addition, type Z has been reserved for applications not coverd by types A through M, and where the configuration of interchange circuits is to be specified, in each case, by the supplier.

This standart is applicable for use at data signaling rates up to a nominal limit of 20 kb/s.

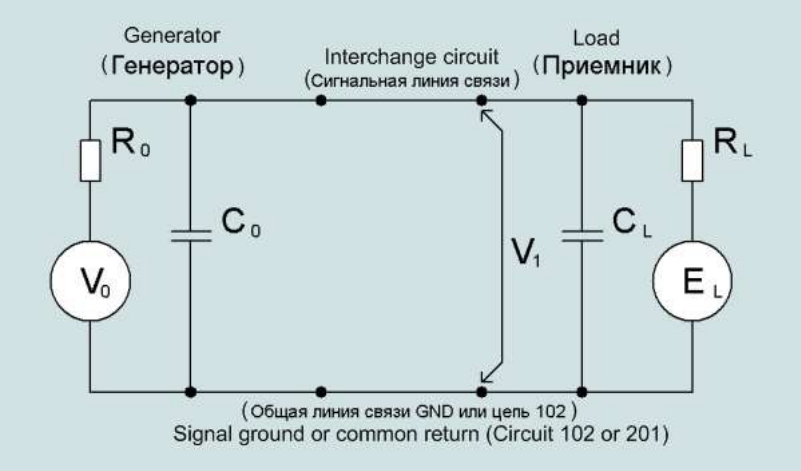
This standart is applicable for the interchange of data, timing and control signals when used in conjunction with electronic equipment, each of which has a single common return, which can be interconnected at the interface point. It does not apply where electrical isolation between equipment on opposite sides of the interface point is required.

This standart applies to both synchronous and nonsynchronous serial binary data communication system.

2.5.2 Signal characteristics.. [1] [3]

Fig.1. shows the equivalent electrical circuit in the exchange of serial data standard RS-232 This equivalent circuit is independent of where the generator is located in the DTE or DCE.
The characteristics of the signal data exchange standard RS-232C are included in the international standard ITU-T v.28.

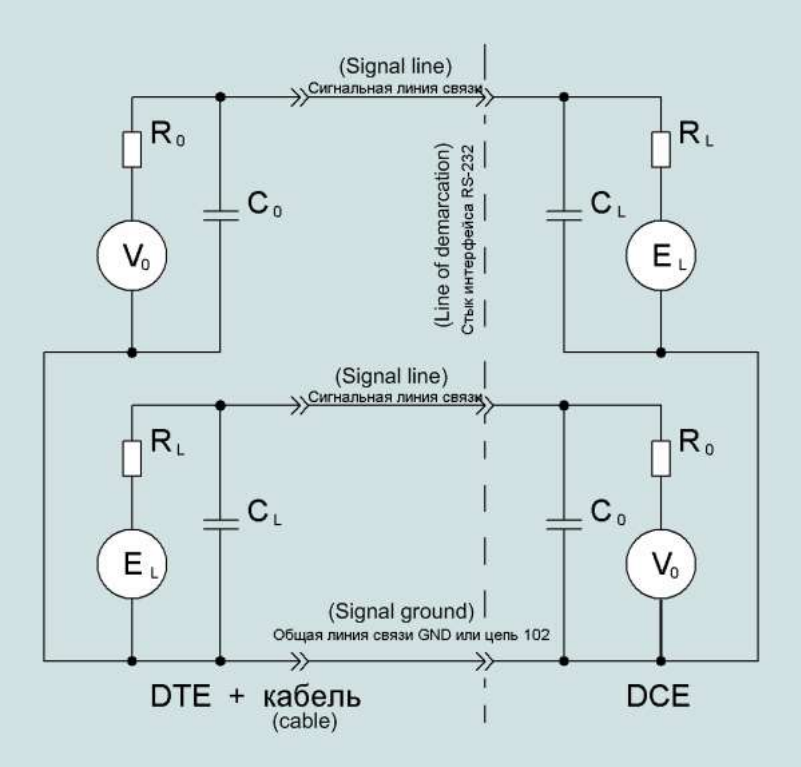
Fig.1 The equivalent electrical circuit RS-232C



- V_0- is the open-circuit generator voltage.
- R_0- is the total ef fective d.c. resistance associated with the generator, measured at the interchange point.
- C_0- is the total ef fective capacitance associated with the generator, measured at the interchange point.
- V_1- is the voltage at the interchange point with respect to signal ground or common return.
- C_L- is the total ef fective capacitance associated with the load, measured at the interchange point.
- R_L- is the total effective d.c. resistance associated with the load, measured at the interchange point.
- E_L- is the open-circuit load voltage (bias).

Junction between the RS-232C interface is the line connecting DTE cable plus DCE That is, the cable interface is part of the DTE.

Fig.2 Practical scheme of interface RS-232C interface



Electrical Characteristics of the receiver signals.

- R_L- total resistance of the receiver must be within 3000 ... 7000 Ohm.
- V_1- voltage at the receiver input must be within ± 3 ... ± 15 V.
- E_L- The open-circuit load voltage (E_L) shall not exceed 2 volts.
- C_L- The effective shunt capacitance (C_L) of the load, measured at the interchange point, shall not exceed 2500 picofarads.
- To avoid inducing voltage surges on interchange circuits the reactive component of the load impedance shall not be inductive.

Electrical characteristics of a signal generator.

- The generator on an interchange circuit shall withstand an open circuit and a short circuit between itself and any other interchange circuit (including generators and loads) without sustaining damage to itself or its associated equipment.
- The open circuit generator voltage (V_0) on any interchange circuit shall not exceed 15 volts in magnitude. The impedance (R_0 and C_0) on the generator side of an interchange circuit is not specified; however, the combination of V_0 and R_0 shall be selected so that a short circuit between any two interchange circuits shall not

result in any case in a current in excess of one-half ampere. NOTE – It should be noted that there may be older equipment in the field, where the open-circuit generator voltage is up to 25 volts.

- Additionally, when the load open-circuit voltage (E_L) is zero, the voltage (V_1) at the interchange point shall not be less than 5 volts and not more than 15 volts in magnitude (either positive or negative polarity), for any load resistance (R_L) in the range between 3000 ohms and 7000 ohms.
- The effective shunt capacitance (C_0) at the generator side of an interchange circuit is not specified. However, in addition to any load resistance (R_L) the generator shall be capable of driving all of the capacitance at the generator side (C_0), plus a load capacitance (C_L) of 2500 picofarads.
- Short-circuiting the circuit of the generator should not cause currents larger than 0.5 A.
- If $E_L = 0$, then the voltage at the receiver input must be $V_1 = \pm 5 ... \pm 15$ V, for any range of load generator $R_L = 3000 ... 7000$ Ohm.

The levels of signals for the standard RS-232C.

- Logical "1" is considered an information signal with a voltage V_1 less than -3 V.
- A logical "0" is considered an information signal with a voltage V_1 over +3 V.
- Service or the clock signal is switched "ON" ("MARK") if V_1 over +3 V.
- Service or the clock signal is switched off "OFF" ("SPACE") if V_1 less than -3 V.
- The voltage in the range of V_1 =- 3 V. .. +3 is the transition region.

The characteristics of signals.

- All signals are included in the transition region V_1 =- 3B ... +3 should go in the opposite signal without re-entering this area (ie, monotone).
- not be the signal fluctuations in the transition region.
- Service and clock signals must undergo the transition region for not more than 1 ms.
- data signals must undergo the transition region for the time not more than 3% of the time a single element, but not more than 1 ms.
- speed of the front signal must not exceed the value of 30V for a millisecond.
- Limitations of the first two paragraphs do not apply to electromechanical devices, opening and closing the circuit.

2.5.3 Interface mechanical characteristics. Connector interface standard RS-232 .

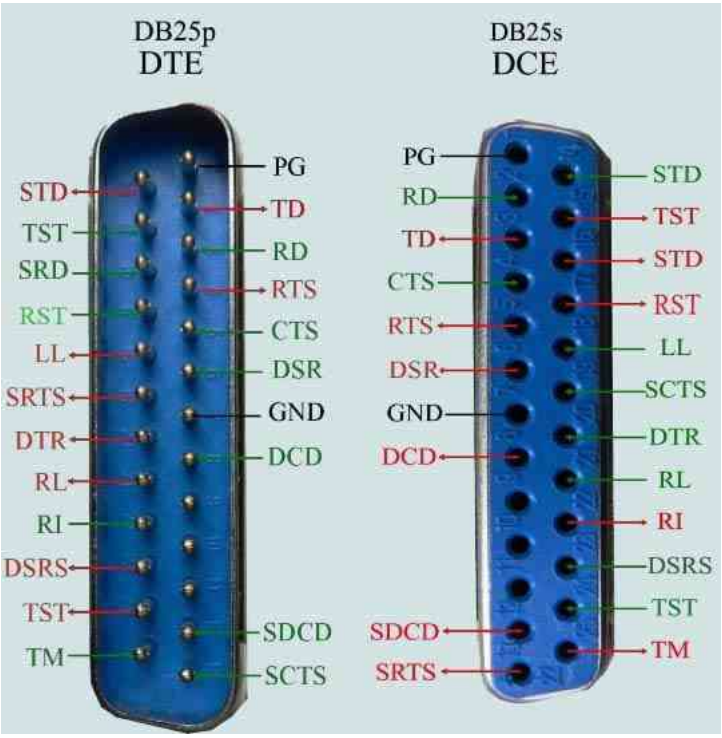
As a connector for RS-232C interface is selected miniature connector D-type (D-subminiature).
Terminal (DTE) - DB25p
For terminals (DCE) -DB25s
When using standard TIA / EIA 574 can be used 9-pin connectors:
For Terminal (DTE) - DE9p
For Endpoint (DCE) -DE9s

Designation connectors D-subminiature:

- The letter-type connector. D-type
- Letter-standard size holder. A, B, C, D, E
- The number is the number of contacts in the holder
- The letter-type contact. P = plug (pin), S = socket (socket).

Now, these connectors are manufactured by many firms around the world and the specified label does not comply.
Often, instead DB25p (plug-"pin") indicate DB25m (male - "Dad"), DB25s (socket-"nest") - DB25f (femini-"Mama").
Also, instead of DE9p (COM-port) may indicate: DB9p, DB9m. (Although the clips "B" and "E" are different in size)

Fig.3. DB25 connector pinout for standard RS-232C



You can directly connect the device connectors DTE and DCE, as their signals are chosen appropriately. That is, the output signals DTE fall on the input signals DCE, and vice versa DCE output signals arrive at inputs DTE. Therefore, to connect the device with DTE DCE devices use a straight line (modem) cable. To connect DTE devices with each other or DCE devices together, use a crossover (crossover) cable.

Signals interface standard RS-232C.

In RS-232 interface is used:
16 service signals
4 information signal
2 common signal
The use of signals and do not necessarily depend on the application, where they are used. For example, a minimum set of signals TD and GND, allows you to transfer data from the DTE to DCE standard RS-232c on the two wires.

International standard ITU-T v.24 includes a description of 37 signals, which are used to transfer binary data between a terminal (DTE) and the terminal connection (DCE). All signals are RS-232C signals are included in the standard ITU-T v.24 under other names. Corresponding signals of the standard RS-232C signals of standard ITU-T v.24 shown in the following table.

2.5.4. The functional description of interchange circuits.

Table 1. Signals RS-232c for DTE [1] [2] [4]

Nr.	ITU v.24	Name for RS232	Defact of DTE		Description
1			PG	Common	Protective Ground
2	103	BA	TD	Output	Transmited Data. The data signals originated by the DTE: 1)to be transmitted via a data channel to one or more remote data stations, 2)to be passed to the DCE for maintenance test purposes under control of the DTE, or 3)or the programming or control of serial automatic calling DCEs,are transferred on this circuit to the DCE.
3	104	BB	RD	Input	Received Data. The data signals generated by the DCE: 1)in response to data channel line signals received from a remote data station, 2)in response to the DTE maintenance test signals, or 3)in response to (or as an echo of) programming or control signals from the DTE where a serial automatic calling facility is implemented in the DCE, are transferred on this circuit to the DTE. Note – The reception conditions for maintenance test signals are specified with circuit 107.
4	105 133	CA/CJ	RTS	Output	Request To Send. Signals on this circuit control the data channel transmit function of the DCE. The ON condition causes the DCE to assume the data channel transmit mode. The OFF condition causes the DCE to assume the data channel non-transmit mode, when all data transferred on circuit 103 have been transmitted.
5	106	CB	CTS	Input	Clear To Send. Signals on this circuit indicate whether the DCE is prepared to accept data signals for transmission on the data channel or for maintenance test purposes under control of the DTE. The ON condition indicates that the DCE is prepared to accept data signals from the DTE. The OFF condition indicates that the DCE is not prepared to accept data signals from the DTE.
6	107	CC	DSR	Input	Data Set Ready. Signals on this circuit indicate whether the DCE is ready to operate. The ON condition, where circuit 142 is OFF or is not implemented, indicates that the signal converter or similar equipment is connected to the line and that the DCE is ready to exchange further control signals with the DTE to initiate transfer of data. The ON condition, in conjunction with the ON condition of circuit 142, indicates that the DCE is prepared to exchange data signals with the DTE for maintenance test purposes. The OFF condition, in conjunction with the ON condition on circuit 106, indicates that the DCE is ready to exchange data signals associated with the programming or control of serial automatic calling DCEs. The OFF condition, in conjunction with the OFF condition on circuit 106, indicates: 1) that the DCE is not ready to operate in the data transfer phase, 2) that the DCE has detected a fault condition (which may be network or DCE dependent) which has lasted longer than some fixed period of time, such period of time being network dependent, or 3) in switched network operation, that the DCE has detected a disconnect indication from the remote station or from the network. The OFF condition, in conjunction with the ON condition on circuit 142, indicates that the DCE is involved in tests from the network or remote station.
7	102	AB	GND	Common	Signal ground or common return This conductor establishes the signal common return for unbalanced interchange circuits with electrical characteristics according to Recommendation V.28 and the d.c. reference potential for interchange circuits according to Recommendations V.10, V.11 and V.35.
8	109	CF	DCD	Input	Data Carrier Detected. Signals on this circuit indicate whether the received data channel line signal is within appropriate limits, as specified in the relevant Recommendation for DCE. Circuit 109 may also be in the ON condition during the exchange of data signals between the DCE and the DTE, associated with the programming or control of serial automatic calling DCEs. The OFF condition indicates that the received signal is not within appropriate limits.
9					available
10					available
11					available
12	122 112	SCF/CI	SDCD	Input	Secondary Carrier Detect. This circuit is equivalent to circuit 109, except that it is used to indicate whether the received backward channel line signal is within appropriate limits, as specified in the relevant Recommendation for DCE.
13	121	SCB	SCTS	Input	Secondary Clear To Send. This circuit is equivalent to circuit 106, except that it is used to indicate whether the DCE is conditioned to transmit data on the

					backward channel. The ON condition indicates that the DCE is conditioned to transmit data on the backward channel. The OFF condition indicates that the DCE is not conditioned to transmit data on the backward channel.
14	118	SBA	STD	Output	Secondary Transmitted Data. This circuit is equivalent to circuit 103, except that it is used to transmit data via the backward channel.
15	114	DB	TST	Input	Transmitter Signal Timing DCE source. Signals on this circuit provide the DTE with signal element timing information. The condition on this circuit shall be ON and OFF for nominally equal periods of time. The DTE shall present a data signal on circuit 103 in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of circuit 114.
16	119	SBB	SRD	Input	Secondary Received Data. This circuit is equivalent to circuit 104, except that it is used for data received on the backward channel.
17	115	DD	RST	Input	Receiver Signal Timing. Signals on this circuit provide the DTE with signal element timing information. The condition of this circuit shall be ON and OFF for nominally equal periods of time, and a transition from ON to OFF condition shall nominally indicate the centre of each signal element on circuit 104.
18	141	LL	LL	Output	Local Loopback. Signals on this circuit are used to control the loop 3 test condition in the local DCE. The ON condition of circuit 141 causes the establishment of the loop 3 test condition in the local DCE. The OFF condition of circuit 141 causes the release of the loop 3 test condition in the local DCE.
19	120	SCA	SRTS	Output	Secondary Request to Send. This circuit is equivalent to circuit 105, except that it is used to control the backward channel transmit function of the DCE. The ON condition causes the DCE to assume the backward channel transmit mode. The OFF condition causes the DCE to assume the backward channel non-transmit mode, when all data transferred on circuit 118 have been transmitted to line.
20	108/2 108/1	CD	DTR	Output	Data Terminal Ready. Signals on this circuit control switching of the signal-converter or similar equipment to or from the line. The ON condition, indicating that the DTE is ready to operate, prepares the DCE to connect the signal-conversion or similar equipment to the line and maintains this connection after it has been established by supplementary means. The DTE is permitted to present the ON condition on circuit 108/2 whenever it is ready to transmit or receive data. The OFF condition causes the DCE to remove the signal-converter or similar equipment from the line, when the transmission to line of all data previously transferred on circuit 103 and/or circuit 118 has been completed. The OFF condition of this circuit may also be used to direct the DCE to abort or to clear a serial automatic calling operation (see Recommendation V.25 bis).
21	140 110	RL/CG	RL	Output	Remote Loopback. Signals on this circuit are used to initiate and release loopback or other maintenance test conditions in DCEs. The ON condition causes initiation of the maintenance test condition. The OFF condition causes release of the maintenance test condition.
22	125 135	CE/CK	RI	Input	Ring Indicator. Signals on this circuit indicate whether a calling signal is being received by the DCE. The ON condition indicates that a calling signal is being received. The OFF condition indicates that no calling signal is being received, and this condition may also appear during interruptions of a pulse-modulated calling signal.
23	111 112	CH/CI	DSRS	Output	Data Signal Rate Selector. Signals on this circuit are used to select one of the two data signalling rates of a dual rate synchronous DCE, or to select one of the two ranges of data signalling rates of a dual range asynchronous DCE. The ON condition selects the higher rate or range of rates. The OFF condition selects the lower rate or range of rates.
24	113	DA	TST	Output	Transmitter Signal Timing DTE source. Signals on this circuit provide the DCE with signal element timing information. The condition on this circuit shall be ON and OFF for nominally equal periods of time and the transition from ON to OFF condition shall nominally indicate the centre of each signal element on circuit 103.
25	142	TM	TM	Input	Test Mode. Signals on this circuit indicate whether a maintenance condition exists. The ON condition indicates that a maintenance condition exists in the DCE, precluding reception or transmission of data signals from or to a remote DTE. The OFF condition indicates that the DCE is not in a maintenance test condition.

