

- ClearHubFeature() request
 - clearing hub features, 11.24.2.6
 - hub class requests, 11.24.2
 - hub class-specific requests, 11.24.2.1
 - clearing pipes, 10.5.2.2
 - ClearPortFeature() request
 - clearing status change bits, 11.12.2, 11.24.2.7.2
 - C_PORT_CONNECTION, 11.24.2.7.2.1
 - C_PORT_ENABLE, 11.24.2.7.2.2
 - C_PORT_OVER-CURRENT, 11.24.2.7.2.4
 - C_PORT_RESET, 11.24.2.7.2.5
 - C_PORT_SUSPEND, 11.24.2.7.2.3
 - hub class requests, 11.24.2, 11.24.2.2
 - PORT_CONNECTION, 11.24.2.7.1.1
 - PORT_ENABLE, 11.5.1.4, 11.24.2.7.1.2
 - PORT_HIGH_SPEED, 11.24.2.7.1.8
 - PORT_INDICATOR, 11.24.2.2, 11.24.2.7.1.10
 - PORT_LOW_SPEED, 11.24.2.7.1.7
 - PORT_OVER_CURRENT, 11.24.2.7.1.4
 - PORT_POWER, 11.24.2.13
 - PORT_POWER, 11.5.1.2, 11.24.2.7.1.6
 - PORT_RESET, 11.24.2.7.1.5
 - PORT_SUSPEND, 11.5.1.10
 - ClearTTBuffer() request, CLEAR_TT_BUFFER
 - checking for busy state, 11.17.5
 - hub class-specific requests, 11.24.2, 11.24.2.3
 - client pipes, 10.5.1.2.2
 - client software
 - in bus topology, 5.2, 5.2.1, 5.2.5
 - client software-to-function relationships, 5.2, 5.2.5
 - in communication flow, 5.3
 - control transfers and, 5.5
 - defined, 2.0 *glossary*
 - as implementation focus area, 5.1
 - notification identification, 10.3.4
 - role in configuration, 10.3.1
 - role in data transfers, 10.3.3
 - service clock and, 5.12.2
 - in source-to-sink connectivity, 5.12.4.4
 - in transfer management, 5.11.1, 5.11.1.1
 - clock model
 - buffering for rate matching, 5.12.8
 - bus clock, 5.12.2
 - clock encoding scheme in electrical specifications overview, 4.2.1
 - clock synchronization, 5.12.3
 - clock-to-clock phase differences, 5.12.3
 - clock tolerance, 11.7.1.3
 - defined, 5.12
 - frame clocks, 11.18.3
 - hub clock source, 11.2.3
 - in non-USB isochronous application, 5.12.1
 - overview, 5.12.2
 - clock model (*continued*)
 - receive clock, 11.7.1.2, 11.7.1.3
 - sample clock, 5.12.2
 - service clock, 5.12.2
 - transmit clock, 11.7.1.3
 - using SOF tokens as clocks, 5.12.5
 - clock timings, 7.3.2 *Table 7-8*, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
 - CMOS driver circuit, 7.1.1.1
 - CMOS implementations, 7.1.1.3
 - codes. *See specific types of codes*
 - Collision conditions, 11.8.3
 - color choices
 - cables, 6.4
 - indicator lights on devices, 11.5.3 to 11.5.3.1
 - plugs, 6.5.4.1
 - receptacles, 6.5.3.1
 - commanded stalls, 8.4.5
 - commands. *See requests*
 - common mode range for differential input
 - sensitivity, 7.1.4.1
 - Communication Cables (UL Subject-444)*, 6.6.5, 6.7.1
 - communication flow, 5.3 to 5.3.3
 - Compare_BC_buff algorithm, 11.17.1
 - completed operations, 9.2.6
 - completed transactions, 11.3.3
 - complete-split transactions
 - buffering, 11.14.2.1, 11.17
 - bulk/control transactions, 11.17, 11.17.1
 - CSPLIT transaction tokens, 8.4.2.3
 - defined, 11.14.1.2
 - isochronous transactions, 11.21
 - notation for, 11.15
 - overview, 11.14.1
 - scheduling, 11.14.2.1, 11.18.4
 - space for, 11.18.6.3
 - split transaction overview, 8.4.2, 8.4.2.1
 - TT state searching, 11.18.8
- completion times for hub requests, 11.24.1
 - composite devices, 5.2.3
 - compound devices
 - bus-powered hubs, 7.2.1.1
 - in bus topology, 5.2.3
 - defined, 4.8.2.2
 - hub descriptors for, 11.23.2.1
 - power configuration, 11.13
 - self-powered hubs, 7.2.1.2
 - conditions in state machine transitions, 8.5, 11.15
 - conductor resistance unbalance, 6.6.3
 - conductors
 - mechanical specifications, 4.2.2
 - power and signal conductors in cables, 6.3, 6.6.2
 - resistance, 6.6.3

configuration

- bus enumeration, 4.6.3, 9.1.2
- configuration management, 10.5.4.1.1
- Configured device state, 9.1.1.5
- control transfers and, 5.5.4
- descriptors, 5.3.1.1, 9.4.3, 9.5, 9.6.1 to 9.6.4, 11.23.1 (*See also* descriptors)
- device attachment, 4.6.1
- device configuration, 10.3.1
- device removal, 4.6.2, 10.5.4.1.4
- function configuration, 10.3.1
- hubs, 11.13
- information in device characteristics, 4.8.1
- initial device configuration, 10.5.4.1.2
- interrupt transfers and, 5.7.4
- modifying device configuration, 10.5.4.1.3
- multiple configurations, 9.6.1
- multiple interfaces, 9.2.3
- operations overview, 9.2.3
- other-speed configurations, 9.6.2
- power distribution and, 7.2.1
- remote wakeup capabilities, 9.2.5.2
- requests
 - configuration requests, 5.11.1.2
 - GetConfiguration() request, 9.4.2
 - SetConfiguration() request, 9.4.7
- required configurations before usage, 10.3.1
- USB configuration, 10.3.1
- USBID mechanisms for getting current settings, 10.5.2.4
- USBID role in, 5.11.1.2, 10.5.4.1 to 10.5.4.1.4
- Configuration = 0 signal/event, 11.5 *Table 11-5*
- CONFIGURATION descriptor, 9.4 *Table 9-5*
- configuration descriptors, 9.4.3, 9.6.4, 11.23.1
- Configured device state
 - in bus enumeration process, 9.1.2
 - overview, 9.1.1.5
 - standard device requests and, 9.4.1 to 9.4.11
 - visible device state table, 9.1.1 *Table 9-1*
- configuring software, defined, 2.0 *glossary*
- Connect bus state, 7.1.7.1, 7.1.7.3
- connecting devices. *See* dynamic insertion and removal
- connection status, 11.24.2.7.2, 11.24.2.7.2.1
- connectivity
 - audio connectivity, 5.12.4.4.1
 - hub fault recovery mechanisms, 11.1.2.3
 - Hub Repeater responsibilities, 11.1
 - hubs, 11.1, 11.1.2 to 11.1.2.3
 - packet signaling connectivity, 11.1.2.1
 - resume connectivity, 11.1.2.2
 - source/sink connectivity, 5.12.4.4
 - synchronous data connectivity, 5.12.4.4.2
 - tearing down, 11.2.5

connectors

- input capacitance, 7.1.6.1
- inrush current and, 7.2.4.1
- interface and mating drawings, 6.5.3, 6.5.4
- keyed connector protocol, 6.2
- mechanical configuration and material requirements, 4.2.2, 6.5 to 6.5.4.3
- orientation, 6.5.1
- reference times, 7.1.6.2
- Series "A" and Series "B" plugs, 6.5.4
- Series "A" and Series "B" receptacles, 6.5.3
- standards for, 6.7
- termination data, 6.5.2
- USB Icon, 6.5
- construction, cable, 6.6.2
- contact arcing, minimizing, 7.2.4.1
- contact capacitance standards, 6.7 *Table 6-7*
- contact current rating standards, 6.7 *Table 6-7*
- contact materials, 6.5.3.3, 6.5.4.3
- control endpoints, 2.0 *glossary*. *See also* control transfers
- controlling hubs, defined, 7.1.7.7
- control mechanisms
 - device states and control information, 11.12.2
 - Host Controller control flow management, 4.9
 - of USB host, 10.1.2
- control pipes, 2.0 *glossary*. *See also* control transfers; message pipes; pipes
- control transfers. *See also* non-periodic transactions
 - buffering, 11.14.2.2, 11.17.4
 - bus access constraints, 5.5.4
 - control pipes in device characteristics, 4.8.1
 - data format, 5.5.1
 - data sequences, 5.5.5
 - defined, 2.0 *glossary*, 5.4
 - device requests, 9.3
 - direction, 5.5.2
 - error handling on last data transaction, 8.5.3.3
 - failures, 11.17.5
 - full-speed limits, 5.5.4 *Table 5-2*
 - high-speed limits, 5.5.4 *Table 5-3*
 - low-speed limits, 5.5.4 *Table 5-1*
 - NAK rates for endpoints, 9.6.6
 - non-periodic transactions, 11.17 to 11.17.5
 - overview, 4.7.1, 5.5
 - packet size, 5.5.3, 9.6.6
 - protocol stalls, 8.4.5
 - reporting status results, 8.5.3.1
 - scheduling, 11.14.2.2
 - simultaneous transfers, 5.5.4
 - split transaction examples, A.1, A.2
 - split transaction notation for, 11.15
 - stages, 2.0 *glossary*, 5.5
 - STALL handshakes returned by control pipes, 8.5.3.4

control transfers (*continued*)
 state machines, 8.5.1, 8.5.1.1, 8.5.2, 11.17.2
 transaction format, 8.5.3
 transaction organization within IRPs, 5.11.2
 USB pipe mechanism responsibilities,
 10.5.3.1.4
 variable-length data stage, 8.5.3.2
 converting split transactions, 11.14.1
 corrupted transfers and requests
 in control transfers, 8.5.3
 corrupted ACK handshake, 8.5.3.3, 8.6.4
 corrupted CRCs, 10.2.6
 corrupted IN tokens, 8.4.6.1
 corrupted PIDs, 8.3.1
 corrupted SOF packets in isochronous
 transfers, 5.12.6
 in data toggle, 8.6.3
 error detection and recovery, 8.7 to 8.7.4
 function response to OUT transactions,
 8.4.6.3
 host response to IN transactions, 8.4.6.2
 NAK or STALL handshake, 8.6.3
 costs of implementation, 3.3
C_PORT_CONNECTION
 clearing, 11.24.2.2
 defined, 11.24.2.7.2.1
 hub class feature selectors, 11.24.2
 Port Change field, 11.24.2.7.2
 port status changes, 11.24.2.7.1.10
 SetPortFeature() request, 11.24.2.13
C_PORT_ENABLE
 ClearPortFeature() request, 11.24.2.2
 defined, 11.24.2.7.2.2
 hub class feature selectors, 11.24.2
 Port Change field, 11.24.2.7.2
 SetPortFeature() request, 11.24.2.13
C_PORT_OVER_CURRENT
 clearing, 11.24.2.2
 defined, 11.24.2.7.2.4
 hub class feature selectors, 11.24.2
 over-current conditions, 11.11.1, 11.12.5
 Port Change field, 11.24.2.7.2
 SetPortFeature() request, 11.24.2.13
C_PORT_RESET
 clearing, 11.24.2.2
 defined, 11.24.2.7.2.5
 hub class feature selectors, 11.24.2
 Port Change field, 11.24.2.7.2
 SetPortFeature() request, 11.24.2.13
C_PORT_SUSPEND
 clearing, 11.24.2.2
 defined, 11.24.2.7.2.3
 hub class feature selectors, 11.24.2
 Port Change field, 11.24.2.7.2
 resume conditions and, 11.4.4
 SetPortFeature() request, 11.24.2.13

CRCs
 in bulk transfers, 8.5.2
 corrupted CRCs, 10.2.6
 CRC16 handling, 11.15, 11.18.5, 11.20.3,
 11.20.4, 11.21.3, 11.21.4
 CRC check failures, 11.15, 11.20.3, 11.20.4,
 11.21.3, 11.21.4
 in data packets, 8.3.5.2, 8.4.4
 defined, 2.0 *glossary*
 in error detection, 8.7.1
 overview, 8.3.5
 protection in isochronous transfers, 5.12.7
 resending, 8.6.4
 in token packets, 8.3.5.1, 8.4.1
 USB robustness and, 4.5, 4.5.1
 cross-over points of data lines, 7.1.13.2.1
 cross-over voltage in signaling, 7.1.2.1
 crystal capacitive loading, 7.1.11
 CSPLIT (complete-split transactions). *See*
 complete-split transactions
 CTI, 2.0 *glossary*, 3.1
 current
 current averaging profile, 7.2.3
 current spikes during suspend/resume, 7.2.3
 high-speed current driver, 7.1 *Table 7-1*
 high-speed signaling and, 7.1.1.3
 supply current, 7.3.2 *Table 7-7*
 current frame in hub timing, 11.2.3.1
 current limiting
 bus-powered hubs, 7.2.1.1
 dynamic attach and detach, 7.2.4.1
 in over-current conditions, 11.12.5
 power control during suspend/resume, 7.2.3
 remote wakeup and, 7.2.3
 self-powered functions, 7.2.1.5
 cyclic redundancy check. *See* CRCs

D

D+ or D- lines
 average voltage, 7.1.2.1
 high-speed signaling and, 7.1, 7.1.1.3
 impedance, 7.1.6.1
 pull-up resistors and, 7.1
 signaling levels and, 7.1.7.1
 signal termination, 7.1.5.1
 during signal transitions, 7.1.4.1
 single-ended capacitance, 7.1.1.2
 standardized contact terminating
 assignments, 6.5.2
 test mode, 7.1.20
 data
 data defined, 5.12.4
 data encoding/decoding, 7.1.8
 data prebuffering, 5.12.5
 data processing role of Host Controller, 10.2.4

- DATA0/DATA1/DATA2 PIDs
 - in bulk transfers, 5.8.5, 8.5.2
 - comparing sequence bits, 8.6.2
 - in control transfers, 8.5.3
 - in data packets, 8.4.4
 - high-bandwidth transactions and, 5.9.1, 5.9.2
 - high-speed DATA2 PIDs, 8.3.1 *Table 8-1*
 - in interrupt transactions, 5.7.5, 8.5.4, 11.20.4
 - synchronization and, 8.6
 - Transaction Translator response generation, 11.18.5
- data field in packets, 8.3.4, 8.4.4
- data flow model. *See* transfers
- data flow types. *See* transfer types
- data formats. *See also specific types of transfers*
 - bulk transfers, 5.8.1
 - control transfers, 5.5.1
 - interrupt transfers, 5.7.1
 - isochronous transfers, 5.6.1, 5.12.4
 - overview, 5.4
- Data J state. *See* J bus state
- Data K bus state. *See* K bus state
- data packets
 - bus protocol overview, 4.4
 - data CRCs, 8.3.5.2
 - in isochronous transfers, 8.5.5
 - packet field formats, 8.3 to 8.3.5.2
 - packet overview, 8.4.4
 - spreading over several frames, 5.5.4
- data payload
 - bulk transfers, 5.8.3
 - calculating transaction times, 5.11.3
 - defined, 5.3.2
 - interrupt transfers, 5.7.3
 - isochronous transfers, 5.6.3
 - maximum sizes, 8.4.4
 - non-zero data payload, 5.6.3
 - packet size constraints, 5.5.3, 5.6.3
- data phases
 - aborting, 11.18.6.1
 - transaction notation for, 11.15
- data PIDs. *See* DATA0/DATA1/DATA2 PIDs; DATA0/DATA1 PIDs; MDATA PIDs
- data rates
 - adaptive endpoints, 5.12.4.1.3
 - asynchronous endpoints, 5.12.4.1.1
 - in buffering calculations, 5.12.8
 - data-rate tolerance, 7.1.11
 - defined, 5.12.4
 - in electrical specifications overview, 4.2.1
 - feedback for isochronous transfers, 5.12.4.2
 - full-speed source electrical characteristics, 7.3.2 *Table 7-9*
 - high-speed source electrical characteristics, 7.3.2 *Table 7-8*
 - data rates (*continued*)
 - low-speed source electrical characteristics, 7.3.2 *Table 7-10*
 - overview, 7.1.11
 - sample clock and, 5.12.2
 - synchronous endpoints, 5.12.4.1.2
- data recovery unit, 11.7.1.2
- data retry indicators in control transfers, 5.5.5
- data sequences
 - bulk transfers, 5.8.5
 - control transfers, 5.5.5
 - interrupt transfers, 5.7.5
 - isochronous transfers, 5.6.5
- data signaling, 7.1.7.4 to 7.1.7.4.2
- data signal rise and fall time. *See* rise and fall times
- data source jitter, 7.1.13.1 to 7.1.13.1.2, 7.1.14.2, 7.1.15.1
- data source signaling, 7.1.13 to 7.1.13.2.2
- Data stage
 - in control transfers, 5.5, 5.5.5, 8.5.3
 - error handling on last data transaction, 8.5.3.3
 - length of data, 9.3.5
 - packet size constraints, 5.5.3
 - variable-length data stages, 8.5.3.2
- data toggle
 - bulk transfers, 5.8.5
 - in bulk transfers, 8.5.2
 - corrupted ACK handshake, 8.6.4
 - data corrupted or not accepted, 8.6.3
 - in data packets, 8.4.4
 - data toggle sequencing, 8.5.5
 - high bandwidth transactions and, 5.9.1
 - initialization via SETUP token, 8.6.1
 - in interrupt transactions, 8.5.4
 - interrupt transfers and, 5.7.5
 - low-speed transactions, 8.6.5
 - overview, 8.6
 - successful data transactions, 8.6.2
- data transfers. *See* data packets; Data stage; transfers
- DC electrical characteristics, 7.3.2 *Table 7-7*
 - DC output voltage specifications, 7.1.6.2
 - DC resistance of plugs, 6.6.3
- debounce intervals in connection events, 7.1.7.3
- debouncing connections, 11.8.2
- declarations in state machines
 - global declarations, B.1
 - Host Controller declarations, B.2
 - Transaction Translator declarations, B.3
- decoupling capacitance, 7.3.2 *Table 7-7*
- default addresses of devices, 2.0 *glossary*, 9.1.1.4, 10.5.1.1
- Default bus state, 7.1.7.5

- Default Control Pipe
 - in bus enumeration process, 9.1.2
 - in communication flow, 5.3
 - control transfer packet size constraints, 5.5.3
 - defined, 4.4, 5.3.2
 - endpoint zero requirements, 5.3.1.1
 - as message pipe, 5.3.2.2
 - size description in descriptors, 9.6.1
- Default device state
 - overview, 9.1.1.3
 - standard device requests and, 9.4.1 to 9.4.11
 - visible device state table, 9.1.1 *Table 9-1*
- default pipes, 2.0 *glossary*, 10.5.1.2.1
- delays. *See* cable delay; differential delay; propagation delay
- delivery rates in isochronous transfers, 4.7.4
- DEOP signal/event, 11.7.2.3 *Table 11-11*
- descriptor index, 9.4.3, 9.4.8
- descriptors
 - accessing, 11.23.1
 - in bus enumeration process, 9.1.2
 - class-specific descriptors, 9.5, 11.23.2.1
 - configuration descriptors, 9.6.3, 9.6.4, 10.3.1, 10.5.2.4
 - control transfers and, 5.5, 5.5.3
 - defined, 9.5
 - descriptor index, 9.4.3, 9.4.8
 - device class definitions, 9.7, 9.7.1
 - device descriptors, 9.4 *Table 9-5*, 9.6.1 to 9.6.5
 - endpoint descriptors, 9.6.6
 - getting descriptors, 9.4.3, 10.5.2.3
 - hub descriptors, 11.23 to 11.23.2.1, 11.24.2.5, 11.24.2.10
 - interface descriptors, 9.2.3, 9.6.5
 - isochronous transfer capabilities, 5.12
 - listing remote wakeup capabilities, 9.2.5.2
 - other speed configuration descriptor, 9.6.4
 - overview, 9.5 to 9.7.3
 - setting descriptors, 5.3.1.1, 9.4.8, 10.5.2.12
 - speed dependent descriptors, 9.2.6.6, 9.6.4
 - string descriptors, 9.6.7
 - USBID mechanisms for getting descriptors, 10.5.2.3
 - vendor-specific descriptors, 9.5
- deserialization of transmissions, 10.2.2
- detachable cables
 - cable delay, 7.1.16
 - connectors and, 6.2
 - detachable cable assemblies, 6.4.1
 - inter-packet delay and, 7.1.18.1
 - low-speed detachable cables, 6.4.4
 - maximum capacitance, 7.1.6.1
 - termination, 7.1.5.1
 - voltage drop budget, 7.2.2
- detached devices, 9.1.1.1, 9.1.2
- detaching devices. *See* dynamic insertion and removal
- detecting connect and disconnect conditions, 7.1.7.3, 7.1.20
- detecting errors. *See* error detection and handling
- detecting hub and port status changes, 7.1.7.5, 11.12.2, 11.12.3, 11.12.4
- detecting over-current conditions, 7.2.1.2.1
- detecting speed of devices. *See* speed detection
- Detection mechanism, 7.1.5.2
- Dev_Do_BCINTI state machine, 8.5.2 *Figure 8-34*
- Dev_Do_BCINTO state machine, 8.5.2 *Figure 8-32*
- Dev_Do_IN state machine, 8.5 *Figure 8-25*
- Dev_Do_Isochl state machine, 8.5.5 *Figure 8-43*
- Dev_Do_IsochO state machine, 8.5.5 *Figure 8-41*
- Dev_Do_OUT state machine, 8.5 *Figure 8-24*
- Dev_HS_BCO state machine, 8.5.1.1 *Figure 8-29*
- Dev_HS_ping state machine, 8.5.1.1 *Figure 8-28*
- device addresses, 2.0 *glossary*. *See also* addresses; devices
- device classes. *See also* USB device framework
 - class codes, 9.2.3
 - defined, 4.8
 - descriptors, 9.2.3, 9.6.1, 9.7
 - device characteristics, 4.8.1
 - device class definitions, 9.7
 - device qualifier descriptors, 9.6.2
 - getting class-specific descriptors, 9.5
 - hub class-specific requests, 11.24.2 to 11.24.2.13
 - interfaces and endpoint usage, 9.7.2
 - requests, 9.7.3
 - standard, class, and vendor information, 4.8.1
- Device Class Specification for Audio Devices Revision 1.0*, 9.6
- DEVICE descriptor, 9.4 *Table 9-5*
- device descriptors
 - descriptor types, 9.4 *Table 9-5*
 - device class descriptors, 9.2.3, 9.7
 - device qualifier descriptors, 9.6.2
 - GetDescriptor() request, 9.4.3
 - getting class-specific descriptors, 9.5
 - hubs, 11.23.1
 - overview, 9.6.1
 - speed dependent descriptors, 9.2.6.6
 - standard definitions, 9.6.1 to 9.6.5
- device drivers, 5.12.4.4, 10.3.1
- device endpoints, 2.0 *glossary*, 5.3.1.1. *See also* endpoints
- device-initiated resume. *See* remote wakeup

