SCSI Bus

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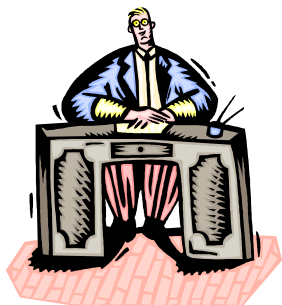
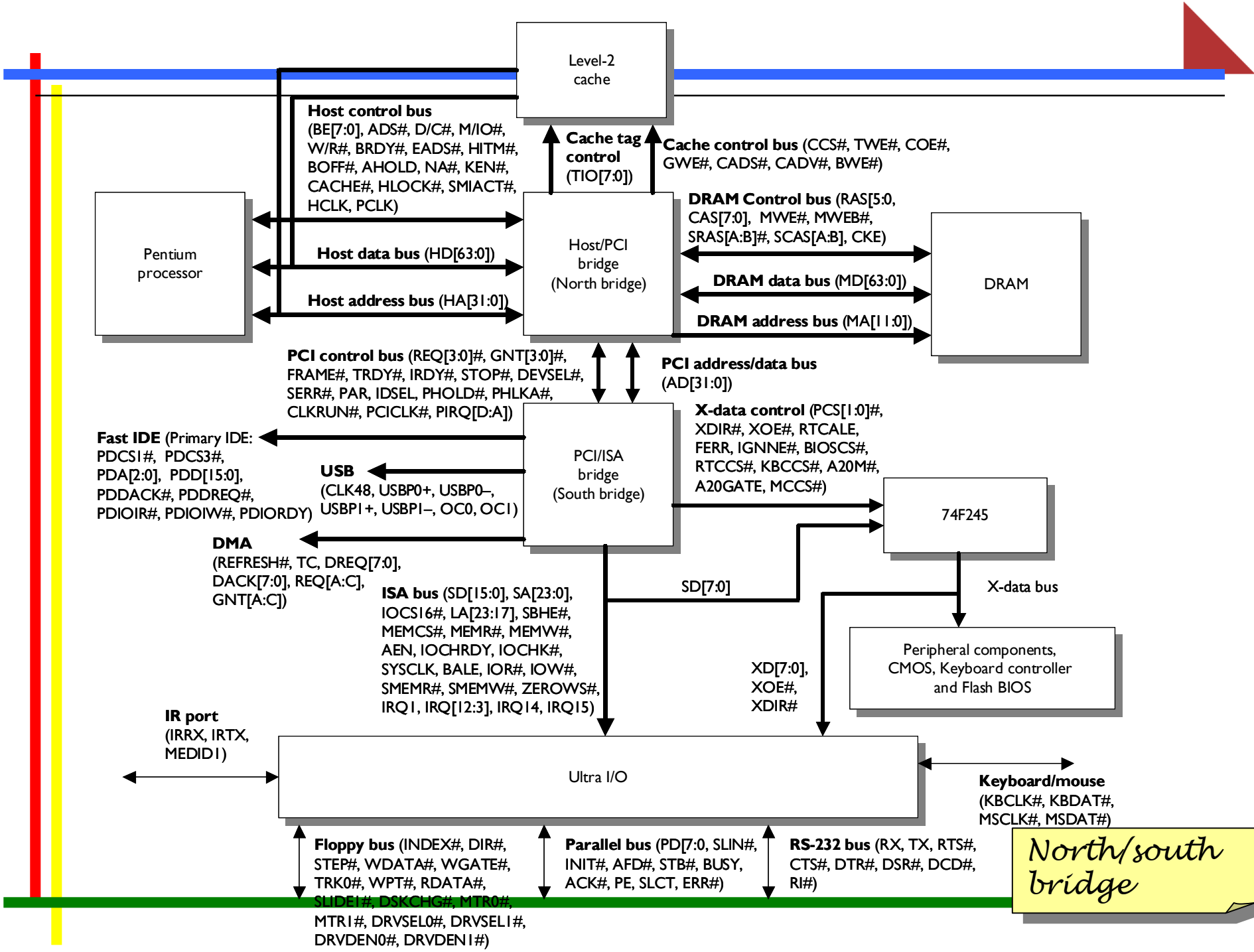
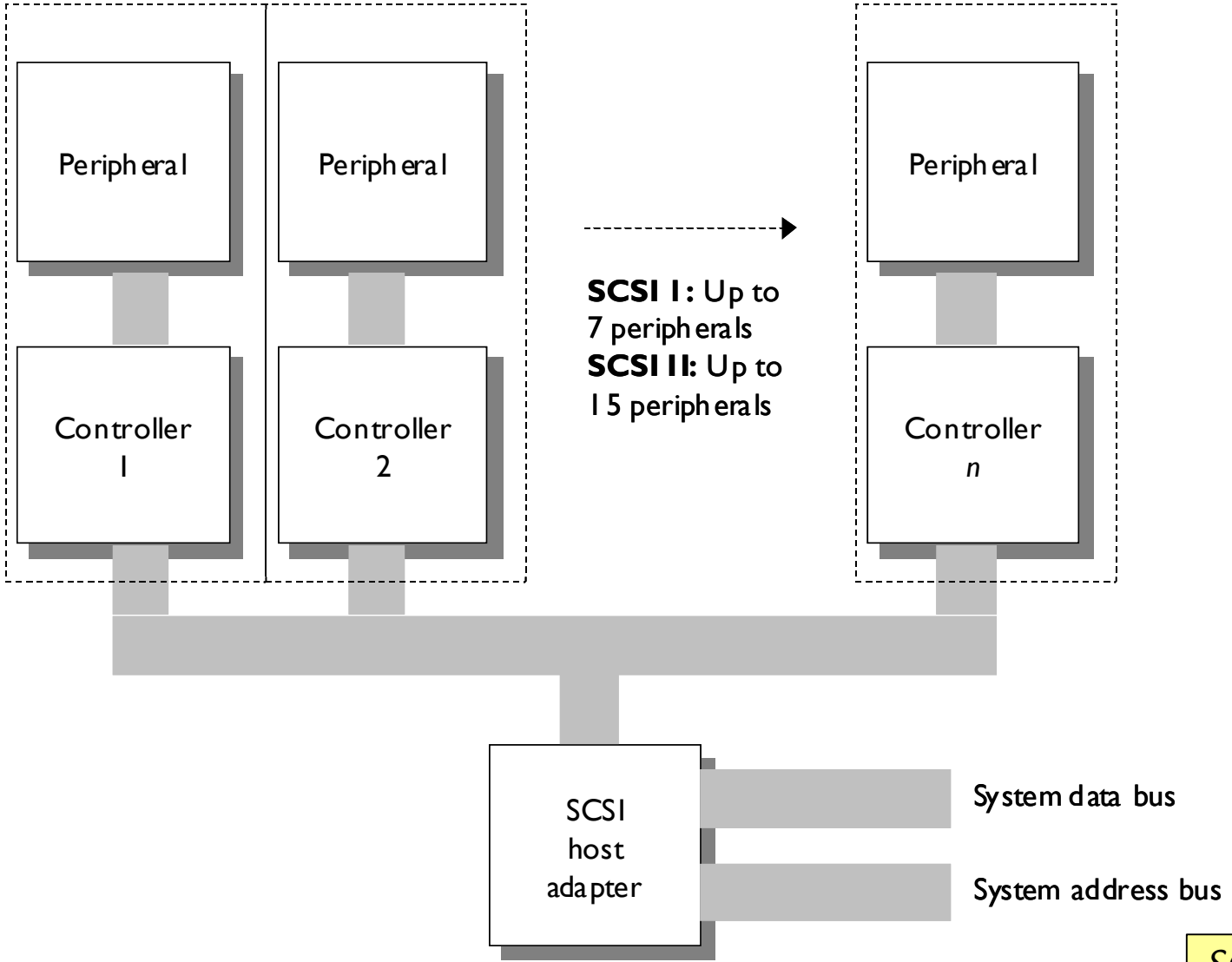



