Technical Note HW25

Macintosh Memory Configurations

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This Technical Note describes the different possible memory configurations of all models of the Macintosh family that use Single In-line Memory Modules (SIMMs) as well as the non-SIMM memory upgrade options of the Macintosh Portable and Macintosh Classic. (Special thanks to Brian Howard for the Macintosh Plus and original SE drawings, and for the inspiration for the other drawings.) This Note also describes the obstacles to using four megabit (Mbit) DRAM SIMMs in Apple Macintosh products to date. **Changes since November 1991:** Corrected error on the RAM configuration chart (page 2); additional information added to Quadra 900 section (page 15).

Developer Technical Support receives numerous questions about the many different possible configurations of RAM on the different Macintosh models, so we'll attempt to answer these questions in this Technical Note, as well as to provide a showcase for some outstanding Macintosh Plus and SE artwork by Apple engineer Brian Howard. Interested readers should refer to the *Guide to the Macintosh Family Hardware*, Second Edition, which contains much more detail on the memory configurations and specifications for all Macintosh models released to date. For information on the newer Macintosh models not mentioned in the *Guide to the Macintosh Family Hardware,* please refer to the companion developer notes for those particular products.

[Nov 01 1987]

RAM Configuration Chart

Caveat:
The upper physical RAM totals expressed here assume the use and compatibility of 4 and 16 MB SIMMs. Since Apple has not yet thoroughly tested SIMMs larger than 1 MB with our Macintosh line, these upper limits should be considered theoretical. At this point Apple cannot claim that these SIMM sizes will work, nor can we

guarantee any information in this Technote that pertains to the use of 4 and 16 MB SIMMs (read: use them at your own risk). All numbers are expressed in terms of megabytes (MB) unless otherwise noted.

	Permanent RAM	No of SIMM slots	Allowable SIMM sizes	Physical RAM Totals	Req. Speed	TN Page
Plus	0	4	256K,1	512K,1,2,2.5,4	150 ns	3,4
SE	0	4	256K,1	512K,1,2,2.5,4	150 ns	3,5,6
Classic	1	2*	256K,1	1,2,2.5,4	150 ns	3,8
Classic II‡	2	2	1,2,4	2,4,6,10	100 ns	17
SE/30	0	8	256K,1,4,16	1,2,4,5,8...128†	120 ns	7,9
II	0	8	256K,1,4,16††	1,2,4,5,8...68†	120 ns	7,9
IIx	0	8	256K,1,4,16	1,2,4,5,8...128†	120 ns	7,9
IIcx	0	8	256K,1,4,16	1,2,4,5,8...128†	120 ns	7,12
LC‡	2	2	1,2,4,16	2,4,6,10	100 ns	8,10
IIsi‡	1	4	256K,512K,1,2,4,16	1,2,3,5,9,17..65	100 ns	8,10
IIci‡	0	8	256K,1,4,16	1,2,4,5,8,16, 10,17,20,32...128	80 ns	10,12
Portable	1	0**	n/a	1,2,3,4,5,6,7,8,9***	100 ns	11,12
Portable (backlit)	1	0**	n/a	1,2,3,4,5,6,7,8***	100 ns	
IIfx‡	0	8	1,4,16	4,8,16,20,32...128	80 ns	13,14
Quadra 700‡	4	4	1,4,16	4,8,20...68	80 ns	16
Quadra 900‡	0	16	1,4,16	4,8,12,16,20, 24,28,32,36, 40,48,52,64..256	80 ns	15
PowerBook 100	2	0**	n/a	2,4,6,8	n/a	19
PowerBook 140‡	2	0**	n/a	2,4,6,8	n/a	18
PowerBook 170‡	2	0**	n/a	2,4,6,8	n/a	18

*The Macintosh Classic has 1 MB of RAM soldered onto the motherboard. Additional RAM can be added by using an expansion card. Apple Macintosh Classic 1 MB Memory Expansion Card has 1 MB of additional RAM and two SIMM connectors.

**The Macintosh Portable and the PowerBook computers allow you to add RAM by using an expansion card. These expansion cards can have from 1 MB to 4 MB of memory for the Portable, 1 MB to 3 MB for the backlit Portable, and 2, 4, or 6 MB for the PowerBook line.

***If the PDS slot is used for other peripherals, then the maximum amount of RAM (by using a RAM expansion card) is 5 MB for the Macintosh Portable, and 4 MB for the backlit Macintosh Portable.

‡These systems have ROMs that are capable of 32-bit addressing (when using the appropriate system software, such as System 7 or A/UX).