- Device layer
 - descriptors, 9.5 to 9.7.3
 - device states, 9.1 to 9.1.2
 - generic USB device operations, 9.2 to 9.2.7
 - standard device requests, 9.4 to 9.4.11
 - in USB device framework, 9
 - USB device requests, 9.3 to 9.3.5
 - Device_Process_trans state machine, 8.5 *Figure 8-23*
 - device qualifier descriptors, 9.2.6.6, 9.4.3, 9.4 *Table 9-5*, 9.6.1, 9.6.2
 - Device release numbers, 9.6.1
 - DEVICE_REMOTE_WAKEUP, 9.4 *Table 9-6*
 - DeviceRemovable field (hub descriptors), 11.23.2.1
 - device resources, 2.0 *glossary*. *See also* buffers; endpoints
 - devices. *See also* USB device framework
 - address assignment, 9.1.2, 9.2.2
 - characteristics and configuration (*See also* device descriptors)
 - configuration, 4.8.2.2, 9.2.3
 - data-rate tolerance, 7.1.11
 - descriptors, 9.5 to 9.7.3, 9.6.1
 - device characteristics, 4.8.1
 - device classes, 4.8, 9.7
 - device descriptions, 4.8.2 to 4.8.2.1
 - device speed, 7.1.5 to 7.1.5.2, 7.1.7.3, 11.8.2
 - host role in configuration, 10.3.1
 - optional endpoints, 5.3.1.2
 - USB role in configuration, 10.5.4.1 to 10.5.4.1.4
 - data transfer, 9.2.4
 - communication flow requirements, 5.3
 - control transfers and, 5.5
 - detailed communication flow illustrated, 5.3
 - differing bus access for transfers, 5.11
 - jitter budget table, 7.1.15.1
 - PING flow control, 8.5.1, 8.5.1.1
 - response to IN transactions, 8.4.6.1
 - response to OUT transactions, 8.4.6.3
 - response to SETUP transactions, 8.4.6.4
 - role in bulk transfers, 8.5.2
 - device event timings, 7.3.2 *Table 7-14*
 - devices defined, 2.0 *glossary*
 - device state machines, 8.5
 - dynamic attach and detach, 9.2.1
 - power distribution, 7.2.4 to 7.2.4.2
 - removing, 10.5.2.6, 10.5.4.1.4
 - USBID mechanisms, 10.5.2.5, 10.5.2.6
 - generic USB device operations, 9.2 to 9.2.7
 - port indicators, 11.5.3 to 11.5.3.1
- devices (*continued*)
 - power distribution, 7.2.1, 9.2.5
 - bus-powered devices, 4.3.1, 7.2.1.1
 - dynamic attach and detach, 7.2.4 to 7.2.4.2
 - high-power bus-powered functions, 7.2.1.4
 - low-power bus-powered functions, 7.2.1.3
 - power supply and, 4.3.1
 - self-powered devices, 4.3.1, 7.2.1.2, 7.2.1.5
 - suspend/resume conditions, 7.2.3
 - voltage drop budget, 7.2.2
 - requests
 - host communication, 10.1.1
 - request errors, 9.2.7
 - request processing, 9.2.6 to 9.2.6.6
 - standard device requests, 9.4 to 9.4.11
 - USB device requests, 9.3 to 9.3.5
 - state machines, 8.5, 8.5.2, 8.5.5
 - status
 - device states, 9.1 to 9.1.2, 11.12.2
 - getting device status, 9.4.5
 - getting port status, 11.24.2.7.1.1
 - subtree devices after wakeup, 10.5.4.5
 - turn-around timers, 8.7.2
 - types of devices
 - composite devices, 5.2.3
 - compound devices, 4.8.2.2, 5.2.3
 - functions, 4.8.2.2
 - hubs, 4.8.2.1
 - mapping physical and virtual devices, 5.12.4.4
 - virtual devices, 2.0 *glossary*
 - in USB topology, 4.1.1.2, 5.2, 5.2.2, 9.0
 - device software, defined, 2.0 *glossary*
 - device state machines, 8.5. *See also* *specific state machines under Dev_*
 - diameter of cables, 6.6.2
 - diamond symbols in state machines, 8.5, 11.15
 - dielectric withstanding voltage standards, 6.7 *Table 6-7*
 - Differential 0 bus state, 7.1.7.2
 - Differential 1 bus state, 7.1.7.1, 7.1.7.2
 - Differential 2 bus state, 7.1.7.1
 - differential data jitter, 7.3.3 *Figure 7-49*, 7.3.3 *Figure 7-52*
 - differential delay, 7.3.2 *Table 7-11*, 7.3.3 *Figure 7-52*
 - differential-ended components in upstream ports, 11.6.1, 11.6.2
 - differential envelope detectors, 7.1
 - differential input receivers, 1, 7.1, 7.1.4.1, 7.1.6, 7.1 *Table 7-1*
 - differential output drivers, USB as, 7.1.1
 - differential signaling, 7.1.7.1, 7.1.7.2, 7.1.7.4.1
 - differential termination impedance, 7.1.6.2
 - differential-to-EOP transition skew, 7.3.3 *Figure 7-50*

- dimensional inspection standards, 6.7 *Table 6-7*
 - Direction bit, 9.3.1, 9.3.4
 - direction of communication flow, 5.4
 - bmRequestType* field, 9.3.1
 - bulk transfers, 5.8.2
 - bus protocol overview, 4.4
 - control transfers, 5.5.2
 - interrupt transfers, 5.7.2
 - isochronous transfers, 5.6.2
 - disabled ports, 11.5, 11.5.1.4, 11.24.2.7.1, 11.24.2.7.2
 - Disabled state, 11.5, 11.5.1.4
 - disabling features, 9.4.1
 - discarding packets, 11.3.2
 - Disconnect_Detect signal/event, 11.5.2, 11.5 *Table 11-5*
 - Disconnected state
 - connect and disconnect signaling, 7.1.7.3
 - detecting, 7.1, 7.1.4.2, 7.1.20
 - downstream ports, 11.5, 11.5.1.3
 - signaling levels and, 7.1.7.1, 7.1.7.2
 - disconnecting devices. *See* dynamic insertion and removal
 - disconnection envelope detectors, 7.1.7.3, 7.1 *Table 7-1*
 - disconnect timer, 11.5.2
 - distortion, minimizing in SOP, 7.1.7.4.1
 - DLL lock, 7.1
 - documents, applicable standards, 6.7.1
 - down counters in hub timing, 11.2.3.1
 - downstream facing ports and hubs
 - Disconnect state detection, 7.1
 - downstream connectivity defined, 11.1.2.1
 - downstream defined, 2.0 *glossary*
 - downstream facing port state machine, 11.5
 - downstream plugs, 6.2
 - downstream ports defined, 4.8.2.1
 - driver speed and, 7.1.2.3
 - enumeration handling, 11.12.6
 - high-speed driver characteristics and, 7.1.1.3
 - high-speed signaling and, 7.1.7.6.1, 7.1.7.6.2, 11.1.1
 - in hub architecture, 11.1.1
 - hub delay, 7.3.3 *Figure 7-52*
 - hub descriptors, 11.23.2.1
 - hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
 - input capacitance, 7.1.6.1
 - jitter, 7.3.2 *Table 7-10*
 - multiple Transaction Translators, 11.14.1.3
 - port state descriptions, 11.5.1 to 11.5.1.14
 - reset state machines, C.1
 - signaling delays, 7.1.14.1
 - signaling speeds, 7.1
 - status changes, 11.12.6
 - test mode support, 7.1.20
 - downstream facing ports and hubs (*continued*)
 - transceivers, 7.1, 7.1.7.1, 7.1.7.2
 - downstream facing transceivers, high-speed signaling and, 7, 7.1
 - downstream packets (HSD1), 8.5, 11.15
 - drain wires, 6.5.2, 6.6.1, 6.6.2
 - dribble, defined, 7.1.9.1
 - drift, 5.12.1, 5.12.3
 - driver characteristics
 - full-speed driver characteristics, 7.1.1.1
 - full-speed source electrical characteristics, 7.3.2 *Table 7-9*
 - high-speed driver characteristics, 7.1.1.3
 - high-speed source electrical characteristics, 7.3.2 *Table 7-8*
 - low-speed driver characteristics, 7.1.1.2, 7.1 *Table 7-1*
 - low-speed source electrical characteristics, 7.3.2 *Table 7-10*
 - overview, 7.1.1
 - drivers
 - defined, 2.0 *glossary*
 - role in configuration, 10.3.1
 - in source-to-sink connectivity, 5.12.4.4
 - droop, 7.2.3, 7.2.4.1
 - dual pin-type receptacles, 6.9
 - durability standards, 6.7 *Table 6-7*
 - DWORD, defined, 2.0 *glossary*
 - dynamic insertion and removal, 9.2.1
 - attaching devices, 4.6.1
 - defined, 2.0 *glossary*
 - detecting insertion and removal, 4.9, 9.2.1
 - Hub Repeater responsibilities, 11.1
 - hub support for, 11.1
 - power control, 7.2.3, 7.2.4 to 7.2.4.2
 - power-on and connection events timing, 7.1.7.3
 - removing devices, 4.6.2
 - USB robustness and, 4.5
- ## E
- E field (End), 8.4.2.2
 - E2PROM defined, 2.0 *glossary*
 - ease-of-use considerations, 1.1
 - EBEmptied signal/event, 11.7.1.4 *Table 11-10*
 - edges of signals
 - cable delay, 7.1.16
 - data source jitter, 7.1.13.1.1
 - edge transition density, 8.2
 - optional edge rate control capacitors, 7.1.6.1
 - EEPROM, defined, 2.0 *glossary*
 - elasticity buffer, 11.7.1.3
 - Electrical Connector/Socket Test Procedures*, 6.7.1
 - Electrically Erasable Programmable Read Only Memory (EEPROM), 2.0 *glossary*

Electrical Performance Properties of Insulation and Jacket for Telecommunication Wire and Cable, 6.7.1

electrical specifications, 6.1, 7
 applicable documents, 6.7.1
 bus timing/electrical characteristics, 7.3.2
 cables, 6.3, 6.4 to 6.4.4, 6.6 to 6.6.5
 connectors, 6.2, 6.5 to 6.5.4.3
 overview, 4.2.1, 6
 PCB reference drawings, 6.9
 physical layer specifications, 7.3 to 7.3.3
 power distribution, 7.2 to 7.2.1.5, 7.2.3, 7.2.4 to 7.2.4.2
 signaling, 7.1 to 7.1.20
 standards for, 6.7, 7.3.1
 timing waveforms, 7.3.3
 USB grounding, 6.8
 embedded hubs, 4.8.2.2, 5.2.3
 EMI, USB grounding and, 6.8
 enabled ports
 connectivity and, 11.1.2.1
 downstream ports, 11.5, 11.5.1.6
 getting port status, 11.24.2.7.1
 PORT_ENABLE bit, 11.24.2.7.1.2
 port status change bits, 11.24.2.7.2
 Enabled state, 11.5, 11.5.1.6
 Enable Transmit state, 11.7.1.4.3
 encoding data, 7.1.8, 11.18.4
 "end" encoding, 11.18.4
 End field (E), 8.4.2.2
 End-of-Frame (EOF). *See* EOFs
 End of High-speed Packet (HSEOP), 7.1.7.2, 7.1.7.4.2
 End-of-Packet (EOP). *See* EOPs
 End-of-Packet bus state, 7.1.7.1, 7.1.7.2, 7.1.7.4.1, 7.1.7.4.2
 end-of-packet delimiter. *See* EOPs
 ENDP field, 8.3.2.2, 8.3.5.1, 8.4.1
 endpoint addresses, 2.0 *glossary*, 5.3.1, 9.6.6
 ENDPOINT descriptor, 9.4 *Table 9-5*
 endpoint descriptors, 9.4.3, 9.6.1, 9.6.5, 9.6.6
 endpoint direction, defined, 2.0 *glossary*
 endpoint field (ENDP), 8.3.2.2, 8.3.5.1, 8.4.1
 ENDPOINT_HALT, 9.4 *Table 9-6*
 endpoint numbers, 2.0 *glossary*, 5.3.1
 endpoints
 addresses, 9.6.6
 characteristics, 5.3.1
 description in descriptors, 9.4.3, 9.6.1, 9.6.5, 9.6.6
 in device class definitions, 9.7.2
 direction of flow, 5.3.1
 endpoint address field, 8.3.2.2
 endpoint aliasing, 8.3.2
 endpoint zero requirements, 4.8.1, 5.3.1.1, 5.3.1.2, 5.3.2

endpoints (*continued*)
 explicit feedback endpoints, 9.6.5, 9.6.6
 getting endpoint status, 9.4.5
 high-bandwidth endpoints, 2.0 *glossary*, 5.7.4
 high-speed signaling attributes, 9.6.6
 Hub Controller endpoint organization, 11.12.1
 in interfaces, 9.2.3, 9.6.3, 9.6.5
 logical devices as collections of endpoints, 5.3
 message pipes and, 5.3.2.2
 non-endpoint zero requirements, 5.3.1.2
 number matching, 9.6.6
 overview, 5.3.1
 pipes and, 4.4, 5.3.2
 programmable data rates, 2.0 *glossary*
 reflected endpoint status, 10.5.2.2
 role in data transfers, 4.7
 samples, 2.0 *glossary*
 specifying in *wIndex* field, 9.3.4
 state machines, 8.5
 stream pipes and, 5.3.2.1
 synchronization frame, 9.4.11
 Transfer Types, Synchronization Types, and Usage Types, 9.6.6
 endpoint synchronization type, 5.12.4, 5.12.4.1
 Endpoint Type field (ET), 8.4.2.2
 endpoint type field (ET), 8.4.2.2
 endpoint zero
 Default Control Pipe and, 5.3.2
 in device characteristics, 4.8.1
 non-endpoint zero requirements, 5.3.1.2
 requirements, 5.3.1.1
 end-to-end signal delay, 7.1.19 to 7.1.19.2
 end users, 2.0 *glossary*, 3.3
 entering test mode, 7.1.20
 entry points into state machines, 8.5
 enumeration. *See* bus enumeration
 envelope detectors, 2.0 *glossary*, 7.1, 7.1.4.2, 7.1.7.3, 7.1 *Table 7-1*
 environmental characteristics for cables, 6.6.4
 environmental compliance standards, 6.7
 EOF1 or EOF2 signal/event
 frame and microframe timers, 11.2.3.2, 11.2.5 to 11.2.5.2
 host behavior at end-of-frame, 11.3
 in Hub Repeater state machine, 11.7.2.3 *Table 11-11*
 in transmitter state machine, 11.6.4 *Table 11-9*

- EOFs
 - advancing, 11.2.3.2
 - defined, 2.0 *glossary*
 - in frame and microframe timer synchronization, 11.2.3.2
 - host behavior at end-of-frame, 11.3 to 11.3.3
 - Host Controller frame and microframe generation, 10.2.3
 - in transaction completion prediction, 11.3.3
- EOI signal/event
 - defined, 11.7.1.4 *Table 11-10*
 - in downstream port state machine, 11.5 *Table 11-5*
 - in internal port state machine, 11.4
 - in receiver state machine, 11.6.3 *Table 11-8*
 - in transmitter state machine, 11.6.4
- EOP bus state, 7.1.7.1, 7.1.7.2, 7.1.7.4.1, 7.1.7.4.2
- EOPs
 - defined, 2.0 *glossary*
 - differential-to-EOP transition skew and EOP width, 7.3.3 *Figure 7-50*
 - EOP delimiter, 8.3
 - EOP dribble defined, 11.7.1.1
 - EOP width, 7.1.13.2 to 7.1.13.2.2, 7.3.3 *Figure 7-50*
 - error detection through bus turn-around timing, 8.7.2
 - extra bits and, 7.1.9, 7.1.9.1
 - false EOPs, 2.0 *glossary*, 8.7.3, 11.15
 - handshake packets and, 8.4.5
 - high-speed signaling and, 7.1
 - hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
 - hub/repeater electrical characteristics, 7.3.2 *Table 7-11*
 - hub signaling at EOF1, 11.3.1
 - intervals between IN token and EOP, 11.3.3
 - propagation delays, 7.1.14.1
- EOR signal/event, 11.6.3 *Table 11-8*
- equations
 - buffering for rate matching, 5.12.8
 - buffer sizes in functions and software, 5.11.4
 - bus transaction times, 5.11.3
- ERR handshake
 - interrupt transactions, 11.20.4
 - isochronous transactions, 11.21.1, 11.21.4
 - Transaction Translator response generation, 11.18.5
- error detection and handling. *See also* corrupted transfers and requests
 - "3 strikes and you're out" mechanism, 11.17.1
 - babble and loss of activity recovery, 8.7.4
 - bit stuff violations, 8.7.1
 - bulk transfers and, 5.8.5, 8.5.2
 - error detection and handling. (*Continued*)
 - bus turn-around timing, 8.7.2
 - busy (ready/x) state, 11.17.5
 - control transfers and, 5.5.5, 8.5.3.1
 - corrupted ACK handshake, 8.5.3.3, 8.6.4
 - corrupted SOF packets in isochronous transfers, 5.12.6
 - CRCs, 8.3.5, 8.7.1, 11.15, 11.20.3, 11.20.4, 11.21.3, 11.21.4
 - data corrupted or not accepted, 8.6.3
 - error count tally, 10.2.6, 11.17.1
 - error handling for transfers, 5.4
 - error handling on last data transaction, 8.5.3.3
 - false EOPs, 2.0 *glossary*, 8.7.3
 - HC_Data_or_error state machine, 11.20.2
 - high bandwidth transactions, 5.9.2
 - Host Controller role in, 10.2.6
 - Hub Repeater responsibilities, 11.1
 - hub role in, 11.1.2.3
 - interrupt transfers and, 5.7.5
 - isochronous transfers and, 5.6.4, 5.6.5, 5.12.7
 - notation for error cases, 11.15
 - overview, 8.7
 - packet error categories, 8.7.1
 - periodic transactions, 11.18.4
 - PID check bits, 8.7.1
 - Port Error conditions, 11.8.1
 - port indicators, 11.5.3 to 11.5.3.1
 - Request Errors, 9.2.7
 - sample size and, 5.12.8
 - short packets and error conditions, 5.3.2
 - split transaction sequencing, 11.21.3
 - status values for, 11.15
 - synchronous data connectivity, 5.12.4.4.2
 - timeouts, 8.7.2, 11.17.1
 - Transaction Translator error handling, 11.22
 - USB role in, 10.5.4.4
 - USB robustness and, 4.5.1, 4.5.2
- ERR PID, 8.3.1 *Table 8-1*, 8.4.5
- ESD, USB grounding and, 6.8
- ET field (Endpoint Type), 8.4.2.2
- event notifications, USB and, 10.5.4.3
- example declarations in state machines, B.1, B.2, B.3
- exception handling. *See* error detection and handling
- Exception Window, 7.1.6.2
- exiting test mode, 7.1.20
- exit points from state machines, 8.5
- explicit feedback endpoints, 9.6.5, 9.6.6
- extended descriptor definitions, 9.7.1
- extensibility of USB architecture, 4.10
- extension cable assemblies, 6.4.4
- externally-powered hubs, 7.2.1. *See also* self-powered hubs
- extraction force standards, 6.7 *Table 6-7*

eye pattern templates
 defined, 2.0 *glossary*
 error rates and jitter tolerance, 7.1.14.2, 7.1.15.2
 high-speed receiver characteristics and, 7.1.4.2
 overview, 7.1.2.2
 transmit eye patterns, 7.1, 7.1.2

F

failed data transactions, 8.6.3
 false EOPs, 2.0 *glossary*, 8.7.3, 11.15
 fault detection. *See* error detection and handling
 features
 hub class feature selectors, 11.24.2
 SetFeature() request, 9.4.9
 setting hub features, 11.24.2.12
 standard feature selectors, 9.4 *Table 9-6*
 feedback endpoints, 9.6.6
 feedback for isochronous transfers, 5.12.4.2, 5.12.4.3, 9.6.5
 ferrite beads, 7.1.6.2
 fields. *See names of specific fields*
 flammability
 cables, 6.6.4
 Series "A" and Series "B" plugs, 6.5.4.1
 Series "A" and Series "B" receptacles, 6.5.3.1
 standards, 6.7 *Table 6-7*
 flexibility of USB devices, 3.3
 flow control mechanisms
 in bus protocol overview, 4.4
 handshake packets and, 8.4.5
 non-periodic transactions, 11.14.2.2
 USB robustness and, 4.5
 flow sequences
 non-periodic transactions, 11.17 to 11.17.5
 periodic transactions, 11.18 to 11.18.8, 11.20 to 11.20.4, 11.21.1
 split transaction notation for, 11.15
 flyback voltage, 7.2.4.2
 format of USB device requests, 9.3
 formulas
 buffering for rate matching, 5.12.8
 buffer sizes in functions and software, 5.11.4
 bus transaction times, 5.11.3
 frame and microframe intervals
 full-speed source electrical characteristics, 7.3.2 *Table 7-9*
 high-speed source electrical characteristics, 7.3.2 *Table 7-8*
 low-speed source electrical characteristics, 7.3.2 *Table 7-10*
 repeatability, 7.1.12

frame and microframe numbers
 buffering for rate matching, 5.12.8
 frame and microframe number field, 8.4.3
 frame number field, 8.3.3
 frame numbers, 8.3.3
 generating frames and microframes, 10.2.3
 illustrated, 8.4.3.1
 SOF tracking, 5.12.6
 frame and microframe timers
 frame wander, 11.2.5.2
 hub frame timer, 11.2 to 11.2.5.2
 timing skew, 11.2.5.1 to 11.2.5.2
 TT loss of synchronization, 11.22.1
 frame clocks, 5.12.3, 5.12.4.1.2, 11.18.3
 frame pattern, defined, 2.0 *glossary*
 frames and microframes. *See also* frame and microframe timers
 allocating bandwidth, 4.7.5, 5.11.1 to 5.11.1.5, 10.3.2
 available time in frames and microframes, 5.5.4, 5.6, 5.6.4, 5.7.4, 5.8.4, 5.11.5
 babble and loss of activity recovery, 8.7.4
 bandwidth reclamation, 5.11.5
 best case full-speed budgets, 11.18.1, 11.18.4
 bit time zero, 11.3
 clock tracking and microframe SOFs, 5.12.4.1.2
 control transfer reserved portions, 5.5.4
 data prebuffering and, 5.12.5
 defined, 2.0 *glossary*, 5.3.3
 error handling in transfers, 5.12.7
 frame and microframe intervals, 7.1.12, 7.3.2 *Table 7-8*, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
 frame and microframe numbers (*See* frame and microframe numbers)
 frame and microframe timer ranges, 11.2.1 to 11.2.2
 frame wander, defined, 11.2.5.2
 generation role of Host Controller, 10.2.3
 generation role of Transaction Translator, 11.18.3
 host behavior at end-of-frame, 11.3
 interrupt transfer limitations, 5.7.4
 isochronous transactions, 5.6.3, 5.6.4, 5.12.4.2, 8.5.5
 jitter, 11.2.4
 maximum allowable transactions, 5.4.1, 11.18.6.3
 microframe numbers, 8.4.3.1

frames and microframes (*Continued*)

- microframe pipelines
 - buffer space, 11.19
 - clearing and aborting transactions, 11.18.6
 - defined, 11.18.2
 - periodic split transactions, 11.14.2.1, 11.18
 - resetting, 11.24.2.9
 - transaction tracking, 11.18.7
- multiple transactions, 5.6.4, 5.7.4, 5.9, 5.9.2, 9.6.6
- organization of transactions within, 5.11.2
- overview, 8.4.3.1
- samples per frame in isochronous transfers, 5.12.4.2
- SOF packets, 8.4.3
- SOF tracking, 5.12.6
- split transactions and, 5.10
- synch frame requests, 9.4.11
- timers, 11.2 to 11.2.5.2
- timer synchronization, 11.2.3 to 11.2.3.3, 11.22.1
- toggle sequencing, 8.5.5
- zeroth microframe, 9.4.11, 11.14.2.3
- freeing pending start-splits, 11.18.6.2
- frequency-locked clocks, 5.12.3
- Fs. *See* SRC
- Fsus state, 11.4, 11.4.3
- full-duplex, defined, 2.0 *glossary*
- full-speed buffers, 7.1.2.1
- full-speed cables. *See* high-/full-speed cables
- full-speed driver characteristics, 7.1.1.1, 7.1 *Table 7-1*
- full-speed functions and hubs
 - bulk transfers and, 5.8.4
 - cable and resistor connections, 7.1.5.1
 - connect detection, 7.1.7.3
 - control transfers and, 5.5.3, 5.5.4, 5.5.4 *Table 5-2*
 - data-rate tolerance, 7.1.11
 - defined, 2.0 *glossary*
 - detachable cables and, 6.4.1
 - full-speed port transceiver, 7.1.7.1
 - full-speed source electrical characteristics, 7.3.2 *Table 7-9*
 - full- vs. low-speed port behavior, 11.8.4
 - getting port status, 11.24.2.7.1
 - hub/repeater electrical characteristics, 7.3.2 *Table 7-11*
 - hub support for, 11.1
 - input capacitance, 7.1.6.1
 - interrupt transfers and, 5.7.3, 5.7.4 *Table 5-7*
 - isochronous transfers and, 5.6.4
 - maximum data payload, 8.4.4
 - optional endpoints, 5.3.1.2
 - in physical bus topology, 5.2.3
 - reset states and, C.2.2

full-speed functions and hubs (*Continued*)

