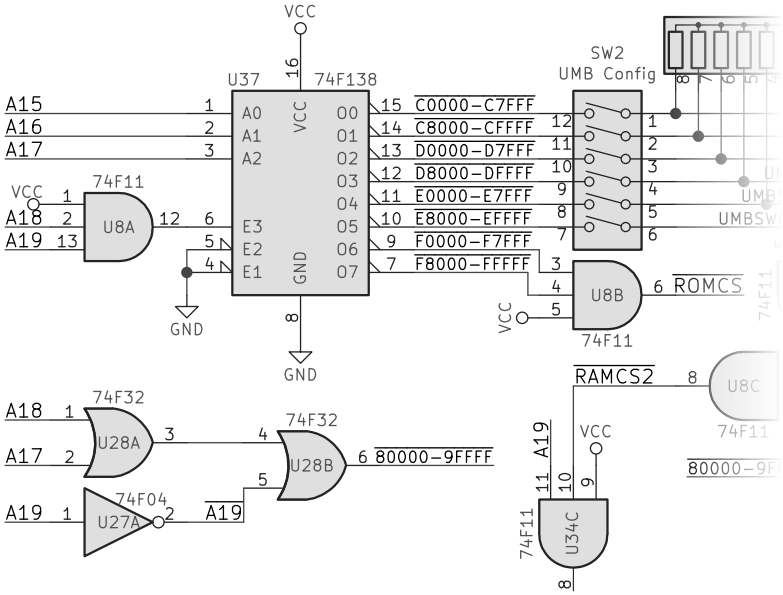
Monotech PCs

NuXT

MicroATX ‘Turbo XT’ Motherboard

User Manual

First edition (July 2019)



Notes:

The schematic of the NuXT, and the System BIOS, are based on various open-source projects by Sergey Kiselev. I highly recommend checking out his projects at www.malinov.com.

This is an open-source project. The source files are at github.com/monotech/NuXT

Terminology:

- **ROM** – Read-only memory: Includes System BIOS and Option ROMs. Also known as firmware.
- **RAM** – Random-access memory: Temporary storage of running program data.
- **Memory** – Often refers to RAM, but can also refer to ROM.
- **Memory address** – the location of some RAM or ROM in the 1MiB memory address space.
- **System ROM** – Located in Upper Memory, the System ROM contains the System BIOS, and optionally, some Option ROMs
- **System BIOS** – The first program that the CPU runs. Initializes the system and boots an OS.
- **Option ROM** – Also known as 'Boot ROM' or 'BIOS Extension'. This is a program stored in ROM that adds more BIOS functions, before the OS loads, allowing extended hardware support.
- **Conventional Memory** – RAM located between 0K and 640K. Usable by DOS and all software.
- **Upper Memory** – RAM or ROM located between 640K and 1024K.
- **High Memory** – RAM above 1024K. Not supported by NuXT; 286 and higher PCs only.
- **UMBs** – Upper memory blocks: RAM that has been placed within upper memory, which can be used by drivers, TSRs, and DOS itself.
- **Hardware resource** – I/O Ports, Memory address ranges, and IRQs are all hardware resources. If multiple devices share one, it can cause a *resource conflict* and instability.

Contents

Features

- IBM PC/XT Compatible Motherboard
- MicroATX form factor. 244 x 185 mm
- Switchable 4.77MHz, 7.16MHz, and 9.55MHz CPU clock
- 640K Conventional Memory
- Up to 192K Upper Memory Blocks
- Dual 64K System ROM – switchable with DIP switch
    - System BIOS is Sergey Kiselev's Micro 8088 BIOS.
    - Up to 32K usable as Option ROM space. XT-IDE BIOS uses half.
- Option ROM socket with write support
- PS/2 Keyboard Port
    - Implemented with AT to XT converter in a microcontroller.
- ATX power input
    - -5V rail not needed. Is generated onboard for ISA slots.
    - 20-pin connector. 24-pin connectors will fit too.
- Four 8-bit ISA Slots
    - Three of the four slots can fit 16-bit cards.
- Onboard peripherals:
    - Advanced floppy controller
        - Supports most floppy drives, including HD and ED
        - Supports single-density (FM) disks
    - Serial port
        - 16550 UART with FIFO buffer
        - Selectable I/O address and IRQ
    - CompactFlash interface
        - Located at I/O port 300h
    - Super VGA graphics
        - Up to 1024 x 768 resolution
        - Up to 256 colours