†The Macintosh II, IIx, IIcx, and SE/30 can benefit from larger SIMM sizes and address more than 8 MB of RAM by using either A/UX or the 32-bit addressing software solution called MODE32 ™ in conjunction with System 7. This will allow you to address up to 128 MB on the IIx, IIcx, and SE/30, and up to 68 MB on the Macintosh II (four 1 MB SIMMs in Bank A, four 16 MB SIMMs in Bank B). If you use SIMMs larger than 1 MB on the Macintosh II or IIx, you must have a PMMU and special SIMMs with PAL ™ logic on them. Please refer to pages 7 and 20 of this Tech Note for more information on these SIMMs. MODE32, by Connectix, has been made available at no charge to all Apple customers. For more information about MODE32, please contact Apple at 1-800-776-2333.

††SIMMs greater than 1 MB can only be in SIMM Bank B. Please refer to Page 7 for more Macintosh II information.

Warning:
Because the video monitor is built in, there are dangerous voltages inside the cases of the Macintosh Plus, SE, Classic, Classic II, and SE/30 computers. The video tube and video circuitry may hold dangerous charges long after the computer's power is turned off. Opening the case of these computers requires special tools and may invalidate your warranty. Installation of RAM in the SIMM sockets in these computers should be done by qualified service personnel only.

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Macintosh Plus

The Macintosh Plus has the following possible configurations (see Figure 1):

512K, using two 256 Kbit SIMMs

1 MB, using four 256 Kbit SIMMs

2 MB, using two 1 Mbit SIMMs

2.5 MB, using two 1 Mbit SIMMs and two 256 Kbit SIMMs

4 MB, using four 1 Mbit SIMMs

It is important to place the SIMMs in the correct location when using a combination of SIMM sizes, as in the 2.5 MB example, and to make sure the right resistors are cut. Refer to Figure 1 for the correct location of the SIMMs and size resistors.

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Macintosh SE

The Macintosh SE configurations (the original motherboard as well as the revised motherboard with a memory jumper

selector) are the same as the Macintosh Plus, except physical locations on the motherboard are different. In addition, memory configurations with only two SIMMs (for example, 512K and 2 MB) use slots 3 and 4 on the revised SE motherboard instead of slots 1 and 2 like the original motherboard and Macintosh Plus. Refer to Figures 2 and 3 for the correct locations and settings.

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Macintosh Classic

The Macintosh Classic has the following possible configurations (see Figure 4):

1 MB, using eight 128 Kbit DRAMs soldered to the motherboard

2 MB, using the memory expansion card and setting the jumper to "SIMM NOT INSTALLED"

2.5 MB, using two 256 Kbit SIMMs on the memory expansion card and setting the jumper to "SIMM INSTALLED"

4 MB, using two 1 Mbit SIMMs on the memory expansion card and setting the jumper to "SIMM INSTALLED"

When adding SIMMs to the memory expansion card, use either two 256 Kbit or two 1 Mbit parts rated at 120 ns or faster.

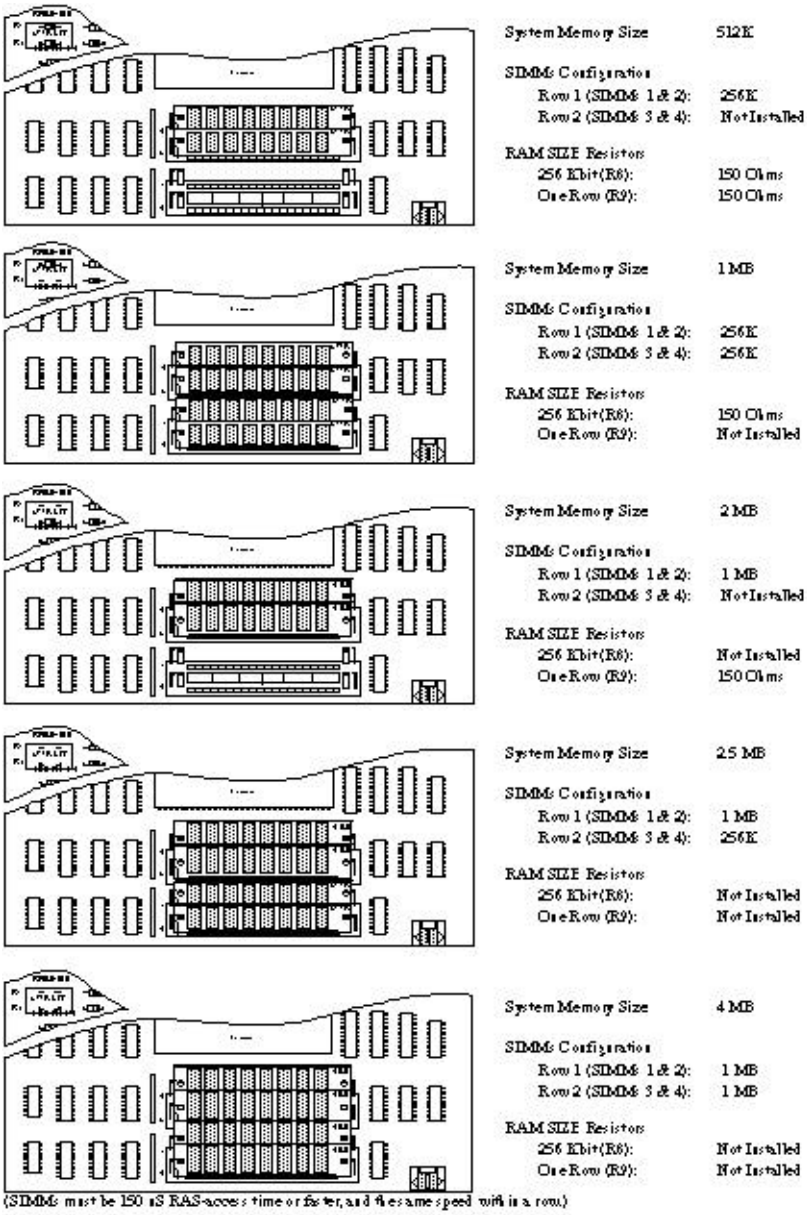
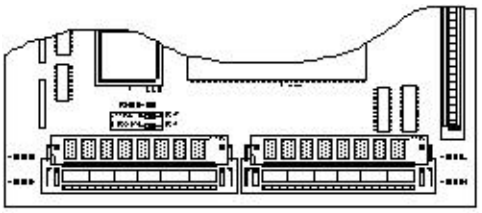


