Introduction

µTasker is an operating system designed especially for embedded applications where a tight control over resources is desired along with a high level of user comfort to produce efficient and highly deterministic code.

The operating system is integrated with TCP/IP stack and important embedded Internet services along side device drivers and system specific project resources.

µTasker and its environment are essentially not hardware specific and can thus be moved between processor platforms with great ease and efficiency.

However the µTasker project setups are very hardware specific since they offer an optimal pre-defined (or a choice of pre-defined) configurations, taking it out of the league of "board support packages (BSP)" to a complete "project support package (PSP)", a feature enabling projects to be greatly accelerated.

This document discusses the implementation and use of the µTasker file system – known as µFileSystem. *This document is valid for µTasker releases from V1.2.008 but is also suitable as an introduction for older releases.*

First things first

The µFileSystem is rather special. It was designed to enable such services as FTP, HTTP and parameter support to be integrated into embedded systems with a minimum amount of resources but with a useable level of comfort and flexibility. It operates in internal FLASH - either in linear or paged systems – and in external SPI EEPROMs. It can in addition be configured to work in small memory environments up to 64k (file system size and individual file sizes) or larger memory environments (file system and/or individual files of larger that 64k).

The µFileSystem was not designed to be a copy of other file systems, so don't be disappointed when you find it is not FAT32 conform. This is not a goal and also not necessarily a benefit in a small embedded system, so if you need that then please check out something like embedded Linux – it is free but will need rather more that a couple of kilobytes code space…

You will however find that it is very easy to use, reliable and all that is usually needed for the more important higher level tasks and protocols in real-world projects based on the supported devices.