Compatibility

- CPU: **8088, NEC V20, or compatible**
  - Must be at least 10MHz rated. Set the CPU speed lower in the System BIOS if it isn't.
  - 8088 provides greater replication of original IBM PC, due to identical speed.
  - NEC V20 provides roughly 20% more performance, and 80186 instructions.
- FPU: Intel **8087**
  - Optional. Only used by applications specifically programmed for it.
  - Must be at least 10MHz rated. Set the CPU speed lower in the System BIOS if it isn't.
- System ROM: **SST39SF010A** 128K Flash ROM
  - First half: XT-IDE Universal BIOS at the start, configured for XT-CF at 300h, Micro 8088 BIOS at the end. Second half: Just Micro 8088 BIOS at the end.
  - Full 128K file to flash with programmer: github.com/monotech/NuXT
- Option ROM Socket: **28C64B or 28C256** EEPROM, or **27C64**
  - Optional, for if another Option ROM is desired.
- Video RAM: Two or four **256Kx4bit 70ns** DRAMs
  - Two ICs, in the sockets closest to the VGA IC, for 256K. All four ICs for 512K.
  - Examples of compatible DRAMs are: TC514256AP-70, MT4C4256-7, MCM514256AP70, MB81C4256A-70P.
- Video BIOS: **27C256**
  - Programmed with TVGA9000i BIOS D4.01E.
- AT to XT keyboard converter: **PIC12F629 Microcontroller**
  - Programmed with AT2XT firmware: vcfed.org/forum/showthread.php?26426
- UART: **16550 or compatible**
- Floppy controller: **National Instruments PC8477* or Intel 82077***
  - PC8477BV-1 is recommended.
  - If an Intel controller is used, the adjacent 4.7nF capacitor must be installed.

- The System BIOS supports booting from floppy disks. The correct drive type must be selected in the BIOS Setup. Supports booting from 360K, 720K, 1.2M, 1.44M, 2.88M.

- The Trident TVGA9000i SVGA chip supports standard VGA modes, plus SVGA modes, as well as MDA, CGA, Hercules, EGA. Some modes require specific support for the chip, such as a driver.
  - Some SVGA modes require 512K VRAM:

VGA mode	256K	512K
640x480, 16 colour	Yes	Yes
640x480, 256 colour		Yes
800x600, 16 colour	Yes	Yes
800x600, 256 colour		Yes
1024x768, 4 colour	Yes	Yes
1024x768, 16 colour		Yes

System BIOS

The NuXT uses Sergey Kiselev's Micro 8088 BIOS. This is IBM PC/XT compatible, with some handy features.

To enter the BIOS Setup, press F1 during the RAM test. The setup utility will then run when the RAM test completes.

You may then press 'H' to see available commands, and any time you may press 'R' to return to the main menu.

- 'C' – Set startup CPU speed
    - 4 – 4.77MHz
    - 7 – 7.16MHz
    - 9 – 9.55MHz
- 'F' – Change first floppy drive type
    - 0 – None
    - 1 – 360K 5 ¼"
    - 2 – 1.2M 5 ¼"
    - 3 – 720K 3 ½"
    - 4 – 1.44M 3 ½"
    - 6 – 2.88M 3 ½"
- 'G' – Change second floppy drive type
    - As above
- 'P' – Display current settings on screen
- 'W' – Write current settings to ROM
    - BIOS settings are saved in the System ROM. No battery is needed.
- 'Q' – Exit without saving changes

