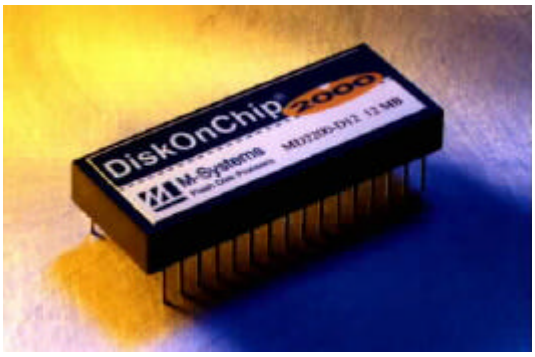
M-Systems
Flash Disk Pioneers

Series 2000

DiskOnChip®2000
MD2200, MD2201 Data Sheet

Features

- **Single chip plug-and-play Flash Disk**
- **2 - 72MB capacity (144MB in 1H99)**
- **Simple, easy to integrate interface**
- **32-pin DIP JEDEC standard EEPROM compatible pin-out**
- **Embedded *TrueFFS*® software provides:**
  - **Full hard disk read/write capability**
  - **Third generation wear leveling**
  - **Automatic management of bad blocks**
- **Operates with DiskOnChip-OSAK in O/S-less environments**
- **EDC/ECC for high data reliability**
- **Full boot capability**
- **Low power consumption**
- **Broad O/S support: DOS, Windows, Windows 95, Windows NT4.0/5.0, Windows CE; Additional support offered: pSOS+, QNX, VxWorks and others**
- **Single 3.3V or 5V supply**
- **Memory window size - 8KB**

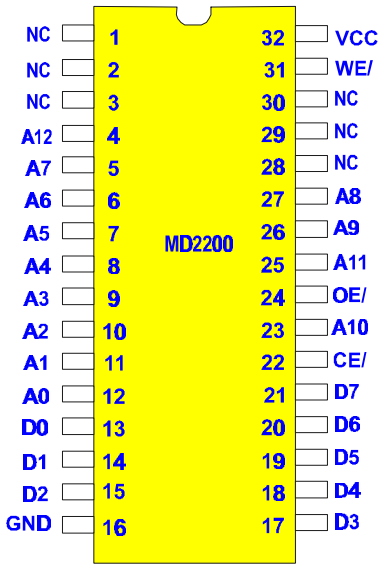


General Description

The DiskOnChip 2000 product line provides a single chip, solid-state flash disk in a standard 32-pin DIP package. The DiskOnChip is intended for use in embedded and portable computers that have limited space and minimal power consumption requirements. By placing the DiskOnChip in a standard socket, physical space requirements are reduced. Unlike standard IDE drives, no cables or extra space is required. The DiskOnChip is a solid-state disk with no moving parts, resulting in a significant reduction in power consumption and an increase in reliability. The DiskOnChip is a small, plug-and-play Flash disk. It is easy to use and reduces integration overhead.

The DiskOnChip family of products is available in capacities ranging from 2MB up to 72 MB, unformatted. In future versions the capacity will be dramatically increased (up to 144MB in 1st half of 1999), yet the same pin-out will be retained. Therefore the socket on the target platform does not have to be changed to accommodate larger capacities. In order to manage the disk, the DiskOnChip includes TrueFFS®, M-Systems' Flash File System. The DiskOnChip package is pin-to-pin compatible with standard 32-pin EEPROM devices.

The DiskOnChip is shipped as a plug-and-play device, i.e. it is programmed, formatted and ready to be used. Future software upgrades and formatting can be done on the target platform. There is no need to remove the DiskOnChip from its socket in order to modify its contents or to reformat it.