- sampling rates, 5.12.4.2
- signal termination, 7.1.5.1
- SOF PID and, 8.4.3
- speed detection and, 11.8.2
- Transmit state and, 11.5.1.7
- full-speed signaling
 - babble and loss of activity recovery, 8.7.4
 - best case full-speed budgets, 11.18.1, 11.18.4
 - bus transactions and, 4.4
 - calculating transaction times, 5.11.3
 - data rates, 4.2.1
 - data signaling overview, 7.1.7.4.1
 - data source jitter, 7.1.13.1.1
 - defined, 2.0 *glossary*
 - differential receivers, 7.1 *Table 7-1*
 - downstream and upstream facing ports, 7.1
 - driver characteristics, 7.1.1
 - driver requirements, 7.1.2.3
 - endpoint zero requirements, 5.3.1.1
 - EOF timing points, 11.2.5.2
 - EOP width, 7.1.13.2.1
 - errors, 8.6.4
 - frame timer ranges, 11.2.2
 - full-speed loads, 7.1.2.1
 - high-speed devices operating at full-speed, 5.3.1.1
 - host behavior at end-of-frame, 11.3 to 11.3.3
 - hub class descriptors and, 11.23.1
 - intervals between IN token and EOP, 11.3.3
 - isochronous transaction limits, 5.6.3
 - J and K states, 7.1.7.1
 - jitter budget table, 7.1.15.1
 - propagation delays, 7.1.14.1
 - receiver characteristics, 7.1.4.1
 - reset signaling, 7.1.7.5
 - sampling rates, 5.12.4.2
 - scheduling, 11.14.2.3
 - speed detection, 9.1.1.3
 - Transaction Translator and, 4.8.2.1, 11.18.3, 11.18.5
- Full Suspend (Fsus) state, 11.4, 11.4.3
- function address field (ADDR), 8.3.2.1, 8.4.2.2
- functional stall, 8.4.5, 8.5.3.4
- Function layer
 - detailed communication flow, 5.3
 - illustrated, 5.1
 - interlayer communications model, 10.1.1

functions. *See also* devices; full-speed functions and hubs; high-speed functions and hubs; low-speed functions and hubs
 address assignment, 9.1.2, 9.2.2
 characteristics and configuration (*See also* device descriptors)
 configuration, 4.8.2.2, 9.2.3
 data-rate tolerance, 7.1.11
 descriptors, 9.5 to 9.7.3, 9.6.1
 device characteristics, 4.8.1
 device classes, 4.8, 9.7
 device speed, 7.1.7.3, 11.8.2
 host role in configuration, 10.3.1
 optional endpoints, 5.3.1.2
 data transfer
 communication flow requirements, 5.3
 control transfers and, 5.5
 detailed communication flow illustrated, 5.3
 differing bus access for transfers, 5.11
 jitter budget table, 7.1.15.1
 overview, 9.2.4
 PING flow control and OUT transactions, 8.5.1, 8.5.1.1
 response to IN transactions, 8.4.6.1
 response to OUT transactions, 8.4.6.3
 response to SETUP transactions, 8.4.6.4
 role in bulk transfers, 8.5.2
 device event timings, 7.3.2 *Table 7-14*
 devices defined, 2.0 *glossary*
 dynamic attach and detach, 9.2.1
 power distribution, 7.2.4 to 7.2.4.2
 removing, 10.5.2.6, 10.5.4.1.4
 USB mechanisms, 10.5.2.5, 10.5.2.6
 generic USB device operations, 9.2 to 9.2.7
 overview, 4.8.2.2
 power distribution, 7.2.1, 9.2.5
 bus-powered devices, 4.3.1, 7.2.1.1
 dynamic attach and detach, 7.2.4 to 7.2.4.2
 high-power bus-powered functions, 7.2.1.4
 low-power bus-powered functions, 7.2.1.3
 power supply and, 4.3.1
 self-powered functions, 7.2.1.2, 7.2.1.5
 suspend/resume conditions, 7.2.3
 voltage drop budget, 7.2.2
 requests
 host communication with, 10.1.1
 request errors, 9.2.7
 request processing, 9.2.6 to 9.2.6.6
 standard device requests, 9.4 to 9.4.11
 USB device requests, 9.3 to 9.3.5
 status, 9.1 to 9.1.2, 9.4.5

types of devices
 compound devices, 4.8.2.2
 functions, 4.8.2.2
 mapping physical and virtual devices, 5.12.4.4
 virtual devices, 2.0 *glossary*
 in USB topology, 4.1.1.2, 5.2.2, 5.2.3, 9.0
 function-to-host transfers. *See* IN PID

G

gang-mode power control, 11.23.2.1
 garbling messages in Collision conditions, 11.8.3
 Generate End of Packet Towards Upstream Port state (GEOPTU), 11.6.4, 11.6.4.5
 Generate Resume state, 11.4, 11.4.4
 generic USB device operations, 9.2 to 9.2.7
 GEOPTU state, 11.6.4, 11.6.4.5
 GetConfiguration() request,
 GET_CONFIGURATION
 hub requests, 11.24.1
 overview, 9.4.2
 returning interface descriptors, 9.6.5
 standard device request codes, 9.4
 GetDescriptor() request, GET_DESCRIPTOR,
 11.23.1
 device_qualifier descriptors, 9.6.2
 endpoint descriptors, 9.6.6
 GetDescriptor(CONFIGURATION) request,
 9.5, 9.6.6
 GetHubDescriptor() request, 11.24.2.5
 hub class requests, 11.24.2
 hub descriptors, 11.24.2.5
 hub requests, 11.24.1
 interface descriptors, 9.6.5
 other_speed_configuration descriptors, 9.6.4
 overview, 9.4.3
 standard device request codes, 9.4
 GetHubDescriptor() request, 11.24.2, 11.24.2.5
 GetHubStatus() request, 11.24.2, 11.24.2.6
 GetInterface() request, GET_INTERFACE
 alternate settings for interfaces, 9.2.3
 hub requests, 11.24.1
 interface descriptors, 9.6.5
 overview, 9.4.4
 standard device request codes, 9.4
 GetPortStatus() request
 class-specific requests, 11.24.2
 overview, 11.24.2.7 to 11.24.2.7.2.5
 PORT_INDICATOR, 11.24.2.7.1.10
 during test mode, 11.24.2.13
 GET_STATE, 11.24.2

- GetStatus() request, GET_STATUS
 - GetHubStatus() request, 11.24.2.6
 - GetPortStatus() request, 11.24.2.7
 - hub class requests, 11.24.2
 - overview, 9.4.5
 - PORT, 11.12.6
 - standard device request codes, 9.4
- GetTTState() request, GET_TT_STATE
 - hub class requests, 11.24.2
 - overview, 11.24.2.8
 - STOP_TT, 11.24.2.11
- global declarations in state machines, B.1
- global resumes
 - frame and microframe timer synchronization, 11.2.3.3
 - hub support, 11.9
 - signaling, 7.1.7.7
- global suspend, 7.1.7.6.1, 11.9
- glossary, 2.0
- GND leads
 - cable electrical characteristics, 7.3.2 *Table 7-12*
 - captive cable assemblies, 6.4.2, 6.4.3
 - detachable cables, 6.4.1
 - electrical specifications overview, 4.2.1
 - standardized contact terminating assignments, 6.5.2
- GResume state, 11.4, 11.4.4
- grounding, 6.8
- H**
- halted pipes, 10.5.2.2
- Halt* feature
 - bulk transfers, 5.8.5
 - control transfers, 5.5.5, 8.5.3.4
 - functional stalls, 8.4.5
 - GetStatus() request, 9.4.5
 - interrupt transfers, 5.7.5, 8.5.4
 - isochronous transfers, 5.6.5
 - responses to standard device requests, 9.4
- handshakes. *See also* ACKs; NAKs; STALLs
 - ACK PID, 8.3.1 *Table 8-1*
 - bulk transfers, 8.5.2
 - bus protocol overview, 4.4
 - defined, 2.0 *glossary*
 - detection handshakes, 7.1.7.5, 7.1.7.6
 - function response to IN transactions, 8.4.6.1
 - function response to OUT transactions, 8.4.6.3
 - function response to SETUP transactions, 8.4.6.4
 - handshake responses, 8.4.6 to 8.4.6.4
 - host response to IN transactions, 8.4.6.2
 - isochronous transfers, 5.6.5, 5.12.7
 - NAK PID, 5.9.1, 8.3.1 *Table 8-1*, 8.5.1, 8.5.1.1
 - NYET PID, 8.3.1 *Table 8-1*, 8.4.5, 8.5.1, 8.5.2
- handshakes (*Continued*)
 - overview, 8.3.1 *Table 8-1*, 8.4.5
 - packet field formats, 8.3 to 8.3.5.2
 - PING flow control and OUT transactions, 8.5.1, 8.5.1.1
 - STALL PID, 8.3.1 *Table 8-1*
 - total allocation of bit times, 11.3.3
 - transaction notation for, 11.15
- hardwired cable assemblies, 6.4.2
- HCD (Host Controller Driver)
 - defined, 2.0 *glossary*, 5.3
- HCDI (Host Controller Driver Interface), 10.1.1, 10.4
 - overview, 10.4
 - software interface overview, 10.3
 - in transfer management, 5.11.1, 5.11.1.3
 - in USB topology, 5.2.1, 10.1.1
- HC_Data_or_error state machine, 11.20.2
- HCDI (Host Controller Driver Interface), 10.1.1, 10.4
- HC_Do_BCINTI state machine, 8.5.2 *Figure 8-33*
- HC_Do_BCINTO state machine, 8.5.2 *Figure 8-31*
- HC_Do_BICS state machine, 11.17.2
- HC_Do_BISS state machine, 11.17.2
- HC_Do_BOCS state machine, 11.17.2
- HC_Do_BOSS state machine, 11.17.2
- HC_Do_complete state machine, 11.16.1.1.2
- HC_Do_IntlCS state machine, 11.20.2
- HC_Do_IntlSS state machine, 11.20.2
- HC_Do_intOCS state machine, 11.20.2
- HC_Do_IntOSS state machine, 11.20.2
- HC_Do_IsochICS state machine, 11.21.2
- HC_Do_IsochISS state machine, 11.21.2
- HC_Do_Isochl state machine, 8.5.5 *Figure 8-42*
- HC_Do_IsochOSS state machine, 11.21.2
- HC_Do_IsochO state machine, 8.5.5 *Figure 8-40*
- HC_Do_nonsplit state machine, 8.5 *Figure 8-26*
- HC_Do_Start state machine, 11.16.1.1.1
- HC_HS_BCO state machine, 8.5.1 *Figure 8-27*
- HC_Process_command state machine, 11.16.1.1
- HEOP signal/event, 11.6.4 *Table 11-9*, 11.7.2.1, 11.7.2.3 *Table 11-11*
- hierarchical state machines, 8.5, 11.15
- high-bandwidth endpoints, 2.0 *glossary*, 5.7.4, 5.9 to 5.9.2, 5.12.3
- high-bandwidth transactions, 5.12.7, 8.5.5

- high-/full-speed cables
 - cable delay, 7.1.16
 - cable impedance tests, 6.7 *Table 6-7*
 - captive cable assemblies, 6.4.2
 - construction, 6.6, 6.6.2
 - description, 6.6.1
 - listing, 6.6.5
 - signal pair attenuation, 6.7 *Table 6-7*
 - specifications, 6.3
 - standards for, 6.6.3, 6.6.4, 6.7
- high-powered devices
 - bus-powered functions, 7.2.1, 7.2.1.4
 - high-power ports, 7.2.1
 - voltage drop budget, 7.2.2
- High-speed Detection Handshake, 7.1.7.5, 7.1.7.6
- high-speed driver characteristics, 7.1 *Table 7-1*
- high-speed functions and hubs
 - in application space taxonomy, 3.2
 - bulk transfers, 5.8.4
 - connect detection, 7.1.7.3
 - control transfers, 5.5.3, 5.5.4, 5.5.4 *Table 5-3*
 - data signaling rates, 7.1.11
 - defined, 2.0 *glossary*
 - detachable cables, 6.4.1
 - device_qualifier descriptors, 9.6.1, 9.6.2
 - frame and microframe numbers, 8.4.3.1
 - full-speed operation, 5.3.1.1
 - getting port status, 11.24.2.7.1
 - high-speed repeaters, 11.2.5, 11.7.2.1
 - high-speed source electrical characteristics, 7.3.2 *Table 7-8*
 - hub/repeater electrical characteristics, 7.3.2 *Table 7-11*
 - input capacitance, 7.1.6.2
 - interrupt transfers, 5.7.3, 5.7.4 *Table 5-8*
 - isochronous transfers, 5.6.4
 - maximum data payload, 8.4.4
 - NAK mechanisms, 8.5.1, 8.5.1.1
 - other_speed_configuration descriptors, 9.6.4
 - performance, 1.1
 - in physical bus topology, 5.2.3
 - port selector state machine, 11.7.1.4 to 11.7.1.4.4
 - reset signaling, 7.1.7.5
 - reset state machines, C.2.3
 - sampling rates, 5.12.4.2
 - signal termination, 7.1
 - SOF PID and, 8.4.3, 8.4.3.1
 - speed detection and, 7.1.5.2, 11.8.2
 - test mode support, 7.1.20
- high-speed port selector state machine, 11.7.1.4 to 11.7.1.4.4
- high-speed signaling
 - bit stuffing, 7.1.9.2
 - bus transactions and, 4.4
 - calculating transaction times, 5.11.3
 - Chirp J and K states, 7.1.4.2, 7.1.7.2
 - control transfers, 5.5.4
 - current drivers, 7.1 *Table 7-1*
 - data handling, 11.14.1.1
 - data rates, 4.2.1
 - data signaling overview, 7.1.7.4.2
 - defined, 2.0 *glossary*
 - Differential 0/Differential 1 bus states, 7.1.7.2
 - differential data receivers, 7.1 *Table 7-1*
 - "disallowed" situations, 7.1.2.3
 - Disconnect state, 7.1.7.2
 - downstream and upstream facing ports, 7.1
 - driver characteristics, 7.1.1, 7.1.1.1, 7.1.1.3, 7.1.2.3
 - End of High-speed Packet (HSEOP), 7.1.7.2, 7.1.7.4.2
 - endpoints
 - attributes, 9.6.6
 - endpoint zero requirements, 5.3.1.1
 - high-bandwidth endpoints, 2.0 *glossary*, 5.9 to 5.9.2
 - EOF timing points, 11.2.5.1
 - EOP width, 7.1.13.2.2
 - error detection, 8.7.3, 8.7.4
 - error handling, 5.12.7, 8.6.4
 - eye patterns, 7.1.2.2
 - frame and microframe generation, 10.2.3
 - full-speed signaling and, 5.3.1.1, 7.1.1.1
 - high-speed devices operating at full-speed, 5.3.1.1
 - hub architecture and, 11.1.1
 - hub class descriptors and, 11.23.1
 - Idle state, 7.1.7.2
 - isochronous transaction limits, 5.6.3
 - J and K states, 7.1.7.2, 7.1.7.4.2
 - jitter, 7.1.13.1.2, 7.1.15.2
 - microframes and, 5.3.3, 11.2.1
 - overview, 7.1
 - packet repeaters, 11.7.1 to 11.7.1.4.4
 - PING flow control protocol and, 5.5.4, 5.8.4
 - propagation delays, 7.1.14.2
 - receiver characteristics, 7.1.4.2
 - reset signaling, 7.1.7.5, 7.1.7.6
 - resume signaling, 7.1.7.7, 11.9
 - sampling rates, 5.12.4.2
 - signaling levels, 7.1.7.2
 - split transactions, 5.10, 8.4.2 to 8.4.2.3

high-speed signaling (*Continued*)

- Squelch state, 7.1.7.2
- Start of High-speed Packet (HSSOP), 7.1.7.4.2
- Start of high-speed Packet (HSSOP), 7.1.7.2
- Suspended state and, 7.1.7.6, 11.9
- synch frame requests, 9.4.11
- timer range, 11.2.1
- toggle sequencing, 8.5.5
- Transaction Translator, 4.8.2.1, 11.1, 11.14 to 11.14.2.3
- types of transactions, 11.17

HJ signal/event, 11.6.3 *Table 11-8*

HK signal/event, 11.6.3 *Table 11-8*

host, 10

- in bus topology, 4.1.1.1, 5.2, 5.2.1
- collecting status and activity statistics, 10.1.4
- components, 10.1.1
- control mechanisms, 10.1.2
 - EOF1 and EOF2 timing points, 11.2.5 to 11.2.5.2
 - host behavior at end-of-frame, 11.3 to 11.3.3
 - host-to-hub communications, 11.1
 - resource management, 10.3.2
 - responsibilities and capabilities, 10.1.1
 - role in assigning addresses, 9.2.2
 - role in configuration, 9.2.3, 10.3.1
 - synchronizing hub (micro)frame timer to host (micro)frame period, 11.2
- data flow, 10.1.3
 - common data definitions, 10.3.4
 - data-rate tolerance, 7.1.11
 - data transfer mechanisms, 10.1.3, 10.3.3
 - detailed communication flow illustrated, 5.3
 - host response to IN transactions, 8.4.6.2
 - interlayer communications model, 10.1.1
 - role in bulk transfers, 8.5.2
- defined, 2.0 *glossary*, 4.9
- electrical considerations, 10.1.5
 - jitter budget table, 7.1.15.1
 - over-current protection, 7.2.1.2.1
 - over-current recovery, 11.12.5
- hardware and software, 10.0
- host accuracy variations, 11.2.1 to 11.2.2
- Host Controller Driver (HCD), 10.4 (*See also* HCD)
- Host Controller responsibilities, 4.9, 10.2 (*See also* Host Controller)
- host jitter, 11.2.1
- host tolerance, hub (micro)frame timer and, 11.2
- operating system environment guides, 10.6
- overview of USB Host, 10.1 to 10.1.5
- power management overview, 4.3.2
- software mechanisms, 10.3 to 10.3.4

host (*Continued*)

- split transaction scheduling, 11.18.4
- state machines, 8.5.1, 8.5.2, 8.5.5
- status in USB pipe state, 10.5.2.2
- turn-around timers, 8.7.2
- Universal Serial Bus Driver (USB Driver), 10.5 to 10.5.5 (*See also* USB Driver)
- USB System Software responsibilities, 4.9 (*See also* USB System Software)

Host Controller, 4.9

- best case full-speed budgets, 11.18.1, 11.18.4
- in bus topology, 5.2.1
- calculating buffer sizes in functions and software, 5.11.4
- data transfer mechanisms, 10.1.3
 - bulk transfers, 5.8.3, 11.17 to 11.17.5
 - control transfers, 5.5.3, 5.5.4, 11.17 to 11.17.5
 - data processing, 10.2.4
 - data-rate tolerance, 7.1.11
 - high bandwidth transfers, 5.9.1, 5.9.2, 11.20.2
 - interrupt transfers, 5.7.3, 5.9.1
 - isochronous transfers, 5.6.3, 5.9.2, 11.21.2
 - non-periodic transactions, 11.17 to 11.17.5
 - periodic transactions, 11.18 to 11.18.8
 - role in transfer management, 5.11.1, 5.11.1.5
 - split transactions, 11.16.1 to 11.16.1.1.2
 - tracking transactions, 5.11.2
 - transaction list, 5.11.1.4
 - transmission error handling, 10.2.6
- declarations in state machines, B.2
- defined, 2.0 *glossary*, 4.9
- frame and microframe generation, 10.2.3
- HCD and HCDI overview, 10.4 (*See also* HCD; HCDI)
- host behavior at end-of-frame, 11.3
- host-system interface, 10.2.9
- as implementation focus area, 5.1
- implemented in USB Bus interface, 10.1.1
- multiple Host Controllers, 4.10
- passing preboot control to operating system, 10.5.5
- port resets, 10.2.8.1
- protocol engine, 10.2.5
- remote wakeup and, 10.2.7
- requirements, 10.2
- root hub and, 10.2.8
- serializer/deserializer, 10.2.2
- state handling, 10.2.1
- state machines, 8.5, 11.16 to 11.16.1.1.2, 11.17.2, 11.20.2, 11.21.2, B.2
- status and activity monitoring, 10.1.4

- Host Controller (*Continued*)
 - test mode support, 7.1.20
 - Transaction Translator and, 11.14.1, 11.14.1.2
 - USB System interaction, 10.1.1
- Host Controller Driver. *See* HCD (Host Controller Driver)
- Host Controller Driver Interface (HCDI), 10.1.1, 10.4
- host resources, 2.0 *glossary*
- host side bus interface. *See* Host Controller
- host software
 - in bus topology, 5.2.1
 - as component of USB System, 10.1.1
 - pipes and, 10.5.1.2
 - status and activity monitoring, 10.1.4
- host-to-function transfers. *See* OUT PID
- hot plugging. *See* dynamic insertion and removal
- HSD1 packets (downstream packets), 8.5, 11.15
- HS_Drive_Enable, 7.1.1.3
- HSEOP (End of High-speed Packet), 7.1.7.2, 7.1.7.4.2
- HS_Idle signal/event, 11.6.2, 11.6.3 *Table 11-8*
- HS signal/event, 11.6.3 *Table 11-8*, 11.6.4 *Table 11-9*
- HSSOP (Start of High-speed Packet), 7.1.7.2, 7.1.7.4.2
- HSU2 packets (upstream packets), 8.5, 11.15
- Hub address field, 8.4.2.2
- Hub Change field, 11.4.4, 11.24.2.6
- hub class definitions
 - additional endpoints, 11.12.1
 - feature selectors, 11.24.2
 - request codes, 11.24.2
 - root hub and, 10.4
- Hub Controller, 11.12 to 11.12.6
 - control commands, 11.1
 - defined, 4.8.2.1
 - endpoint organization, 11.12.1
 - hub and port change information processing, 11.12.3, 11.12.4
 - in hub architecture, 11.1.1, 11.12.2
 - internal port connection, 11.4
 - over-current reporting and recovery, 11.12.5
 - power distribution and, 7.2.1.1
 - role in host-to-hub communications, 11.1
 - status commands, 11.1
- hub descriptors, 11.12.2
- Hub Repeater
 - Collision conditions, 11.8.3
 - connectivity setup and tear-down, 11.1
 - data recovery unit, 11.7.1.2
 - defined, 4.8.2.1
 - dynamic insertion and removal, 11.1
 - elasticity buffer, 11.7.1.3
 - electrical characteristics, 7.3.2 *Table 7-11*
 - fault detection and recovery, 11.1
 - high-speed packet repeaters, 11.7.1 to 11.7.1.4.4
 - in hub architecture, 11.1.1
 - hub signaling timings, 7.1.14.1
 - internal port connection, 11.4
 - packet signaling connectivity, 11.1.2.1
 - repeater state descriptions, 11.2.3.3, 11.7 to 11.7.6
 - squelch circuit, 11.7.1.1
 - Wait for End of Packet (WFEOP), 11.7.6
 - Wait for End of Packet from Upstream Port state (WFEOPFU), 11.7.4
 - Wait for Start of Packet (WFSOP), 11.7.5
 - Wait for Start of Packet from Upstream Port state (WFSOPFU), 11.7.3
- Hub Repeater state machine, 11.2.3.3, 11.7.2
- hubs, 11. *See also* Hub Controller; Hub Repeater; ports
 - accuracy variations, 11.2.1 to 11.2.2
 - architecture, 4.1.1.2, 11.1
 - bus states
 - bus state evaluation, 11.8 to 11.8.4.1
 - collision, 11.8.3
 - connect/disconnect detection, 11.1
 - full- vs. low-speed behavior, 11.8.4
 - low-speed keep-alive, 7.1.7.1, 11.8.4.1
 - port error, 11.8.1
 - reset behavior, 11.10
 - speed detection, 11.8.2
 - status change detection, 7.1.7.5, 11.12.2, 11.12.4
 - in bus topology, 5.2.3, 5.2.4
 - characteristics and configuration, 11.13
 - clearing features, 11.24.2.6
 - data-rate tolerance, 7.1.11
 - descriptors, 11.12.2, 11.23 to 11.23.2.1, 11.24.2.10
 - full- vs. low-speed behavior, 11.8.4
 - input capacitance, 7.1.6.1
 - speed detection of devices, 11.8.2
 - typical configuration illustrated, 4.8.2.1
 - connectivity behavior, 11.1, 11.1.2 to 11.1.2.3
 - controlling hubs, 7.1.7.7
 - defined, 2.0 *glossary*
 - downstream ports, 11.5 to 11.5.1.15
 - dynamic insertion and removal role, 4.6.1, 4.6.2
 - embedded hubs, 4.8.2.2
 - enumeration handling, 11.12.6
 - fault detection and recovery, 11.1
 - Hub Controller, 4.8.2.1, 11.1, 11.12 to 11.12.6 (*See also* Hub Controller)
 - hub drivers, 10.3.1
 - Hub Repeater, 4.8.2.1, 7.3.2 *Table 7-11*, 11.1, 11.7 to 11.7.6 (*See also* Hub Repeater)
 - hub tier, 2.0 *glossary*

hubs (*Continued*)