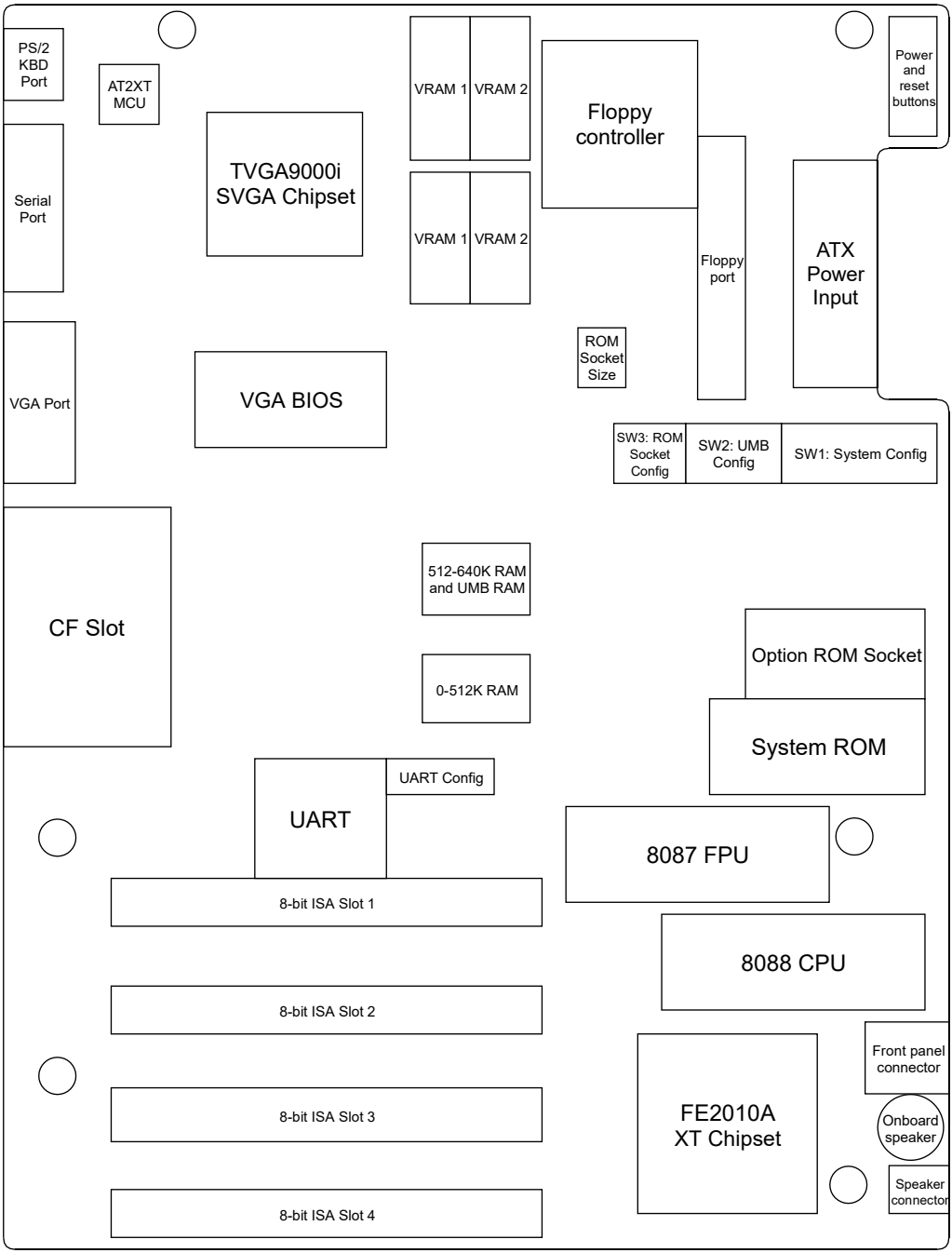
At any time while in DOS, you may switch CPU speeds with a hotkey. This works in some applications, but not others. It always works at the DOS prompt.

4.77MHz: Ctrl, Alt, Numpad –

7.16MHz: Ctrl, Alt, Numpad *

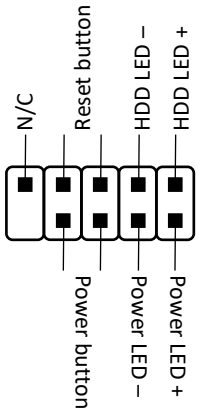
9.55MHz: Ctrl, Alt, Numpad +

Board Layout – NuXT Rev1.2



Connectors

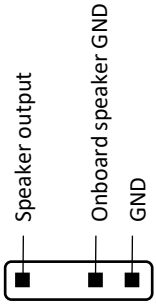
Front panel connector:



Speaker connector:

Jumper pins 1 and 2 to enable the onboard speaker. Otherwise, connect a speaker to pins 1 and 4.

This is slightly different to most 4-pin speaker connectors. They usually have +5V and Speaker output. This has GND and Speaker output. Take note if connecting to the "PC Speaker" input on sound cards, to not cause a short of +5V to GND.



Serial port configuration jumper: – Default: COM1

Remove both jumpers to disable the onboard serial port.

