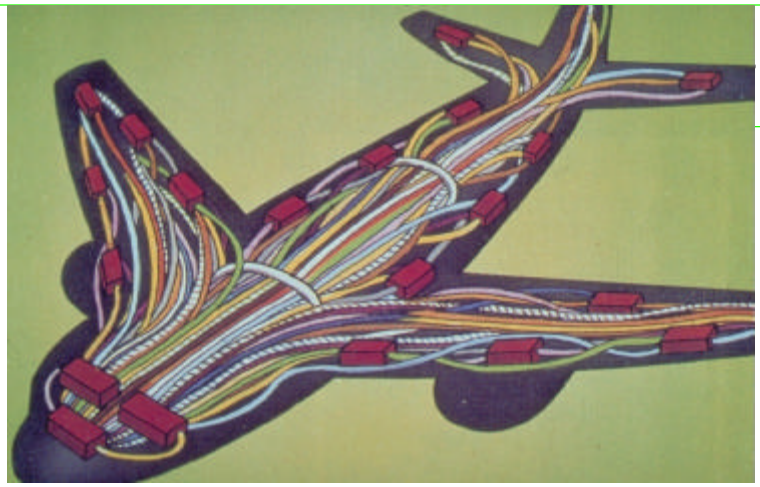
Avionics Databuses

Advantages of multiplexing:
- Weight reduction
- Simplicity
- Standardization
- Flexibility



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4.10.2001
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Agenda

- Basics
- Military applications
- Civilian examples

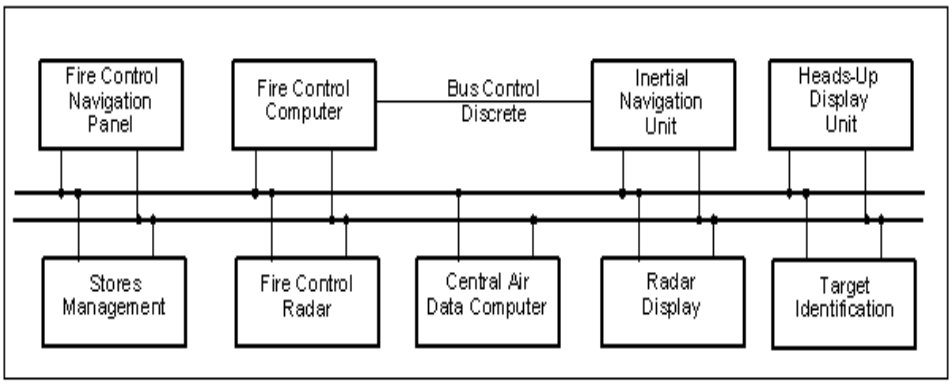


Figure 5. Typical Bus Architecture

Digital bus options

- Feasibility
  - maturity
  - availability
- Topology
  - linear, ring, star
- Redundancy
  - single, dual,..
  - number of buses
- Data transmission
  - unidirectional, bidirectional
  - half-duplex, full-duplex
- Control
  - autonomous, bus controller
  - self-clocking, separate clock
- Aspects
  - transmission rate
  - parallel or serial
  - number of transmitters
  - number of terminals
  - media (wire, light)
  - failure tolerance
  - EMI protection

