

uALFAT™ User Manual

Revision 1.10



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1. Introduction

1.1. *FAT File System*

Memory cards are very popular these days. Their small size and rather huge storage makes them ideal for digital cameras and MP3 players. Managing and organizing data on a memory card is not an easy task. It requires a robust file system. There are many file systems out there but FAT, which stands for File Allocation Table, is the most popular one. FAT was introduced by Microsoft with DOS operating system and FAT is still supported by all versions of Windows operating systems, even Windows XP. To be compatible with PCs, many other companies developed their own FAT code for different applications, such as digital cameras. There are three versions of FAT file system, FAT12, FAT16 and FAT32.

1.2. *Adding File System to Your Products*

Adding a file system, such as FAT, to a product can cost a company thousands of dollars. A reliable FAT stack source code costs between \$4,000 and \$10,000. That is not all, FAT is useless without driver for the connected media, an SD card for example. Understanding the media, porting, compiling and linking are also other complicated steps. Our own research shows that adding a file system to a product would take about 6 months or cost about \$10,000!!!

1.3. *uALFAT™ in general*

uALFAT is a full FAT file system on a chip. uALFAT requires very few external components to run. For communication, a simple microcontroller (PIC, AVR, basic stamp...etc.) with UART, SPI or I2C can be used.

1.4. Features

- FAT12, FAT16 and FAT32 support.
- Runs on UART, SPI or I2C.
- Programmable UART (serial port) baud-rate.
- Can open 4 files at the same time using file handles.
- Fast startup and media reconnect.
- Fast file write, average 60Kbytes/Sec.
- Supports Secure Digital (SD) and Multi Media Card (MMC)
- No SD license is required.
- Field upgradeable firmware through UART, SPI, or I2C.
- Field upgradeable firmware through a file on the connected media!
- Very few external components.
- 10-bit ADC.
- RTC (Real Clock Time) capable of running on external battery.
- Low power consumption, about 8mA.
- Sleep mode, 10uA
- All I/O pins are 5 volt tolerant.
- Small surface mount package, LQFP 48 pin.
- -40°C to +85°C temperature operating range.
- Lead free.

1.5. Some Example Applications

- Digital cameras
- Printers
- Digital picture viewer
- MP3 players
- Data logger
- Automated machines

2. Pin-Out and Description

Pin	Name	Description
1	SD_MISO	SD card signal
2	SD_MOSI	SD card signal
4	VBAT	Power source for the internal RTC. Connect to 3V battery or VCC. Always use 2 diodes to connect a battery and VCC in case the battery runs out of power.
5	VDD 1.8V	1.8V power source
6	RESET#	uALFAT reset signal.
7	VSS	Ground
8	TRST#	Do not connect
9	TMS	Do not connect
10	TCK	Do not connect
11	X1	Pin 1 for 10 MHz oscillator
12	X2	Pin 2 for 10 MHz oscillator
13	UART_TX SPI_DATARDY I2C_DATARDY	UART mode: Transmit pin of UART (output) SPI and I2C modes: When high, it signals that uALFAT wants to send some data and the host must read it
14	UART_RX SPI_BUSY I2C_BUSY	Receive pin of UART (input) SPI and I2C: When high, it signals that uALFAT is being busy and not ready for new data.
15	TDI	Do not connect
16	TDO	Do not connect
17	VCC	3.3V power source
18	I2C_SCL	Clock pin for I2C
19	VSS	Ground
20	RTXC1	Pin 1 for 32.768 KHz oscillator. Optional for RTC with backup battery.
21	I2C_SDA	Data pin for I2C
22	SPI_SCK	Clock pin for SPI
23	SPI_MISO	Master In Slave out for SPI (output)
24	SPI_MOSI	Master Out Slave In for SPI (input)
25	RTXC2	Pin 2 for 32.768 KHz oscillator. Optional for RTC with backup battery.
26	RTCK	Do not connect
27	DBGSEL	Do not connect
28	SPI_SSEL#	Slave Select for SPI (input)
31	VSSA	Analog Ground
36	CD_SSEL#	SD card signal
37	MISC	A miscellaneous pin. Functionality will be determined in special releases

Pin	Name	Description
42	VCC	3.3V Power source
43	VSS	Ground
44	SD_SCK BL# WAKE	SD card signal. This pin must be high when RESET# is low. Also, when sending deep sleep command, a toggle on this pin will wake up uALFAT

All pins that are not listed in the table above must be left unconnected. Always consult uALFAT-SD schematics.

