From: Hale Landis 94-046r0
Subject: Master/Slave Handshaking

On the subject of master/slave handshaking...

One of the problems with ATA-1 is the unclear way that master/slave handshaking is described and how the results of this activity affect following operations. This is really unfortunate since there are more pages of the ATA-1 document devoted to this topic than to any other part of the ATA interface.

Lets review the background... The only reasons that this handshaking is needed is to make ATA devices "look" like a single device controller with one or two devices, or in other words, to "look" like an MFM controller with one or two drives. Why do this? Only one reason: software compatibility -- making two controllers "look" like one controller.

There are three events that invoke master/slave handshaking (master is also known as drive 0, slave is also known as drive 1):

- after power on or hardware reset, drive 0's controller sets BSY=0 when the reset function is completed by both controllers.

- after software reset, drive 0's controller sets BSY=0 when the reset function is completed by both controllers.

- after a Diagnostic command, drive 0's controller sets BSY=0 when the diagnostic command is completed by both controllers.

The master/slave handshaking is uni-directional: the slave sends signals to the master so that the master can determine when the slave has completed one of these three functions.

Another "feature" of the MFM type controller was that if there was only one drive, a master, and the host selected the non-existant slave drive, all of the drive status bits would be zero (because there was no drive to assert any of the these bits). In the ATA world, this means that the master must respond with status of 00H if the non-existant slave drive is selected.

Note that DRDY is a DRIVE status bit, not a controller status bit, and just because the controller is "not busy" does not imply anything about the "ready" status of a drive.

Now to the root to the problem... Following a hard reset, a soft reset or a Diagnostic command, when is it illegal to issue a command to the master or slave drive?

The answer is not simple and depends on several things: which drive and which command are the most important. For all three

events, the sequence of events can be summarized as follows...

Drive 0 sets BSY=1, does the master/slave handshake, which could take up to 31 seconds, and then drive 0 may set BSY=0. Then drive 0 can complete spinup, etc, and set DRDY=1. The ATA has no specification for when DRDY=1 should happen. Please note that there is NO reference to the DRDY bit of the Status register in Annex A or B. What is in Annex A and B is the statement

> "Drive 0 clears BSY when ready to accept commands (within 31 seconds)."

I think a lot of people read this sentence as if it said

> "Drive 0 clears BSY and sets DRDY when ready to accept commands (within 31 seconds)."

If people do interpret this sentence in this way, they are wrong.

Don't forget that traditionally there are two commands that were legal when BSY=0 and DRDY=0: Execute Diagnostics and Initialize Drive Parameters. These are "controller commands" and may not require media access. Media access commands are not legal until BSY=0 AND DRDY=1.

So how can we clear this up? Well... ATA-1 Annex A and Annex B both describe master/slave handshaking, Annex A from the drive standpoint and Annex B from the host standpoint. For ATA-2, I assmue that Annex A will be move into the body of the document and that Annex B will be discarded. Therefore, I recommend the following changes to the Annex A text. My changes are marked by || at the left margin. I do realize that my suggested changes may not be acceptable to everyone for several reasons.

Also note the sentence marked by "->". I would bet that a lot of people fail to "see" this sentence when they read Annex A!

----- begin Hale's marked up Annex A -----

Annex A (informative)

Diagnostic and reset considerations

This annex describes the following timing relationships during:

a) Power on and hardware resets
   - One drive
   - Two drives
b) Software reset
   - One drive
   - Two drives
c) Diagnostic command execution
   - One drive
   - Two drives
   - Two drives - drive 1 failed

The timing assumes the following:

- DASP- is asserted by Drive 1 and received by Drive 0 at power-on or hardware reset to indicate the presence of Drive 1. At all other times it is asserted by Drive 0 and Drive 1 to indicate when a drive is active.
- PDIAG- is asserted by Drive 1 and detected by Drive 0. It is used by Drive 1 to indicate to Drive 0 that it has completed diagnostics and is ready to accept commands from the Host (BSY bit is cleared).

-> This does not indicate that the drive is ready, only that it can
-> accept commands. This line may remain asserted until the next reset occurs or an Execute Diagnostic command is received.

- Unless indicated otherwise, all times are relative to the event that triggers the operation (RESET-, SRST=1, Execute Diagnostic Command).

A.1 Power on and hardware resets

A.1.1 Power on and hardware resets - one drive

- Host asserts RESET- for a minimum of 25 usec.
- Drive 0 sets BSY within 400 nsecs after RESET- is negated.
- Drive 0 negates DASP- within 1 msec after RESET- negated.
- Drive 0 performs hardware initialization
- Drive 0 may revert to its default condition
- Drive 0 waits 1 msec then samples for at least 450 msec for DASP- to be asserted from Drive 1.

|| - Drive 0 clears BSY when ready to accept non-media access commands
|| (optional, within 31 seconds).
|| - Drive 0 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.1.2 Power on and hardware resets - two drives

- Host asserts RESET- for a minimum of 25 usec.
- Drive 0 and Drive 1 set BSY within 400 nsec after RESET- negated.
- DASP- is negated within 1 msec after RESET- is negated.