2.5.5 Standard interfaces for selected communication system configurations. Recommendations and explanatory notes.

Since the RS-232C interface is universal, it means the use in different applications and conditions. For each application can use different combinations of interface signals, which are called configurations. Standard RS-232C provides 13 standard configurations, A-M and one custom configuration Z.

Standard configuration:
A - Transmit Only
- Basic Interchange Circuits: AB(GND), BA(TxD), CB(CTS), CC(DSR)
- Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
- Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST)
- Additional Interchange Circuits required for Test Mode: TM(TM)

B - only the first channel transmission with strobe (RTS)
- Basic Interchange Circuits: AB(GND), BA(TxD), CA(RTS), CB(CTS), CC(DSR)
- Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
- Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST)
- Additional Interchange Circuits required for Test Mode: TM(TM)

C - only the first channel reception
- Basic Interchange Circuits: AB(GND), BB(RxD), CC(DSR), CF(DCD)
- Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)

Additional Interchange Circuits required for Synchronous Channel: DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

D - the first channel with duplex strobe (RTS)
Basic Interchange Circuits: AB(GND), BA(TxD), BB(RxD), CA(RTS), CB(CTS), CC(DSR), CF(DCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST), DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

E - the first channel duplex
Basic Interchange Circuits: AB(GND), BA(TxD), BB(RxD), CB(CTS), CC(DSR), CF(DCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST), DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

F - only the first channel transmission with strobe (RTS), the second channel reception only
Basic Interchange Circuits: AB(GND), BA(TxD), CA(RTS), CB(CTS), CC(DSR), SBB(SRD), SCF(SDCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST)
Additional Interchange Circuits required for Test Mode: TM(TM)

G - Receive only the first channel, second channel of transmission from only Strobe (SRTS)
Basic Interchange Circuits: AB(GND), BB(RxD), CA(RTS) CC(DSR), CF(DCD), SBA(STD), SCA(SRTS), SCB(SCTS)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

H - only the first channel transmission, the second channel reception only
Basic Interchange Circuits: AB(GND), BA(TxD), CB(CTS), CC(DSR),SBB(SRD), SCF(SDCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST)
Additional Interchange Circuits required for Test Mode: TM(TM)

I - Receive only the first channel, the second channel only transfer
Basic Interchange Circuits: AB(GND), BB(RxD), CC(DSR), CF(DCD), SBA(STD), SCB(SCTS)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

J - only the first channel transmission with strobe (RTS), the second channel half-duplex
Basic Interchange Circuits: AB(GND), BA(TxD), CA(RTS), CB(CTS), CC(DSR), SBA(STD), SBB(SRD), SCA(SRTS), SCB(SCTS), SCF(SDCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST)
Additional Interchange Circuits required for Test Mode: TM(TM)

K - Receive only the first channel, second channel half-duplex
Basic Interchange Circuits: AB(GND), BB(RxD), CC(DSR), CF(DCD), SBA(STD), SBB(SRD), SCA(SRTS), SCB(SCTS), SCF(SDCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST), DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

L - the first channel with duplex strobe (RTS), a second channel with duplex strobe (SRTS)
Basic Interchange Circuits: AB(GND), BA(TxD), BB(RxD), CA(RTS), CB(CTS), CC(DSR), CF(DCD), SBA(STD), SBB(SRD), SCA(SRTS), SCB(SCTS), SCF(SDCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST), DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

M - the first channel is a duplex, a second channel duplex
Basic Interchange Circuits: AB(GND), BA(TxD), BB(RxD), CA(RTS), CB(CTS), CC(DSR), CF(DCD), SBA(STD), SBB(SRD), SCB(SCTS), SCF(SDCD)
Additional Interchange Circuits required for Switched Service: CD(DTR), CE(RI)
Additional Interchange Circuits required for Synchronous Channel: DA(TST), DB(TST), DD(RST)
Additional Interchange Circuits required for Test Mode: TM(TM)

Z - configuration of the manufacturer, allows any combination of signals.

For example, COM port of your PC uses the configuration D, with the option of switched services.

§3.Description of the COM port of a personal computer IBM XT.

3.1 Basic properties of COM ports.

The work of communication ports implemented on the universal asynchronous receiver / transmitter UART.
UART-IC is that work on standard RS-232C D configuration with the option of switching services (2.5.5) For the COM port of your computer using a 25-pin connector DB25p according to the standard RS-232C or 9-pin connector DE9p according to standard TIA-574. This connector uses six service signals and one duplex communication channel.

Basic properties of the COM ports:

1.Full-duplex data exchange.
Means that you can simultaneously send and receive data stream. There are two hardware and software-independent data transmission channel. One channel for data transmission, another channel for receiving data. Moreover, the COM-port care what the processor is busy at this time, they present their own buffers transmit and receive data. In these buffers the data to queue for transmission and turn on the reading of the data processor. Any program may apply to the COM port and receive data from its buffer, thereby clearing it. Natural buffers are not infinite, their size is specified when configuring the ports. RS-485, Modbus, USB, etc. (except for network protocols) are half-duplex and not physically able to exchange data in both directions simultaneously.

2.A set of service signals
The service signals in the standard RS-232c, allow to organize the exchange of data between two devices simultaneously in both directions. Service signals are represented by individual digital inputs and outputs with memory. For example, the code on the phone to the modem receives a call from the station, the modem on 9-th contact (RI) informed RL that he was called, and the procedure starts with the exchange of data. And with the help of service signals of the PC and modem to

suspend the exchange of data or make repeat them. Variants of service signals a great set. The developer can use their discretion. For example, using these signals conveniently interview contact limit switch or photosensor, and you can enable / disable various devices powered or low voltage device.

3.Software independence

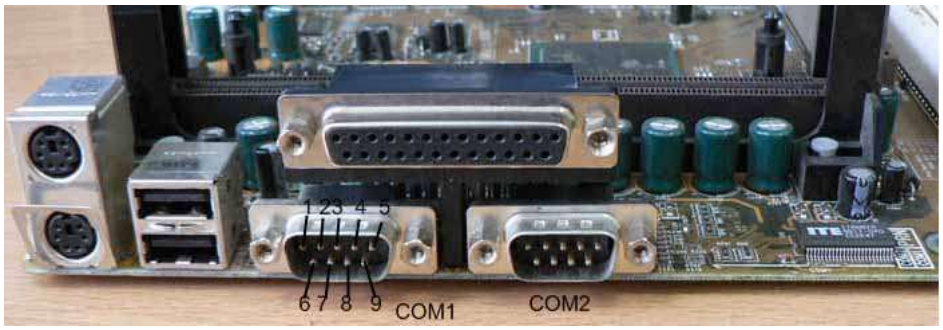
UART is fully implemented in hardware and does not depend on the software and operating systems.

4. Asynchronous data transmission over the communications channel

Means that the PC can send data to the target device without worrying about the synchronization of their income. The final device itself adapts to the data obtained. In synchronous protocols for this is a special signal that is transmitted on a separate wire. In the communication ports sync is built into each transmitted symbol, in the form of start and stop bits. The method, which synchronizes the data on standard RS-232C, was commonly used for all asynchronous data exchange protocols.

3.2 Specifications COM ports

Fig.4 Type connectors COM1 and COM2 on the motherboard.

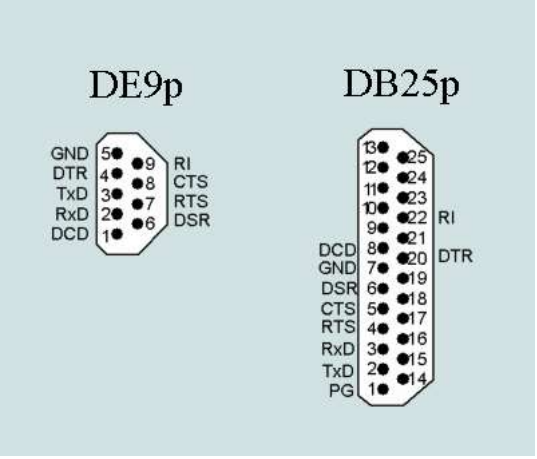


- Connector Type: DE9p (DB9P) or DB25P male (dad), mate DE9s (DB9s) or DB25s femini (mom)
- Hardware Implementation: IC UART intel8250/16450/16550
- Signal level for TxD, RxD: 1 = -3 ...- 12 V, 0 = +3 ... +12 V (signal inverted)
- Level signals RTS, DTR, CTS, DSR, DCD, RI: 1 (True) = +3 ... +12 V; 0 (False) = -3 ...- 12V
- Dead zone: -3 ... +3 in
- Number of ports IBM XT: 4 COM1, COM2, COM3, COM4
- Addresses in the space of I / O: COM1 = 3F8h, COM2 = 2F8h, COM3 = 3E8h, COM4 = 2E8h
- Hardware interrupts: COM1, COM3 = IRQ4 (IQ11) COM2, COM4 = IRQ3 (IQ10)
- Features BIOS: 14h (initialization, write, read, status polling, setting)
- Standard rate, bps: 50,75,110,150,300,600,1200,1800,2000,2400,3600,4800,7200,9600,14400,19200,28800,38400,57600,115200
- maximum speed bps: 1,500,000
- Number of data bits in the transmitted symbol: 5,6,7,8
- Length of stop bit: 1, 1.5, 2
- Modes of control bits (Parity): N (None), E (Even), M (Mark), O (Odd), S (Space)
- Synchronization mode exchange (Handshaking): 0-None, 1-XOnXoff, two-RTS, 3-RTSXOnXoff
- Channel data (inverse): TxD (3)-GND (5)
- Channel receive data (inverse): RxD (2)-GND (5)
- Weekend service signals: RTS (7)-CND (5); DTR (6)-GND (5)
- Input service signals: CTS (8)-GND (5); DSR (6)-GND (5); DCD (1)-GND (5); RI (9)-GND (5)
- Distances connection: standard - 25ft (7.62m), maximum (as determined by many factors)

3.3 The appointment signals the COM port for standard RS-232C.

- GND- Ground, (Common) second wire for all signals. (Signals are always passed on two wires!)
- TxD- Transmited Data, asynchronous channel for data transmission.
- RxD- Received Data, asynchronous channel for data reception.
- RTS- Request To Send.Output which indicates that the computer has data for transmission via TxD to the end device.
- DTR- Data Terminal Ready.Output which indicates that the computer (terminal) is ready to exchange data with the final device.
- CTS- Clear To Send.Input, which suggests that the target device is ready to receive data from the terminal via TxD. Typically, this signal puts the final device after it receives a signal from the computer RTS = True (request for transfer) and will be ready to accept data from your computer. If the final instrument is not will put the signal CTS = True, then the transfer via TxD not start. This signal is used for hardware flow control.
- DSR- Data Set Ready.Input which suggests that the target device has complied with all installed and ready to transmit and receive data from the computer. the target device modem, the installation of DSR = True perceived computer (terminal) so that the modem has established a link with another modem and is ready to begin the process of exchange between two computers equipped with modems.
- DCD- Data Carrier Detected.Sign that informs a computer (terminal) of the discovery of another terminal, that is the final device, such as a modem, found another modem that wants to initialize the data exchange between terminals. Modem signal exhibits DCD = True, which is found at the entrance to the computer (terminal). If the terminal is ready to exchange data, it is a signal DCD = True should be set ready signal terminal to exchange data DTR = True, then begins data exchange between the two terminals.
- RI- Ring Indicator.Modem signal exhibits DCD = True, which is found at the entrance to the computer (terminal). Input says that the computer (terminal) that the target device receives a signal call. For example, the modem signal was received a call from the telephone exchange, it is not necessary that this challenge will end the exchange of data.
- PG - Protective Ground.

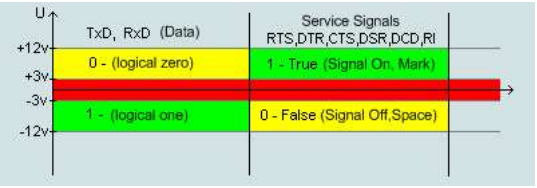
Figure 5 The numbering of contacts for the connector COM-port



3.4 Levels signals UART.

UART uses signal levels ....+ 12V-12V. Dead zone, ie the absence of signals is the voltage-3V to +3 .... However, note that the adopted / transmitted data is inverted

Fig.6. Levels of signals UART standard RS-232c



Initial state:

- port is not initialized - in all lines of voltage in the range-3V to +3 ...
- standby - on all lines of voltage in the range-3c ...- 12V

3.5 Data transfer via UART.

When transferring data symbols are transmitted from the transmitter buffer sequentially (first-come-first-out). Specially called characters, not bytes as characters may have a size of 5 to 8 bits. Each transmitted symbol is provided with start and stop bits, designed to synchronize at the receiving side. After the start bit followed by data bits, starting with low bit and ending with the seniors. For the last bit of data symbol may be followed by a bit of parity to detect transmission errors of data bits. The last stop bit is transmitted, which is required for the temporary separation of transmitted symbols

Fig.7 is shown the transfer of characters "0" "0" no parity, one stop bit

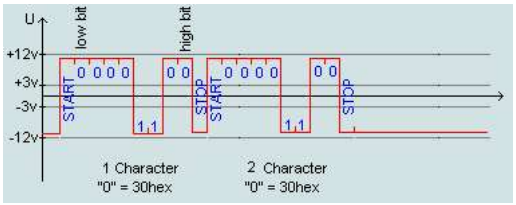
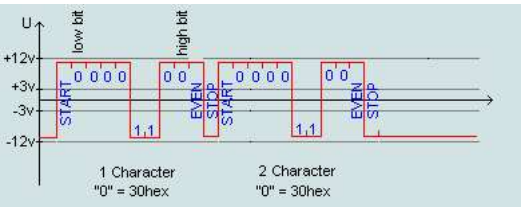


Figure 7 clearly seen that the stop bit separates the two transmitted symbol. You can increase this interval to 2 stop bits, if the endpoint is unable to separate symbols.

Fig.8 is shown the transfer of characters "0" "0" with parity (EVEN), with one stop bit

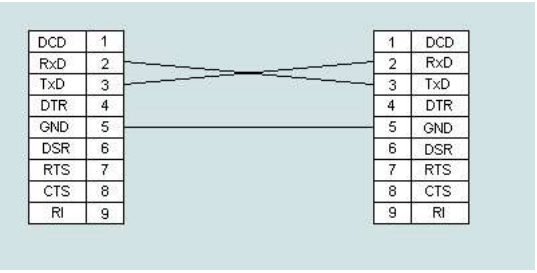


3.6 Connecting cables.

Null-modem connection between two COM ports.

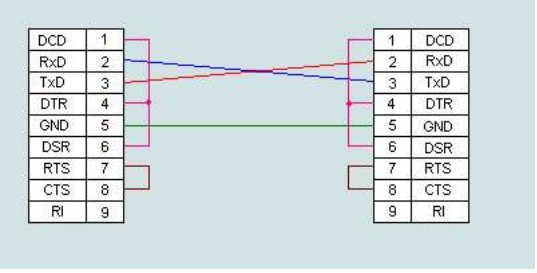
In this connection, computers (terminals) connected to each other directly via COM ports without the use of modems. As computers have high-speed data processing, then synchronize their work is not necessary. It is therefore assumed that the synchronization mode exchange (Handshaking): 0-None, that is, service signals do not affect the data exchange procedures. To do this, use a null-modem cable.