3. Boot Loader

3.1. General description

The boot loader is used to update the firmware of uALFAT. When there is a new firmware release, you can simply download the file from our website and, using simple commands, uALFAT can update itself. At power up uALFAT will send 2 characters 'B' and 'L' indicating that the boot loader is ready to load new file. To exit the boot loader and start uALFAT firmware, send 'R' character. If uALFAT chip detects invalid firmware then it returns 'BL' again. In such case, reprogramming uALFAT chip is required. If uALFAT powers up in standalone mode, it will execute the firmware immediately, no BL will be sent.

3.2. Boot Loader Use

The easiest way to update uALFAT is by placing the new firmware on any SD card using any PC and a card reader. Once you have the firmware on the card, connect the same card to uALFAT. The file must be placed in the root directory, not in any folder. We recommend using newly formatted media. Now you are ready to send the update command. The command is 3 characters, LOK (Load OK)

If needed, a user can update the new firmware by sending it over SPI, I2C or UART. All commands return '!' followed by the error number. Also, the boot loader will respond with 'Wxx<CR>' on every sector write, where xx is the sector number. The firmware file is encrypted file. Loading an incorrect file on uALFAT can damage the chip. Never tamper with the firmware files.

3.3. Boot Loader Commands

Command	Use	Notes
R	Load and run uALFAT firmware	If Boot loader return BL then reprogramming uALFAT is required
LOK	Load firmware file from connected media	Returns !00 if pass or !xx error code
W	Write one sector to internal FLASH	Follow 'W' by the sector number then 512 bytes of sector data. Transaction must be terminated by a checksum byte. Checksum byte is calculated by adding all 512 data bytes
V	Returns the loader version	Returned value is ASCII

Note: The boot loader is entirely separate program that loads uALFAT firmware. The version number of the boot loader may not match the version number of uALFAT. New uALFAT chips come with no firmware loaded and must load the latest firmware available on our website.

3.4. Communication Interfaces in boot Loader

The boot loader runs simpler drivers for UART, SPI and I2C. All drivers run in pooled mode. Also, there are few things to keep in mind:

1. The processor runs at 10 MHz always.
2. SPI clock has to be lower than 1.25 MHz
3. SPI driver is half duplex.

3.5. Boot Loader Error Codes

The boot loader error codes are same as uALFAT error codes with the addition of the following.

0xD1	ERROR_FLASH_NOT_BLANK
0xD2	ERROR_VERIFY
0xD3	ERROR_INTERNAL
0xD4	ERROR_CHECKSUM
0xD7	ERROR_INVALID_FIRMWARE
0xD8	ERROR_BR_COMMAND
0xDA	ERROR_FILE_IS_EMPTY
0xDB	ERROR_FILE_NOT_FOUND
0xDE	ERROR_UNKNOWN_COMMAND

4. uALFAT™ Interfaces

uALFAT uses UART, I2C or SPI to communicate with any external microcontroller. At power up, uALFAT samples SPI_SSEL# and SPI_SCK pins to determine what interface to use. The following table describes the states

SPI_SSEL#	SPI_SCK	Interface
0	0	UART
0	1	Skip boot loader*
1	0	I2C
1	1	SPI

* Do not use.

4.1. UART Interface

In UART interface mode, UART_TX pin is used to send data to your microcontroller and UART_RX pin to receive commands from your microcontroller. The default baud rate for UART is 9600. Always use 8 bit with no parity and 1 stop bit. Baud rate is changeable through BR command. CTS and RTS lines must be used to insure not loss of data at high speeds. CTS pin is an input to uALFAT and when it is high uALFAT will not send data and will wait for it to go low. CTS should be high as long as possible to not slow down uALFAT. RTS pin is output from uALFAT and it is set high when uALFAT FIFO is full. Depending on data transfer speed, RTS pin may never go high because uALFAT is contentiously emptying the FIFO.

Note: The internal UART have a hardware TX FIFO that is 16 byte long. After asserting CTS, uALFAT may still send the internal FIFO, up to 16 bytes.

Important: uALFAT will NOT send any data if CTS pin is high! If this pin is not used then it must be connected to ground.

4.2. SPI Interface Mode

In SPI mode six pins are used for communication, to implement slave SPI. Two pins are used for handshaking. SPI_SSEL, SPI_SCK, SPI_MISO, and SPI_MOSI are the standard SPI pins where SSEL is used for Slave Select, SCK is the Serial Clock, MISO is the data line going from uALFAT to your microcontroller, and MOSI is the data line going from your microcontroller to uALFAT.

