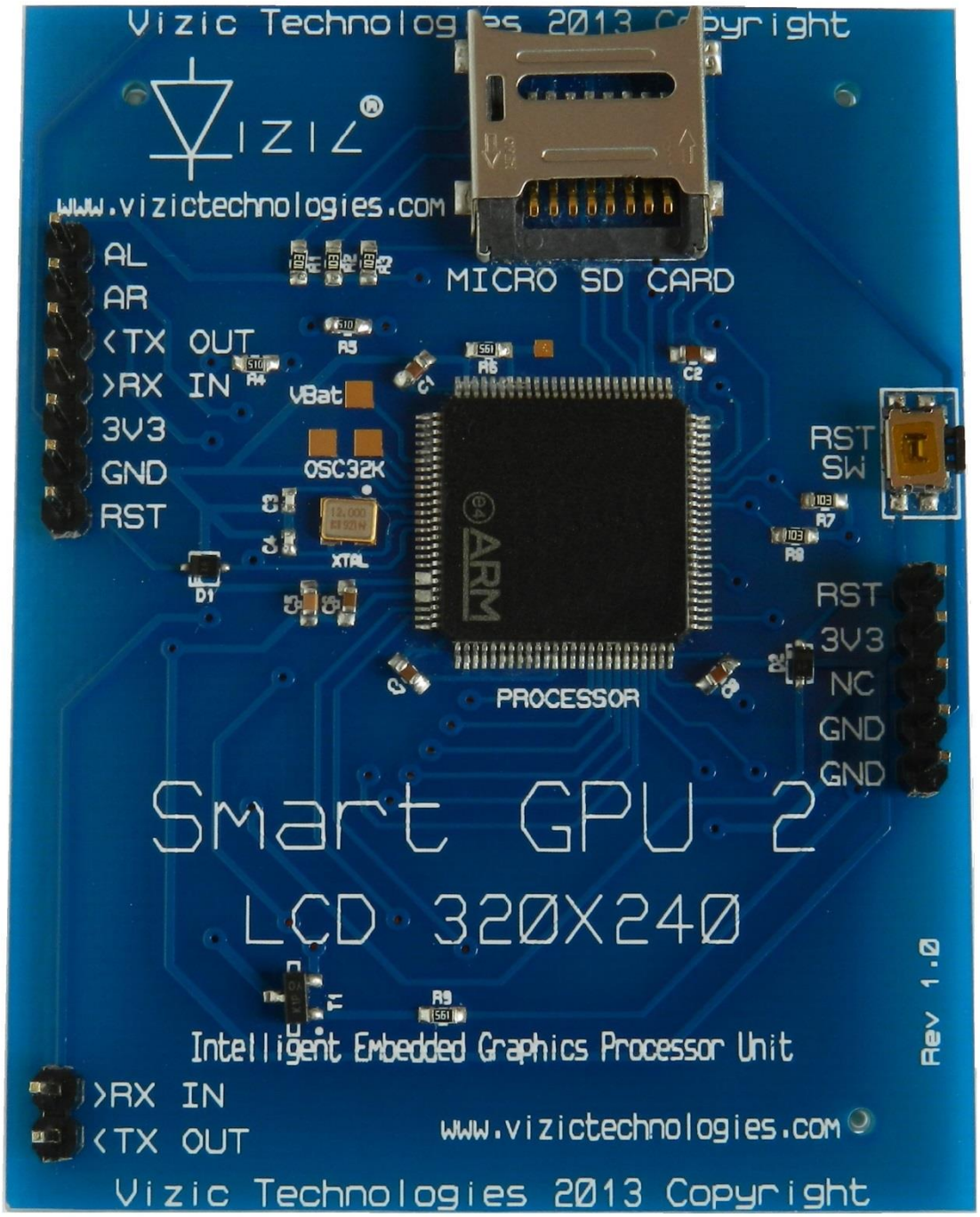
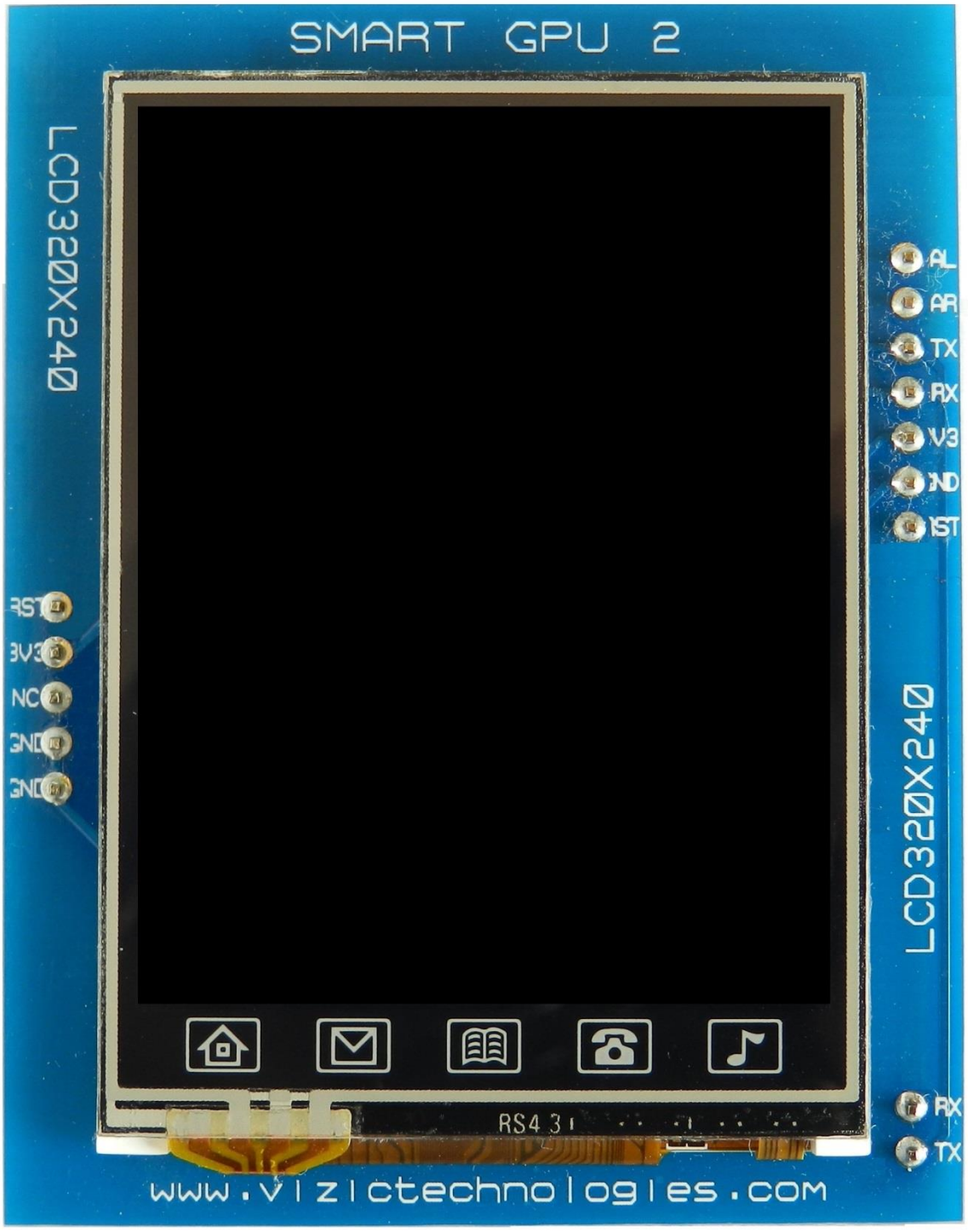
VIZIC TECHNOLOGIES