Databus standards

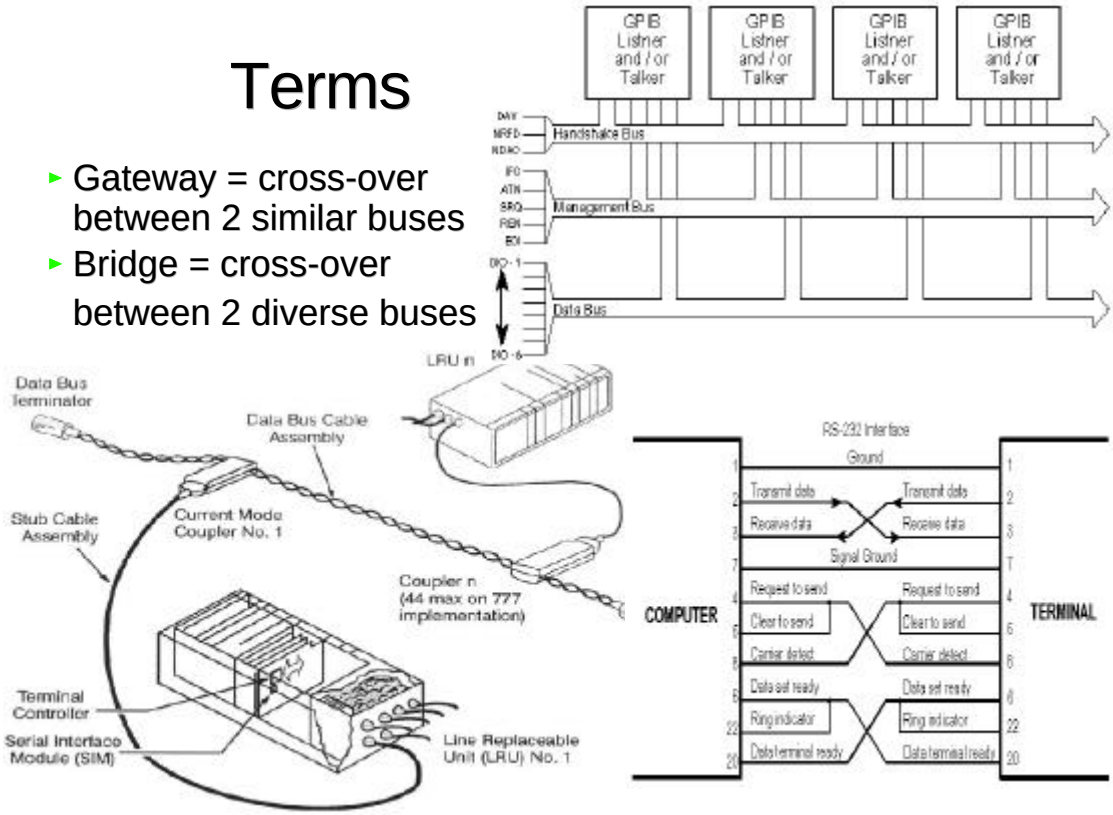
- Mil-Std-1553 Digital Time Division Command /Response Multiplex Data Bus
- Mil-Std-1773
- Stanag 3838/3910
- AS 4074.1 Linear Token Passing Bus
- AS 4074.2 High Speed Ring Bus
- FIBRE Channel
- LAN/Ethernet
- ARINC 429 Mk 33 Digital Information Transfer System
- ARINC 629 Multi-Transmitter Data Bus
- ARINC 659
- CSDB Commercial Standard Communications Bus
- ASCB Avionics Standard Communications Bus
- RS-232, 422, 485, IEEE-488

Comparison of databuses

	Mil-Std-1553	ARINC 429	ARINC 629
Bus architecture	time division multiplex	simplex point-to-point	time division multiplex
Encoding	bipolar Manchester II	bipolar, return to zero	bipolar, doublets Manchester
Transmission mode & coupling	voltage, direct or transformer	voltage direct connection	current coupling
Media	shielded twisted wire pair	shielded twisted wire pair	shielded twisted wire pair
Data bit rate	1 Mbps	12-14,5 kbps HS 100 kbps	2 Mbps
Effective data rate	800 kbps	HS 53 kbps	1,6 Mbps
# of terminals	1BC+31RT+xM	1TX+20RC	120

Terms

- Gateway = cross-over between 2 similar buses
- Bridge = cross-over between 2 diverse buses



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): 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.

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 linklevel 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).

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.

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.

Digital coding

DEC	BIN	BCD		HEX	OCT
	msb lsb				
0	0000	0000	0000	0	0
1	0001	0000	0001	1	1
2	0010	0000	0010	2	2
3	0011	0000	0011	3	3
4	0100	0000	0100	4	4
5	0101	0000	0101	5	5
6	0110	0000	0110	6	6
7	0111	0000	0111	7	7
8	1000	0000	1000	8	10
9	1001	0000	1001	9	11

digital coding 2

DEC	BIN	BCD		HEX	OCT
	msb lsb				
10	1010	0001	0000	A	12
11	1011	0001	0001	B	13
12	1100	0001	0010	C	14
13	1101	0001	0011	D	15
14	1110	0001	0100	E	16
15	1111	0001	0101	F	17
16	1000	0001	0110	10	20
17	10011	0001	0111	11	21
99	1100011	1001	1001	63	143
100	1100100	0001 0000	0000	64	144
723	1011010011	0111 0010	0011	2D3	1323

