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Technical Note DV15

SCSI Termination

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This Technical Note discusses SCSI termination on the Macintosh, including the new rules of termination that are necessary with the advent of the high-speed Macintosh IIx.

Updated: [May 01 1992]

Why Is the Terminator After Sarah Connor?

One of the features of the now obsolete Macintosh IIx was a new SCSI chip that provides SCSI data transfer rates up to 3 megabytes per second, faster than any Macintosh model prior to the Macintosh Quadra. To achieve these transfer rates, components on the Macintosh IIx logic board were smaller and faster, requiring different termination configurations from those of previous Macintosh models.

The Macintosh IIx requires the use of a combination of the following three new termination parts. Users need to use these parts instead of existing SCSI termination parts to configure a Macintosh IIx with SCSI devices. The Macintosh Quadra does *not* require special termination as the Macintosh IIx does, but it does have some special rules of its own and these are discussed in a later section.

Apple SCSI Cable Terminator II: The Apple SCSI Cable Terminator II is a revised external terminator for the Macintosh IIx. All finished goods Macintosh IIx systems ship with this terminator in the box. It is easily recognized because of the black color. Under no circumstances should one use more than a single Apple SCSI Cable Terminator II on an external SCSI chain--doing so may damage the logic board.

Internal SCSI Termination Block: The Internal SCSI Termination Block provides internal termination resistance for Macintosh IIx systems without internal hard drives. All finished goods systems shipping without internal hard drives have the Internal SCSI Termination Block installed.

Internal SCSI Filter: The Internal SCSI Filter provides termination capacitance for internal Macintosh IIx hard drives that shipped prior to March 19, 1990. All finished goods systems shipping without internal hard drives have the Internal SCSI Filter installed.

The new termination configurations are simple, and you can remember them with a single rule: Macintosh IIx systems with external SCSI chains require a terminator at both ends of the SCSI chain. One is internal to the system, while the second is external, located at the end of the chain.

The reason for the new terminator is that on the Macintosh IIx and future hardware, the SCSI controller chip is a 2 micron part, which makes it very fast. One of the results of this speed is that the chip now thinks that glitches in the /REQ line are real signals. This problem is not likely to occur on all of the Macintosh IIx machines, but if you have a problem with your hard drive not getting mounted on the new machine, you should try a new terminator first. The symptom is more likely to show up on machines with several (three or more) external SCSI devices attached to the computer and long strands of SCSI cables. Figure 1 illustrates the old-style terminator with the signal showing the spike propagation.

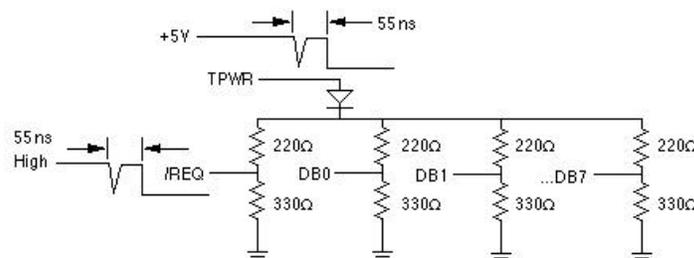


Figure 1 - Old-Style Terminator (Gray)

Basically, if a majority of the data lines change state at once, there is a sudden drain on the TPWR line, which is resistively coupled to all of the lines, including the /REQ line. This sudden drain causes a spike in the line, and this spike is propagated into the /REQ line and to the SCSI controller chip. The newer SCSI controller chip in the Macintosh IIfx interprets this spike as a /REQ signal and starts reading data from the data lines; however, since the data lines need 55 ns to settle, the data that the controller chip reads is junk.

All internal hard disk drives sold by Apple with the Macintosh IIfx and later machines have the Internal SCSI Filter installed; however, most third-party drives do not yet have this filter installed and must be modified by a qualified service provider to work correctly with the Macintosh IIfx.

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How to Stop the Terminator

Since the problem is caused by a drop in the TPWR line, the fix is to smooth out the line. One need only add a 2.2 uF capacitor and a 0.01 uF ceramic capacitor as illustrated in Figure 2. These capacitors act like a battery and provide a little extra current when it is needed. This extra current results in a smoother signal, which the SCSI controller chip does not interpret as a /REQ signal.