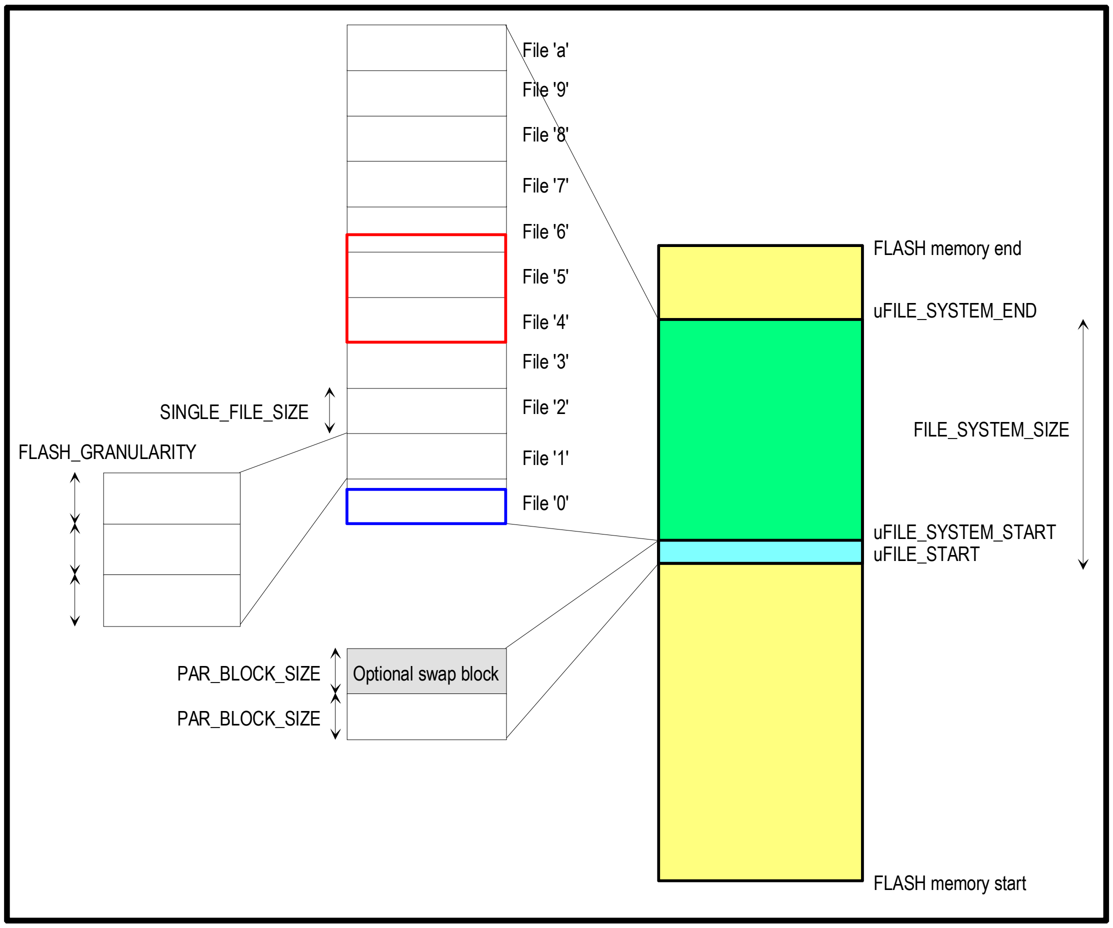
Configuring µFileSystem

There are several parameters which need to be configured so that the µFileSystem operates with size constraints suiting your project. Such things are:

- The structure of the FLASH within the device (its granularity) – a SPI EEPROM doesn't have the save restrictions but uses an emulation technique where this parameter is also specified.
- The block size of the files which you want to use in your project. (This can not be smaller that the FLASH granularity).
- The number of files which the file system should support (equivalent to its total size).
- The size of parameters which should also be saved within the file system and whether there should be a swap block.
- The maximum single file size within the file system (basically whether smaller than 64k or not).
- Whether the total file system space is larger than 64k or not.

Some parameters are limited by the physical properties of the devices used and so are predefined and not real user parameters in this sense.

Before going in to details about each of these parameters, let's start with a graphical representation of a typical µFileSystem in the internal FLASH of a small device.



Typical µFileSystem block positioned in the on-chip FLASH of a device

Here is an example configuration of the µFileSystem in the hardware configuration file (eg. app_hw_sam7x.h)

```
#define uFILE_START 0x118000                     // FLASH location at 96k start
#define SINGLE_FILE_SIZE (4*FLASH_GRANULARITY)  // each file a multiple of 1k
#define FILE_SYSTEM_SIZE (32*SINGLE_FILE_SIZE)  // 32k reserved for file system
                                                   (including parameter blocks)
```

It can be seen that the start of the block can be set to a fixed address, which must obviously be in the real FLASH address range. The FLASH granularity is defined by the device used (here 256 byte granularity – or FLASH sector size [smallest block which can be individually erased] is assumed and the SINGLE_FILE_SIZE is set 4 times larger to achieve 1k file blocks. *The FLASH granularity is usually a constant defined by the chip used – see the header file belonging to the hardware device, eg. \Hardware\SAM7X\sam7x.h*

The complete size of the FLASH memory used by the file system is defined as 32k, although this includes also any parameter blocks which may be used. These are explained towards the end of the document in more detail, but we will assume here that 1k space is reserved for them (always at the beginning of the file system space). This will thus result in space for 31 files of 1k size, or correspondingly less when using multiples of 1k.

There are a few simple rules involved, as follows:

- File locations are specified by names, which are essentially one number or letter (or the first number or letter in a longer name). The file locations count from '0' to '9', and then from 'a' to 'z', then from 'A' to 'Z'. This gives a maximum of 62 individual files in all. The actual amount useable is given by the total size defined and the SINGLE_FILE_SIZE used.
- A file smaller that SINGLE_FILE_SIZE occupies still SINGLE_FILE_SIZE space in the FLASH, where SINGLE_FILE_SIZE can be made up of more than one FLASH sector (FLASH_GRANULARITY).
- A file larger than SINGLE_FILE_SIZE occupies as many SINGLE_FILE_SIZE blocks as necessary to fit in to the file system.
- The files system is flat, meaning that it doesn't support directories.
- When copying files to the file system (for example via FTP) only the first letter is observed but certain extensions can be optionally respected. Te following are examples of valid names: MyFile.txt; MyFile.TXT; MyFile.001.txt [This file will be copied to the 'M' space in the file system and it will be understood as a text file] {Note that <u>m</u>yFile.txt uses a different case and so is positioned at another address – it is not the same file!}