Mil-Std-1553 bus structure

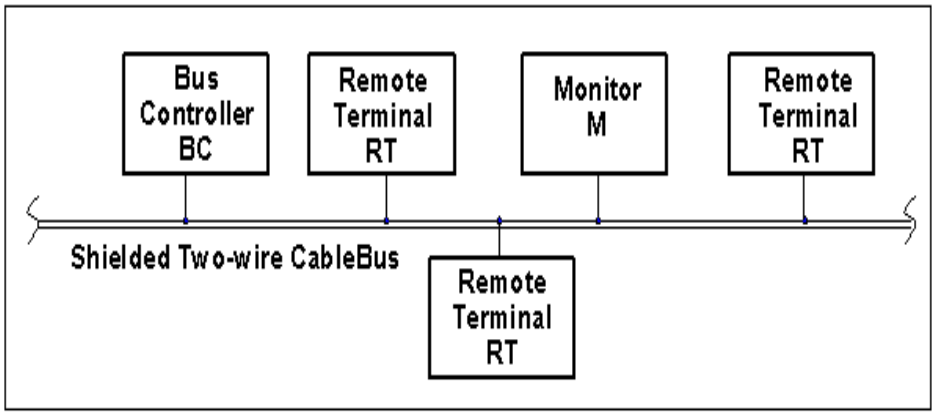
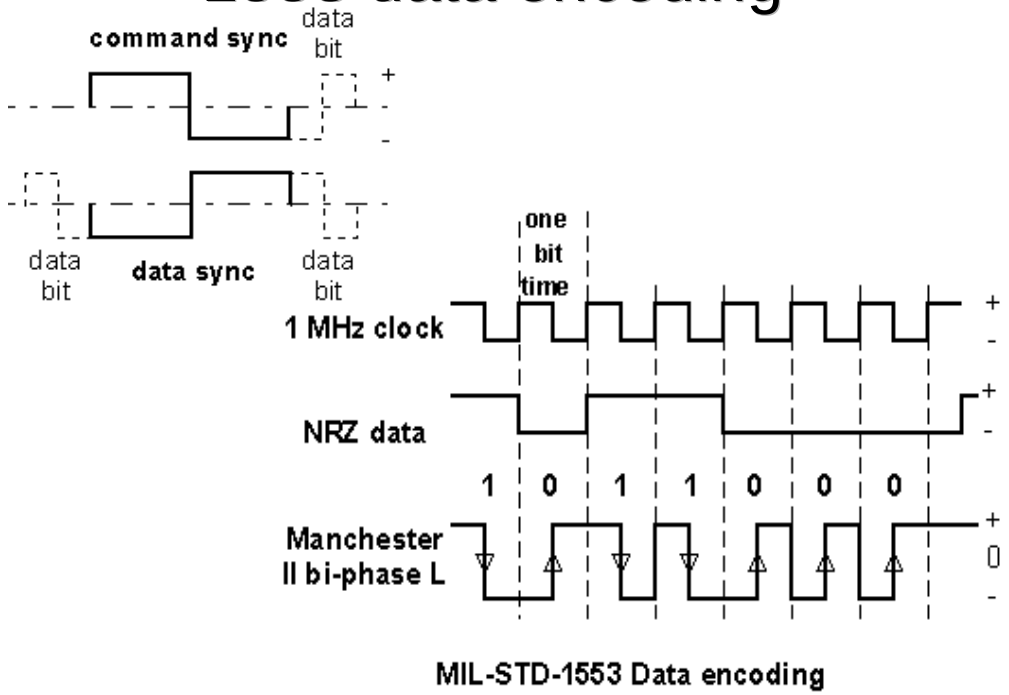


Figure 1. 1553 Bus Structure

1553 data encoding



MIL-STD-1553 Data encoding

Bus components

- Bus Controller - initiates information transfers on the data bus. It sends commands to the remote terminals which reply with a response.
  - The bus supports multiple BCs, but only one may be active at a time.
  - BC is "the key part of the data bus system,"
  - "the sole control of information transmission on the bus shall reside with the bus controller."
- Bus Monitor - "the terminal assigned the task of receiving bus traffic and extracting selected information to be used at a later time."
  - Bus monitors are frequently used for instrumentation.
- Remote Terminal - Any terminal not operating in either the BC or M mode is operating in the remote terminal mode.
  - Remote terminals are the largest group of bus components.