Fig.9 null-modem cable for Handshaking = 0 (None)



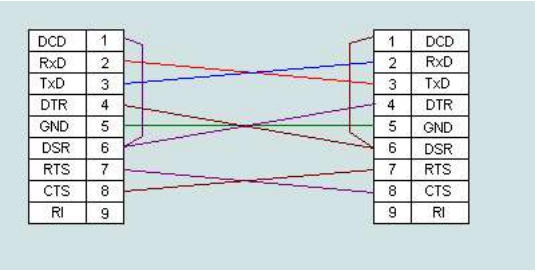
Since the synchronization mode of exchange at the COM ports can be switched on, the service often signals the COM ports enclose themselves to themselves, thereby eliminating their influence on the exchange procedure.

Fig.10 null-modem cable for all modes Handshaking



If you can use a full cable, but the COM ports must be configured with a hardware synchronization exchange.

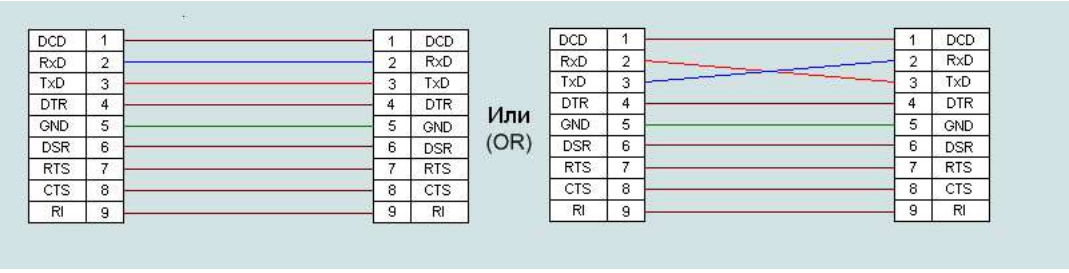
Fig. 11 null-modem cable for hardware synchronization mode Handshaking = 2



Modem connection.

Modem connection means connect the two computers (DTE) via modems (DCE). Modems (modulator-demodulator) - a special device to allow exchange of data on almost unlimited range, using the modulation and demodulation of information signals. Therefore, dial-up connection means to connect the COM port on your computer (DTE) to the end device (DCE). Usually in such a connection using a hardware synchronization Handshaking = 2. This mode allows the modem to manage the process of data.

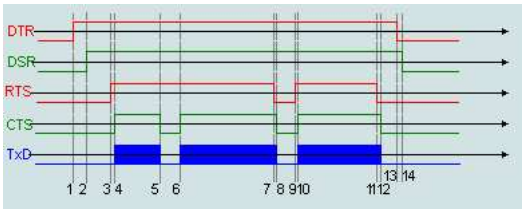
Fig. 12 A typical modem cable.



3.7 Organization of data exchange with the hardware synchronization mode.

Hardware synchronization of data exchange RTS / CTS (hardware flow control) Handshaking = 2, uses the service signals to RS-232C to control the flow of data.

Fig.13. Sharing with the hardware synchronization.



The order of service signals exhibiting the exchange via a modem:

- DTR = True computer indicates a desire to use the modem
- In response, the modem signals a connection with another modem, and its willingness to putting DSR = True.
- Signaled RTS = True computer requests permission to transfer and expresses its readiness to receive data from the modem.
- Signaled CTS = True modem notifies its readiness to receive data from the computer and transfer them into line. At this signal starts the exchange of data between terminals via modems.
- Set of CTS = False modem signals the impossibility of further admission, the computer must suspend transmission of data.
- Set of CTS = True, the modem reports that it can continue to exchange data.
- Set RTS = False computer tells the modem to the temporary suspension of the exchange.
- Modem stops receiving a signal exchange RTS = False, announces the suspension of the exchange of signal CTS = False
- Computer is once again ready to receive data and it exhibits a signal RTS = True
- Modem receives a signal from computer readiness for exchange of exhibits its willingness CTS = True. Then resumed the exchange of data.
- Computer indicates the completion of the exchange of putting RTS = False
- Modem confirms the completion of the exchange of signal CTS = False
- Computer removes the signal DTR, which is a message for the modem to break the connection and hang up.
- The modem lost connection setting signal DSR = False

As shown in Figure 13 uses a modem signal CTS, which allows you to stop the transmission of data, if the receiver is not ready to receive them. The transmitter "released" the next byte only when the line CTS. Bight, which had already begun to spread, delay signal CTS is impossible (this ensures the integrity of the parcel). The hardware protocol provides the fastest response of the transmitter on the state of the receiver.

3.8 Organization of data exchange with software sync

The software protocol for flow control XON / XOFF (Handshaking = 1). Protocol works as follows: if the device receiving the data reveals the reasons why it can not continue to take it on the reverse channel sends a byte-symbol XOFF (13hex). The opposite device, by adopting this symbol, suspend the transfer. When the receiving device is again ready to receive data, it sends a XON (11hex), which is taking the opposite device resumes the transfer. The response time of the transmitter to change the status of the receiver compared to a hardware protocol increases, at least at the time of transmission character (XON or XOFF), plus the response time of the program the transmitter to the reception symbol. The advantage of software protocol is not necessary to transfer control signals interface - minimal cable for two-way exchange can only have 3 wires. The disadvantage of this method is more time to respond and exclusion from the transmitted flux of the two characters (13hex, 11hex).

There is a mixed method for synchronizing data exchange RTS / XOn / Xoff (Handshaking = 3), which is an amalgamation of two previous methods.

3.9 Description of control bits (Parity Control Bit)

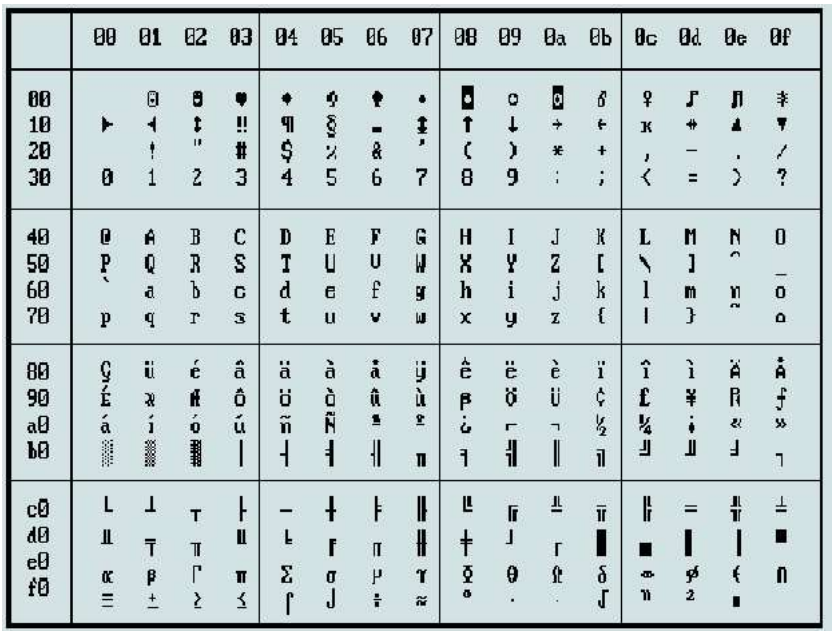
Modes of control bits (Parity Control Bit)

- **N(None) -** checking for parity bit is not used and not exposed;
- **E(EVEN) -** parity, complements transmitted symbols, so that the number of units in the transmitted symbol was even;
- **O(Odd)-** check for odd complements transmitted symbol, so that the number of units in the transmitted symbol was odd;
- **M(MARK) -** parity bit is always equal to one;
- **S(SPACE)-** parity bit is always zero.

3.10 ASCII code table.

To encode characters transmitted via RS-232C uses a table of encoding used symbols and control characters.

Fig.14 The standard ASCII code table



The first 32 characters of code page are the control characters that are designed to control the modem. For example, the use of symbols 17 (11hex) and 19 (13hex) described above, in a software method of controlling the exchange. These characters were developed mainly to manage printers and modems

Table 2. Control characters ASCII.

00(00hex) - NUL empty symbol	08(08hex)- BS backspace	16(10hex)- DLE code switching	24(18hex)- CAN cancel
01(01hex)- SOH start of header	09(09hex)- HT horizontal tab	17(11hex)- DC1 control the first device (XON)	25(19hex)- EM end of medium
02(02hex)- STX start of text	10(0Ahex)- LF line feed	18(12hex)- DC2 control the second device	26(1Ahex)- SUB substitution
03(03hex)- ETX end of text	11(0Bhex)- VT vertical tabulation	19(13hex)- DC3 control device to third (XOFF)	27(1Bhex)- ESC escape
04(04hex)- EOT end of transmission	12(0Chex)- FF Form feed (new page)	20(14hex)- DC4 fourth control device	28(1Chex)- FS file separator
05(05hex)- ENQ request	13(0Dhex)- CR carriage return	21(15hex)- NAK originator referral	29(1Dhex)- GS group separator
06(06hex)- ACK confirmation	14(0Ehex)- SO transition to upper case	22(16hex)- SYN synchronous standby	30(1Ehex)- RS record separator
07(07hex)- BEL bell	15(0Fhex)- SI transition to lower case	23(17hex)- ETB end of transmission block	31(1Fhex)- US unit separator

3.11 Hardware implementation of the COM ports.

For the hardware implementation of the COM ports for RS-232 standard uses a specialized chip UART. UART (Universal Asynchronous Receiver-Transmitter) - universal asynchronous receiver-transmitter. I8250 chip installed in the IBM XT marked the beginning of a series of chip UART, which were installed on the motherboard PC.

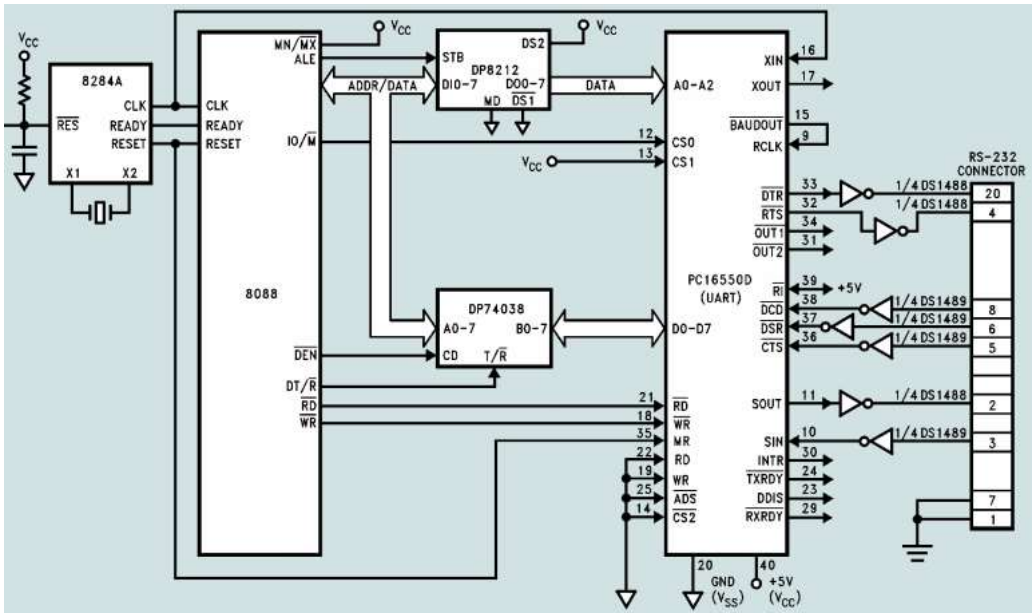
IC UART:

- 8250 - buffer 1 byte
- 16450 - buffer 8 byte
- 16550 - buffer 16 byte
- 16650 - buffer 32 byte
- 16750 - buffer 64 byte
- 16850 - buffer 128 byte
- 16950 - buffer 512 byte
- Hayes ESP - buffer 1024 byte

ICs manufactured by various companies producing: Intel, National Semiconductor, Maxim, etc.

This chip is controlled by a logic circuit with a buffer register for receiving and transmitting serial data. Buffer registers allow to transmit and receive data without CPU. Accordingly, the greater the capacity of the buffer register, the less chip interrupts CPU. Buffer registers are arranged on a "queue" (FIFO) - first come, first-served. Having a portion of data in the transmitting buffer register, UART begins transmitting it to the network RS-232, while it can receive data from the network RS-232 to the reception buffer register. Software at any time may apply to the receive buffer UART, thus freeing him to receive the following data. When filling out the receive buffer UART can interrupt CPU, informing him of the buffer is full. Filling in the receive buffer will stop receiving data from the network RS-232, until it will not be read. Consider the example of the work UART chip PC16550D

Fig.15 Standard scheme include UART PC16550D with microprocessor Intel 8088



Appeal to the chip via the address space I / O ports CPU. Circuit is connected to the system bus when activated signal CS0, which is produced when handling CPU to the specified range of addresses of the port. Address I / O ports are set in the BIOS. Usually they have the values: COM1 = 3F8h, COM2 = 2F8h, COM3 = 3E8h, COM4 = 2E8h. The inputs UART A0, A1, A2 served three junior level address bus CPU. Address specified in the BIOS is the start address of address range (A2A1A0 = 000). Hence a full range of addresses for each port is 8 addresses (from A2A1A0 = 000 A2A1A0 = 111). For example, COM4, 2E8h, 2E9h, 2EAh, 2EBh, 2ECh, 2EDh, 2EEh, 2EFh.
The distance between the starting port address is 16, which allows further use of chips with four initial address lines. Appeal to the chip at a particular address provides access to the group of control registers or buffer registers to send and receive. CPU can write data to the UART registers putting signal WR = 0, or read the data, putting the signal RD = 0.

3.12 Software implementation of UART.

UART has 12 registers that can be accessed on the eight input-output port address.
Since the individual addresses for each register is missing, then use the splitting of the address space using the following methods:

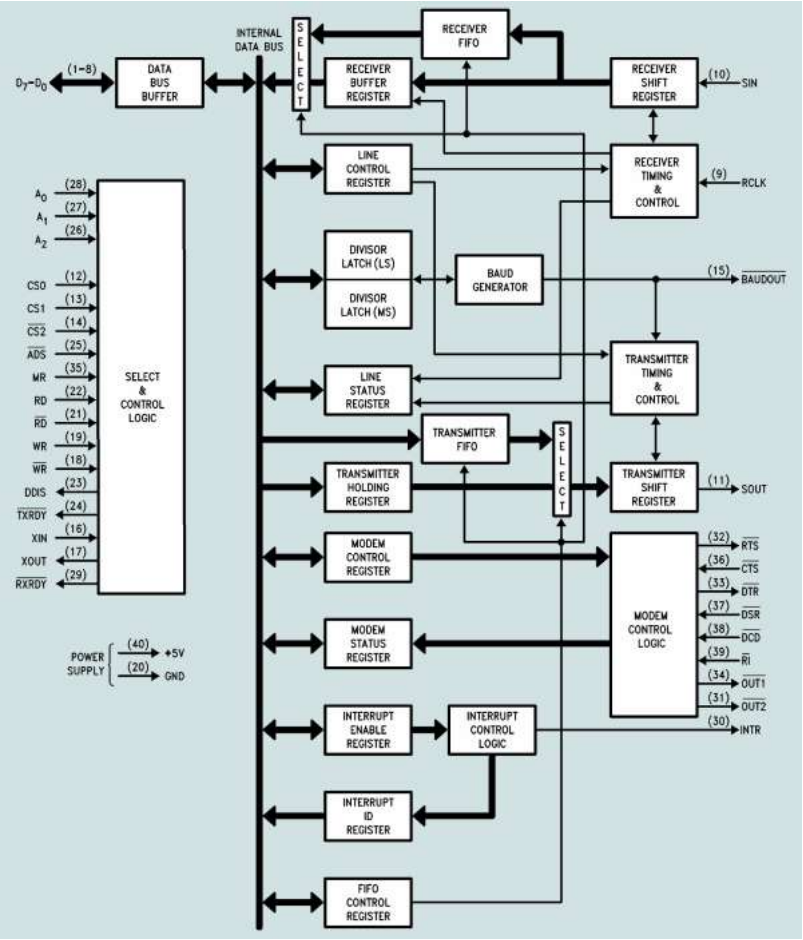
1.Separation of one address space into two register write / read.
When the signal is read RD = 0 read one register, on a signal recording WR = 0 is written the second register.
That is, data on the same address written to or read from different registers
There are four registers:
THR, RBR - at UART 00h(A2A1A0=000)
IIR, FOR - at UART 02h(A2A1A0=010)
These registers are unilateral, that is, one can only record, in others only read the data.