SMART GPU 2
2.4” TOUCH

Datasheet----Rev 1.0

SMART GPU 2– Intelligent Embedded Graphics, Audio and Touch Processor.




SMART GPU 2
LCD320X240
AL
AR
TX
RX
V3
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RST
3V3
NC
GND
GND
LCD320X240
RX
TX
RS43
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Smart GPU 2:

Intelligent Embedded Graphics, Audio and Touchscreen Processor.

Description:

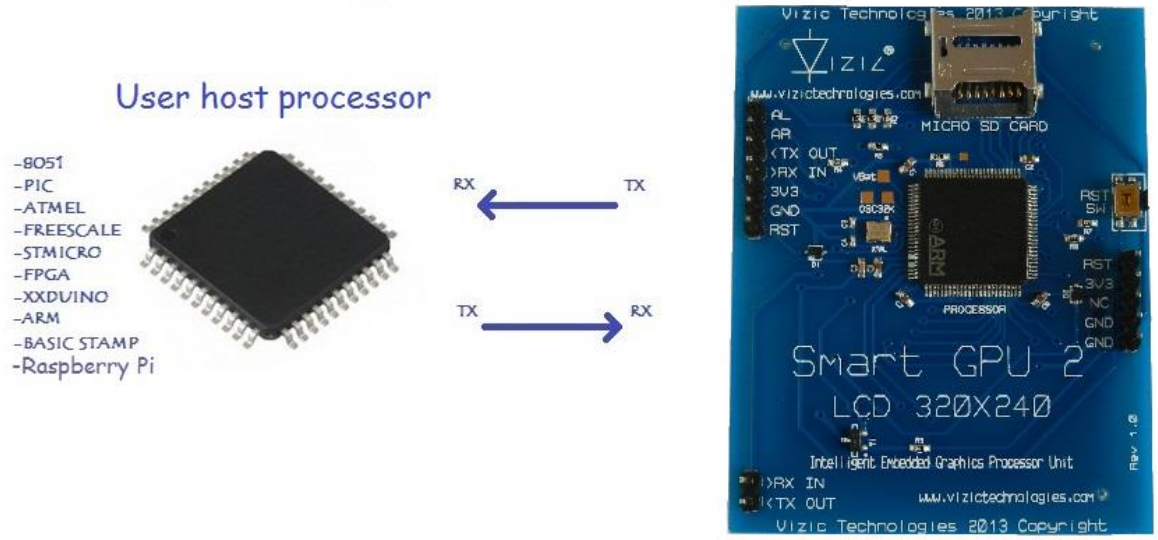
The Smart GPU 2 is a powerful easy to use, intellectual property, embedded graphics, audio and touchscreen processor in a state-of-the-art ARM Cortex-M3 chip; this is mounted on a board with a touchscreen color LCD. It's aimed to help developers to create advanced Graphical User Interfaces (GUIs) in a very easy way. It features high end FAT format data management functions (Data Logger) to create even more advanced applications in just minutes, not days. The Smart GPU 2 processor doesn't need any configuration or programming on itself, it's a slave device that only receives orders, reducing and facilitating dramatically the code size, complexity and processing load in the master host processor.

The Smart GPU 2 offers a simple yet effective serial interface UART to any host micro-controller/microprocessor that can communicate via a serial port(8051, PIC, ATMEL, FREESCALE, STMICRO, ARM, CORTEX, ARDUINO, raspberry PI, FPGA MBED, etc. even PCs(RS232)). All graphics, audio and touchscreen related functions are sent using simple commands via the serial interface.

The main goal of the Smart GPU 2 processor it's to bring a very easy way to add colour, audio and touch interfacing to any application or project without the need of having experience in handling LCDs and graphics algorithms. The Smart GPU 2 it's a low power/very high performance processor, it integrates the FAT/FAT12/FAT16 or FAT32 universal PCs file System for data storage (read/write), supporting up to 32 GB of storage with a microSD/HC card, NO special format is required.