1553 word format

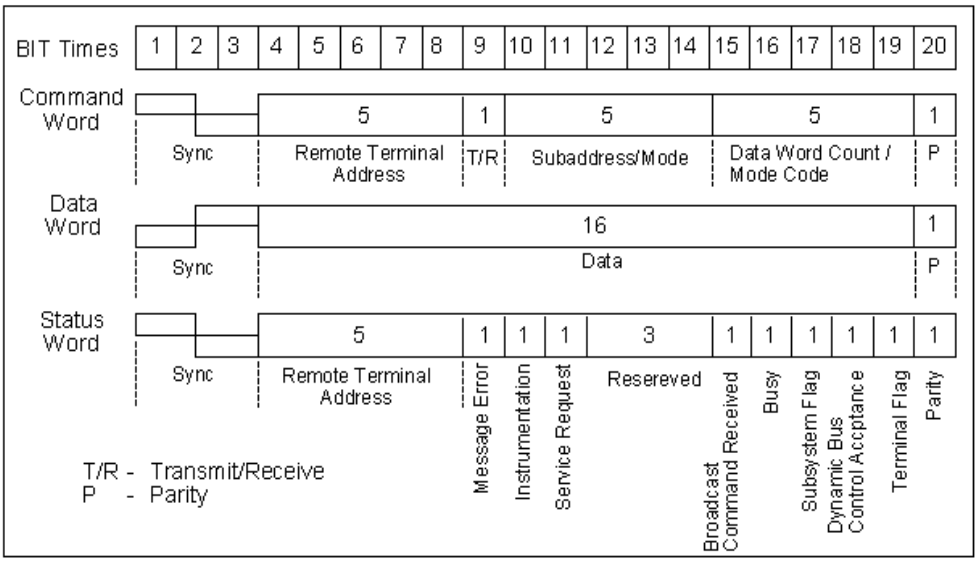


Figure 3. 1553 Word Format

1553 information transfers

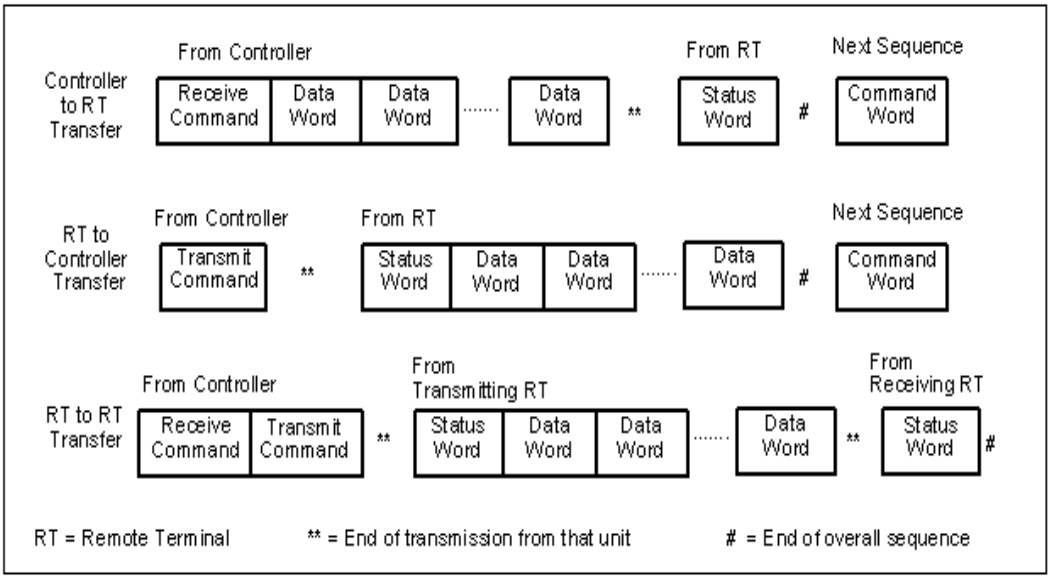
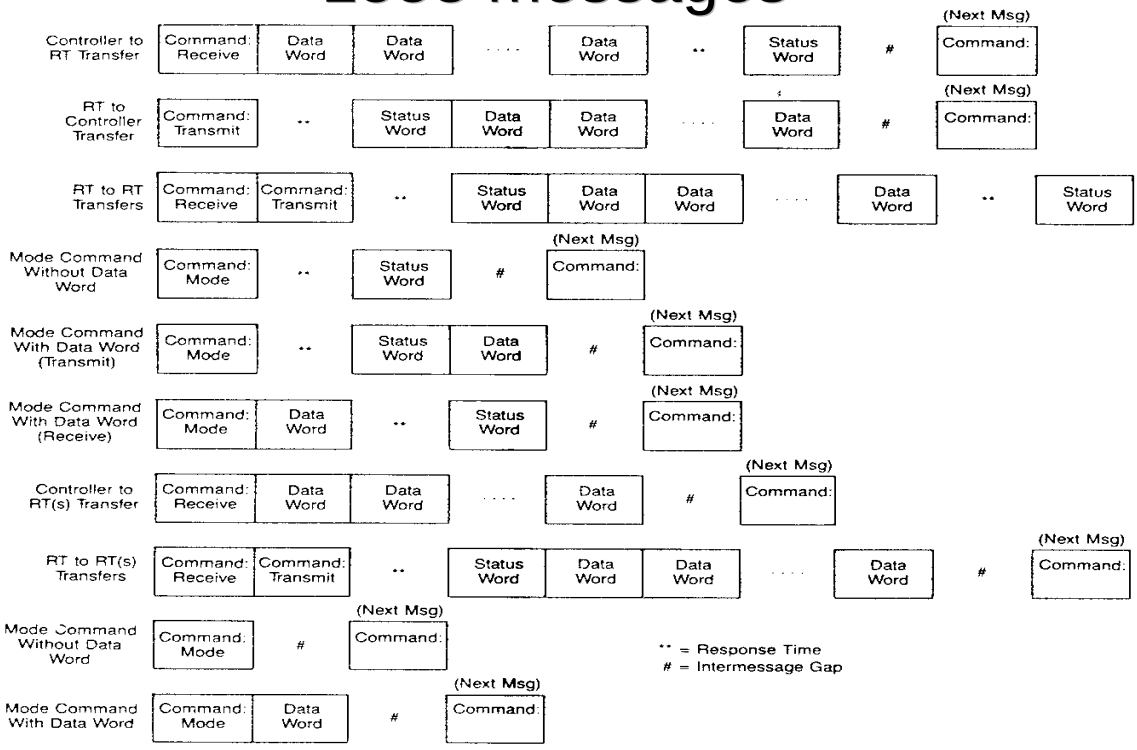
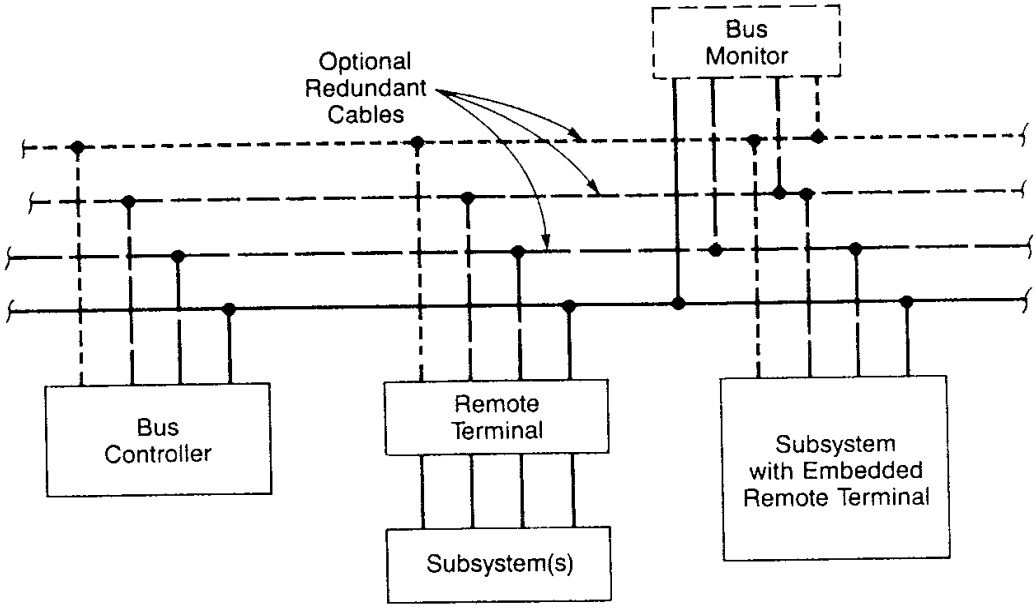