2.The use of additional address bits
Use the 7th bit register LCR-located at UART 03h (A2A1A0 = 011).
This bit is called the DLAB, when DLAB = 0, then the read / write using one register
If DLAB = 1, then the read / write using the second register.
Such registers are five:
THR & RBR), DLL - at UART 00h (A2A1A0 = 000)
DIM, IER - at UART 01h (A2A1A0 = 001)

Table 3. Registers of UART.

address	DLAB	Read/Write	Register Name
00h	0	WR	THR(Transmit Holding Register)
00h	0	RD	RBR(Receiver Buffer Register)
00h	1	RD/WR	DLL(Divisor Latch LSB)
01h	1	RD/WR	DIM(Divisor Latch MSB)
01h	0	RD/WR	IER(Interrupt Enable Register)
02h	x	RD	IIR(Interrupt Identification Register)
02h	x	WR	FCR(FIFO Control Register)
03h	x	RD/WR	LCR(Line Control Register)
04h	x	RD/WR	MCR(Modem Control Register)
05h	x	RD/WR	LSR(Line Status Register)
06h	x	RD/WR	MSR(Modem Status Register)
07h	x	RD/WR	SCR(Scratch Pad Register)

Figure 14 Functional diagram of UART PC16550.



THR-Transmit Holding Register (write-only) (Transmit Holding Register)

Fig.17 Register THR (address=00h, DLAB=0, WR)

7	6	5	4	3	2	1	0
D7	D6	D5	D4	D3	D2	D1	D0

In this register write data bytes, defined as a character (from 5 to 8 bits) which will be referred to a communication line. Symbol, adopted at THR is transmitted further in the shift register bit junior forward (see Figure 7). At the beginning of a symbol is added to start bit, the end of the symbol is added to stop bit. Before the stop bit may be a bit of parity. If the symbol is shorter than 8 bits, then the older bits in the register THR ignored (not used, although written in this register). Register THR may take only one byte of data and transmit it to the serial shift register. Most UART mode is FIFO, where data is loaded not in THR, but the register FIFO. For example, UART PC16550 a register FIFO, which can take 16 bytes of data. In addition, there are some UART mode DMA, in this mode, the shift register is filled with bytes of data directly from memory without the microprocessor.
To indicate that the THR register is empty and it can be downloaded the next byte of data using bit 5 of register LSR. This bit is called the THRE (Transmitter Holding Register Empty) - "awaiting transfer data register is empty." If the THRE = 1, then the register THR can send another data byte in the FIFO mode, this bit indicates that the register FIFO is empty and you can send the next packet of data bytes. Beat THRE interrupt may be the source CPU.

RBR- receiver buffer register (read only) (Receiver Buffer Register)

Fig.18 Register RBR (Address=00h, DLAB=0, RD)

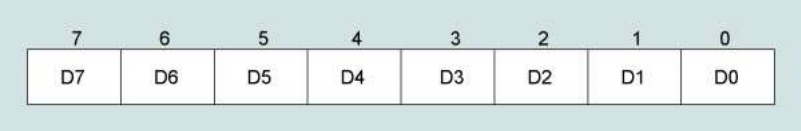
7	6	5	4	3	2	1	0
D7	D6	D5	D4	D3	D2	D1	D0

In this case bytes (characters) are taken from the receive shift register. Register of RBR can take only one byte of shearing the receiver register. Similarly, the transmission of UART there is a register FIFO, which can take longer than one byte of data passing register RBR. By the time of completion of a shift register receiving register RBR must be released to receive the next byte, otherwise there will be overflow error. When RBR register occurs when data is read from the microprocessor. That character is lost as a result of the overflow register bit 1 reports LSR. This bit is called the OE (Overrun Error) - "overflow error", OE = 1 means that one of the transmitted symbols is lost.
That byte is ready for reading by a microprocessor (ie fully detrained from the output shift register or FIFO) said bit 0 register LSR. This bit called DR (Receiver Data

Ready) - "These receivers are ready." DR = 1 indicates that the register RBR (or FIFO) has received bytes and must be read, DR is reset to zero after reading the register RBR microprocessor. This bit may also initiate interrupt the microprocessor.

DLL-low byte of the frequency divider: 16 (read / write) (Divisor Latch LSB)

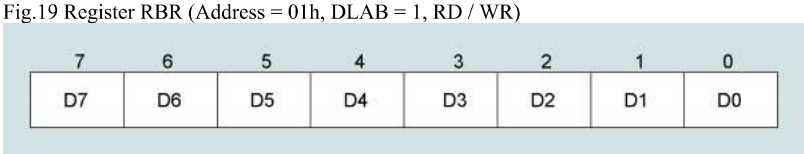
Fig.19 Register RBR (Address=00h, DLAB=1, RD/WR)



In this register is the low byte of the frequency divider divided by 16.

DIM-hig byte on the frequency divider: 16 (read / write) (Divisor Latch MSB)

Fig.19 Register RBR (Address = 01h, DLAB = 1, RD / WR)



In this case is the highest byte of the frequency divider divided by 16.
In the chip UART frequency quartz master is divided by frequency divider (Decimal Divisor), which is obtained from the two-byte number (DIM, DLL) multiplied by 16. Thus the frequency divider sets the speed of data exchange via UART.
Entry registration DIM and DLL senior and junior two-byte number of bytes that you specify the exchange rate of the COM port in bits / sec
For quartz UART frequency f = 1,8432 MHz frequency divider: 16 is the formula

D=115200/V, where V-speed in bit / sec, D = frequency divider: 16

For quartz UART frequency f = 24 MHz, the frequency divider: 16 is the formula

D=1 500 000/V, where V-speed in bit / sec, D = frequency divider: 16

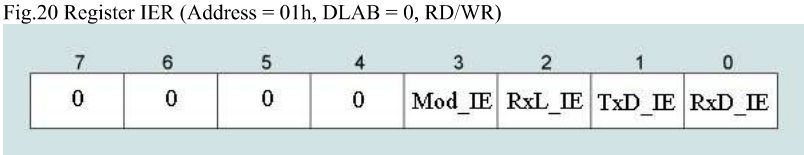
Table 4. Frequency divider for UART PC16550.

	1,8432 МГц			**24 МГц**		
Speed bps	subgroup: 16	DIM	DLL	subgroup: 16	DIM	DLL
50	2304	09h	00h	30000	75h	30h
75	1536	06h	00h	20000	4Eh	20h
110	1047	41h	07h	13636	35h	44h
150	768	03h	00h	10000	27h	10h
300	384	01h	80h	5000	13h	88h
600	192	00h	C0h	2500	09h	C4h
1 200	96	00h	60h	1250	04h	E2h
1 800	64	00h	40h	833	03h	41h
2 000	58	00h	3Ah	750	02h	EEh
2 400	48	00h	30h	625	02h	71h
3 600	32	00h	20h	417	0h	A1h
4 800	24	00h	18h	312	01h	38h
7 200	16	00h	10h	208	00h	D0h
9 600	12	00h	0Ch	156	00h	9Ch
14 400	8	00h	08h	104	00h	68h
19 200	6	00h	06h	78	00h	4Eh
28 800	4	00h	04h	52	00h	34h
38 400	3	00h	03h	39	00h	27h
57 600	2	00h	02h	26	00h	1Ah
115 200	1	00h	01h	13	00h	0Dh
250 000	x	x	x	6	00h	06h
300 000	x	x	x	5	00h	05h
375 000	x	x	x	4	00h	04h
500 000	x	x	x	3	00h	03h
750 000	x	x	x	2	00h	02h
1 500 000	x	x	x	1	00h	01h

As seen from Table 4, the COM port of your PC (with UART 16550 and above) can operate at speeds up to 1,5 Mb/s

IER-interrupt enable register (read / write) (Interrupt Enable Register)

Fig.20 Register IER (Address = 01h, DLAB = 0, RD/WR)



7	6	5	4	3	2	1	0
0	0	0	0	Mod_IE	RxL_IE	TxD_IE	RxD_IE

Interrupt enable register allows the resolution of certain events causing interruption of the microprocessor.

Bit 0. **RxD_IE** If RxD_IE = 1, then allowed to interrupt for receiving data, this interrupt occurs when it is necessary to take a symbol from the register of RBR (in regime FIFO - interrupt timeout).

Bit 1. **TxD_IE** - If TxD_IEE = 1, then allowed to interrupt for data transmission, this interrupt occurs when the transmitting buffer is empty and need to download the bytes in the register of THR.

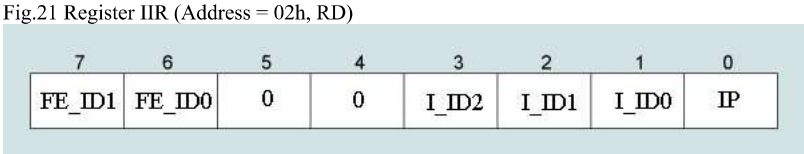
Bit 2. **RxL_IE** - If RxL_IE = 1, then allowed to interrupt at breakage of communication lines or an error in receiving data, this interrupt occurs when the line status register LSR connection will be exposed bits of these errors.

Bit 3. **Mod_IE** - If Mod_IE = 1, then allowed to interrupt when changing the status of any of the input signals RST, CTS, DCD, RI, this interrupt occurs when the state of the input signals COM-port has changed.

Bit 4..7. Not used, always equal to 0.

IIR-register identifies the interrupting (Read) (Interrupt Identification Register)

Fig.21 Register IIR (Address = 02h, RD)



7	6	5	4	3	2	1	0
FE_ID1	FE_ID0	0	0	I_ID2	I_ID1	I_ID0	IP

To minimize software, UART has prioritized interrupts into four levels and records these interruptions in the IIR. Four levels of interrupt are arranged in order of priority conditions for termination specified register - RLS; RDR; THR; and MSR. When the CPU accesses IIR, UART freezes all interrupts and indicates the highest priority deferred interrupt for the CPU. During interrupt processing, UART records new interrupts, but does not alter their current sign, to complete processing.

Bit 0. **IP**(Interrupt Pending) If IP = 1, then all interrupts are processed. If IP = 0, ie the raw interrupts.

Bit 1. **I_ID0**(Interrupt ID Bit0) Zero bit interrupt identifier
Bit 2. **I_ID1**(Interrupt ID Bit1)- First bit of the interrupt identifier
Bit 3. **I_ID2**(Interrupt ID Bit2)- The second bit interrupt identifier

Table 5. Identification of the interrupt (normal mode)

I_ID2	I_ID1	I_ID0	Priority	Identification
x	0	0	Fourth	Changed the modem status, reset the register reading MSR.
x	0	1	Third	Register THR launch, expected bytes of CPU. Reset write byte in THR
x	1	0	Second	Received data bytes in the register of RBR, resets the register reading RBR.
x	1	1	Highest	Break the line or error on the line, reset the register reading LSR.

Table 6. Identification of the interrupt (mode FIFO)

I_ID2	I_ID1	I_ID0	Priority	Identification
0	0	0	Fourth	Changed the modem status, reset the register reading MSR.
0	0	1	Third	The buffer register transfer FIFO trigger, waiting for data from the CPU. Reset the record in the transmitting FIFO buffer
0	1	0	Second	Receiving FIFO buffer is full, reset reading the receive buffer FIFO.
0	1	1	Highest	Break lines or error on the line, dropped reading LSR register
1	0	0		
1	0	1		
1	1	0	Second	LED timeout (per 4-fold interval symbol is not transmitted and not taken a single character, although in buffer FIFO has at least one character). Reset is performed reading the receive buffer FIFO.
1	1	1		

Bit 4..5.Reserved

Bit 6. **FE_ID0**(FIFOs Enabled ID Bit0) -Zero bit identifier mode FIFO
Bit 7. **FE_ID1**(FIFOs Enabled ID Bit1)- First bit identifier mode FIFO

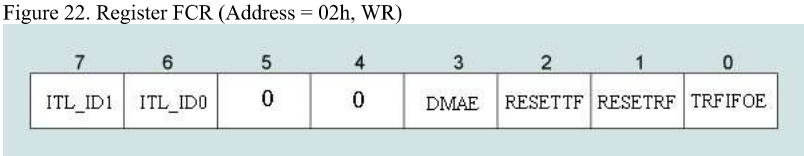
Table 7. Identification FIFO mode

FE_ID1	FE_ID0	Mode
0	0	Normal mode, data is transferred byte by byte through the registers and THR RBR
0	1	

1	0	mode FIFO for UART 16550.
1	1	mode FIFO for UART 16550A.

FCR-register mode control FIFO (record) (FIFO Control Register)

Figure 22. Register FCR (Address = 02h, WR)



This register is used only for recording, the data are located in the register IIR. This register is used to resolve regimes FIFO, clear the buffers FIFO, set the level of filling buffers FIFO, and select the type of DMA (direct memory access).

Bit 0. **TRFIFOE**(Transmit And Receive FIFO Enable)- Record 1 to this bit allows both FIFO mode transmitter (XMIT) and receiver (RCVR). Reset bit to 0 will clear all bytes in both buffers FIFO. When FIFO mode is changed to 16450 and vice versa, FIFO buffers are automatically cleared. This bit must be 1, when the recording of your other bits of the register FCR, otherwise they will not be programmed.

Bit 1. **RESETRF**(Reset Receiver FIFO)-Record 1 to this bit clears all bytes in the receive buffer FIFO and resets its counter to 0. Shift register is not cleared at the same time. Thereafter 1 in this bit is reset to 0.

Bit 2. **RESETTF**(Reset Transmitter FIFO)- Record 1 to this bit clears all bytes in the transmitter buffer FIFO and resets its counter to 0. Shift register is not cleared at the same time. Thereafter 1 in this bit reset to 0.

Bit 3. **DMAE**(DMA Enabled)- Record 1 in this bit changes the signal UART RxRDY and TxRDY from 0 to 1, provided that the FCR (bit0) = 1. These hardware signals are used to organize work properly for DMA in the microprocessor system.

Bit 4..5.Reserved.

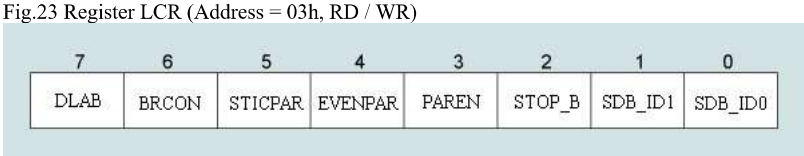
Bit 6. **ITL_ID0** (Interrupt Trigger Level ID bit0) - Zero bit identifier trigger level interrupts.
Bit 7. **ITL_ID1**(Interrupt Trigger Level ID bit1)- First bit of the ID trigger level interrupt.
These two bits set identifier, which specifies the level at which the interrupt will be generated when receiving data in a mode FIFO. Level sets the number of bytes in the receiver (RCVR) buffer FIFO.

Table 8. Identification Triger level interrupt

ITL_ID1	ITL_ID0	level interrupt byte
0	0	01
0	1	04
1	0	08
1	1	14

LCR-line control register communication (read / write) (Line Control Register)

Fig.23 Register LCR (Address = 03h, RD / WR)



This register is used to determine (set) the format of the exchange of asynchronous data transfer Also in this mode, set bit DLAB, which allows the programmer to write and read data from the desired registers .. The programmer can not only write but also read the contents of register LCR. The ability to read simplifies system programming and eliminates the need for a separate area in system memory for storing the characteristics of the line.

Bit 0. **SDB_ID0**(Serial Data Bits ID0) Zero bit ID number of bits in the transmitted symbol.
Bit 1. **SDB_ID1**(Serial Data Bits ID1)- First bit of the ID number of bits in the transmitted symbol.
With these bits specify the number of bits to send or receive symbol.

Table 9. The number of bits in a symbol data

SDB_ID1	SDB_ID0	the number of bits in a symbol
0	0	5
0	1	6
1	0	7
1	1	8

Bit 2. **STOP_B**(Stop Bits)- This bit determines the number of stop bits transmitted or received in each sequence of characters. If bit STOP_B = 0, then transferred to one stop bit. If bit STOP_B = 1, then stop bit is equal to two for 6,7,8 bit characters and a half stop bits for the 5-bit characters. The receiver checks only the first stop bit, regardless of the exposed stop bits.

Bit 3. **PAREN**(Parity Enable) -If PAREN = 1, then allowed to use the parity bit and this bit is inserted between the last bit of data and stop bit. If PAREN = 0, then the parity bit is not exposed and is not included in the transmitted symbol.

Bit 4. **EVENPAR**(Even Parity Select) - Beat choose the type of parity control. If EVENPAR = 1, it is parity. If EVENPAR = 0, then the system checks for odd.

Bit 5. **STICPAR** (Sticky Parity)- If STICPAR = 0, then bit parity bit is generated in accordance with the parity of the displayed character. If STICPAR = 1, then the constant value control bits: when EVENPAR = 1 - zero, when EVENPAR = 0 - single.

Bit 6. **BRCON**(Break Control)- Managing a bit disconnected. If BRCON = 1, The price of a break in data reception, the transmitter UART will transmit line zeros.

Bit 7. **DLAB**(Divisor Latch Access Bit)- This bit access to the frequency divider. When DLAB = 1, then you can apply to the registers of DIM, DLL are stored junior and senior bytes scaler: 16.Esli DLAB = 0, then you can apply to the registers THR, RBR, IER.

MCR-modem control register (read / write) (Modem Control Register)

Fig.24 register MCR (Address = 04h, RD / WR)

7	6	5	4	3	2	1	0
0	0	0	LOOP	OUT2	OUT1	RTS	DTR

This register controls the interface modem or peripheral device.