- intermediate hubs, 7.1.7.7
- internal ports, 11.4 to 11.4.4
- labeling on port connectors, 11.5.3.1
- overview, 4.8.2.1, 11.1 to 11.1.2.3
- port indicators, 11.5.3 to 11.5.3.1
- power management, 11.1
 - bus-powered hubs, 4.3.1, 7.2.1.1
 - hub port power control, 11.11
 - multiple gangs, 11.11.1
 - over-current reporting and recovery, 11.12.5
 - power source and sink requirements, 7.2.1
 - self-powered hubs, 7.2.1.2
 - surge limiting, 7.2.4.1
- requests, 11.24 to 11.24.2.13
- root hubs, 2.0 *glossary*
- signaling and timing
 - high-speed rise and fall times, 7.1.2.2
 - high-speed signal isolation, 8.6.5
 - high-speed support, 7
 - host behavior at end-of-frame, 11.3 to 11.3.3
 - hub chain jitter, 11.2.1
 - hub differential delay, 7.3.3 *Figure 7-52*
 - hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
 - hub event timings, 7.3.2 *Table 7-13*
 - hub frame timer, 11.2 to 11.2.5.2
 - hub (micro)frame timer, 11.2
 - hub signaling timings, 7.1.14 to 7.1.14.2
 - hub switching skews, 7.1.9.1
 - jitter budget table, 7.1.15.1
 - low-speed keep-alive strobe, 7.1.7.1, 11.8.4.1
 - power-on and connection events timing, 7.1.7.3
 - reset signaling, 7.1.7.5
 - resume signaling, 7.1.7.7
 - signaling delays, 7.1.14.1
 - suspend and resume signaling, 11.9
 - tracking frame and microframe intervals, 7.1.12
- sync pattern, 7.1.10
- test mode support, 7.1.20
- Transaction Translator, 4.8.2.1, 11.1, 11.14 to 11.14.2.3
- upstream ports, 11.6 to 11.6.4.6
- Hub State Machine, 11.1.1
- Hub Status field, 11.24.2.6
- humidity life standards, 6.7 *Table 6-7*
- hybrid powered hubs, 7.2.1.2
- hysteresis in single-ended receivers, 7.1.4.1

I

- iConfiguration* field
 - configuration descriptors, 9.6.3, 11.23.1
 - other speed configuration descriptors, 9.6.4, 11.23.1
- Icon for USB plugs and receptacles, 6.5, 6.5.1
- Idle bus state
 - data signaling overview, 7.1.7.4.1, 7.1.7.4.2
 - downstream facing ports in high-speed, 7.1.7.6.1, 7.1.7.6.2
 - high-speed driver characteristics and, 7.1.1.3
 - high-speed signaling, 7.1
 - high-speed TDR measurements, 7.1.6.2
 - hub connectivity and, 11.1.2.1
 - Idle-to-K state transition, 7.1.14.1
 - NRZI data encoding, 7.1.8
 - signaling levels and, 7.1.7.1, 7.1.7.2
- idle pipes, 5.3.2, 10.5.2.2
- idProduct* field (device descriptors), 9.6.1
- idVendor* field (device descriptors), 9.6.1
- iInterface* field (interface descriptors), 9.6.5, 11.23.1
- iManufacturer* field (device descriptors), 9.6.1
- impedance
 - cable impedance tests, 6.7 *Table 6-7*
 - detachable cable assemblies, 6.4.1
 - differential cable impedance, 7.1, 7.3.2 *Table 7-12*
 - Exception Window, 7.1.6.2
 - full-speed connections, 7.1.1.1
 - high-/full-speed captive cable assemblies, 6.4.2
 - high-speed driver characteristics, 7.1.1.3
 - input impedance, 7.3.2 *Table 7-7*
 - input impedance of ports, 7.1.6.1
 - Termination Impedance, 7.1.6.2
 - test mode, 7.1.20
 - Through Impedance, 7.1.6.2
 - zero impedance voltage sources, 7.1.1
- Implementers Forum, 1.4, 2.0 *glossary*
- implementer viewpoints of data flow models, 5.1
- implicit feedback for transfers, 5.12.4.3, 9.6.5
- Inactive state, 11.4, 11.4.1, 11.6.4, 11.6.4.1, 11.7.1.4.1
- in-band signaling, 10.1.2
- incident rise times, 7.1.6.2
- indicators
 - descriptors, 11.23.2.1
 - lights on devices, 11.5.3 to 11.5.3.1
 - port status indicators, 11.24.2.7.1, 11.24.2.7.1.10
 - selectors, 11.24.2.12

- initial frequency inaccuracies, 7.1.11
- initialization of USB D, 10.5.1.1
- initial states, 8.5, 11.15
- injection molded thermoplastic insulator material, 6.5.3.1, 6.5.4.1
- inner shielding in cables, 6.6.2
- IN PID, 8.3.1 *Table 8-1*
 - aborting IN transactions, 11.18.6.1
 - ACK handshake and, 8.4.5
 - ADDR field, 8.3.2.1
 - bit times and, 11.3.3
 - bulk transfers, 8.5.2, 8.5.2 *Figure 8-33*, 8.5.2 *Figure 8-34*, 11.17.1, 11.17.2
 - complete-split flow sequence, 11.20.1
 - control transfers, 8.5.2 *Figure 8-33*, 8.5.2 *Figure 8-34*, 8.5.3, 8.5.3.1, 11.17.1, 11.17.2
 - ENDP field, 8.3.2.2
 - error handling on last data transaction, 8.5.3.3
 - function response to, 8.4.6.1
 - high bandwidth transactions and, 5.9.2
 - host response to, 8.4.6.2
 - interrupt transfers, 8.5.2 *Figure 8-33*, 8.5.2 *Figure 8-34*, 8.5.4, 11.20.4
 - intervals between IN token and EOP, 11.3.3
 - isochronous transfers, 8.5.5, 8.5.5 *Figure 8-42*, 8.5.5 *Figure 8-43*, 11.21 to 11.21.4
 - low-speed transactions, 8.6.5
 - NAK handshake and, 8.4.5
 - prebuffering data, 5.12.5
 - scheduling IN transactions, 11.18.4
 - split transaction conversion, 8.4.2.1
 - split transaction examples, A.2, A.4, A.6
 - STALL handshake and, 8.4.5
 - start-split flow sequence, 11.20.1
 - state machines
 - bulk/control state machines, 8.5.2 *Figure 8-33*, 8.5.2 *Figure 8-34*, 11.17.2
 - interrupt state machines, 8.5.2 *Figure 8-33*, 8.5.2 *Figure 8-34*, 11.20.2
 - isochronous state machines, 8.5.5 *Figure 8-42*, 8.5.5 *Figure 8-43*, 11.21.2
 - token CRCs, 8.3.5.1
 - token packets, 8.4.1
 - Transaction Translator response generation, 11.18.5
- input capacitance, 7.1.2.1, 7.3.2 *Table 7-7*
- input characteristics (signaling), 7.1.6.1
- input impedance, 7.3.2 *Table 7-7*
- input impedance of ports, 7.1.6.1
- input levels, 7.3.2 *Table 7-7*
- inputs (Series "B" receptacles), 6.2
- input sensitivity of differential input receivers, 7.1.4.1
- input transitions in state machines, 8.5
- inrush current limiting
 - bus-powered hubs, 7.2.1.1
 - dynamic attach and detach, 7.2.4.1
 - remote wakeup and, 7.2.3
 - self-powered functions, 7.2.1.5
 - suspend/resume and, 7.2.3
- inserting devices. *See* dynamic insertion and removal
- insertion force standards, 6.7 *Table 6-7*
- instancing of USB D, 10.5
- insulation
 - cables, 6.6.2
 - insulator materials, 6.5.3.1, 6.5.4.1
 - resistance standards, 6.7 *Table 6-7*
- interconnect model, 4.1, 5.12.4.4
- interface class codes, 9.6.5
- INTERFACE descriptor, 9.4 *Table 9-5*
- interface descriptors
 - GetDescriptor() request, 9.4.3
 - hubs, 11.23.1
 - INTERFACE_POWER descriptor, 9.4 *Table 9-5*
 - overview, 9.6.5
- interface numbers, 9.2.3, 9.6.5
- INTERFACE_POWER descriptor, 9.4 *Table 9-5*
- interfaces
 - alternate interfaces, 9.2.3, 10.5.2.10
 - alternate settings, 9.6.5
 - in configuration descriptors, 9.6.3, 9.6.4
 - defined, 9.2.3
 - in device class definitions, 9.7.2
 - as endpoint sets, 5.3
 - getting interface status, 9.4.4, 9.4.5
 - host-system interface, 10.2.9
 - interface class codes, 9.6.5
 - interface descriptors, 9.4.3, 9.6.5, 11.23.1
 - interface numbers, 9.2.3, 9.6.5
 - interface subclass codes, 9.6.5
 - plug interface and mating drawings, 6.5.4
 - setting interface state, 9.4.10, 10.5.2.1
 - specifying in *wIndex* field, 9.3.4
- interfaces of plugs, 6.5.3
- interface state control, 10.5.2.1
- interface subclass codes, 9.6.5
- interlayer communications model, 4.1, 10.1.1
- intermediate hubs, 7.1.7.7
- internal clock source jitter, 7.1.13.1.1
- internal ports
 - Full Suspend (F_{sus}) state, 11.4.3
 - Generate Resume (GResume) state, 11.4.4
 - Inactive state, 11.4.1
 - Suspend Delay state, 11.4.2
- internal port state machine, 11.4
- interpacket delay, 7.1.18 to 7.1.18.2
- interpacket gaps, 11.18.2

- interrupt endpoints, 11.12.1
- interrupt requests, defined, 2.0 *glossary*
- interrupt transfers. *See also* periodic transactions
 - aborting, 11.18.6.1
 - bus access constraints, 5.7.4
 - data format, 5.7.1
 - data sequences, 5.7.5
 - defined, 2.0 *glossary*, 5.4
 - direction, 5.7.2
 - flow sequences, 11.18.8, 11.20 to 11.20.4
 - full-speed transfer limits, 5.7.4
 - high-bandwidth endpoints, 5.9.1
 - high-speed transfer limits, 5.7.4 *Table 5-8*
 - low-speed transfer limits, 5.7.4
 - multiple transactions and, 9.6.6
 - overview, 4.7, 4.7.3, 5.7
 - packet size, 5.7.3, 9.6.6
 - periodic transactions, 11.18 to 11.18.8
 - required bus access period, 5.7.4
 - scheduling and buffering, 11.14.2.1
 - sequencing, 11.20.3, 11.20.4
 - split transactions
 - examples, A.3, A.4
 - host handling of, 5.10
 - notation for, 11.15
 - state machines, 8.5.2, 11.20 to 11.20.4
 - transaction format, 8.5.4
 - transaction organization within IRPs, 5.11.2
 - Transaction Translator response generation, 11.18.5
 - USB pipe mechanism responsibilities, 10.5.3.1.2
- intervals
 - debounce intervals in connection events, 7.1.7.3
 - frame and microframe intervals, 7.1.12, 7.3.2 *Table 7-8*, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
 - Resetting state and Resuming state intervals, 11.5.1.10
 - resume and recovery intervals for devices, 9.2.6.2
 - service and polling intervals, 2.0 *glossary*, 9.6.6, 10.3.3
 - timeout intervals, 8.7.3
 - between IN token and EOP, 11.3.3
- interwoven tinned copper wire, 6.6.2
- IN transactions. *See* IN PID
- I/O buffers. *See* buffers
- I/O Request Packets. *See* IRPs
- iProduct* field (device descriptors), 9.6.1
- IRPs. *See also* requests; transfers
 - aborting/retiring, 5.3.2, 10.5.3.2.1
 - class-specific requests, 9.2.6.5
 - client software role in, 5.11.1.1
 - defined, 2.0 *glossary*, 5.3.2
 - HCD tracking of, 5.11.1.3
 - multiple data payloads in, 5.3.2
 - pipes and, 5.3.2
 - queuing IRPs, 10.5.3.2.3
 - request processing overview, 9.2.6
 - reset/resume recovery time, 9.2.6.2
 - set address processing, 9.2.6.3
 - STALLS and, 5.3.2
 - standard device requests, 9.2.6.4, 9.4 to 9.4.11
 - timing, 9.2.6.1, 9.2.6.3, 9.2.6.4
 - transaction organization within IRPs, 5.11.2
 - USB device requests, 9.3 to 9.3.5
 - USB role in, 10.1.1
- IRQs, defined, 2.0 *glossary*
- iSerialNumber* field (device descriptors), 9.6.1
- isochronous data, defined, 2.0 *glossary*
- isochronous devices, defined, 2.0 *glossary*
- isochronous sink endpoints, defined, 2.0 *glossary*
- isochronous source endpoints, defined, 2.0 *glossary*
- isochronous transactions. *See also* periodic transactions
- isochronous transfers
 - buffering, 5.12.8, 11.14.2.1
 - bus access constraints, 5.6.4
 - clock model, 5.12.2
 - clock synchronization, 5.12.3
 - connectivity, 5.12.4.4
 - data format, 5.6.1
 - data prebuffering, 5.12.5
 - data sequences, 5.6.5
 - defined, 2.0 *glossary*, 5.4
 - direction, 5.6.2
 - endpoint attributes, 9.6.6
 - endpoint synchronization frame, 9.4.11
 - error handling, 5.12.7
 - feedback, 5.12.4.2
 - high-bandwidth endpoints, 2.0 *glossary*, 5.9.2
 - illustrated, 5.12.2
 - implicit feedback, 5.12.4.3, 9.6.5
 - isochronous device framework, 5.12.4
 - multiple transactions and, 9.6.6
 - non-USB example isochronous application, 5.12.1
 - non-zero data payload, 5.6.3

isochronous transfers (*Continued*)

- overview, 4.7.4, 5.6, 11.21 to 11.21.4
 - packet size, 5.6.3, 9.6.6
 - periodic transactions, 11.18 to 11.18.8
 - rate matching, 5.12.8
 - scheduling, 11.14.2.1
 - sequencing, 11.21.3, 11.21.4
 - SOF tracking, 5.12.6
 - special considerations, 5.12 to 5.12.8
 - specifying required bus access period, 5.6.4
 - split transactions
 - examples, A.5, A.6
 - flow sequences, 11.18.8
 - host controller and, 5.10
 - notation for, 11.15
 - state machines, 8.5.5, 11.21 to 11.21.4
 - synchronization types, 5.12.4.1.1, 5.12.4.1.2, 5.12.4.1.3
 - transaction format, 8.5.5
 - transaction organization within IRPs, 5.11.2
 - Transaction Translator response generation, 11.18.5
 - USBD pipe mechanism responsibilities, 10.5.3.1.1
 - USB features and, 3.3
 - USB System Software role, 4.9
- ISO transfers. See isochronous transfers
- ITCW (interwoven tinned copper wire), 6.6.2

J

- J bus state
 - data signaling overview, 7.1.7.4.1
 - high-speed signaling and, 7.1, 7.1.1.3
 - J-to-K state transition, 7.1.14.1
 - NRZI data encoding, 7.1.8
 - signaling levels and, 7.1.7.1, 7.1.7.2
 - test mode, 7.1.20
- J signal/event
 - differential transmissions, 11.6.1
 - receiver state machine, 11.6.3 *Table 11-8*
 - transmission sequence, 7
 - transmitter state machine, 11.6.4 *Table 11-9*
- jacketing in cables, 6.6.2
- jitter
 - clock jitter, 5.12.3
 - cumulative jitter in high-speed signaling, 7.1.14.2
 - data source jitter, 7.1.13.1 to 7.1.13.1.2
 - defined, 2.0 *glossary*
 - differential data jitter, 7.3.3 *Figure 7-49*
 - differential jitter, 7.3.3 *Figure 7-52*
 - frame and microframe jitter, 11.2.4
 - full-speed source electrical characteristics, 7.3.2 *Table 7-9*
 - high-speed source electrical characteristics, 7.3.2 *Table 7-8*

jitter (*Continued*)

- host jitter, 11.2.1
- hub chain jitter, 11.2.1
- hub/repeater electrical characteristics, 7.3.2 *Table 7-11*
- internal clock source jitter, 7.1.13.1.1
- low-speed source electrical characteristics, 7.3.2 *Table 7-10*
- in non-USB isochronous application, 5.12.1
- output driver jitter, 7.1.15.1
- receiver data jitter, 7.1.15 to 7.1.15.2, 7.3.3 *Figure 7-51*
- service jitter, 2.0 *glossary*
- test mode, 7.1.20
- Transaction Translator frame clock and, 11.18.3
- joint symbols in state machine transitions, 8.5, 11.15

K

- K bus state
 - data signaling overview, 7.1.7.4.1
 - high speed signaling and, 7.1.1.3
 - high-speed signaling and, 7.1
 - Idle-to-K state transition, 7.1.14.1
 - K-to-J state transition, 7.1.14.1
 - NRZI data encoding, 7.1.8
 - signaling levels and, 7.1.7.1, 7.1.7.2, 7.1.7.4.2
 - test mode, 7.1.20
- K signal/event
 - differential transmissions, 11.6.1
 - downstream port state machine, 11.5 *Table 11-5*
 - receiver state machine, 11.6.3 *Table 11-8*
 - transmission sequence, 7
 - transmitter state machine, 11.6.4 *Table 11-9*
- kB/S and kb/S, defined, 2.0 *glossary*
- keep-alive strobe, 7.1.7.1, 7.1.7.6, 11.8.4.1
- keyed connector protocol, 6.2

L

- labeling on port connectors, 11.5.3.1
- LANGID code array, 9.6.7
- language IDs in string descriptors, 9.6.7
- latency
 - constraints for transfers, 5.4
 - packets, 11.7.1.3
- latest host packet, 11.3.1
- least-significant bit (LSb), 2.0 *glossary*, 8.1
- least-significant byte (LSB), 2.0 *glossary*, 8.1
- length of cables, 6.4.1, 6.4.2, 6.4.3
- listing, UL listing for cables, 6.6.5
- little endian order, 2.0 *glossary*, 8.1
- LOA, 2.0 *glossary*, 8.7.4
- load capacitance, 6.4.3, 6.7 *Table 6-7*
- Local Power Source field, 11.24.2.6

- Local Power Status Change field, 11.24.2.6
- Local Power Status field, 11.24.2.7.1.6
- local power supplies, 7.2.1.2, 7.2.1.5
- locking hub frame timer, 11.2.3
- Lock signal/event, 11.7.2.3 *Table 11-11*
- logical bus topology, 5.2, 5.2.4
- logical devices
 - in bus topology, 5.2.2
 - as collections of endpoints, 5.3
 - detailed communication flow illustrated, 5.3
 - unique addresses and endpoints, 5.3.1
- Logical Power Switching Mode field, 11.11, 11.11.1, 11.23.2.1
- logo location on connectors, 6.5.1
- LOI, 6.5.3.1, 6.5.4.1
- loss, cable, 7.1.17
- loss of bus activity. See LOA
- loss of synchronization, 11.22.1
- low level contact resistance standards, 6.7 *Table 6-7*
- low-power bus-powered functions, 7.2.1, 7.2.1.3
- low-power hubs, 7.2.2
- low-power ports, 7.2.1
- low-speed buffers, 7.1.2.1
- low-speed cables
 - cable environmental characteristics, 6.6.4
 - captive cable assemblies, 6.4.3
 - configuration overview, 6.6
 - construction, 6.6.2
 - description, 6.6.1
 - detachable cables, 6.4.4
 - listing, 6.6.5
 - specifications, 6.3
 - standards for, 6.6.3, 6.7
- low-speed driver characteristics, 7.1.1.2, 7.1 *Table 7-1*
- low-speed functions and hubs
 - cable and resistor connections, 7.1.5.1
 - connect detection, 7.1.7.3
 - control transfers and, 5.5.3, 5.5.4, 5.5.4 *Table 5-1*
 - data-rate tolerance, 7.1.11
 - defined, 2.0 *glossary*
 - detachable cables and, 6.4.1
 - detecting, 11.24.2.7.1.7
 - full- vs. low-speed port behavior, 11.8.4
 - getting port status, 11.24.2.7.1
 - high-/full-speed captive cable assemblies, 6.4.2
 - hub/repeater electrical characteristics, 7.3.2 *Table 7-11*
 - hub support for, 11.1
 - input capacitance, 7.1.6.1
 - interrupt transfers and, 5.7.3, 5.7.4 *Table 5-6*
 - low-speed captive cable assemblies, 6.4.3
 - maximum data payload, 8.4.4
 - low-speed functions and hubs (*Continued*)
 - optional endpoints, 5.3.1.2
 - in physical bus topology, 5.2.3
 - signal termination, 7.1.5.1
 - speed detection and, 11.8.2
 - Transmit state and, 11.5.1.7
 - low-speed keep-alive strobe, 7.1.7.1, 7.1.7.6, 11.8.4.1
 - low-speed signaling
 - babble and loss of activity recovery, 8.7.4
 - bus transactions and, 4.4
 - calculating transaction times, 5.11.3
 - data rates, 4.2.1
 - data signaling overview, 7.1.7.4.1
 - data source jitter, 7.1.13.1.1
 - data toggle synchronization and retry, 8.6.5
 - defined, 2.0 *glossary*
 - differential receivers, 7.1 *Table 7-1*
 - downstream and upstream facing ports, 7.1
 - driver characteristics, 7.1.1, 7.1.2.3, 7.1 *Table 7-1*
 - EOP width, 7.1.13.2.1
 - errors, 8.6.4
 - host behavior at end-of-frame, 11.3 to 11.3.3
 - hub class descriptors and, 11.23.1
 - intervals between IN token and EOP, 11.3.3
 - J and K states, 7.1.7.1
 - jitter budget table, 7.1.15.1
 - low-speed loads, 7.1.2.1
 - propagation delays, 7.1.14.1
 - receiver characteristics, 7.1.4.1
 - reset signaling, 7.1.7.5
 - scheduling, 11.14.2.3
 - speed detection, 9.1.1.3
 - transactions illustrated, 8.6.5
 - Transaction Translator, 4.8.2.1, 11.18.5
 - low-speed source electrical characteristics, 7.3.2 *Table 7-10*
- LSb and LSB
 - in bit ordering, 8.1
 - defined, 2.0 *glossary*
- LS signal/event, 11.5
- lumped capacitance guidelines for transceivers, 7.1.6.2

M

- male plug contact materials, 6.5.4.3
- manual port color indicators, 11.5.3
- Manufacturer's logo location, 6.5.1
- Manufacturer's names in device descriptors, 9.6.1
- mapping physical and virtual devices, 5.12.4.4
- marking on cables, 6.6.2
- master clock, 5.12.1

material requirements
 cables, 6.6 to 6.6.5
 connectors, 6.5 to 6.5.4.3
 mating area materials, 6.5.3.3, 6.5.4.3
MaxPower field, 9.6.4, 11.13
 MB/S, defined, 2.0 *glossary*
 Mb/S, defined, 2.0 *glossary*
 MDATA PID
 in data packets, 8.4.4
 defined, 8.3.1 *Table 8-1*
 high-bandwidth endpoints and, 2.0 *glossary*,
 5.9.2
 interrupt IN sequencing, 11.20.4
 Transaction Translator response generation,
 11.18.5
 measurement planes in speed signaling eye
 patterns, 7.1.2.2
 mechanical specifications, 6, 6.1
 applicable documents, 6.7.1
 architectural overview, 6.1
 cable assembly, 6.4 to 6.4.4
 cables, 6.3, 6.6 to 6.6.5
 connectors, 6.2, 6.5 to 6.5.4.3
 overview, 4.2.2, 6
 PCB reference drawings, 6.9
 standards for, 6.7, 6.7.1
 USB grounding, 6.8
 message pipes. *See also* control pipes; pipes
 in bus protocol overview, 4.4
 defined, 2.0 *glossary*, 5.3.2
 overview, 5.3.2.2
 microframe pipelines. *See under* frames and
 microframes
 microframes. *See* frames and microframes
 microframe timers. *See* frame and microframe
 timers
 microphone non-USB isochronous application,
 5.12.1
 microphone USB isochronous application, 5.12.2
 "middle" encoding, 11.18.4
 modifying device configuration, 10.5.4.1.3
 monotonic transitions, 7.1.2.1, 7.1.2.2
 most-significant bit (MSb), 2.0 *glossary*, 8.1
 most-significant byte (MSB), 2.0 *glossary*, 8.1,
 11.24.2.13
 MSb and MSB, 2.0 *glossary*, 8.1
 multiple gangs, hubs and, 11.11.1
 multiple Transaction Translators, 11.14.1.3,
 11.23.1, 11.24.2.8

