MIL-STD-1553 Protocol Overview
• MIL-STD-1553 Chronology
• 1553 Physical Layer and Bus Connections
• 1553 Protocol
  – Electrical Encoding
  – Word Types
  – Terminal Types
  – Message Types
  – Redundancy
  – Things to Remember
MIL-STD-1553 Chronology

- 1980 – 1553B Notice 1 – USAF
- 1986 – 1553B Notice 2 – USAF, Army, Navy – RT Validation Test Plan first defined
- 1988 – MIL-HDBK-1553A
Physical Layer

Shielded Twisted Pair
Blue wire is the Positive Signal
White wire is the Negative Signal
78 ohm characteristic impedance
Transformer-Coupled Bus Connections

Innovation, Quality and Service
MIL-STD-1553 & ARINC-429
MIL-STD-1553 Protocol Summary

- Serial digital data, 1 Mbps (1us per bit)
- Self-clocking data (sync at the start of each word)
- Bi-phase (Manchester II) encoding
- Half-duplex
- Terminal Types – Bus Controller (BC), Remote Terminal (RT), Bus Monitor (BM)
- Word types – Command, Data, Status
  - BC sends Command and Data words
  - RT sends Status and Data words
  - BM does not transmit anything
- 20 bit-times per word (20us)
- Minimum of 4us gap between messages
- RT must respond with status in 4us to 12us
- BC allows 14us for status response timeout
1553 Electrical Encoding

1 MHz clock

(+)-
(0)-

NRZ data

(+)-
(0)-

Manchester II biphase level

(0)-
(0)-

NRZ: non-return to zero

Innovation, Quality and Service
MIL-STD-1553 & ARINC-429
This is an example of a 1553 Command Word
• Three terminal types:
  – Bus Controller (BC)
    • Only ONE BC on the bus.
    • Only the BC can send command words.
    • Initiates ALL messages with a command word, may also send data words.
  – Remote Terminal (RT)
    • Up to 31 RTs on the bus (addresses 0-30)
    • Only an RT can send status words.
    • RTs only transmit in response to a command word – they send status words, may also send data words.
  – Bus Monitor (BM)
    • Only listens, does not transmit.
Message Types

- BC to RT – Receive message
- RT to BC – Transmit message
- RT to RT – Receive to one RT, Transmit to other RT
- Mode Code without Data
- Mode Code with Receive Data
- Mode Code with Transmit Data
Broadcast Message Types

- Broadcast BC to RT
- Broadcast RT to RT
- Broadcast Mode Code without Data
- Broadcast Mode Code with Receive Data

An RT Address of 31 indicates BROADCAST
## 1553B Mode Codes

A Subaddress of 0 or 31 indicates MODE CODE

<table>
<thead>
<tr>
<th>T/R Bit</th>
<th>Mode Code</th>
<th>Function</th>
<th>Assoc. Data Word</th>
<th>Broadcast Command Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>00000 (0)</td>
<td>Dynamic Bus Control</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>00001 (1)</td>
<td>Synchronize (without Data)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>00010 (2)</td>
<td>Transmit Status Word</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>00011 (3)</td>
<td>Initiate Self-Test</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>00100 (4)</td>
<td>Transmitter Shutdown</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>00101 (5)</td>
<td>Override Transmitter Shutdown</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>00110 (6)</td>
<td>Inhibit Terminal Flag Bit</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>00111 (7)</td>
<td>Override Inhibit Terminal Flag Bit</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>01000 (8)</td>
<td>Reset Remote Terminal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>01001 (9)</td>
<td>Reserved</td>
<td>No</td>
<td>TBD</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>1</td>
<td>01111 (15)</td>
<td>Reserved</td>
<td>No</td>
<td>TBD</td>
</tr>
<tr>
<td>1</td>
<td>10000 (16)</td>
<td>Transmit Vector Word</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>0</td>
<td>10001 (17)</td>
<td>Synchronize (with Data)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>10010 (18)</td>
<td>Transmit Last Command</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>10011 (19)</td>
<td>Transmit BIT Word</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>0</td>
<td>10100 (20)</td>
<td>Selected Transmitter Shutdown</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>0</td>
<td>10101 (21)</td>
<td>Override Selected Transmitter Shutdown</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>0 or 1</td>
<td>10110 (22)</td>
<td>Reserved</td>
<td>Yes</td>
<td>TBD</td>
</tr>
<tr>
<td>0 or 1</td>
<td>11111 (31)</td>
<td>Reserved</td>
<td>Yes</td>
<td>TBD</td>
</tr>
</tbody>
</table>
BC to RT Message

MESSAGE #2

(89)17:22:30.074.576.560 IM Gap: 15154.6us
BUS A - CMD:1820 (3-R-1-32) BCRT
9EF3 1D47 FB99 A306 5A18 CAC8 BFEE 607D
FB0C ED27 27C5 04A9 22CE 6B31 A22A C0AF
9C44 15FA 086B D872 0E5F 187E 08BC CFB1
92EB 038A 7152 1D6D 388F 6EF6 4325 C051
Rsp Time 7.7us STS:1800
Message Time = 685.7us
MESSAGE #3