Bit 0. **DTR**(Serial Data Bits ID0)(Data Terminal Ready)- This bit controls the output signal DTR (data terminal ready).
When the bits DTR = 1, DTR UART output is set to logic 0, the IBM XT, this signal is inverted by inverter buffer DS1488 (sm.ris.15) to logic 1 ie U = +12 in the (signal DTR COM-port is included)
Accordingly, when the bits DTR = 0, the signal DTR COM-port U =-12V logic 0 (DTR signal is off)

Bit 1. **RTS**(Request To Send)- This bit controls the output signal of RTS (Request to send).
When a bit RTS = 1, RTS UART output is set to logic 0, the IBM XT, this signal is inverted by inverter buffer DS1488 (sm.ris.15) to logic 1 ie U = +12 in the (signal RTS COM-port is included)
Accordingly, when a bit of RTS = 0, the signal RTS COM-port U =-12V logic 0 (RTS signal is turned off)

Bit 2. **OUT1**(OUT1 Bit Control) - Control of auxiliary output OUT1.

Bit 3. **OUT2**(OUT2 Bit Control) - Control of auxiliary output OUT2.

Bit 4. **LOOP**(Loopback Mode Enable) Bit mode diagnosis. When LOOP = 0, then the UART operates normally. When LOOP = 1, then URAT member of the stuff diagnostic mode with feedback, in this mode auxiliary signals OUT1 and OUT2.

Bit 5..7. Reserved.

LSR-line status register communication (read / write) (Line Status Register)

Fig.25 Register LSR (E = 05h, RD / WR)

7	6	5	4	3	2	1	0
FIFOE	TEMPT	THRE	BD	FE	PE	OE	DR

This register shows the state of the transceiver.

Bit 0. **DR**(Receiver Data Ready) — Availability of data priemnika.DR = 1 informs that the data received and loaded into the RBR register or receive buffer FIFO. Bit is reset to zero when all data will be read from the CPU register or buffer RBR FIFO.

Bit 1. **OE**(Overrun Error) — bits overflow. Bit indicates that the data in the register of RBR were not read by CPU before the next character was transferred to the RBR, which led to the loss of the previous character. Bit set to OE = 1, after the detection of overflow and reset whenever the SPU reads the contents of the register LSR.

Bit 2. **PE**(Parity Error) Bit-error control bits pariteta.PE = 1 if the character is received with parity error.

Bit 3. **FE**(Framing Error) Frame error (wrong stopbit).

Bit 4. **BD**(Break Detected)- Indicator line break (the receiver input is at 0 least now make a character).

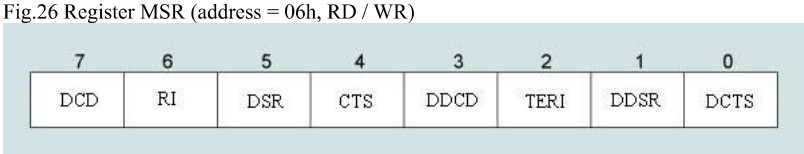
Bit 5. **THRE**(Transmitter Holding Register Empty) - Register the transmitter is ready to accept bytes for transmission. In the FIFO mode, indicating a lack of characters in the FIFO-buffer transfer. It may be the source of interruption.

Bit 6. **TEMPT**(Transmitter Empty Status) Register the transmitter is empty (no data for transmission or in the shift register, or in the buffer THR or FIFO).

Bit 7. **FIFOE**(FIFO Error Status) Error is made on-line data FIFO (buffer contains at least one symbol, adopted by the error size, parity or a cliff). In no FIFO-mode is always 0.

MSR-modem status register (Modem Status Register)

Fig.26 Register MSR (address = 06h, RD / WR)



This register allows the CPU to control the current state of control lines modem or peripheral device. In addition, four bits (0 .. 3) MSR register control signal change at the inputs of CTS, RTS, RI, DCD chips and generate interrupt the microprocessor.

Bit 0. **DCTS**(Delta Clear To Send) - Change state signal CTS (cleared to send). Bit is set to DCTS = 1 when changing the CTS signal at the input circuit and is reset when reading the MSR register of the microprocessor. When you install the bits in a generated interrupt the microprocessor.

Bit 1. **DDSR**Delta Data Set Ready) - Changing the status signal DSR (setting data is ready). Bit is set in DDSR = 1 when changing the DSR signal input circuit and is reset when reading the MSR register of the microprocessor. When installing a bit in a microprocessor interrupt is generated.

Bit 2. **TERI**(Trailing Edge Of Ring Indicator) - Detect the trailing edge signal RI (ring indicator). Bit set to TERI = 1, when the signal on pins RI changes its level from low to high. Bit is reset to TERI = 0 when reading MSR register microprocessor. When installing a bit in a microprocessor interrupt is generated.

Bit 3. **DDCD**(Delta Data Carrier Detect) - Changing the status signal DCD (detected information carrier). Bit is set in DDCD = 1 when changing the DCD signal on the input circuit and is reset when reading the MSR register of the microprocessor. When installing a bit in a microprocessor interrupt is generated ..

Bit 4. **CTS**(Clear To Send) - Line Status CTS. If CTS = 1, then the input of the CTS COM port voltage is +12 V (CTS signal is active). If CTS = 0, then the input COM port voltage is-12V (CTS signal is passive). In the diagnostic mode this bit is equivalent to the RTS bit register MCR.

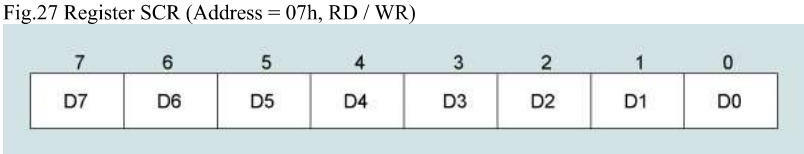
Bit 5. **DSR**Data Set Ready) - Line Status DSR. If DSR = 1, then the input of the DSR COM port voltage is +12 V (DSR signal is active). If DSR = 0, then the input COM port voltage is-12V (DSR signal is passive). In the diagnostic mode this bit is equivalent to the DTR bit register MCR.

Bit 6. **RI**(Ring Indicator) - Status line RI. If RI = 1, then the input of the DSR COM port voltage is +12 V (RI signal is active). If RI = 0, then the input COM port voltage is-12V (RI signal is passive). In the diagnostic mode this bit is equivalent to OUT1 bit register MCR.

Bit 7. **DCD**(Data Carrier Detect) - Line Status DCD. If DCD = 1, then the input DCD COM port voltage is +12 V (DCD signal is active). If DCD = 0, then the input COM port voltage is-12V (DCD signal is passive). In the diagnostic mode this bit is equivalent to OUT2 bit register MCR.

(SCR-register for temporary storage (read / write) (Scratch Pad Register)

Fig.27 Register SCR (Address = 07h, RD / WR)



Register for temporary storage, work does not affect UART is designed for temporary storage of data (UART i8250 absent).

3.13 Diagnostic mode UART.

UART mode diagnosis enables you to test COM ports are not connected to them peripherals. Diagnostic mode enabled bit LOOP = 1 register MCR.
It is organized within the UART hardware "flags":

- transmitter output is translated into a state of the logical unit;
- receiver input is turned off;
- output shift register of the transmitter is connected to the input of the receiver;
- inputs DSR, CTS, RI, DCD are disconnected from the input lines of COM-port and the data they receive from the register MCR (bits RTS, DTR, OUT1, OUT2);
- modem control outputs are translated into a passive state (logic nil).

The hardware "flags" can send and receive data directly COM port, without any connection to it. As a result, may test the shift register and the refinement of the system interrupts, etc.

§4 Programming the COM-port.

4.1. Programming in MS-DOS.

In MS-DOS programming COM ports can be the whole range of software tools: the direct source microprocessor (assembler), features BIOS, operating system, high level programming language.

4.1.1. Programming the COM port direct code microprocessor.

Under the direct programming code refers to programming the microprocessor UART chip through I / O ports with the commands of the microprocessor. The system commands the microprocessor commands the OUT and IN, which allow to read / write bytes to the address I / O port. In p.3.12 described 12 registers chip UART, which completely determine the specified chip. You simply write the necessary data to these registers to make the COM port to perform the desired action. When programming the UART registers to keep in mind that the memory addresses are BIOS I / O ports for COM 1 ... COM4. By default, they equal COM1 = 3F8h, COM2 = 2F8h, COM3 = 3E8h, COM4 = 2E8h, but there are "Crank" that can change them in the settings of BIOS. Therefore, before the programming port to MS-DOS it is desirable to check the addresses of the COM ports. The BIOS address of COM port occupies 2 bytes, and are in the memory cells at addresses COM1: 40 ... 41h, COM2: 42 ... 43h, SOM3: 44 ... 45h, COM4: 46 ... 47h.

Command I / O CPU:

- **IN AL,port8-** input byte in the AL register from the specified port;
- **IN AL,DX-** input byte in the AL register from the port at the address specified in DX;
- **OUT port8,AL-**output byte of register AL specified port;
- **OUT DX,AL-** output byte of register AL port at the address listed in the DX;

Example:

```
'write the LCR mode COM port:
'8 bits per symbol, 1 stop bit, parity check on the parity issue in the case of termination 0, DLAB = 1
        mov al,DBh 'writes in the AL value for the register LCR = DBh
        mov dx,3fbh
        out dx,al'writes data to the register UART LCR
'set the exchange rate 115 000 bps DIM = 00h, DLL = 01h
        mov al,01h
        mov dx,3f8h
        out dx,al 'write register DLL = 01h
        mov al,00h
        mov dx,3f9h
        out dx,al 'write register DIM=00h
'charge a bit DLAB = 1
        mov al,5Bh 'DLAB=0
        mov dx,3fbh
        out dx,al
'send byte 03h in the line of communication
        mov al,03h
        mov dx,3f8h
        out dx,al 'sends a byte of 03h at a speed of 115,000 bits / sec
```

Before recording bytes of data in the register of the transmitter must ensure that the register storing the transmitter is free, that is to make sure that the transfer of the previous character is complete. Indication that the transmitter register is free, is set bit 5 (THRE = 1) line status register LSR

In the same way as is done in the transfer of data before entering a character from the port receiver must make sure that bit 0 of LSR register is set (ie, DR = 1). This means that the symbol adopted from the line and is located in the buffer unit.

4.1.2. Programming the COM port using the BIOS functions.

The BIOS has functions that can be performed by a team of software interrupts microprocessor INT 00h ... INT 1Fh. Since the code of these functions is located in the BIOS, then their implementation is possible even when no operating system on your PC.
In addition, the BIOS functions operate on the numbers of COM ports, but not at I / O, significantly more convenient.

Consider the BIOS functions that are used to working with the COM port of:

The function of interrupt INT 14h

Program interrupt handler that, as we have said, is in the BIOS on the vector 14h
BIOS is a non-volatile memory of the PC, so download the program handles the interrupts do not, it is always in memory.
A function call made to the number function, which is written in the byte on the battery (AH).
Example:

```
        mov ah,00h 'number function
        int 14h    'function call
```

Consider the function caused by INT 14h:

INT 14h AH=00h-Initialize the COM port.
By initializing the port (also used the term "opening") understand the installation of all its parameters: the port number, the length of the symbol, the number of the stop bit, the parity and the rate of exchange.

inputs INT14h AH=00h		
Register	Hig	low

AX	00h	byte communication parameters
BX		
CX		
DX	(n-1), Where n-number of COM port	

DX: 0000h-COM1, 0001h-COM2, 0002h-COM3, 0003h-COM4

byte communication parameters									
7	6	5	4	3	2	1	0	description	allowable values
x	x	x						speed bps	000- 110 001- 150 010- 300 011- 600 100- 1200 101- 2400 110- 4800 111- 9600
			x	x				parity	00- no 01- odd 10- no 11- even
					x			length of stop bit	0- 1 1- 2
						x	x	count. bits per symbol	10- 7 11- 8

Example function call:

```
mov ah,00h 'number function
mov al,EBh '9600 bps,odd,1 stop, 8 bit
int 14h    'function call
```

After the function returns the output parameters:

output parameters INT14h AH=00h		
register	Hig	Low
AX	byte state line LSR	byte of the modem status MSR
BX		
CX		
DX		

As an output parameter in the accumulator register are copied to registers of UART LSR (see.fig.25) and MSR (see fig.). From the above, will be seen that work with COM port via BIOS INT14h function is limited in speed and number of bits per symbol.

*INT 14h AH=01h*Write the character in the COM port.
When calling this function is transferred to the character from the register AL to port number specified in register DX.

inputs INT14h AH=01h		
register	Hig	Low
AX	01h	character
BX		
CX		
DX	(n-1), where n-number of COM port	

After the function returns the output parameters:

output parameters INT14h AH=01h		
register	Hig	Low
AX	byte state line LSR	character
BX		
CX		
DX		

INT 14h AH=02h-Read a character from the COM port.
When calling this function is reading the symbol from the output register the COM port number specified in register DX, to register AL.

inputs INT14h AH=02h		
register	Hig	Low
AX	02h	
BX		
CX		
DX	(n-1), where n-number of COM port	

After the function returns the output parameters:

output parameters INT14h AH=02h		
register	Hig	Low
AX	byte state line LSR	character
BX		
CX		
DX		

INT 14h AH=03h Query the state of the COM port.
When calling this function reads the LSR and MSR registers from the specified UART.

output parametersINT14h AH=03h		
register	Hig	Low
AX	03h	
BX		
CX		
DX	(n-1), where n-number of COM port	

After the function returns the output parameters:

output parameters INT14h AH=03h		
register	Hig	Low
AX	byte state line LSR	byte of the modem status MSR
BX		
CX		
DX		

*INT 14h AH=04h*Extended-initialize the COM port.
Suitable for models PS / 2.

inputs INT14h AH=04h		
register	Hig	Low
AX	04h	setting interrupt
BX	Set Parity	setting of stop bit
CX	bits per character	speed, bps
DX	(n-1), where n-number of COM port	

- AL: 00h-no interruptions, 01h-is interrupted
- BH: 00h-no, 01h-odd, 02h-even, 03h-stack at the odd, 04h-stack even
- BL: 00h-1 stop,01h-2 stop (1.5 for 5 bit per character)
- CH: 00h-5 bit,01h- 6 bit,02h- 7 bit,03h- 8 bit
- CL: 00h-110,01h-150,02h-300,03h-600,04h-1200,05h-2400,06h-4800,07h-9600,08h-19200 bps
- DX: 00h-COM1,01h-COM2,02h-COM3,03h-COM4

After the function returns the output parameters:

output parameters INT14h AH=04h		
register	Hig	Low
AX	byte state line LSR	byte of the modem status MSR
BX		
CX		
DX		

INT 14h AH=05h Read / write modem control register MCR.
Suitable for models PS / 2.
Reading the register MCR

output parameters INT14h AH=05h		
register	Hig	Low
AX	05h	00h
BX		
CX		
DX	(n-1), where n-number of COM port	

After the function returns the output parameters:

output parameters INT14h AH=05h		
register	Hig	Low

AX	
BX	Register MCR
CX	
DX	

Writes Register MCR

output parameters INT14h AH=05h		
register	Hig	Low
AX	05h	01h
BX		Register MCR
CX		
DX	(n-1), where n-number of COM port	

After the function returns the output parameters:

output parameters INT14h AH=05h		
register	Hig	Low
AX	byte state line LSR	byte of the modem status MSR
BX		
CX		
DX		

4.1.3. Programming the COM port by means of MS-DOS.

Although the COM port and is the main communication tool for PC, MS-DOS is practically very little software tools to work effectively with the port. Consider the basic software operating system MS-DOS:

The function of interrupt INT 21h

There are four functions of the software interrupt INT 21h to work with the COM port: 03h, 04h, 3Fh, 40h.
Before the description of these functions take a look at the concept of "descriptor. Descriptor is an identifier of the serial device (object) or a file in the MS-DOS. From the perspective of the program descriptor is an integer that indicates a specific program structure (object), which (who) provides a performance from the unit (object) with the OS. Who are "friendly" with Windows, knows how important a descriptor (handle) in this system, but the beginning of this was in MS-DOS.
In MS-DOS first number of descriptors given standard serial devices:

Handle	Name	Device
0	CON	standard input device (keyboard)
1	CON	standard output device (display)
2	CON	standard output errors (always CON)
3	AUX	accessory (default COM1)
4	PRN	standard printing (default LPT1)

Descriptor number 3 is called AUX, I / O address of the device is in the cells BIOS addresses 40h, 41h. These cells determine the input / output COM1, if these cells to record the number 2f8h, then the input-output device on the handle 3 will COM2. Thus, the descriptor 3 (AUX) can be assigned to any serial device

INT 21h AH=03h-Character input from AUX.
This function is waiting for input characters from a standard accessory, AUX

inputs INT21h AH=03h		
register	Hig	Low
AX	03h	
BX		
CX		
DX		

After the function returns the output parameters:

output parameters INT21h AH=03h		
register	Hig	Low
AX		Character
BX		
CX		
DX		

Entering characters on this function is not buffered and should poll on the readiness of data in UART. To read the next symbol must be sure that the 5-th bit LSR register is 1 (DR = 1).