The Handshaking lines are SPI_DATARDY and SPI_BUSY. When uALFAT has data to send to the PC, it raises DATARDY line. The host (SPI master) must read the data from uALFAT as fast as possible. Data and commands can be sent to uALFAT at any time except when SPI_BUSY is high.

In the nature of SPI, the data flow is full duplex. On every SPI transaction, a data is swapped between the master (your system) and the slave (uALFAT). This is great until you need to read data from uALFAT but you don't want to send a command. uALFAT implements a software mechanism to handle this issue. Two special numbers are used to handle the flow control. 0xFF and we will call it NDT (No Data Token) and 0xFE and will call it HDT (Half Data Token)

Whenever uALFAT SPI sees NDT (again, it is 0xFF,) it will ignore it. This allows you to read uALFAT without sending data. Of course you are sending NDT but it will be ignored by uALFAT SPI driver.

This is everything you need to do if you are using numbers from 0 to 0xFD. Usually, this is good in most cases as uALFAT commands are ASCII based and most users save files as ASCII text. If you need to send 0xFF to uALFAT, you have to send HDT followed by NDT. uALFAT will understand this as real 0xFF number and will not ignore it. For 0xFE, you have to send HDT followed by HDT. Here is a simple example in 'C' language on how your transmit routine should work:

```
SendData(char c)
{
    if( (c==FF) || (c==0xFE) )
        SendSPI(0xFE);
    SendSPI(c);
}
```

If pooling is a preferred, it is possible to keep pooling uALFAT and not check DATARDY pin at all. When there is no data, uALFAT will return NDT (0xFF)

Important: uALFAT requires the following in order for SPI to work:

- SCK is output from your system.
- SCK is idle High.
- SCK is slower than 8 MHz in full power mode and slower than 1.25 in rediced power mode.
- Data is shifted out MSB first.
- Data is latched on the rising edge of SCK.

4.3. I2C Interface Mode

Four pins are needed for I2C communication. The USER_I2C_SCL and USER_I2C_SDA are the two I2C bus lines. I2C_DATARDY and I2C_BUSY lines work exactly the same way as SPI_DATARDY and SPI_BUSY work except the interface is half duplex. When DATARDY is high, you can't send data to uALFAT until all the data is read and DATARDY is back low.

uALFAT runs in slave I2C mode always. The slave address of uALFAT is 0xA4. This address is fixed and can't be changed.

5. Commands Structure

uALFAT implements a very simple commands structure. Commands are one character. The following table is a complete listing of the commands

CMD	Usage	Parameters	Example	Notes
A	Change (access) directory	Folder Name string	A MYFOLDER	Folder must exist
M	Make new directory	Folder Name string	M MYFOLDER	Folder must not exist
E	Erase an empty directory	Folder Name string	E MYFOLDER	Folder must exist
O	Open File	filehandle Openmode>filename Openmode : 1. R Open to Read only 2. W Open new file to write. 3. A Open to write data starting from the end of existing file.	O 0R>TEST.TXT O 1W>TEST2.TXT O 3A>DATA.LOG	
C	Close file handle	Filehandle	C 2	Always close when done writing
F	Flush File	Filehandle	F 1	Flush guarantees the data is on the SD card.
D	Delete file	Filename	D test.txt	
W	Writes data to an open file	Filehandle>datasize Datasize (1 – FFFFFFFF) bytes	W B>4D	Must open file for write first
R	Read data from an open file	FilehandleFiller>datasize Datasize (1 – FFFFFFFF) bytes	R 0Z>E8	Must open file for read first
P	Seek read file pointer	Filehandle>newposition newposition is a hex number (0 - (filesize-1))	P 0>FFA3	This function works on files open for read only
@	Initialize the file entry pointer	none	@	
N	Get next file	none		Use @ command first
?	Get File Information	Filename	? file.txt	
V	Version number	None	V	
Q	Quick Format	Confirming string which is: CONFIRM FORMAT	Q CONFIRM FORMAT	Memory cards must be formatted on a PC first

CMD	Usage	Parameters	Example	Notes
B	Set baud rate divider	Divider value	B 1234	Read “UART Baud Rate” section below
#	Enable Echo	1 to enable and 0 to disable	# 1	Always disable echo for speed and when using SPI and I2C
K	Media Statistics	None	K	Can take a bit of time depending on the media size
Z	Sleep	F for full R for reduced H for hibernate		Read Power Modes section for more details
T	Init time	B for backup and S for shared	T S	
S	Set Time and Date	DWORD hex Time&Date structure †		Not fully implemented yet
G	Get current Time and Date	X for hex Time&Date structure and F for formatted	G F	Displays the current time
{	Read sector	SectorNumber	{ 1234	Sector size is always 512 bytes
}	Write sector	SectorNumber	} 1234	Use only if you know what you are doing!!