Level-2 cache
Host control bus (BE[7:0], ADS#, D/C#, M/IO#, W/R#, BRDY#, EADS#, HITM#, BOFF#, AHOLD, NA#, KEN#, CACHE#, HLOCK#, SMIACT#, HCLK, PCLK)
Cache tag control (TIO[7:0])
Cache control bus (CCS#, TWE#, COE#, GWE#, CADS#, CADV#, BWE#)
Pentium processor
Host data bus (HD[63:0])
Host address bus (HA[31:0])
Host/PCI bridge (North bridge)
DRAM Control bus (RAS[5:0, CAS[7:0], MWE#, MWEB#, SRAS[A:B]#, SCAS[A:B], CKE)
DRAM data bus (MD[63:0])
DRAM address bus (MA[11:0])
DRAM
PCI control bus (REQ[3:0]#, GNT[3:0]#, FRAME#, TRDY#, IRDY#, STOP#, DEVSEL#, SERR#, PAR, IDSEL, PHOLD#, PHLKA#, CLKRUN#, PCICLK#, PIRQ[D:A])
PCI address/data bus (AD[31:0])
Fast IDE (Primary IDE: PDCS1#, PDCS3#, PDA[2:0], PDD[15:0], PDDACK#, PDDREQ#, PDIOIR#, PDIOIW#, PDIORDY)
USB (CLK48, USBP0+, USBP0–, USBP1+, USBP1–, OC0, OC1)
DMA (REFRESH#, TC, DREQ[7:0], DACK[7:0], REQ[A:C], GNT[A:C])
PCI/ISA bridge (South bridge)
X-data control (PCS[1:0]#, XDIR#, XOE#, RTCALE, FERR, IGNNE#, BIOSCS#, RTCCS#, KBCCS#, A20M#, A20GATE, MCCS#)
74F245
SD[7:0]
X-data bus
ISA bus (SD[15:0], SA[23:0], IOCS16#, LA[23:17], SBHE#, MEMCS#, MEMR#, MEMW#, AEN, IOCHRDY, IOCHK#, SYSCLK, BALE, IOR#, IOW#, SMEMR#, SMEMW#, ZEROWS#, IRQ1, IRQ[12:3], IRQ14, IRQ15)
Peripheral components, CMOS, Keyboard controller and Flash BIOS
XD[7:0], XOE#, XDIR#
IR port (IRRX, IRTX, MEDID1)
Ultra I/O
Keyboard/mouse (KBCLK#, KBDAT#, MSCLK#, MSDAT#)
Floppy bus (INDEX#, DIR#, STEP#, WDATA#, WGATE#, TRK0#, WPT#, RDATA#, SLIDE1#, DSKCHG#, MTR0#, MTR1#, DRVSEL0#, DRVSEL1#, DRVDEN0#, DRVDEN1#)
Parallel bus (PD[7:0, SLIN#, INIT#, AFD#, STB#, BUSY, ACK#, PE, SLCT, ERR#)
RS-232 bus (RX, TX, RTS#, CTS#, DTR#, DSR#, DCD#, RI#)
North/south bridge


Peripheral
Peripheral
Peripheral
Controller 1
Controller 2
Controller n
SCSI 1: Up to 7 peripherals
SCSI II: Up to 15 peripherals
SCSI host adapter
System data bus
System address bus

SCSI

- A single bus system for up to seven connected devices (with SCSI-I).
- It supports many different peripherals, such as hard disks, tape drives, CD-ROMs, and so on.
- It supports device priority where a higher SCSI-ID has priority over a lower SCSI-ID.
- It supports both high-quality connectors and cables, and low-quality connection and ribbon cable.
- It supports differential signals, which gives longer cable lengths.
- Extended support for commands and messaging.
- Devices do not need individual IRQ lines (as they do in IDE) as the controller communicates with the devices.
- It has great potential for faster transfer and enhanced peripheral support.

