



**Installation Manual**  
**IM-DOC-022**

# **Using DiskOnChip<sup>®</sup> with VxWorks**

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**SEP-2000**

91-SR-005-38-7L REV. 1.3

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## 1 Introduction

M-Systems' DiskOnChip<sup>®</sup> is a family of high performance flash disk. DiskOnChip provides a flash disk in several standard form factors:

- **DiskOnChip 2000** – Standard 32-pin DIP package, single chip flash disk.
- **DiskOnChip Millennium** – Standard 32-pin DIP package or standard TSOP-II 32-pin package single die flash disk.
- **DiskOnChip DIMM2000** – Standard 144-pin Small Outline DIMM (Dual In-line Memory Module) flash disk.

When used under VxWorks, the DiskOnChip is managed by TrueFFS<sup>®</sup> (True Flash File System), a technology based device driver, attached to VxWorks' `dosFS` file system. Most of VxWorks' disk oriented calls (including all ANSI C file I/O facilities) work correctly with the DiskOnChip.

This installation manual is intended for system integrators designing with the DiskOnChip 2000, DiskOnChip Millennium or DiskOnChip DIMM2000 and describes how the DiskOnChip can be installed as an additional disk or as a boot device under VxWorks. In this manual, all of the devices described above will be referred to as DiskOnChip.

A single TrueFFS driver is capable of supporting up to 4 DiskOnChip devices, possibly of different types and capacities, in parallel. The driver is fully re-entrant and takes care of all issues related to a multitasking environment, thus freeing an application from this task.

It is assumed that the reader is familiar with the Operating System in use.

The hardware requirements of the DiskOnChip will be briefly discussed. The main part of this installation manual is related to software installation. This will include basic driver installation and boot issues.

## 2 Hardware Requirements for the DiskOnChip

Originally designed for PC environments, the DiskOnChip can also be used in different hardware environments. The minimum requirements are a 12-bit address bus, an 8-bit data bus, and three active low control signals (#CE, #OE, #WR). Figure 1 below is a drawing of the DiskOnChip and its pins. For more detailed information of the DiskOnChip hardware environment, refer to the following Application Notes:

- AP-DOC-010 “Designing with the DiskOnChip DIP”
- AP-DOC-030 “Designing with the DiskOnChip Millennium in a RISC Environment”
- AP-DOC-031 “Designing with the DiskOnChip Millennium in a PC Environment”

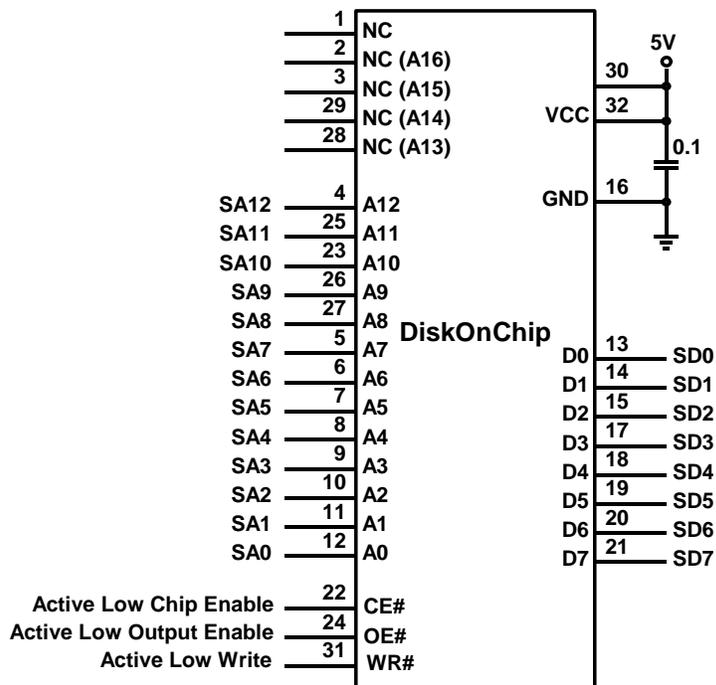


Figure 1 DiskOnChip Pin-out

## 3 Installing the TrueFFS Driver into VxWorks

### 3.1 Preparing VxWorks

Verify that the BSP library (Tornado/target/lib<CPU>gnumvx.a) or the BSP object directory (Tornado/target/obj<CPU>gnumvx) contain the following object modules and if so, delete them:

tffsDrv.o	nftllite.o
tffsLib.o	flflash.o
dosfmt.o	nfdc2148.o
fatlite.o	reedsol.o
flt1.o	flsocket.o
flbase.o	

#### Example:

To check the contents of the 'pc486' BSP library (libI80486gnumvx.a), use the following command:

```
ar386 -tv libI80486gnumvx.a
```

#### Example:

To delete the module flt1.o from the BSP library libI80486gnumvx.a, use the following command:

```
ar386 -dv libI80486gnumvx.a flt1.o
```

Ensure that the BSP configuration .H file (Tornado/target/config/pc486/config.h in case of pc486 BSP) excludes the following VxWorks components:

```
#undef INCLUDE_TFFS /* include TrueFFS driver for Flash */
#undef INCLUDE_PCMCIA /* include PCMCIA driver */
```

### 3.2 Contents of TrueFFS Driver Package

The distribution of the TrueFFS driver for VxWorks on x86 compatible platforms consists of the following files:

MSYSVXW.o	x86 binary of the TrueFFS driver for VxWorks
fldrvvxw.h	TrueFFS driver's "include" file
flioctl.h	Extended functionality "include" file
Readme	Readme file

## MSYSVXW.o

The object module `MSYSVXW.o` contains the x86 binaries of the TrueFFS driver for VxWorks. This object module should be added to the application's linking process, either statically or dynamically.

One possible way to accomplish this is to copy the file `MSYSVXW.o` to the directory `Tornado/target/lib` and then add it to the existing `VxWorks/I80486` object library as follows:

```
ar386 -cru libI80486gnuvx.a MSYSVXW.o
```

## fldrsvvxw.h

Include file for the TrueFFS driver that must be `#included` by the application in order to access the driver's API. Furthermore, make sure it is on the compiler's `INCLUDE` path.

## flioct1.h

Extended functionality "include" file. This file must be `#included` by the application in order to be able to access the Extended functionality API.

## 3.3 Customizing the TrueFFS Driver

### 3.3.1 Setting the Address Range

The initialization routine of the TrueFFS driver scans the host address space for the DiskOnChip(s). By default, the driver will look for a single DiskOnChip in the address range `0xc8000..0xe0000`.

In most x86 architecture scanning, the default address range will be sufficient, but in certain cases, there might be a need to change it. Changing the area to be scanned can be accomplished by calling the routine `tffsSetup()`.