N

NAKs
 in bulk transfers, 8.5.2, 11.17.1
 busy endpoints, 5.3.2
 in control transfers, 8.5.3.1, 11.17.1
 data corrupted or not accepted, 8.6.3
 defined, 2.0 *glossary*
 function response to IN transactions, 8.4.6.1
 function response to OUT transactions,
 8.4.6.3
 high bandwidth transactions and, 5.9.1
 in interrupt transfers, 5.7.4, 8.5.4, 11.20.4
 NAK limiting via Ping flow control, 8.5.1,
 8.5.1.1
 non-periodic transactions, 11.14.2.2, 11.17.1
 overview, 8.3.1 *Table 8-1*, 8.4.5
 Ready/NAK status, 11.15
 test mode, 7.1.20
 NEC Article 800 for communications cables,
 6.6.4
 next frame in hub timing, 11.2.3.1
 No Acknowledge packet. *See* NAKs
 nominal cable diameter, 6.6.2
 nominal cable temperatures, 6.6.4
 nominal twist ratio in signal pair, 6.6.2
 non-acceptable cables, 6.4.4
 non-periodic transactions
 buffers, 11.14.1, 11.14.2.2, 11.19
 failures, 11.17.5
 overview, 11.17 to 11.17.5
 scheduling, 11.14.2.2
 Non Return to Zero Invert. *See* NRZI encoding
 non-twisted power pair in cables, 6.6.1, 6.6.2
 non-USB isochronous application, 5.12.1
 non-zero data payloads, 5.6.3
 Not Configured state, 11.5, 11.5.1.1
 Not Packet state, 11.7.1.4.4
 NRZI encoding, 7.1.8
 bit stuffing, 7.1.9
 defined, 2.0 *glossary*
 in electrical specifications overview, 4.2.1
 high-speed signaling and, 7.1
 sync pattern, 7.1.7.4.2, 7.1.10
 NYET handshake
 aborting, 11.18.6.1
 bulk/control transactions, 8.5.2, 11.17.1
 defined, 8.3.1 *Table 8-1*, 8.4.5
 isochronous transactions, 11.21.1
 Ping flow control and, 8.5.1
 Transaction Translator response generation,
 11.18.5

O

objects, defined, 2.0 *glossary*
 offsets between host and hub, 11.2
 Old status, 11.15
 one-way propagation delay, 7.1.16, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
 open architecture, USB development and, 1.2
 open-circuit voltage, 7.1.1
 operating systems
 companion specifications, 10.6
 device configuration, 10.3.1
 interaction with USB, 10.5
 passing preboot control to, 10.5.5
 operating temperatures for cables, 6.6.4
 operations, generic USB device operations, 9.2 to 9.2.7
 optional edge rate control capacitors, 7.1.6.1
 OTHER_SPEED_CONFIGURATION descriptor, 9.2.6.6, 9.4 *Table 9-5*, 9.4.3, 9.6.2, 9.6.4
 (other speed) device_qualifier descriptor, 9.2.6.6
 other_speed requests, 9.2.6.6
 out-of-band signaling, 10.1.2
 OUT PID, 8.3.1 *Table 8-1*
 aborting OUT transactions, 11.18.6.1
 ACK handshake and, 8.4.5
 ADDR field, 8.3.2.1
 in bulk transfers, 8.5.2, 8.5.2 *Figure 8-31*, 8.5.2 *Figure 8-32*, 11.17.1, 11.17.2
 complete-split flow sequence, 11.20.1
 in control transfers, 8.5.2 *Figure 8-31*, 8.5.2 *Figure 8-32*, 8.5.3, 8.5.3.1, 11.17.1, 11.17.2
 in data toggle, 8.6.1
 ENDP field, 8.3.2.2
 function response to OUT transactions, 8.4.6.3
 high bandwidth transactions and, 5.9.2
 high-speed PING flow control protocol, 5.8.4
 in interrupt transfers, 8.5.2 *Figure 8-31*, 8.5.2 *Figure 8-32*, 8.5.4, 11.20.3
 in isochronous transfers, 8.5.5, 8.5.5 *Figure 8-40*, 8.5.5 *Figure 8-41*, 11.21 to 11.21.4
 NAK handshake and, 8.4.5
 OUT/DATA transactions, 8.5.1, 8.5.1.1
 PING flow control and OUT transactions, 8.5.1, 8.5.1.1
 prebuffering data, 5.12.5
 scheduling OUT transactions, 11.18.4
 split transaction conversion, 8.4.2.1, 8.4.2.2
 split transaction examples, A.1, A.3, A.5
 STALL handshake and, 8.4.5
 start-split flow sequence, 11.20.1

OUT PID (*Continued*)

state machines
 bulk/control state machines, 8.5.2 *Figure 8-31*, 8.5.2 *Figure 8-32*, 11.17.2
 interrupt state machines, 8.5.2 *Figure 8-31*, 8.5.2 *Figure 8-32*, 11.20.2
 isochronous state machines, 8.5.5 *Figure 8-40*, 8.5.5 *Figure 8-41*, 11.21.2
 token CRCs, 8.3.5.1
 in token packets, 8.4.1
 Transaction Translator response generation, 11.18.5
 output driver jitter, 7.1.15.1
 output levels, 7.3.2 *Table 7-7*
 output receptacles, 6.2
 output rise and fall times, 7.1.2.1
 output transitions in state machines, 8.5
 outside plating, 6.5.3.2, 6.5.4.2
 over-current conditions
 C_PORT_OVER-CURRENT bit, 11.24.2.7.2.4
 getting port status, 11.24.2.7.1
 over-current gangs, 11.11.1
 over-current protection in self-powered hubs, 7.2.1.2.1
 port indicators, 11.5.3
 PORT_OVER-CURRENT bit, 11.24.2.7.1.4
 port status change bits, 11.24.2.7.2
 protection mode descriptors, 11.23.2.1
 reporting and recovery, 11.12.5
 signaling, 11.11.1
 Over-current Indicator Change field, 11.24.2.6
 Over-current Indicator field, 11.24.2.6
 Over-current Reporting Mode field, 11.11.1
 Over-current signal/event, 11.5 *Table 11-5*
 over-sampling state machine DPLLs, 7.1.15.1
 oxygen index, 6.5.3.1, 6.5.4.1

P

packet buffers, defined, 2.0 *glossary*
 packet field formats, 8.3
 address fields, 8.3.2 to 8.3.2.2
 cyclic redundancy checks (CRC), 8.3.5 to 8.3.5.2
 data field, 8.3.4, 8.4.4
 frame number field, 8.3.3, 8.4.3
 packet identifier field, 8.3.1 (*See also* PIDs)

- packet formats
 - data packets, 4.4, 8.3 to 8.3.5.2, 8.4.4, 8.5.2, 8.5.5
 - handshake packets, 8.4.5 (*See also* handshakes)
 - handshake responses, 8.4.6 to 8.4.6.4
 - overview, 8.4
 - packet field formats, 8.3 to 8.3.5.2
 - SOF packets, 5.12.2, 5.12.4.1.1, 5.12.4.1.2, 8.4.3
 - token packets, 4.4, 8.3.5.1, 8.4.1, 8.5.2, 8.5.5
- packet identifier field (PID). *See* PIDs
- packet IDs. *See* PIDs
- packet nullification, 11.3.2
- packets. *See also* packet field formats; packet formats; packet size
 - bit stuffing, 7.1.9 to 7.1.9.2
 - blocking in Collision conditions, 11.8.3
 - bus protocol overview, 4.4
 - data packets defined, 4.4
 - data signaling overview, 7.1.7.4 to 7.1.7.4.2 defined, 2.0 *glossary*
 - error detection and recovery, 8.7 to 8.7.4
 - handshake packets defined, 4.4
 - high-speed packet repeaters, 11.7.1 to 11.7.1.4.4
 - hub connectivity and, 11.1.2.1
 - inter-packet delay, 7.1.18 to 7.1.18.2
 - one transaction per frame in isochronous transfers, 5.12.7
 - packet field formats, 8.3 to 8.3.5.2
 - packet formats, 8.4 to 8.4.6.4
 - packet nullification, 11.3.2
 - packet size (*See* packet size)
 - packet voltage levels, 7.1.7.4.1
 - short packets, 5.3.2
 - splitting samples across packets, 5.12.8
 - SYNC field, 8.2
 - test mode packets, 7.1.20
 - token packets defined, 4.4
 - total latency, 11.7.1.3
 - transaction formats, 8.5 to 8.5.5
- packet size
 - in buffering calculations, 5.12.8
 - bulk transfer constraints, 5.8.3
 - characteristics for transfers, 5.4
 - control transfer constraints, 5.5.3
 - determining missing packet size, 5.12.7
 - in device descriptors, 9.6.1
 - in device_qualifier descriptor, 9.6.2
 - in endpoint descriptors, 9.6.6
 - interrupt transfer constraints, 5.7.3
 - isochronous transfer constraints, 5.6.3
- packet voltage levels, 7.1.7.4.1
- parasitic loading, 7.1, 7.1.1.3, 7.1.6.2
- partitioning of power, 7.2.1.1
- paths, notations for, 11.15
- pattern synchronization, 9.4.11
- PBT (polybutylene terephthalate), 6.5.3.1, 6.5.4.1
- PCB reference drawings, 6.9
- PC industry, USB and, 3.3
- PC-to-telephone interconnects, 1.1
- pending start-splits, 11.18.6.2
- Pending status, 11.15, 11.17.1
- pending transactions, 11.18.6
- performance criteria for electrical, mechanical and environmental compliance, 6.7
- periodic buffer sections, 11.14.1
- periodic transactions. *See also* interrupt transfers; isochronous transfers
 - after loss of synchronization, 11.22.2
 - buffer space required, 11.14.1, 11.19
 - handling requirements, 11.18.6 to 11.18.6.3
 - interrupt transaction sequencing, 11.20.3, 11.20.4
 - IN transaction sequencing, 11.20.4, 11.21.4
 - isochronous split transactions, 11.21 to 11.21.4
 - OUT transaction sequencing, 11.20.3, 11.21.3
 - overview, 11.18 to 11.18.8
 - periodic transaction pipelines, 11.14.2.1
 - scheduling and buffering, 11.14.2.1
 - split transaction flow sequences, 11.18.8
- peripheral devices, 4.8.2.2. *See also* devices; functions
- per-port current limiting, 11.12.5
- per-port power switching, 11.11, 11.12.5
- PET (polyethylene terephthalate), 6.5.3.1, 6.5.4.1
- phase delay for SOF packets, 11.3.1
- phase differences, clock synchronization and, 5.12.3
- phase-locked clocks, 5.12.3
- Phase Locked Loop, defined, 2.0 *glossary*
- phases, defined, 2.0 *glossary*
- Physical and Environmental Performance Properties of Insulation and Jacket for Telecommunication Wire and Cable*, 6.7.1
- physical bus topology, 5.2, 5.2.3, 6.1
- physical devices
 - connectivity illustrated, 5.12.4.4
 - defined, 2.0 *glossary*
 - as implementation focus area, 5.1
 - logical components in bus topology, 5.2.2
- physical interface, 4.2 to 4.2.2
- physical shock standards, 6.7 *Table 6-7*
- PID errors, defined, 8.3.1

PIDs

- corrupted PIDs, 8.3.1
- in data packets, 8.4.4
- data PIDs
 - DATA0/DATA1/DATA2 PIDs
 - in bulk transfers, 5.8.5, 8.5.2
 - comparing sequence bits, 8.6.2
 - in control transfers, 8.5.3
 - in data packets, 8.4.4
 - high-bandwidth transactions and, 5.9.1, 5.9.2
 - high-speed data PIDs, 8.3.1 *Table 8-1*
 - in interrupt transactions, 5.7.5, 8.5.4, 11.20.4
 - synchronization and, 8.6
 - Transaction Translator response generation, 11.18.5
 - error handling in high-speed transactions, 5.12.7
 - high bandwidth transactions and, 5.9.2
- MDATA PIDs
 - in data packets, 8.4.4
 - defined, 8.3.1 *Table 8-1*
 - high-bandwidth endpoints and, 5.9.2
 - interrupt IN sequencing, 11.20.4
 - Transaction Translator response generation, 11.18.5
- defined, 2.0 *glossary*
- full- vs. low-speed port behavior, 11.8.4
- in handshake packets, 8.4.5
- handshake PIDs, 8.3.1 *Table 8-1*
- ACK PIDs
 - in bulk transfers, 8.5.2, 11.17.1
 - in control transfers, 8.5.3, 8.5.3.1, 11.17.1
 - corrupted ACK handshake, 8.5.3.3, 8.6.4
 - in data toggle, 8.6, 8.6.1, 8.6.2
 - defined, 2.0 *glossary*
 - function response to OUT transactions, 8.4.6.3
 - host response to IN transactions, 8.4.6.2
 - overview, 8.3.1 *Table 8-1*, 8.4.5
 - PING flow control and OUT transactions, 8.5.1, 8.5.1.1
 - Ready/ACK status, 11.15
 - in request processing, 9.2.6
- NAK PIDs
 - in bulk transfers, 8.5.2, 11.17.1
 - busy endpoints, 5.3.2
 - in control transfers, 8.5.3.1, 11.17.1
 - data corrupted or not accepted, 8.6.3
 - defined, 2.0 *glossary*
 - function response to IN transactions, 8.4.6.1
 - function response to OUT transactions, 8.4.6.3

PIDs (*Continued*)

- handshake PIDs
- NAK PIDs
 - high bandwidth transactions and, 5.9.1
 - in interrupt transfers, 5.7.4, 8.5.4, 11.20.4
 - NAK limiting via Ping flow control, 8.5.1, 8.5.1.1
 - non-periodic transactions, 11.14.2.2, 11.17.1
 - overview, 8.3.1 *Table 8-1*, 8.4.5
 - Ready/NAK status, 11.15
 - test mode, 7.1.20
- NYET PIDs
 - aborting, 11.18.6.1
 - bulk/control transactions, 8.5.2, 11.17.1
 - defined, 8.3.1 *Table 8-1*, 8.4.5
 - isochronous transactions, 11.21.1
 - Ping flow control and, 8.5.1
 - Transaction Translator response generation, 11.18.5
- STALL PIDs
 - in bulk transfers, 5.8.5, 8.5.2, 11.17.1
 - in control transfers, 8.5.3.1, 11.17.1
 - data corrupted or not accepted, 8.6.3
 - functional and commanded stalls, 8.4.5
 - function response to IN transactions, 8.4.6.1
 - function response to OUT transactions, 8.4.6.3
 - in interrupt transfers, 5.7.5, 8.5.4, 11.20.4
 - overview, 8.3.1 *Table 8-1*, 8.4.5
 - protocol stalls, 8.4.5
 - Ready/Stall status, 11.15
 - Request Error responses, 9.2.7
 - responses to standard device requests, 9.4
 - returned by control pipes, 8.5.3.4
- incorrect PID errors, 11.15
- overview, 8.3.1
- PID check bits, 8.7.1
- PID errors, 8.3.1
- special PIDs
 - ERR PIDs, 8.3.1 *Table 8-1*, 8.4.5
 - PING PIDs, 8.3.1 *Table 8-1*, 8.3.2.2, 8.3.5.1, 8.4.1, 8.4.5, 8.5.2, 8.5.3.1
- PRE PIDs
 - inter-packet delays and, 7.1.18.1
 - low-speed port behavior and, 11.8.4
 - low-speed transactions, 8.6.5
 - overview, 8.3.1 *Table 8-1*
 - Transmit state and, 11.5.1.7
- Reserved PIDs, 8.3.1 *Table 8-1*
- SPLIT PIDs, 8.3.1 *Table 8-1*, 8.3.2.1, 8.3.5.1, 8.4.2 to 8.4.2.3
- in start-of-frame packets, 8.4.3
- in token packets, 8.4.1

PIDs (Continued)

token PIDs, 8.3.1 *Table 8-1*

OUT PIDs

aborting OUT transactions, 11.18.6.1
 ACK handshake and, 8.4.5
 ADDR field, 8.3.2.1
 in bulk transfers, 8.5.2, 8.5.2 *Figure 8-31*,
 8.5.2 *Figure 8-32*, 11.17.1, 11.17.2
 complete-split flow sequence, 11.20.1
 in control transfers, 8.5.2 *Figure 8-31*,
 8.5.2 *Figure 8-32*, 8.5.3, 8.5.3.1,
 11.17.1, 11.17.2
 in data toggle, 8.6.1
 ENDP field, 8.3.2.2
 function response to OUT transactions,
 8.4.6.3
 high bandwidth transactions and, 5.9.2
 high-speed PING flow control protocol,
 5.8.4
 in interrupt transfers, 8.5.2 *Figure 8-31*,
 8.5.2 *Figure 8-32*, 8.5.4, 11.20.3
 in isochronous transfers, 8.5.5, 8.5.5
Figure 8-40, 8.5.5 *Figure 8-41*,
 11.21 to 11.21.4
 NAK handshake and, 8.4.5
 OUT/DATA transactions, 8.5.1, 8.5.1.1
 overview, 8.3.1 *Table 8-1*
 PING flow control and OUT transactions,
 8.5.1, 8.5.1.1
 prebuffering data, 5.12.5
 scheduling OUT transactions, 11.18.4
 split transaction conversion, 8.4.2.1,
 8.4.2.2
 split transaction examples, A.1, A.3, A.5
 STALL handshake and, 8.4.5
 start-split flow sequence, 11.20.1
 state machines, 8.5.2, 8.5.5, 11.17.2,
 11.20.2, 11.21.2
 token CRCs, 8.3.5.1
 in token packets, 8.4.1
 Transaction Translator response
 generation, 11.18.5

IN PIDs

aborting IN transactions, 11.18.6.1
 ACK handshake and, 8.4.5
 ADDR field, 8.3.2.1
 bit times and, 11.3.3
 bulk transfers, 8.5.2, 8.5.2 *Figure 8-33*,
 8.5.2 *Figure 8-34*, 11.17.1, 11.17.2
 complete-split flow sequence, 11.20.1
 control transfers, 8.5.2 *Figure 8-33*, 8.5.2
Figure 8-34, 8.5.3, 8.5.3.1,
 11.17.1, 11.17.2
 ENDP field, 8.3.2.2
 error handling on last data transaction,
 8.5.3.3

PIDs (Continued)

token PIDs

IN PIDs

function response to, 8.4.6.1
 high bandwidth transactions and, 5.9.2
 host response to, 8.4.6.2
 interrupt transactions, 8.5.4
 interrupt transfers, 8.5.2 *Figure 8-33*,
 8.5.2 *Figure 8-34*, 11.20.4
 intervals between IN token and EOP,
 11.3.3
 isochronous transfers, 8.5.5, 8.5.5 *Figure*
8-42, 8.5.5 *Figure 8-43*, 11.21 to
 11.21.4
 low-speed transactions, 8.6.5
 NAK handshake and, 8.4.5
 overview, 8.3.1 *Table 8-1*
 prebuffering data, 5.12.5
 scheduling IN transactions, 11.18.4
 split transaction conversion, 8.4.2.1
 split transaction examples, A.2, A.4, A.6
 STALL handshake and, 8.4.5
 start-split flow sequence, 11.20.1
 state machines, 8.5.2, 8.5.5, 11.17.2,
 11.20.2, 11.21.2
 token CRCs, 8.3.5.1
 token packets, 8.4.1
 Transaction Translator response
 generation, 11.18.5

SETUP PIDs

ACK handshake and, 8.4.5
 ADDR field, 8.3.2.1
 in control transfers, 8.5.3
 in data toggle, 8.6.1
 ENDP field, 8.3.2.2
 function response to SETUP
 transactions, 8.4.6.4
 overview, 8.3.1 *Table 8-1*
 token CRCs, 8.3.5.1
 in token packets, 8.4.1

SOF PIDs (See also SOFs)

frame number field, 8.3.3
 frames and microframes, 8.4.3.1
 overview, 8.3.1 *Table 8-1*
 start-of-frame packets, 8.4.3

PID to PID_invert bits check failure, 11.15

PING flow control protocol

high-speed signaling, 5.8.4
 high-speed signaling and, 5.5.4
 as limited to high-speed transactions, 8.5.1
 NAK limiting and, 8.5.1, 8.5.1.1
 NYET handshake and, 8.4.5
 PING PIDs, 8.3.1 *Table 8-1*, 8.3.2.2, 8.3.5.1,
 8.4.1, 8.4.5, 8.5.2, 8.5.3.1

- pins
 - dual pin-type receptacles, 6.9
 - inrush current and, 7.2.4.1
 - single pin-type receptacles, 6.9
- pipes
 - aborting or resetting, 10.5.2.2, 10.5.3.2.1
 - active, stalled, or idle status, 10.5.2.2
 - allocating bandwidth for, 4.7.5
 - characteristics and transfer types, 5.4
 - client pipes, 10.5.1.2.2
 - data transfer mechanisms, 10.1.3
 - Default Control Pipe, 4.4 (*See also* Default Control Pipe)
 - default pipes, 10.5.1.2.1
 - defined, 2.0 *glossary*, 4.4
 - in device characteristics, 4.8.1
 - identification, 10.3.4
 - overview, 5.3.2, 10.5.1, 10.5.3
 - pipe state control, 10.5.2.2
 - pipe usage, 10.5.1.2
 - Policies, 10.3.1, 10.3.3, 10.5.3.2.2
 - queuing IRPs, 10.5.3.2.3
 - role in data transfers, 4.7
 - service and polling intervals, 10.3.3
 - stream and message pipes, 4.4, 5.3.2, 5.3.2.1, 5.3.2.2
 - supported pipe types, 10.5.3.1 to 10.5.3.1.4
 - USB pipe mechanism responsibilities, 10.5.1 to 10.5.3.2.4
 - USB robustness and, 4.5
- pipe state control, 10.5.2.2
- pipe status, 10.5.2.2
- PK signal/event, 11.5 *Table 11-5*
- plating
 - plug contact materials, 6.5.4.3
 - plug shell materials, 6.5.4.2
 - receptacle contact materials, 6.5.3.3
 - receptacle shell materials, 6.5.3.2
- PLL, defined, 2.0 *glossary*
- plugs
 - DC resistance, 6.6.3
 - interface and mating drawings, 6.5.3
 - keyed connector protocol, 6.2
 - materials, 6.5.4.1, 6.5.4.2, 6.5.4.3
 - orientation, 6.5.1
 - Series "A" and Series "B" plugs, 6.5.4
 - standards for, 6.7
 - termination data, 6.5.2
 - USB Icon, 6.5, 6.5.1
- Policies
 - defined, 10.3.1
 - setting, 10.3.3
 - USB DI mechanisms, 10.5.3.2.2
- polling
 - defined, 2.0 *glossary*
 - endpoints, 9.6.6
 - setting intervals for pipes, 10.3.3
- polybutylene terephthalate (PBT), 6.5.3.1, 6.5.4.1
- polyethylene terephthalate (PET), 6.5.3.1, 6.5.4.1
- POR signal/event
 - Bus_Reset state and, 11.6.3.9
 - defined, 2.0 *glossary*
 - in receiver state machine, 11.6.3 *Table 11-8*
- Port Change field, 11.4.4, 11.24.2.7.2
- PORT_CONNECTION
 - defined, 11.24.2.7.1.1
 - hub class feature selectors, 11.24.2
 - Port Status field, 11.24.2.7.1
- PORT_ENABLE
 - clearing, 11.24.2.2
 - defined, 11.24.2.7.1.2
 - hub class feature selectors, 11.24.2
 - Port Error condition, 11.24.2.7.2.2
 - PORT_HIGH_SPEED and, 11.24.2.7.1.8
 - Port Status field, 11.24.2.7.1
- Port Error condition, 11.8.1, 11.24.2.7.2.2
- Port_Error signal/event, 11.5 *Table 11-5*
- Port field, 8.4.2.2
- PORT_HIGH_SPEED
 - Port Status field, 11.24.2.7.1
 - speed detection and, 11.8.2, 11.24.2.7.1.8
- PORT_INDICATOR
 - clearing port features, 11.24.2.2
 - getting indicator status, 11.24.2.7.1.10, 11.24.2.13
 - hub class feature selectors, 11.24.2
 - indicator selectors, 11.24.2.12
 - Port Status field, 11.24.2.7.1
- port indicators
 - descriptors, 11.23.2.1
 - lights on devices, 11.5.3 to 11.5.3.1
 - port status indicators, 11.24.2.7.1, 11.24.2.7.1.10
 - selectors, 11.24.2.12
- PORT_LOW_SPEED
 - defined, 11.24.2.7.1.7
 - hub class feature selectors, 11.24.2
 - Port Status field, 11.24.2.7.1
 - speed detection and, 11.8.2, 11.24.2.7.1.8
- PORT_OVER_CURRENT
 - defined, 11.24.2.7.1.4
 - hub class feature selectors, 11.24.2
 - over-current conditions and, 11.11.1, 11.12.5
 - port indicators, 11.24.2.7.1.10
 - Port Status field, 11.24.2.7.1