Figure 4. 1553 Data Message Format

1553 messages

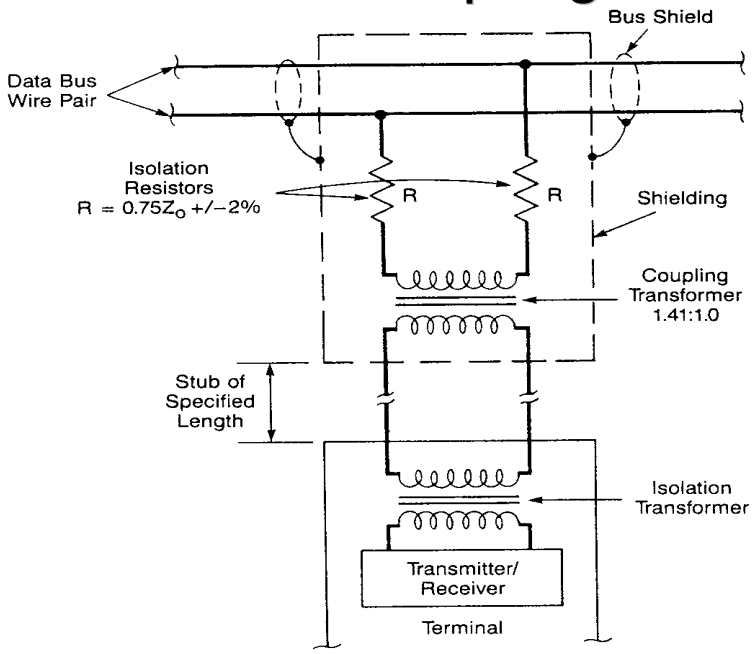


1553 bus structure



Typical MIL-STD-1553 Bus Structure.