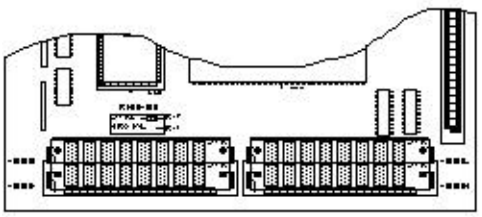
Figure 1–Macintosh Plus Memory Configurations



System Memory Size 512K

SIMMs Configuration
Row 1 (SIMMs 1 & 2) 256K
Row 2 (SIMMs 3 & 4) Not Installed

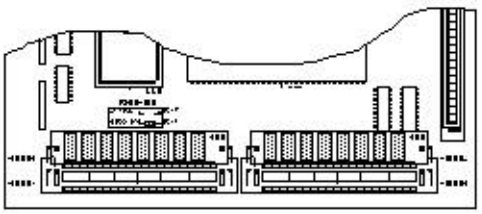
RAM SIZE Resistors
256 Kbit (RS5) 150 Ohms
One Row (RS6) 150 Ohms



System Memory Size 1 MB

SIMMs Configuration
Row 1 (SIMMs 1 & 2) 256K
Row 2 (SIMMs 3 & 4) 256K

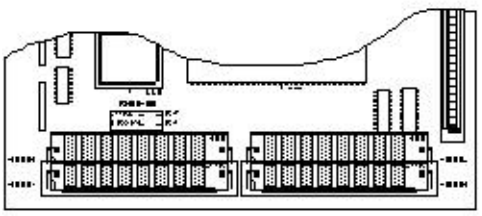
RAM SIZE Resistors
256 Kbit (RS5) 150 Ohms
One Row (RS6) Not Installed



System Memory Size 2 MB

SIMMs Configuration
Row 1 (SIMMs 1 & 2) 1 MB
Row 2 (SIMMs 3 & 4) Not Installed

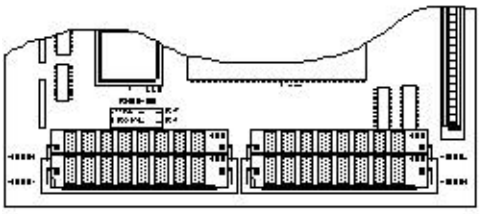
RAM SIZE Resistors
256 Kbit (RS5) Not Installed
One Row (RS6) 150 Ohms



System Memory Size 2.5 MB

SIMMs Configuration
Row 1 (SIMMs 1 & 2) 1 MB
Row 2 (SIMMs 3 & 4) 256K

RAM SIZE Resistors
256 Kbit (RS5) Not Installed
One Row (RS6) Not Installed



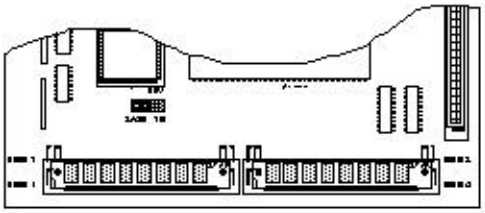
System Memory Size 4 MB

SIMMs Configuration
Row 1 (SIMMs 1 & 2) 1 MB
Row 2 (SIMMs 3 & 4) 1 MB

RAM SIZE Resistors
256 Kbit (RS5) Not Installed
One Row (RS6) Not Installed

(SIMMs must be 150 nS RAS-access time or faster, and the same speed within a row)

