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Proposal for a Portable Machine SCSI Bus Termination

1. Scope:

This document outlines a proposal for a SCSI bus termination configuration suitable for "portable devices".

A "portable device" includes any CPU or peripheral which under normal operation conditions may derive its power from a battery and for which the average power consumption is a primary concern.

The SCSI bus under consideration may have a total length greater than 8 inches and thus has to be analyzed as a transmission line.

2. Objectives:

2.1. Back compatibility:

The system shall be able to operate with already existing external SCSI cables with a characteristic impedance as low as 65 Ω. Such cables may also have a TERMPWR DC resistance as high 0.400 Ω / cable assembly including termination resistance and contact resistance..

It shall be able to handle in a user friendly manner resistive SCSI terminations of 220/330 Ω 5% .

It will operate with SCSI devices which do not provide TERMPWR or with a blown TERMPWR fuse.

The system shall handle SCSI devices with input loading capacitance as high as 100 pF.

2.2. Signal integrity:

The operational parameters should be within the SCSI specified input and output voltage and current ranges.

2.3. Power consumption:

The portable device average power consumption shall be minimal.

It is assumed that for a battery powered device the average power consumption is the major concern while the instantaneous power consumption is of secondary importance.

The user of the portable device shall be adviced of any configuration that may severely reduce the available battery capacity.

Whenever possible, the TERMPWR power shall not be supplied by a portable device.

2.4. "Disk mode" operation:

A portable CPU device shall be able to sense the "disk mode" configuration. In this situation it may elect to provide or not power to the TERMPWR line.

The power negotiation feature in "disk mode" tries to balance the power reserve between multiple portable devices which can supply TERMPWR to the bus,

3. Specifications:

- A portable device shall provide a TERMPWR voltage V_{term} = 3.65 to 4.25 volts dc with a transient current source capability of 980 mA.

- A portable device shall use as internal or external SCSI terminator an alternative 2 type terminator providing an output voltage of 2.85 V ± 3% and a line termination impedance of 110 Ω ± 1 %.

Such a terminator shall operate within these specifications with an input voltage (TERMPWR voltage) as low as 3.45 volts dc.

This terminator is the only acceptable one for a SCSI system including portable devices if it is expected that TERMPWR may be supplied by a portable device during normal operation.

While it is strongly discouraged, a SCSI system including a portable device may use a resistive terminator. When the TERMPWR power is supplied by the portable device the user shall be adviced that the current configuration may rapidly deplete the available power reserve.

- A portable device shall be able to stop providing power to the TERMPWR line under power shortage conditions even if such an action will disable the bus. Such an action shall not compromise data integrity.

- A portable CPU device shall be able to sense the "disk mode" configuration.

Such a device shall be able to negotiate with the initiator device to provide power to the TERMPWR. The default decision shall be not to provide any power on the bus. The objective of the power negotiation shall be to balance the power reserves when the initiator device is also a portable device.

- The maximum length of a SCSI bus with TERMPWR being supplied by a portable device shall be limited to 4 meters.

- The DC resistance of the TERMPWR line shall not exceed 0.250 Ω including the termination resistance and the contact resistance for a 1 meter cable segment.

- All the parameters of the SCSI system for a portable device which are not specifically mentioned above should conform to the general SCSI system specification.

4. Discussion:

4.1. Termination impedance:

There is a general belief that a high termination impedance will significantly reduce the portable device power consumption. For a real life

system this statement is incorrect as it is shown at point 4.4. In the same time a low termination resistance presents two significant advantages:

- increased pull-down current for the SCSI drivers which translates into a high deassertion step. A high deassertion step provides a large ac noise margin during deassertion and therefore more immunity to reflections generated by various bus imperfections like stubs, capacitive loading and impedance mismatch.

- reduced reflections at bus ends. The characteristic impedance of a good quality real life SCSI bus is between 80 Ω and 110 Ω while many SCSI configurations already in service present a characteristic impedance as low as 60 Ω. During the assertion period reduced reflections translate into reduced undershoot which improves the SCSI driver reliability. During the deassertion period due to the voltage levels involved the bus-end reflections are less significant.

The 110 Ω 1% termination resistor chosen provides the maximum allowed pull-down current and is the closest available match to the bus impedance.

A lower value may be considered if the 2.85 V termination voltage is decreased. While this action may have a number of benefits it makes such a termination incompatible with already existing SCSI standard proposals.

4.2. TERMPWR voltage:

Starting with the assumption that the termination voltage has to be 2.85 V and that the available voltage regulator technology requires a minimum drop-out voltage of 0.6 V, the minimum acceptable TERMPWR voltage is 3.45 V. I also assume a worst case SCSI bus activity of 13.2 lines low 100 % of the time.

A minimum TERMPWR voltage of 3.75 V will provide operation conditions within specifications for a SCSI bus containing a maximum of 4 cable segments of 1 meter each with a TERMPWR dc resistance of 0.250 Ω par cable. This dc resistance number includes the TERMPWR contact resistance and termination resistance for the cable segment.