Pin Name	Description	Pin Number	Direction
A0 - A12	Address bus	4-12,23,25-27	Input
D0 - D7	Data bus	13-15,17-21	I/O
CE/	Chip Enable	22	Input
OE/	Output Enable	24	Input
WE/	Write Enable	31	Input
NC	Not Connected	1,2,3,28,29,30	
VCC	Power	32	
GND	Ground	16	

Figure 1 - MD2200, MD2201 Pin Out

2. Operation In a PC Compatible Platrform

2.1 Functional

In PC compatible platform, the DiskOnChip is mounted in a 32-pin DIP socket, compatible with a standard EEPROM. The DiskOnChip should be mapped into the expansion BIOS memory space of the PC. During the boot process, the DiskOnChip loads its software into the PC's memory and installs itself as an additional disk drive in the system. When the PC's operating system is loaded, the DiskOnChip is recognized as a standard disk. No external software is required. The DiskOnChip can be used as the only disk in the system, allowing the system to boot from it. In addition, the DiskOnChip can also work with other hard disks or floppies as the boot device or as a secondary disk.

Figure 3 shows the DiskOnChip memory location in relation to the PC memory map.

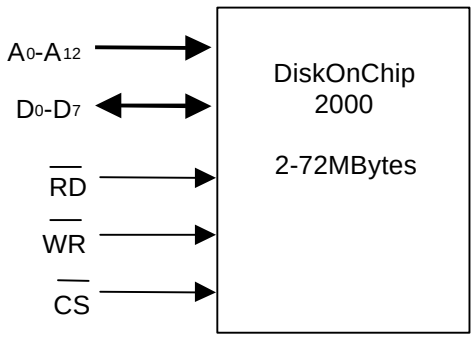


Figure 2 - DiskOnChip Interface Diagram

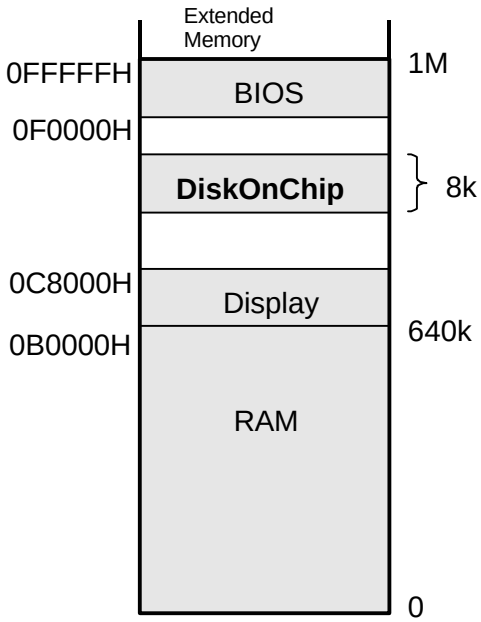


Figure 3 - PC memory

The DiskOnChip should be mapped to an 8 KB window in the BIOS expansion range, which is usually located between 0C0000H to 0EFFFFH. Note that the 32 KB of BIOS expansion range from 0C0000H to 0C8000H is typically reserved for the video BIOS expansion ROM.

After reset, the BIOS first executes the POST (Power on Self-Test). Then the BIOS searches for all expansion ROM devices. When the DiskOnChip is found, the BIOS executes the initialization code ("IPL") located on the DiskOnChip. This code loads the TrueFFS driver into system memory, installs the DiskOnChip as a disk in the system, and then returns control back to the BIOS code. The operating system subsequently attempts to identify the disks that are available and the DiskOnChip software (i.e. the TrueFFS) responds by emulating a hard disk.

From this point on the DiskOnChip appears as a standard disk drive, i.e. it is assigned a drive letter and it can be used by any software application. No BIOS set-up modifications or autoexec.bat/config.sys modifications are required.

The flash memory within the DiskOnChip is accessed by the TrueFFS software through an 8KB window in the PC's upper memory area. TrueFFS handles the paging of this window in the flash array, as well as providing Flash Disk emulation, which includes flash table management, wear leveling and background space reclamation on unused flash blocks. The same window will be used with larger capacities in future versions of the DiskOnChip . No redesign of the socket or larger memory resources will be required.

The DiskOnChip in combination with TrueFFS provides a true sector-based disk emulation that is compatible with conventional hard disks. Furthermore, it provides a bootable drive that is compatible with standard disk utilities.

