OTL Engineering

X3T9.2/88-092 Rev 0

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To: X3T9.2 SCSI Working Group and Committee Members

From: Paul R. Nitza

Subject: Auto Bus Configuration (ABC) Proposal

Note: This document is a draft proposal for the working group and as such is not complete and is subject to modifications in future revisions or may be dropped for a better solution.

1.0 SCSI Bus Configuration

Throughout the history of SCSI one of the main features missing from the protocol was the ability to configure the bus without using hardware jumpers. The use of jumpers to select the bus ID not only made it difficult for the end user to add devices to the system it also forced manufacturers to provide these jumpers or some external switch for selecting the bus ID. This proposal is an attempt to eliminate the manual selection of bus IDs by providing an Auto Bus Configuration (ABC) state within the existing physical architecture of SCSI. The ABC state provides a means for devices to be assigned bus IDs at system power up and also reconfigure those IDs after the initial configuration has been completed.

2.0 Bus Configuration Requirements

At the July working group meeting in Boise Idaho, 22 requirements for bus configuration were discussed and assigned a level of importance from 1 to 10 with 10 being the highest. The following is a list of those requirements and how this Auto Bus Configuration proposal meets those requirements.

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Item	Importance	ABC	Description
1.	10	Yes	Any device may perform the configuration.
2.	10	Yes	The device performing the configuration may be in any position on the bus.
3.	9	Yes(1)	"New" and "Old" devices may be mixed on the bus. (1) Using ABC old devices must respond to a selection within (TBD) for them to be recognized or the device doing the configuration must be passed a list of bus IDs in use by the old devices.
4.	9	Yes	The order of new and old devices should not matter.
5.	10	Yes	The solution works for both single ended and differential.
6.	8	Yes(1)	Add a minimum of new signals. (1) ABC uses the existing 50 pin connectors with no new signals defined.
7.	7	Yes	New devices should have one or two identical connectors on each device (same sex wired one-to-one). No "IN" and "OUT" connectors.
8.		TBD	Time to accomplish configuration should not exceed 10 seconds.
9.	10	Yes	New devices must remember their assigned address through all but a power outage. They must request re-configuration when they are powered on.
10.	10	Yes	The solution must be able to accommodate more than 8 devices (SCSI-3).
11a.	10	Yes	Powered down devices do not effect the process, including the device that normally does the configuration.
11b.	10	Yes	More than one device can do configuration.
12a.	4.5	N/A	Must detect no terminators, only one terminator and more than two terminators.

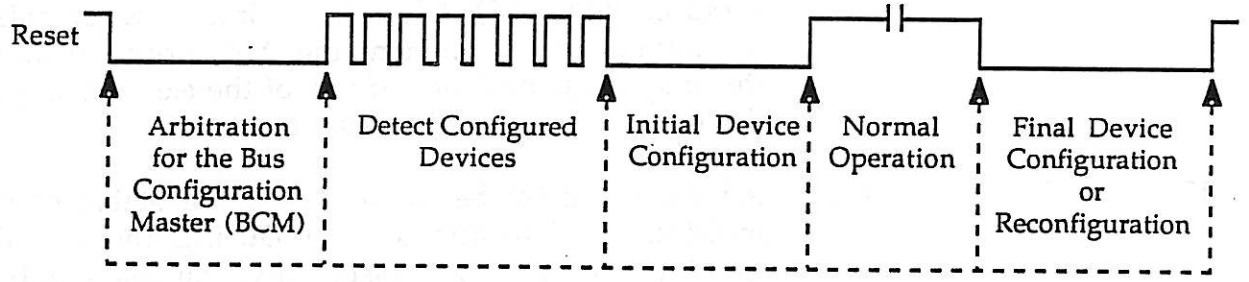
Item	Importance	ABC	Description
12b.	4.5	N/A	Must detect that terminators are at the end of the cable.
13.	10	Yes	Cabling between devices must be identical.
14.	10	????	In mixed systems of old and new devices, reconfiguration must not change any addresses that were previously assigned. Old devices could be very confused by a device that changes addresses.
15.	10	N/A	All terminator assemblies must be identical.
16.	10	Yes(1)	The solution must be compatible with existing protocol chips. (1) Additional wired "OR" signals are required to implement the ABC proposal and this may cause problems if any of the existing chips drive these signals to the false state.
17.	10	No(1)	Addressing must be capable of being stable over multiple configurations. (1) During the Initial Configuration ABC will assign any available bus ID to a device. However, ABC also provides a mode where a specific ID can be assigned to a device after the Initial Configuration is completed.
17a.			Via Software [to be considered later].
17b.			Via Hardware [to be considered later].
18.	10	Yes	Uses existing 50 pin connectors.
19.	9	Yes	Bi-directional cable.
20.	10	Yes	Must comply with the ANSI Patent policy.
21.	2	No	Device can have no SCSI ID to handle more than the maximum number of devices connected to the bus.
22.	10	Yes	Possible to daisy-chain devices with only a single connector.