A.1.2.1 Drive 1

- Drive 1 negates PDIAG- before asserting DASP-.
- Drive 1 asserts DASP- within 400 msecs after RESET- (to show presence).
- Drive 1 performs hardware initialization and executes its internal diagnostics.
- Drive 1 may revert to its default condition
- Drive 1 posts diagnostic results to the Error Register

|| - Drive 1 clears BSY when ready to accept non-media access commands
|| (optional, within 30 seconds from RESET-).

- Drive 1 asserts PDIAG- to indicate that it is ready to accept commands (within 30 seconds from RESET-).

|| - Drive 1 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

- Drive 1 negates DASP- after the first command is received or negates DASP-if no command is received within 31 seconds after RESET-.

A.1.2.2 Drive 0

- Drive 0 performs hardware initialization and executes its internal diagnostics.
- Drive 0 may revert to its default condition
- Drive 0 posts diagnostic results to the Error Register
- After 1 msec, Drive 0 waits at least 450 msec for DASP- to be asserted (from Drive 1). If DASP- is not asserted, no Drive 1 is present (see POWER-ON RESET - One Drive operation).
- Drive 0 waits up to 31 seconds for Drive 1 to assert PDIAG-. If PDIAG- is not asserted, Drive 0 sets Bit 7=1 in the Error Register.
- Drive 0 clears BSY when ready to accept non-media access commands (optional, within 31 seconds).
- Drive 0 clears BSY (if not previously done) and sets DRDY when ready to accept any commands.

A.2 Software reset

A.2. A.2.1 Software reset - one drive

- Host sets SRST=1 in the Device Control Register.
- Drive 0 sets BSY within 400 nsec after detecting that SRST=1.
- Drive 0 performs hardware initialization and executes its internal diagnostics.
- Drive 0 may revert to its default condition.
- Drive 0 posts diagnostic results to the Error Register.
- Drive 0 clears BSY when ready to accept non-media access commands (optional, within 31 seconds).
- Drive 0 clears BSY (if not previously done) and sets DRDY when ready to accept any command.

A.2.2 Software reset - two drives

- Host sets SRST=1 in the Device Control Register.
- Drive 0 and Drive 1 set BSY within 400 nsec after detecting that SRST=1.
- Drive 0 and Drive 1 perform hardware initialization.
- Drive 0 and Drive 1 may revert to their default condition.

A.2.2.1 Drive 1

- Drive 1 negates PDIAG- within 1 msec.
- Drive 1 clears BSY when ready to accept non-media access commands (within 30 seconds).
- Drive 1 asserts PDIAG- to indicate that it is ready to accept commands (within 30 seconds).
- Drive 1 clears BSY (if not previously done) and sets DRDY when ready to accept any command.

A.2.2.2 Drive 0

- Drive 0 waits up to 31 seconds for Drive 1 to assert PDIAG-.
- Drive 0 clears BSY when ready to accept non-media access commands (within 31 seconds).

|| - Drive 0 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.3 Diagnostic Command Execution

A.3.1 Diagnostic command execution - one drive (passed)

- Drive 0 sets BSY within 400 nsec after the Execute Diagnostic command was received.
- Drive 0 performs hardware initialization and internal diagnostics.
- Drive 0 resets Command Block registers to default condition.
- Drive 0 posts diagnostic results to the Error Register
|| - Drive 0 clears BSY when ready to accept non-media access commands
|| (within 6 seconds).
|| - Drive 0 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.3.2 Diagnostic command - two drives (passed)

- Drive 0 and Drive 1 set BSY within 400 nsec after the Execute Diagnostic command was received.

A.3.2.1 Drive 1

- Drive 1 negates PDIAG- within 1 msec after command received.
- Drive 1 performs hardware initialization and internal diagnostics.
- Drive 1 resets the Command Block registers to their default condition.
- Drive 1 posts diagnostic results to the Error Register
|| - Drive 1 clears BSY when ready to accept non-media access commands.
- Drive 1 asserts PDIAG- to indicate that it is ready to accept commands (within 5 seconds).
|| - Drive 1 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.3.2.2 Drive 0

- Drive 0 performs hardware initialization and internal diagnostics.
- Drive 0 resets the Command Block registers to their default condition.
- Drive 0 waits up to 6 seconds for Drive 1 to assert PDIAG-.
- Drive 0 posts diagnostic results to the Error Register
|| - Drive 0 clears BSY when ready to accept non-media access commands
|| (within 6 seconds).
|| - Drive 0 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.3.3 Diagnostic command execution - one drive (failed)

- Drive 0 sets BSY within 400 nsec after Diagnostic command received.
- Drive 0 performs hardware initialization and internal diagnostics.
- Drive 0 resets Command Block registers to default condition.
- Drive 0 posts a Diagnostic Code to the Error Register indicating a failure.

|| - Drive 0 clears BSY when ready to accept non-media access commands
|| (within 6 seconds).
|| - Drive 0 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.3.4 Diagnostic command execution - two drives (drive 1 failed)

- Drive 0 and Drive 1 set BSY within 400 nsec after Diagnostic command received.