SmartGPU2 chip is also sold as "bare chip" for high end applications and can be adapted to drive any LCD with parallel 8080 interface.

The next image clearly explains the roles played by the user host main processor and the Smart GPU 2 processor:



Main Host Processor:

-Main application processing
-Serial commands processing
-I/O processing

VS

SMART GPU 2 Processor:

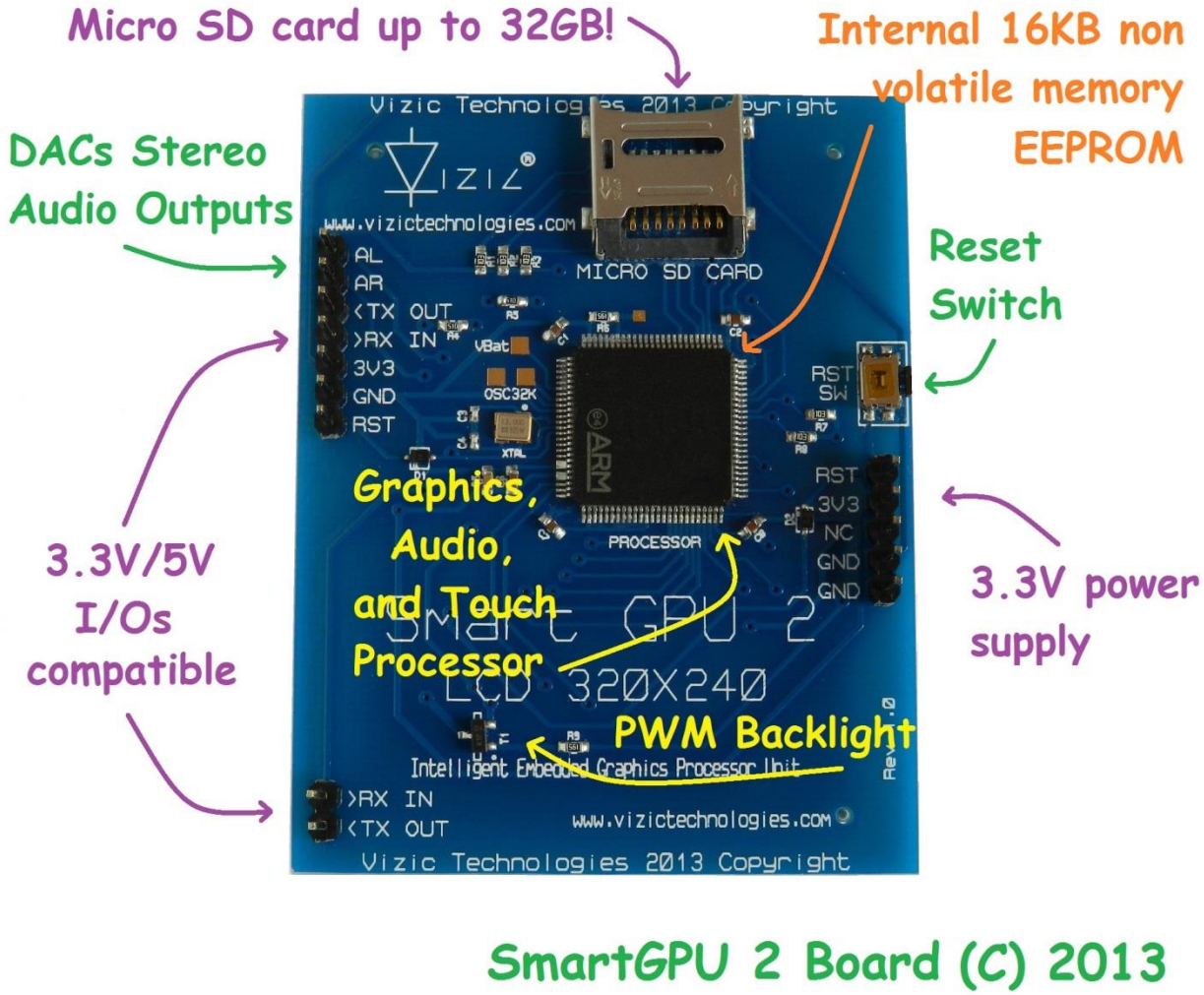
-Colour processing.
-Geometry processing.
-Images processing.
-Video processing.
-Audio processing.
-Micro SD card FAT processing.
-Text processing.
-Touchscreen processing.
-Memory management.
-And more...

Instead of loading all the Geometry, Images, audio, video, SD FAT memory access, etc. processing to the main host processor, the Smart GPU 2 does the entire job and stuff in parallel with the user microcontroller/microprocessor by receiving simple orders or commands.

Board Features:

- 2.4“, 320x240 pixels resistive touchscreen LCD, capable of displaying 262,144 colours.
- Easy 5 pin interface to any host device: **VCC, TX, RX, GND, RESET.**
- On-board uSD/uSDHC card adaptor, FAT(windows PC) Support up to **32GB** for storing images and text, **Data Logger functions (read-write)** and LFN(long File Names).
- BMP and JPG images support.
- Video and Audio(CD quality) capable.
- Integrated 2 channel DACs outputs can play **stereo** audio.
- Integrated Touch screen driver, 12 bit accuracy touch.
- 5 general purpose Icons on touchscreen panel.
- Integrated RTC - Real Time Clock with battery back-up.
- PWM controlled display brightness.
- Sleep mode.
- UART/USART Baud Rate speeds from 9600bps up to 2000000bps, 8 bits, no parity, 1 stop bit.
- 5V and 3V3 I/O compatible, 3V3 power supply.

Smart GPU 2 Board – EXPLAINED



1.-Host Interface

The Smart GPU 2 is a slave peripheral device and it provides a bidirectional serial interface to a host controller via its USART(Universal Serial Asynchronous Receiver - Transmitter).