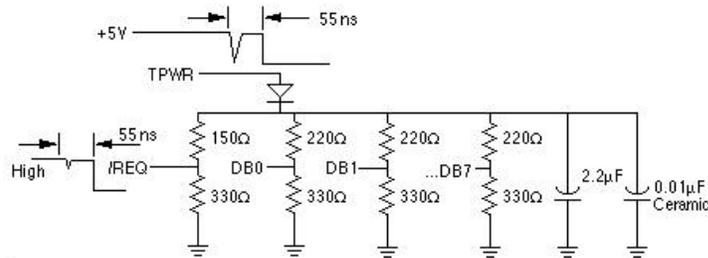


Figure 2 - New-Style Terminator (Black)

This new type of filter is only for internal hard disk drives. The Macintosh IIfx ships with a new and improved external terminator (black in color), so hard drive manufacturers do not need to worry about external termination. Apple also ships an internal filter with every Macintosh IIfx that handles the capacitance problem. This internal terminator has two parts. The first is the resistors for the terminator. This part should already be installed on all internal hard disk drives, so it is used only for CPUs that do not have an internal hard drive. The second part of the internal terminator is the capacitor filter. This filter should be installed on the hard disk drive end of the SCSI internal cable. If your hard drive implements the new capacitors, you can, and should, install the capacitor filter--you cannot have too much capacitance.

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External Termination

If you manufacture an external SCSI device, **do not** include termination in it. The only terminator that should be outside a Macintosh IIfx is Apple's external terminator, and it should be at the end of the SCSI chain. If you make a SCSI terminator, it is most likely incompatible and may cause damage to the hardware or the data. If your SCSI device cannot connect with Apple's terminator, then you should provide an adapter that allows your SCSI device to attach to the provided terminator.

Note: A notice in the Macintosh IIfx finished goods box instructs customers to return self-terminating SCSI devices to the service provider to disable termination.

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You're Terminated

Not every Macintosh IIfx owner is likely to experience this inconvenience, but a few will. If your customers report problems that appear to be termination related, then the first possible solution is to fix the terminator (for external devices) or implement the filter (for internal devices). If you manufacture an external SCSI device that is self-terminating, you should remove it. This incompatibility will continue with future hardware products and could even surface on the Macintosh IIfx.

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Macintosh Quadra Termination

Proper SCSI termination is critical for correct operation of the Macintosh Quadra computers, just as with all Macintosh computers. The Macintosh Quadra computers require external SCSI termination at the end of the device chain, either supplied by the last device in the chain, or using a standard Apple SCSI Cable Terminator (M0332LL/A). Note that this is the standard SCSI terminator, *not* the black terminator required by the Macintosh IIfx (although the black IIfx terminator may be used as well).

Termination is generally supplied at the factory for use with internal SCSI devices. Some early floppy-only Macintosh Quadra 700 units may not have internal termination, so users who attach external SCSI devices (without having added an internal SCSI device) may need to double terminate their external SCSI chain. Properly terminated floppy-only Macintosh Quadra 700 units will have a terminator inserted into the motherboard internal SCSI cable connector. Users of internal SCSI devices must, of course, remove this terminator before connecting their internal SCSI device.

The Macintosh Quadra 900 is the first Macintosh computer to provide a separate, internal SCSI bus. This bus is physically isolated from the external SCSI bus and must also be properly terminated. The cable provided with the machine includes all the termination necessary, so *all* internal devices must have SCSI termination removed before connecting to the internal Macintosh Quadra 900 SCSI cable. If extra termination is supplied it may cause intermittent hardware failures as well as physical damage to the device.

Developers who ship terminated SCSI devices for possible internal use in the Macintosh Quadra 900 must provide users with instructions for removing the termination.

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PowerBook Termination

There are two important points that one must be aware of when it comes to termination on the Macintosh PowerBook computers. The first point is that termination on the PowerBook computers is supplied by the internal hard drive. PowerBook computers depend on the internal hard drive to supply termination so that they are properly terminated when placed in SCSI disk mode. In SCSI disk mode, the PowerBook is just another hard drive in the SCSI chain. This is because all other subsystems have been shut down. Because the PowerBook is internally terminated by the hard drive, it must always be at the *end* of the SCSI chain. If you have two PowerBook computers and other devices on the chain, one PowerBook must be the very last device in the SCSI chain (in SCSI disk mode) and the second PowerBook must be at the beginning of the chain (Initiator). This also means that it is not possible to have more than one PowerBook on a single SCSI bus in SCSI disk mode.

The second point to be aware of is that the PowerBook computers do not supply termination power. They rely on external devices to provide termination power on the bus. If there are other devices on the bus that provide termination power, we recommend that the connection to the first device out of the PowerBook be terminated. It is not required that you do this. This ensures that the cable is as close to ideal as possible.

Because termination power is not supplied by the PowerBook computers, we also advise that you do not have powered off devices on the bus. This is true not only for the PowerBook computers but for all Macintosh products. It has been found that having devices powered off and on the bus causes degradation to performance and signals. A termination problem can cause incorrect data to be passed during a SCSI transfer. Therefore, the rule is this: Do *not* have powered off devices connected to the bus. Also, do not power on a device connected to the bus after booting, and never connect one while the system is on.