A.3.4.1 Drive 1

- Drive 1 negates PDIAG- within 1 msec after command received.
- Drive 1 performs hardware initialization and internal diagnostics.
- Drive 1 resets the Command Block registers to their default condition.
- Drive 1 posts a Diagnostic Code to the Error Register indicating failure.

|| - Drive 1 clears BSY when ready to accept non-media access commands.
- Drive 1 does not assert PDIAG-, indicating that it failed diagnostics.
|| - Drive 1 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

A.3.4.2 Drive 0

- Drive 0 performs hardware initialization and internal diagnostics.
- Drive 0 resets the Command Block registers to their default condition.
- Drive 0 waits 6 seconds for Drive 1 to assert PDIAG- but PDIAG- is not asserted by Drive 1.
- Drive 0 posts a Diagnostic Code to the Error Register setting Bit 7=1 to indicate that Drive 1 failed diagnostics.

|| - Drive 0 clears BSY when ready to accept non-media access commands
|| (within 6 seconds).
|| - Drive 0 clears BSY (if not previously done) and sets DRDY when
|| ready to accept any command.

NOTE 1 The 6 seconds referenced above is a host-oriented value.

----- end Hale's marked up Annex A -----

Now lets look at all of this from a host software standpoint...

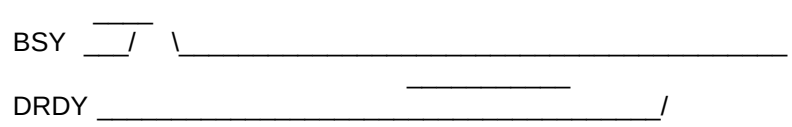
There are three different methods implemented in drives to handle the BSY and DRDY bits following a hard reset, a soft reset or a Diagnostic command. Host software MUST be designed to handle all three methods since drives have been built using all three methods. Note that all three methods are allowed by the ATA.

"m/s" denotes when the master/slave handshaking takes place (up to 31 seconds!) and "spin-up" denotes the time required to become ready to accept media access commands (no time limit! REPEAT -

NO TIME LIMIT IS SPECIFIED BY THE ATA FOR THIS ACTIVITY!).

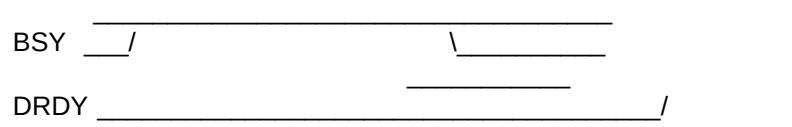
Method 1 -- The traditional method.

Most drives implementing Method 1 will reject a media access command received during the spin-up time with Error and Command Abort. Don't forget about the commands that are legal during the spin-up time when a drive's status is 00H: Initialize Drive Parameters and Execute Diagnostics.



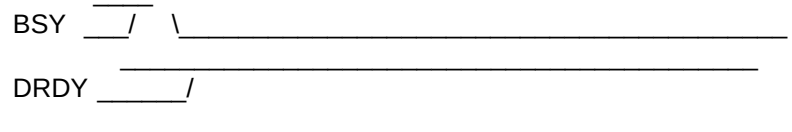
Method 2 -- Very popular these days.

Method 2 is very popular these days probably because it is the most simple to implement in drive firmware. Time to DRDY=1/BSY=0 must not exceed 31 seconds to be ATA compatible.



Method 3 -- Makes for complex drive firmware.

Method 3 requires that the drive "accept and queue" a media access command that is received during the spin-up time and this way cause a command time-out on some host systems. This is tricky... the time from BSY=0 until the actual start of the "queued" command's execution should not exceed 31 seconds.



Remember, host software MUST be implemented such that all three methods are acceptable. And also remember that the master may implement a different method than the slave.

--- And now, one final comment ---

If I could change the way host software is designed, I would do the following (and I would definitely do this in a notebook computer if there was no possibility that a second drive could be

added to the computer's ATA host adapter):

Support only one drive per ATA host adapter with that drive configured as slave (drive 1). This would be great... No master/slave handshaking to worry about... No multi-vendor compatibility problems... No problems with a Drive 0 that "hangs" waiting for a Drive 1 to do something... No problems with a Drive 0 that thinks there is no Drive 1 when there really is a Drive 1... No problems with a Drive 0 that thinks there is a Drive 1 when there really is no Drive 1...

Ahhh... Life would be wonderful! But then there is nothing more difficult in the entire universe than getting software people to change the way they do things.

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