From these first rules it is clear that the location of a file in the µFileSystem is directly defined by its name. It also becomes clear that the user must thus know which files are to be saved so that they actually fit (this can be controlled by the names given to the files to be saved). For example, it is not possible to write a file requiring more than one file block to the last block in the file system – it will just not fit.

The µFileSystem interface routines coordinate reading files and writing them and also handles the following cases appropriately, giving the next important rule:

- If a file is written to a file block which is already occupied, the new file takes preference. This means that the existing file will first be deleted from all blocks with it may occupy.

Now this may sound quite strange at first but as I said before, the µFileSystem is not designed to be a copy other file systems, but designed to allow useful things to be performed in a very efficient manor. The application software designer is however involved a little since he/she must in fact also design the use of the available file system space.

The µTasker demo project is delivered with web pages which are loaded by FTP. Check out the names of the files to see where they are located. Check out the size of the files and you will see that these also dictate the names of the web pages, since they must fit without clobbering existing ones when loaded (see last but one rule above). But it does work and for such tasks this system is very useable.

See also the following folder in the µTasker demo project
`\Applications\uTaskerV1.3\WebPages\WebPages`*`HWType`*`\FileSystem`

It contains a word document used as a template for designing the positioning of files within the file system for the project and can be used as a template for further work. It should also be easily understandably now after this introduction.

Before moving to more details about how the files are built up and how to use the access routines, it is important to quickly mention two typedefs in the project. These are found in `types.h` [belonging to the application] and the two which interest us here are `MAX_FILE_LENGTH` and `MAX_FILE_SYSTEM_OFFSET`.

These control the use of variables (basically `unsigned short` and `unsigned long` types) which are used within the routines controlling the files. The value `unsigned short` restricts values from 0x0000 to 0xffff (64k) and so also limits the size of the file system and file offsets within. If you require a file system length of more than 64k it is necessary to redefine the typedef for `MAX_FILE_SYSTEM_OFFSET` to be `unsigned long` so that this will work properly. This will allow a larger file system length and individual files to 64k in length. If also individual files are required to be longer than 64k, then also `MAX_FILE_LENGTH` should be specified to be an `unsigned long`.

Here's a table for clarity:

	MAX_FILE_SYSTEM_OFFSET	MAX_FILE_LENGTH
File system of less that 64k	`typedef unsigned` **`short`**	`typedef unsigned` **`short`**
File system larger than 64k but individual files smaller than 64k	`typedef unsigned` **`long`**	`typedef unsigned` **`short`**
File system larger than 64k **AND** individual files larger than 64k	`typedef unsigned` **`long`**	`typedef unsigned` **`long`**

Of course all projects could use unsigned `long typedefs` and no one would have to decide, but this is of course a waste of resources in systems where it is not necessary, making the code also less efficient than it could be as a 16 bit device may have to mess around with 32 bit words for no real reason at all. So best to be able to tune it…the demo project is set up to suit the particular target used and so may set the most common settings for that device.

File contents

The individual files within the system are copied and read from fixed locations which are referenced by file name. This means that there doesn't have to be any central file management keeping track of where they are.

The files themselves do however have some characteristics otherwise it would not be possible to know whether they are valid and how long their contents actually are.

The µFileSystem doesn't try to do anything about file access rights or file date and times – if an application requires such support (which is rather unlikely in most small embedded systems) this will have to be handled somewhere else – like in the application.