**Note:** The routine `tffsSetup()` must be called only once, before the call to the initialization routine `tffsDrv()`. Normally, this is done from `usrRoot`.

The routine `tffsSetup()` can be found in the header file `fldrsvvxw.h` and has the following declaration:

```
extern void tffsSetup (int diskonchips, long *addressRange);
```

where `diskonchips` is the number of DiskOnChip devices installed in the system and `addressRange` is an array of address pairs that restricts the area of scanning.

#### Example 1:

For instance, if the platform allows an installation of up to three DiskOnChips, and the regions to search for the DiskOnChips are as follows:

```
[ 0xc8000 .. 0xd0000 ]      1st DiskOnChip  
[ 0xd0000 .. 0xd2000 ]      2nd DiskOnChip
```

[0xd2000 .. 0xd4000]           3rd DiskOnChip

Then the following code fragment should be included in the application:

```
#include "fldrvvxw.h"
/* address ranges to search for the DiskOnChip */
long tffsAddresses[] = {0xc8000, 0xd0000, /* 1st DiskOnChip */
                       0xd0000, 0xd2000, /* 2nd DiskOnChip */
                       0xd2000, 0xd4000}; /* 3rd DiskOnChip */
/* Configure the driver to detect up to three DiskOnChips */
tffsSetup(3, tffsAddresses);
```

In some cases, when the DiskOnChip is located at a known address, it is required to prevent the TrueFFS driver from performing its scanning routine. In such cases both the upper and lower boundary of the search range can be set to the exact DiskOnChip address.

### Example 2:

If the DiskOnChip is always installed at address 0xd0000, then the application can instruct the TrueFFS driver to look for the DiskOnChip at that particular address by executing the following code fragments:

```
#include "fldrvvxw.h"
/* single address to look for a DiskOnChip */
long tffsAddresses[ ] = { 0xd0000, 0xd0000 };
/* configure the driver to detect a single DiskOnChip */
tffsSetup(1, tffsAddresses);
```

### 3.3.2 Configuring the TrueFFS Driver

The TrueFFS driver provides configuration options that are described in detail in Section 4 . Most applications can use the default settings for these options.

If it is required to change some of the driver's configuration options, you should do so at this stage.

#### Example:

To enable the TrueFFS driver's built-in diagnostics (refer to Section 5.4), include the following code fragment:

```
#include "fldrvvxw.h"

/* enable built-in diagnostics and allocate 4KB for logging diagnostics messages */
fl_useDebug = 4;
```

**Note:** All the driver's configuration options must be set to the desired values before calling the initialization routine `tffsDrv()`. Once the routine `tffsDrv()` has been called, the configuration options must NOT be changed.

### 3.4 Creating a 'device' for the DiskOnChip

Before a 'device' for each physical DiskOnChip installed in the system can be created, the TrueFFS driver must be initialized. This is done through a call to the routine `tffsDrv()`.

**Note:** The routine `tffsDrv()` should be called only once, after the call to routine `tffsSetup()`. Normally, this is done from `usrRoot`.

The next step is to create a 'device' for each DiskOnChip, which is done by calling the routine `tffsDevCreate()`. The routine `tffsDevCreate()` can be found in the header file `fldrvvxw.h` and has the following declaration:

```
extern BLK_DEV* tffsDevCreate (int tffsDriveNo,
                              int removableMediaFlag);
```

where `tffsDriveNo` is the DiskOnChip sequential number (zero-based). The argument `removableMediaFlag` must always be zero.

The routine `tffsDevCreate()` routine returns a pointer of type `(BLK_DEV *)`, which must be saved by the application for later use.

#### Example 1:

If there is only one DiskOnChip in the system, the application should include the following code fragment:

```
#include "fldrvvxw.h"

BLK_DEV *tffs_blk_dev = tffsDevCreate (0, 0);
```

In a system containing three DiskOnChips, the code fragment is as follows:

```
#include "fldrvvxw.h"
BLK_DEV *tffs_blk_dev[3] = { NULL, NULL, NULL };
tffs_blk_dev[0]=tffsDevCreate (0, 0); /*1st DiskOnChip*/
tffs_blk_dev[1]=tffsDevCreate (1, 0); /*2nd DiskOnChip*/
tffs_blk_dev[2]=tffsDevCreate (2, 0); /*3rd DiskOnChip*/
```

Once the 'devices' have been created for every DiskOnChip, they must be given names and associated with the file system (dosFs). This is accomplished by calling the routine `dosFsDevInit()` (refer to the VxWorks Reference Manual). The parameter that is passed to this routine is a pointer of type (BLK\_DEV \*) that has been returned by the preceding call to `tffsDevCreate()`.

The routine `dosFsDevInit()` returns a pointer of type (DOS\_VOL\_DESC \*) which must be saved by the application for later use.

### Example 2:

If there is only one DiskOnChip in the system, the following code section names it `/tffs0` and associates it with the `dosFs` file system:

```
#include "fldrvvxw.h"
DOS_VOL_DESC *tffs_dosFs_vol =
    dosFsDevInit ("/tffs0:", tffs_blk_dev, NULL);
```

In a system containing three DiskOnChips, the code fragment is as follows:

```
#include "fldrvvxw.h"
DOS_VOL_DESC *tffs_dosFs_vol[3] = { NULL, NULL, NULL };
tffs_dosFs_vol[0] = dosFsDevInit("/tffs0:", tffs_blk_dev[0], NULL);
tffs_dosFs_vol[1] = dosFsDevInit("/tffs1:", tffs_blk_dev[1], NULL);
tffs_dosFs_vol[2] = dosFsDevInit("/tffs2:", tffs_blk_dev[2], NULL);
```

## 3.5 Configuring 'dosFs' File System

M-Systems guarantees that the low-level format of the DiskOnChip never becomes corrupted by unexpected power shutdowns. Unfortunately, the default configuration of VxWorks' `dosFs` file system is aimed at providing high I/O performance by caching user data in RAM rather than immediately writing it onto the disk.

If unexpected power shutdowns are likely, this data will be lost. To minimize the risk, it is possible to eliminate data caching by `dosFs`. This can be achieved by calling the routine `dosFsVolOptionsSet()` (refer to the VxWorks Reference manual), as follows:

```
#include "fldrvvxw.h"
```

```
dosFsVolOptionsSet(tffs_dosFs_vol,  
    tffs_dosFs_vol->dosvd_options | DOS_OPT_CHANGENOWARN);
```

where `tffs_dosFs_vol` is a pointer returned by the routine `dosFsDevInit()`.  
(Refer to Section 3.4).

More detailed information on unexpected power shutdowns can be found in Chapter 7.