SCSI

1. **SCSI-I.** Transfer rate of 5MB/s with an 8-bit data bus and seven devices per controller.
2. **SCSI-II.** Support for SCSI-1 and with one or more of the following:
   - Fast SCSI, which uses a synchronous transfer to give 10MB/s transfer rate. The initiator and target initially negotiate to see if they can both support synchronous transfer. If they can they, then go into a synchronous transfer mode.
   - Fast/wide SCSI-2, which doubles the data bus width to 16 bits to give 20 MB/s transfer rate.
   - 15 devices per master device.
   - Tagged command queuing (TCQ), which greatly improves performance and is supported by Windows, NetWare and OS/2.
   - Multiple commands sent to each device.
   - Commands executed in whatever sequence will maximize device performance.
3. **Ultra SCSI** (SCSI-III). Operates either as 8-bit or 16-bit with either 20MB/s or 40MB/s transfer rate.

SCSI types

	Seek time (ms)	*Latency* (ms)	*Rotational speed* (rpm)	*Sustained data read* (MB/s)	*PFA*	*ADR*
1 GB SCSI-II fast	10.5	5.56	5400	4	✓	✓
4.5 GB SCSI-II fast/ wide	8.2	4.17	7200	12	✓	✓

SCSI-II disk

	Data bus (bits)	*Transfer rate* (MB/s)	*Tagged command queuing*	*Parity checking*	*Maximum devices*	*Pins on cable and connector*
SCSI-I	8	5	×	×/✓ (optional)	7	50
SCSI-II fast	8	10 (10MHz)	✓	✓	7	50
SCSI-II fast/ wide	16	20 (10MHz)	✓	✓	15	68
Ultra SCSI	16	40 (20MHz)	✓	✓	15	68

SCSI types

	Single-ended cable				Differential cable			
Pin	*Signal*	*Pin*	*Signal*	*Pin*	*Signal*	*Pin*	*Signal*
1	GND	2	$\overline{D0}$	1	GND	2	GND
3	GND	4	$\overline{D1}$	3	+$\overline{D0}$	4	–$\overline{D0}$
5	GND	6	$\overline{D2}$	5	+$\overline{D1}$	6	–$\overline{D1}$
7	GND	8	$\overline{D3}$	6	+$\overline{D2}$	8	–$\overline{D2}$
9	GND	10	$\overline{D4}$	8	+$\overline{D3}$	10	–$\overline{D3}$
11	GND	12	$\overline{D5}$	11	+$\overline{D4}$	12	–$\overline{D4}$
13	GND	14	$\overline{D6}$	13	+$\overline{D5}$	14	–$\overline{D5}$
15	GND	16	$\overline{D7}$	15	+$\overline{D6}$	16	–$\overline{D6}$
17	GND	18	$\overline{D(PARITY)}$	17	+$\overline{D7}$	18	–$\overline{D7}$
19	GND	20	GND	19	D(PARITY)	20	–$\overline{D(PARITY)}$
21	GND	22	GND	21	DIFFSEN	22	GND
23	RESERVED	24	RESERVED	23	RESERVED	24	RESERVED
25	Open	26	TERMPWR	25	TERMPWR	26	TEMPWR
27	RESERVED	28	RESERVED	27	RESERVED	28	RESERVED
29	GND	30	GND	29	+$\overline{ATN}$	30	–$\overline{ATN}$
31	GND	32	$\overline{ATN}$	31	GND	32	GND
33	GND	34	GND	33	+ $\overline{RST}$	34	– $\overline{RST}$
35	GND	36	$\overline{BSY}$	35	+$\overline{ACK}$	36	–$\overline{ACK}$
37	GND	38	$\overline{ACK}$	37	+ $\overline{RST}$	38	– $\overline{RST}$
39	GND	40	$\overline{RST}$	39	+$\overline{MSG}$	40	–$\overline{MSG}$
41	GND	42	$\overline{MSG}$	41	+ $\overline{SEL}$	42	– $\overline{SEL}$
43	GND	44	$\overline{SEL}$	43	+$\overline{C}$ /D	44	–$\overline{C}$ /D
45	GND	46	$\overline{C}$ /D	45	+ $\overline{REQ}$	46	– $\overline{REQ}$
47	GND	48	$\overline{REQ}$	47	+$\overline{I}$ /O	48	–$\overline{I}$ /O
49	GND	50	$\overline{I}$ /O	49	GND	50	GND