The result of this simplification is that also the files themselves require very little information saved. The files are built up with a very short header made up of the file length (which will be either 2 bytes or 4 bytes in length depending on the setting of `MAX_FILE_LENGTH` (see above). This also operates as a file validity check since blank FLASH will return a file length of 0xffff or 0xffffffff, which are interpreted as zero length. This also means that there is in fact an additional restriction to the real file content length since space for the header is required, but this is only of the order of 2 or 4 bytes here.

It is often also interesting to know what type of data has been saved in a file (*.txt, *.GIF, *.JPG etc.) and this may also be optionally saved by setting the define `SUPPORT_MIME_IDENTIFIER` in config.h

When using `SUPPORT_MIME_IDENTIFIER` the FTP server will for example display the file extensions and the HTTP server will better be able to work with images, CSS and Java etc. since it will know not to try to interpret the wrong types of data. Its use increases the file header by just one byte and is recommended!

When working with file extensions, the user has the capability to control exactly which types are supported in the project. This can be set in config.h in the following table:

```
const CHAR *cMimeTable[] = {
    (const CHAR *)"HTM",    // HTML file - will be interpreted by web server
    (const CHAR *)"JPG",    // JPG image
    (const CHAR *)"GIF",    // GIF image
    (const CHAR *)"CSS",    // CSS Cascading Style Sheets
    (const CHAR *)"JS",     // Java script
    (const CHAR *)"BIN",    // Binary data file
    (const CHAR *)"TXT",    // Text data file
    (const CHAR *)"???",    // all other types will be displayed as unknown
};
```

The number of extensions can be reduced or extended by removing or adding them from/to the list. The extensions are not case sensitive so test.htm and test.HTM will be identified as being equivalent – in the FTP server they will however be displayed as HTM, as defined in the list.

The entry for HTM is very useful since it is used by the HTML parser in the web server to identify which types of files are to be parsed – it should therefore be present to enable this to operate correctly (unless `SUPPORT_MIME_IDENTIFIER` is not activated).

Note also that longer file names, such as html (a typical extension also used for HTML files) will also be interpreted as equal to HTM. Such a file will later be displayed by the FTP server as HTM – from the list.

Interface routines

Since the basic workings of the µFileSystem should be quite clear by now, it is worth looking at how the application can make use of it through its interface routines. These interface routines are hardware independent and so are portable between processor types and storage locations (internal or external memory). The prototypes for the routines are found in driver.h.

Note that the FTP and HTTP server make use of the various file interface routines and so are a good practical reference. The application can of course make use of the calls if required.

```
extern unsigned char *uOpenFile(CHAR *ptrfileName);
```

This call passes a pointer to a file name and returns a pointer to its contents.

Example:

```
unsigned char * ptrFile = uOpenFile("MyFile.txt");
```

`uOpenFile("M")` is also adequate to access the same named file. The pointer to the contents can be later used for content retrieval and modification purposes.

```
extern MAX_FILE_LENGTH uGetFileLength(unsigned char *ptrFile);
```

This call passes a pointer to a file name and returns the file content length.

Example:

```
MAX_FILE_LENGTH file_length = uGetFileLength(ptrFile);
```

```
extern MAX_FILE_LENGTH uGetFileData
                (unsigned char *ptrFile,
               MAX_FILE_SYSTEM_OFFSET FileOffset,
               unsigned char *ucData,
               MAX_FILE_LENGTH DataLength);
```

This call retrieves the specified amount of bytes content from the offset in the file referred to by its file pointer. It returns the number of bytes copied, which will be the same as the number specified (`DataLength`) if there are enough remaining or else the number of bytes which could be copied. Using this function it is not actually necessary to know the file length before accessing.