**Note:** Disabling the file system cache reduces the I/O performance of the DiskOnChip.

## 4 Booting VxWorks from the DiskOnChip (on an x86 Platform)

### 4.1 Boot Options

There are three basic VxWorks boot options supported by the TrueFFS driver:

- Network boot
- One-step standalone boot
- Two-step standalone boot

#### Network boot

The bootfile `BOOTROM.SYS` that is located on the DiskOnChip acts as a secondary program loader and uses the network connection to download the VxWorks application from the remote host. This scenario is usually used during application development/debugging stage.

#### One-step standalone boot

The bootfile `BOOTROM.SYS` includes the application itself. This scenario is used for relatively small applications that fit entirely into the first 640KB of RAM.

#### Two-step standalone boot

The bootfile `BOOTROM.SYS` acts as a secondary program loader and loads the application from the DiskOnChip. This scenario is used with large VxWorks applications where a one-step boot cannot be used because of the application's size.

The DiskOnChip supports both the network boot and the one-step boot and there is no need to make any changes to the VxWorks boot code.

The two-step boot requires some minimal changes to the following VxWorks files:

- BSP configuration .H file (i.e. `Tornado/target/config/pc486/config.h` in case of pc486 BSP)
- `Tornado/target/config/all/bootConfig.c`
- `Tornado/target/config/all/usrConfig.c`

The procedures outlined in Sections 4.2–4.3 are common to all three-boot scenarios. When using the two-step boot, follow the extra procedures outlined in Appendix 1.

**Note:** The procedures described in Sections 4.2–4.3 are typically done only once, on the very first DiskOnChip you use. Once you have successfully gone through one of these procedures, it is possible to copy the binary image of the DiskOnChip to other DiskOnChips (i.e. cloning the first DiskOnChip)<sup>1</sup>.

## 4.2 Requirements for Installation of the DiskOnChip into VxWorks

In order to prepare the DiskOnChip to boot VxWorks, the following software tools are required:

- DiskOnChip DOS utilities diskette. The utilities can also be found on M-Systems' website: [www.m-sys.com](http://www.m-sys.com).
- DiskOnChip firmware file DOC121 . EXB file (where '121' is the firmware version. Any firmware version higher than '121' will do). This file can be found on the DOS utilities diskette or can be downloaded from the M-Systems website.
- Standard VxWorks VXSYS utility.
- VxWorks bootfile BOOTROM . SYS.
- DOS-bootable floppy.

## 4.3 Preparing the DiskOnChip to boot VxWorks

If you wish to boot VxWorks from the DiskOnChip either using the network boot, the one-step standalone or two-step standalone boot option, follow the steps as described below.

1. Boot DOS on the target board from a DOS diskette.
2. Reformat the DiskOnChip by running the DOS utility DFORMAT.EXE as shown below:  

```
DFORMAT /WIN={address} /S={firmware} /FIRST /Y
```
3. where {address} is the base address of the DiskOnChip (i.e. D000 , D400 and so on), and {firmware} is the DiskOnChip firmware file (DOC110 . EXB , DOC121 . EXB , and so on).
4. Reboot the target system from the DOS diskette and check that the driver letter C: was assigned to the DiskOnChip:  

```
dir c:
```
5. At the DOS prompt, run WindRiver's VXSYS utility to write the VxWorks bootstrap code onto the DiskOnChip:  

```
VXSYS c:
```

---

<sup>1</sup> Another solution to copy the binary image of the DiskOnChip to various target DiskOnChip is through the usage of the GANG programmer. For further details refer to “DiskOnChip GANG programmer User Manual” or contact M-Systems.

6. Copy the file `BOOTROM.SYS` to the root directory of the DiskOnChip.

At this point, the DiskOnChip is ready to boot VxWorks. If you wish to follow the two-step standalone boot scenario, refer to Appendix A.

## 5 TrueFFS Driver Run-time Configuration Options

### 5.1 Introduction

The TrueFFS driver provides a number of run-time configuration options. The default settings of these options are adequate for most applications. However, in some situations it may be required to change these settings. All the driver's configuration options are described in detail in Sections 5.2 to 5.5.

**Note:** All the configuration variables must be set to the desired values before the initialization routine `tfFsDrv()` is called. The value of the configuration variables must NOT be changed after the call to `tfFsDrv()`.

### 5.2 8-Bit/32-Bit Access to the DiskOnChip

By default, the TrueFFS driver accesses the DiskOnChip in 32-bit mode. Most platforms are capable of breaking down a single 32-bit cycle into correct sequences of 8-bit access cycles to the DiskOnChip. However, there are some platforms that don't support this mode and accessing the DiskOnChip in 8-bit mode is required.

To configure the TrueFFS driver to access the DiskOnChip in 8-bit mode, set the configuration variable `flUse8bit` to '1' in your application:

```
extern unsigned char flUse8bit;  
  
/* Access the DiskOnChip in 8-bit mode */  
  
flUse8bit = 1;
```

**Note:** The DiskOnChip I/O performance decreases by 10-20% (depending on the platform) when the TrueFFS driver is configured to run in 8-bit mode.

### 5.3 Configuring RAM Usage

By default, the TrueFFS driver is configured to store the internal mapping and translation tables in RAM, allowing fast I/O performance to the DiskOnChip.

However, for high capacity DiskOnChip's, the amount of RAM taken by these tables can be significant. To minimize RAM usage, set the configuration variable `flUseNFTLCache_useSCache` to zero:

```
extern unsigned char flUseNFTLCache;  
/* Minimize RAM usage */  
flUseNFTLCache = 0;  
0;
```

**Note:** The configuration variable `flUseNFTLCache` is not related to the issue of unexpected power shutdowns. The settings of this variable is purely a matter of I/O performance vs. RAM usage.

### 5.4 Built-in Diagnostics

The TrueFFS driver provides built-in diagnostics, allowing messages issued at critical points of the DiskOnChip operation to be logged into an internal buffer.

By default, the diagnostics feature is disabled, but can be enabled by setting the configuration variable `fl_useDebug` to any non-zero value, as follows:

```
extern int fl_useDebug;  
/* Enable built-in diagnostics */  
fl_useDebug = 4;
```

The size of the allocated buffer (in KBytes) is equal to the numerical value of the `fl_useDebug` variable (in the example above, the buffer size will be 4KB).

The diagnostics buffer will contain C-style zero-terminated strings that can either be viewed (using the debugger) or printed on the console at any time.

A pointer to the start of the diagnostics buffer is returned by the routine `tfFsViewDebugLog()` (see `fldrvvxw.h`).

**Note:** In most cases, a value of 2 for the variable `fl_useDebug` (thus allocating 2KB for the diagnostic buffer) will suffice.