To enable the serial port, put a jumper on an I/O address, and on an IRQ line.

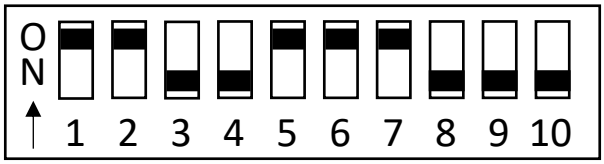
Ensure the setting doesn't conflict with any other devices in the system.

COM designation	I/O Address	IRQ Line
COM1	3F8	IRQ4
COM2	2F8	IRQ3
COM3	3E8	IRQ4
COM4	2E8	IRQ3

DIP Switches

SW1: System Config – Default: 1, 2, 5, 6, 7 ON

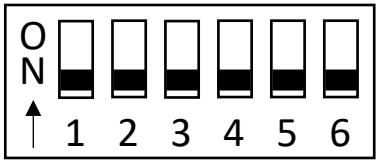
Switches 1 and 2 set the video card type:



Video card type	1	2
VGA or EGA or None	ON	ON
80x25 CGA	ON	OFF
40x25 CGA	OFF	ON
MDA or Hercules	OFF	OFF

3. Enable keyboard E0 scancode passthrough for the AT to XT keyboard converter.
4. Use secondary System ROM.
    - When switched ON, this will use the second half of the 128K ROM chip as the System ROM instead of the first half.
5. Enable onboard floppy controller.
    - Switch off if using a floppy controller card.
6. Enable onboard CF card interface.
    - Switch off if another device needs to use I/O address 300h.
    - If switching off, you should also switch to secondary System ROM, which by default doesn't contain XT-IDE Universal BIOS. This will speed up boot time.
7. Enable onboard VGA.
    - Switch off if using any video card.
8. Enable for VGA monitors with H-sync less than 48.7 kHz.
9. Enable onboard Option ROM socket.
10. Allow writing to the onboard Option ROM socket.

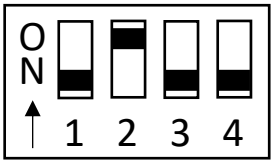
SW2: Upper Memory Blocks Config – Default: all OFF



1. C0000-C8000 (768-800K)
2. C8000-D0000 (800-832K)
3. D0000-D8000 (832-864K)
4. D8000-E0000 (864-896K)
5. E0000-E8000 (896-928K)
6. E8000-F0000 (928-960K)

These switches put 32K blocks of usable RAM into Upper Memory. There must not be any Option ROMs or ISA card RAM at the selected locations, or you'll get instability or inability to boot. This UMB RAM can be used for TSRs, Drivers, and DOS itself, to free up conventional memory. More on that on page 10/11.

SW3: Option ROM Socket Memory Address – Default: 2 ON



This switch sets the starting memory address of the Option ROM socket.

All addresses are compatible with an 8K E(E)PROM (28C64B or 27C64).

Only the specified addresses are compatible with 32K EEPROMs (28C256).