Example: (the complete contents of the file are retrieved in packets of 50 bytes each. After the retrieval `file_offset` also contains the file length)

```
MAX_FILE_LENGTH file_offset = 0;
MAX_FILE_LENGTH bytes_retrieved = 0;
unsigned char ucBuffer[50];
do {
    bytes_retrieved  = uGetFileData(ptrFile, file_offset,
                                    ucBuffer, 50);
    file_offset += bytes_retrieved;
} while (bytes_retrieved < 50);
```

```
extern MAX_FILE_LENGTH uFileWrite(unsigned char *ptrFile,
               unsigned char *ptrData,
               MAX_FILE_LENGTH DataLength);
```

This pointer writes the specified amount of data to the file. Note that only one user can be writing to a file at one time (single user write). Each call to the write function appends the data to the previous write position (that is, in a linear fashion starting at the beginning of the file on the first write and progressing through the file system space on each subsequent write. The write is terminated after all data has been copied by using the close command as detailed below.

The routine returns the total length of data copied since the first call. Writes and the total length are restricted to within the reserved file system space to avoid writing outside of this space.

The routine automatically deletes and files which may already occupy the space required by the write, meaning that the user doesn't have to know whether the space is free or not beforehand – it will be "bulldozed" free if needed…

Example: The routine copies two blocks of data to the file, where they will be programmed to the memory (usually FLASH) resulting in the sequence 100 x 0x5a : 100 x 0xb3 – 200 bytes in total. Note that the file contents is not valid until the file has been closed (see next routine)

```
unsigned char ucData[100];
uMemset(ucData, 0x5a, 100);
uFileWrite(ptrFile, ucData, 100);
uMemset(ucData, 0xb3, 100);
uFileWrite(ptrFile, ucData, 100);
```

```
extern MAX_FILE_LENGTH uFileClose(unsigned char *ptrFile);
```

This routine is used to close a file whose contents have been fully written. It returns the length of the file which has been in the process of being written. Note that this is only used when extensions are not supported – when using `SUPPORT_MIME_IDENTIFIER` the following close routine must be used instead.

Example: The file written in the last routine example is closed. It will return the length 200 and is now valid for reading – its name and length are valid.

```
if (uFileClose(ptrFile) != 200) {
    // Error
}
```

```
extern MAX_FILE_LENGTH uFileCloseMime(unsigned char *ptrFile,
               unsigned char *ucMimeType);
```

This routine is used to close a file whose contents have been fully written. It returns the length of the file which has been in the process of being written. This version of close is used always when `SUPPORT_MIME_IDENTIFIER` is defined so that the file extension can be set.

Example: The file written in the last routine example is closed. It will return the length 200 and is now valid for reading – its name, length and extension type are valid.

```
unsigned char ucMimeType = MIME_BINARY;
if (uFileCloseMime(ptrFile, &ucMimeType) != 200) {
    // Error
}
```

```
extern int uFileErase(unsigned char *ptrFile,
               MAX_FILE_LENGTH FileLength);
```

This routine is used to erase an area in FLASH. It returns a zero if the erase was successful or a negative value if not. The erase length is the length of the file to be erased, or can also be a value equivalent to a number of file granularity sizes (which is automatically rounded up to suit).

Example: this example shows how one file is deleted by passing its length to the function.

```
MAX_FILE_LENGTH Length = uGetFileLength(ptrFile);
uFileErase(ptrFile, Length);
```

```
extern CHAR uGetFileName(unsigned char *ptrFile)
```

This routine is passed the name (single digit) of the file. Note that this also returns the name of the file position pointed to even when the file is not present.

Example:

```
CHAR cFileName = uGetFileName(ptrFile)
```

```
extern unsigned char fnConvertName(CHAR cName);
```

This routine takes a file name (0..9, 'a'..'z' or 'A'..'Z' and converts it to a file offset number from 0 (for '0') to 61 (for 'Z'). This routine can also be useful for similar signalling methods often used in the µTasker web interface for control purposes.

Example:

```
unsigned chat ucValue = fnConvertName(*ptrFileName);
```

Low level FLASH routines

In addition to the file system interface, there are user accessible low level routines supported by the FLASH driver of each device. The prototypes to these functions are in `hardware.h`.