### 5.5 Yielding the CPU During Long Flash Operation

Inherent to flash technology is the need to erase the flash media before new data is written to it. The erase operation is done “on-the-fly” whenever available media becomes scarce, taking typically

around 4 milliseconds to complete. During an erase operation, by default the TrueFFS driver polls the DiskOnChip, waiting for the erase operation to complete.

Alternatively, the TrueFFS driver can suspend itself during the erase operation, allowing other tasks to use the CPU's resources. To instruct the TrueFFS driver to always release the CPU right after starting the erase operation, set the configuration variable `flDelay` to non-zero value:

```
extern unsigned char flDelay;
flDelay = (unsigned char) 1;
```

**Note:** Suspending the TrueFFS driver for a certain amount of clock ticks can affect the write performance of the DiskOnChip. This may occur when the TrueFFS driver is not given the CPU right after the specified number of clock ticks, but rather be put at the end of the queue of tasks that are waiting for the CPU resource, the write performance is reduced.

Furthermore, the duration of a clock tick in VxWorks (usually 10 msec, or 2.5 times longer than the erase operation) provides poor granularity for suspending the TrueFFS driver.

## 6 Formatting the DiskOnChip Under VxWorks

It is possible to format the DiskOnChip under VxWorks, instead of using the standard DiskOnChip DOS utilities `DFORMAT.EXE`.

In order to format the DiskOnChip under VxWorks the routine `tffsDevFormat()` is called. The routine `tffsDevFormat()` can be found in the header file `fldrvvxw.h` and has the following declaration:

```
extern STATUS tffsDevFormat (int tffsDriveNo, int arg);
```

where `tffsDriveNo` is the DiskOnChip sequential number (zero-based) and `arg` is a pointer (type casted to `int`) to the `struct tffsDevFormatParams`, containing the parameters of the format call.

**Note:** A brief description of the fields in the `struct tffsDevFormatParams` can be found in the header file `fldrvvxw.h`.

In most cases, the `struct tffsDevFormatParams` can be initialized using the `#define TFFS_STD_FORMAT_PARAMS` (see `fldrvvxw.h`) as shown below:

```
struct tffsDevFormatParams format_params = TFFS_STD_FORMAT_PARAMS;
```

### Example:

If there are three DiskOnChips present in the system, the application can format each DiskOnChip separately. The following code sample formats the first and third DiskOnChip available in the system:

```
#include "fldrvvxw.h"
/* use standard format parameters */
```

```
struct tffsDevFormatParams format_params = TFFS_STD_FORMAT_PARAMS;
/* format the first DiskOnChip */
tffsDevFormat(0, (int) (&format_params));
/* skip the second DiskOnChip */
/* tffsDevFormat(1, (int) (&format_params)); */
/* format the third DiskOnChip */
tffsDevFormat(2, (int) (&format_params));
```

## 7 Data Integrity on the DiskOnChip

The data structures on the DiskOnChip can be divided into low-level data structures and file system data structures. The low-level data structures are M-Systems' proprietary flash-specific data structures that are maintained by the TrueFFS driver. The file system data structures are maintained by VxWorks' dosFS filesystem and basically consist of the FAT, root directory, and so on.

The flash management algorithms that are used inside the TrueFFS driver have been carefully designed to keep the low-level format consistent at any given moment of time and guarantee the integrity of the low-level data structures, even after a power failure or an unexpected system shutdown.

Data integrity on the file system level is the responsibility of the OS and not the TrueFFS driver. By default, VxWorks' dosFS file system does not immediately write data onto the storage device (i.e. DiskOnChip), but instead caches data in RAM. While this increases the I/O performance of the system, it also becomes more vulnerable to corruption in cases of power failure or unexpected system shutdown.

It is possible to prevent dosFS from caching the data in RAM by using the option `DOS_OPT_CHANGENOWARN` (refer to Section 3.5).

Unfortunately, the risk of data corruption at file system level due to power failures or an unexpected system shutdown cannot be reduced to zero. Repair of corrupted data structures on file system level, such as broken FAT chains or corrupted directory entries, can be done by tools similar to `CHKDSK` in DOS. Please contact WindRiver Systems regarding the availability of similar tools for VxWorks.

## 8 Garbage Collection

Inherent to flash technology is the need to erase flash media before new data is written to it. The process of erasing previously used blocks of flash is known as "garbage collection".

The TrueFFS driver automatically performs a "garbage collection" whenever there is not enough free space on the media available to complete the write operation. This implies that at random times the write operation is delayed due to "garbage collection" that needs to be performed. The result is that the time it takes to write a certain amount of data varies.

For most applications it is of minor concern that the length of a write operation varies. However, there are certain applications that have special requirements regarding the write operation's timing. In these cases, it is possible to provide a separate "garbage collection" task that runs at a relatively low priority, when the system is idle.

The sole purpose of this task is to perform a "garbage collection" on the DiskOnChip and guarantee that there will be enough "free" media available for the next write operation.

The routine `tffsRecycle()` that provides the "garbage collection" task can be found in the header file `fldrdrvwx.h` and has the following declaration:

```
extern STATUS tffsRecycle (int volNo, int mode);
```

where `volNo` is the DiskOnChip sequential number (zero-based) and 'mode' is the mode of recycling (0 for single, quick "garbage collection" action and 1 for long, full "recycling" of all "dirty" flash memory regions)..

**Note:** The second parameter of the routine `tffsRecycle` has been changed from the "number of flash KBytes to recycle" to the "mode of recycling" (0 or 1) from version 4.2.

### Example:

If there is only one DiskOnChip in the system, then the "garbage collection" task can be implemented:

```
#include "fldrdrvwx.h"

void garbageCollectionTask(void)
{
while (1) {
    /* quick "recycle" action on the first DiskOnChip */
    if (tffsRecycle(0, 0) != OK)
        break;
    /* sleep for a while (5 ticks) */
    taskDelay(5);
}
}
```

The priority of the "garbage collection" task should be slightly lower than the priorities of all the tasks that write/read data to/from the DiskOnChip. At the same time, it shouldn't be too low as it could effectively block the access to the DiskOnChip for a long time if it is pre-empted by other tasks while running.

**Note:** The "garbage collection" task should be started after the application has called all the routines mentioned in Section 3.

**Note:** The TrueFFS driver performs all the necessary synchronization between multiple tasks that access the DiskOnChip concurrently. This means that there is no need for the application to synchronize the "garbage collection" task with all the other tasks that access the DiskOnChip.