2.2 System Requirements

In a PC compatible platform there are only two requirements for the socket into which the DiskOnChip is inserted:

1. The socket should be mapped into the BIOS expansion space of the PC (typically 0C8000H to 0E0000H).
2. The socket memory window must occupy at least an 8KB-memory space.

The first requirement allows the BIOS to load the DiskOnChip firmware into the memory automatically during the boot process. The second requirement defines the minimum window size required by the DiskOnChip. The window size can be larger than 8KB, due to the internal anti-alias algorithm of the DiskOnChip.

2.3 TrueFFS

TrueFFS is M-Systems' FTL Flash File System management technology that allows flash components to fully emulate a hard disk. This capability simplifies the usage of flash, as no special or complicated algorithms are needed to work with it - just read and write to it like any other disk drive.

Working under the native O/S and file system, TrueFFS acts as a block device driver. In this way it maintains full compatibility with other disks in the system and all disk utilities and drivers that accompany them. Because TrueFFS is loaded at start-up, it allows the flash disk to function as the boot device. No other system disk is required.

TrueFFS enables the Flash Disk to nearly match the maximum read/write speed boundaries inherent to the flash components. Background erasure of used flash blocks eliminates the long delays commonly encountered when writing to flash, and read speeds are exceptionally fast due to direct access to the flash. Additionally, there are no access, seek or spin-up delays that are typically encountered when using mechanical disk drives.

2.4 Boot

As described above, the DiskOnChip is recognized by the system like any hard disk. The DiskOnChip can be used as the only disk in the system, in which case it will be accessed as drive C:. The DiskOnChip can work together with or without a floppy drive, or with another hard disk(s). When working with another hard disk, the DiskOnChip can be configured as the last drive (default). In this case the hard disk will be C: and the DiskOnChip will be D:. It can also be configured as the first drive. In this case the hard disk will be D: and the DiskOnChip will be C:.

The DiskOnChip can be used as the boot device when configured as drive C:. In this configuration, the user is required to format the DiskOnChip as a bootable device, i.e. copy the OS files onto the disk. When running DOS, this can be done by using the SYS command.

2.5 Integrating the DiskOnChip 2000

The DiskOnChip is plug-and-play, making it very easy to integrate:

1. Plug the DiskOnChip into the DIP socket.
2. Power up the system.
3. If the DiskOnChip is to be the bootable drive, format it as a bootable disk and re-boot the system.
4. Begin accessing the DiskOnChip as a regular drive, and copy your application files onto the DiskOnChip.

The DiskOnChip is shipped formatted and pre-programmed to be plug-and-play. In addition, M-Systems provides utilities for testing and formatting the DiskOnChip . Utilities are also provided for updating the DiskOnChip's internal firmware (TrueFFS) in the system. This eliminates the need to remove the DiskOnChip from the socket.

3. Operation in non-PC Architectures

In addition to DOS or Windows, the DiskOnChip can work with any other CPU or operating system. The following sections describe how to use the DiskOnChip in these environments.

3.1 Operation with Standard Operating Systems

The DiskOnChip is compatible with many operating systems in addition to DOS, including QNX, pSOS+, VxWorks, WindowsCE, Windows NT4.0, Windows NT5.0 and many others.

In order to use the DiskOnChip with these operating systems, the appropriate DiskOnChip device driver should be installed. The DiskOnChip device driver can be part of the operating system or it can be supplied by M-Systems.

When operating under one of these Operating Systems in a PC compatible host system (i.e. x86 CPU and standard BIOS), the boot process is performed in the same way as described above for DOS.