These routines are used by the file system for accessing the memory and are normally the details are hidden from the user. The functions can however be used if there is a special need to do so.

```
extern int  fnEraseFlashSector(unsigned char *ptrSector);
```

This routine is passed a pointer to any location within a sector of FLASH. The individual sector is then erased and the return value 0 indicates that the erase completed successfully.

```
extern int fnWriteBytesFlash(unsigned char *ucDestination,
                      unsigned char *ucData,
                      MAX_FILE_LENGTH Length);
```

This routine copies a buffer of data to the memory starting at the destination address. It has to be noted that the caller must ensure that the memory has been deleted previously since it is only possible to program bits from '1' to '0'. In some cases, depending on the device, it is possible to program individual bits and in some cases a minimum word size is imposed. Such details can be found in the users' manual to the specific device.

The routine will check to ensure that important programming rules are observed but may choose to not write if there is an invalid type of access. This is not signalled as an error but rather the particular write (possibly within a buffer) is silently ignored.

The value 0 is returned when no programming errors occurred.

```
extern void fnGetParsFile(unsigned char *ParLocation,
                          unsigned char *ptrValue,
                          MAX_FILE_LENGTH Size);
```

This routine is used to retrieve the data directly from the device. It does no further checking.

Parameter system

The µFileSystem supports an optional parameter system allowing user data to be saved and restored as required. This is very useful for application variables which must be preserved when the system is powered off (examples are MAC and IP addresses, password information, serial interface settings, and many other possibilities).

The parameter system has also an option to use a 'swap-block' which will ensure that the parameters can not be lost when the system is powered down just then as new values were being saved and also that previous parameters can be retrieved if necessary. The µTasker demo project makes use of this possibility when saving new IP configuration values which are used temporarily until the user confirms that they are good, or a trial period times out with no confirmation. Since the original parameters are still available, they can be re-activated so that a device doesn't remain unreachable due to inappropriate settings.

The parameter system can be activated by setting the define `USE_PARAMETER_BLOCK` in config.h and the 'swap-block' by setting the define `USE_PAR_SWAP_BLOCK` in config.h.

The size of the parameter block is defined by `PARAMETER_BLOCK_SIZE`, which must be a multiple of the FLASH sector size (`FLASH_GRANULARITY`) as is the case for sizes in the file system. When `USE_PAR_SWAP_BLOCK` is activated, two such blocks are reserved and used.

Here are the important differenced between using the parameter system with and without a 'swap-block'

- When no 'swap-block' is present, the block has to be deleted before modifying parameters. There is a risk of loosing parameters if the system crashes or is powered off at this instant.
- A 'swap-block' requires twice the FLASH memory since the parameters are present twice.
- Previous parameters can be recovered after testing temporary values when the 'swap-block' is activated.

The following are generally valid.

- The space for user parameters is the size of the parameter block – 2 to 8 bytes (these 2 to 8 bytes are used for block management and the exact size depends on the hardware involved).
- If a device doesn't support "accumulative writes" it is necessary to use one FLASH word (size of word depends on device) per variable byte. An example of this is the M9S12NE64, which uses 16 bit FLASH words and can not perform accumulative writes. When a block of user parameters is saved, each of the bytes in the block of variables is saved in an individual word. A parameter block of 512 bytes (the FLASH granularity in the NE64) can therefore save (512 – 4)/2 bytes [254] of user data. Other FLASH devices supporting accumulative writes with the same granularity can save (512 – 2) [510] bytes of user data. This means the limit is given by the chip and it is always best to know such details… There is a define in the header file belonging to the device called `MAX_SECTOR_PARS` which gives the limit for a parameter block of the size `FLASH_GRANULARITY`, which may be helpful…

The parameter block management is very simple but it ensures that it is possible to identify if a block is valid, as opposed to deleted or corrupted by a power cycle during writing. It also can identify a block with temporarily valid content which may require validation before being accepted for general use.