If you still have troubles with the PowerBook after following the termination rules, be sure to check that you have proper cables and that the other devices on the bus also follow termination rules. Some devices are *not* following the description of how Apple's devices work, and following the guidelines of the Apple cable guide does not apply with non-Apple devices. If you have non-Apple cables, be sure that they meet Apple SCSI specifications. It is possible that other devices on the bus and improper cabling are what is causing trouble for you.

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PowerBook Duo Termination

Unlike the other Macintosh PowerBook computers, the PowerBook Duo models do not rely on an external device to provide termination power. Both the Deskbar and the DuoDock provide termination power to the bus. They are actively terminated, which means that they provide termination power and have the best architecture for termination of any other device on the bus.

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Termination Outlined for Each Macintosh

Below is a table that outlines the termination specifics of all Macintosh models (current as of this writing). It also describes whether termination power (TPWR) is supplied for either the internal or external SCSI bus, depending on which is present (one or both). The column on the far right describes which terminator is required when the CPU (currently PowerBook computers only) are in SCSI disk mode and functioning as an external storage device on the external SCSI chain of a Macintosh. Below the table is an ASCII representation of the active termination concept, which is new as of the Macintosh IIx, Macintosh Centris, and Macintosh Quadra models.

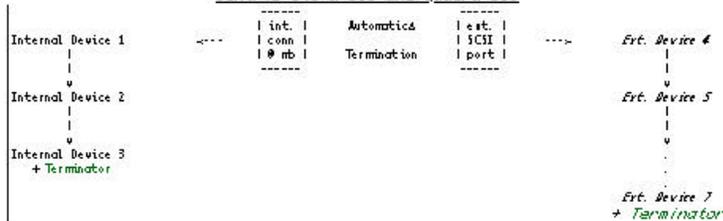
CPU Name	Additional Termination Needed for Separate Internal Drive?		Internal Device or Bus: TPWR Supplied?	External Device or Bus: TPWR Supplied?	Terminator Type for External Bus	For SCSI Disk Mode?
	Internal Drive?	Internal Drive?	Internal Device or Bus: TPWR Supplied?	External Device or Bus: TPWR Supplied?	Terminator Type for External Bus	For SCSI Disk Mode?
Macintosh Plus	no	no	No	No	GRAM	no
Macintosh SE	no	Yes	Yes	Yes	GRAM	no
Macintosh SE/30	no	Yes	Yes	Yes	GRAM	no
Macintosh Classic	no	Yes	Yes	Yes	GRAM	no
Macintosh Classic II	no	Yes	Yes	Yes	GRAM	no
Performa 200	no	Yes	Yes	Yes	GRAM	no
Macintosh Color Classic	no	Yes	Yes	Yes	GRAM	no
Macintosh II	no	Yes	Yes	Yes	GRAM	no
Macintosh IIfx	no	Yes	Yes	Yes	GRAM	no
Macintosh IIfx	no	Yes	Yes	Yes	GRAM	no
Macintosh IIx	no	Yes	Yes	Yes	GRAM	no
Macintosh IIx	no	Yes	Yes	Yes	GRAM	no
Macintosh IIfx	Automatic*	Yes	Yes	Yes	GRAM	no

CPU Name	Additional Termination Needed for Separate Internal Bus?		Internal Device or Bus: TPWR Supplied?	External Bus: TPWR Supplied?	Terminator Type for External Bus	For SCSI Disk Mode?
	Internal Bus?	Internal Bus?	Supplied?	Supplied?	External Bus	Mode?
Macintosh IIvi	Automatic*	Yes	Yes	Yes	Gray	n/a
Performa 600	Automatic*	Yes	Yes	Yes	Gray	n/a
Macintosh Centris 650	Supplied on last device †	Yes	Yes	Yes	Gray	n/a
Macintosh LC	nb	Yes	Yes	Yes	Gray	n/a
Macintosh LC II	nb	Yes	Yes	Yes	Gray	n/a
Macintosh LC III	nb	Yes	Yes	Yes	Gray	n/a
Macintosh LC 520	Supplied by internal hd	Yes	Yes	Yes	Gray	n/a
Performa 400	nb	Yes	Yes	Yes	Gray	n/a
Macintosh Centris 610	Supplied on last device †	Yes	Yes	Yes	Gray	n/a
Macintosh Quadra 700	Supplied on internal device	Yes	Yes	Yes	Gray	n/a
Macintosh Quadra 800	Supplied on last device †	Yes	Yes	Yes	Gray	n/a
Macintosh Quadra 900	Supplied on cable	Yes	Yes	Yes	Gray	n/a
Macintosh Quadra 950	Supplied on cable	Yes	Yes	Yes	Gray	n/a
Macintosh Portable	nb	No	No	No	Gray	n/a
Macintosh PowerBook 100	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 140	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 145	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 145b	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 160	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 165c	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 170	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 180	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook 180c	nb	Yes	No	No	Gray	Determined by Mac
Macintosh PowerBook Duo 210	nb	Yes	No	No	Gray	nb
Macintosh PowerBook Duo 230	nb	Yes	No	No	Gray	nb
DuoDock	nb	Yes	Yes	Yes	Gray	nb

* "...an active termination circuit automatically terminates the [internal device] when it is the last device on the bus. If a terminated device is attached to the external SCSI port, the internal termination is deactivated." --p. 18 of Macintosh IIvx, IIvi, Performa 600 Developer Note.