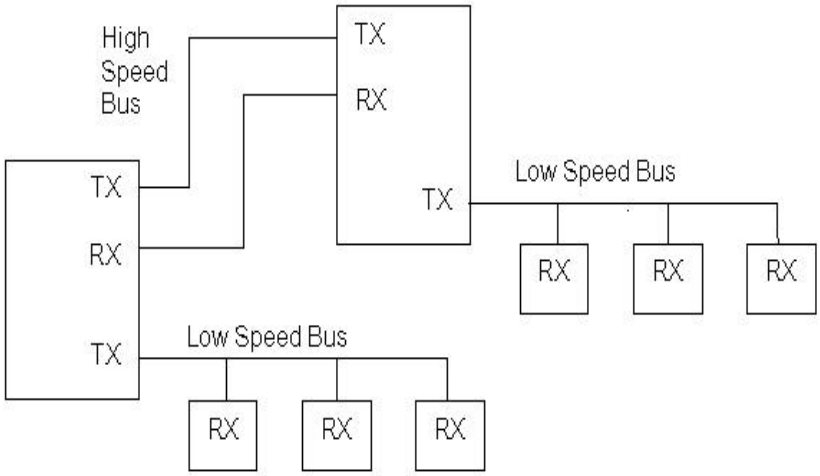
1553 coupling



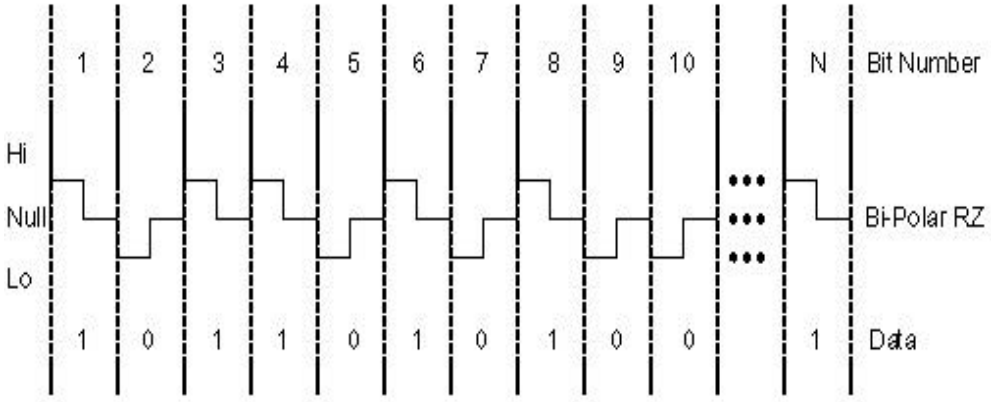
MIL-STD-1553 Standard Transformer Coupled Stub.

ARINC 429 architecture

- One direction
- one Transmitter (source)
- multiple Receivers (sink)



429 Data encoding

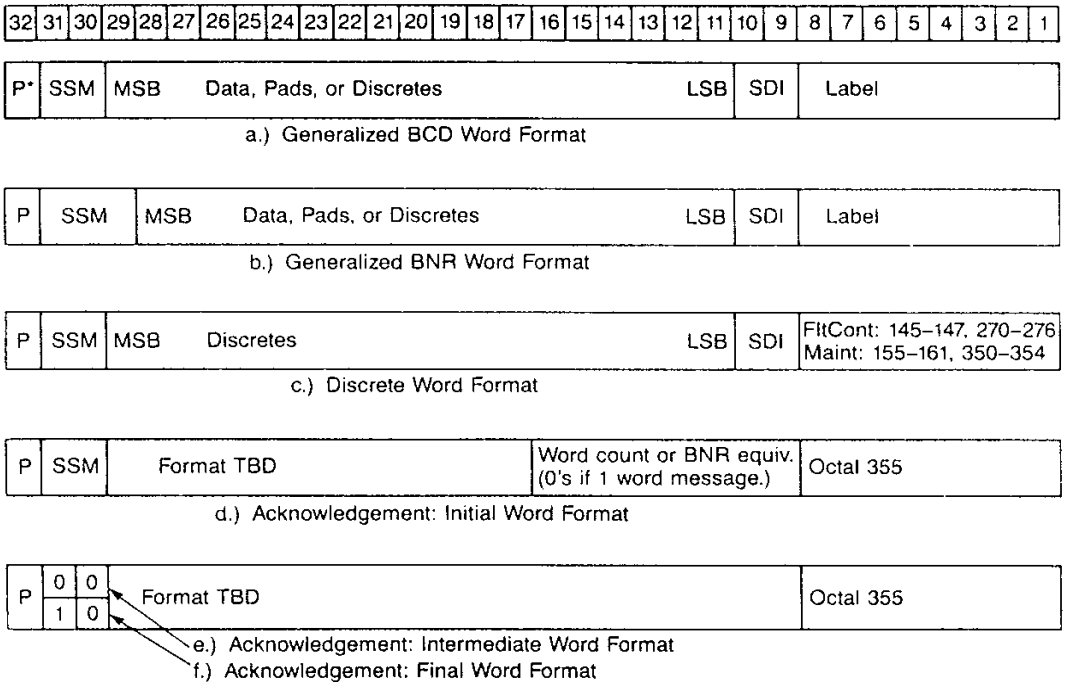


Bi-Polar RZ (Return to Zero) Format Encoding

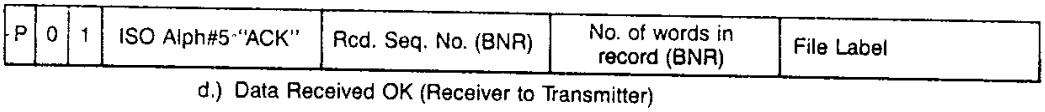
429 word format

- word = 32 bits
  - Label
    - Information Identifier
    - bit 8 = LSB, bit 1 = MSB
    - 00011001 (230) = TAS
  - Data
    - bits 9-10 Source/Destination Identifier SDI
    - bits 30-31 for BCD data or 29-31 for BIN data Sign/Status Matrix SSM
    - bits 11-28 or 11-29 18/19 bits of ISO alphabets or in BCD ordinary
  - Parity - odd
- 5 data word types
  - Binary (BIN) data
  - Binary Coded Decimal (BCD)
  - Discrete Data
  - Maintenance Data (general) & Acknowledgement
    - labels 350-354
  - ISO Alphabet No 5 & Maintenance (ISO Alphabet No 5)