- A blank parameter block is a block of FLASH memory completely filled with the value 0xff.
- A block being written but not valid is a block with the first two entities (size of the entity is a byte where possible but can be up to an `unsigned long` if the FLASH doesn't support byte write) with the value 0xff (up to 0xffffffff). The rest of the data is presently being written with parameters and some locations will no longer be 0xff
- A valid parameter block is identified by the first entity being set to 0x55 (up to 0x55555555). By simply checking the first entity for this pattern it is clear whether it contains valid data or not. When using swap blocks it is possible to have two valid blocks although only one of them is validated (see next paragraph). The valid entity is already written to the FLASH block after all data has successfully be written – it therefore ensures that it is never possible to have a valid block with garbage in it due to a system crash.
- A validated block, as opposed to a temporary valid block, has the value 0x55 (up to 0x55555555) at the second entity location. By using the valid entity and also the validated entity it is possible to distinguish between the validated block and the temporary block.

The µTasker demo project makes use of the parameter system and supports both single and swap blocks. Should the parameter block support be deactivated, the project will always runs with default setting which means that the desired values (such as IP address) have to be hard coded and can then not be changed by the normal user.

Although the swap block can be deactivated it is advised also to use it since its advantages are very useful in real-world projects.

The µTasker demo project provides additional cover functions which use the parameter system interface routines but add a higher level of user comfort (examples are `fnGetEthernetPars(), fnGetOurParameters()` and `fnSaveNewPars()).` These serve as useful examples for your own application and can of course be used as they are in your own project if you wish.

The routine **int** fnSaveNewPars(**int**), although an example cover function, is described here in a little more detail since it shows how the parameter system is used in a typical application – this has in fact been used in many projects and so why not use its basic idea in your own? In the following examples it is assumed that a swap block is also being used. To get to know exactly how it works it is advised to use the µTasker simulator and set a break point in the function. The details become clear when the code is stepped though.

```
fnSaveNewPars(SAVE_NEW_PARAMETERS);
```

Here user parameters are saved from an application structure to the swap block. The swap block will be set as valid and also as validated while any existing block will be deleted.

```
fnSaveNewPars(SAVE_NEW_PARAMETERS_VALIDATE);
```

Here user parameters are saved from an application structure to the swap block. The swap block will be set as valid but not validated. The original block (if existing) will therefore still contain the generally valid data. This block can be validated at a later time (for example after verification that they are indeed suitable) and used as general parameters.

```
fnSaveNewPars(SAVE_NEW_PARAMETERS_CHECK_CRITICAL);
```

Here user parameters are saved only when no critical data has been changed. I critical data has indeed been modified the user could then receive a warning before they are really saved.

Parameter System Routines

The µTasker supports the following interface functions for retrieval, deleting and modifying information in the parameter system. Their prototypes are defined in driver.h.

```
extern int fnGetPar(unsigned short usParameterReference,
                    unsigned char *ucValue,
                    unsigned short usLength);
```

This function retrieves `usLength` bytes of data from the parameter block and copies them into the buffer pointed to by `ucValue`. `usParameterReference` is the offset to the start of data to be retrieved from the beginning of the data. The function returns a zero on success or a negative value if the requested parameters do not exist.

Either the validated parameter set or the temporary parameter set can be specified as shown in the following example:

```
unsigned char ucBuffer[10];
if (fnGetPar((TEMPORARY_PARAM_SET | 0) , ucBuffer, 10) < 0) {
    if (fnGetPar(0 , ucBuffer, 10) < 0) {
        // no parameters available, use defaults
    }
}
```

In the example 10 bytes are retrieved from the start of the parameter block. First an attempt to retrieve them from the temporarily valid parameter block is made, followed by the validated block. If both fail it means that no parameters are available and so default values should be used.

```
extern int fnSetPar(unsigned short usParameterReference,
                    unsigned char *ucValue,
                    unsigned short usLength);
```

This function saves `usLength` data from the buffer `ucValue` to the parameter block at the offset `usParameterReference` from its start. Note that the caller should carefully manage the use of this function since it is only possible to change values in FLASH when they are previously deleted. Therefore this can be called a number of times to save blocks of data at various FLASH locations but a repeat of a save to certain block is likely to fail.