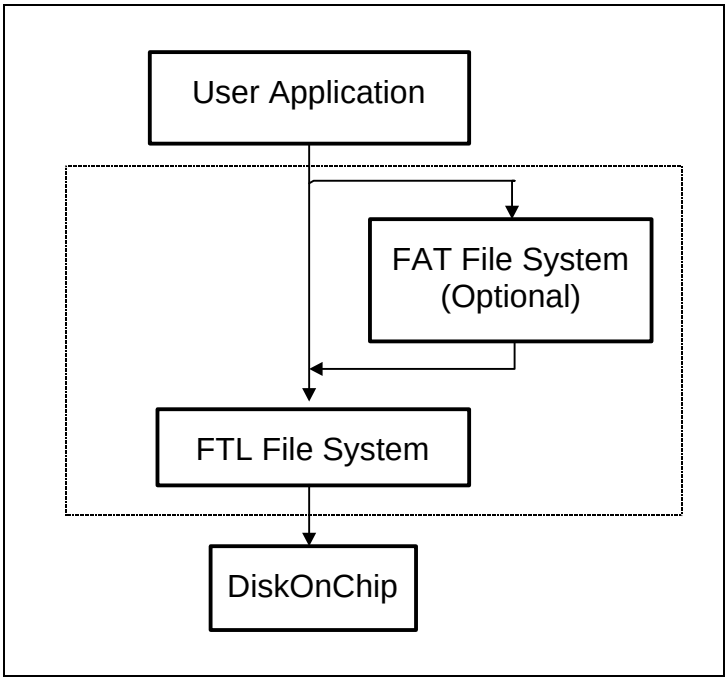


Figure 4 - Software Block Diagram

4. Theory of Operation

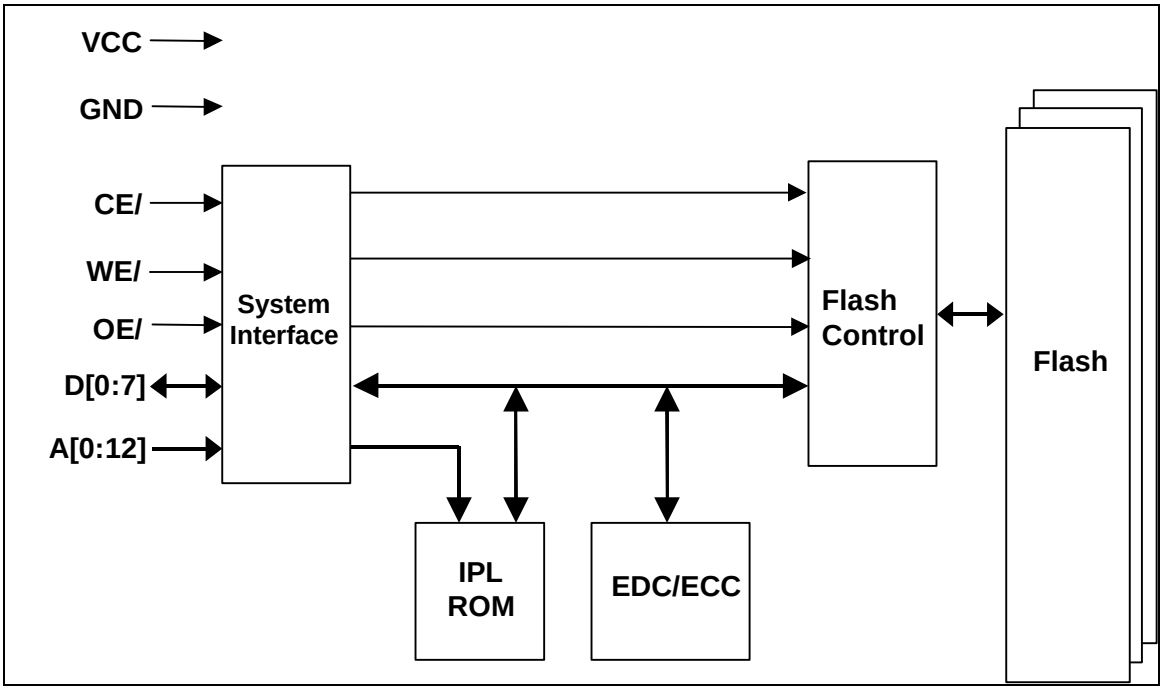


Figure 5 - DiskOnChip Block Diagram

The DiskOnChip is integrated into the system as a standard EEPROM. The system interface is controlled by the host bus signals (read, write, chip select, addresses and data), which generate the appropriate control signals to the internal blocks.