3.0 Auto Bus Configuration Proposal

3.1 Overview

The Auto Bus Configuration proposal uses a single Bus Configuration Master (BCM) that is chosen through a Ethernet like collision detection arbitration method. Once the BCM is chosen it has full responsibility for assigning the bus IDs to the devices on the bus and insuring that the bus is in an initial state that will operate correctly. Once this initial state is achieved any device which supports the Auto Bus Configuration option may reconfigure the bus IDs to any value for system operation.

The Auto Bus Configuration process consists of the states shown in the following diagram:



During the Arbitrate for Bus Configuration Master state, which occurs at device power up, any devices that want to configure the bus arbitrate to determine which device is to be the Bus Configuration Master (BCM). Under normal operation only one device, usually an Initiator (system host adapter), will participate in this arbitration process.

The Detect Configured Devices state is initiated by the Bus Configuration Master to detect any devices on the bus which may have already been configured in the system and reserves the bus IDs used by those devices. This state is also used to detect devices which do not support the Auto Bus Configuration process (i.e. "Old" devices). The bus IDs of all devices detected during this state are marked as reserved and will not be used by the BCM during the Initial Device Configuration state.

During the Initial Device Configuration state the BCM configures those devices which require configuration by assigning them bus IDs that were not reserved in the previous step. After this state the reset signal is released by the BCM and normal SCSI bus operation may commence.

The Final Device Configuration or Reconfiguration state enables the BCM or any other device that supports the ABC option to reconfigure the bus IDs of the configurable devices to any desired value.

3.2 Power Up/Reset State Diagram

The state diagram in figure 1 shows the power up sequence that all devices which support the Auto Bus Configuration shall use. This power up sequence insures the device will be in the correct state no matter when it is powered up. Devices that are powered up after the system has been configured will enter the ABC mode and configure themselves into the system. Devices that are powered up during the ABC mode will attempt to join the current configuration sequence. If they are unable to join the current configuration sequence they will configure themselves into the system after the current configuration sequence is completed.