SCSI signals

- A SCSI bus is made up of a SCSI host adapter connected to a number of SCSI units via a SCSI bus. As all units connect to a common bus, only **two units can transfer data at a time**, either from one SCSI unit to another or from one SCSI unit to the SCSI host. The great advantage of this transfer is that is does not involve the processor.
- Each unit on a SCSI is assigned a **SCSI ID address**. In the case of SCSI-I, this ranges from 0 to 7 (where 7 is normally reserved for a tape drive). The host adapter takes one of the addresses, thus a maximum of seven units can connect to the bus.
- Most systems allow the units to take on any **SCSI ID address**. When the system is initially booted, the host adapter sends out a Start Unit command to each SCSI unit. This allows each of the units to start in an orderly manner (and not overloading the local power supply). The host will start with the highest priority address (ID=7) and finishes with the lowest address (ID=0). Typically, the ID is set with a rotating switch selector or by three jumpers.

SCSI

- **BSY#**. indicates that the bus is busy, or not (an OR-tied signal).
- **ACK#**. activated by the initiator to indicate an acknowledgement for a **REQ#** information transfer handshake.
- **RST#**. when active (low) resets all the SCSI devices (an OR-tied signal).
- **ATN#**. activated by the initiator to indicate the attention state.
- **MSG#**. activated by the target to indicate the message phase.
- SEL. activated by the initiator, and used to select a particular target device (an OR-tied signal).
- **C#/D** (control/data). activated by the target to identify whether there is data or control on the SCSI bus.
- **REQ#**. activated by the target to acknowledge to indicate a request for an **ACK#** information transfer handshake.
- **I#/O** (input/output) – activated by the target to show the direction of the data on the data bus. Input defines that data is an input to the initiator, else it is an output.

SCSI signals

- **OR-tied driven**, where the driver does not drive the signal to the false state. In this case, the bias circuitry of the bus terminators pulls the signal false whenever it is released by the drivers at every SCSI device. If any driver is asserted, then the signal is true. The **BSY#**, **SEL#** and **RST#** signals are OR-tied. In the ordinary operation of the bus, the **BSY#** and **RST#** signals may be simultaneously driven true by several drivers.
- **Non-OR-tied driven**, where the signal may be actively driven false. No signals other than **BSY#**, **RST#** and **D(Parity)#** are driven simultaneously by two or more drivers.

SCSI OR-tied

- **Free-bus**. In this state, there are no units that either transfer data or have control of the bus. It is identified by deactivate **SEL#** and **BSY#** (both will be high). Thus, any unit can capture the bus.
- **Arbitration**. In this state, a unit can take control of the bus and become an initiator. To do this, it activates the **BSY#** signal and puts its own ID address on the data bus. After a delay, it tests the data bus to determine whether a high-priority unit has put its own address on the bus. If it has, then it will allow the other unit access to the bus. If its address is still on the bus, then it asserts the **SEL#** line. After a delay, it then has control of the bus.

- **Selection**. In this state, the initiator selects a target unit and gets the target to carry out a given function, such as reading or writing data. The initiator outputs the OR value of its SCSI-ID and the SCSI-ID of the target onto the data bus (for example, if the initiator is 2 and the target is 5 then the OR-ed ID on the bus will be 00100100). The target then determines that its ID is on the data bus and set the **BSY#** line active. If this does not happen within a given time, then the initiator deactivates the **SEL#** signal, and the bus will be free. The target determines that it is selected when the **SEL#** signal and its SCSI ID bit are active and the **BSY#** and **I#/O** signals are false. It then asserts the signal within a selection abort time.