Any microcontroller or processor (AVR, PIC, BASICstamp, XXDUINO, raspberry PI, 8051, MBED, FPGA, ARM, STmicro, etc) or PC(by serial interface RS232) as host, can communicate to the device over this serial interface from 9600bps up to 4000000bps.

The Smart GPU 2 doesn't need to be configured in any way; it's a plug-and-play device, could be used by students, up to industrial and professional applications, its compatible with any device and existing development board with a USART/UART.

The serial protocol is universal and very easy to implement.
Serial Data Format: 8 Bits, No Parity, 1 Stop Bit.
BaudRate: 9600 bps (default; could be changed).
Serial data is true and not inverted.

1.1 Command Protocol : Flow Control

The Smart GPU 2 Intelligent Graphics Processor Unit is a slave device and all communication and events must be initiated first by the host. Commands consist of a sequence of data bytes beginning with the command/function byte.

When a command is sent from host to the device, this process the command and when the operation is completed, it will always return a response*. The device will send back a single acknowledge byte called the ACK (4Fhex, 'O' ascii), in the case of success, or NAK (46hex, 'F' ascii), in the case of failure or not recognized command.

** Commands having specific responses may send back varying numbers of bytes, depending upon the command and response. It will take the device a certain amount of time to respond, depending on the command type and the operation that has to be performed.*

1.2 Serial Set-up

The Smart GPU 2 is configured to be always initialized at a standard **baud rate of 9600 bps**. So the first command that the host sends to the Smart GPU 2 must be at that speed.

Always after any power-up or reset, the Smart GPU 2 must be initialized by sending the uppercase ascii character '**U**' (55hex) at 9600bps. This will initialize all the processor, and when done it will respond with an ACK byte (4Fhex, 'O'ascii).

If the Smart GPU 2 respond with a NAK(46hex, 'F'ascii), Host must try to send the uppercase ascii character '**U**' (55hex) again until a valid ACK is received, meaning this that Smart GPU 2 is ready and running.

Once the chip is initialized, user can change the baud rate speed to a total of 8 different speeds up to 2Mbps.

Remember:
The SMART GPU 2 always initializes the micro SD card after a valid 'U' character is received. If a micro SD card is detected the ACK 'O' will be response almost immediately, however if no micro SD card is detected, the ACK 'O' could be delayed while the SMART GPU 2 retries to initialize a micro SD card, however if no micro SD card is detected after several tries, the SMART GPU 2 will send the ACK 'O' and the processor will function normally without the SD card functions.

1.3 Power-up and Reset

When the Smart GPU 2 device comes out of a power up or external reset, a 200ms delay before sending any command must be met, do not attempt to communicate with the module before this period.

If no valid uppercase ascii character '**U**' (55hex) is sent before 3 seconds, the Smart GPU 2 logo will automatically show up, host still can send the uppercase ascii character '**U**' (55hex) to initialize the processor even if the logo has already appeared.

Remember:
*The host transmits the upper case character ('**U'**, **55**hex) as the first command so the device to start communication.*

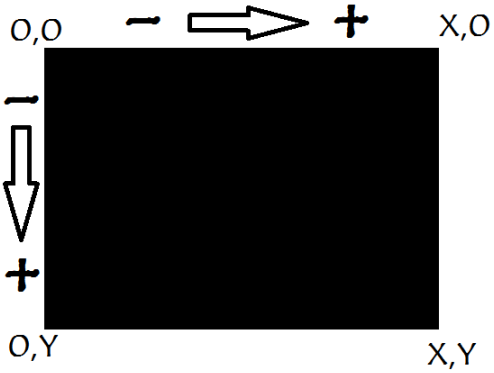
1.4 Splash Screen on Power Up

The Smart GPU 2 will wait up to 3 seconds with its screen in black, for the host to transmit the Initial command ('U', 55hex). If the host has not transmitted this initial command the module will display its splash screen. If the host has transmitted only the initial command and has received a valid ACK, the screen will remain in black. This wait period of the splash screen to appear, is to allow the user initialize the Smart GPU 2 before the welcome screen appears when it is undesired.

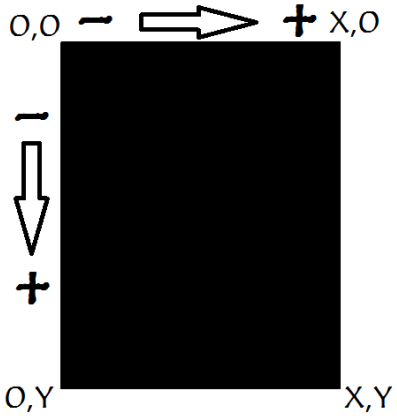
1.5 Understanding the Computer's graphic coordinate system

As well as a computer monitor's coordinate system, the Smart GPU 2 uses the same universal coordinate system, on computer's there's only one positive coordinate quadrant, and there's no negative numbers or points. This quadrant is represented as follows:

The upper left corner is 0,0 if we go right the X values increases, as we go down the Y values increase.