- PORT_POWER
 - clearing, 11.24.2.2
 - defined, 11.24.2.7.1.6
 - hub class feature selectors, 11.24.2
 - Port Status field, 11.24.2.7.1
 - SetPortFeature() request, 11.24.2.13
 - shared power switching and, 11.11.1
 - PortPwrCtrlMask field
 - hub descriptors for, 11.23.2.1
 - multiple gangs and, 11.11.1
 - power switching settings, 11.11
 - PORT_RESET
 - defined, 11.24.2.7.1.5
 - hub class feature selectors, 11.24.2
 - Port Status field, 11.24.2.7.1
 - SetPortFeature() request, 11.24.2.13
 - ports. *See also* hubs
 - in bus topology, 5.2.3
 - clearing features, 11.24.2.2
 - data source signaling, 7.1.13 to 7.1.13.2.2
 - defined, 4.8.2.1
 - disconnect timer, 11.5.2
 - downstream facing ports, 4.8.2.1, 11.5 to 11.5.1.15
 - full- vs. low-speed port behavior, 11.8.4
 - in hub architecture, 11.1.1
 - hub configuration and, 11.13
 - hub descriptors, 11.23 to 11.23.2.1
 - hub internal ports, 11.4 to 11.4.4
 - indicators, 11.5.3 to 11.5.3.1, 11.24.2.7.1, 11.24.2.7.1.10
 - indicator selectors, 11.24.2.12
 - input capacitance, 7.1.6.1
 - over-current reporting and recovery, 11.12.5
 - port expansion considerations in USB development, 1.1
 - port selector state machine, 11.7.1.4 to 11.7.1.4.4
 - power control, 11.11
 - resetting, 10.2.8.1
 - root ports, 2.0 *glossary*
 - setting port features, 11.24.2.13
 - signal speed support, 7
 - status
 - bus state evaluation, 11.8 to 11.8.4.1
 - detecting status changes, 7.1.7.5, 11.12.2, 11.12.3
 - hub and port status change bitmap, 11.12.4
 - port status bits, 11.24.2.7.1 to 11.24.2.7.2.5
 - testing mode, 11.24.2.7.1.9, 11.24.2.13
 - upstream facing ports, 4.8.2.1, 11.6 to 11.6.4.6
 - port selector state machine, 11.7.1.4 to 11.7.1.4.4
 - port status change bits, 11.24.2.7.1 to 11.24.2.7.2.5
 - Port Status field, 11.24.2.7.1
 - PORT_SUSPEND
 - clearing, 11.24.2.2
 - defined, 11.24.2.7.1.3
 - hub class feature selectors, 11.24.2
 - Port Status field, 11.24.2.7.1
 - SetPortFeature() request, 11.24.2.13
 - PORT_TEST
 - hub class feature selectors, 11.24.2
 - overview, 11.24.2.7.1.9
 - Port Status field, 11.24.2.7.1
 - specific test modes, 11.24.2.13
 - power budgeting, 7.2.1.4, 9.2.5.1
 - power conductors in cables, 6.3
 - power control circuits in bus-powered hubs, 7.2.1.1
 - power distribution and management. *See also* over-current conditions; power switching
 - classes of devices, 7.2.1 to 7.2.1.5
 - bus-powered devices or hubs, 4.3.1, 7.2.1.1
 - high-power bus-powered functions, 7.2.1.4
 - low-power bus-powered functions, 7.2.1.3
 - self-powered devices or hubs, 4.3.1, 7.2.1.2, 7.2.1.5
 - configuration characteristics
 - hub descriptors for power-on sequence, 11.23.2.1
 - information in device characteristics, 4.8.1
 - power consumption in configuration descriptors, 9.6.3
 - power source capability in configuration, 9.1.1.2
 - dynamic attach and detach, 7.2.3, 7.2.4 to 7.2.4.2
 - Host Controller role in, 4.9
 - host role in, 10.1.5
 - hub support for, 11.1
 - loss of power, 7.2.1.2
 - over-current conditions, 7.2.1.2.1, 11.12.5 (*See also* over-current conditions)
 - overview, 4.3.1, 4.3.2, 9.2.5
 - power budgeting, 7.2.1.4, 9.2.5.1
 - power status
 - control during suspend/resume, 7.2.3
 - device states, 9.1.1.2
 - port power states, 11.24.2.7.1.6, 11.24.2.13
 - power switching, 11.11, 11.11.1
 - remote wakeup, 7.2.3, 9.2.5.2
 - USB System role, 10.5.4.2
 - USB System Software role, 4.9
 - voltage drop budget, 7.2.2
- Powered device state, 9.1.1.2, 9.1.1 *Table 9-1*
 - Powered Off state, 11.5, 11.5.1.2
 - powered-on ports, 11.24.2.13
 - Power On Reset. *See* POR signal/event
 - power-on sequence, 11.23.2.1

- power pair construction, 6.6.2
 - power pins, 7.2.4.1
 - Power_source_off signal/event, 11.5 *Table 11-5*
 - power switching
 - bus-powered hubs, 7.2.1.1
 - getting port status, 11.24.2.7.1
 - hub descriptors for, 11.23.2.1
 - hub port power control, 11.11
 - power-on and connection events timing, 7.1.7.3
 - power switching gangs, 11.11.1
 - staged power switching, 7.2.1.4
 - preamble packet. *See* PRE PID
 - preambles, 8.6.5
 - preboot control, passing to operating systems, 10.5.5
 - prebuffering data, 5.12.5
 - prepared termination, 6.4.2, 6.4.3
 - PRE PID, 8.3.1 *Table 8-1*
 - inter-packet delays and, 7.1.18.1
 - low-speed port behavior and, 11.8.4
 - low-speed transactions, 8.6.5
 - overview, 8.3.1 *Table 8-1*
 - Transmit state and, 11.5.1.7
 - priming elasticity buffer, 11.7.1.3
 - Priming state, 11.7.1.4.2
 - product descriptions in device descriptors, 9.6.1
 - Product IDs in device descriptors, 9.6.1
 - programmable data rate, defined, 2.0 *glossary*
 - prohibited cable assemblies, 6.4.4
 - Promoters, USB Implementers Forum, 1.4, 2.0 *glossary*
 - propagation delay
 - cable delay, 7.1.16
 - detachable cables, 6.4.1
 - end-to-end signal delay, 7.1.19 to 7.1.19.2
 - EOF point advancement and, 11.2.3.2
 - full- and low-speed signals, 7.1.14.1
 - full-speed source electrical characteristics, 7.3.2 *Table 7-9*
 - high-/full-speed cables, 6.4.2
 - high-speed signaling, 7.1.1.3, 7.1.14.2
 - low-speed cables, 6.4.3, 7.1.1.2
 - low-speed source electrical characteristics, 7.3.2 *Table 7-10*
 - tests, 6.7 *Table 6-7*
 - propagation delay skew, 6.7 *Table 6-7*
 - protected fields in packets, 8.3.5
 - protocol codes
 - defined, 9.2.3
 - in device descriptors, 9.6.1
 - in device qualifier descriptors, 9.6.2
 - in interface descriptors, 9.6.5
 - protocol engine requirements of Host Controller, 10.2.5
 - protocol errors, detecting, 10.2.6
 - Protocol field, 9.2.3
 - Protocol layer, 8
 - bit ordering, 8.1
 - bus protocol, 4.4
 - data toggle synchronization and retry, 8.6 to 8.6.5
 - error detection and recovery, 8.7 to 8.7.4
 - packet field formats, 8.3 to 8.3.5.2
 - packet formats, 8.4 to 8.4.6.4
 - SYNC field, 8.2
 - transaction formats, 8.5 to 8.5.5
 - protocols
 - defined, 2.0 *glossary*
 - protocol codes, 9.2.3, 9.6.1, 9.6.2, 9.6.5
 - protocol stall, 8.4.5, 8.5.3.4
 - PS signal/event, 11.5 *Table 11-5*
 - pull-up and pull-down resistors
 - buffer impedance measurement, 7.1.1.1
 - high-speed signaling and, 7.1
 - power control during suspend/resume, 7.1.7.6, 7.2.3
 - signaling speeds and, 7.1 *Table 7-1*
 - signal termination, 7.1.5.1
- Q**
- quantization in high-speed microframe timer range, 11.2.1
 - queuing IRPs, 10.5.3.2.3
- R**
- RA (rate adaptation)
 - asynchronous RA, 2.0 *glossary*
 - audio connectivity and, 5.12.4.4.1
 - defined, 2.0 *glossary*
 - in source-to-sink connectivity, 5.12.4.4
 - synchronous data connectivity, 5.12.4.4.2
 - synchronous RA, 2.0 *glossary*
 - random vibration standards, 6.7 *Table 6-7*
 - rate adaptation. *See* RA (rate adaptation)
 - rate matchers
 - asynchronous endpoints, 5.12.4.1.1
 - buffering for rate matching, 5.12.8
 - client software role, 5.12.4.4
 - in non-USB isochronous application, 5.12.1
 - synchronous endpoints, 5.12.4.1.2
 - ratings, full-speed, 6.4.1, 6.4.2
 - read/write sequences
 - in bulk transfers, 8.5.2
 - in control transfers, 8.5.3, 8.5.3.1
 - Ready/ACK status, 11.15
 - Ready/Data status, 11.15
 - Ready/lastdata status, 11.15
 - Ready/moredata status, 11.15
 - Ready/NAK status, 11.15
 - Ready/Stall status, 11.15
 - Ready status, 11.15

- Ready/trans-err status, 11.15
- real-time clock, 5.12.1
- real-time data transfers. *See* isochronous transfers
- receive clock, 11.7.1.2, 11.7.1.3
- receiver eye pattern templates. *See* eye pattern templates
- receivers
 - differential data receivers, 7.1 *Table 7-1*
 - receive phase of signaling, 7.1.1
 - receiver characteristics, 7.1.4 to 7.1.4.2
 - receiver jitter, 7.1.15 to 7.1.15.2, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*, 7.3.3 *Figure 7-51*
 - receiver sequence bits, 8.6, 8.6.2
 - receiver state machine, 11.6, 11.6.3
 - sensitivity requirements, 7.1.2.2 *Figure 7-15*, 7.1.2.2 *Figure 7-16*, 7.1.2.2 *Figure 7-18*
 - single-ended receivers, 7.1 *Table 7-1*
 - snore detection, 7.1, 7.1.4.2
- ReceivingHJ state, 11.6.3.2
- ReceivingHK state, 11.6.3.5
- ReceivingIS state, 11.6.3.1
- ReceivingJ state, 11.6.3, 11.6.3.3
- ReceivingK state, 11.6.3, 11.6.3.6
- ReceivingSE0 state, 11.6.3, 11.6.3.8
- receptacles
 - interface and mating drawings, 6.5.3
 - keyed connector protocol, 6.2
 - materials, 6.5.3.1, 6.5.3.2, 6.5.3.3
 - PCB reference drawings, 6.9
 - Series "A" and Series "B" receptacles, 6.5.3
 - standards for, 6.7
 - termination data, 6.5.2
 - USB Icon, 6.5, 6.5.1
- Recipient bits, 9.4.5
- reclocking, defined, 11.7.1
- recovering from errors. *See* error detection and handling
- recovery intervals for devices, 9.2.6.2
- re-enumerating sub-trees, 10.5.4.5
- reflected endpoint status, 10.5.2.2
- registers in hub timing, 11.2.3.1
- regulators in bus-powered hubs, 7.2.1.1
- regulatory compliance, 7.0
- regulatory requirements for USB devices, 7.3.1
- reliable delivery in isochronous transfers, 5.12
- remote wakeup
 - in configuration descriptors, 9.6.3
 - Host Controller role, 10.2.7
 - inrush current and, 7.2.3
 - overview, 9.2.5.2
 - resume signaling, 7.1.7.7, 9.1.1.6
 - timing relationships, 11.9
 - USB System role in, 10.5.4.5
- Remote Wakeup field, 9.4.5
- removable devices, 11.23.2.1
- removing devices. *See* dynamic insertion and removal
- RepeatingSE0 state, 11.6.4, 11.6.4.3
- replacing configuration information, 10.5.4.1.3
- reporting rates for feedback, 5.12.4.2
- request codes, 9.4 *Table 9-4*, 11.24.2
- Request Errors, 9.2.7
- requests. *See also* PIDs; *names of specific requests*
 - bRequest field, 9.3.2
 - class-specific requests, 9.2.6.5, 10.5.2.8, 11.24 to 11.24.2.13
 - completion times for hub requests, 11.24.1
 - control transfers and, 5.5
 - defined, 2.0 *glossary*
 - in device class definitions, 9.7.3
 - hub standard and class-specific requests, 11.24 to 11.24.2.13
 - information requirements for, 10.3.4
 - overview, 9.2.6
 - port status reporting, 11.12.3
 - request processing timing, 9.2.6.1
 - reset/resume recovery time, 9.2.6.2
 - set address processing, 9.2.6.3
 - standard device requests, 9.2.6.4, 9.4 to 9.4.11
 - standard feature selectors, 9.4 *Table 9-6*
 - standard hub requests, 11.24 to 11.24.2.13
 - standard request codes, 9.4 *Table 9-4*
 - USB command mechanisms, 10.5.2 to 10.5.2.12
 - USB device requests, 9.3 to 9.3.5
 - vendor-specific requests, 10.5.2.9
- required data sequences for transfers, 5.4
- Reserved PID, 8.3.1 *Table 8-1*
- reserved portions of frames, 5.5.4
- Reserved test mode, 9.4.9
- Reset bus state
 - downstream ports, 11.5, 11.5.1.5
 - high- and full-speed operations, 5.3.1.1
 - high-speed detection and, 7.1.5.2
 - high-speed signaling and, 7.1.7.6
 - in power-on and connection events, 7.1.7.3
 - reset signaling, 7.1.7.5
 - signaling levels and, 7.1.7.1
- reset condition
 - in bus enumeration process, 9.1.2
 - C_PORT_RESET bit, 11.24.2.7.2.5
 - Default device state and, 9.1.1.3
 - device characteristics, 9.2.1
 - getting port status, 11.24.2.7.1
 - hub reset behavior, 11.10
 - PORT_RESET bit, 11.24.2.7.1.5
 - port status change bits, 11.24.2.7.2
 - remote wakeup and, 10.5.4.5
 - reset handshake, C.2.4

reset condition (*Continued*)
 reset recovery time, 7.1.7.5, 9.2.6.2
 reset signaling, 7.1.7.5
 resetting pipes, 10.5.2.2
 SetPortFeature(PORT_RESET) request,
 11.24.2.13
 state machine diagrams, C.0
 USB System and, 10.2.8.1
 reset devices, communicating with, 10.5.1.1
 reset handshake, C.2.4
 Resetting state, 11.5.1.5
 ResetTT() request, RESET_TT, 11.24.2,
 11.24.2.9
 resistance ratings, 6.6.3
 resistors
 high-speed signaling and, 7.1
 pull-up and pull-down resistors, 7.1.1.1,
 7.1.5.1, 7.1.7.6, 7.2.3
 series damping resistors, 7.1.1.1
 speed detection and, 9.1.1.3
 resonators, data-rate tolerance and, 7.1.11
 resource management, USB System role in,
 10.3.2
 Restart_E state, 11.5, 11.5.1.13
 Restart_S state, 11.5, 11.5.1.12
 Resume bus state
 downstream ports, 11.5, 11.5.1.10
 overview, 7.1.7.7
 receivers, 11.6.3, 11.6.3.7
 reset signaling and, 7.1.7.5
 signaling levels and, 7.1.7.1
 Resume_Event signal/event, 11.4
 resume intervals for devices, 9.2.6.2
 resume signaling
 after loss of synchronization, 11.22.2
 hub support, 11.1.2.2, 11.9
 power control during suspend/resume, 7.2.3
 remote wakeup and, 10.5.4.5
 resume conditions in Hub Controller, 11.4.4
 single-ended transmissions, 11.6.1
 retire, defined, 2.0 *glossary*
 retiring IRPs. *See* aborting/retiring transfers
 RFI, USB grounding and, 6.8
 rise and fall times
 data source jitter, 7.1.13.1.1
 full-speed connections, 7.1.1.1
 full-speed source electrical characteristics,
 7.3.2 *Table 7-9*
 high-speed signaling, 7.1.2.2
 high-speed source electrical characteristics,
 7.3.2 *Table 7-8*
 low-speed source electrical characteristics,
 7.3.2 *Table 7-10*
 overview, 7.1.2.1 to 7.1.2.2
 SE0 from low-speed devices, 7.1.14.1
 testing, 7.1.20

robustness of USB, 3.3, 4.5 to 4.5.2
 root hub
 in bus topology, 5.2.3
 defined, 2.0 *glossary*
 HCDI presentation of, 10.4
 Host Controller and, 10.2.8, 10.2.8.1
 state handling, 10.2.1
 root port hub, defined, 7.2.1
 root ports, 2.0 *glossary*, 11.9
 round trip times, 7.1.6.2
 Rptr_Enter_WFEOPFU signal/event, 11.5 *Table*
11-5
 Rptr_Exit_WFEOPFU signal/event, 11.5 *Table*
11-5
 Rptr_WFEOP signal/event, 11.6.4 *Table 11-9*
 Run timer status, C.0
 Rx_Bus_Reset signal/event, 11.6.4 *Table 11-9*,
 11.7.1.4 *Table 11-10*, 11.7.2.3 *Table 11-*
11
 Rx_Resume signal/event, 11.5 *Table 11-5*,
 11.7.2.3 *Table 11-11*
 Rx_Suspend signal/event, 11.4, 11.5 *Table 11-5*,
 11.6.4 *Table 11-9*, 11.7.2.3 *Table 11-11*

S

S field (Start), 8.4.2.2
 sample clock
 buffering for rate matching, 5.12.8
 defined, 5.12.2
 synchronous endpoints, 5.12.4.1.2
 sampled analog devices, 5.12.4
 sample declarations in state machines, B.1, B.2,
 B.3
 Sample Rate Conversion. *See* SRC
 samples
 defined, 2.0 *glossary*
 sample size in buffering calculations, 5.12.8
 samples per (micro)frame in isochronous
 transfers, 5.12.4.2
 SC field (Start/Complete field), 8.4.2.2, 8.4.2.3
 scheduling
 access to USB interconnect, 4.1
 host split transaction scheduling, 11.18.4
 microframe pipeline scheduling, 11.18.2
 periodic split transaction scheduling, 11.18
 transaction schedule in bus protocol overview,
 4.4
 Transaction Translator transaction scheduling,
 11.14.2 to 11.14.2.3
 SE0sent signal/event, 11.6.4 *Table 11-9*

- SE0 signal/event
 - in data signaling, 7.1.7.4.1
 - downstream port state machine, 11.5 *Table 11-5*
 - Not Configured state, 11.5.1.1
 - propagation delays, 7.1.14.1
 - pull-down resistors and, 7.1.7.3
 - receiver state machine, 11.6.3 *Table 11-8*
 - reset signaling, 7.1.7.5
 - SE0 interval of EOP, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
 - signaling levels and, 7.1.7.1
 - single-ended transmissions, 11.6.1
 - test mode, 7.1.20
- SE0 width, 7.1.13.2.1, 7.1.14.1, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
- SE1 signal/event, 7.1.1, 11.6.1
- selective resume signaling, 11.9
- selective suspend signaling
 - defined, 9.1.1.6
 - hub support, 11.9
 - overview, 7.1.7.6.2
- self-powered devices and functions
 - configuration descriptors, 9.6.3
 - defined, 4.3.1, 7.2.1
 - device states, 9.1.1.2
 - overview, 7.2.1.5
- Self Powered field, 9.4.5
- self-powered hubs
 - configuration, 11.13
 - defined, 7.2.1
 - device states, 9.1.1.2
 - over-current protection, 7.2.1.2.1
 - overview, 7.2.1.2
 - power switching, 11.11
- self-recovery, USB robustness and, 4.5
- SendEOR state, 11.5, 11.5.1.11
- SendJ state, 11.6.4, 11.6.4.4
- Send Resume state (Sresume), 11.6.4, 11.6.4.6
- sequence of transactions in frames, 5.11.2
- Serial Interface Engine (SIE), 10.1.1, 10.2.2
- serializer/deserializer, 10.2.2
- serial numbers in device descriptors, 9.6.1
- Series "A" and "B" connectors
 - detachable cables and, 6.4.1
 - keyed connector protocol, 6.2
 - plugs
 - injection molded thermoplastic insulator material, 6.5.4.1
 - interface drawings, 6.5.4
 - plug (male) contact materials, 6.5.4.3
 - plug shell materials, 6.5.4.2
- Series "A" and "B" connectors (*Continued*)
 - receptacles
 - injection molded thermoplastic insulator material, 6.5.3.1
 - interface and mating drawings, 6.5.3
 - PCB reference drawings, 6.9
 - receptacle contact materials, 6.5.3.3
 - receptacle shell materials, 6.5.3.2
 - standards for, 6.7
 - USB Icon, 6.5, 6.5.1
- series damping resistors, 7.1.1.1
- service, defined, 2.0 *glossary*
- service clock, 5.12.2, 5.12.8
- service intervals, 2.0 *glossary*, 10.3.3
- service jitter, defined, 2.0 *glossary*
- service periods of data, 5.12.1
- service rates, defined, 2.0 *glossary*
- SetAddress() request, SET_ADDRESS
 - hub requests, 11.24.1
 - overview, 9.4.6
 - reset recovery time and, 7.1.7.5
 - standard device request codes, 9.4
 - time limits for completing processing, 9.2.6.3
- SetConfiguration() request, SET_CONFIGURATION
 - hub requests, 11.24.1
 - overview, 9.4.7
 - Powered-off state and, 11.5.1.2
 - setting configuration in descriptors, 9.1.1.5, 9.6.3
 - standard device request codes, 9.4
- SetDescriptor() request, SET_DESCRIPTOR
 - getting endpoint descriptors, 9.6.6
 - hub class requests, 11.24.2
 - hub requests, 11.24.1
 - interface descriptors and, 9.6.5
 - overview, 9.4.8
 - SetHubDescriptor() request, 11.24.2.10
 - standard device request codes, 9.4
- SetDeviceFeature(DEVICE_REMOTE_WAKEUP) request, 10.5.4.5
- SetFeature() request, SET_FEATURE, 9.4.5, 9.4.9
 - hub class requests, 11.24.2
 - hub requests, 11.24.1
 - overview, 9.4.9
 - SetHubFeature() request, 11.24.2.12
 - SetPortFeature() request, 11.24.2.13
 - standard device request codes, 9.4
 - TEST_MODE, 7.1.20, 9.4.9
 - TEST_SELECTOR, 9.4.9

- SetHubDescriptor() request, 11.24.2, 11.24.2.10
- SetHubFeature() request, 11.24.2, 11.24.2.6, 11.24.2.12
- SetInterface() request, SET_INTERFACE, 9.2.3, 9.4, 9.4.10, 9.6.5, 11.24.1
- SetPortFeature() request
 - hub class requests, 11.24.2, 11.24.2.13
 - PORT_CONNECTION, 11.24.2.7.1.1
 - PORT_ENABLE, 11.24.2.7.1.2
 - PORT_HIGH_SPEED, 11.24.2.7.1.8
 - PORT_INDICATOR, 11.24.2.7.1.10, 11.24.2.12
 - PORT_LOW_SPEED, 11.24.2.7.1.7
 - PORT_OVER_CURRENT, 11.24.2.7.1.4
 - PORT_POWER
 - Disconnected state and, 11.5.1.3
 - port power settings, 11.11
 - port power states, 11.24.2.7.1.6, 11.24.2.13
 - requirements, 11.24.2.13
 - PORT_RESET
 - completion, 9.2.6
 - C_PORT_ENABLE bit, 11.24.2.7.2.2
 - evaluating device speed during, 11.8.2
 - initiating port reset, 11.24.2.7.1.5, 11.24.2.13
 - in port enabling, 11.24.2.7.1.2
 - requirements, 11.24.2.13
 - Resetting state and, 11.5.1.5
 - PORT_SUSPEND, 10.5.4.5
 - selective suspend, 7.1.7.6.2
 - suspending ports, 11.5.1.9, 11.24.2.7.1.3
 - PORT_TEST, 11.24.2.7.1.9, 11.24.2.13
 - power-off conditions and, 11.13
 - TEST_MODE, 7.1.20
- SetTest signal/event, 11.5 *Table 11-5*
- SETUP PID, 8.3.1 *Table 8-1*
 - ACK handshake and, 8.4.5
 - ADDR field, 8.3.2.1
 - in control transfers, 8.5.3
 - in data toggle, 8.6.1
 - ENDP field, 8.3.2.2
 - function response to, 8.4.6.4
 - overview, 8.3.1 *Table 8-1*
 - split transaction examples, A.1
 - token CRCs, 8.3.5.1
 - in token packets, 8.4.1
- Setup stage
 - in control transfer data sequences, 5.5.5
 - in control transfers, 5.5, 8.5.3
 - data format for USB device requests, 9.3
- SETUP transactions. *See* SETUP PID
- shell
 - conductors, 6.5.2
 - plug shell materials, 6.5.4.2
 - receptacle shell materials, 6.5.3.2
- shielding
 - grounding, 6.8
 - low-speed and high-/full-speed cables, 6.6
 - outer and inner cable shielding, 6.6.1
 - shielded cables illustrated, 6.4.1
 - standardized contact terminating assignments, 6.5.2
- short circuits, USB withstanding capabilities, 7.1.1
- short packets
 - defined, 9.4.3
 - detecting, 10.2.6
 - multiple data payloads and, 5.3.2
- SIE (Serial Interface Engine), 10.1.1, 10.2.2
- signal conductors in cables, 6.3
- signal edges. *See* edges of signals
- signaling
 - bit stuffing, 7.1.9 to 7.1.9.2
 - cable attenuation, 7.1.17
 - connect and disconnect signaling, 7.1.7.3
 - data encoding/decoding, 7.1.8
 - data rate, 7.1.11
 - data signaling, 7.1.7.4 to 7.1.7.4.2
 - delay
 - bus turn-around time and inter-packet delay, 7.1.18 to 7.1.18.2
 - cable delay, 7.1.16
 - cable skew delay, 7.1.3
 - maximum end-to-end signal delay, 7.1.19 to 7.1.19.2
 - high-speed driver characteristics, 7.1.1.3
 - hub signaling timings, 7.1.14 to 7.1.14.2
 - in-band and out-of-band, 10.1.2
 - input characteristics, 7.1.6.1
 - jitter, 7.1.13.1 to 7.1.13.1.2, 7.1.15 to 7.1.15.2 (*See also* jitter)
 - low-speed (1.5Mb/S) driver characteristics, 7.1.1.2
 - (micro)frame intervals and repeatability, 7.1.12
 - overview, 7.1
 - receiver characteristics, 7.1.4 to 7.1.4.2, 7.1.15.1
 - reset signaling, 7.1.7.5
 - resume signaling, 7.1.7.7
 - rise and fall time, 7.1.2.1 to 7.1.2.2
 - signal attenuation, 7.1.17
 - signal edges (*See* edges of signals)
 - signaling levels, 7.1.7 to 7.1.7.5
 - signal integrity, 4.5
 - signal termination, 7.1.5.1
 - source signaling, 7.1.13 to 7.1.13.2.2
 - suspend signaling, 7.1.7.6
 - sync pattern, 7.1.10
 - USB driver characteristics, 7.1.1