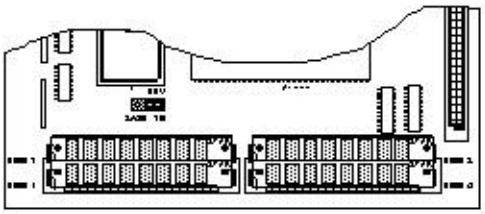
Figure 2–Macintosh SE Memory Configurations



System Memory Size 512K

SIMMs Configuration
Row 1 (SIMMs 1 & 2): Not Installed
Row 2 (SIMMs 3 & 4): 256 K

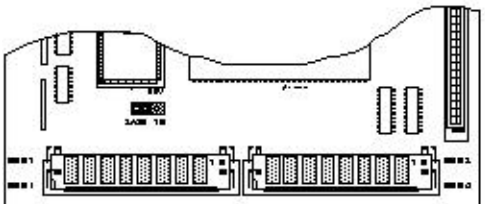
Jumper on 2/4M



System Memory Size 1 MB

SIMMs Configuration
Row 1 (SIMMs 1 & 2): 256 K
Row 2 (SIMMs 3 & 4): 256 K

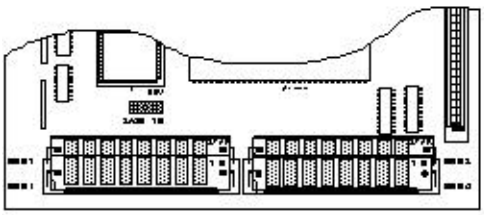
Jumper on 1M



System Memory Size 2 MB

SIMMs Configuration
Row 1 (SIMMs 1 & 2): Not Installed
Row 2 (SIMMs 3 & 4): 1 MB

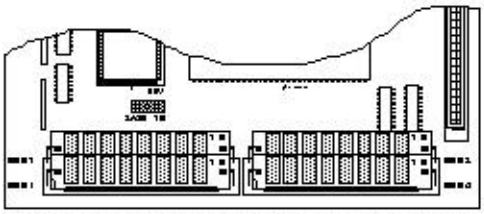
Jumper on 2/4M



System Memory Size 2.5 MB

SIMM Configuration
Row 1 (SIMMs 1 & 2): 256K
Row 2 (SIMMs 3 & 4): 1 MB

Jumper off



System Memory Size 4 MB

SIMM Configuration
Row 1 (SIMMs 1 & 2): 1 MB
Row 2 (SIMMs 3 & 4): 1 MB

Jumper off

(SIMMs must be 150 nS RAS-access time or faster, and the same speed within a row.)

Figure 3–Macintosh SE (with jumper) Memory Configurations

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Macintosh SE/30, II, IIx, and IIcx

Since these machines use a 32-bit data bus with eight-bit SIMMs, you must always upgrade memory in four SIMM chunks. The eight SIMM connectors are divided into two banks of four SIMM slots, Bank A and Bank B.

On the Macintosh SE/30, Bank A is located next to the ROM SIMM while Bank B is next to the 68882 coprocessor. On the Macintosh II and IIx, Bank A is the bank closest to the edge of the board, while on the Macintosh IIcx, Bank A is the bank closest to the disk drives and power supply. Refer to Figure 5 for the proper locations of Banks A and B on the SE/30, II, and IIx, and refer to Figure 6 for the proper locations on the IIcx.

Unlike the Macintosh Plus and the Macintosh SE, the Macintosh II and IIx have no resistors to cut and no jumpers to set; you need only install the SIMMS in the correct banks and you'll be up and running. You can implement the following configurations:

1 MB, using four 256 Kbit SIMMs in Bank A

2 MB, using eight 256 Kbit SIMMs in Banks A and B

4 MB, using four 1 Mbit SIMMs in Bank A

5 MB, using four 1 Mbit SIMMs in Bank A and four 256 Kbit SIMMs in Bank B

8 MB, using eight 1 Mbit SIMMs in Banks A and B >8 MB: see the 32-bit addressing information below

Again, it is important to make sure the right size SIMMs are in the right Bank; when you are using a combination of SIMMs, the larger SIMMs (in terms of Mbits) must typically be in Bank A (see the exception below). When you are using only four SIMMs, they must be in Bank A as well.