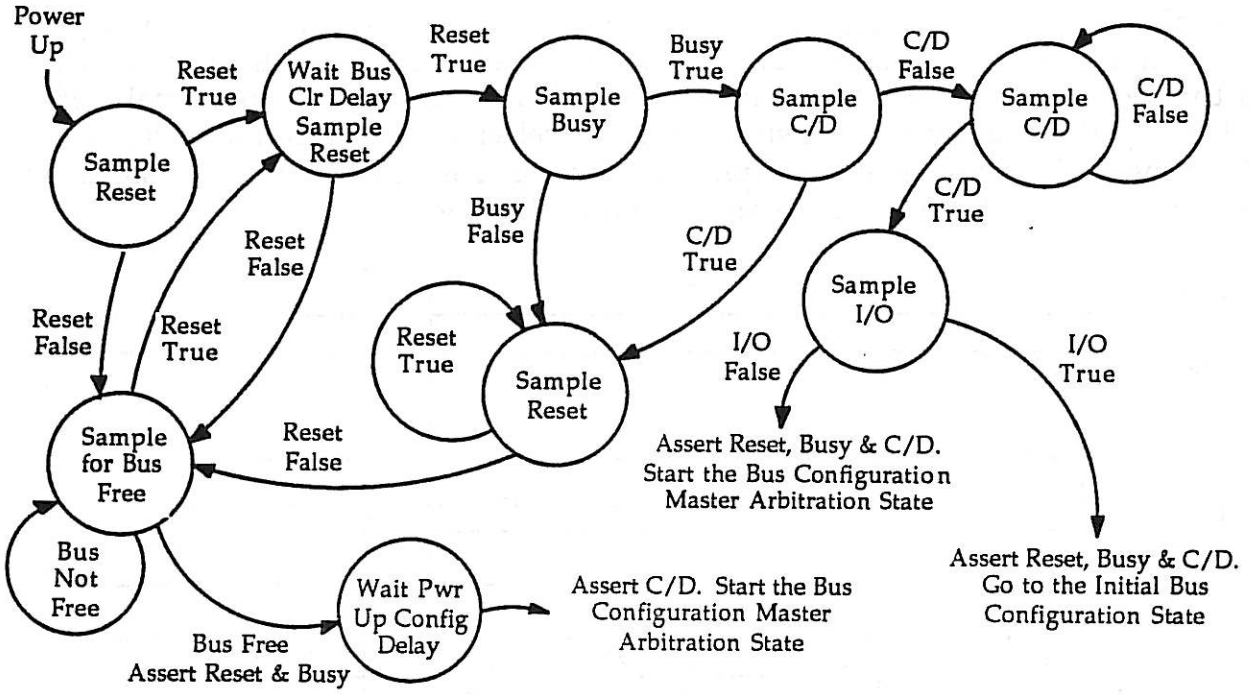


Figure 1 -- Power Up/Reset State Diagram

3.3 Arbitrate for Bus Configuration Master (BCM)

During the Arbitrate for Bus Configuration Master state, which only occurs at device power up, any devices that want to configure the bus arbitrate to determine which device is to be the Bus Configuration Master (BCM). Under normal operation only one device, usually an Initiator (system host adapter), will participate in this arbitration process. A special mode is provided for those devices that do not want to participate in the BCM arbitration but will still configure themselves if powered on after the system has been configured.

The BCM arbitration uses an Ethernet like collision detection method to select a single device from all the devices that attempt to perform configuration at system power up.

At power up all devices that wish to participate in the arbitration for Bus Configuration Master shall sample the reset, busy and C/D signals and take the action specified in the Power Up/Reset State Diagram section above.

Please refer to figure 2 for the following explanation. Upon entry to the BCM arbitration state from the Power Up/Reset state, the device shall wait a select sample delay (the reset, busy and C/D signals have already been asserted by the Power Up/Reset state). Note: Devices that do not wish to participate in the initial power up configuration shall wait for one select sample delay plus one configuration holdoff time. After waiting the select sample delay (or select sample delay plus configuration holdoff time) the device shall test the select signal. If the select signal is true the device has lost the arbitration and shall release all the bus signals. If the select signal is false the device shall assert the select signal for an initial select time. After the initial select time has expired the devise shall release the select signal and wait a select sample delay before sampling the select signal..