*INT 21h AH=04h*Write the character in AUX.
This function writes the character in a standard accessory AUX

inputs INT21h AH=04h		
register	Hig	Low
AX	04h	
BX		
CX		
DX		Character

Output parameters of this function is not.

*INT 21h AH=3Fh*Read-data through a descriptor.
When you call this function reads the number of characters stored in the register CX from the device to handle the number of which is recorded in the register BX. Read data stored in the buffer, the first element of which is specified in DS: DX. After performing a function in register AX displays the number of received symbols. If CX = AX and flag CF = 0, then the function is executed without errors.

INT 21h AH=40h-Write data through a descriptor.
When you call this function, number of characters specified in the CX written to the device number of the descriptor specified in BX. The data contained in the buffer at the address listed in the DS: DX. After calling in the AX register returns the number of transmitted symbols.

Hardware interrupts

As the process of serial data is slow, you can do it in the background using interrupts at the end of the transmission or reception of a symbol. Recall that the COM1 port corresponds to the hardware interrupt IRQ4 with the vector INT 0Ch, and COM2 - IRQ3 with the vector INT 0Bh. To enable interrupts, you must install bits of interrupt control register IER (UART), corresponding to those interrupts that need to handle. When there is an interrupt handler routine located at the specified interrupt vector must analyze the cause of the interruption, by reading a register that identifies the interrupt IIR. Do not forget that at the end of hardware interrupt handler should be on the sequence of commands:

```
mov al, 20h
out 20h, al
iret
```

To be able to handle multiple interrupts.

Using MS-DOS commands

In MS-DOS has a number of built-in commands to run and configure the COM port. Commands can be inserted into a batch file with the extension. Bat to execute them in a given scenario.

Command MODE

Command Mode is intended to change the mode of peripheral devices. Format:

```
Mode COMx,bps,parity,frame,stop,P

  where: x-number of the COM port;
 bps- speed: 110,150,300,600,1200,2400,4800,9600,19200 bps;
  parity-n-No, o-Odd, e-Even;
  Frame- Bit per Charscter: 7,8;
  Stop- number stops bit: 1,2
  P- specifies the mode of repeat attempts transmission failure.
```

Example of MS-DOS commands to control the COM ports:

- Create a text file (such as Notepad) Test.txt
- Write to him the lines and save:

```
Mode COM1,9600,n,8,1,P
type c:\data.txt>com1
```

- Change the file extension from. Txt to. Bat
- Create a text file c: \ data.txt
- Write down a string of text and end the string Enter
- Run Test.bat

As a result of the execution batch file Test.bat string recorded in the data.txt file will be sent to COM1 at 9600 baud, with parity, 8 bits in a symbol, with one stop bit.
In this batch file we used three MS-DOS command:

- **Mode** Setting the COM port
- **Type** Output
- >- Output redirection

In Windows it is also possible execution of batch files, but the parameters should be recorded commands somewhat differently:

```
mode com1 baud=9600 parity=n data=8 stop=1
type c:\data.txt>com1
```

In addition, the Windows line ends with Enter symbol not necessarily.

4.2. Programming Windows.

Programming with Windows 2000 and above differs from programming in MS-DOS. First, COM1-COM4 in these systems is not the standard I / O addresses and interrupt standard rooms, Windows automatically allocates resources for COM-ports. So if you want to program a serial port through the I / O ports, you will need, first determine the resources that takes a serial port on this PC. Secondly, Windows did not give a direct opportunity to work with I / O ports is possible only in programming at the kernel level OS (which is not easy). In principle, the option of programming is possible, that is, write a kernel module to work with I / O ports and a program to work with the COM port is working through this driver.

But, not all that bad. Naturally Windows developers should consider the possibility of working with communication ports via the user interface of Windows. This method is probably even easier than programming COM port via I / O ports. In Windows, a COM-port can be accessed as a file (stream). The advantage of this method are obvious: you do not have to think about the type of chip UART, on numbers of I / O ports and IRQ numbers. OS transparent to the programmer works with the hardware part of the communication port.

4.2.1. Programming the COM port using Windows API functions.

Try to create a folder in Windows Explorer or a file named "COM1", do not work it out. The Windows reserved names from COM1 to SOM9 to work with COM ports.

Let us consider the programming of COM port using API-functions:

1. To work with the COM port, the first thing to do is open the port.
This can be done using API functions **CreateFile** from the library "kernel32" :
This function creates new object and assigns it a handle by which this object will be working. Example descriptions CreateFile function in C:

```
HANDLE CreateFile(
                LPCTSTR               lpFileName,
                DWORD                 dwDesiredAccess,
                DWORD                 dwShareMode,
                LPSECURITY_ATTRIBUTES lpSecurityAttributes,
                DWORD                 dwCreationDistribution,
                DWORD                 dwFlagsAndAttributes,
                HANDLE                hTemplateFile
                        );
```

Example of declaring a function CreateFile in the language of VB6:

```
Declare Function CreateFile Lib "kernel32" Alias "CreateFileA" (ByVal lpFileName As String, ByVal dwDesiredAccess As Long, ByVal dwShareMode As Long, ByVal lpSecurityAttributes As Long, ByVal dwCreationDisposition As Long, ByVal dwFlagsAndAttributes As Long, ByVal hTemplateFile As Long) As Long
```

To open the COM port you have to perform this function in the code of his program, with given input parameters. The result of this function will be 32-bit number handle (handle), which you can access the established function of the program object associated with the selected COM port.

Parameters of the function CreateFile:

- **lpFileName**The name of the COM port. It can take values: "COM1" "COM2", "COM3", "COM4", "COM5", "COM6", "COM7", "COM8", "COM9, if more than one digit, the format" \\.\COM47 "
- **dwDesiredAccess-** Access mode faylu.Eto chetyrehbaytovoe number that specifies the various modes of access to the file. We are interested only in reading and writing mode, this mode is given a number: S0000000hex in SI can be written, instead of a constant named "GENERIC_READ | GENERIC_WRITE".
- **dwShareMode-** Mode of sharing. COM port on your PC do not support shared, only one program can open the port. Therefore, this parameter must be set to 0 (regime banned).
- **lpSecurityAttributes-** Attributes of file protection. For the COM port is not used so always equal to 0 ("NULL").
- **dwCreationDistribution-** Auto-mode control file. This chetyrehbaytovoe number, which for the COM port should always be 00000003hex ("OPEN_EXISTING")
- **dwFlagsAndAttributes-** Sets the attributes created fayla.Eto chetyrehbaytovoe number, which for the COM port should always be 0 ("NULL")
- **hTemplateFile-** Descriptor file "template" which was created fayl.Dlya COM ports are not used therefore always equal to 0 ("NULL").

Example opening COM1 in VB6:

```
Com_Handle = CreateFile("COM1:", &HC0000000, 0, 0, 3, 0, 0)
```

Example opening COM1 in C:

```
Com_Handle = CreateFile("COM1", GENERIC_READ | GENERIC_WRITE, NULL, NULL, OPEN_EXISTING, NULL, NULL);
```

2. After opening the COM port you can send and receive data through the COM port.
Used for data transfer API function **WriteFile** from the library **kernel32.**
To receive data using API function **ReadFile** from the library **kernel32.**

Sample of ReadFile and WriteFile in C:

```
BOOL ReadFile(
  HANDLE       hFile, // handle COM port
  LPVOID       lpBuffer, // Pointer to a buffer that receives the read data from the port of
  DWORD        nNumberOfBytesToRead,// The number of bytes that are read from the port of
  LPDWORD      lpNumberOfBytesRead, // Pointer to a variable that receives the number of bytes read
  LPOVERLAPPED lpOverlapped    // Pointer to a structure OVERLAPPED.
                       );

BOOL WriteFile(
  HANDLE       hFile,// handle COM port
  LPCVOID      lpBuffer,// Pointer to a buffer containing the data to be recorded in the file.
  DWORD        nNumberOfBytesToWrite,// The number of bytes to be written to a file.
  LPDWORD      lpNumberOfBytesWritten,//  Pointer to a variable that receives the number of bytes written
  LPOVERLAPPED lpOverlapped // Pointer to a structure OVERLAPPED
        );
```

Example of declaring a function ReadFile and WriteFile in the language of VB6

```
Declare Function ReadFile Lib "kernel32" (ByVal hFile As Long, lpBuffer As Any, ByVal nNumberOfBytesToRead As Long, lpNumberOfBytesRead As Long, lpOverlapped As Long) As Boolean

Declare Function WriteFile Lib "kernel32" (ByVal hFile As Long, lpBuffer As Any, ByVal nNumberOfBytesToWrite As Long, lpNumberOfBytesWritten As Long, lpOverlapped As Long) As Boolean
```

With these functions of the software package can read or write data to the specified buffer.
Example of reading 255 bytes from the port to the array in the language of VB6:

```
Dim File_Buffer(255) As Byte 'receive buffer
Dim Com_Byte_Read As Long 'the number of received bytes
Dim Retval As Boolean
Retval = ReadFile(Com_Handle, File_Buffer(0), 255, Com_Byte_Read, 0)
```

3. After working with the port it needs to close.
Closure of the port is carried API function **CloseHandle** from the library **kernel32.**

Example descriptions of the function CloseHandle in C:

```
BOOL CloseHandle(
         HANDLE hObject   // port handle
          );
```

Example of declaring a function CloseHandlena language VB6:

```
Declare Function CloseHandle Lib "kernel32" (ByVal hObject As Long) As Boolean
```

Example of closing the port in the language VB6:

```
Dim Com_Exit as Boolean
Com_Exit = CloseHandle(Com_Handle)
```

4. Setting of COM port by using the data structures that represent a set of variables of different types. Strukturuy downloaded and read using the API functions.
Consider the basic structure for setting modes COM port:

DCB structure

DCB structure defines the basic settings of the COM port.
It contains the actual information from the registers of UART.

```
  typedef struct _DCB {
      DWORD DCBlength;            // length of the structure (DCB)
      DWORD BaudRate;             // speed bps
      DWORD fBinary:1;            // binary mode
      DWORD fParity:1;            // permission parity
      DWORD fOutxCtsFlow:1;       // tracking CTS
      DWORD fOutxDsrFlow:1;       // tracking of DSR
      DWORD fDtrControl:2;        // mode signal DTR
      DWORD fDsrSensitivity:1;    // sensitivity DSR
      DWORD fTXContinueOnXoff:1;  // continued transmission when XOFF
      DWORD fOutX:1;              // software flow control in transmission (XON / XOFF)
      DWORD fInX:1;               // software flow control when receiving (XON / XOFF)
      DWORD fErrorChar:1;         // replacement of erroneous character
      DWORD fNull:1;              // actions when receiving a zero char
      DWORD fRtsControl:2;        // Specifies the mode of flow control to RTS signal
      DWORD fAbortOnError:1;      // ignoring the read / write error
      DWORD fDummy2:17;           // reserved
      WORD  wReserved;            // not used, is 0
      WORD  XonLim;               // min. number of characters to send XON
      WORD  XoffLim;              // max. number of characters to send XOFF
      BYTE  ByteSize;             // the number of bits in a character
      BYTE  Parity;               // mode of parity 0-4 = no, odd, even, mark, space
      BYTE  StopBits;             // length of stop bit 0,1,2 = 1, 1.5, 2
      char  XonChar;              // Charcter for XON
      char  XoffChar;             // Charcter for XOFF
      char  ErrorChar;            // Charcter for replace errors
      char  EofChar;              // Charcter for End Data
      char  EvtChar;              // Charcter for the event
      WORD  wReserved1;           // reserved
  } DCB;
```

To work with the DCB structure using API functions from the library **kernel32.**:

BuildCommDCB Fills these structures DCB values given in the line management device. Line control device uses the syntax mode MS-DOS.
SetCommState- Configures the communication device according to the data specified in the structure of DCB. The function re-initializes all the hardware and control settings, but not emptied the queue output or input data
GetCommState- Reads the DCB structure.

COMMTIMEOUTS Structure

This structure specifies the timing parameters (delay and timeouts) of the COM port and determines the behavior of ReadFile and WriteFile.

```
typedef struct _COMMTIMEOUTS {
  DWORD ReadIntervalTimeout; //character spacing
  DWORD ReadTotalTimeoutMultiplier; //factor for the idle reader
  DWORD ReadTotalTimeoutConstant; //constant for a period of inactivity reading
  DWORD WriteTotalTimeoutMultiplier; //factor for the idle time record
  DWORD WriteTotalTimeoutConstant; //constant for a period of inactivity account
} COMMTIMEOUTS,
*LPCOMMTIMEOUTS;
```

To work with COMMTIMEOUTS structure using API functions from the library **kernel32.** :

SetCommTimeouts- Sets the idle time for all read and write operations for a given communication device.
GetCommTimeouts Retrieves the parameters of downtime for all read and write operations on a given communication device.

COMMSTAT Stucture

The structure that tells the status of the COM port after detecting communication failures.

```
  typedef struct _COMSTAT {
  DWORD fCtsHold    :1;//Wait signal CTS (Clear To Send)
  DWORD fDsrHold    :1;//Wait signal DSR(Ready Modem)
  DWORD fRlsdHold   :1;//Wait RSLD(detector signal line)
  DWORD fXoffHold   :1;//Wait trnslation (was obtained XOFF)
  DWORD fXoffSent   :1;//transfer character XOFF
  DWORD fEof        :1;//adopted the symbol of the end of data EOF
  DWORD fTxim       :1;//a queue of characters to transfer
  DWORD fReserved   :25;//reserved
  DWORD cbInQue;//number of bytes received from ReadFile
  DWORD cbOutQue;//number of bytes for WriteFile
} COMSTAT,
*LPCOMSTAT;
```

To work with COMMSTAT structure using API functions from the library **kernel32.**:

ClearCommError- ClearCommError function retrieves information about the communications error and reports the current status of the communication device. This function is called when an error occurs the exchange of information and resets the error box device to include in the work of additional input and output (I/O).

COMMPROP structure

The structure that reports information about the properties of a communication device.

```
  typedef struct _COMMPROP {
  WORD wPacketLength;//packet size
  WORD wPacketVersion;//version structure
  DWORD dwServiceMask;//bitmask service provider
  DWORD dwReserved1;//reserved
  DWORD dwMaxTxQueue;//max. size of the transmitting buffer
  DWORD dwMaxRxQueue;//max. size of the receive buffer
  DWORD dwMaxBaud;//max. speed bps
  DWORD dwProvSubType;//type of communication device
  DWORD dwProvCapabilities;//opportunities offered by the supplier
  DWORD dwSettableParams;//parameter which can vary
  DWORD dwSettableBaud;//speed permissible to use
  WORD wSettableData;//number of bits in a symbol that is allowed to set
  WORD wSettableStopParity;//stop bits and parity that can be selected
  DWORD dwCurrentTxQueue;//the current size of the sending buffer
  DWORD dwCurrentRxQueue;//the current size of the receive buffer
  DWORD dwProvSpec1;//data determined by the supplier
  DWORD dwProvSpec2;//data determined by the supplier
  WCHAR wcProvChar;//characters defined by the supplier
} COMMPROP;
```

To work with COMMPROP structure using API functions from the library **kernel32**:

GetCommProperties - GetCommProperties function retrieves information about the communication characteristics of these communication devices.

4.2.2. Programming the COM port using external ActiveX component

Programming of the COM port using the external component of one of the most common and easiest ways to work with the COM port. The external component is a software module that performs the specified functions and has all the parameters of the program object. The external component is being developed by technology ActiveX, which allows it to be integrated into any project programs written in programming languages support this technology. Almost all modern means of technology development programs support ActiveX. You can create a draft of its application to C + +, Delphi, VB, 1C, MS-Office and work with the COM port to connect an external component finished. However, you do not need to understand how a COM port, it makes the program object external components, the developer only uses the properties, methods and events of this object. ActiveX technology is a logical extension dll, DDE, OLE, COM technology.

External component (element ActiveX) is a complete software product and has all the copyrights. Therefore, the designer needs to remember that the connecting element of the ActiveX, you plug in someone else's software code to your project, and therefore part of your program will be written by the developer components, which requires payment. External component to work with COM ports written many. Must decide which component, and on what terms will you use in your project.

External components are arranged in the form of files and have the extension. Ocx or earlier. Dll. In order for an external component can be used in the project, it must be registered in the OS. Register components by recording the keys in the system registry, using special software, or with the "Register" from the context menu of the file

To take consideration of the known components MSCOMM32.ocx written by Microsoft and included in the package developer Visual Studio Enterprise. Attach MSCOMM32.ocx to your project. After connecting the components to the project you can work with the object MSComm1.