- **Reselection**. When the arbitration phase is complete, the winning SCSI device asserts the **BSY#** and **SEL#** signals and has delayed at least a bus clear delay plus a bus settle delay. The winning SCSI device sets the DATA BUS to a value that is the logical OR of its SCSI ID bit and the initiator's SCSI ID bit. Sometimes, the target takes some time to reply to the initiator's request. The initiator determines that it is reselected when the **SEL#** and **I#/O** signals and its SCSI ID bit are true and the **BSY#** signal is false. The reselected initiator then asserts the **BSY#** signal within a selection abort time of its most recent detection of being reselected. An initiator does not respond to a reselection phase if other than two SCSI ID bits are on the data bus. After the target detects that the **BSY#** signal is true, it also asserts the **BSY#** signal and waits a given time delay and then releases the **SEL#** signal. The target may then change the **I#O** signal and the data bus. After the reselected initiator detects the **SEL#** signal is false, it releases **BSY#** the signal. The target continues to assert the **BSY#** signal until it gives up the SCSI bus.

- **Command**. The command phase is used by the target to request command information from the initiator. The target asserts the **C#/D** signal and negates the **I#/O** and **MSG#** signals during the **REQ#/ACK#** handshake(s) of this phase.
- **Data**. The data phase covers both the data-in and data-out phases. In the data-in phase, the target requests that data be sent to the initiator from the target. For this purpose, the target asserts the **I#/O** signal and negates the **C#/D** and **MSG#** signals during the **REQ#/ACK#** handshake(s) of this phase. In the data-out phase, the target requests that data be sent from the initiator to the target. The target negates the **C#/D**, **I#/O** and **MSG#** signals during the **REQ#/ACK#** handshake(s) of this phase.

- **Arbitration delay**, 2–4ms. This is the minimum time that a SCSI device waits from asserting **BSY#** for arbitration until the data bus can be examined to see whether arbitration has been won.
- **Power-on to selection time**, 10s. This is the maximum time from power start-up until a SCSI target is able to respond with appropriate status and sense data.
- **Selection abort time**, 200us. This is the maximum time that a target (or initiator) takes from its most recent detection of being selected (or reselected) until asserting a **BSY#** response. This is required to ensure that a target (or initiator) does not assert **BSY#** after a select (or reselection) phase has been aborted.
- **Selection time-out delay**, 250ms. The minimum time that a SCSI device should wait for a **BSY#** response during the selection or reselection phase before starting the time-out procedure.
- **Disconnection delay**, 200us. The minimum time that a target shall wait after releasing **BSY#** before participating in an arbitration phase when honouring a disconnect message from the initiator.
- **Reset hold time**, 25us. The minimum time for which RST#

SCSI timings

- **Message**. The message phase covers both the message-out and message-in phases. The first byte transferred in either of these phases can be either a single-byte message or the first byte of a multiple-byte message. Multiple-byte messages are contained completely within a single message phase.
- **Status**. The status phase allows the target to request that status information be sent from the target to the initiator. The target shall assert the **C#/D** and **I#/O** signals and negate **MSG#** the signal during the **REQ#/ACK#** handshake of this phase.

$\overline{MSG}$	$\overline{C}$ /D	$\overline{I}$ /O	*Phase*	*Direction*
0	0	0	Data out	Initiator→target
0	0	1	Data in	Initiator←target
0	1	0	Command	Initiator→target
0	1	1	Status	Initiator←target
1	0	0	–	–
1	0	1	–	–
1	1	0	Message out	Initiator→target
1	1	1	Message in	Initiator←target

SCSI operation

The handshaking operation for a transfer **to the initiator** is as follows:

- The I#/**O** signal is asserted as a true.
- The target sets the data bus lines.
- The target asserts the **REQ#** signal.
- The initiator reads the data bus.
- The initiator then indicates its acceptance of the data by asserting the **ACK#** signal.
- The target may change or release the data bus.
- The target negates the **REQ#** signal.
- The initiator shall then negate the **ACK#** signal.
- The target may continue the transfer by driving the data bus and asserting the **REQ#** signal, and so on.

SCSI read/write