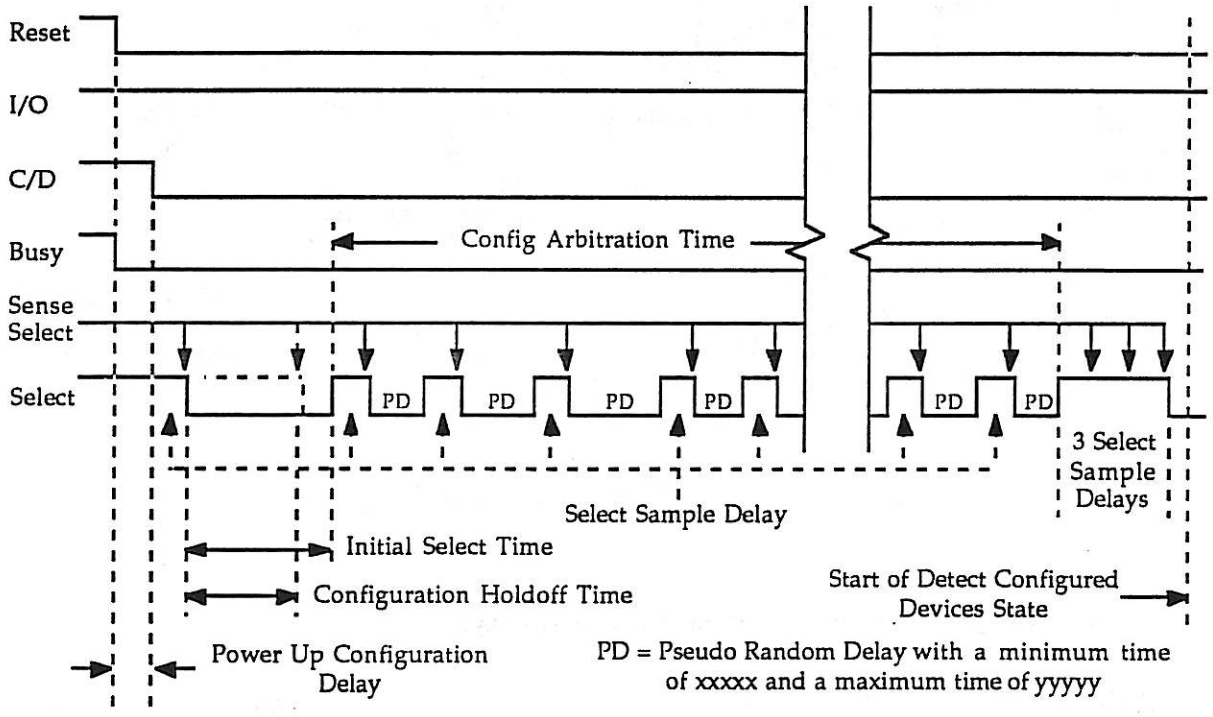


Figure 2 -- Arbitration for Bus Configuration Master

If the select signal is true the device has lost the arbitration and shall release all bus signals. If the select signal is false the device shall repeatedly execute the following sequence for at least a configuration arbitration time:

1. Assert the select signal.
2. Wait for a pseudo random delay.
3. Release the select signal.
4. Wait a select sample delay.
5. Sample the select signal.

If the select signal is true when the device samples it in the above sequence then the device has lost the arbitration and shall release all bus signals. After the configuration arbitration time has expired the device shall release the select signal for at least three select sample delays. After the expiration of each of the three select sample delays the device shall sample the select signal and if it is true the device has lost the arbitration and shall release all bus signals. If after the three select sample delays no other device has asserted the select signal the device has won the Bus Configuration Master arbitration and shall assert the select signal and start the Detect Configured Devices state.

3.4 Detect Configured Devices

The Detect Configured Devices state is initiated by the Bus Configuration Master to detect any devices on the bus which may have already been configured in the system and reserves the bus IDs used by those devices. This state is also used to detect devices which do not support the Auto Bus Configuration process.

The BCM uses the old single initiator option (this option was removed from SCSI-2) to select all 8 IDs on the bus, one at a time, to determine which bus IDs are in use. Devices which have already been configured will respond to the selection so their bus IDs will be reserved and they will not be reconfigured by the BCM. Old SCSI devices will be detected if they respond to the selection by asserting busy within a detect configuration delay after the BCM releases the reset signal. If any old devices cannot meet this criteria then the host system software must pass a list of the IDs used by these old devices so the IDs can be reserved.

Please refer to figure 3 for the following explanation. If the BCM is coming from the BCM arbitration state then the busy and reset signals will both be asserted. However, after completing one bus ID and before progressing to the next ID the BCM shall assert the busy signal and the reset signal. The reset signal shall be asserted for a minimum of a reset hold time. During this reset hold time the BCM shall place the ID of the next device to check on the data bus a minimum of a bus clear delay after the assertion of reset but at least a bus settle time before the release of the reset signal. Note: The select and C/D signals which were asserted in the BCM arbitration state remain asserted through the entire Detect Configured Devices state.

