

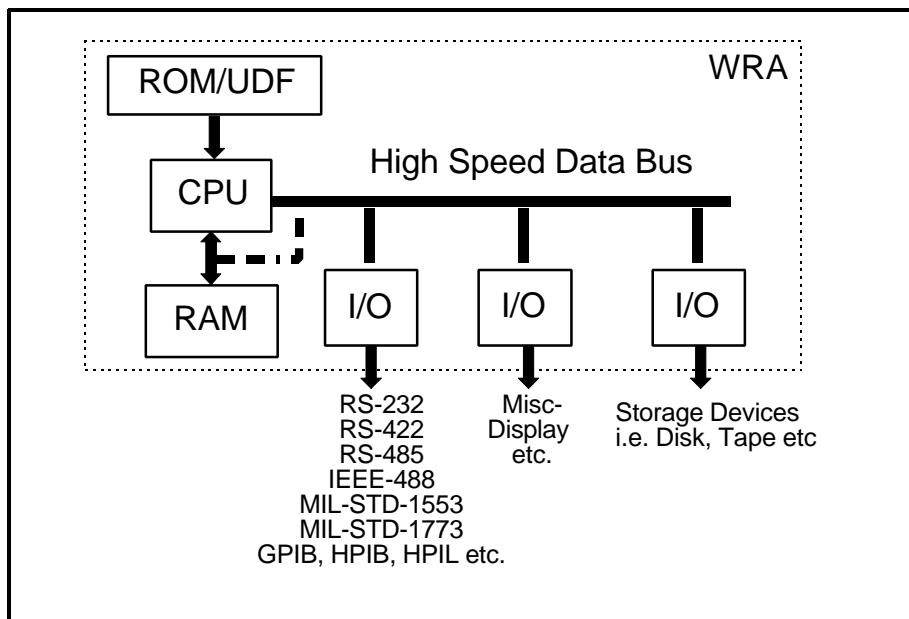
## DATA BUSES

### INTRODUCTION

The avionics systems on aircraft frequently contain general purpose computer components which perform certain processing functions, then relay this information to other systems. Some common examples are the mission computers, the radar processors, RWRs, and Jammers. Each system is frequently laid out as shown in Figure 1.

The Input/Output (I/O) modules will vary in function, but all serve the same purpose - to translate the electrical signals from one protocol to one of another in order to exchange information. I/O modules are used similarly in general purpose computers

in laboratories to test equipment and/or tie computers together via a local area network (LAN) to exchange information. Some of the methodologies include a star, ring, or bus type network (see terminology at the end of this section). The high speed data busses on avionics/computers do not operate as fast as the CPU clock speed, but they are much faster than the interface busses they connect to. There are a number of interface busses which are widely used by aircraft, avionics systems and test equipment. The most common include the RS-232, the RS-422, the RS-485, the IEEE-488 (GP-IB/HP-IB) and the MIL-STD-1553A/B. The MIL-STD-1773 bus is a fiber optic implementation of the 1553 bus and may be used in the future when technology requires it to reduce susceptibility to emissions or other reasons. A summary follows in Table 1, then a brief description of each follows immediately, while a section covering each in more detail is provided later.



**Figure 1.** Avionics Block Diagram

**Table 1. Summary of Bus Characteristics**

See notes on next page

Bus	Max Length	Max Number of Terminals <sup>(1)</sup>	Type	# of Lines <sup>(2)</sup>	Data Rate	Rise Time <sup>(3)</sup>	Data Format
RS-232C	100 feet max 50 ft at 20k BPS	1	Serial	3-20	150 - 19,200 baud per sec		5- to 8- bit serial
RS-422	1.2 km <sup>(4)</sup>	10 <sup>(5)</sup>	Serial	3	see figure in RS-232 section	<0.1 T <sub>b</sub>	unspecified
RS-485	unspecified	32	Serial	3	10 MHz	<0.3 T <sub>b</sub>	unspecified
IEEE-488 (GP-IB/HP-IB)	20 meters	14	Parallel	16	500 kHz <sup>(6)</sup>		8-bit parallel
HP-IL	100 meters	30	Serial	2	20 k BPS		serial
MIL-STD-1553B MIL-STD-1773	300 feet N/A	32 <sup>(7)</sup>	Serial	3	1 MHz	100-300 ns	20-bit serial

## NOTES FROM TABLE:

- (1) Max Number of Terminals does not include the bus controller.
  - (2) Including ground/shield
  - (3)  $T_b$  = time duration of the unit interval at the applicable data signalling rate (pulse width)
  - (4) Length is function of data signalling rate influenced by the tolerable signal distortion, amount of longitudinally coupled noise and ground potential difference introduced between the controller and terminal circuit grounds as well as by cable balance. See RS-422 section for graph.
  - (5) Physical arrangement of multiple receivers involves consideration of stub line lengths, fail-safe networks, location of termination resistors, data rate, grounding, etc.
  - (6) Rate can go up to 1 MHz if special conventions are followed.
  - (7) Max Number of Terminals includes terminal reserved for broadcast commands.
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## BUS TERMINOLOGY

**ADDRESS:** A unique designation for the location of data or the identity of an intelligent device; allows each device on a single communications line to respond to its own message.