32-Bit Addressing With the Macintosh SE/30, II, IIx, and IIcx

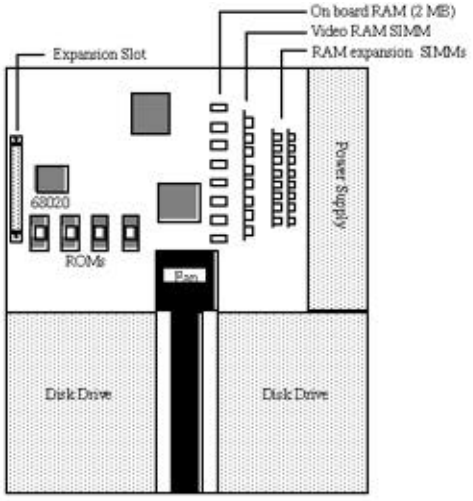
The Macintosh SE/30, II, IIx, and IIcx ROMs are not capable of 32-bit addressing. These models can overcome this limitation, however, by using the appropriate system software. A/UX is a 32-bit operating system, as is System 7 when used in conjunction with MODE32 or when used on a Macintosh with 32-bit clean ROMs.

To have more than 8 MB of RAM in a Macintosh II or IIx, special 120 ns PAL SIMMs are required. These SIMMs incorporate PAL logic chips that overcome problems caused by the refresh logic on the Macintosh II and IIx. In addition, a PMMU is required on the Macintosh II. Please refer to the end of this Note ("4 MBit DRAMs in Revolt") for more information on this subject.

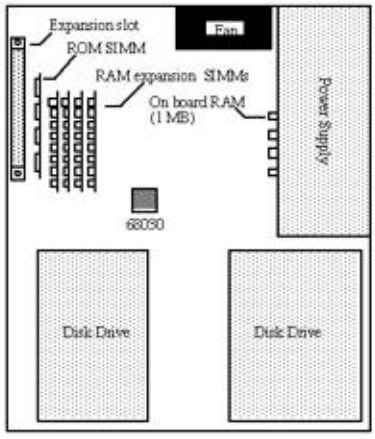
Due to an undocumented feature in the ROM firmware shipped with the original Macintosh II, a Macintosh II with original ROMs is limited to using SIMMs no larger than 1 MB in Bank A. Large SIMMs can only be put in Bank B (that is, 4 and 16 MB SIMMs). Remember that if Bank B is to be used at all, Bank A must be populated first. As a result of this limitation, the largest memory configuration on an unmodified Macintosh II using 1 MB SIMMs in Bank A and 4 MB SIMMs in Bank B is 20 MB. This problem is avoided if you've installed the SuperDrive upgrade kit, which includes a set of Macintosh IIx ROMs. The Macintosh IIx ROMs can handle 4 MB SIMMs, and expect the presence of a SWIM chip in place of the old IWM.

The theoretical maximum memory that a Macintosh SE/30, IIx, IIcx (and II with IIx ROMs) can address is 128 MB using 16 MB SIMMs.

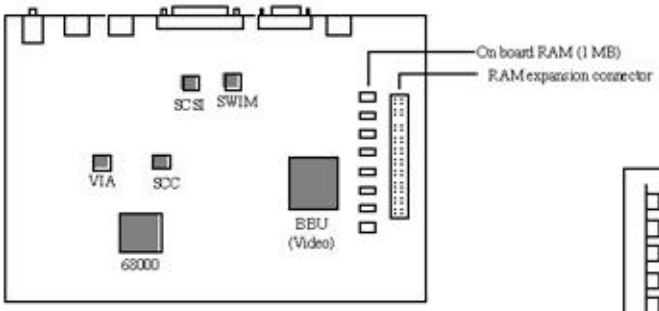
Please remember that the use of large SIMM sizes with the Macintosh hardware line has not yet been tested thoroughly. It is mentioned here for your consideration and should be considered theoretical until we have been able to further test all of these possible configurations.



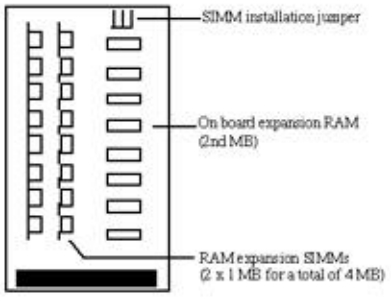
Macintosh LC
(RAM SIMMs must be 100 nS RAS-access time or faster.)



Macintosh IIsi
(SIMMs must be 100 nS RAS-access time or faster.)

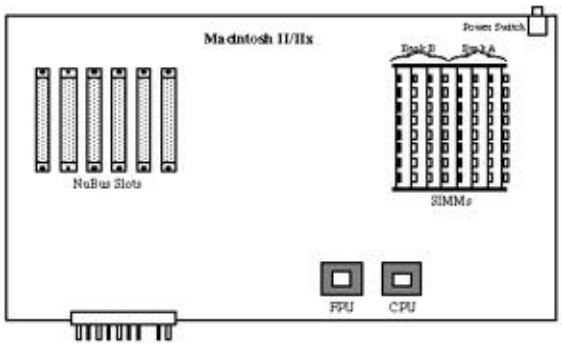


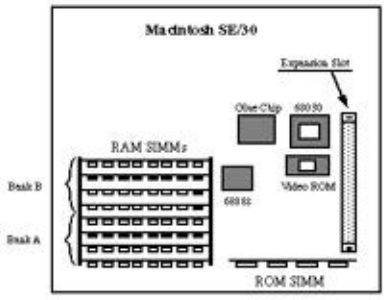
Macintosh Classic
(SIMMs must be 120 nS RAS-access time or faster.)