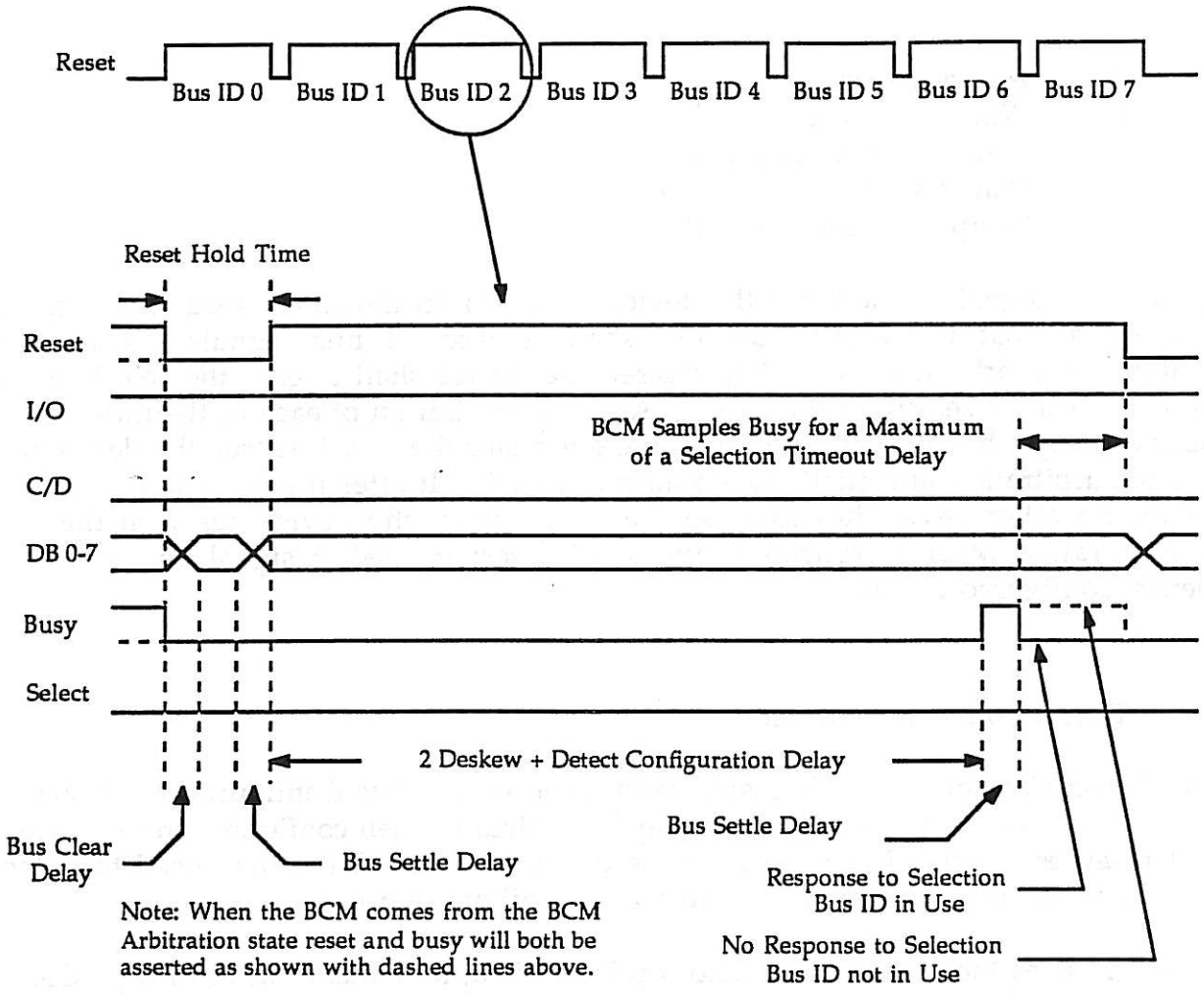


Figure 3 -- Detect Configured Devices

After the reset signal is released the BCM shall wait a minimum of two deskew delays plus a detect configuration delay then release the busy signal. After the busy signal is released the BCM shall wait a minimum of of bus settle delay before sampling the busy signal and shall continue to sample the busy signal for a maximum of a selection timeout delay. If the busy signal is true at any time during this sampling period the BCM shall flag the current bus ID as reserved, assert the reset and busy signals and proceed to test the next ID. If the busy signal is false after a selection timeout delay the BCM shall assert the reset signal, flag this bus ID is not in use and proceed to test the next ID.

After completion of all the bus IDs the BCM shall assert the reset, busy and I/O signals and release the C/D and select signals. This combination of signals marks the start of the Initial Device Configuration state.

3.5 Initial Device Configuration

During the Initial Device Configuration state the BCM configures those devices that require configuration by assigning them bus IDs that were not reserved in the Detect Configured Devices state. Before starting this state the BCM assigns the highest unused bus ID for itself and uses the remaining available IDs for any unconfigured devices.