* "...an active termination circuit automatically terminates the [internal device] when it is the last device on the bus. If a terminated device is attached to the external SCSI port, the internal termination is deactivated." --p. 18 of Macintosh IIvx, IIvi, Performa 600 Developer Note.

Location of SCSI bus terminators for Centris 610 & 650 and Quadra 800



"The Macintosh Centris 610, Macintosh Centris 650, and Macintosh Quadra 800 computers include a new feature that automatically provides the proper termination when no external device is connected. . . . When one or more devices are connected, the circuitry detects the external termination during system reset and disconnects the termination on the logic board." --p. 19 of Macintosh Centris 610, Macintosh Centris 650, and Macintosh Quadra 800 Computers Developer Note.

Termination on Apple Printers

The Apple LaserWriter IIf and IIG and Apple LaserWriter Pro 630 printers require the same terminator as the IIfx--Apple SCSI Terminator II (M5871G/A)--when connecting up to seven external SCSI storage devices (which are for storing downloadable fonts, *not* for connecting the printer to a Macintosh).

The LaserWriter Pro 630 is the first Apple LaserWriter that can also take a single internal SCSI hard drive (for font storage) in addition to six (for a total of seven) external hard drives. Any internal drive must *not* be terminated internally since permanent termination is supplied on the motherboard. This termination cannot be removed. The internal hard drive's SCSI ID is hardwired to the motherboard; it is ID 6. Since this drive also counts as one of the seven total devices allowed on the bus, any external device must not have SCSI ID 6 when the internal drive is present. If no internal hard drive is present, SCSI ID 6 is still reserved--external SCSI devices may not use ID 6 even if no internal hard drive is present. The end of the external SCSI chain must also be terminated, whether an internal drive is present or not.

The LaserWriter Pro 630 does supply termination power (TPWR) to the internal device but *not* to external devices. The LaserWriter IINTX, IIf, and IIG printers do not supply TPWR.

The Apple LaserWriters IINTX and IINTXJ require the standard, gray Apple terminator (MO332LL/A) when connecting external storage devices.

The Apple Personal LaserWriter SC and IISC printers as well as the Apple Color Printer are SCSI devices themselves; that is, rather than being networkable printers, they connect directly to the SCSI bus of the Macintosh. These printers require the standard, gray Apple terminator, unless you're using them with a Macintosh IIfx, in which case you should use the black terminator. In other words, for the SCSI printers (only), the termination requirements are dictated by the Macintosh since the printer functions as just another SCSI device on the Macintosh computer's SCSI bus.

Below is a chart that will help you determine the termination characteristics of *all* of Apple's printers. Printers with no SCSI implementation are included just for the sake of completeness, so those characteristics that do not apply will list n/a, for "not applicable," under the appropriate heading(s).

Printer Name	Direct-Connect SCSI?	External SCSI Port (for AUI)?	Terminator Type	TPWR Supplied?	Reserved SCSI ID?
LaserWriter	No	No	na	na	na
LaserWriter Plus	No	No	na	na	na
LaserWriter IIcx	Yes	No	External by Mac	Yes	Reserved
LaserWriter IINT	No	No	na	na	na
LaserWriter IINTX	No	Yes	Gray	No	?
LaserWriter IINTX2	No	Yes	Gray	No	?
LaserWriter II	No	Yes	Black	No	?
LaserWriter IIx	No	Yes	Black	No	?
LaserWriter Pro 600	No	No	na	na	na
LaserWriter Pro 650	No	Yes	Black	Internal - Yes External - No	6 & 7
LaserWriter Select III	No	No	na	na	na
LaserWriter Select IIIx	No	No	na	na	na
Personal LaserWriter SC	Yes	No	External by Mac	Yes	Reserved
Personal LaserWriter LX	No	No	na	na	na
Personal LaserWriter III	No	No	na	na	na
Personal LaserWriter IIIE	No	No	na	na	na
Apple Color Printer	Yes	No	External by Mac	No	Reserved
StyleWriter	No	No	na	na	na
StyleWriter II	No	No	na	na	na

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References

Macintosh Technical Note "Fear No SCSI"

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Change History

- 01-April-1990 Originally written.
- 01-May-1992 Added a discussion of Macintosh PowerBook and PowerBook Duo termination and termination for Apple printers.

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