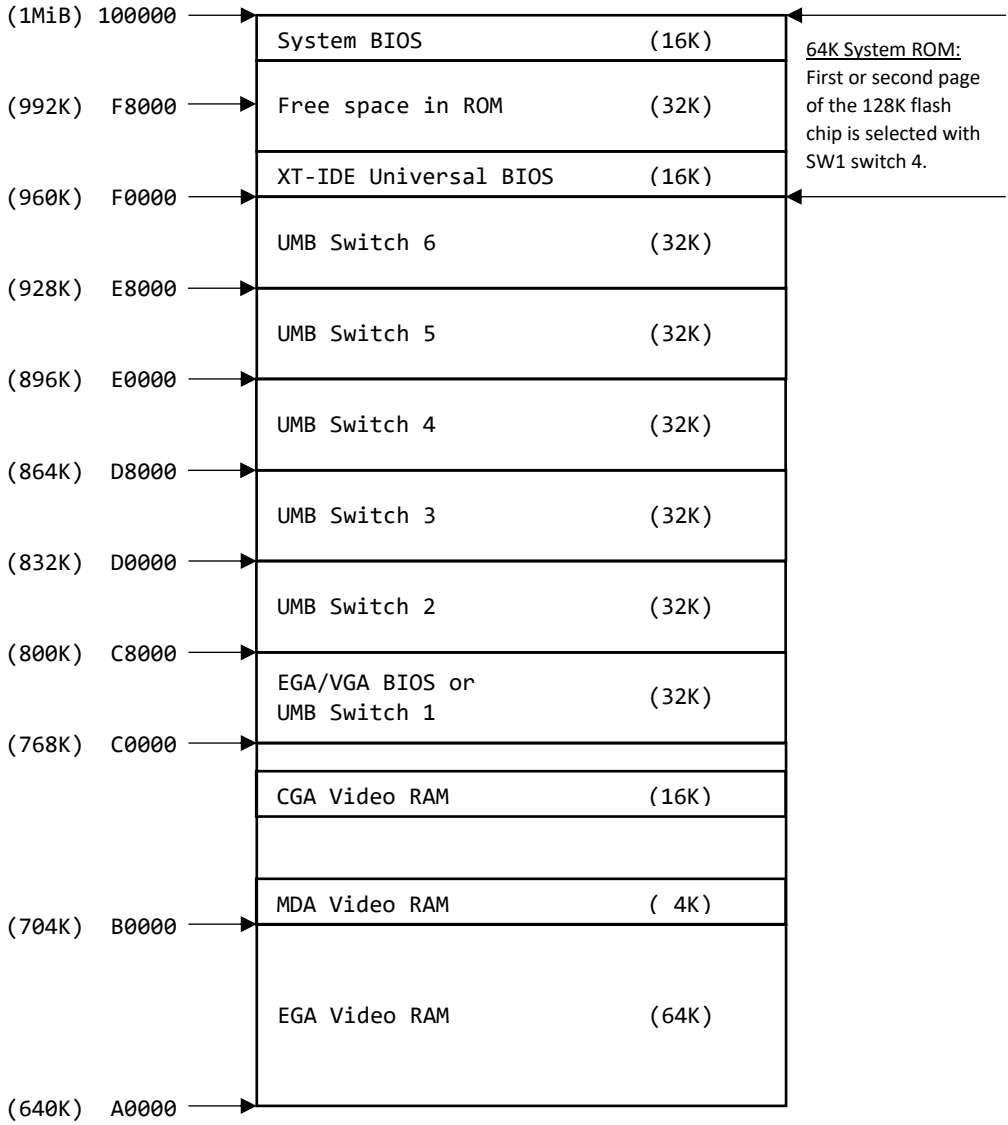
27C256 is not compatible, as it has a different pinout.

Memory address	1	2	3	4	32K support
C0000	OFF	OFF	OFF	OFF	YES
C2000	OFF	OFF	OFF	ON	
C4000	OFF	OFF	ON	OFF	
C6000	OFF	OFF	ON	ON	
C8000	OFF	ON	OFF	OFF	YES
CA000	OFF	ON	OFF	ON	
CC000	OFF	ON	ON	OFF	
CE000	OFF	ON	ON	ON	
D0000	ON	OFF	OFF	OFF	YES
D2000	ON	OFF	OFF	ON	
D4000	ON	OFF	ON	OFF	
D6000	ON	OFF	ON	ON	
D8000	ON	ON	OFF	OFF	YES
DA000	ON	ON	OFF	ON	
DC000	ON	ON	ON	OFF	
DE000	ON	ON	ON	ON	

U35 ROM Size: This switch must be set to 8K (28C64B/27C64) or 32K (28C256) depending on what size ROM you have installed in the Option ROM Socket.

Beware that the addresses below C8000 (above on the table), are used by the Video BIOS if you're using VGA or EGA. See next page for clarification.

Upper Memory Map



The Micro 8088 BIOS scans for Option ROMs from C0000 (768K) to F8000 (992K), so some of the 64K System ROM can be used for Option ROMs.

By default, XT-IDE Universal BIOS is located here (along with some more free space), and configured for an XT-CF circuit at I/O address 300h.

Upper Memory Blocks DOS Setup

To use the upper memory blocks in DOS, you need a driver. USE!UMBS 2.20 is the recommended driver, along with DOSMAX to move DOS to upper memory. This configuration should leave you with only 10K Conventional Memory used. DOS 5.0 or later is required.

Ensure there are no other cards that use the upper memory ranges that you've enabled as RAM on the SW2 DIP switch.