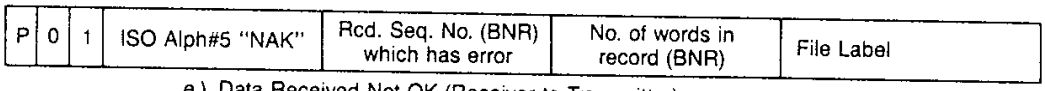
429 word types



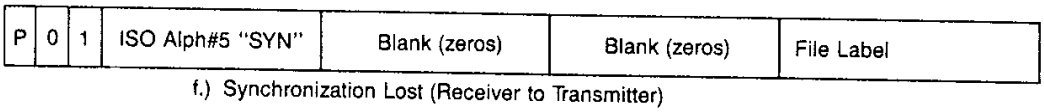
429 word types 2



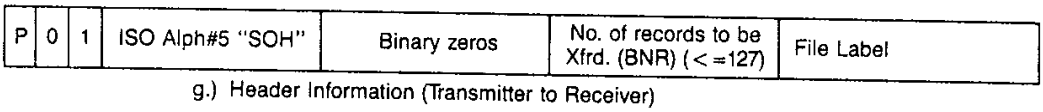
d.) Data Received OK (Receiver to Transmitter)



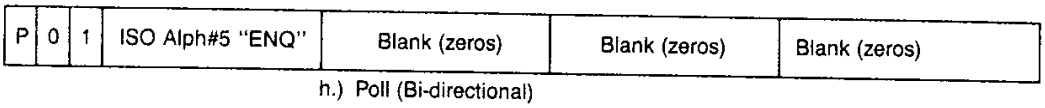
e.) Data Received Not OK (Receiver to Transmitter)



f.) Synchronization Lost (Receiver to Transmitter)



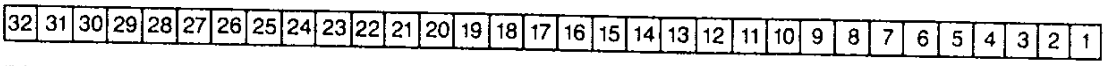
g.) Header Information (Transmitter to Receiver)

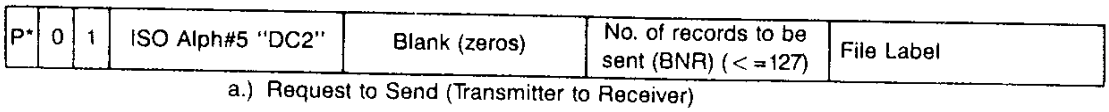


h.) Poll (Bi-directional)

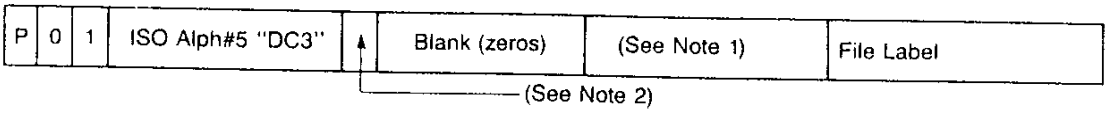
* = Parity bit (odd)

429 transfer word formats





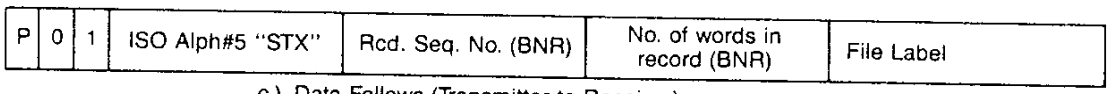
a.) Request to Send (Transmitter to Receiver)



Note 1: Bits 9–15: "0000000" if receiver is not ready to accept data
If receiver is ready then:
BNR count of number of maximum length records or
Number of 32-bit words receiver can accept

Note 2: Bit 22: "0" when receiver is not ready to accept data and
when bits 9–15 are maximum length record count
"1" when bits 9–15 are 32-bit word count

b.) Clear to Send (Receiver to Transmitter)



c.) Data Follows (Transmitter to Receiver)