The routine returns a zero when the write was successful.

Examples:

```
unsigned char ucBuffer[10] = {0,1,2,3,4,5,6,7,8,9};
fnSetPar((TEMPORARY_PARAM_SET | 0) , ucBuffer, 10);
```

The data bytes 0..9 are written to the start of the temporary parameter lock – if the temporary parameter block is initially empty it will be marked as temporarily valid.

```
unsigned char ucBuffer[10] = {0,1,2,3,4,5,6,7,8,9};
fnSetPar(0 , ucBuffer, 10);
```

The data bytes 0..9 are written to the start of the valid parameter block – if there is initially no valid parameter block (empty FLASH) a block will be marked as valid after this call.

```
extern int fnDelPar(unsigned char ucDeleteType)
```

This routine is used to delete and manipulate the parameter block(s). It returns a zero when successful.

Examples:

`fnDelPar(INVALIDATE_PARAMETER_BLOCK);`

All data will be deleted from the valid parameter block and the block will become invalid.

`fnDelPar(INVALIDATE_TEST_PARAMETER_BLOCK);`

All data will be deleted from the temporary parameter block and the block will become invalid.

`fnDelPar(SWAP_PARAMETER_BLOCK);`

All data will be deleted from the valid parameter block and the block will become invalid. A valid temporary parameter block will be set as validated block. This call is used to swap between a backup and a new parameter set.

Practical Example of a user parameter block

```
typedef struct stPARS
{
    unsigned char  ucParVersion;     // Versions number to avoid loading incorrect
                                        structure after major changes
    unsigned short telnet_timeout;   // TELNET timeout in seconds (0xffff means no
                                        timeout) - max 18 hours
    unsigned short usSerialMode;     // serial settings
    unsigned short usTelnetPort;     // the port number of our TELNET service
    unsigned char  ucServers;        // active servers
    unsigned char  ucSerialSpeed;    // Baud rate of serial interface
    unsigned char  ucTrustedIP[IPV4_LENGTH]; // Trusted IP address
    CHAR           cUserName[8];     // The single user administrator
    CHAR           cUserPass[8];     // The administrator's password
    CHAR           cDeviceIDName[21]; // 20 characters for recognition plus null
                                        terminator
    unsigned char  ucFlowHigh;       // High water flow level for XOFF/CTS (%)
    unsigned char  ucFlowLow;        // Low water flow level for XON/CTS (%)
    unsigned char  ucUserOutputs;    // ports set as outputs
    unsigned char  ucUserOutputValues; // port values
} PARS;
```

The µTasker demo project uses a structure containing various settings which can be modified and saved by the user. This structure is saved along with network parameters whenever the parameters are saved to FLASH using the parameter system.

This structure can be easily modified or extended to suit your own purposes and then the changed or extended parameters will also be saved.

Note that the first location is defined as a version number. This is very helpful when working on a project where the parameters are occasionally being modified since it allows the routine retrieving the parameters to be sure that the contents are compatible with the structure in the software.

Imaging that the variable `ucSerialSpeed` were to be removed. This would mean that the variables below it in the structure will move up a byte and when retrieving a copy of the structure from FLASH which was saved using the previous version, they would then be shifted by one byte.

However if the version number is incremented every time a critical change is made, the retrieval routine can easily notice that the contents of FLASH are no longer valid and use the defaults instead. This avoids mistakes being made due to incompatible parameters and is recommended for general use.

Modifications:
V0.02 5.1.2007:
- updated to include parameter description and be valid for *µTasker* release V1.3