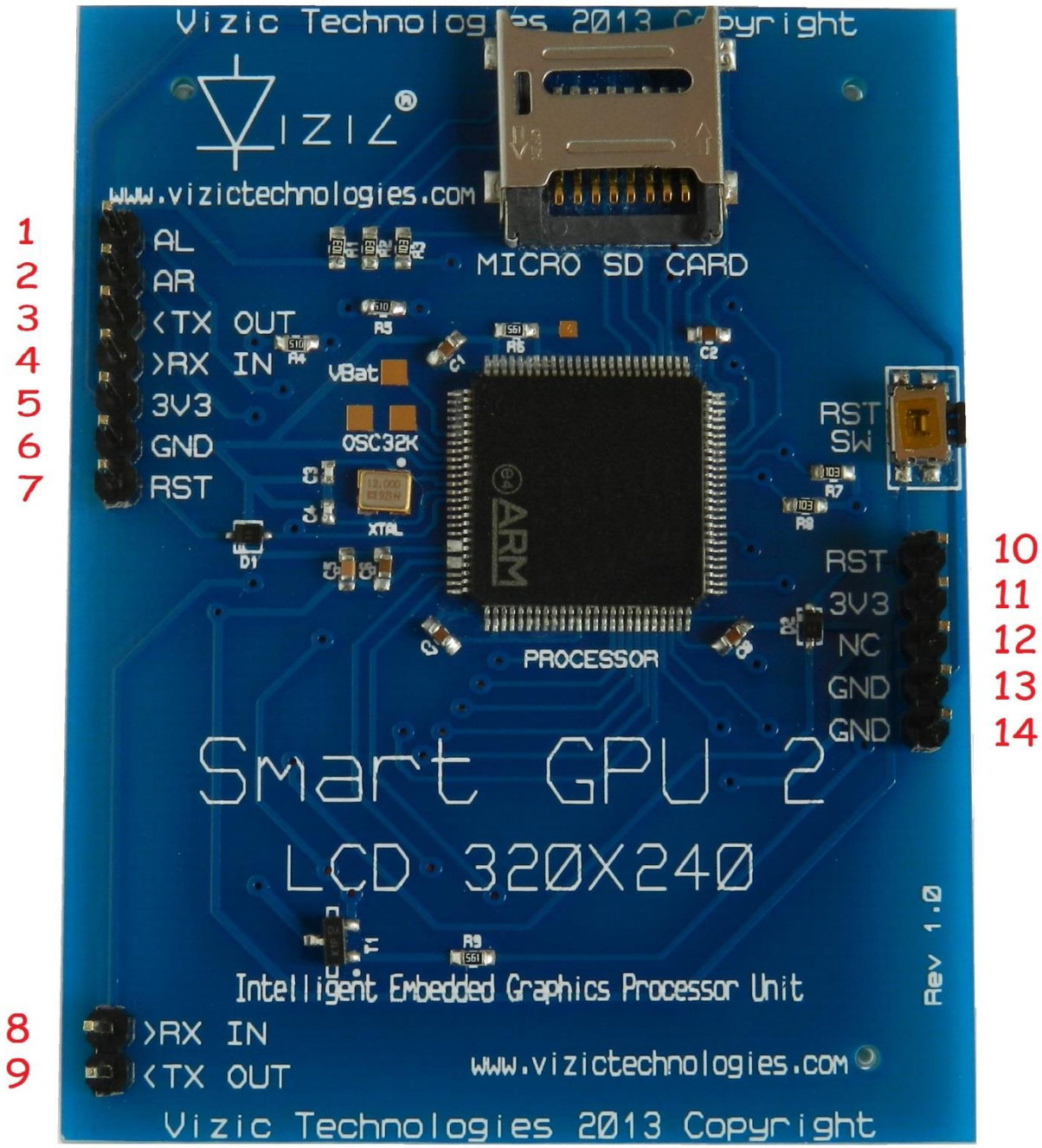


This image shows a LANDSCAPE orientation of the screen, the upper left corner is 0,0 (zero,zero). The maximum values of the SMART GPU 2 in LANDSCAPE mode are X:319,Y:239.



This image shows a PORTRAIT orientation of the screen, the upper left corner is 0,0 (zero,zero). The maximum values of the SMART GPU 2 in PORTRAIT mode are X:239,Y:319.