- signal matching, 7.1.2.1
- signal pair attenuation, 6.4.1, 6.7 *Table 6-7*
- signal pair construction, 6.6.2
- signal pins, 7.2.4.1
- signal swing, 7.1.2.1
- signal termination, 7.1, 7.1.5.1
- simple states, notation for, 11.15
- Single-ended 0 bus state (SEO)
 - in data signaling, 7.1.7.4.1
 - pull-down resistors and, 7.1.7.3
 - reset signaling, 7.1.7.5
 - signaling levels and, 7.1.7.1
 - test mode, 7.1.20
- single-ended capacitance, 7.1.1.2
- single-ended components in upstream ports, 11.6.1
- single-ended receivers, 7.1.4.1, 7.1.6.1, 7.1 *Table 7-1*
- "single packets" and split transactions, 5.12.3
- single pin-type receptacles, 6.9
- sink endpoints
 - adaptive sink endpoints, 5.12.4.1.3
 - audio connectivity, 5.12.4.4.1
 - connectivity overview, 5.12.4.4
 - feedback for isochronous transfers, 5.12.4.2
 - synchronization types, 5.12.4.1
 - synchronous data connectivity, 5.12.4.4.2
- skew
 - cable skew delay, 6.7 *Table 6-7*, 7.1.3, 7.3.2 *Table 7-12*
 - differential-to-EOP transition skew, 7.3.3 *Figure 7-50*
 - hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
 - hub/repeater electrical characteristics, 7.3.2 *Table 7-11*
 - hub switching skew, 7.1.9.1
 - Idle-to-K state transition, 7.1.14.1
 - minimizing signal skew, 7.1.1
 - timing skew accumulation, 11.2.5.1 to 11.2.5.2
- slips in synchronous data, 5.12.4.4.2
- small capacitors, 7.1.6.1
- SOF PID, 8.3.1 *Table 8-1*
 - frame number field, 8.3.3
 - frames and microframes, 8.4.3.1
 - start-of-frame packets, 8.4.3
- SOFs
 - after loss of synchronization, 11.22.2
 - bus clock and, 5.12.2
 - defined, 2.0 *glossary*
 - in downstream port state machine, 11.5
 - error recovery in isochronous transfers, 5.12.7
 - frame and microframe intervals, 7.1.12
- SOFs (*Continued*)
 - frame and microframe timer synchronization, 11.2, 11.2.3 to 11.2.3.3
 - frame clock tracking and microframe SOFs, 5.12.4.1.2
 - high-speed SOF in connect detection, 7.1.7.3
 - Host Controller frame and microframe generation, 10.2.3
 - loss of consecutive SOFs, 11.2.5
 - loss of TT synchronization, 11.22.1
 - microframe synchronization and, 11.2.4
 - overview, 8.4.3
 - tracking, 5.12.6, 5.12.7
 - using as clocks, 5.12.5
- soft-start circuits, 7.2.4.1
- software interfaces. *See* client software; HCDI; host; USBDI; USB System software
- SOHP, 11.7.2.1
- solderability standards, 6.7 *Table 6-7*
- solder tails, 6.5.3.3, 6.5.4.3
- SOP bus state, 7.1.7.1, 7.1.7.2, 7.1.7.4.1, 7.1.7.4.2
- SOP_FD signal/event
 - generating, 11.4.4
 - in Hub Repeater state machine, 11.7.2.3 *Table 11-11*
- SOP_FU signal/event, 11.7.2.3 *Table 11-11*
- SOPs, 8.3
 - error detection through bus turn-around timing, 8.7.2
 - frame and microframe timer synchronization, 11.2.3 to 11.2.3.3
 - Idle-to-K state transition, 7.1.14.1
 - SOP distortion, 7.3.3 *Figure 7-52*
 - timeout periods and, 7.1.19.1
- SORP signal/event, 11.7.1.4 *Table 11-10*
- source endpoints
 - adaptive source endpoints, 5.12.4.1.3
 - audio connectivity, 5.12.4.4.1
 - connectivity overview, 5.12.4.4
 - feedback for isochronous transfers, 5.12.4.2
 - synchronization types, 5.12.4.1
 - synchronous data connectivity, 5.12.4.4.2
- source jitter, 7.3.2 *Table 7-8*, 7.3.2 *Table 7-9*, 7.3.2 *Table 7-10*
- source/sink connectivity, 5.12.4.4
- special PIDs
 - ERR PID, 8.3.1 *Table 8-1*, 8.4.5
 - PING PID, 8.3.1 *Table 8-1*, 8.3.2.2, 8.3.5.1, 8.4.1, 8.4.5, 8.5.2, 8.5.3.1

special PIDs (*Continued*)

- PRE PID
 - defined, 8.3.1 *Table 8-1*
 - inter-packet delays and, 7.1.18.1
 - low-speed port behavior and, 11.8.4
 - low-speed transactions, 8.6.5
 - Transmit state and, 11.5.1.7
- Reserved PID, 8.3.1 *Table 8-1*
- SPLIT PID, 8.3.1 *Table 8-1*, 8.3.2.1, 8.3.5.1, 8.4.2 to 8.4.2.3
- specific-sized data payloads, 5.3.2
- speed
 - downstream facing ports and hubs, 7.1
 - high-speed devices operating at full-speed, 5.3.1.1
 - hubs and signaling speeds, 11.1.1
 - measurement planes in speed signaling eye patterns, 7.1.2.2
 - pull-up and pull-down resistors and, 7.1 *Table 7-1*
 - speed dependent descriptors, 9.2.6.6
 - upstream facing ports and hubs, 7.1
- speed detection
 - attached devices, 11.8.2
 - detecting low-speed functions and hubs, 11.24.2.7.1.7
 - detecting speed of devices, 7.1.7.3
 - other_speed_configuration descriptor, 9.6.4
 - PORT_HIGH_SPEED, 11.24.2.7.1.8
 - reset condition and Default device state, 9.1.1.3
 - speed indication bits, 7.1.5.2
 - termination and, 7.1.5.1
- SPI, defined, 2.0 *glossary*
- SPLIT PID, 8.3.1 *Table 8-1*, 8.3.2.1, 8.3.5.1, 8.4.2 to 8.4.2.3
- splitting sample across packets, 5.12.8
- split transactions. *See also* complete-split transactions; start-split transactions
 - best case full-speed budgets, 11.18.1, 11.18.4
 - bulk/control transactions
 - control transfers, 5.5.4
 - IN examples, A.2
 - OUT and SETUP examples, A.1
 - sequencing, 11.17.3
 - state machines, 11.17.2
 - data handling, 11.14.1.1
 - data packet types, 8.4.4
 - defined, 2.0 *glossary*, 5.10
 - failures, 11.17.5
 - host controller and, 11.14.1.2
 - host scheduling, 11.18.4

split transactions (*Continued*)

- IN transactions
 - bulk/control examples, A.2
 - interrupt examples, A.4
 - interrupt transaction sequencing, 11.20.4
 - isochronous examples, A.6
 - isochronous transaction sequencing, 11.21.4
- interrupt transactions
 - IN examples, A.4
 - flow sequences and state machines, 11.20 to 11.20.4
 - OUT examples, A.3
- isochronous transactions
 - IN examples, A.6
 - OUT examples, A.5
 - overview, 11.21 to 11.21.4
- microframe pipeline, 11.18.2
- non-periodic transactions
 - IN examples, A.2
 - OUT and SETUP examples, A.1
 - overview, 11.17 to 11.17.5
 - sequencing, 11.17.3
 - state machines, 11.17.2
- notation for, 11.15
- OUT transactions
 - bulk/control examples, A.1
 - interrupt examples, A.3
 - interrupt sequencing, 11.20.3
 - isochronous examples, A.5
 - isochronous sequencing, 11.21.3
- periodic transactions
 - interrupt IN examples, A.4
 - interrupt OUT examples, A.3
 - interrupt transaction state machines, 11.20 to 11.20.4
 - isochronous IN examples, A.6
 - isochronous OUT examples, A.5
 - isochronous transaction state machines, 11.21 to 11.21.4
 - overview, 11.18 to 11.18.8
- SETUP transactions, A.1
- "single packets" and, 5.12.3
- state machines
 - bulk/control state machines, 11.17.2
 - interrupt state machines, 11.20 to 11.20.4
 - isochronous transaction state machines, 11.21 to 11.21.4
 - overview, 11.16
 - split transaction state machines, 8.5
- token packets, 8.4.2 to 8.4.2.3
- Transaction Translator, 11.1.1, 11.14.1

- squelch circuit, 7.1.20, 11.7.1.1
 - squelch detection
 - error detection and, 8.7.3, 8.7.4
 - turn-around timing and, 8.7.2
 - Squelch signal/event, 11.7.1.4 *Table 11-10*
 - Squelch state, 7.1, 7.1.4.2, 7.1.7.2
 - SRC
 - asynchronous SRC, 2.0 *glossary*
 - audio connectivity and, 5.12.4.4.1
 - defined, 2.0 *glossary*
 - synchronous SRC, 2.0 *glossary*
 - Sresume state, 11.6.4, 11.6.4.6
 - SSPLIT. *See* start-split transactions (SSPLIT)
 - staged power switching, 7.2.1.4
 - stages in control transfers, defined, 2.0 *glossary*, 5.5. *See also* Data stage; Setup stage; Status stage
 - STALLs, 8.3.1 *Table 8-1*
 - in bulk transfers, 5.8.5, 8.5.2, 11.17.1
 - in control transfers, 8.5.3.1, 11.17.1
 - data corrupted or not accepted, 8.6.3
 - functional and commanded stalls, 8.4.5
 - function response to IN transactions, 8.4.6.1
 - function response to OUT transactions, 8.4.6.3
 - in interrupt transfers, 5.7.5, 8.5.4, 11.20.4
 - overview, 8.4.5
 - protocol stalls, 8.4.5
 - Ready/Stall status, 11.15
 - Request Error responses, 9.2.7
 - responses to standard device requests, 9.4
 - returned by control pipes, 8.5.3.4
 - standard device information, 4.8.1
 - standard device requests, 9.2.6.4, 9.4 to 9.4.11, 11.24.1
 - standards (applicable documents), 6.7.1
 - standard USB descriptor definitions, 9.6.1 to 9.6.5
 - Start/Complete field (SC), 8.4.2.2
 - Started timer status, C.0
 - Start field (S), 8.4.2.2
 - Start-of-Frame. *See* SOFs
 - Start of High-speed Packet (HSSOP), 7.1.7.2, 7.1.7.4.2
 - Start-of-Packet. *See* SOPs
 - Start-of-Packet bus state (SOP), 7.1.7.1, 7.1.7.2, 7.1.7.4.1, 7.1.7.4.2
 - start-of-packet delimiter. *See* SOPs
 - star topology, 5.2.3
 - start-split transactions (SSPLIT)
 - after loss of synchronication, 11.22.2
 - buffering, 11.14.2.1, 11.14.2.2, 11.14.2.3, 11.17
 - bulk/control split transactions, 11.17, 11.17.1
 - defined, 8.4.2, 11.14.1.2
 - freeing pending transactions, 11.18.6.2
 - start-split transactions (*Continued*)
 - isochronous transactions, 11.21
 - notation for, 11.15
 - overview, 11.14.1
 - scheduling, 11.14.2.1, 11.14.2.2, 11.14.2.3, 11.18.4
 - split transaction overview, 8.4.2.1
 - SSPLIT token, 8.4.2.2
 - tracking, 11.18.7
 - state handling. *See* bus states; status
 - state machines. *See also* names of specific state machines under Dev_, HC_, and TT_
 - actions in, 8.5, 11.15
 - bulk/control transaction state machines, 8.5.2, 11.17.2
 - conditions in, 8.5
 - device state machines, 8.5, 8.5.2, 8.5.5
 - diamond symbols in, 8.5, 11.15
 - downstream facing port state machines, 11.5
 - endpoint state machines, 8.5
 - example declarations, B.1, B.2, B.3
 - Host Controller state machines, 8.5, 11.16 to 11.16.1.1.2, 11.17.2, 11.20.2, 11.21.2
 - host state machines, 8.5.1, 8.5.2, 8.5.5
 - Hub Repeater state machine, 11.2.3.3, 11.7.2, 11.7.2.3 *Table 11-11*
 - Hub state machine, 11.1.1
 - initial states in, 8.5
 - input transitions in, 8.5
 - internal port state machine, 11.4
 - interrupt transaction state machines, 8.5.2, 8.5.2 *Figure 8-33*, 8.5.2 *Figure 8-34*, 11.20 to 11.20.4
 - isochronous transaction state machines, 8.5.5 *Figure 8-42*, 8.5.5 *Figure 8-43*, 11.21.2
 - notation in, 8.5, 11.15
 - output transitions in, 8.5
 - over-sampling state machine DLLs, 7.1.15.1
 - overview, 8.5
 - port indicator colors, 11.5.3
 - port selector state machine, 11.7.1.4 to 11.7.1.4.4
 - receiver state machine, 11.6, 11.6.3 *Table 11-8*
 - reset protocol diagrams, C.0
 - resetting TT state machines, 11.24.2.9
 - split transaction state machine overview, 11.16
 - state hierarchy, 8.5
 - states defined, 8.5
 - Transaction Translator state machines, 11.16, 11.16.2 to 11.16.2.1.7, 11.24.2.9
 - transitions in, 8.5
 - transmitter state machine, 11.6, 11.6.4, 11.6.4.2, 11.6.4 *Table 11-9*
 - static output swing of USB, 7.1.1

- status. *See also* status change bits
 - device states, 10.5.2.7, 11.12.2
 - Host Controller role in, 4.9
 - host's role in monitoring status and activity, 10.1.4
 - hub and port status change bitmap, 11.12.4
 - hub and port status changes, 7.1.7.5, 11.12.6
 - hub status, 11.24.2.6
 - notification of completion status, 10.3.4
 - port change information processing, 11.12.3
 - port indicators, 11.5.3 to 11.5.3.1
 - port status change bits, 11.24.2.7.2 to 11.24.2.7.2.5
 - USB D event notifications, 10.5.4.3
 - USB D status reporting and error recovery, 10.5.4.4
- status change bits. *See also* Status Change endpoint
 - detecting changes, 11.12.2
 - device states, 11.12.2
 - hub and port status change bitmap, 11.12.4
 - hub status, 11.24.2.6
 - over-current status change bits, 11.12.5
 - port status change bits, 11.24.2.7.2 to 11.24.2.7.2.5
- Status Change endpoint
 - defined, 11.12.1
 - device states and, 11.12.2
 - hub and port status change bitmap, 11.12.4
 - hub configuration and, 11.13
 - hub descriptors, 11.23.1
- Status stage
 - in control transfers, 5.5, 5.5.5, 8.5.3
 - reporting status results, 8.5.3.1
- StopTT() request, STOP_TT
 - hub class requests, 11.24.2
 - overview, 11.24.2.11
- storage temperatures for cables, 6.6.4
- stranded tinned conductors, 6.6.2
- streaming real time transfers. *See* isochronous transfers
- stream pipes
 - bulk transfers and, 5.8.2
 - in bus protocol overview, 4.4
 - defined, 2.0 *glossary*, 5.3.2
 - interrupt transfers and, 5.7.2
 - isochronous transfers and, 5.6.2
 - overview, 5.3.2.1
- STRING descriptor, 9.4 *Table 9-5*
- string descriptors
 - GetDescriptor() request, 9.4.3
 - as optional, 9.5
 - overview, 9.6.7
- stuffed bits. *See* bit stuffing
- subclasses
 - device_qualifier descriptor codes, 9.6.2
 - device subclass codes, 9.2.3, 9.6.1
 - interface subclass codes, 9.2.3, 9.6.5
- SubClass field, 9.2.3
- substrate materials
 - plug contact materials, 6.5.4.3
 - plug shell materials, 6.5.4.2
 - receptacle contact materials, 6.5.3.3
 - receptacle shell materials, 6.5.3.2
- subtree devices after wakeup, 10.5.4.5
- successful transfers, 8.6.2, 10.3.4
- supply current, 7.3.2 *Table 7-7*
- supply voltage
 - DC electrical characteristics, 7.3.2 *Table 7-7*
 - oscillators, 7.1.11
- surge limiting, 7.2.4.1
- Suspend bus state
 - global suspend, 7.1.7.6.1
 - overview, 7.1.7.6
 - power control during suspend/resume, 7.2.3
 - reset signaling, 7.1.7.5
 - resume signaling, 7.1.7.7
 - selective suspend, 7.1.7.6.2
- Suspend Delay state, 11.4, 11.4.2
- suspended devices
 - global suspend, 7.1.7.6.1
 - hub support for suspend signaling, 11.9
 - power control during suspend/resume, 7.2.3
 - power-on and connection events, 7.1.7.3
 - remote wakeup, 9.2.5.2, 10.2.7, 10.5.4.5
 - reset state machines, C.2.1
 - resume signaling, 7.1.7.7
 - selective suspend, 7.1.7.6.2
 - single-ended transmissions, 11.6.1
 - Suspend bus state, 7.1.7.6
 - Suspended device state, 9.1.1.6
- suspended hubs
 - hub reset behavior, 11.10
 - resume signaling and, 11.1.2.2
- suspended ports
 - C_PORT_SUSPEND, 11.24.2.7.2.3
 - getting port status, 11.24.2.7.1
 - port status change bits, 11.24.2.7.2
 - PORT_SUSPEND, 11.24.2.7.1.3, 11.24.2.13
- Suspended state, 9.1.1.6, 9.1.1 *Table 9-1*, 11.5, 11.5.1.9. *See also* Suspend bus state; Suspend state
- suspend sequencing, 11.22.2
- Suspend state, 11.6.3, 11.6.3.4
- switching thresholds for single-ended receivers, 7.1.4.1

- SYNC field
 - in data signaling, 7.1.7.4.1
 - in electrical specifications overview, 4.2.1
 - high-speed signaling and, 7.1
 - overview, 8.2
 - squelch detection and, 11.7.1.1
 - SynchFrame() request, SYNCH_FRAME, 9.4, 9.4.11, 11.24.1
 - synchronization. *See also* synchronization types
 - clock synchronization, 5.12.3
 - data-per-time synchronization, 5.12.7
 - data toggle synchronization, 8.4.4, 8.6 to 8.6.5
 - endpoint synchronization frame, 9.4.11
 - frame and microframe timer synchronization, 11.2, 11.2.3 to 11.2.3.3
 - jitter, 2.0 *glossary* (*See also* jitter)
 - physical and virtual devices, 5.12.4.4
 - SYNC field, 8.2
 - sync pattern, 7.1.10
 - Transaction Translator loss of synchronization, 11.18.6, 11.22.1
 - transmitter and receiver synchronization in isochronous transfers, 5.12
 - synchronization types
 - adaptive, 5.12.4.1.3
 - asynchronous, 5.12.4.1.1
 - defined, 2.0 *glossary*, 5.12.4
 - endpoints and, 9.6.6
 - overview, 5.12.4.1
 - synchronous, 5.12.4.1.2
 - synchronous data connectivity, 5.12.4.4.2
 - synchronous data devices, 5.12.4
 - synchronous endpoints, 5.12.4.1.2, 5.12.4.4
 - synchronous RA, 2.0 *glossary*, 5.12.4.4
 - synchronous SRC, 2.0 *glossary*
 - sync pattern, 7.1.7.4.2, 7.1.9, 7.1.10
 - system configuration. *See* configuration
 - System Programming Interface, defined, 2.0 *glossary*
 - system software. *See* USB System Software
- T**
- TDM, defined, 2.0 *glossary*
 - TDR loading specification, 2.0 *glossary*, 7.1.6.2
 - telephone interconnects, 1.1
 - temperature
 - data-rate inaccuracies and, 7.1.11
 - ranges for cables, 6.6.4
 - templates. *See* receiver eye pattern templates
 - termination
 - blunt cut and prepared termination, 6.4.2, 6.4.3
 - DC electrical characteristics, 7.3.2 *Table 7-7*
 - defined, 2.0 *glossary*
 - detachable cable assemblies, 6.4.1
 - electrical specifications overview, 4.2.1
 - termination (*Continued*)
 - high-/full-speed captive cable assemblies, 6.4.2
 - low-speed captive cable assemblies, 6.4.3
 - signal termination, 7.1, 7.1.5.1
 - USB topology rules, 6.4.4
 - termination data, 6.5.2
 - Termination Impedance, 7.1.6.2
 - test criteria for electrical, mechanical and environmental compliance, 6.7
 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances*, 6.7.1
 - Testing state, 11.5.1.14
 - Test_J test mode, 7.1.20, 9.4.9, 11.24.2.13
 - Test_K test mode, 7.1.20, 9.4.9, 11.24.2.13
 - test mode, 7.1.20, 9.4.9, 11.24.2.7.1.9, 11.24.2.13
 - TEST_MODE, 7.1.20, 9.4.9, 9.4 *Table 9-6*
 - Test_Packet test mode, 7.1.20, 9.4.9, 11.24.2.13
 - test planes in high-speed signaling, 7.1.2.2
 - Test_SE0_NAK test mode, 7.1.20, 9.4.9, 11.24.2.13
 - TEST_SELECTOR, 9.4.9
 - thermal shock standards, 6.7 *Table 6-7*
 - Thevenin resistance, 7.1.5.1
 - "think time," 11.18.2, 11.23.2.1
 - "three strikes and you're out" mechanism, 11.17.1
 - Through Impedance, 7.1.6.2
 - tiered topology
 - EOF point advancement and, 11.2.3.2
 - tiered star topology, 5.2.3
 - tiers in bus typology, 4.1.1
 - Time Division Multiplexing (TDM), 2.0 *glossary*
 - Time Domain Reflectometer loading specification, 2.0 *glossary*, 7.1.6.2
 - timed states
 - Disconnected state, 11.5.1.3
 - Resuming state, 11.5.1.10
 - timeout
 - bus transaction timeout, 5.12.7
 - defined, 2.0 *glossary*
 - detecting timeout conditions, 10.2.6
 - high bandwidth transactions and, 5.9.1
 - split transaction flow sequences, 11.18.8
 - timeout intervals in error detection, 8.7.2, 8.7.3
 - timeouts, 11.15, 11.17.1
 - timing. *See also* cable delay; propagation delay; skew; synchronization; timing waveforms
 - bus timing/electrical characteristics, 7.3.2
 - bus transaction time calculations, 5.11.3
 - bus turn-around timing, 8.7.2
 - clock model, 5.12.2
 - clock synchronization, 5.12.3
 - completion times for hub requests, 11.24.1

timing (*Continued*)