Examples of cards that would conflict with some of the SW2 switches:

- EMS memory cards. These usually have a 64K block of upper memory used as their window.
- Ethernet cards. Some Ethernet cards are memory-mapped. Check the Ethernet card configuration.
- Cards with Option ROMs. Some examples:
    - Hard Drive controllers
    - HD floppy controllers
    - Ethernet card Boot ROMs
    - EGA and VGA cards, including the onboard VGA

For a graphical representation of the upper memory area, see the NuXT Upper Memory chart to the left. This is also on the back of the motherboard itself.

To add the USE!UMBS 2.20 driver to your CONFIG.SYS, add the following two lines to the start of the file, after any FILES or BUFFERS lines: (Find USE!UMBS 2.20 at github.com/monotech/NuXT)

```
DOS=UMB
DEVICE=C:\USE!UMBS.SYS C800-F000
```

- "C800-F000" specifies the range of upper memory that can be used as RAM (take a zero off the end). Ensure this matches what you have SW2 set to.
- C800-F000 matches switches 2 through 6 being ON.
- If switch 3 through 5 was ON instead, it would be D000-E800. Refer to the chart on the left.

Then add DOSMAX to your CONFIG.SYS to move DOS into upper memory. Add the following line right after USE!UMBS.SYS: (This assumes you have all the DOSMAX files copied to C:\UTILS\DOSMAX)

```
DEVICE=C:\UTILS\DOSMAX\DOSMAX.EXE /R+ /N+ /P-
```

And the following line at the end of CONFIG.SYS:

```
SHELL=C:\UTILS\DOSMAX\SHELLMAX.COM C:\COMMAND.COM C:\ /E:256 /P
```

Preparing a CompactFlash card for DOS

This guide applies to any DOS PC, not just the NuXT.

You will need:

- A modern PC, with software that can wipe a drive by filling with zeroes
- A USB card reader with a CF slot
- A DOS 6.22 floppy. Boot Disk or Disk 1.
- (optional) A DOS 3.x floppy if you wish to use DOS 3.x. The DOS 6.22 floppy is still needed.

To prepare a CF card for MS-DOS 6.22:

1. Wipe the CF card on a modern PC. Software such as a partition editor, or 'dd' under Linux/macOS, can do this. You want to write zeroes to the whole card. "Formatting" a card is not wiping it.
2. Put the CF card into the vintage PC, turn the PC on, and boot from a DOS 6.22 floppy.
3. Run **`FDISK /MBR`**
4. Run **`FDISK`**, and create any partitions.
5. Reboot and boot from the same DOS floppy.
6. Run **`FORMAT C: /S`**
7. Done! The CF card is now bootable with minimal DOS 6.22. Feel free to install the rest of DOS, or move the CF card to a modern PC to transfer apps and games.

To prepare a CF card for DOS 3.x:

1. Wipe the CF card on a modern PC. Software such as a partition editor, or 'dd' under Linux/macOS, can do this. You want to write zeroes to the whole card. "Formatting" a card is not wiping it.
2. Put the CF card into the vintage PC, turn the PC on, and boot from a **DOS6.22 floppy**.
3. Run **`FDISK /MBR`**
4. Run **`FDISK`**, and create one partition. 32MB max. 512MB max for MS-DOS 3.31.
5. Reboot and boot from a **DOS 3.x floppy**.
6. Run **`FORMAT C: /S`**
7. If you'd like more partitions, run DOS 3.x FDISK now to create them.
8. Done! The CF card is now bootable with minimal DOS 3.x. Feel free to install the rest of DOS, or move the CF card to a modern PC to transfer apps and games.

If you'd like to back up or clone your kitted out CF card to another of identical size, you can use software such as Win32DiskImager, or 'dd' in Linux/macOS.

Structure of the NuXT System ROM

The NuXT System ROM is a 128KiB Flash ROM (SST39SF010A), split into two pages, with the selected page (SW2 Switch 4) located at F0000 to 100000 (960K to 1M).

We effectively have two 64K System ROMs that we can switch between.

You may wish to create another for various reasons, or insert more Option ROMs into it. A common reason to alter the System ROM is to change XT-IDE Universal BIOS from the 8088-compatible version to the faster 186-compatible version that requires a NEC V20. By default, the NuXT comes with the 8088-compatible version, so users may use an 8088 if they wish, and also because the speed difference isn't hugely noticeable.

The System ROM must contain the System BIOS for the NuXT to work at all. The NuXT uses Sergey Kiselev's Micro 8088 BIOS. This BIOS has a settings menu, and all settings are saved to the System ROM itself, negating the need for a battery.