The internal ROM provides the IPL (Initial Program Loader) code that loads the TrueFFS software from the Flash into the PC memory during boot (after power up or reset). This code is necessary since NAND-type flash devices have no linear address space and therefore cannot be used as boot code storage devices.

The Flash Control block interfaces with the NAND flash devices. The Flash block is comprised of the Flash devices, which are mounted inside the DiskOnChip. There may be more than one Flash device. The software automatically detects the number of Flash devices and their capacity by reading their ID code and calculates the total formatted capacity of the DiskOnChip.

5. Disk Capacities

Each DiskOnChip device is fully tested and formatted when shipped from M-Systems. The exact capacity of each model is detailed in the following table:

Model	Formatted Capacity (bytes)	Sectors	Formatted Capacity under DOS 6.22 (bytes)	Sectors under DOS 6.22
MD2200-D02MB	1,998,848	3904	1,986,560	3880
MD2200-D04MB	4,038,656	7888	4,022,272	7856
MD2200-D08MB	8,151,040	15920	8,128,512	15876
MD2200-D12MB	12,263,424	23952	12,228,608	23884
MD2200-D24MB	24,592,384	48032	24,516,608	47884
MD2201-D40MB	41,033,728	80,144	40,908,800	79,900
MD2201-D72MB	73,891,840	144,320	73,789,440	144,120

6. Electrical Specifications

6.1 Absolute Maximum Ratings

Parameter	Symbol	Rating[1]	Units	Notes
DC supply voltage	V_{CCS}	-0.3 to 6.0	V	
Input pin voltage[2]	V_{IN}	-0.3 to V_{CC} + 0.3	V	
Input pin current	I_{IN}	-10 to 10	mA	25°C
Storage temperature	T_{STG}	-45 to 100	°C	

Notes:

1 Permanent device damage may occur if Absolute Maximum Ratings are exceeded. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

2 The voltage on any pin may undershoot to -2.0V or overshoot to Vcc+2.0V for periods <20ns.

6.2 Capacitance

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$C_{I/O}$	Input/Output Capacitance	MD2200, V_{IN} =0V			15	pF
		MD2201, V_{IN} =0V			45	pF

Note: Capacitance is not 100% tested.

6.3 Operating Temperature Ranges

Commercial operating temperature.....0°C to +70°C

Enhanced operating temperature .....-25°C to +75°C

Extended operating temperature .....-40°C to +85°C

6.4 Humidity

10% - 90% relative, non condensing.

6.5 EDC/ECC

Enhanced Reed-Solomon ECC:

- Corrects up to two 10-bit symbols, including two random bit errors.
- Corrects single bursts up to 11 bits.
- Detects single bursts up to 31 bits and double bursts up to 11 bits.
- Detects up to 4 random bit errors.

6.6 DC Electrical Characteristics Over Operating Range

6.6.1 Vcc = 5V Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CCS}	System Supply Voltage		4.5	5.0	5.5	V
V_{IH}	High Level Input Voltage		2.0			V
V_{IL}	Low Level Input Voltage				0.8	V
V_{OH}	High Level Output Voltage	I_{OH} = -16 mA	2.4			V
V_{OL}	Low Level Output Voltage	I_{OL} = 16 mA			0.4	V
I_{IL}	Input Leakage Current	MD-2200			±1	µA
		MD-2201			±3	µA
I_{OZ}	Output Leakage Current	MD-2200			±10	µA
		MD-2201			±30	µA
I_{VCC}	Supply Current	Cycle Time = 200 ns, Outputs open		40	50	mA
I_{STDBY}	Standby Current	MD-2200		60	400	µA
		MD-2201		240	1200	µA