Macintosh Classic RAM expansion board

Figure 4–Macintosh Classic, LC, and IIsi





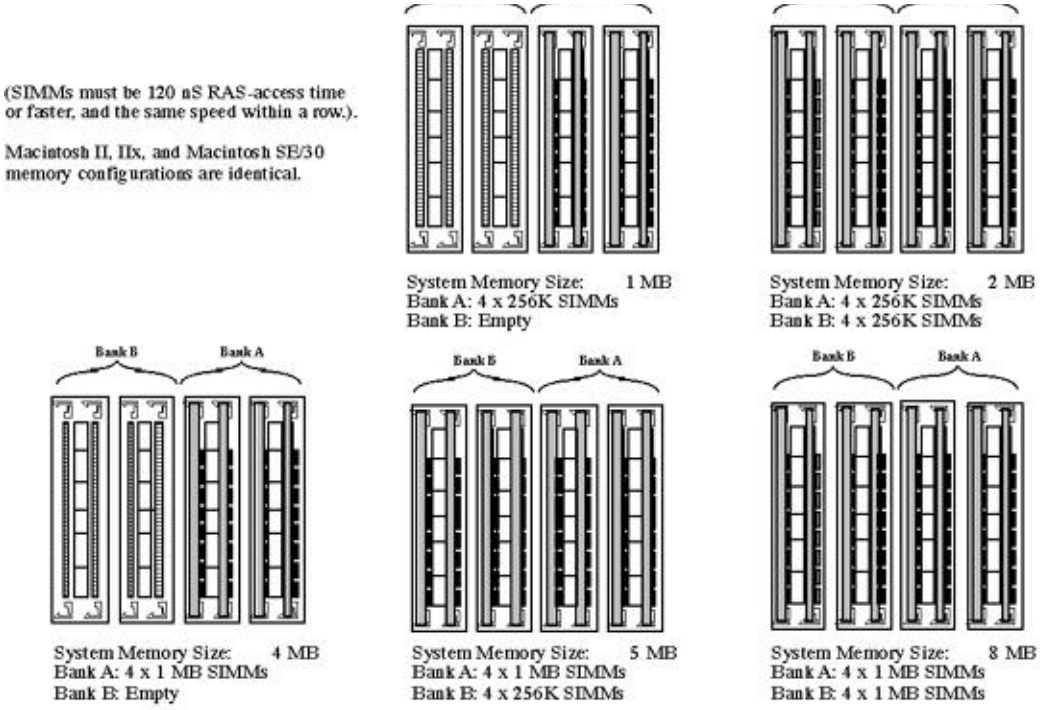


Figure 5–Macintosh SE/30, II, and IIx Memory Configurations

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Macintosh LC

The Macintosh LC uses a 16-bit data bus with 8-bit SIMMs, so upgrades must always be performed two SIMMs at a time. The LC has two SIMM connectors that are used as a single additional RAM bank (see Figure 4) in addition to the 2 MB already soldered to the motherboard. The following memory configurations can be implemented by installing SIMM pairs in this additional bank:

2 MB, using four 1 Mbit x 4 DRAMs soldered to the motherboard

4 MB, using two 1 Mbit SIMMs in the SIMM connectors

6 MB, using two 2 Mbit SIMMs in the SIMM connectors

10 MB, using two 4 Mbit SIMMs in the SIMM connectors

The Macintosh LC requires 100 ns or faster SIMMs.

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Macintosh IIsi

The Macintosh IIsi is similar to the SE/30, II, IIx, and IIcx in that it uses a 32-bit data bus with 8-bit SIMMs; you must always upgrade memory in four SIMM chunks. The IIsi differs in that it only has one SIMM bank instead of two (see Figure 4).

If future 16 Mbit DRAMs are compatible with the current refresh frequency, then the IIsi will support 16 Mbit SIMMs, enabling a RAM configuration of 65 MB (4 x 16 MB + 1 MB). The IIsi requires 100 ns or faster SIMMs.

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Macintosh IIci

The Macintosh IIci motherboard layout is somewhat different from the IIcx, but the location of the RAM SIMMs is unchanged. Bank A is still the bank closest to the disk drives. Refer to Figure 6 for the proper locations of Banks A and B on the IIci.

The IIci has a much improved RAM interface and allows a great deal more freedom when installing SIMMs. Banks A and B are interchangeable, meaning that when mixing two sizes of RAM, the larger SIMMs do not necessarily have to go in Bank A. In fact, for best performance when using on-board video, Apple recommends that the smaller SIMMs be installed in Bank A. Note, however, that if on-board video is used, then RAM **must** be present in Bank A.