## 9 IOCTL calls to the TrueFFS driver

### 9.1 Introduction

Version 4.1 of the TrueFFS driver for VxWorks allows the user to implement the following new features of the DiskOnChip software:

- Obtain information on DiskOnChip
- Software write protection
- Run "garbage collection" in the background
- Access the Binary Partition<sup>2</sup>, allowing the user to boot VxWorks on BIOS-less systems
- Bypass the file system and access the DiskOnChip at virtual sector level

These new features are accessible through standard VxWorks IOCTL calls to the TrueFFS driver<sup>3</sup> (provided by the API given in the file `fliioctl.h`). The following IOCTL calls are supported:

IOCTL call	Usage
FL_IOCTL_GET_INFO	Obtain information on DiskOnChip
FL_IOCTL_DEFRAGMENT	Background "garbage collection"
FL_IOCTL_WRITE_PROTECT	Software write protection of the DiskOnChip
FL_IOCTL_BDK_OPERATION	Accessing Binary Partition of DiskOnChip
FL_IOCTL_READ_SECTORS	Read virtual sectors from DiskOnChip
FL_IOCTL_WRITE_SECTORS	Write virtual sectors to DiskOnChip

**Note:** All the data structures in the file `fliioctl.h` are assumed to be packed, i.e. all the members of these data structures are NOT aligned in any way. For instance, the function `sizeof(flDiskInfoOutput)` should return 55.

Sections 9.2 to 9.6 provide sample codes on how an application can issue IOCTL calls to the TrueFFS driver.

<sup>2</sup> For more information on accessing the Binary Partition on the DiskOnChip, refer to Application Note AP-DOC-020 "Boot Developers Kit".

<sup>3</sup> For more information on IOCTL calls, refer to Application Note AP-DOC-046 "Extended functions of TrueFFS driver for DiskOnChip".

## 9.2 FL\_IOCTL\_GET\_INFO

The following code sample shows how to obtain general information on the DiskOnChip's flash array:

```
#include <ioLib.h>
#include <dosFsLib.h>
#include <stdlib.h>
#include <stdio.h>
#include <errno.h>
#include "fldrvvxw.h"
#include "flioctl.h"
flDiskInfoOutput  out;
int                fd;
int                status;

/* open the DiskOnChip raw device (assuming it is "/dev/tffs0") */
fd = open ("/dev/tffs0", O_RDWR, 0);
if (fd == ERROR) {
    printf ("0x%x error in open()\n", (int) errno);
    return;
}
/* issue IOCTL call to the driver */
status = ioctl (fd, FL_IOCTL_GET_INFO, (int) &out);
if (status == ERROR) {
    printf ("0x%x error in ioctl()\n", (int) errno);
}
(void) close (fd);
/* check out the out.status */
printf ("status 0x%x\n", (int) out.status);
/* reply data is in out.info */
```

### 9.3 FL\_IOCTL\_DEFRAGMENT

The following code sample describes how to perform a short cycle of the "garbage collection" process on the DiskOnChip:

```
#include <ioLib.h>
#include <dosFsLib.h>
#include <stdlib.h>
#include <stdio.h>
#include <errno.h>
#include "fldrvvxw.h"
#include "fliioctl.h"

typedef union {
    flDefragInput    in;
    flDefragOutput  out;
} flDefragReq;

flDefragReq  ioctl_req;
int          fd;
int          status;

/* request minimal garbage collection */
ioctl_req.in.requiredNoOfSectors = (long) -1;

/* open the DiskOnChip raw device (assuming it is "/dev/tffs0") */
fd = open ("/dev/tffs0", O_RDWR, 0);
if (fd == ERROR) {
    printf ("0x%x error in open()\n", (int) errno);
    return;
}

/* issue IOCTL call to the driver */
```

```
status = ioctl (fd, FL_IOCTL_DEFRAGMENT, (int) &ioctl_req);
if (status == ERROR) {
    printf ("0x%x error in ioctl()\n", (int) errno);
}
```

```
(void) close (fd);
```

```
/* check out the ioctl_req.out.status */
printf ("status 0x%x\n", (int) ioctl_req.out.status);
```

```
/* reply data is in ioctl_req.out.actualNoOfSectors */
```

**Note:** The TrueFFS driver also provides the routine `tffsRecycle()`, which can be used instead of the `FL_IOCTL_DEFRAGMENT` IOCTL call. Refer to Section 8 for further details.

## 9.4 FL\_IOCTL\_WRITE\_PROTECT

The code sample below describes how to software write protect on the DiskOnChip.

**Note:** Before executing the code fragment below, ensure that the DiskOnChip has been unmounted by a call to the routine `dosFsVolUnmount()`. When write-protecting the DiskOnChip, please be aware of the fact that ALL the attempts to write data onto the DiskOnChip will be rejected, including the write requests which are generated by the filesystem internally for its own purposes.

```
#include <ioLib.h>
#include <dosFsLib.h>
#include <stdlib.h>
#include <stdio.h>
#include <errno.h>
#include "fldrvvxw.h"
#include "fliioctl.h"

typedef union {
    flWriteProtectInput    in;
    flOutputStatusRecord  out;
} flWriteProtectReq;
```

```
flWriteProtectReq  ioctl_req;
int                fd;
int                status;

/* specify type of operation */
ioctl_req.in.type = (unsigned char) FL_UNPROTECT;

/* replace the password below with your own */
ioctl_req.in.password[0] = 0x11223344;
ioctl_req.in.password[1] = 0x55667788;

/* open the DiskOnChip raw device (assuming it is "/dev/tffs0") */
fd = open ("/dev/tffs0", O_RDWR, 0);
if (fd == ERROR) {
    printf ("0x%x error in open()\n", (int) errno);
    return;
}

/* issue IOCTL call to the driver */
status = ioctl (fd, FL_IOCTL_WRITE_PROTECT, (int) &ioctl_req);
if (status == ERROR) {
    printf ("0x%x error in ioctl()\n", (int) errno);
}

(void) close (fd);

/* check out the ioctl_req.out.status */
printf ("status 0x%x\n", (int) ioctl_req.out.status);
```

## 9.5 FL\_IOCTL\_BDK\_OPERATION

The code sample below shows how to access the Binary (BDK) Partition on the DiskOnChip.