The maximum length SCSI bus will operate just slightly below specifications. The worst case input voltage available for the terminator is 3.30 V. As a consequence, the voltage regulator used for the active termination scheme proposed will decrease its output voltage from 2.85 V to 2.70 V.

The maximum TERMPWR voltage of 4.25 V is dictated by the requirement that any regular device on the bus which outputs a TERMPWR voltage between 4.25 and 5,25 volts should win and supply the bus power.

In a simple implementation the TERMPWR voltage can be generated using two diode drops (a regular silicon diode and a Schottky diode) from the internal 5 V power supply. This solution has many potential problems. In general the voltage drop across the diodes vary within a large range making it very difficult to guarantee the 3.75 to 4.25 volts range.

A better implementation will include the TERMPWR generator in the same package as the 2.85 volts regulator for the terminator. The TERMPWR voltage can be controlled quite easy and additional functions can be added.

Additional functions that can be included in such a part are:

- TERMPWR current sense combined with a local termination current sense. Such a circuit will be able to detect the use of a resistive termination at the other end of the bus and advise the user of the additional power drain. The accuracy of such a circuit can be quite low.

- local power management. The local device can decide not to supply TERMPWR to the bus or to disable completely the local termination.

4.3. Back compatibility:

A SCSI bus using one alternative 2 termination as specified and one resistive termination 220/330 Ω ± 5% will have a V_{oh} level of more than 2.41 V which is just 90 mV below the 2.5 V minimum specification.

A SCSI bus using one alternative 2 termination as specified and one resistive termination 220/330 Ω ± 5% together with a SCSI cable with a char-

acteristic impedance of 65 Ω will have an initial deassertion voltage of minimum 1.53 V . This is significantly below the 2.0 V minimum V_{IL} but not unusual for a real life SCSI system. A large input hysteresis combined with a time domain "glitch eater" will provide the necessary immunity to such a transition and there is a significant probability that the SCSI bus will remain operational but again, the use of resistive terminators is strongly discouraged.

The "glitch eater" and input hysteresis mentioned above are very necessary and should be defended with fanatic devotion. They are the only factors enabling back compatibility with with such SCSI bus components as devices with 100 pF node capacitance or cables with TERMPWR DCR as high as 0.4 Ω/ 1 meter cable

4.4. Power consumption:

For the power consumption calculations on portable devices it is customary to consider a SCSI transfer rate of 2 Kbytes every 10 minutes. Assuming a system that uses exclusively the recommended termination configuration the TERMPWR power consumption is:

- a single terminated system (no external SCSI devices) with no SCSI transfers requires less than 5 mA average current.

- a double terminated bus with no SCSI transfers requires less than 10mA average current.

- a single terminated system (no external SCSI devices) requires an average of 250 mA of current per SCSI byte transfer. This calculation assumes 9.2 SCSI signal lines active 100 % of the time.

- a double terminated bus requires an average of 500 mA of current per SCSI byte transfer. This calculation assumes 9.2 SCSI signal lines active 100 % of the time.

- a single terminated system (no external SCSI devices) requires a worst case of 350 mA of current per SCSI byte transfer. This calculation assumes 13.2 SCSI signal lines active 100 % of the time.

- a double terminated bus requires a worst case of 700 mA of current per SCSI byte transfer. This calculation assumes 13.2 SCSI signal lines active 100 % of the time.

- a single terminated system (no external SCSI devices) requires as a worst less than 5.002 mA average current. This calculation assumes 13.2 SCSI signal lines active 100 % during a SCSI byte transfer, a byte transmission duration of 1.67 µs and a transfer rate of 2 Kbytes every 10 minutes.

- a double terminated system (no external SCSI devices) requires as a worst less than 10.004 mA average current. This calculation assumes 13.2 SCSI signal lines active 100 % during a SCSI byte transfer, a byte transmission duration of 1.67 µs and a transfer rate of 2 Kbytes every 10 minutes.

It is obvious from the above numbers that the only significant component of the SCSI bus power consumption is the voltage regulator quiescent current specification.

This number can be also significantly lowered by using a regulator shut-down mode in a similar fashion with the customary hard-drive shut-down mode on present portable devices.

In order to be able to implement such a control, the voltage regulator for the terminator requires a shut-down control. On the other hand it is not possible to control the external terminator in a similar manner.

An alternate solution which will control both terminators is to be able to stop supplying TERMPWR from the portable device to the bus.

Such a feature can also be used to negotiate power consumption between two portable devices in "disk mode".

4.5. Power sensing:

When a resistive type terminator is connected to a bus whose TERMPWR is supplied by a portable device a significant power drain will occur. The

average current consumption will be about 150 mA instead of the expected maximum of 10 mA. In this circumstance the system shall display an appropriate warning message for the user.

A solution to this problem would be to sense the current used by the far end terminator and compare it with the current used by the local terminator. If the first is significantly larger than the second it can be safely assumed that the far end terminator is a resistive type.