The IIci **requires** that SIMMs be 80 ns time or faster and the same speed within a row. You can implement the following memory configurations with 256K and 1 MB SIMMs:

1 MB using four 256 Kbit SIMMs in Bank A or in Bank B

2 MB using eight 256 Kbit SIMMs in Banks A and B

4 MB using four 1 Mbit SIMMs in Bank A or in Bank B

5 MB using four 256 Kbit SIMMs in Bank A and four 1 Mbit SIMMs in Bank B

5 MB using four 1 MBit SIMMs in Bank A and four 256 Kbit SIMMs in Bank A

8 MB using eight 1 Mbit SIMMs in Banks A and B

The 1 MB and 4 MB configurations using only Bank B are not compatible with on-board video, since Bank A must contain memory when using on-board video. The first 5 MB configuration (with 256 Kbit SIMMs in Bank A) is recommended for 5 MB configurations using on-board video.

Parity RAM

Some specially ordered versions of the Macintosh IIci are equipped with a PGC chip and support parity for RAM error detection. These machines require parity RAM. SIMMs for these machines are nine bits wide instead of eight, so there is generally an extra RAM IC on the SIMM. There is no difference in the installation of 256K x 9 or 1M x 9 SIMMs.

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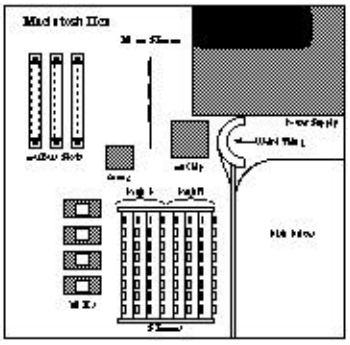
Macintosh Portable

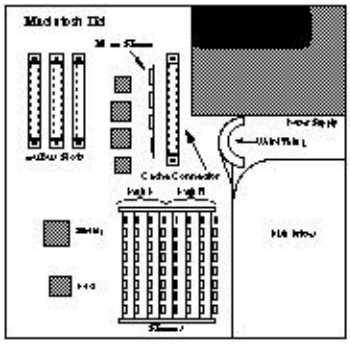
Memory expansion on the Macintosh Portable is different from other members of the Macintosh family since the Portable uses memory expansion cards in place of SIMMs. The base Portable is equipped with 1 MB of RAM on the motherboard and has one RAM expansion card slot. Apple currently supplies a 1 MB memory expansion kit that takes the Portable to 2 MB total. Apple and third-party developers may produce higher-capacity expansion boards (2 MB to 8 MB) in the future.

Since the Portable has only one RAM expansion slot, you may use only one memory expansion board at a time. This limit means that a 1 MB expansion board would have to be completely replaced by a higher-capacity board when it became available.

Total RAM for the Portable will always be 1 MB plus the size of your one RAM expansion board (if installed). Refer to Figure 6 for the location of the RAM expansion slot.



(SIMMs must be 120 nS RAS-access time or faster, and the same speed within a row.)



(SIMMs must be 80 nS RAS-access time or faster, and the same speed within a row.)

Macintosh IIcx memory configurations are identical to the II, IIx, and SE/30.

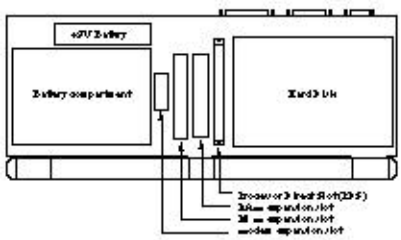


Figure 6–Macintosh IIcx, IIci, and Portable Memory Configurations

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Macintosh IIfx

The Macintosh IIfx motherboard layout has its SIMMs located in the same general area as the IIx, but they are oriented transversely. Bank A is the bank closest to the rear of the machine; bank B is closest to the main processor. Refer to Figure 7 for the proper memory bank locations.

The IIfx has a RAM SIMM interface similar to that of the IIcx, et al.: when you are using a combination of SIMMs, the larger SIMMs (in terms of Mbits) must be in Bank A. When you are using only four SIMMs, they must be in Bank A as well. The description in the *Guide to the Macintosh Family Hardware*, Second Edition inaccurately states the larger SIMMs can be placed in either bank.