6.6.2 Vcc = 3.3V Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CCS}	System Supply Voltage		3.0	3.3	3.6	V
V_{IH}	High Level Input Voltage		1.4			V
V_{IL}	Low Level Input Voltage				0.5	V
V_{OH}	High Level Output Voltage	I_{OH} = -6 mA	2.4			V
V_{OL}	Low Level Output Voltage	I_{OL} = 6 mA			0.4	V
I_{IL}	Input Leakage Current	MD-2200			±1	µA
		MD-2201			±3	µA
I_{OZ}	Output Leakage Current	MD-2200			±10	µA
		MD-2201			±30	µA
I_{VCC}	Supply Current	Cycle Time = 200 ns, Outputs open		30	40	mA
I_{STDBY}	Standby Current	MD-2200		60	400	µA
		MD-2201		240	1200	µA

6.7 AC Operating Conditions

Timing specifications are based on the following conditions:

Parameter	Value
Supply Voltage	V_{CC} = 5V ± 0.5V or 3.3V ± 0.3V
Input Pulse Levels	0.4V to 2.6V
Input Rise and Fall Times	5 ns
Input and Output Timing Levels	0.8V and 2.0V
Output Load	50 pF

6.8 Timing Specifications

6.8.1 Read Cycle Timing

Symbol	Description	Min (ns)	Max (ns)	Min (ns)	Max (ns)	Notes
		3.3V		5V		
$T_{SU}(A)$	Address to OE# setup	10		10		
$T_{HO}(A)$	OE# to Address hold	80		56		
$T_{SU}(CE0)$	CE# to OE# setup	0		0		1
$T_{HO}(CE0)$	OE# to CE#=0 hold	0		0		2
$T_{HO}(CE1)$	OE# or WE# to CE#=1 hold	36		42		
$T_{SU}(CE1)$	CE# to WE# or OE# setup time	36		42		
T_{REC}	OE# to start of next cycle	46		59		
T_{ACC}	Read access time		160		130	
$T_{EN}(D)$	OE# to D active delay		130		91	
$T_{DIS}(D)$	OE# to D Hi-Z delay		45		44	

Notes:

1 CE# may be asserted any time before or after OE# is asserted. If CE# is asserted after OE#, all timing relative to OE# asserted will be referenced instead to the time of CE# asserted.

2 CE# may be negated any time before or after OE# is negated. If CE# is negated before OE#, all timing relative to OE# negated will be referenced instead to the time of CE# negated.