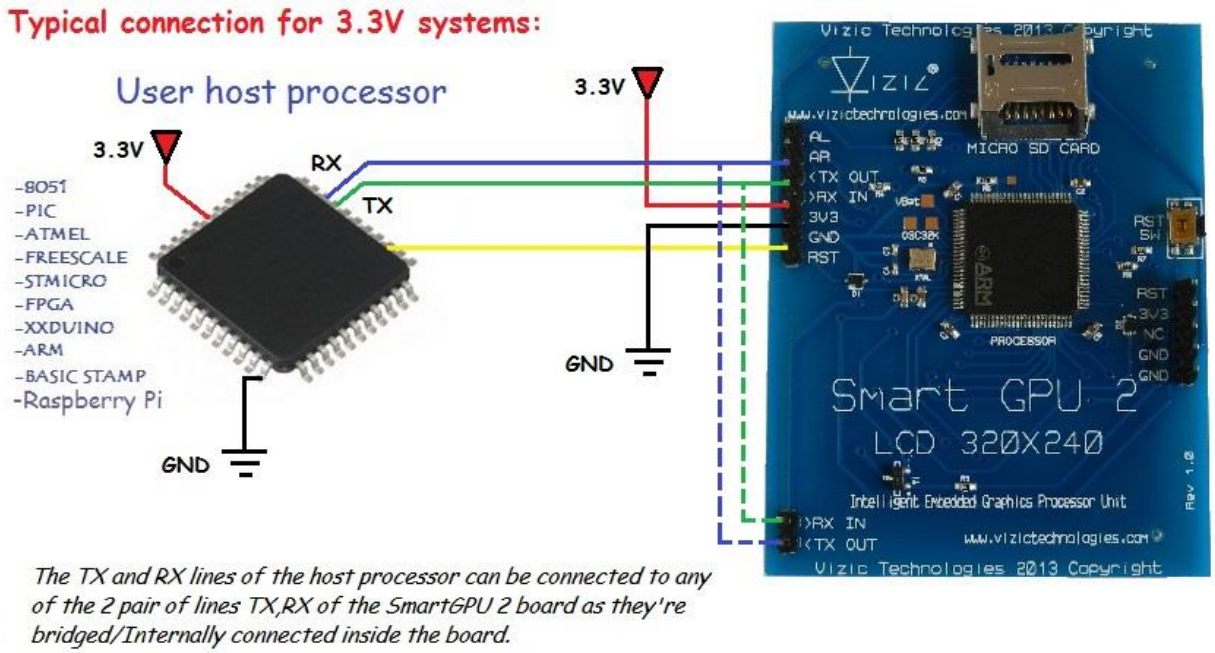
1.6 Board Pin configuration



Pin	Symbol	I/O	Description
1	AL(DAC)	Out	Audio Left Channel Output analog pin, always use a >=100uF capacitor to decouple output.
2	AR(DAC)	Out	Audio Right Channel Output analog pin, always use a >=100uF capacitor to decouple output.
3	Transmitter Out 5V / 3.3V	Out	Asynchronous serial transmit output pin, for 5V and 3.3V logic.
4	Receiver In 5V / 3.3V	In	Asynchronous serial receiver input pin for 5V and 3.3V logic.
5	VCC 3.3V	In	Main voltage supply, 2.8v-3.3v.
6	Ground	In	Supply Ground.
7	Reset	In	Master reset signal, Internally pulled up to 3.3V via a 40K resistor. An active low pulse greater than 100ns will reset the module. 5V tolerant input.
8	Receiver In 5V / 3.3V	In	Asynchronous serial receiver input pin for 5V and 3.3V logic.
9	Transmitter Out 5V / 3.3V	Out	Asynchronous serial transmit output pin, for 5V and 3.3V logic.
10	Reset	In/Out Switch	Master reset signal, Internally pulled up to 3.3V via a 40K resistor. An active low pulse greater than 100ns will reset the module. This pin acts as input when is connected to an external logic or microcontroller, and as output when the on board reset switch is pressed. 5V tolerant.
11	VCC 3.3V	In	Main voltage supply, 2.8v-3.3v.
12	No Connect	-	Not connected pin.
13	Ground	In	Supply Ground.
14	Ground	In	Supply Ground.

1.7 TYPICAL HOST CONNECTION: for 3.3V Systems

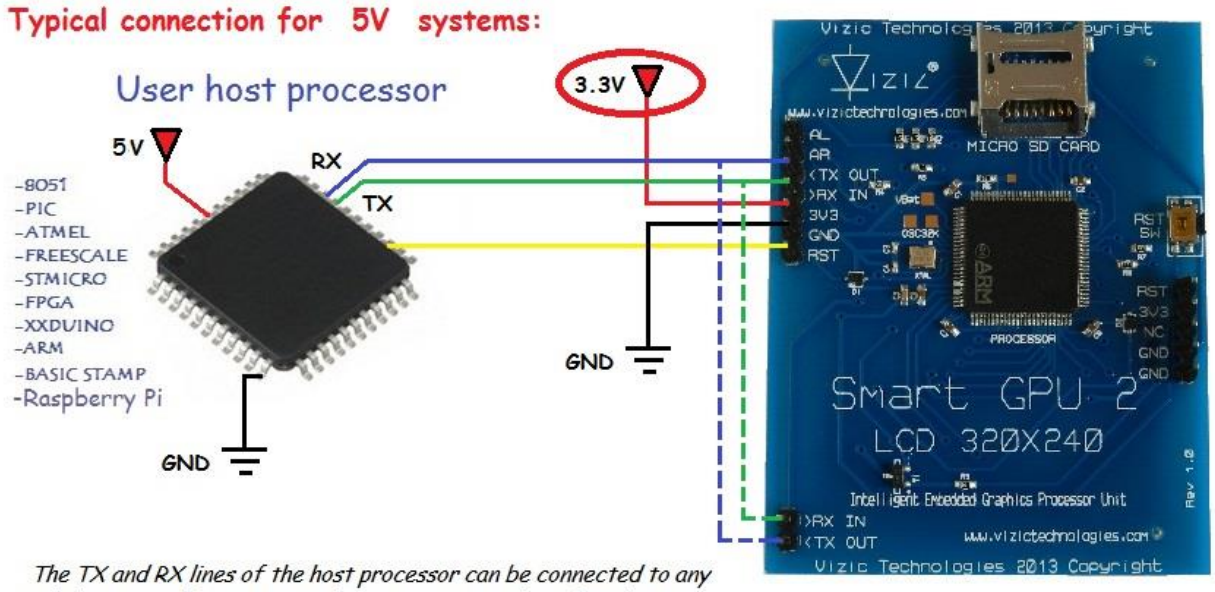
*The SmartGPU2 must always be powered with 3.3V (TX, RX, and Reset pins are 5V tolerant).



The TX and RX lines of the host processor can be connected to any of the 2 pair of lines TX,RX of the SmartGPU 2 board as they're bridged/Internally connected inside the board.

1.8 TYPICAL HOST CONNECTION: for 5V Systems

*The SmartGPU2 must always be powered with 3.3V (TX, RX, and Reset pins are 5V tolerant).