429 transfer word formats 2

P	0	1	ISO Alph#5 "STX"	Spares (zeros)	Word count or BNR equiv. (0's if 1 word message.)	Maint: 356; Alpha: 357

g.) Alphanumeric (ISO Alphabet No. 5) Data: Initial Word Format

P	1	1	Spares (zeros)	F**	Char. size	Int.	Color	Line Count	Maint: 356; Alpha: 357

** = Flashing display

h.) Alphanumeric (ISO Alphabet No. 5) Data: Control Word Format

P	0	0	Character No. 3	Character No. 2	Character No. 1	Maint: 356; Alpha: 357

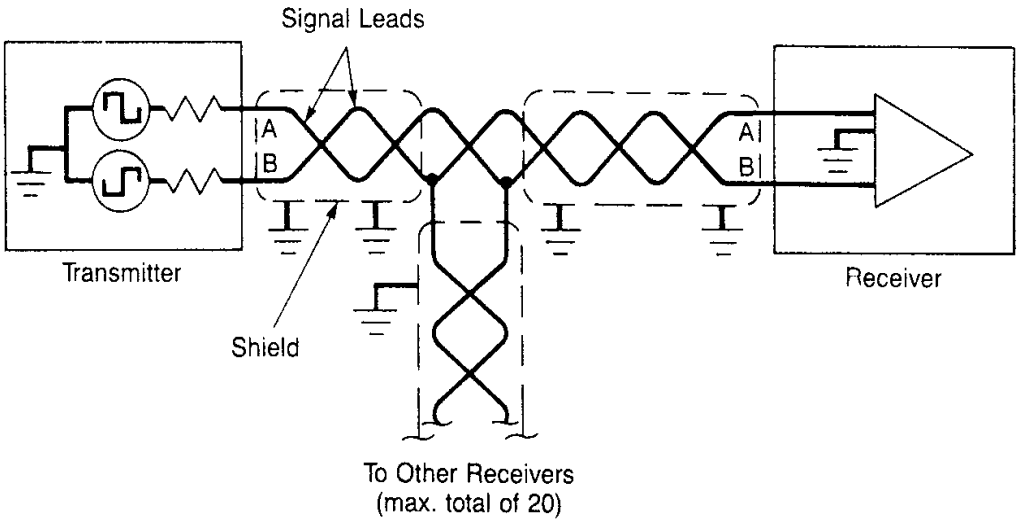
i.) Alphanumeric (ISO Alphabet No. 5) Data: Intermediate Word Format

P	1	0	Character No. n	Character No. n−1	Character No. n−2	Maint: 356; Alpha: 357

j.) Alphanumeric (ISO Alphabet No. 5) Data: Final Word Format

* = Parity bit (odd)

Generalized 429

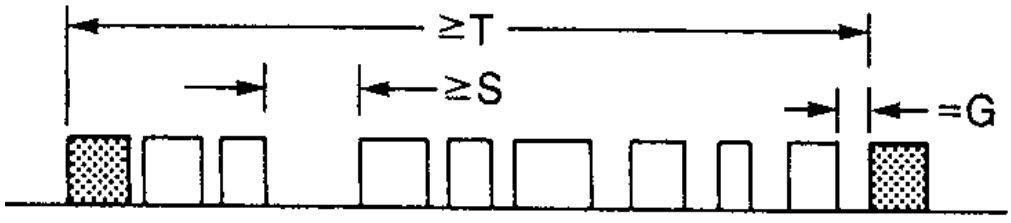


Generalized ARINC 429 Bus.

ARINC 629

- word formats similar to Mil-Std-1553
- 2 Mbps
- Inductive coupling wire
- no bus controller - dead time logic
  - 3 unique timing parameters
    - Transmit Interval 0.5...64ms
    - Syncronication Gap 17,7/33,7/65,7/128,7 µs
    - Terminal Gap 1...125 µs

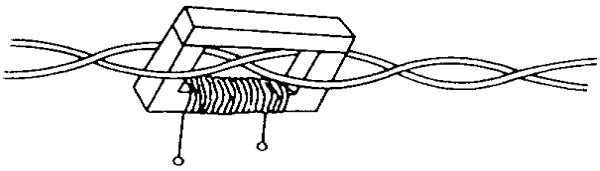
629 timing



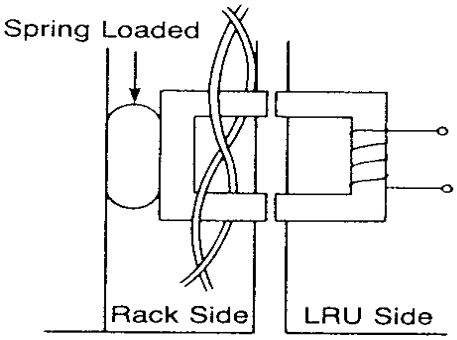
T = Frame Time
S = Unique Bus Gap Time
G = Unique LRU Gap Time

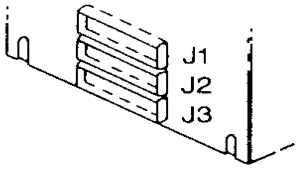
ARINC 629 Timing Parameters

629 coupling



- U-1 Core Implementation of Remotely Located Coupler





LRU Back View

- C Core Implementation of LRU Mounted Coupler

ARINC 629 Inductive Coupler