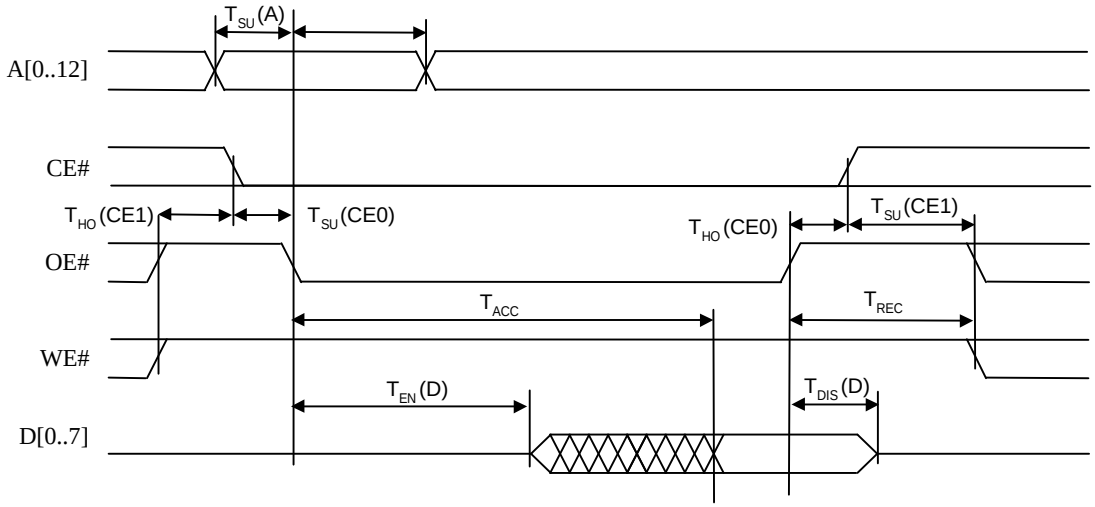


Figure 6 – Read Cycle

6.8.2 Write Cycle Timing

Symbol	Description	Min (ns)	Max (ns)	Min (ns)	Max (ns)	Notes
		3.3V		5V		
t_{SU}(A)	Address to WE# setup time	10		10		
t_{HO}(A)	WE# to Address hold time	80		56		
t_{W}(WE)	WE# asserted width	118		98		
t_{SU}(CE0)	CE# to WE# setup time	0		0		1
t_{HO}(CE0)	WE# to CE#=0 hold time	0		0		2
t_{HO}(CE1)	OE# or WE# to CE#=1 hold time	36		42		
t_{SU}(CE1)	CE# to WE# or OE# setup time	36		42		
t_{REC}	WE# to start of next cycle	46		59		
t_{SU}(D)	D to WE# setup time	45		48		
t_{HO}(D)	WE# to D hold time	30		40		

Notes:

1 CE# may be asserted any time before or after WE# is asserted. If CE# is asserted after WE#, all timing relative to WE# asserted will be referenced instead to the time of CE# asserted.

2 CE# may be negated any time before or after WE# is negated. If CE# is negated before WE#, all timing relative to WE# negated will be referenced instead to the time of CE# negated.