**Note:** For further details on the Binary Partition of the DiskOnChip and its usage, refer to Application Note AP-DOC-020 “Boot Developers Kit”.

```
#include <ioLib.h>
#include <dosFsLib.h>
#include <stdlib.h>
#include <stdio.h>
#include <errno.h>
#include "fldrvvxw.h"
#include "fliioctl.h"

typedef union {
    flBDKOperationInput    in;
    flOutputStatusRecord  out;
} flBDKOperationReq;

flBDKOperationReq  ioctl_req;
int                fd;
int                status;
unsigned char      buf[512];
                  /* buffer to read BDK data to/write from */

switch (bdkOperation) {
case BDK_WRITE:
    ioctl_req.in.type           = (unsigned char) BDK_WRITE;
    ioctl_req.in.bdkStruct.bdkBuffer = buf;
    ioctl_req.in.bdkStruct.length  = sizeof(buf);
    /* place your BDK data to buf[] */
    break;
case BDK_READ:
```

```
    ioctl_req.in.type          = (unsigned char) BDK_READ;
    ioctl_req.in.bdkStruct.bdkBuffer = buf;
    ioctl_req.in.bdkStruct.length   = sizeof(buf);
break;
default: /* add other BDK operations here */
return;
}

/* open the DiskOnChip raw device (assuming it is "/dev/tffs0") */
fd = open ("/dev/tffs0", O_RDWR, 0);
if (fd == ERROR) {
    printf ("0x%x error in open()\n", (int) errno);
    return;
}

/* issue IOCTL call to the driver */
status = ioctl (fd, FL_IOCTL_BDK_OPERATION, (int) &ioctl_req);
if (status == ERROR) {
    printf ("0x%x error in ioctl()\n", (int) errno);
}

(void) close (fd);

/* check out the ioctl_req.out.status.status */
printf ("status 0x%x\n", (int) ioctl_req.out.status);

if (bdkOperation == BDK_READ) {
/* the returned BDK data is in buf[] */
}
}
```

## 9.6 FL\_IOCTL\_READ\_SECTORS and FL\_IOCTL\_WRITE\_SECTORS

The code sample below demonstrates how to read virtual sectors from a source DiskOnChip and then write these virtual sectors to a target DisknChip.

```
#include <ioLib.h>
#include <dosFsLib.h>
#include <stdlib.h>
#include <stdio.h>
#include <errno.h>
#include "fldrvvxw.h"
#include "fliioctl.h"

#define FL_SECT_SIZE 512

typedef union {
    flReadWriteInput  in;
    flReadWriteOutput out;
} flReadWriteReq;

/*
Assuming :
char *fromVolName  is the name of the source TrueFFS volume
char *toVolName    is the name of the target TrueFFS volume
*/

int          fd1, fd2;
long         sectors1, sectors2, iSect, hiddenSectors;
flDiskInfoOutput  out;
flReadWriteReq  rwReq;
char         buf[FL_SECT_SIZE]; /* sector buffer */
```

```
/* get the number of sectors on the source and target TrueFFS
volumes. Abort is target is smaller then the source
*/
fd1 = open (fromVolName, O_RDONLY, 0);
if (fd1 == ERROR)
    return; /* error */
if (ioctl (fd1, FL_IOCTL_GET_INFO, (int) &out) == ERROR)
    return; /* error */
sectors1      = (long) out.info.logicalSectors;
hiddenSectors = (long) out.info.sectors;

fd2 = open (toVolName, O_RDWR, 0);
if (fd2 == ERROR)
    return; /* error */
if (ioctl (fd2, FL_IOCTL_GET_INFO, (int) &out) == ERROR)
    return; /* error */
sectors2 = (long) out.info.logicalSectors;
if (sectors1 > sectors2)
    return; /* error */

/* Copy source TrueFFS volume to the target. Sector ## are zero-
based. */
for (iSect = 0; iSect < sectors1; iSect++) {
    /* read the sector from the source volume */
    rwReq.in.firstSector      = iSect - hiddenSectors;
    rwReq.in.numberOfSectors = (long) 1;
    rwReq.in.buf              = buf;
    if (ioctl (fd1, FL_IOCTL_READ_SECTORS, (int) &rwReq) == ERROR)
        return; /* error */
    if((rwReq.out.numberOfSectors != 1) || (rwReq.out.status != f1OK))
        return; /* error */
    /* write the sector to the target volume */
```

```
rwReq.in.firstSector      = iSect - hiddenSectors;
rwReq.in.numberOfSectors = (long) 1;
rwReq.in.buf              = buf;
if (ioctl (fd2, FL_IOCTL_WRITE_SECTORS, (int) &rwReq) == ERROR)
    return; /* error */
if ((rwReq.out.numberOfSectors != 1) || (rwReq.out.status!=f1OK))
    return; /* error */
}
(void) close (fd1);
(void) close (fd2);
```

**Note:** The IOCTL calls `FL_IOCTL_READ_SECTORS` and `FL_IOCTL_WRITE_SECTORS` use an atypical sector numbering scheme. They assume that the sector numbers are zero-based, and map sector #0 to the starting sector of the FAT partition (i.e VxWorks bootsector). To access the sectors located before the starting sector of the FAT partition (for instance, the Master Boot Record), the application needs to specify negative sector numbers. The code fragment above illustrates how to read the Master Boot Record. It sets the parameter `rwReq.in.firstSector` to the '0 - hiddenSectors' (i.e. negative) value.

## 10 Known Problem

Version 4.1 and up of the TrueFFS driver for VxWorks contains the following known problem:

- The VxWorks' routine `dosFsMkfs ( )` is incompatible with the original MS-DOS FAT volume formats. Use the `tfFsDevFormat ( )` routine instead (refer to Section 5 “TrueFFS Driver Runtime Configuration Options”) for creating dosFs file system structures on the DiskOnChip. Refer to Appendix I: Two Step Stand Alone Boot

## Appendix I - Two Step Standalone Boot

To boot VxWorks two-step standalone from the DiskOnChip, perform the following:

1. Add the following line to the BSP configuration .H file (i.e. Tornado/target/config/pc486/config.h in case of pc486 BSP):
2. Change the #define DEFAULT\_BOOT\_LINE in the BSP configuration .H file (i.e. Target/target/config/pc486/config.h in case of pc486 BSP) as follows:

```
#define INCLUDE_DISKONCHIP /* M-SYSTEMS TFFS */
```

```
#define DEFAULT_BOOT_LINE  
    \"tffs=0,0(0,0)host:/tffs0/vxWorks  
    h=90.0.0.3 e=90.0.0.50 u=target\"
```

**Note:** The above code instructs the BOOTROM.SYS to look for an application named `vxWorks` located in the root directory of the device `/tffs0` (i.e. first DiskOnChip).

If it is required to name the application differently or to place it in a different location other than the root directory of the first DiskOnChip, change the respective fields in the code.