**ASCII (American Standard Code for Information Interchange):** Pronounced asky. A seven-bit-plus-parity code established by ANSI to achieve compatibility between data services.

**ASYNCHRONOUS OPERATION:** Asynchronous operation is the use of an independent clock source in each terminal for message transmission. Decoding is achieved in receiving terminals using clock information derived from the message.

**BAUD:** Unit of signalling speed. The speed in baud is the number of discrete events per second. If each event represents one bit condition, baud rate equals bits per second (BPS). When each event represents more than one bit, baud rate does not equal BPS.

**BIT:** Contraction of binary digit: may be either zero or one. A binary digit is equal to one binary decision or the designation of one or two possible values of states of anything used to store or convey information.

**BIT RATE:** The number of bits transmitted per second.

**BROADCAST:** Operation of a data bus system such that information transmitted by the bus controller or a remote terminal is addressed to more than one of the remote terminals connected to the data bus.

**BUS CONTROLLER:** The terminal assigned the task of initiating information transfers on the data bus.

**BUS MONITOR:** The terminal assigned the task of receiving bus traffic and extracting selected information to be used at a later time.

**BYTE:** A binary element string functioning as a unit, usually shorter than a computer "word." Eight-bits per byte are most common. Also called a "character".

**COMMAND/RESPONSE:** Operation of a data bus system such that remote terminals receive and transmit data only when commanded to do so by the bus controller.

**CRC:** Cyclic Redundancy Check; a basic error-checking mechanism for link-level data transmissions; a characteristic link-level feature of (typically) bit-oriented data communications protocols. The data integrity of a received frame or packet is checked via a polynomial algorithm based on the content of the frame and then matched with the result that is performed by a sender and included in a (most often, 16-bit) field appended to the frame.

**DATA BUS:** Whenever a data bus or bus is referred to in MIL-STD-1553B, it shall imply all the hardware including twisted shielded pair cables, isolation resistors, transformers, etc., required to provide a single data path between the bus controller and all the associated remote terminals.

**DCE (Data Communications Equipment):** Devices that provide the functions required to establish, maintain, and terminate a data-transmission connection; e.g., a modem.

**DTE (Data Terminal Equipment):** Devices acting as data source, data sink, or both.

**DYNAMIC BUS CONTROL:** The operation of a data bus system in which designated terminals are offered control of the data bus.

**EIA (Electronic Industries Association):** A standards organization in the U.S.A. specializing in the electrical and functional characteristics of interface equipment.

**FDM (Frequency-Division Multiplexor):** A device that divides the available transmission frequency range into narrower banks, each of which is used for a separate channel.

**FDX (Full Duplex):** Simultaneous, two-way, independent transmission in both directions (4-wire).

**GPIB:** General Purpose Interface Bus (see section 9-5)

**HALF DUPLEX:** Operation of a data transfer system in either direction over a single line, but not in both directions on that line simultaneously.

**HANDSHAKING:** Exchange of predetermined signals between two devices establishing a connection. Usually part of a communications protocol.

**HPIB / HPIL:** Hewlett-Packard Interface Bus / Hewlett-Packard Interface Loop

**IEEE (Institute of Electrical and Electronic Engineers):** An international professional society that issues its own standards and is a member of ANSI and ISO.

**MANCHESTER ENCODING:** Digital encoding technique (specified for the IEEE 802.3 Ethernet baseband network standard) in which each bit period is divided into two complementary halves; a negative-to-positive (voltage) transition in the middle of the bit period designates a binary "1," while a positive-to-negative transition represents a "0". The encoding technique also allows the receiving device to recover the transmitted clock from the incoming data stream (self-clocking).