The Initial Device Configuration is very similar to the Bus Configuration Master arbitration state in that it uses an Ethernet like collision detection method so one unconfigured device can become the target of the BCM configuration. Only unconfigured devices participate in this state.

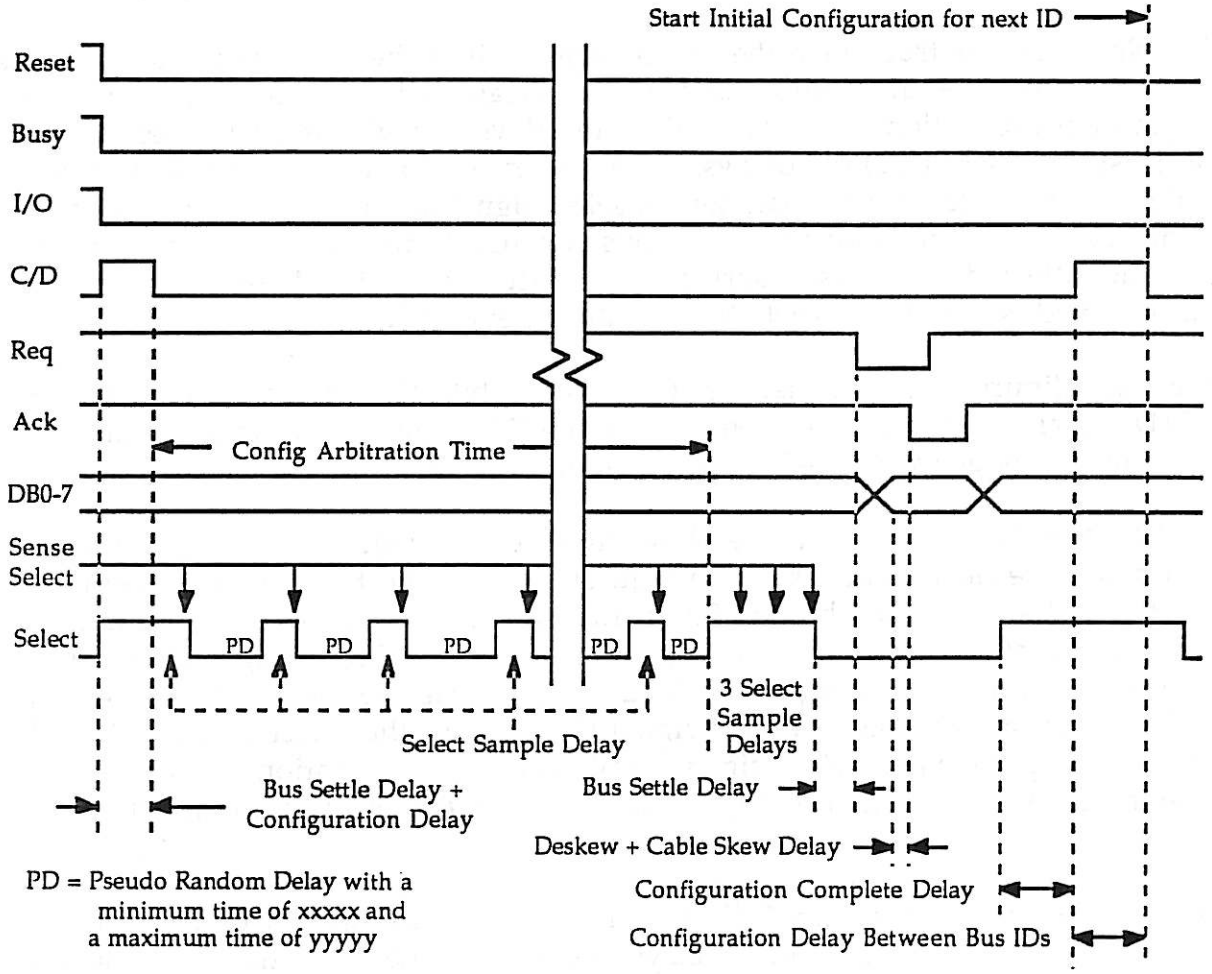


Figure 4 -- Initial Device Configuration

Please refer to figure 4 for the following explanation. After the Detect Configured Devices state the BCM shall assert the reset, busy and I/O signals, release the C/D and select signals, wait a bus settle delay plus a configuration delay then assert the C/D signal.