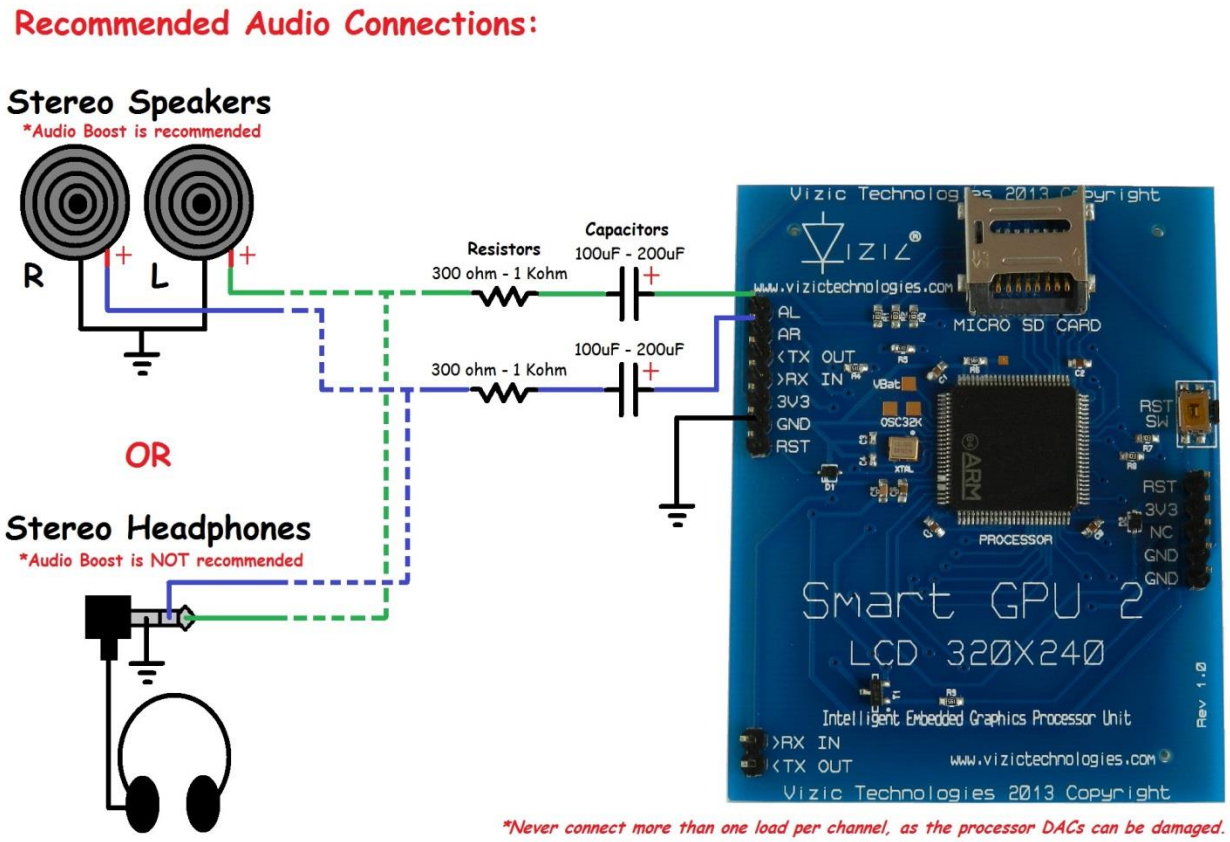


The TX and RX lines of the host processor can be connected to any of the 2 pair of lines TX,RX of the SmartGPU 2 board as they're bridged/Internally connected inside the board.

1.9 Typical Audio headphones/speakers connections:

The Smart GPU 2 supports stereo audio output, the pins labeled AL(Audio Left Channel) and AR(Audio Right Channel) are the audio DACs outputs. The processor can manage any Audio file, so files with **.wav** extension will be easily opened and played.

The following circuit connections are recommended to achieve a good CLEAN headphones or speaker's connection, no LPF or HPF Filter is applied to outputs.



The SMART GPU 2 can play any RIFF-WAVE format sound files known as Microsoft wave file in LPCM: 8/16 bits, Mono or Stereo sound, and up to 48KHz sampling rate (CD Quality). Any other format of sound files (mp3,acc,wma,etc) must be converted to the .wav format.

A complete tutorial on how to load Audio Files to the SD card is explained on this PDF file at the SD card file management section.

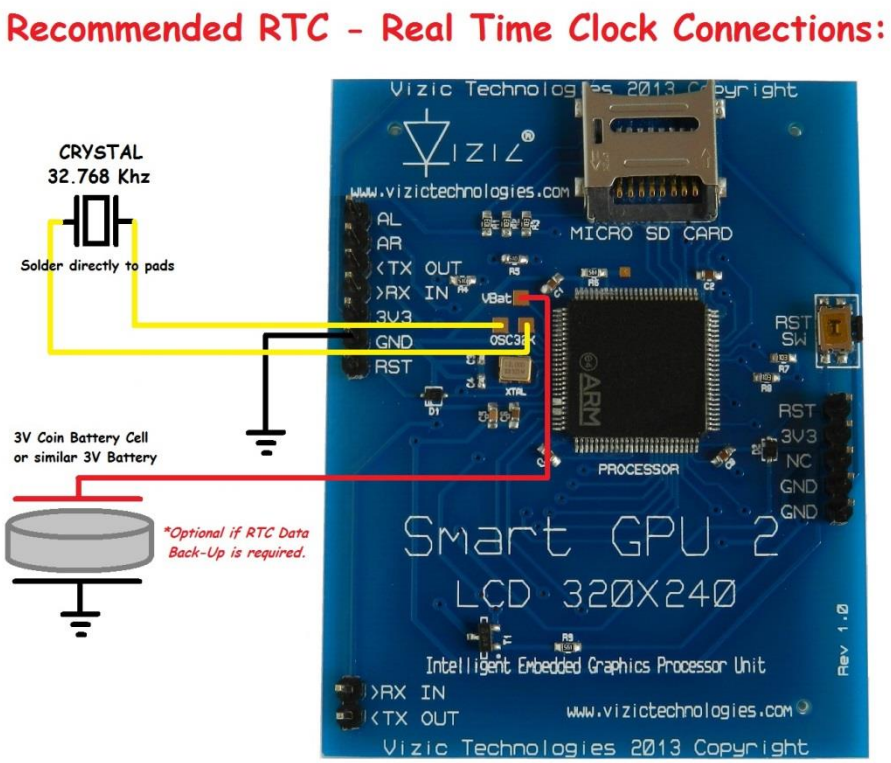
1.10 Typical RTC Real Time Clock connections:

The Smart GPU 2 processor has an embedded RTC Real Time Clock to support full Time-Date calendar functions, also Data Logger applications that require a precise timestamp.

The real-time clock is an independent timer that counts every second and keeps information about Date(day, month, year) and Time(hours, minutes, seconds). The next RTC Timer Functions enable full possibilities with the Smart GPU 2. User can create full real time Graphic User Interfaces and Data-logger applications with clock-calendar functions with the accuracy that only a RTC provides.