**** File Attributes are one byte Standard Attribute Structure in FAT system**

File attributes:

```
ATTR_READ_ONLY      0x01
ATTR_HIDDEN          0x02
ATTR_SYSTEM          0x04
ATTR_VOLUME_ID       0x08
ATTR_DIRECTORY       0x10
ATTR_ARCHIVE         0x20
```

† Time & Date DWORD structure
 struct FATtime // 32 bits

```
{
    WORD Second2:5; // seconds divided by 2 (0..30)
    WORD Minute:6; // 0..59
    WORD Hour:5; // 0..23
    WORD Day:5; // 1..31
    WORD Month:4; // 1..12
    WORD Year1980:7; // Years since 1980
};
```

5.1. UART Baud Rate

uALFAT contains a fancy divider for baud rate. Using the divider we can set the UART to almost any possible baud rate. Below is a table with some standard baud rates. Note that the values do not work in boot loader. Always run boot loader at default 9600 and after firmware execution, change the baud rate. The table contains two sets of divider values, at 10 MHz and 70 MHz. Use the 70 MHz when run in full power mode and the 10 MHz when running reduced power mode.

Baud Rate	Divider at 70 MHz	Divider at 10 MHz
9600	DCEF	1FAB
119200	6EEF	0386
38400	37EF	067C
57600	43F2	08E5
115200	1EF4	04E5
230400	0FF4	02E5
460800	05A9	01E5
921600	028B	Not possible!

For example: B 1EF4 will set the baud rate to 115200 when using full power mode. uALFAT responds with !00 if command is accepted at the old baud rate and then it changes the baud rate. You will then receive a second !00 at the new baud rate.

6. Getting Started

All commands are text based. User can use a terminal program to type in the commands (if using a PC and RS323 level converter.) Also, any microcontroller can send commands to write/read files/folders. NOTE: Each line is terminated by carriage return only, to make parsing easier. If you use Hyper Terminal (or similar) program you have to configure it to append LF to each CR. In Hyper terminal, you will find it at “properties→Settings→ASCII Setup→Append Line Feed”

Important: uALFAT doesn't echo back the data by default. Use '# 1' command to enable echo if needed.

At power up uALFAT will send BL (Read boot loader section for more details.) Follow BL by 'R' and you should get the following. No carriage return is needed.

*GHI Electronics, LLC
uALFAT(TM) 1.xx*

>

The > prompt means that uALFAT is ready to take commands

uALFAT can connect to two kinds of media types, SD and MMC cards.
To initialize the media, use the 'I' (initialize) command followed by carriage return.

uALFAT doesn't detect card removal or replacement. The final application must detect card removal. Also, uALFAT doesn't check the protection switch on SD cards. This means uALFAT will write on protected cards.

No harm will be caused to the card if removed as long as no files were open for write.

For step-by-step on how to use the commands, consult uALFAT Tutorial.

6.1. Directories (Folders)

Folders are fully supported by uALFAT. uALFAT doesn't display what folder it is accessing but it will keep track of the folders internally.

M UALFAT ← this command will create "UALFAT" folder

6.2. Files

Files can be opened for read, write or append. Opening a file for read requires that the file exists on the media. Opening a file for write requires that the file doesn't exist on the media or it will be overwritten. Opening a file to append data to it will add data to a file if it exists. If the file doesn't exist then new file will be made.

With uALFAT you can open up to 4 files at the same time using file handles.

Keep in mind that all values here are ASCII based so when you need to send 0 to uALFAT you will have to press 0 key on keyboard but when sending it through external microcontroller you would have to end ASCII 0 which is 0x30 hexadecimal.

When sending data to the opened file, data can be anything, ASCII or binary!

Handles are used for fast access to a file. If a user needs to log data to 2 files at the same time, "*VOLTAGE.LOG*" and "*CURRENT.LOG*" file handles become very use full.