The IIfx **requires** that SIMMs be 80 ns RAS-access time or faster and the same speed within a row. You can implement the following memory configurations with 1 and 4 MB SIMMs (256K address-depth SIMMs are not supported):

4 MB using four 1 Mbit SIMMs in Bank A

8 MB using eight 1 Mbit SIMMs in Banks A and B

16 MB using four 4 Mbit SIMMs in Bank A

20 MB using four 4 Mbit SIMMs in Banks A and four 1 Mbit SIMMs in Bank B

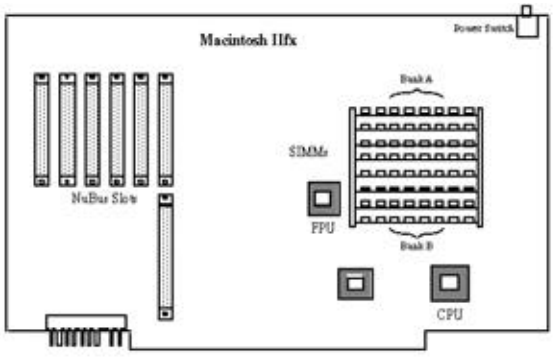
32 MB using eight 4 Mbit SIMMs in Banks A and B

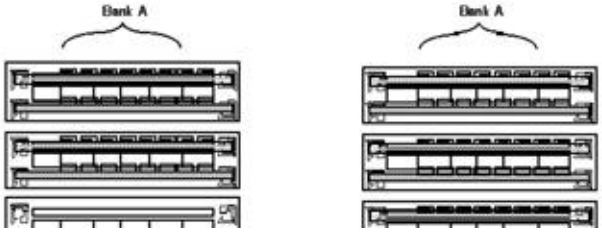
Parity RAM

Parity RAM requirements are as follows: if using 1 MB or 4 MB SIMMs, the RAM speed must be 60 ns. However, the parity circuit programmable array that goes on the motherboard as well as the parity PALs that go on the SIMMs are proprietary to Apple--their equations are not expected to be released to developers. Because of this proprietary design, Apple does not recommend third-party development of parity products.

The IIfx has 64-pin SIMMs, which are different from previous Macintosh models. Developers can request mechanical drawings and electrical specifications of the IIfx RAM SIMM modules from DTS. Please send the request with a mailing address and include the words "IIfx SIMM information request" in the title of the electronic mail request or letter to facilitate handling.

Warning:
To avoid degradation of signal quality, it is critical to adhere to the strict timing parameters of the IIfx and to use a good layout that takes high-speed circuits into account.





(SIMMs must be 80 nS RAS-access time

or faster, and the same speed within a row).

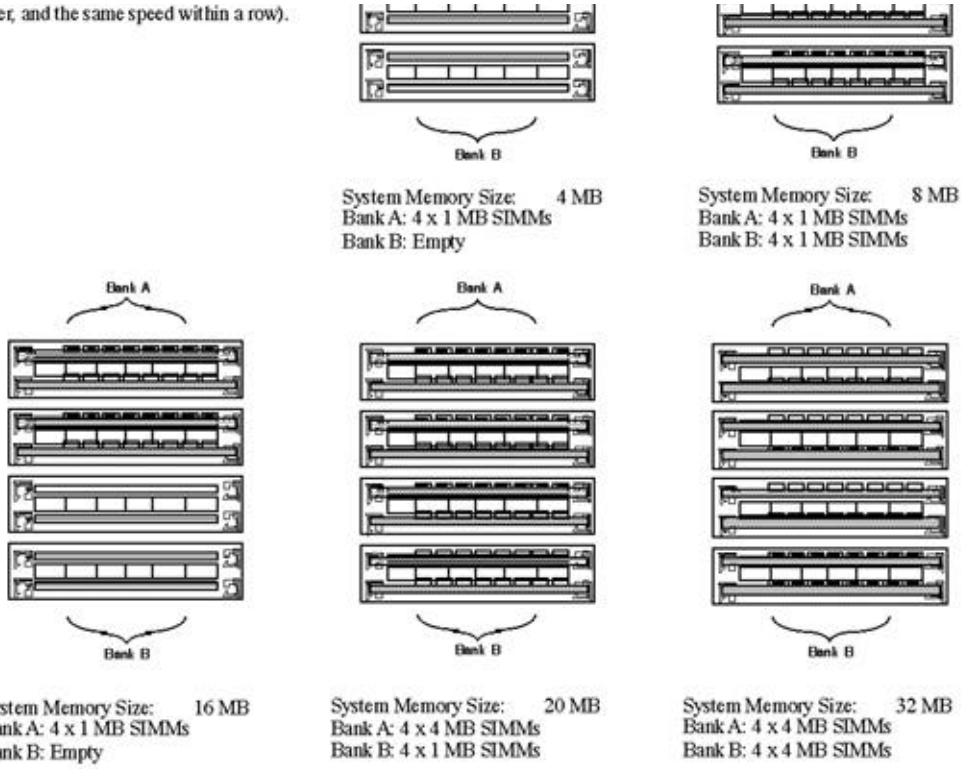


Figure 7–Macintosh IIfx Memory Configurations

Click here for part 2 of the Macintosh Memory Configurations Technote.

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