Basic Properties of Object**MSCOMM1**:

- **MSComm1.CommPort -**Sets the number of COM port
- **MSComm1.Settings-** specifies the basic parameters of the port
- **MSComm1.PortOpen-** opens and closes port
- **MSComm1.Output -**transmits data to port
- **MSComm1.Input-** reads data from port
- **MSComm1.RTSEnable-** control signal RTS
- **MSComm1.DTREnable-** control signal DTR
- **MSComm1.CTSHolding-** state signal CTS
- **MSComm1.DSRHolding-** state signal DSR

- **MSComm1.DCDHolding-** state signal DCD

An example of a COM port to VB:

```
Private Sub Command1_Click()
    Dim Data_S As String

    MSComm1.CommPort = 1 'COM port number
    MSComm1.PortOpen = True 'open port
    MSComm1.Settings = "9600,n,8,1" 'speed of 9600 bps, no parity, 8 bits per char, 1 stop.
    Data_S = MSComm1.Input 'receive data from port
    MSComm1.Output = "Hello" ' send data to the port
    MSComm1.DTREnable = True ' enable signal DTR
    MSComm1.PortOpen = False 'close port
End Sub
```

In this program when you click an open port COM1 at 9600 bps, no parity check, 8 bits per symbol, with one stop bit. In the variable DATA_S read a string of characters from the receive buffer COM1 and COM1 output buffer transmits the word "Hello". After that, turn signals DTR and the port is closed.

As can be seen from this example work with COM ports, when you use the ActiveX, is simple enough.
Besides these properties MSCOMM32.ocx component has a large number of other properties, events, and methods which implement a fully functional work of the COM port to the operating system Windows.

§5 Software for work with COM ports of PC.

RS-232, became the basis for industrial data networks. Protocols such as ModBus, HART, ProfiBus DP, DCON, DH-485, work on networks RS-485, RS-422, Bell-202, etc. The hardware processing in these networks is the chip UART (COM port), which is implemented on PC hardware or software form. Even when using the USB modem, for example RS-485, it still works via emulated COM port of your PC.

Communication protocols are the most secretive and classified part of the information channels. This is due to the vulnerability of information during its transmission in the physical environment. For information on this or any other communication protocol has to be assembled bit by bit.
Specialists working with industrial networks need a program to read all the information transmitted in the information networks. Key secrets industrial protocols can be found only when the full analysis of transmitted and received data. Consider a program for analyzing networks.

5.1 Program ComRead v.2.0 - A window into the world of digital networks.

This program is designed to preserve and display the data and service signals transmitted in the information networks that operate on standard RS-232, RS-485, ModBus, HART, etc. The program not only preserves all the information, but also creates a temporary scan data and service signals. The program scans ComRead v.2.0 news channel, without affecting its operation, ie running in listening mode of the physical environment of information transfer. In addition, the program can operate in the translator data and service signals. In this case it becomes a direct part of the information communication channel. More information can be found here .

5.2 Program ComPort v.1.0

This is a simple program to display the state of the 4 x COM ports of your PC. In text and graphic form can see the state of all signal lines COM port in the current time. Ports can be configured for any mode of operation. ComPort v.1.0 program can generate and receive cyclic send data. The program is very useful for various tasks.
More information can be found here.

§6.Deduction

Advantages of the standard RS-232

- Full hardware implementation;
- Software independence;
- Availability in the management of all levels;
- Full-duplex transmission;
- Developed system of service signals;
- Advanced system settings: speed, mode, parity;
- Universal application

Disadvantages of the standard RS-232

- Insufficient rate of exchange;
- Insufficient power to supply the periphery of the connector;
- Inability to turn off the hot / connectivity
- Inability to multi-point connections;
- Short distance communications.

Appendix 1

Examples of programming COM-port to Win32 using the API functions.

The implementation of simple functions, com-port:
-open port
-setting port
-write port
-read port
-close port

Write a program implementing these functions in various programming languages: VB6, MASM32, C

Source in VB6 COMAPIvb v.1.00 download
Source in MASM32 COMAPIas v.1.00 download
Source in C, MS VC6++ COMAPIc v.1.00 download

Fig.28 Project COMAPI

The program works as follows:
-Clicking Open port opens COM port COM1
-Configuring COM1: 1200 baud, 8 bits per character, 1 stop bit, no parity check
-by pressing the Write port, runoff recorded in Text2 (Hello World!) is sent to COM1
-Clicking Read port, in Text1 is placed a row of the receive buffer COM1
-Clicking Close port, COM1 port is closed

Example 1 COMAPI program in VB6 in the package Visual Studio Enterprise with SP6 in OS XP ??SP3

- create a project Standart.exe
- name the project COMAPIvb v.1.00
- added to the project module (ADD Module)
- place in the form of the 4 buttons
- place to form 2 text boxes
- enter the title buttons: Open port, Close Port, Read Port, Write port
- in the Text1 box will contain the string obtained from the COM port
- box Text2 will be a listing which will be sent via

Introduce a code module:

```
'COMAPIvb v.1.01
'Yahkardin Vladimir
'www.softelectro.ru
'Russia, Peterburg
'06.04.2012

Option Explicit

'The declaration of used functions API
Declare Function CreateFile Lib "kernel32" Alias "CreateFileA" (ByVal lpFileName As String, ByVal dwDesiredAccess As Long, ByVal dwShareMode As Long, ByVal lpSecurityAttributes As Long, By
Declare Function ReadFile Lib "kernel32" (ByVal hFile As Long, lpBuffer As Any, ByVal nNumberOfBytesToRead As Long, lpNumberOfBytesRead As Long, lpOverlapped As Long) As Boolean
Declare Function WriteFile Lib "kernel32" (ByVal hFile As Long, lpBuffer As Any, ByVal nNumberOfBytesToWrite As Long, lpNumberOfBytesWritten As Long, ByVal lpOverlapped As Long) As Boolean
Declare Function CloseHandle Lib "kernel32" (ByVal hObject As Long) As Long
Declare Function SetCommState Lib "kernel32" (ByVal hFile As Long, lpDCB As DCB) As Boolean
Declare Function SetCommTimeouts Lib "kernel32" (ByVal hFile As Long, lpCommTimeouts As COMMTIMEOUTS) As Boolean
Declare Function GetLastError Lib "kernel32" () As Long


Public Com_Handle As Long 'Descriptor of port
Public Buf(255) As Byte 'The buffer of port
Public Com_Byte_Read As Long 'количество принятых байт
'Structure for parameter setup of port
Type DCB
    DCBlength As Long       'Length of structure in byte.
    BaudRate As Long        'Speed of data exchange6, bps
    fBitFields As Long      'Bit field for setting of port
    wReserved As Integer    'Reserved
    XonLim As Integer       'minimum number of bytes in the buffer to send Xon
    XofflIm As Integer      'maximum number of bytes in the buffer for sending Xof
    ByteSize As Byte        'the number of bits in a symbol
    Parity As Byte          'parity check mode
    StopBits As Byte        'Stop bit length
    XonChar As Byte         'character code Xon
    XoffChar As Byte        'character code Xof
    ErrorChar As Byte       'code symbol error
    EofChar As Byte         'character code data end
    EvtChar As Byte         'character code Events
    wReserved1 As Integer   'Reserved
End Type
Public DCB1 As DCB
'Structure for parameter setup of port
Type COMMTIMEOUTS
    ReadIntervalTimeout As Long       'интервал между символами
    ReadTotalTimeoutMultiplier As Long        'множитель для периода простоя чтения
    ReadTotalTimeoutConstant As Long      'постоянная для периода простоя чтения
    WriteTotalTimeoutMultiplier As Long     'множитель для периода простоя записи
    WriteTotalTimeoutConstant As Long       'постоянная для периода простоя записи
```

```
End Type
Public COMMTIMEOUTS1 As COMMTIMEOUTS


'Function of opening of port
Function Com_Open()
    Dim Retval As Long
    Dim Retval_B As Boolean
    Dim Retval_S As Boolean

    Retval = CreateFile("COM1:", &HC0000000, 0, 0, 3, 0, 0)
    If Retval = -1 Then
        MsgBox ("The open error of port:" & GetLastError)
    Else
        Com_Handle = Retval
        'set dcb
        DCB1.BaudRate = 1200
        DCB1.ByteSize = 8
        DCB1.DCBlength = 28
        DCB1.EofChar = 0
        DCB1.ErrorChar = 0
        DCB1.EvtChar = 0
        DCB1.fBitFields = 1
        DCB1.Parity = 0
        DCB1.StopBits = 0
        DCB1.wReserved = 0
        DCB1.wReserved1 = 0
        DCB1.XoffChar = 0
        DCB1.XoffLim = 0
        DCB1.XonChar = 0
        DCB1.XonLim = 0
        Retval_S = SetCommState(Com_Handle, DCB1)
        'set timeout
        COMMTIMEOUTS1.ReadIntervalTimeout = -1
        COMMTIMEOUTS1.ReadTotalTimeoutConstant = 0
        COMMTIMEOUTS1.ReadTotalTimeoutMultiplier = 0
        COMMTIMEOUTS1.WriteTotalTimeoutConstant = 5000
        COMMTIMEOUTS1.WriteTotalTimeoutMultiplier = 0
        Retval_B = SetCommTimeouts(Com_Handle, COMMTIMEOUTS1)

        If Retval_B = False Or Retval_S = False Then
            MsgBox ("Error DCB&Timout:" & GetLastError)
        End If
        MsgBox ("Open port HANDLE:" & Com_Handle)

    End If

End Function
'Function of closing the port
Function Com_Close()
    Dim Retval As Long

    Retval = CloseHandle(Com_Handle)
    If Retval = 0 Then
        MsgBox ("Close port ERROR:" & GetLastError)
    Else
        MsgBox ("Close port")
    End If
End Function

'Recording function to the port
Function Com_Write()
    Dim Len_Buf As Long
    Dim Retval As Boolean
    PurgeBuf
    Retval = WriteFile(Com_Handle, Buf(0), 255, Len_Buf, 0)
    If Retval = False Then
        MsgBox ("Write port ERROR:" & GetLastError)
    Else
        MsgBox ("Data write: Ok")
    End If

End Function

'function of reading from the port
Function Com_Read()
    Dim Retval As Boolean
    PurgeBuf
    Retval = ReadFile(Com_Handle, Buf(0), 255, Com_Byte_Read, 0)
    If Retval = False Then
        MsgBox ("Read port ERROR:" & GetLastError & Err.Description)
    Else
        MsgBox ("Data read: Ok")
    End If

End Function
'clear buffer
Sub PurgeBuf()
    Dim a As Integer

    For a = 0 To 255
        Buf(a) = &H20
    Next a
End Sub
```

Input code for Form:

```
'COMAPIvb v.1.01
'Yahkardin Vladimir
'www.softelectro.ru
'Russia, Peterburg
'06.04.2012
Option Explicit

'Open port
Private Sub Command1_Click()
    Dim Retval As Boolean
```

```
    Retval = Com_Open
End Sub
'Close port
Private Sub Command2_Click()
    Dim Retval As Boolean
    Retval = Com_Close
End Sub
'Read port
Private Sub Command3_Click()
    Dim s As String
    Dim a As Long
    Com_Read
    For a = 1 To Com_Byte_Read
            s = s & Chr(Buf(a - 1))
    Next a
    Text1.Text = s
End Sub
'Write port
Sub Command4_Click()
    Dim s As String
    Dim n As Long
    Dim a As Integer
    Dim Retval As Long
    s = Text2.Text
    s = Mid(s, 1, 255)
    n = Len(s)
    For a = 1 To n
        Buf(a - 1) = Asc(Mid(s, a, 1))
    Next a
    Com_Write
End Sub
'Exit programm
Private Sub Form_Unload(Cancel As Integer)
    Dim Retval As Long
    Retval = CloseHandle(Com_Handle)
End Sub
```