- current frame timer, 11.2.3.1
- data source signaling, 7.1.13 to 7.1.13.2.2
- device event timings, 7.3.2 *Table 7-14*
- frame and microframe intervals, 7.1.12
- frame and microframe timers, 11.2.3 to 11.2.3.3
- hub event timings, 7.3.2 *Table 7-13*
- hub frame timer, 11.2 to 11.2.5.2
- hub signaling timings, 7.1.14 to 7.1.14.2
- isochronous transfer feedback, 5.12.4.2
- isochronous transfer importance, 5.12
- low, full, and high-speed turn-around timing, 8.7.2
- next frame timer, 11.2.3.1
- in non-USB isochronous application, 5.12.1
- port disconnect timer, 11.5.2
- power-on and connection events timing, 7.1.7.3
- remote wakeup timing relationships, 11.9
- request processing timing, 9.2.6.1
- Resetting state and Resuming state intervals, 11.5.1.10
- Run, Clear, and Started timer status, C.0
- SE0 for EOP width timing, 7.1.13.2.1
- skew accumulating between host and hub, 11.2.5.1 to 11.2.5.2
- SOF PID timing information, 8.4.3
- SOF tokens as clocks, 5.12.5
- synchronization types, 5.12.4.1
- timing waveforms, 7.3.3
 - differential data jitter, 7.3.3 *Figure 7-49*
 - differential-to-EOP transition skew and EOP width, 7.3.3 *Figure 7-50*
 - hub differential delay, differential jitter, and SOP distortion, 7.3.3 *Figure 7-52*
 - hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
 - receiver jitter tolerance, 7.3.3 *Figure 7-51*
- toggle mode. *See* data toggle
- toggle sequencing, 8.5.5
- token packets
 - in bulk transfers, 8.5.2
 - bus protocol overview, 4.4
 - CRCs, 8.3.5.1
 - defined, 2.0 *glossary*
 - in isochronous transfers, 8.5.5
 - overview, 8.4.1
 - packet field formats, 8.3 to 8.3.5.2
 - split transaction token packets, 8.4.2 to 8.4.2.3
- token phases, notation for, 11.15
- token PIDs, 8.3.1 *Table 8-1*. *See also* IN PID; OUT PID; SETUP PID; SOF PID

topology

- bus topology, 4.1, 4.1.1, 5.2 to 5.2.5
- EOF point advancement and, 11.2.3.2
- hub tiers defined, 2.0 *glossary*
- trace delays, 7.1.14.2
- tracking transactions, 11.18.7
- transaction completion prediction, 11.3.3
- transaction list
 - defined, 5.11.1.4
 - HCD role in, 5.11.1.3
 - Host Controller and, 5.11.1.5
- transactions. *See also specific types of transactions*
 - aborting, 11.18.6, 11.18.6.1
 - allocating bandwidth for, 5.11.1 to 5.11.1.5, 10.3.2
 - buffer size calculations, 5.11.4
 - bus protocol overview, 4.4
 - defined, 2.0 *glossary*
 - error detection and recovery, 8.7 to 8.7.4
 - maximum allowable transactions per microframe, 5.4.1, 11.18.6.3
 - multiple transactions in microframes, 5.9, 5.9.2
 - organization within IRPs, 5.11.2
 - packet sequences, 8.5
 - pending, 11.18.6
 - PING flow control protocol and, 5.5.4
 - scheduling, 4.4, 11.14.2 to 11.14.2.3
 - split transactions, 5.5.4, 8.4.2 to 8.4.2.3, A.1, A.2, A.3, A.4
 - state machine overview, 8.5
 - timeout, 5.12.7
 - tracking transactions, 5.11.2
 - transaction completion prediction, 11.3.3
 - transaction formats
 - bulk transfers, 5.8.4, 8.5.2, A.1, A.2
 - control transfers, 5.5.4, 8.5.3 to 8.5.3.4, A.1, A.2
 - IN transactions, A.2, A.4, A.6
 - interrupt transfers, 8.5.4, A.3, A.4
 - isochronous transfers, 5.6.3, 5.12.6, 5.12.7, 8.5.5, A.5, A.6
 - non-periodic transactions, 11.17 to 11.17.5
 - OUT transactions, A.1, A.3, A.5
 - overview, 8.5
 - periodic and non-periodic transactions, 11.14.1, 11.18 to 11.18.8, 11.22.1
 - SETUP transactions, A.1
 - transaction list, 5.11.1.3, 5.11.1.4, 5.11.1.5
 - transaction time calculations, 5.11.3
 - Transaction Translator, 4.8.2.1, 11.18.7

- Transaction Translator
 - aborting transactions, 11.18.6.1
 - buffers
 - buffer space required, 11.17.4, 11.19
 - clearing buffers, 11.17.5, 11.24.2.3
 - periodic and non-periodic buffer sections, 11.14.1
 - complete-split state searching, 11.18.8
 - data handling, 11.14.1.1
 - defined, 2.0 *glossary*, 4.8.2.1, 11.1
 - delay in bus times, 5.11.3
 - error handling, 11.22
 - frame and microframe jitter, 11.2.4
 - freeing pending start-splits, 11.18.6.2
 - full-speed frame generation, 11.18.3
 - GET_TT_STATE, 11.24.2.8
 - host controller and, 11.14.1.2
 - hub architecture and, 11.1.1
 - hub class descriptors and, 11.23.1
 - loss of synchronization, 11.18.6, 11.22.1
 - low-speed signaling, 8.6.5
 - microframe pipelines and, 11.18.2
 - multiple TTs, 11.14.1.3, 11.23.1, 11.24.2.8
 - resetting, 11.24.2.9
 - response generation, 11.18.5
 - scheduling, 11.14.2 to 11.14.2.3
 - split transaction notation, 11.15
 - state machines
 - bulk/control state machines, 11.17.2
 - declarations, B.3
 - interrupt transaction state machines, 11.20.2
 - isochronous transaction state machines, 11.21.2
 - overview, 11.16, 11.16.2 to 11.16.2.1.7
 - stopping normal execution, 11.24.2.11
 - "think time," 11.18.2, 11.23.2.1
 - in transactions
 - bulk/control transactions, 11.17.2, 11.17.4
 - interrupt transactions, 11.20.2
 - isochronous transactions, 11.21.2, 11.21 to 11.21.4
 - non-periodic transactions, 11.17 to 11.17.5
 - periodic transactions, 11.18 to 11.18.8, 11.22.1
 - transaction tracking, 11.18.7
- transceivers
 - downstream facing ports and hubs, 7.1.4.2, 7.1.7.1
 - full- and high-speed signaling, 7.1, 7.1.1.1
 - lumped capacitance guidelines for transceivers, 7.1.6.2
 - transfer management, 5.11.1 to 5.11.1.5
 - allocating bandwidth, overview, 4.7.5, 5.11.1.1
 - client software, 5.11.1.1
 - HCD, 5.11.1.3
 - Host Controller, 5.11.1.5
 - illustrated, 5.11.1
 - transaction list, 5.11.1.4
 - USB driver, 5.11.1.2
 - USB System, 10.3.2
 - transfers, 5.0. *See also* transactions; *names of specific transfer types (i.e., bulk transfers)*
 - bulk transfers, 2.0 *glossary*, 4.7.2, 5.8 to 5.8.5, 8.5.2
 - bus access for transfers, 5.11 to 5.11.5
 - bus bandwidth reclamation, 5.11.5
 - calculating buffer sizes in functions and software, 5.11.4
 - calculating bus transaction times, 5.11.3
 - transaction tracking, 5.11.2
 - transfer management, 5.11.1 to 5.11.1.5
 - bus protocol overview, 4.4
 - bus topology, 5.2 to 5.2.5
 - communication flow, 4.1, 5.3 to 5.3.3
 - control transfers, 4.7.1, 5.5 to 5.5.5, 8.5.2, 8.5.3 to 8.5.3.4
 - data prebuffering, 5.12.5
 - data signaling overview, 7.1.7.4 to 7.1.7.4.2
 - defined, 2.0 *glossary*
 - error detection and recovery, 8.7 to 8.7.4
 - frames and microframes, 5.3.3
 - high-bandwidth transfers, 5.9.1, 5.9.2
 - high-speed transfer rates in 2.0, 1.1
 - Host Controller responsibilities, 4.9, 10.1.3
 - hub connectivity and, 11.1.2.1
 - implementer viewpoints, 5.1
 - interrupt transfers, 2.0 *glossary*, 4.7, 4.7.3, 5.7 to 5.7.5, 5.9.1, 8.5.2, 8.5.4
 - isochronous transfers, 2.0 *glossary*, 4.7.4, 5.6 to 5.6.5, 5.9.2, 5.12 to 5.12.8, 8.5.5
 - operations overview, 9.2.4
 - organization of transactions within frames, 5.11.2
 - overview, 5.0
 - periodic transfers, 5.6.4, 5.7.4
 - power management, 9.2.5
 - request processing, 9.2.6 to 9.2.6.6
 - standard device requests, 9.4 to 9.4.11
 - time limits for completing, 9.2.6.4, 9.2.6.5
 - transaction formats, 8.5 to 8.5.5
 - transfer types, 4.7 to 4.7.5, 5.4 to 5.8.5
 - USB device requests, 9.3 to 9.3.5
 - USB role in, 10.1.1, 10.5.3 to 10.5.3.2.3
 - USB System role in, 10.3.3

transfer types. *See also* transactions; transfers; *names of specific transfer types (i.e., bulk transfers)*
 allocating USB bandwidth, 4.7.5
 bulk transfers, 2.0 *glossary*, 4.7.2, 5.8
 in calculating transaction times, 5.11.3
 control transfers, 4.7.1, 5.5
 endpoint field indicators, 9.6.6
 high-bandwidth transfers, 5.9.1, 5.9.2
 interrupt transfers, 2.0 *glossary*, 4.7.3, 5.7
 isochronous transfers, 2.0 *glossary*, 4.7.4, 5.6
 for message pipes, 5.3.2.2
 overview, 4.7 to 4.7.5, 5.4
 pipes and, 4.4
 split transactions and, 5.10
 for stream pipes, 5.3.2.1
 transfer types defined, 2.0 *glossary*
 transitions in state machines, 8.5, 11.15
 transmission envelope detectors, 7.1.4.2, 7.1
 Table 7-1
 transmit clock, 11.7.1.3
 transmit eye patterns, 7.1, 7.1.2
 transmit phase of signaling, 7.1.1
 TransmitR state, 11.5.1.8
 Transmit state, 11.5, 11.5.1.7
 Transmitter/Receiver Test Fixture, 7.1.2.2 *Figure 7-12*
 transmitters
 Active state, 11.6.4.2
 Generate End of Packet Towards Upstream Port state (GEOPTU), 11.6.4.5
 Inactive state, 11.6.4.1
 RepeatingSE0 state, 11.6.4.3
 SendJ state, 11.6.4.4
 Send Resume state (Sresume), 11.6.4.6
 transmitter data jitter, 7.1.13.1.1
 transmitter sequence bits, 8.6, 8.6.2
 transmitter state descriptions, 11.6.4
 transmitter state machine, 11.6, 11.6.4
 transmitter state machine, 11.6, 11.6.4
 transmit waveform requirements, 7.1.2.2 *Figure 7-13*, 7.1.2.2 *Figure 7-14*, 7.1.2.2 *Figure 7-17*
 TrueRWU signal/event, 11.5 *Figure 11-10*, 11.5
 Table 11-5
 truncated packets, 11.3.2
 TT. *See* Transaction Translator
 TT_BulkCS state machine, 11.16.2.1.4
 TT_BulkSS state machine, 11.16.2.1.3
 TT_Do_BICS state machine, 11.17.2
 TT_Do_BISS state machine, 11.17.2
 TT_Do_BOCS state machine, 11.17.2
 TT_Do_BOSS state machine, 11.17.2
 TT_Do_complete state machine, 11.16.2.1.2
 TT_Do_IntlCS state machine, 11.20.2
 TT_Do_IntlSS state machine, 11.20.2

TT_Do_IntOCS state machine, 11.20.2
 TT_Do_IntOSS state machine, 11.20.2
 TT_Do_IsochISS state machine, 11.21.2
 TT_Do_IsochOSS state machine, 11.21.2
 TT_Do_Start state machine, 11.16.2.1.1
 TT_Flags bits, 11.24.2.8
 TT_IntCS state machine, 11.16.2.1.6
 TT_IntSS state machine, 11.16.2.1.5
 TT_IsochlCS state machine, 11.21.2
 TT_IsochSS state machine, 11.16.2.1.7
 TT_Process_Packet state machine, 11.16.2.1
 TT_Return_Flags field, 11.24.2.8
 TT_specific_state field, 11.24.2.8
 turn-around times
 defined, 2.0 *glossary*
 error detection, 8.7.2
 overview, 7.1.18 to 7.1.18.2
 turning power on for ports, 11.11
 twisted data pair in cables, 6.6.1
 Tx_active signal/event, 11.6.3 *Table 11-8*
 Tx_resume signal/event, 11.6.3 *Table 11-8*

U

UEOP signal/event, 11.7.2.3 *Table 11-11*
 UL listing for cables, 6.6.5
 UL STD-94, 6.7.1
 UL Subject-444, 6.6.5, 6.7.1
 unacceptable cables, 6.4.4
 underplating
 plug contact materials, 6.5.4.3
 plug shell materials, 6.5.4.2
 receptacle contact materials, 6.5.3.3
 receptacle shell materials, 6.5.3.2
 Underwriter's Laboratory, Inc., 6.6.5, 6.7.1
 The Unicode Standard, *Worldwide Character Encoding*, 9.6.7
 UNICODE string descriptors, 9.6.7
 unique addresses
 assigning after dynamic insertion or removal, 4.6.3
 device initialization, 10.5.1.1
 operations overview, 9.2.2
 SetAddress() request, 9.4.6
 time limits for completing addressing, 9.2.6.3
 Universal Serial Bus
 architectural extensions, 4.10
 backwards compatibility, 3.1
 bus protocol, 4.4
 clock model, 5.12, 5.12.2
 components, 5.1
 configuration, 4.6 to 4.6.3, 10.3.1
 data flow and transfers, 4.7 to 4.7.5, 5.1 to 5.10.8
 description, 4.1 to 4.1.1.2
 feature list, 3.3
 goals, 3.1

- Universal Serial Bus (*Continued*)
 - high-speed applications, 3.2
 - host hardware and software, 4.9, 10.2 to 10.6
 - hubs, 11.1 to 11.16
 - mechanical and electrical specifications, 6.1 to 6.9, 7.1 to 7.1.20, 7.3 to 7.3.3
 - motivation for development, 1.1
 - physical interface, 4.2 to 4.2.2
 - power distribution, 4.3 to 4.3.2, 7.2 to 7.2.4.2
 - protocol layer, 8.1 to 8.7
 - range of USB data traffic workloads, 3.2
 - robustness and error detection/recovery, 4.5 to 4.5.2
 - USB device framework, 9.1 to 9.7.3
 - USB devices, 4.8 to 4.8.2.2
 - USB schedule, 4.1
- Universal Serial Bus Driver. *See* USB (USB Driver)
- Universal Serial Bus Resources, 2.0 *glossary*
- up counters in hub timing, 11.2.3.1
- upgrade paths, 3.3
- upstream facing ports and hubs
 - defined, 4.8.2.1
 - driver speed and, 7.1.2.3
 - full-speed port transceiver, 7.1, 7.1.7.1
 - high-speed detection, 7.1.5.2
 - high-speed signaling and, 11.1.1
 - hub architecture, 11.1.1
 - hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
 - input capacitance, 7.1.6.1
 - jitter, 7.3.2 *Table 7-10*
 - low-speed source electrical characteristics, 7.3.2 *Table 7-10*
 - receivers, 11.6.3 to 11.6.3.9
 - reset on upstream port, 11.10
 - reset state machines, C.2
 - signaling delays, 7.1.14.1
 - signaling speeds and, 7.1
 - test mode support, 7.1.20
 - transmitters, 11.6 to 11.6.4.6
 - upstream connectivity defined, 11.1.2.1
 - upstream defined, 2.0 *glossary*
 - upstream hub delay, 7.3.3 *Figure 7-52*
- upstream facing transceivers, signaling speeds and, 7, 7.1
- upstream packets (HSU2), 8.5
- upstream plugs, 6.2
- Usage Types, 9.6.6
- USB. *See* Universal Serial Bus
- USB 2.0 Adopters Agreement, 1.4
- USB Bus Interface layer
 - in bus topology, 5.2.2
 - detailed communication flow illustrated, 5.3
 - Host Controller implementation, 10.1.1
 - illustrated, 5.1
 - interlayer communications model, 10.1.1
- USB (USB Driver). *See also* USB (USB Driver Interface)
 - in bus topology, 5.2.1
 - command mechanisms, 10.5.1 to 10.5.2.12
 - as component of USB System, 10.1.1
 - configuration and, 10.3.1
 - control mechanisms, 10.1.2
 - data transfer mechanisms, 10.1.3
 - defined, 2.0 *glossary*, 5.3, 10.5
 - driver characteristics, 7.1.1
 - driver speed and, 7.1.2.3
 - full-and low-speed drivers, 7.1.1.1, 7.1.1.2
 - HCD interaction with, 10.4
 - hub drivers, 10.3.1
 - initialization, 10.5.1.1
 - overview, 10.5.1
 - passing preboot control to operating system, 10.5.5
 - pipe mechanisms, 5.11.1.2, 10.5.1 to 10.5.3.2.4
 - request data format mechanisms, 10.3.4
 - service capabilities, 10.5.1.3
 - software interface overview, 10.3
 - in transfer management, 5.11.1, 5.11.1.2
 - USB System and, 10.5.4 to 10.5.4.5
- USB device framework, 9, 9.7.2
 - descriptors, 9.5 to 9.7.3
 - device class definitions, 9.7 to 9.7.3
 - generic USB device operations, 9.2 to 9.2.7
 - address assignment, 9.2.2
 - configuration, 9.2.3
 - data transfer, 9.2.4
 - dynamic attachment and removal, 9.2.1
 - power management, 9.2.5
 - request error, 9.2.7
 - request processing, 9.2.6 to 9.2.6.6
 - standard descriptor definitions, 9.6 to 9.6.7
 - standard device requests, 9.4 to 9.4.11
 - USB device requests, 9.3 to 9.3.5
 - USB device states, 9.1 to 9.1.2
- USB Device layer
 - detailed communication flow illustrated, 5.3
 - illustrated, 5.1
 - interlayer communications model, 10.1.1
- USB devices. *See* devices

USBDI (USB Driver Interface)
 adding devices, 10.5.2.5
 alternate interface mechanisms, 10.5.2.10
 getting descriptors, 10.5.2.3
 removing devices, 10.5.2.6
 role in request data format, 10.3.4
 sending class commands, 10.5.2.8
 sending vendor commands, 10.5.2.9
 setting descriptors, 10.5.2.12
 software interface overview, 10.3

USB host. *See* host

USB host controller. *See* Host Controller

USB Icon, 6.5, 6.5.1

USB-IF (USB Implementers Forum, Inc.), 1.4, 2.0 *glossary*

USB Implementers Forum, 1.4, 2.0 *glossary*

USB interconnect model, 4.1, 5.12.4.4

USB Logical Devices. *See* logical devices

USB Physical Devices. *See* physical devices

USB schedule, 4.1

USB Specification Release Number, 9.6.1

USB System. *See also* HCD; host software; USB D

- allocating bandwidth, 10.3.2
- buffers and, 10.2.9
- data transfer role, 10.3.3
- HCD component, 10.1.1
- Host Controller interaction, 10.1.1
- host software component, 10.1.1
- power management, 10.5.4.2
- remote wakeup, 10.2.7, 10.5.4.5
- software interface overview, 10.3
- state handling, 10.2.1
- status and activity monitoring, 10.1.4
- USB D component, 10.1.1

USB System Software

- asynchronous data transfers, 4.9
- bus enumeration, 4.9
- in bus topology, 5.2.1
- in communication flow, 5.3
- detecting hub and port status changes, 11.12.2
- as implementation focus area, 5.1
- interrupt transfer support, 5.7.3
- isochronous transfer support, 4.9
- power management, 4.9
- role, 4.9

V

variable-length data stages, 8.5.3.2

variable-sized data payloads, 5.3.2

VBus leads

- bypassing, 7.2.4.1
- cable electrical characteristics, 7.3.2 *Table 7-12*
- detachable cables, 6.4.1

VBus leads (*Continued*)

- in electrical specifications overview, 4.2.1
- high-/full-speed captive cable assemblies, 6.4.2
- low-speed captive cable assemblies, 6.4.3
- standardized contact terminating assignments, 6.5.2
- upstream port power supply and, 7.2.1

Vendor IDs in device descriptors, 9.6.1

vendor information in device characteristics, 4.8.1

vendor-specific descriptors, 9.5

vendor-specific requests, 10.5.2.9

version numbers in device descriptors, 9.6.1

version numbers in device_qualifier descriptor, 9.6.2

VHDL syntax, 11.15

V/I characteristics of full-speed connections, 7.1.1.1

virtual devices, 2.0 *glossary*, 5.12.4.4

visible device states, 9.1.1

visual inspection standards, 6.7 *Table 6-7*

voltage

- average voltage on D+/D- lines, 7.1.2.1
- cross-over voltage in signaling, 7.1.2.1
- DC output voltage specifications, 7.1.6.2
- droop, 7.2.3, 7.2.4.1
- flyback voltage, 7.2.4.2
- full-speed connections, 7.1.1.1
- high-speed signaling and, 7.1
- open-circuit voltage, 7.1.1
- ratings for cables, 6.6.3
- reduction due to cable resistive effects, 7.2.3
- reversing in high-speed signaling, 7.1.1.3
- supply voltage, 7.3.2 *Table 7-7*
- test mode, 7.1.20
- voltage drop budget, 7.2.2
- voltage drops, 7.2.1.1
- voltage drop topology, 7.2.2
- zero impedance voltage sources, 7.1.1

W

Wait for End of Packet from Upstream Port state (WFEOPFU), 11.7.2.3 *Figure 11-16*, 11.7.4

Wait for End of Packet (WFEO) state, 11.7.2.3 *Figure 11-16*, 11.7.6

Wait for Start of Packet from Upstream Port state (WFSOPFU), 11.7.2.3 *Figure 11-16*, 11.7.3

Wait for Start of Packet (WFSOP) state, 11.7.2.3 *Figure 11-16*, 11.7.5

wander, defined, 11.2.5.2

waveforms

- differential data jitter, 7.3.3 *Figure 7-49*
- differential-to-EOP transition skew and EOP width, 7.3.3 *Figure 7-50*
- full-speed driver signal waveforms, 7.1.1.1
- hub differential delay, differential jitter, and SOP distortion, 7.3.3 *Figure 7-52*
- hub EOP delay and EOP skew, 7.3.3 *Figure 7-53*
- maximum input waveforms for signaling, 7.1.1
- receiver jitter tolerance, 7.3.3 *Figure 7-51*
- testing, 7.1.20
- WFEOPFU state, 11.5.1.6, 11.7.2.3 *Figure 11-16*, 11.7.4
- WFEOP state, 11.7.2.3 *Figure 11-16*, 11.7.6
- WFSOPFU state, 11.7.2.3 *Figure 11-16*, 11.7.3
- WFSOP state, 11.7.2.3 *Figure 11-16*, 11.7.5
- wHubChange* field, 11.24.2.6
- wHubCharacteristics* field
 - hub descriptor, 11.23.2.1
 - multiple gangs and, 11.11.1
 - over-current reporting, 11.12.5
 - port indicator status, 11.5.3
 - power switching settings, 11.11
- wHubStatus* field, 11.24.2.6
- wIndex* field
 - hub class requests, 11.24.2
 - overview, 9.3.4
 - Setup data format, 9.3
 - standard device requests, 9.4
- wire gauge in cables, 6.6.2
- wire insulation in cables, 6.6.2
- wiring assignments for conductors, 6.5.2
- wLANGID[]* field (string descriptors), 9.6.7

wLength field

- hub class requests, 11.24.2
- overview, 9.3.5
- Setup data format, 9.3
- standard device requests, 9.4
- wMaxPacketSize* field
 - bulk transfers and, 5.8.3
 - control transfer packet size, 5.5.3
 - endpoint descriptors, 9.6.6, 11.23.1
 - high bandwidth endpoints and, 5.9
 - interrupt transfer packet size, 5.7.3
 - variable-length data stages, 8.5.3.2
- words, defined, 2.0 *glossary*
- working space, location and length of, 10.3.4
- worst-case bit stuffing, 5.11.3
- worst-case signal delay, 7.1.17.1, 7.1.17.2
- wPortChange* field, 11.24.2.7, 11.24.2.7.2
- wPortStatus* field, 11.24.2.7, 11.24.2.7.1
- wTotalLength* field
 - configuration descriptors, 9.6.3, 11.23.1
 - other speed configuration descriptors, 9.6.4, 11.23.1
- wValue* field
 - hub class requests, 11.24.2
 - overview, 9.3.3
 - Setup data format, 9.3
 - standard device requests, 9.4

Z

- zero impedance voltage sources, 7.1.1
- zeroth microframe, 9.4.11, 11.14.2.3, 11.18.3, 11.22.2