3. Modify the file Tornado/target/config/all/bootConfig.c by adding the following code after the line #define INCLUDE\_DISKONCHIP, just before the routine `usrInit()`:

```
#ifdef INCLUDE_DISKONCHIP  
#ifdef __cplusplus  
extern "C" {  
#endif  
#ifndef _ASMLANGUAGE  
#include "blkIo.h"  
/* TrueFFS driver configuration variables. */  
/* See Section 4 for details */  
extern unsigned char flUse8bit;  
extern unsigned char flUseNFTLCache;  
extern int fl_useDebug;  
#if defined(__STDC__) || defined(__cplusplus)  
extern void tffsSetup (int diskonchips,  
long addressRange);  
extern STATUS tffsDrv (void);
```

```
extern BLK_DEV * tffsDevCreate (int tffsDriveNo, int
                               removableMediaFlag);

#else /* __STDC__ */
    extern void tffsSetup ();
    extern STATUS tffsDrv ();
    extern BLK_DEV * tffsDevCreate ();
#endif /* __STDC__ */
#endif /* _ASMLANGUAGE */
#ifdef __cplusplus
}
#endif
/* forward declarations */
#ifdef __STDC__
void devSplit (char *fullFileName, char *devName);
#else
void devSplit ();
#endif /* __STDC__ */
extern unsigned noOfDrives;
STATUS usrTffsConfig
(
    int drive,          /* drive number of TFFS */
    int removable,     /* 0 - non removable flash media */
    char * filename /* mount point */
)
{
    {BLK_DEV * pBootDev;
    char bootDir [BOOT_FILE_LEN];
    if ((UINT)drive >= noOfDrives)
    {
        printErr ("Drive is out of range (0-%d).\n",
        NoOfDrives - 1);
        return (ERROR);
    }
}
```

```
/* Create a block device spanning the entire disk */
/* (non-destructive) */
if ((pBootDev = tffsDevCreate (drive, 0)) == NULL)
{
printErr ("tffsDevCreate failed.\n");
return (ERROR);
}

/* Split off boot device from boot file */
devSplit (fileName, bootDir);
/* Initialize the boot block device as a dosFs */
/* device named <bootDir> */
if (dosFsDevInit (bootDir, pBootDev, NULL) == NULL)
{
printErr ("dosFsDevInit failed.\n");
return (ERROR);
}
return (OK);
}

LOCAL STATUS tffsLoad
(
int drive,          /* TFFS drive number (0 - (noOfDrives-1)) */
int removable,     /* 0 - non removable flash media */
char * fileName,   /* file name to download */
FUNCPTR * pEntry
)
{
int fd;
/*
* Call tffsSetup() as appropriate for your application.
* If you want to change the settings of the driver's
* configuration variables flUse8bit,
```

```
flUseNFTLCache and fl_useDebug, do it here.
*/
if (tffsDrv () != OK)
{
printErr ("Could not initialize.\n");
return (ERROR);
}
printf ("Attaching to TFFS... ");
dosFsInit (NUM_DOSFS_FILES); /* initialize DOS-FS */
if (usrTffsConfig (drive, 0, fileName) == ERROR)
{
printErr ("usrTffsConfig failed.\n");
return (ERROR);
}
printErr ("done.\n");
/* load the boot file */
printErr ("Loading %s...", fileName);
if ((fd = open (fileName, O_RDONLY, 0)) == ERROR)
{
printErr ("\nCannot open \"%s\".\n", fileName);
return (ERROR);
}
if (bootLoadModule (fd, pEntry) != OK)
goto tffsLoadErr;
close (fd);
return (OK);
tffsLoadErr:
printErr ("\nError loading file: status = 0x%x.\n",
        errnoGet ())
close (fd);
return (ERROR);
```

```
}
```

```
#endif /* INCLUDE_DISKONCHIP */
```

4. Modify the file `Tornado/target/config/all/bootConfig.c` by adding the following code after the line `#define INCLUDE_DISKONCHIPTFFS` to the `helpMsg[ ]` in the routine `bootHelp()`:

```
#ifdef INCLUDE_FD
```

```
 /fd0/vxWorks", "",
```

```
#endif /* INCLUDE_FD */
```

```
#ifdef INCLUDE_IDE
```

```
 /ide0/vxWorks", "",
```

```
 */
```

```
#ifdef INCLUDE_ATA
```

```
 "boot device: ata=ctrl,drive file name: /ata0/vxWorks", "",
```

```
#endif /* INCLUDE_ATA */
```

```
#ifdef INCLUDE_PCMCIA
```

```
 "boot device: pcmcia=sock file name: /pcmcia0/vxWorks", "",
```

```
#endif /* INCLUDE_PCMCIA */
```

```
#ifdef INCLUDE_DISKONCHIP
```

```
 "boot device: tffs=drive,removable file name:
```

```
 /tffs0/vxWorks", "",
```

```
#endif /* INCLUDE_DISKONCHIP */
```

```
 "Boot flags:", "",
```

5. Modify the file `Tornado/target/config/all/bootConfig.c` by adding the following code after the line `#define INCLUDE_DISKONCHIP` to the routine `bootHelp()`:

```
INCLUDE_FD
```

```
printf (" fd");
```

```
#endif /* INCLUDE_FD */
```

```
#ifdef INCLUDE_IDE
```

```
printf (" ide");
```

```
#endif /* INCLUDE_IDE */
```

```
#ifdef INCLUDE_ATA
```

```
printf (" ata");
#endif /* INCLUDE_ATA */
#ifdef INCLUDE_DISKONCHIP */
printf (" tffs");
#endif /* INCLUDE_DISKONCHIPTFFS */
#ifdef INCLUDE_TFFS
printf (" tffs");
#endif /* INCLUDE_TFFS */
printf ("\n");
}
```