Example 2: Program COMAPIas on MASM32 v.10 in OS XP ??SP3

- create a file comapias.asm
- specify the prototypes and libraries
- declare Data
- obtain the application descriptor
- create a function WinMain
- create the main window
- established a procedure for processing the message window
- create 4 buttons
- create 2 editing window
- write event handling code buttons

```
;COMAPIas v.1.00
;htpp:\\www.softelectro.ru
;Electron18
.386
.model flat,stdcall
option casemap:none

STYLBTN equ WS_CHILD + BS_DEFPUSHBUTTON + WS_VISIBLE
STYLEDT equ WS_CHILD+WS_VISIBLE+WS_BORDER+WS_TABSTOP

WinMain PROTO :DWORD,:DWORD,:DWORD,:DWORD
PurgeBuf PROTO

include \masm32\include\windows.inc
include \masm32\include\user32.inc
include \masm32\include\kernel32.inc
includelib \masm32\lib\user32.lib
includelib \masm32\lib\kernel32.lib

.DATA
    ClassName db "SimpleWinClass",0
    AppName  db "COMAPIas v.1.00",0
        ;data button

    CLSBUTN         DB 'BUTTON',0
    CPBUT1          DB 'Open port',0
    HWNDBTN1        DD 0
    CPBUT2          DB 'Close port',0
    HWNDBTN2        DD 0
    CPBUT3          DB 'Read port',0
    HWNDBTN3        DD 0
    CPBUT4          DB 'Write port',0
    HWNDBTN4        DD 0
        ;data edit
    CLSEDIT         DB 'EDIT',0
    CPEDT1          DB ' ',0
    HWNDEDT1        DD 0
    CPEDT2          DB 'Hello World!',0
    HWNDEDT2        DD 0
    TEXT            DB 'Line editing',0

        ;Message App
        ;App message
    uType           EQU 0
    lpCapApp        DB "App message",0
    lpApp1          DB "Open port HANDLE:", 6 dup(" "),0
    lpApp2          DB "Close port",0
    lpApp3          DB "Data read: Ok",0
    lpApp4          DB "Data write: Ok",0

        ;error message
    lpCapERR        DB "Error Message",0
    lpERR1          DB "Open port Error:",10 dup(" "),0
```

```
    lpERR2          DB "DCB Structure ERROR:",10 dup(" "),0
    lpERR3          DB "SetComm Function ERROR:",10 dup(" "),0
    lpERR4          DB "Read port ERROR:",10 dup(" "),0
    lpERR5          DB "Write port ERROR:",10 dup(" "),0
    lpERR6          DB "Close port ERROR:",10 dup(" "),0

        ;data com port
    Mem1            DD 0
    Par1            DB "%lu",0
    Buf             DB 255 dup(" "),0
    HWNDCOM         DD 0
    LenBuf          DD 0
    NumCOM          DB "COM1:",0
    COMSETTING      DB "Com1: baud=1200 parity=N data=8 stop=1",0
    DCB1            DCB <>

.DATA?
    hInstance       HINSTANCE ?
    CommandLine     LPSTR ?


.CODE
START:
        INVOKE GetModuleHandle, NULL
           mov    hInstance,eax                                          ;handle app
        INVOKE GetCommandLine                                           ;handle command line
        INVOKE WinMain, hInstance,NULL,CommandLine, SW_SHOWDEFAULT      ;input to app
        INVOKE ExitProcess,eax                                          ;exit app
                                                                       ;main window
WinMain PROC hInst:HINSTANCE,hPrevInst:HINSTANCE,CmdLine:LPSTR,CmdShow:DWORD
        LOCAL wc:WNDCLASSEX
        LOCAL msg:MSG
        LOCAL hwnd:HWND
           mov   wc.cbSize,SIZEOF WNDCLASSEX
           mov   wc.style, CS_HREDRAW or CS_VREDRAW
           mov   wc.lpfnWndProc, OFFSET WndProc
           mov   wc.cbClsExtra,NULL
           mov   wc.cbWndExtra,NULL
           push  hInst
           pop   wc.hInstance
           mov   wc.hbrBackground,4;COLOR_MENU;COLOR_WINDOW
           mov   wc.lpszMenuName,NULL
           mov   wc.lpszClassName,OFFSET ClassName
        INVOKE LoadIcon,NULL,IDI_APPLICATION
           mov   wc.hIcon,eax                                           ;handle icon
           mov   wc.hIconSm,0
        INVOKE LoadCursor,NULL,IDC_ARROW
           mov   wc.hCursor,eax                                         ;handle cursor
        INVOKE RegisterClassEx, addr wc                                 ;register class window
                                                                       ;create main window
        INVOKE CreateWindowEx,NULL,ADDR ClassName,ADDR AppName,WS_OVERLAPPEDWINDOW,20,20,800,200,NULL,NULL,hInst,NULL
           mov   hwnd,eax
        INVOKE ShowWindow, hwnd,SW_SHOWNORMAL                           ;show window
        INVOKE UpdateWindow, hwnd                                       ;update window

                                                                       ;loop message
        .WHILE TRUE
                INVOKE GetMessage, ADDR msg,NULL,0,0                    ;get message
                .BREAK .IF (!eax)
                INVOKE TranslateMessage, ADDR msg                       ;get key char
                INVOKE DispatchMessage, ADDR msg                        ;call Win Proc

        .ENDW
                  mov     eax,msg.wParam
                  ret
WinMain endp


                                                                       ;procedure window
WndProc PROC hWnd:HWND, uMsg:UINT, wParam:WPARAM, lParam:LPARAM

      .IF uMsg==WM_DESTROY
        INVOKE PostQuitMessage,NULL
      .ELSEIF uMsg==WM_COMMAND
                mov EAX, HWNDBTN1
                cmp lParam, EAX
                je  BUTTON1_CLICK

                mov EAX, HWNDBTN2
                cmp lParam, EAX
                je  BUTTON2_CLICK

                mov EAX, HWNDBTN3
                cmp lParam, EAX
                je  BUTTON3_CLICK

                mov EAX, HWNDBTN4
                cmp lParam, EAX
                je  BUTTON4_CLICK

      .ELSEIF uMsg==WM_CREATE
                                                                        ;create button1..4
            INVOKE CreateWindowEx, 0,OFFSET CLSBUTN,OFFSET CPBUT1,STYLBTN,10,10,100,20,hWnd,0,hInstance,0
                mov HWNDBTN1, EAX                                       ; handle button1
            INVOKE CreateWindowEx, 0,OFFSET CLSBUTN,OFFSET CPBUT2,STYLBTN,10,40,100,20,hWnd,0,hInstance,0
                mov HWNDBTN2, EAX                                       ; handle button2
            INVOKE CreateWindowEx, 0,OFFSET CLSBUTN,OFFSET CPBUT3,STYLBTN,10,70,100,20,hWnd,0,hInstance,0
                mov HWNDBTN3, EAX                                       ; handle button3
            INVOKE CreateWindowEx, 0,OFFSET CLSBUTN,OFFSET CPBUT4,STYLBTN,10,100,100,20,hWnd,0,hInstance,0
                mov HWNDBTN4, EAX                                       ; handle button4
                                                                        ;create edit1 and edit2
            INVOKE CreateWindowEx, 0,OFFSET CLSEDIT,OFFSET CPEDT1,STYLEDT,120,70,600,20,hWnd,0,hInstance,0
                mov HWNDEDT1, EAX                                       ; handle edit1
            INVOKE CreateWindowEx, 0,OFFSET CLSEDIT,OFFSET CPEDT2,STYLEDT,120,100,600,20,hWnd,0,hInstance,0
                mov HWNDEDT2, EAX                                       ; handle edit2

        .ELSE
                INVOKE DefWindowProc,hWnd,uMsg,wParam,lParam                ;default message
                  ret
        .ENDIF
      jmp ENDMESS

BUTTON1_CLICK:                                                          ;open port
```

```
            INVOKE CreateFile,OFFSET NumCOM, GENERIC_READ or GENERIC_WRITE, NULL, NULL, OPEN_EXISTING, NULL,NULL
                mov HWNDCOM, eax
                .IF EAX==-1
                    INVOKE GetLastError
                        mov Mem1,eax
                    INVOKE wsprintf,OFFSET lpERR1(17),OFFSET Par1,Mem1;
                    INVOKE MessageBoxA,NULL,OFFSET lpERR1,OFFSET lpCapERR,uType
                .ELSE
                    INVOKE wsprintf,OFFSET lpApp1(18),OFFSET Par1,HWNDCOM
                    INVOKE MessageBoxA,NULL,OFFSET lpApp1,OFFSET lpCapApp,uType
                    INVOKE BuildCommDCB,OFFSET COMSETTING, OFFSET DCB1
                    .IF EAX==0
                        INVOKE GetLastError
                            mov Mem1,eax
                        INVOKE wsprintf,OFFSET lpERR2(21),OFFSET Par1,Mem1;
                        INVOKE MessageBoxA,NULL,OFFSET lpERR2,OFFSET lpCapERR,uType
                    .ENDIF
                    INVOKE SetCommState,HWNDCOM,OFFSET DCB1
                    .IF EAX==0
                        INVOKE GetLastError
                            mov Mem1,eax
                        INVOKE wsprintf,OFFSET lpERR3(24),OFFSET Par1,Mem1;
                        INVOKE MessageBoxA,NULL,OFFSET lpERR3,OFFSET lpCapERR,uType
                    .ENDIF
                .ENDIF
            jmp ENDMESS

BUTTON2_CLICK:                                                          ;close port
            INVOKE CloseHandle,HWNDCOM
             .IF EAX==0
                INVOKE GetLastError
                    mov Mem1,eax
                INVOKE wsprintf,OFFSET lpERR6(18),OFFSET Par1,Mem1;
                INVOKE MessageBoxA,NULL,OFFSET lpERR6,OFFSET lpCapERR,uType
            .ELSE
                INVOKE MessageBoxA,NULL,OFFSET lpApp2,OFFSET lpCapApp,uType
            .ENDIF



            jmp ENDMESS

BUTTON3_CLICK:
            CALL  PurgeBuf                                                          ;read port
            INVOKE ReadFile,HWNDCOM,OFFSET Buf, SIZEOF Buf,OFFSET LenBuf, NULL
            .IF EAX==0
                INVOKE GetLastError
                    mov Mem1,eax
                INVOKE wsprintf,OFFSET lpERR4(17),OFFSET Par1,Mem1;
                INVOKE MessageBoxA,NULL,OFFSET lpERR4,OFFSET lpCapERR,uType
            .ELSE
                INVOKE SendMessage,HWNDEDT1,WM_SETTEXT,SIZEOF Buf,OFFSET Buf
                INVOKE MessageBoxA,NULL,OFFSET lpApp3,OFFSET lpCapApp,uType
            .ENDIF
            jmp ENDMESS

BUTTON4_CLICK:                                                          ;write port
                CALL  PurgeBuf
                INVOKE SendMessage,HWNDEDT2,WM_GETTEXT,SIZEOF Buf,OFFSET Buf
                INVOKE WriteFile,HWNDCOM,OFFSET Buf, SIZEOF Buf,OFFSET LenBuf, NULL
            .IF EAX==0
                INVOKE GetLastError
                    mov Mem1,eax
                INVOKE wsprintf,OFFSET lpERR5(18),OFFSET Par1,Mem1;
                INVOKE MessageBoxA,NULL,OFFSET lpERR5,OFFSET lpCapERR,uType
            .ELSE
                INVOKE MessageBoxA,NULL,OFFSET lpApp4,OFFSET lpCapApp,uType
            .ENDIF

            jmp ENDMESS



ENDMESS:
        xor    eax,eax
        ret
WndProc ENDP
                                                                ; clear buffer
PurgeBuf PROC
    push ebx
    push ecx

    mov cx,255
    mov ebx,offset Buf
    mov al,20h
 L:
    mov [ebx],al
    inc ebx
    LOOP L

    pop ecx
    pop ebx
    xor    eax,eax
    ret
PurgeBuf ENDP

END START
```

Example 3 COMAPIc v.1.00 program in C, compiled in MS VC6 + + Enterpise SP6 in OS XP SP3

```
// COMAPIc.cpp
// www.softelectro
//Yshkardin V.

#include "stdafx.h"
#define STYLBTN WS_CHILD|BS_DEFPUSHBUTTON|WS_VISIBLE
#define STYLEDT WS_CHILD|WS_VISIBLE|WS_BORDER|WS_TABSTOP
```

```
		//data main window
	HINSTANCE hInst;
	LPCTSTR szTitle="COMAPIc v.1.00";
	LPCTSTR szWindowClass="SimpleWinClass";
		//data control
	LPCTSTR CLSBUTN="BUTTON";
	LPCTSTR CPBUT1="Open port";
	LPCTSTR CPBUT2="Close port";
	LPCTSTR CPBUT3="Read port";
	LPCTSTR CPBUT4="Write port";
	LPCTSTR CLSEDIT="EDIT";
	LPCTSTR CPEDT1;
	LPCTSTR CPEDT2="Hello World!";
	HWND HWNDBTN1;
	HWND HWNDBTN2;
	HWND HWNDBTN3;
	HWND HWNDBTN4;
	HWND HWNDEDT1;
	HWND HWNDEDT2;
	HMENU ID_BTN1=(HMENU) 101;
	HMENU ID_BTN2=(HMENU) 102;
	HMENU ID_BTN3=(HMENU) 103;
	HMENU ID_BTN4=(HMENU) 104;

	//App message
	LPCTSTR  lpCapApp = "App message";
	char  lpApp1[40]   = "Open port HANDLE:";
	LPCTSTR  lpApp2    ="Close port";
	LPCTSTR  lpApp3    ="Data read: Ok";
	LPCTSTR  lpApp4    ="Data write: Ok";

	//error message
	LPCTSTR  lpCapERR  ="Error Message";
	char lpERR1[40]={"Open port Error:"};
	char lpERR2[40]={"DCB Structure ERROR:"};
	char lpERR3[40]={"SetComm Function ERROR:"};
	char lpERR4[40]={"Read port ERROR:"};
	char lpERR5[40]={"Write port ERROR:"};
	char lpERR6[40]={"Close port ERROR:"};
	DWORD Mem1;
	LPCTSTR Par1        ="%Lu";

		//data com port
	HANDLE HWNDCOM;
	LPCTSTR lpNumCOM="COM1:";
	LPCTSTR COMSETTING="Com1: baud=1200 parity=N data=8 stop=1";
	char Buf[255];
	DWORD lenBuf;
	DCB DCB1;


LRESULT CALLBACK	WndProc(HWND, UINT, WPARAM, LPARAM);

void PurgeBuf()
{
	int a;
	for (a=0;a<255;a++)
	{
		Buf[a]=0x20;
	}
	return;
}

int APIENTRY WinMain(HINSTANCE hInstance,HINSTANCE hPrevInstance,LPSTR lpCmdLine,int nCmdShow)
{

	MSG msg;
	WNDCLASSEX wcex;
	HWND hWnd;
    hInst=hInstance;

	wcex.cbSize = sizeof(WNDCLASSEX);
	wcex.style			= CS_HREDRAW | CS_VREDRAW;
	wcex.lpfnWndProc	= (WNDPROC)WndProc;
	wcex.cbClsExtra		= 0;
	wcex.cbWndExtra		= 0;
	wcex.hInstance		= hInstance;
	wcex.hIcon			= LoadIcon(NULL, IDI_APPLICATION);
	wcex.hIconSm		= 0;
	wcex.hCursor		= LoadCursor(NULL, IDC_ARROW);
	wcex.hbrBackground	= (HBRUSH)(4);
	wcex.lpszMenuName	= 0;
	wcex.lpszClassName	= szWindowClass;
	RegisterClassEx(&wcex);

	hWnd = CreateWindow(szWindowClass, szTitle, WS_OVERLAPPEDWINDOW,20, 20, 800, 200, NULL, NULL, hInstance, NULL);

   if (!hWnd)
   {
      return FALSE;
   }

   ShowWindow(hWnd, SW_SHOWNORMAL);
   UpdateWindow(hWnd);



	while (GetMessage(&msg, NULL, 0, 0))
	{
			TranslateMessage(&msg);
			DispatchMessage(&msg);
	}

	return 0;
}


LRESULT CALLBACK WndProc(HWND hWnd, UINT message, WPARAM wParam, LPARAM lParam)

{
	int wmId, wmEvent;
```

```
        int Retval;
        switch (message)

        {
                case WM_COMMAND:
                                wmId    = LOWORD(wParam);
                                wmEvent = HIWORD(wParam);
                                switch (wmId)
                        {
                                case 101: //open port
                                        HWNDCOM=CreateFile(lpNumCOM, GENERIC_READ|GENERIC_WRITE, NULL, NULL, OPEN_EXISTING, NULL,NULL);

                                        if (HWNDCOM==INVALID_HANDLE_VALUE)
                                                {
                                                        Mem1= GetLastError();
                                                        wsprintf(&lpERR1[16],Par1,Mem1);
                                                        MessageBox(0,lpERR1,lpCapERR,0);
                                                }
                                        else
                                                {
                                                        wsprintf(&lpApp1[17],Par1,HWNDCOM);
                                                        MessageBoxA(0,lpApp1,lpCapApp,0);
                                                        Retval=BuildCommDCB(COMSETTING,&DCB1);
                                                        if (Retval==0)  //error DCB
                                                                {
                                                                        Mem1= GetLastError();
                                                                        wsprintf(&lpERR2[20],Par1,Mem1);
                                                                        MessageBox(0,lpERR2,lpCapERR,0);
                                                                }
                                                        Retval=SetCommState(HWNDCOM,&DCB1);
                                                        if (Retval==0)  //error SetCom
                                                                {
                                                                        Mem1= GetLastError();
                                                                        wsprintf(&lpERR3[23],Par1,Mem1);
                                                                        MessageBox(0,lpERR3,lpCapERR,0);
                                                                }


                                                }
                                                        break;

                                case 102:                       //close port
                                        Retval=CloseHandle(HWNDCOM);
                                        if (Retval==0) //error close port
                                                {
                                                        Mem1= GetLastError();
                                                        wsprintf(&lpERR6[17],Par1,Mem1);
                                                        MessageBox(0,lpERR6,lpCapERR,0);
                                                }
                                        else
                                                {
                                                        MessageBox(0,lpApp2,lpCapApp,0);
                                                }
                                        break;

                                case 103:               //read port
                                        PurgeBuf();
                                        Retval= ReadFile(HWNDCOM,&Buf, 255,&LenBuf, NULL);
                                        if (Retval==0) //error read port
                                                {
                                                        Mem1= GetLastError();
                                                        wsprintf(&lpERR4[16],Par1,Mem1);
                                                        MessageBox(0,lpERR4,lpCapERR,0);
                                                }
                                        else
                                                {
                                                        SendMessageA(HWNDEDT1,WM_SETTEXT,sizeof Buf,(LPARAM) Buf);
                                                        MessageBox(0,lpApp3,lpCapApp,0);
                                                }

                                                break;
                                case 104:               //write port
                                        PurgeBuf();
                                        SendMessage(HWNDEDT2,WM_GETTEXT,sizeof Buf,(LPARAM) Buf);
                                        Retval= WriteFile(HWNDCOM,&Buf, sizeof Buf,&LenBuf, NULL);
                                        if (Retval==0) //error write port
                                                {
                                                        Mem1= GetLastError();
                                                        wsprintf(&lpERR5[17],Par1,Mem1);
                                                        MessageBox(0,lpERR5,lpCapERR,0);
                                                }
                                        else
                                                {
                                                        MessageBox(0,lpApp4,lpCapApp,0);
                                                }
                                                break;
                                default:
                                                {
                                                        return DefWindowProc(hWnd, message, wParam, lParam);
                                                }
                        }
                        break;
                case WM_CREATE:
                        HWNDBTN1= CreateWindowEx( 0,CLSBUTN,CPBUT1,STYLBTN,10,10,100,20,hWnd,ID_BTN1,hInst,0);
                        HWNDBTN2= CreateWindowEx( 0,CLSBUTN,CPBUT2,STYLBTN,10,40,100,20,hWnd,ID_BTN2,hInst,0);
                        HWNDBTN3= CreateWindowEx( 0,CLSBUTN,CPBUT3,STYLBTN,10,70,100,20,hWnd,ID_BTN3,hInst,0);
                        HWNDBTN4= CreateWindowEx( 0,CLSBUTN,CPBUT4,STYLBTN,10,100,100,20,hWnd,ID_BTN4,hInst,0);
                        HWNDEDT1= CreateWindowEx(0,CLSEDIT,CPEDT1,STYLEDT,120,70,600,20,hWnd,0,hInst,0);
                        HWNDEDT2= CreateWindowEx(0,CLSEDIT,CPEDT2,STYLEDT,120,100,600,20,hWnd,0,hInst,0);

                        break;
                case WM_DESTROY:
                        PostQuitMessage(0);
                        break;
                default:
                        return DefWindowProc(hWnd, message, wParam, lParam);
   }
   return 0;
}
```

```
// stdafx.cpp : source file that includes just the standard includes
//      COMAPIc.pch will be the pre-compiled header
//      stdafx.obj will contain the pre-compiled type information

#include "stdafx.h"

// TODO: reference any additional headers you need in STDAFX.H
// and not in this file



// stdafx.h : include file for standard system include files,
//  or project specific include files that are used frequently, but
//      are changed infrequently
//

#if !defined(AFX_STDAFX_H__A9DB83DB_A9FD_11D0_BFD1_444553540000__INCLUDED_)
#define AFX_STDAFX_H__A9DB83DB_A9FD_11D0_BFD1_444553540000__INCLUDED_

#if _MSC_VER > 1000
#pragma once
#endif // _MSC_VER > 1000

#define WIN32_LEAN_AND_MEAN             // Exclude rarely-used stuff from Windows headers

#include


// TODO: reference additional headers your program requires here

//{{AFX_INSERT_LOCATION}}
// Microsoft Visual C++ will insert additional declarations immediately before the previous line.

#endif // !defined(AFX_STDAFX_H__A9DB83DB_A9FD_11D0_BFD1_444553540000__INCLUDED_)
```

Sources of information:

1. American National Standart. ANSI/TIA/EIA-232-F-1997 30.09.1997
   Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

2. ITU-T v.24 02.2000
   List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)

3. ITU-T v.28 03.1993
   ELECTRICAL CHARACTERISTICS FOR UNBALANCED DOUBLE-CURRENT INTERCHANGE CIRCUITS

4. GOST 18145-81
   Circuit at the junction of C2 equipment data to the terminal equipment with serial input / output data.

5. National Semiconductor. DataSheet.
   PC16550D Universal Asynchronous Receiver/Transmitter with FIFOs. June 1995.

Back Home