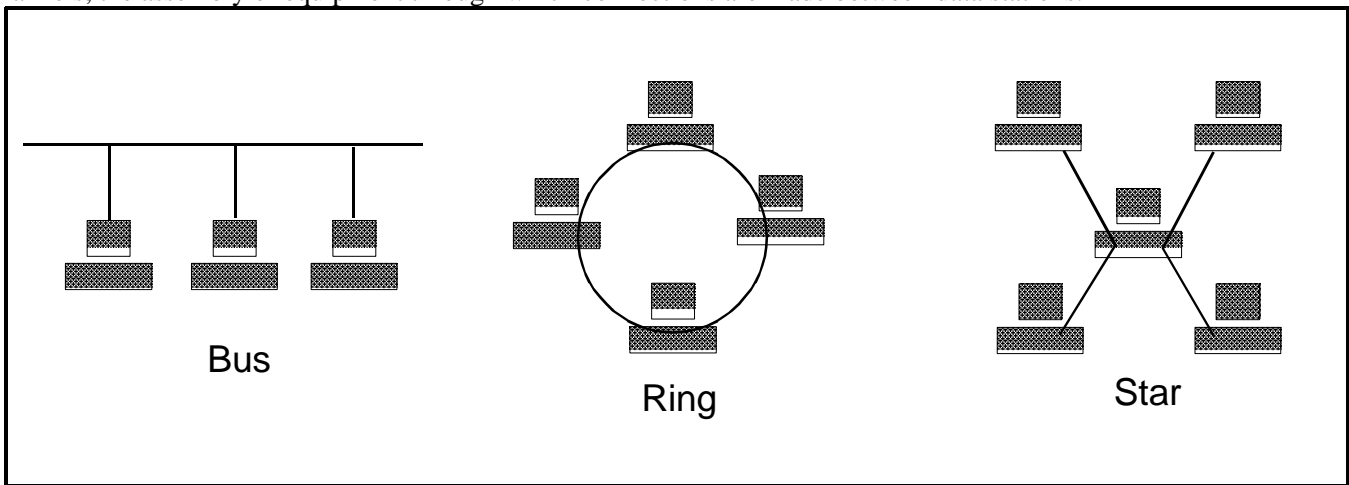
**MESSAGE:** A single message is the transmission of a command word, status word, and data words if they are specified. For the case of a remote terminal to remote terminal (RT to RT) transmission, the message shall include the two command words, the two status words, and data words.

**MODE CODE:** A means by which the bus controller can communicate with the multiplex bus related hardware, in order to assist in the management of information flow.

**MODEM (Modulator-Demodulator):** A device used to convert serial digital data from a transmitting terminal to a signal suitable for transmission over a telephone channel, or to reconvert the transmitted signal to serial digital data for acceptance by a receiving terminal.

**MULTIPLEXOR:** A device used for division of a transmission into two or more subchannels, either by splitting the frequency band into narrower bands (frequency division) or by allotting a common channel to several different transmitting devices one at a time (time division).

**NETWORK:** An interconnected group of nodes; a series of points, nodes, or stations connected by communications channels; the assembly of equipment through which connections are made between data stations.



**NODE:** A point of interconnection to a network. Normally, a point at which a number of terminals or tail circuits attach to the network.

**PARALLEL TRANSMISSION:** Transmission mode that sends a number of bits simultaneously over separate lines (e.g., eight bits over eight lines) to a printer. Usually unidirectional.

**PHASE MODULATION:** One of three ways of modifying a sine wave signal to make it "carry" information. The sine wave or "carrier" has its phase changed in accordance with the information to be transmitted.

**POLLING:** A means of controlling devices on a multipoint line.

**PROTOCOL:** A formal set of conventions governing the formatting and relative timing of message exchange between two communicating systems.

**PULSE CODE MODULATION (PCM):** The form of modulation in which the modulation signal is sampled, quantized, and coded so that each element of information consists of different types or numbers of pulses and spaces.

**REMOTE TERMINAL (RT):** All terminals not operating as the bus controller or as a bus monitor.

**SERIAL TRANSMISSION:** The most common transmission mode; in serial, information bits are sent sequentially on a single data channel.

**STUBBING:** Stubbing is the method wherein a separate line is connected between the primary data bus line and a terminal. The direct connection of stub line causes a mismatch which appears on the waveforms. This mismatch can be reduced by filtering at the receiver and by using bi-phase modulation. Stubs are often employed not only as a convenience in bus layout but as a means of coupling a unit to the line in such a manner that a fault on the stub or terminal will not greatly affect the transmission line operation. In this case, a network is employed in the stub line to provide isolation from the fault. These networks are also used for stubs that are of such length that the mismatch and reflection degrades bus operation. The preferred method of stubbing is to use transformer coupled stubs. The method provides the benefits of DC isolation, increased common mode protection, a doubling of effective stub impedance, and fault isolation for the entire stub and terminal. Direct coupled stubs should be avoided if at all possible. Direct coupled stubs provide no DC isolation or common mode rejection for the terminal external to its subsystem. Further, any shorting fault between the subsystems' internal isolation resistors (usually on the circuit board) and the main bus junction will cause failure of that entire bus. It can be expected that when the direct stub length exceeds 1.6 feet, that it will begin to distort the main bus waveforms. Note that this length includes the cable runs internal to a given subsystem.

**SUBSYSTEM:** The device or functional unit receiving data transfer service from the data bus.

**SYNCHRONOUS TRANSMISSION:** Transmission in which data bits are sent at a fixed rate, with the transmitter and receiver synchronized. Synchronized transmission eliminates the need for start and stop bits.

**TERMINAL:** The electronic module necessary to interface the data bus with the subsystem and the subsystem with the data bus. Terminals may exist as separate units or be contained within the elements of the subsystem.

**TIME DIVISION MULTIPLEXING (TDM):** The transmission of information from several signal sources through one communication system with different signal samples staggered in time to form a composite pulse train.

**WORD:** A set of bits or bytes comprising the smallest unit of addressable memory. In MIL-STD-1553B, a word is a sequence of 16 bits plus sync and parity.