Option ROMs may be placed in the first 32K of each half of the ROM chip, at 4K boundaries.

The hardware is capable of flashing the System ROM in-system from DOS, but requires a software utility to be written.

If you'd like to alter the System ROM in a hex editor on a modern PC, I recommend acquiring the pre-made 128K ROM image from github.com/monotech/NuXT. This is ready to program with a programmer device such as a universal programmer or a PCI Ethernet card with a 32-pin socket.

This pre-made image is structured like this, and it is recommended to keep to that structure:

- Start of the file – XT-IDE Universal BIOS, configured for XT-CF at 300h.
- Empty space (FF's)
- C000 – FFFF – Micro 8088 BIOS

--- this is the 64K boundary where the 'secondary System ROM' starts ---

- 10000 – 1BFFF – Empty space (FF's)
- 1C000 – 1FFFF – Micro 8088 BIOS

One alternative would be to place the 186-compatible XT-IDE BIOS (configured for XT-CF at 300h) at the start of the first half, and the original 8088-compatible XT-IDE BIOS at the start of the second half. This would allow switching to an 8088-compatible BIOS if switching to an 8088 CPU from a NEC V20.

The default layout is so you may disable XT-IDE Universal BIOS with a DIP switch, in case you aren't using the onboard XT-CF. If you don't have a CF card installed, but XT-IDE Universal BIOS is still active, there will be a delay at boot as XT-IDE Universal BIOS tries to detect a CF card.

Configuring XT-IDE Universal BIOS (XUB)

Most of this applies to XUB in general, not just on the NuXT.

XUB can be found at xtideuniversalbios.org/binaries

XUB is a hard disk Option ROM, that supports a wide range of HDD controllers and HDDs, including special modern XT controllers such as “XT-IDE” and “XT-CF”.

The NuXT has an XT-CF circuit for the CF slot, and uses XUB to detect and access the drive. XUB is located in the 32K half of the System ROM that is scanned by the System BIOS for Option ROMs. The IDE I/O Address for the NuXT’s onboard XT-CF, is fixed at 300h.

You may wish to reconfigure XUB for the following reasons:

- Update to a newer version that may fix issues or increase compatibility.
- Change to the 186-compatible version, which is faster, but requires a NEC V20.
- Add more controllers for XUB to handle, such as ones on a card you add to the NuXT, including XT-IDE, XT-CF, and a “16-bit IDE interface in 8-bit mode” (supports CF cards only).

XUB releases have the following files:

Filename	Minimum CPU	Size	Boot menu
IDE_XT.BIN	8088	8K	
IDE_XTL.BIN	8088	12K	Yes
IDE_XTP.BIN	NEC V20	8K	
IDE_XTPL.BIN	NEC V20	12K	Yes
IDE_AT.BIN	286	8K	
IDE_ATL.BIN	286	12K	Yes
IDE_386.BIN	386	8K	
IDE_386L.BIN	386	12K	Yes

XTIDECFG.COM – Configuration utility. Used to alter the XUB BIOS images, and to flash any image (not just XUB) to an EEPROM, in-system. Can be run in DOSBOX to alter the images on a modern PC, and then flash to EEPROM with a programmer.

The higher minimum CPU images will generally provide greater disk performance.

The 12K releases may be only 10K sometimes. Either way, they won’t fit on an 8K ROM.

The regular 8K ROM will boot from the first hard drive, unless you press ‘A’ to boot from the first floppy drive instead. This can be swapped. The 12K ROM has a boot menu, which lets you choose from any drive to boot from. This may swap drive letters to please DOS, and isn’t always hassle-free.

Since the NuXT System ROM has 32K of free space for Option ROMs, you can freely use the 12K release here.

The higher CPU versions can work with even higher CPUs. For example, the 186-compatible version will work on a 286 just fine, and the 8088-compatible will work with all CPUs.

When reconfiguring an XT-IDE or XT-CF card, use the following table to determine action:

Desired change	Must change switches on card	Must configure and re-flash XUB
Change Boot ROM Address	Yes	No
Change IDE I/O Address	Yes	Yes
Change XT-IDE HiSpeed mode	Yes	Yes
Change other XUB settings	No	Yes

The Boot ROM address for XUB on the NuXT is well out of the way of other devices that use upper memory, because it's stored in the System ROM above F0000 (960K). See page 10 for clarification.