(89)17:22:30.090.935.360  IM Gap: 15674.5us
BUS B - CMD:1440 (2-T-2-32) RTBC
Rsp Time 10.3us STS:1000
49EB A931 E18C 9E5E E357 994E 92AE D1FC
75CB 6CCC 84A8 78D1 ECA7 2D91 6EF8 C0A9
A487 578D AC90 04A4 4B67 8674 148B 2BE8
101A 568D 5975 A281 27EE 8C15 AA01 6773
Message Time = 688.3us
MESSAGE #4 -------------------------------

(89)17:22:30.105.771.740  IM Gap: 14428.3us
BUS B - CMD:0870:1470 (1-R-3-16,2-T-3-16) RTRT
Rsp Time 5.7us STS:1000
2145 F8F9 DF23 FDE6 32A2 6F1D 45C4 3C63
A2B3 9BEF 4B08 1A1A 16E3 43C1 AE74 77E5
Rsp Time 10.3us STS:0800
Message Time = 412us
Mode Code (No Data) Message

MESSAGE #7

(89)17:22:30.152.325.720   IM Gap: 15816.6us
BUS A - CMD:0C01 (1-T-0-1) MODE CODE
    Synchronize Without Data
Rsp Time 5.7us STS:0800

Message Time = 43.7us
Mode Code (Receive Data) Message

MESSAGE #161

(89)18:49:36.231.538.660  IM Gap: 98428.2us
BUS A - CMD:2811 (5-R-0-17) MODE CODE
Synchronize With Data

25A9
Rsp Time 8.6us STS:2800
Message Time = 66.6us
Mode Code (Transmit Data) Message

MESSAGE #162

(89)18:49:36.231.613.740  IM Gap: 10.6us
BUS A - CMD:1C10 (3-T-0-16) MODE CODE
Transmit Vector Word
Rsp Time 8.5us STS:1800
0000
Message Time = 66.5us
Broadcast BC to RT Message

MESSAGE #163

(89)18:49:36.231.688.660  IM Gap: 10.6us
BUS A - CMD:F920 (31-R-9-32) BRDCST BCRT
F61A D948 A114 9625 294B 86CD BD20 7E4F
FAA4 856A 3A88 4F92 5A16 2070 4CEC 98A2
F809 78F0 13AA A101 5647 C9E8 42E6 C39C
C57E 836B 4654 679B 8FCB 0396 1953 488B
Message Time = 660us
Broadcast RT to RT Message

MESSAGE #164

(89)18:49:36.232.357.260 IM Gap: 10.7us
BUS A - CMD:FA20:2F00 (31-R-17-32,5-T-24-32) BRDCST RTRT
Rsp Time 8.8us STS:2800
25A9 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 Message Time = 706.8us
Broadcast Mode (No Data) Message

MESSAGE #702

(89)19:32:30.751.531.260  IM Gap: 11.6us
BUS A - CMD:FC03 (31-T-0-3) BRDCST MODE CODE
Initiate Self Test

Message Time = 20us
Broadcast Mode (Rcv Data) Message

MESSAGE #165 --------------------------------------------------------
(89)18:49:36.233.072.540 IM Gap: 10.6us
BUS A - CMD: F811 (31-R-0-17) BRDCST MODE CODE
Synchronize With Data
0000
Message Time = 40us
• 1553 can use a single bus or a dual-redundant bus.

• Dual-redundant bus:
  – Bus A (primary) and Bus B (secondary)
  – Bus Controller can send messages on either bus.
  – Remote Terminals respond on the bus where they saw the command word.
  – CANNOT have traffic on both busses at the same time.
Single Bus – No Redundancy

Remote Terminal

Remote Terminal

Bus Controller

Bus A

Innovation, Quality and Service
MIL-STD-1553 & ARINC-429
Things to Remember

- 1553 is a 1Mbps serial data bus
  - Single or dual-redundant bus configurations
  - Transformer coupled (direct coupling should not be used)

- Three terminal types – BC, RT, BM
  - Bus Controller initiates everything
    - Only one BC on a bus
    - Only the BC can send command words
    - A message can have up to 32 data words
    - The BC should allow 14us for the RT to respond with status
    - The BC must allow at least a 4us gap between messages
  - Remote Terminals respond to commands from the BC
    - Only RTs can send status words, RT must respond with status in 4us to 12us.
    - Up to 31 RTs on a bus (RT address 0-30)
    - RT address 31 is BROADCAST
    - Each RT can have 30 subaddresses (1-30)
    - Subaddresses 0 and 31 indicate MODE CODE
  - Bus Monitor only listens, never transmits
• **Bus Controller Implementations**
  - Message scheduling – Minor frames, major frames, aperiodic messages
  - Message retries and error recovery
  - Conditional Branching
  - Enabled and disabled (NOP) messages

• **Remote Terminal Implementations**
  - Mode Code handling – BIT word, vector word, etc.
  - Usage of Status Word bits – Busy, Service Request, etc.
  - MIL-STD-1760 power-up response and checksums

• **Bus Monitor Implementations**
  - Data processing, error checking, archiving
  - Backup Bus Controller
Summary

• MIL-STD-1553 Chronology
• 1553 Physical Layer and Bus Connections
• 1553 Protocol
  – Electrical Encoding
  – Word Types
  – Terminal Types
  – Message Types
  – Redundancy
  – Things to Remember