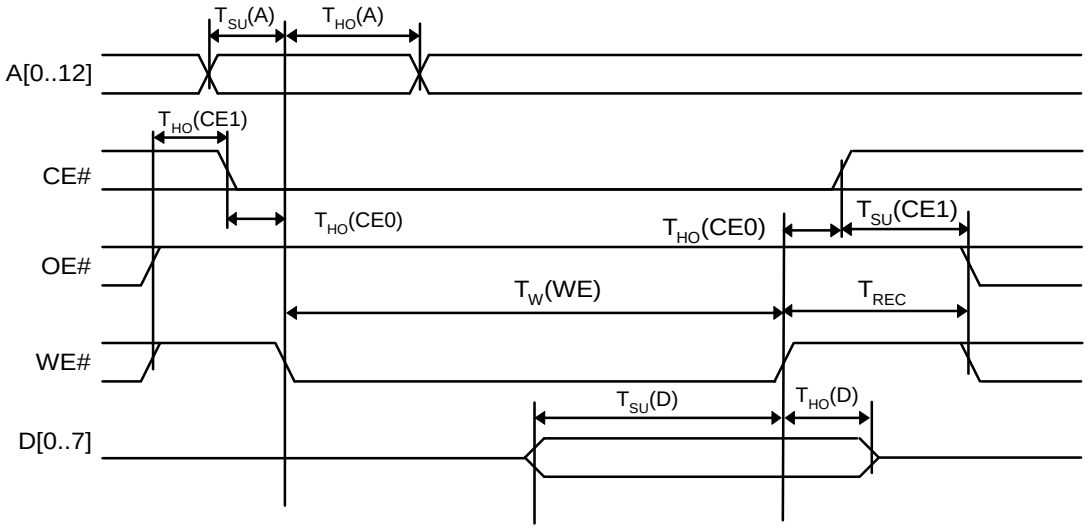


Figure 7 - Write Cycle

7. Mechanical Dimensions

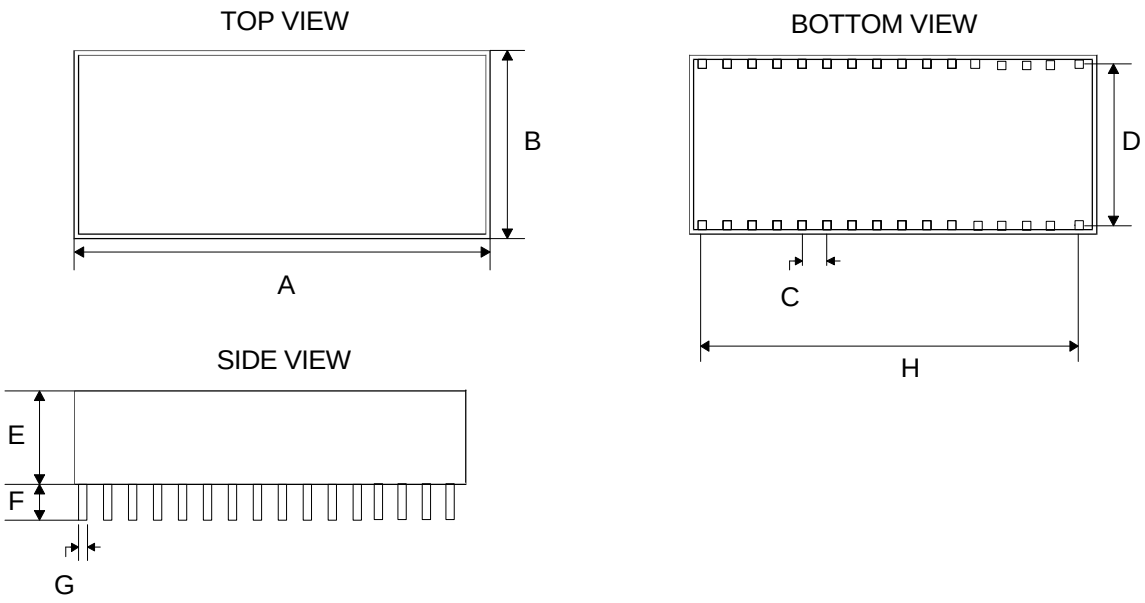


Figure 8 - MD2200 Mechanical Dimensions

	MD-2200-Dxx (Low)		MD-2201-Dxx (High)	
	Millimeters	**Inches**	**Millimeters**	**Inches**
A[1]	41.65 ± 0.10	1.64 ± 0.004	41.8 + 0.20	1.650 + 0.008
B	17.90 ± 0.10	0.704 ± 0.004	18.1+ 0.20	0.713 + 0.008
C	2.54	0.100	2.54	0.100
D	15.24	0.600	15.24	0.600
E	5.50 ± 0.20	0.216 ± 0.008	11.8 ± 0.20	0.464 ± 0.008
F	3.70 ± 0.20	0.145 ± 0.008	3.7 ± 0.10	0.153 ± 0.004
G	0.46 + 0.04	0.018 + 0.001	0.51 - 0.01	0.020-0.0004
H	38.10 ± 0.10	1.5 ± 0.004	38.10 ± 0.10	1.5 ± 0.004

Notes:

1 In future models of the DiskOnChip A=43.7± 0.10, in order to accommodate new and improved Flash technologies M-Systems recommends to use this as a reference when designing new socket for the DiskOnChip.

8. Ordering Information

MD-YYYY-DCC-V-T-PX

Y:	Package Dimensions	2200	Low
		2201	High
CC:	Capacity (MB)	02, 04, 08, 12, 24, 40, 72	
V:	Supply Voltage	Blank	5V
		V3	3.3V[1]
T:	Temperature Range	Blank	Commercial 0°C to +70°C
		N	Enhanced -25°C to +75°C
		X	Extended -40°C to +85°C
PX:	Packaging	PB	Bulk
		PI	Individual (incl. manual and utilities diskette)

[1] Please contact M-Systems for availability.

9. Additional Information

Document / Tool	Description
DiskOnChip 2000 Data Sheet	DiskOnChip 2000 Data Sheet
DiskOnChip 2000 Utilities	DiskOnChip 2000 Utilities User Manual
DiskOnChip 2000 Quick Installation Guide	DiskOnChip 2000 Quick Installation Guide (provided with the individual package)
AP-DOC-010	Application note - Designing with DiskOnChip 2000
AP-DOC-017	Application note - Using the DiskOnChip 2000 with Win CE
AP-DOC-016	Application note - Using the DiskOnChip 2000 with QNX
AP-DOC-019	Application note - Using the DiskOnChip 2000 with Win 95
AP-DOC-011	Application note - Write protecting the DiskOnChip 2000
DiskOnChip2000-EVB	DiskOnChip Evaluation Board
DiskOnChip2000-PIK	DiskOnChip Programmer and Integrator's Kit
DiskOnChip2000-GANG	8 Socket Gang Programmer

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