To do so, open *VOLTAGE.LOG* under handle 1 and *CURRENT.LOG* under handle 2. Now start sending your data to handle 1 and 2 instead to the file name.
To open a file use,

O 1W VOLTAGE.LOG

The previous command will create new file at the current directory with name “*VOLTAGE.LOG*” and the file handle is *1*. Now to save data to that file use

W 1>10

Now the “*W*” will write data to a file that is open at handle 1 and will write 16 bytes (10 hexadecimal = 16 decimal) to it. After sending carriage return (enter,) uALFAT will return !00. This indicates that uALFAT is ready for your data. Now, start sending your 16 byte of data. When 16 bytes are sent, uALFAT will return another error code.

Note: All numbers given to uALFAT commands are hexadecimal numbers.

This is an example session:

>M LOG_DATA	← create new directory
!00	
>A LOG_DATA	← change directory
!00	
>O 1W>VOLTAGE.LOG	← create new file for write inside LOG_DATA folder
!00	
>O 2W>CURRENT.LOG	← create new file for write inside LOG_DATA folder
!00	
>W 1>7	← command to write 7 bytes (characters) to file at handle 1
!00	← uALFAT accepted the write command
12.123V	← enter the data to go to the file
!00	← data written successfully
>W 7>A	← writes 10 bytes to file at handle 7
!00	← uALFAT accepted the write command
1234567890	← enter your data
!00	← data written successfully
W 1>7	← add 7 bytes(characters) to file at handle 1
!00	← uALFAT accepted the write command
10.194V	← enter the data to go to the file
!00	← data written successfully
>	← uALFAT is ready for more commands.

Note1: file names must **not** contain its path (i.e. “\sub1\file.txt”). **Only** pure names are allowed (i.e. “file.txt”).

Note2: Folders and files use naming convention that is same of DOS naming convention. Names must be 8 characters or less and 3 characters or less for the extension and they must be upper case. All upper case letters, numbers and underscore ‘_’ can be used for names and extensions.

Example “DATA.LOG”, “NOEXT”, “FOLDER”, “FOLDER.123”, “NO_SPACE.TXT”, “12345678.123”

If an error occurred, uALFAT returns the symbol ‘!’ followed by the error number.

7. uALFAT™ Error Codes

All Commands return with prompt or with error codes.

Error Number	Description
0x00	No Error
0x01	ERROR_READ_SECTOR
0x02	ERROR_WRITE_SECTOR
0x03	ERROR_ERASE_SECTOR
0x11	ERROR_MBR_SIGNATURE_MISMATCH
0x12	ERROR_BS_SIGNATURE_MISMATCH
0x13	ERROR_SECTOR_SIZE_NOT_512
0x14	ERROR_FSINFO_SIGNATURE_MISMATCH
0x21	ERROR_CLUSTER_OVER_RANGE
0x22	ERROR_CLUSTER_UNDER_RANGE
0x23	ERROR_NEXT_CLUSTER_VALUE_OVER_RANGE
0x24	ERROR_NEXT_CLUSTER_VALUE_UNDER_RANGE
0x25	ERROR_NO_FREE_CLUSTERS
0x31	ERROR_FILE_NAME_FORBIDDEN_CHAR
0x32	ERROR_FILE_NAME_DIR_NAME_OVER_8
0x33	ERROR_FILE_NAME_DIR_EXTENSION_OVER_3
0x34	ERROR_FILE_NAME_FIRST_CHAR_ZERO
0x35	ERROR_MEDIA_FULL
0x40	DIR_ENT_FOUND
0x41	DIR_ENT_NOT_FOUND
0x42	ERROR_FOLDER_IS_CORRUPTED_FIRST_CLUSTER
0x43	ERROR_FOLDER_IS_CORRUPTED_DIR_DOT_NOT_FOUND
0x44	ERROR_FOLDER_IS_CORRUPTED_DIR_DOTDOT_NOT_FOUND
0x45	ERROR_ROOT_DIRECTORY_IS_FULL
0x46	ERROR_OPEN_FOLDER_FILE
0x47	ERROR_WRITE_TO_READ_MODE_FILE
0x48	ERROR_SEEK_REQUIRE_READ_MODE
0x49	ERROR_INVALID_SEEK_POINTER
0x4A	ERROR_FOLDER_NOT_EMPTY
0x4B	ERROR_IS_NOT_FOLDER
0x4C	ERROR_READ_MODE_REQUIRED
0x4D	ERROR_END_OF_DIR_LIST
0x4E	ERROR_FILE_PARAMETERS
0x4F	ERROR_INVALID_HANDLE
0x61	ERROR_COMMANDER_BAD_COMMAND
0x62	ERROR_COMMANDER_STR_LEN_TOO_LONG
0x63	ERROR_COMMANDER_NAME_NOT_VALID
0x64	ERROR_COMMANDER_NUMBER_INVALID
0x65	ERROR_COMMANDER_WRITE_PARTIAL_FAILURE
0x66	ERROR_COMMANDER_UNKNOWN_MEDIA_LETTER
0x67	ERROR_COMMANDER_FAILED_TO_OPEN_MEDIA
0x68	ERROR_COMMANDER_INCORRECT_CMD_PARAMETER
0xFD	ERROR_COMMANDER_UNKNOWN_ERROR