6. Modify the file `Tornado/target/config/all/bootConfig.c` by adding the following code after the line `#define INCLUDE_DISKONCHIP` to the routine `bootLoad()`:

```
#ifdef INCLUDE_FD
    0)
    {
        int type = 0;
        int drive = 0;
    2)
        return (ERROR);
    else
        &type);
    OK)
    {
        0x%x.\n",
        errno);
        return (ERROR);
    }
    return (OK);
}
#endif /* INCLUDE_FD */
#ifdef INCLUDE_IDE
    0)
    {
```

```
    int type = 0;
    int drive = 0;
    3)
    return (ERROR);
else
    &type);
OK)
    {
    errno);
    return (ERROR);
    }
    return (OK);
}
#endif /* INCLUDE_IDE */
#ifdef INCLUDE_ATA
    if (strncmp (params.bootDev, "ata", 3) == 0)
    {
    int ctrl = 0;
    int drive = 0;
    if (strlen (params.bootDev) == 3)
    return (ERROR);
    else
    sscanf (params.bootDev, "%*3s%c%d%c%d", &ctrl, &drive);
    if (ataLoad (ctrl, drive, params.bootFile, pEntry) != OK)
    {
    printErr ("\nError loading file: errno = 0x%x.\n",
    errno);
    return (ERROR);
    }
    return (OK);
    }
#endif /* INCLUDE_ATA */
#ifdef INCLUDE_PCPCIA
    pcmciaInit (); /* init PCPCIA Lib */
    if (strncmp (params.bootDev, "pcmcia", 6) == 0)
```

```

    {
    int sock = NONE;
    if (strlen (params.bootDev) == 6)
    return (ERROR);
    else
        sscanf (params.bootDev, "%*6s*c%d", &sock);
    if (pcmciaLoad (sock, params.bootFile, pEntry) == OK)
    return (OK);
    /* fall through if the PC card is not a block device
    * let's try to boot it from an ethernet device.
    */
    }
#endif /* INCLUDE_PCMCIA */
#ifdef INCLUDE_DISKONCHIP
    if (strncmp (params.bootDev, "tffs", 4) == 0)
    {
    int drive = 0;
    int removable = 0;
    (strlen (params.bootDev) == 4)
    return (ERROR);
    else
        sscanf (params.bootDev, "%*4s*c%d*c%d",
        &drive, &removable);
    if (tffsLoad (drive, 0, params.bootFile, pEntry) != OK)
    {
    printErr ("\nError loading file: errno = 0x%x.\n",
    errno);
    return (ERROR);
    }
    return (OK);
    }
#endif /* INCLUDE_DISKONCHIP */

```

7. Modify the file Tornado/target/config/all/bootConfig.c by adding the line #define INCLUDE\_DISKONCHIP as follows:

```

#if (defined (INCLUDE_SCSI_BOOT) || defined (INCLUDE_FD) || \
    defined (INCLUDE_IDE) || defined (INCLUDE_ATA) || \
    defined (INCLUDE_DISKONCHIPTFFS) || defined (INCLUDE_TFFS))
#define SPIN_UP_TIMEOUT 45 /* max # of seconds to wait for spinup
*/

```

8. Modify the file `Tornado/target/config/all/bootConfig.c` by adding the following code after the line `#define INCLUDE_DISKONCHIP`, just before the routine `usrRoot()`:

```
#ifndef INCLUDE_DISKONCHIP
#ifdef __cplusplus
extern "C" {
#endif
#ifndef _ASMLANGUAGE
/* TrueFFS driver's configuration variables. */
extern unsigned char flUse8bit;
extern unsigned char flUseNFTLCache;
extern int fl_useDebug;
#if defined(__STDC__) || defined(__cplusplus)
extern void tffsSetup (int diskonchips, long *addressRange);
extern STATUS tffsDrv (void);
#else /* __STDC__ */
extern void      tffsSetup ();
extern STATUS  tffsDrv ();
#endif /* __STDC__ */
#endif /* _ASMLANGUAGE */
#ifdef __cplusplus
}
#endif
#endif /* INCLUDE_DISKONCHIP */
```

9. Modify the file `Tornado/target/config/all/bootConfig.c` by adding the following code after the line `#define INCLUDE_DISKONCHIP`, just before the routine `usrRoot()`:

```
*/
#ifdef INCLUDE_FD

*/
*/
#ifdef INCLUDE_IDE
```

```
*/
*/
#ifdef INCLUDE_ATA
{
    IMPORT ATA_RESOURCE ataResources[];
    ATA_RESOURCE *pAtaResource;
    for (ix = 0; ix < ATA_MAX_CTRLIS; ix++)
    {
        pAtaResource = &ataResources[ix];
        if (pAtaResource->ctrlType == IDE_LOCAL)
            ataDrv (ix, pAtaResource->drives, pAtaResource->
                intVector, pAtaResource->intLevel,
                pAtaResource->configType, pAtaResource->semTimeout,
                pAtaResource->wdgTimeout);
    }
}
#endif INCLUDE_SHOW_ROUTINE
ataShowInit (); /* install ATA/IDE show routine */
#endif /* INCLUDE_SHOW_ROUTINES */
#endif /* INCLUDE_ATA */
#ifdef INCLUDE_LPT
{
    IMPORT LPT_RESOURCE lptResources[];
    lptDrv (LPT_CHANNELS, &lptResources[0]);
    /* init LPT parallel driver */
}
#endif /* INCLUDE_LPT */
#ifdef INCLUDE_PCMCIA
#ifdef INCLUDE_SHOW_ROUTINE
    pcmciaShowInit (); /* install PCMCIA show routines */
#endif /* INCLUDE_SHOW_ROUTINES */
    pcmciaInit (); /* init PCMCIA Lib */
#endif /* INCLUDE_PCMCIA */
```

```
#ifdef INCLUDE_DISKONCHIP
    /*
    * Call tffsSetup() as appropriate for your application.
    */
    /*
    * If you want to change the settings of the driver's
    * configuration variables flU_use8bit,
    flUseNFTLCache_useUCache,
    and fl_useDebug, do it here.
    */
    tffsDrv ();
#endif /* INCLUDE_DISKONCHIPTFFS */
#ifdef INCLUDE_FORMATTED_IO
    */
```

10. Recompile the `BOOTROM.SYS` and copy it to the root directory of the first DiskOnChip. Also copy the VxWorks application itself to the DiskOnChip.

Unless you have a `#defined DEFAULT_BOOT_LINE` different from the one described in step 2, the application should be called `vxWorks` and it should be located in the root directory of the first DiskOnChip.

## Additional Information and Tools

Additional information about the DiskOnChip, including application notes, can be found at <http://www.m-sys.com>.

Additional tools and documents are listed in the following table:

<b>Document/Tool</b>	<b>Description</b>
AP-DOC-010	Designing with the DiskOnChip DIP
AP-DOC-020	Boot Developers Kit
AP-DOC-030	Designing with the DiskOnChip Millennium in a RISC Environment
AP-DOC-031	Designing with the DiskOnChip Millennium in a PC Environment
AP-DOC-039	Programming of the DiskOnChip Millennium TSOP-II
AP-DOC-040	Programming DiskOnChip Millennium TSOP, Using a Bed of Nails
AP-DOC-042	Designing the DiskOnChip with Hyundai ARM720 CPU
AP-DOC-046	Extended Functions of TrueFFS Driver for DiskOnChip
DiskOnChip 2000 Data Sheet	DiskOnChip 2000 Data Sheet
DiskOnChip Millennium Data Sheet	DiskOnChip Millennium Data Sheet
DiskOnChip DIMM2000 Data Sheet	DiskOnChip DIMM2000 Data Sheet
DiskOnChip Utilities	DiskOnChip Utilities User Manual
DiskOnChip DIP EVB	DiskOnChip Evaluation Board
DiskOnChip-GANG	DiskOnChip GANG Programmer

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