When unconfigured devices detect the reset, busy and I/O signals true with the C/D signal false they shall wait for the C/D signal to be asserted. After the BCM asserts the C/D signal the unconfigured devices shall wait a select sample delay and sample the select signal. If the select signal is true the device has lost the arbitration and shall release all bus signals. If the select signal is false the device shall repeatedly execute the following sequence for at least a configuration arbitration time:

1. Assert the select signal.
2. Wait for a pseudo random delay.
3. Release the select signal.
4. Wait a select sample delay.
5. Sample the select signal.

If the select signal is true when the device samples it in the above sequence then the device has lost the arbitration and shall release all bus signals. After the configuration arbitration time has expired the device shall release the select signal for at least three select sample delays. After the expiration of each of the three select sample delays the device shall sample the select signal and if it is true the device has lost the arbitration and shall release all bus signals. If after the three select sample delays no other device has asserted the select signal the device has won the arbitration and is now the Target Configuration Device (TCD).

Those unconfigured devices that lost the above arbitration sequence shall wait for the C/D signal to become false, then wait for the C/D signal to become true and retry the arbitration sequence defined in the above paragraph.

The TCD (the device that won the above arbitration) shall assert the select signal, wait a bus settle delay and assert the request signal. The BCM upon detecting the request signal shall assert the bus ID on the data bus lines, wait a minimum of a deskew delay plus a cable skew delay and assert the acknowledge signal. Upon detecting the acknowledge signal the TCD shall release the request signal, wait for the BCM to release the acknowledge signal then release the select signal. The BCM upon detecting the false select signal shall wait a configuration complete delay, release the C/D signal, wait a configuration delay between bus IDs and assert the C/D signal.

Whenever the BCM asserts the C/D signal during the Initial Device Configuration state it shall wait two select sample delays then sample the select signal. If the select signal is true another device needs configuration and Initial Device Configuration state proceeds. However, if the select signal is false no other devices need configuration (Initial Device Configuration state has been completed) and the BCM releases all the bus signals.

3.6 Final Device Configuration

The Final Device Configuration or Reconfiguration state enables the BCM or any other device that supports the ABC option to reconfigure the bus IDs of the configurable devices to any desired value.

Additional Information to be Provided.

3.7 Devices Powered On after System Configuration

Devices powered on after the system has been configured perform the above Auto Bus Configuration up through and including the Initial Device Configuration state. During the Initial Device Configuration state no other devices will assert the select signal in response to the reset, busy, I/O and C/D signals being asserted so the powered on device will simply complete the ABC process.

3.8 Device Reconfiguration

Additional Information to be provided.

3.9 Changes to Existing SCSI Signals

The Select, C/D, I/O and MSG signals need to be "wired or" signals for this proposal to work. See section 3.11 for possible problems with this.

3.10 Auto Bus Configuration Timing Definitions

Configuration Arbitration Time --

Configuration Complete Delay --

Configuration Delay --

Configuration Delay Between Bus IDs --

Configuration Holdoff Time --

Detect Configuration Delay --

Initial Select Time --

Power Up Configuration Delay --

Pseudo Random Delay --

Select Sample Delay --

3.11 Possible Problem Areas

1. How can we stop the BCM during the auto configure process since the reset signal is being used to hold off other devices? In other word there is no reset during the configuration process.

2. SCSI-2 must define a maximum time from the release of reset until a device will respond to a selection. "Respond to Selection" means the device will recognize that it has been selected and assert the busy signal (the device is not required to execute a command or even take the ID message or CDB). Note: This is listed as a problem since the working group, after considerable discussion, was unable to reach agreement on this matter.

3. Will the re-definition of the Select, C/D, I/O and Msg signals to "wired or" signals cause any timing problems with normal SCSI?

4. Do protocol chip drive the Select, C/D, I/O or Msg signals to their false (+5V) state or do they rely on the terminators to pull these signals up? Maybe we can define all signals as "wired or" when reset is asserted and leave the current definitions when reset is negated.