8. Power Modes

In some applications power consumption is very critical. uALFAT is designed with low power in mind. Although you can completely shut off uALFAT's power for zero power consumption, some user may prefer to put uALFAT to sleep instead of power off to keep the file handles open. Also, uALFAT can run at 2 different speeds.

uALFAT oscillator is 10 MHz. When executing the boot loader or the firmware, uALFAT runs in reduced power mode. In this mode, uALFAT draws about 8mA including 1.8V regulator.

If high performance is required, you can run uALFAT at full power where the core runs at 70 MHz. In this mode, the complete uALFAT-SD board draws about 38mA.

Hibernation is also another option. If the system doesn't need any file operations, uALFAT can hibernate and the core draws about 10uA. Keep in mind that regulators have their own current draw and a minimum draw. uALFAT-SD board draws 1mA when in hibernate.

The command to change the power mode is 'Z'. When changing the clock speed, you have to keep many things in mind. For example, the SPI clock can be the system clock divided by 8 maximum. So if the system is in reduced power mode running at 10 MHz, the SPI SCK can be 1.25 MHz maximum. Also, the UART baud rate needs to be adjusted to hold the correct divider value. Look at "UART Baud Rate" section for more details on the divider values.

Z F>DCEF ← switch to run at 70 MHz and set the UART baud rate to 9600.

Z R>1FAB ← set the system to run at 10 MHz and baud rate of 9600

Now, what if we are using SPI or I2C interfaces? Even in this case you are required to set the UART divider and you can use any one of the values.

When uALFAT goes in hibernation mode, it can be woken up by toggling the WAKE pin. This is multi purpose and must always be left disconnected from your system except when there is a need to wake uALFAT. This can be accomplished by setting the pin of your micro that connects to WAKE to be input. When there is a need to wake uALFAT, set your pin to low then make the pin output, wait for few micro seconds and then set the pin back to input.

9. Power and Oscillator

uALFAT is very simple to add to your new or existing designs, it requires very few components. Two voltages are needed; 3.3V and 1.8V, crystal and very few RCs, Check the pin description and schematics for more details. You can also find more details on the chipset base (LPC2103) data sheet on Philips website www.semiconductors.philips.com and the schematics of uALFAT-SD on our website www.ghielectronics.com

10. Special Firmware

uALFAT's standard firmware contains many features to suite any application. If your application requires a special need, we can implement a special firmware to suite your needs. Loading the updated firmware or special firmware is extremely easy. Look at the boot loader section.

Cost for special firmware is fairly low. We charge \$60/h with a minimum of 25 hours.

11. Development and OEM Circuit Boards

uALFAT-SD is our uALFAT chip on a small size board. The low cost and the ease of use make uALFAT-SD the ultimate solution for OEMs or hobbyists. The SD/MMC media connector is placed on one side of the board, making it possible to mount the uALFAT-SD board inside your product case using 90 degree brackets. The full schematic and board layout is on our website www.ghielectronics.com.

uALFAT-SD board contains 1.8 V regulator onboard. You will only need 3.3V for power. The pin out of the board gives you access to SD card detect and pins to all uALFAT's signals.

We are also capable of designing special boards to fit your needs.

12. Licensing

Each uALFAT chip comes with unconditional license of use from GHI Electronics, LLC. There are many patented technologies utilized in uALFAT that must be account for.

- The SD card is used in MMC compatibility mode; therefore, no license is required from the SD organization.
- FAT file system is a patent of Microsoft Corporation. Licensing fee for using FAT file system must be paid by companies who wish to use FAT file system in their products. For more information, visit Microsoft's website.
<http://www.microsoft.com/mscorp/ip/tech/fat.asp>
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