HiSpeed mode (also known as "Chuck mod", named after Chuck(G) on VCF who discovered it) only applies to XT-IDE cards, not XT-CF. It improves disk performance, but is incompatible with a small number of systems.

If using in a 386 or up, once everything is working how it should, you should enable ROM Shadowing in your System BIOS Setup, for the location of the XUB Boot ROM, to improve disk performance.

To configure XUB, do the following:

1. Run **XTIDECFG.COM** from DOS.
2. Select 'Load BIOS from file'. Select an appropriate XUB image as per previous page.
3. Select 'Configure XTIDE Universal BIOS'.
4. Set the number of IDE controllers to whatever number you'd like XUB to handle. Default is 1. If configuring more than 2, you must enable 'Full operating mode'.
5. You can then enter each of the IDE controller menus, and set the **Device Type**, and **I/O address**. You can usually leave 'Master Drive' and 'Slave Drive' as default, and XUB will autodetect drives at boot. Choose from the following Device Types:
    - 16-bit ISA/VLB/PCI – this is a standard IDE interface as seen on motherboards, Multi-I/O cards, and some sound cards. Only works in a 286 and up.
    - 32-bit VLB/PCI IDE – this is for 486 machines and up with those interfaces.
    - XTIDE rev 1 – this is an XT-IDE card in Compatibility Mode.
    - XTIDE rev 2 or modded rev 1 – this is an XT-IDE card in HiSpeed mode.
    - XT-CF PIO8 – this is an XT-CF, as seen built onto the NuXT, or as a card.
    - For the other controllers, refer to xtideuniversalbios.org
6. Go back, and enter Boot Settings. Here, you can change Display Mode, and the default drive.
7. Go back to the main menu. You can now either save the XT-IDE configuration to the original ROM image you selected at the start, or you can flash it if you're doing this in-system.
    - Flashing the XT-IDE BIOS **in-system** can be done on XT-IDE and XT-CF cards, but not on the NuXT's System ROM unless a special utility is written.
    - To flash the EEPROM, you must have the card switched to enable writes.
    - Ensure the EEPROM Type and Address are correct, and choose Start Flashing.
    - If it fails, and you are sure the above settings are correct, change the Page Size to 64 bytes, and then each of the other Page Size settings, until it works. Some systems need this setting set differently.

Troubleshooting

Here are a few steps to take if you encounter trouble with the NuXT:

- Beeping on and off and not booting up – general error
    - Bad CPU or FPU, bad RAM, or bad logic
        - Reseat the ICs
        - To disable onboard RAM in order to try a RAM card, you can disconnect pin 19 of U14 from the board, and connect the pin to +5V (pin 20).
    - Shorted ISA bus lines
        - Check for debris in the ISA slots
        - Remove all ISA cards
        - Check CF slot for bent pins
- You hear the POST jingle, but there is no display
    - VGA issue, bad connection, or incompatible display
        - Try another monitor
        - Disable the onboard VGA and try another video card
        - Reseat the VRAM and Video BIOS ICs
        - Check your VGA cable for bent pins
- Keyboard issues
        - Check your keyboard's mini-DIN connector for bent pins
        - Enable keyboard E0 scancode passthrough (SW1 switch 3)
        - Try another keyboard. A small number aren't compatible
        - Ensure the PIC12F629 microcontroller is programmed with AT2XT
- Serial port unreliability
    - This was an issue with all of the Rev1.0 NuXT, and one of the three Rev1.1 boards produced (since been recycled). Please report it if you encounter it with the Rev1.2.
        - Reseat the UART IC
        - Ensure jumper settings are correct, and don't conflict. Refer to page 7
    - Incompatible serial card. Some work better than others with the NuXT. The serial port on the DeluxeFloppy card is not suitable for use with the NuXT.
        - Try another serial card. A common multi-I/O card perhaps.
- CF card not detected, detected with a corrupted name, or has intermittent corruption issues
    - Incompatible CF card. The XT-CF circuit, as used on the NuXT, works with most CF cards, but a good number aren't compatible. There is no correlation between CF card size and brand, and compatibility.
        - Try another CF card
    - Board damage
        - Check CF slot for bent pins
- Floppy controller issues
    - Bad floppy controller
        - Reseat the floppy controller IC
    - Resource conflict
        - Ensure there are no other floppy controllers in the system