The RTC is internal and ready to run, however to lower production costs, the RTC Crystal hasn't been mounted on the board, a 32.768 Khz Crystal can be soldered to the **OSC32** external pads to enable full RTC support. To avoid the RTC lose time and date data each time main VCC power is removed or shut down from the chip, a Standard 3V coin backup battery or similar can be connected between the pads noted as **VBat** and **GND** pin on the board, this way the RTC will continuously running conserving Time and Date data even the Smart GPU 2 chip is power off.

The following circuit connections are recommended to achieve a good RTC Crystal and Back-Up Battery connection.

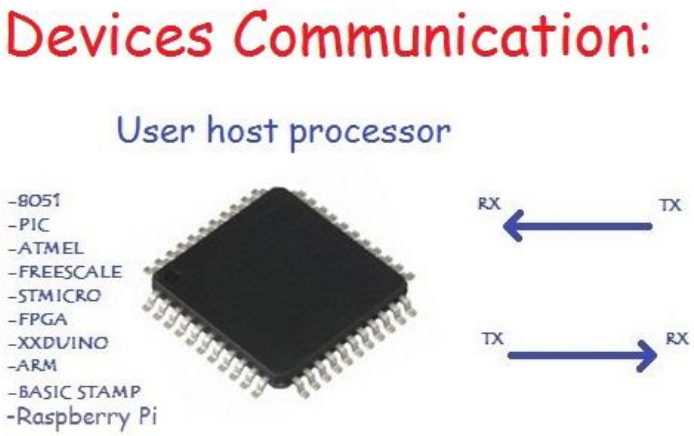


2. SMART GPU 2 Command Set - Software Interface Specification

As mentioned before the command interface between the Smart GPU 2 and the host processor is via the serial interface USART/UART.

A list of very easy to learn commands provide complete access to all the available functions. Commands and responses can be a single byte or a byte package. All commands always return a response, either a single ACK, or data followed by an ACK.

Remember all commands start with a uppercase letter (ascii).



2.1 Command summary

For detailed information, be sure to check the SmartGPU 2 COMMAND SET Sheet.

General Commands:
• Initialize SMART GPU – **55hex 'U'**

Master Commands:
• Erase Screen – **45hex 'E'**
• Set Erase Background Colour – **43hex 'C'**
• Display Orientation – **4Fhex 'O'**
• Display Brightness – **42hex 'B'**
• BaudRate Change – **58hex 'X'**
• Sleep – **5Ahex 'Z'**
• Calibrate Touch – **54hex 'T'**
• Software Reset – **52hex 'R'**

Geometry Commands:
• Put Pixel – **50hex 'P'**
• Draw Line – **4Chex 'L'**
• Draw Rectangle – **52hex 'R'**
• Draw Round Rectangle – **4Fhex 'O'**
• Draw Gradient Rectangle – **47hex 'G'**
• Draw Arc – **41hex 'A'**
• Draw Circle – **43hex 'C'**
• Draw Ellipse – **45hex 'E'**
• Draw Triangle – **54hex 'T'**

String/Text Commands:
• Put Letter – **4Chex 'L'**
• Print Number – **4Ehex 'N'**
• Display String – **53hex 'S'**
• Display String SD – **46hex 'F'**
• Strings Configuration – **43hex 'C'**

Image Commands:
• Draw Image/Icon – **49hex 'I'**
• Image BMP SD – **42hex 'B'**
• Image JPG SD – **4Ahex 'J'**
• Memory Read – **4Dhex 'M'**
• Screenshot BMP – **53hex 'S'**

Video Commands:
- Allocate Video SD – **41hex 'A'**
- Play Video SD – **50hex 'P'**
- Set Frame Video SD – **46hex 'F'**
- De-allocate Video SD – **44hex 'D'**

Audio Commands:
- Initialize/De-initialize DACs/Audio – **49hex 'I'**
- Play WAV File – **50hex 'P'**
- Pause WAV File – **57hex 'W'**
- Advance WAV File – **41hex 'A'**
- Stop WAV File – **53hex 'S'**
- Set Volume WAV – **56hex 'V'**
- Get Playing State – **47hex 'G'**
- Audio Boost – **42hex 'B'**

Touch Commands:
- Get Touchscreen – **53hex 'S'**
- Get Touch icons – **49hex 'I'**

FAT Data Management/ Data Logger:
- List Dirs and Files –**4Chex 'L'**
- Get name Item# –**47hex 'G'**
- Get Dir Path –**48hex 'H'**
- New Dir/File –**4Ehex 'N'**
- Open Dir –**44hex 'D'**
- Open File –**4Fhex 'O'**
- Read File –**52hex 'R'**
- Write File –**57hex 'W'**
- Set/Get Pointer –**50hex 'P'**
- Sync File –**53hex 'S'**
- Test Error-EOF –**51hex 'Q'**
- Close File –**43hex 'C'**
- Truncate File –**56hex 'V'**
- Erase Dir/File –**45hex 'E'**
- Dir/File Rename/move –**4Dhex 'M'**
- Set/Get Time and Date Dir/File –**54hex 'T'**
- Get Dir/File Info –**49hex 'I'**
- Get Free and Total Space –**46hex 'F'**

RTC Real Time Clock Commands:
- RTC Setup – **53hex 'S'**
- RTC Set/Get Time and Date – **50hex 'P'**

EEPROM-FLASH Commands:

- Read from EEPROM Buffer – **52hex 'R'**
- Write to EEPROM Buffer – **57hex 'W'**
- Fill Buffer with EEPROM Page# – **46hex 'F'**
- Save Buffer to EEPROM Page# – **53hex 'S'**
- Erase EEPROM Page# – **45hex 'E'**
- Compare Buffer to EEPROM Page# – **43hex 'C'**
- Init/Clear EEPROM Buffer – **49hex 'I'**

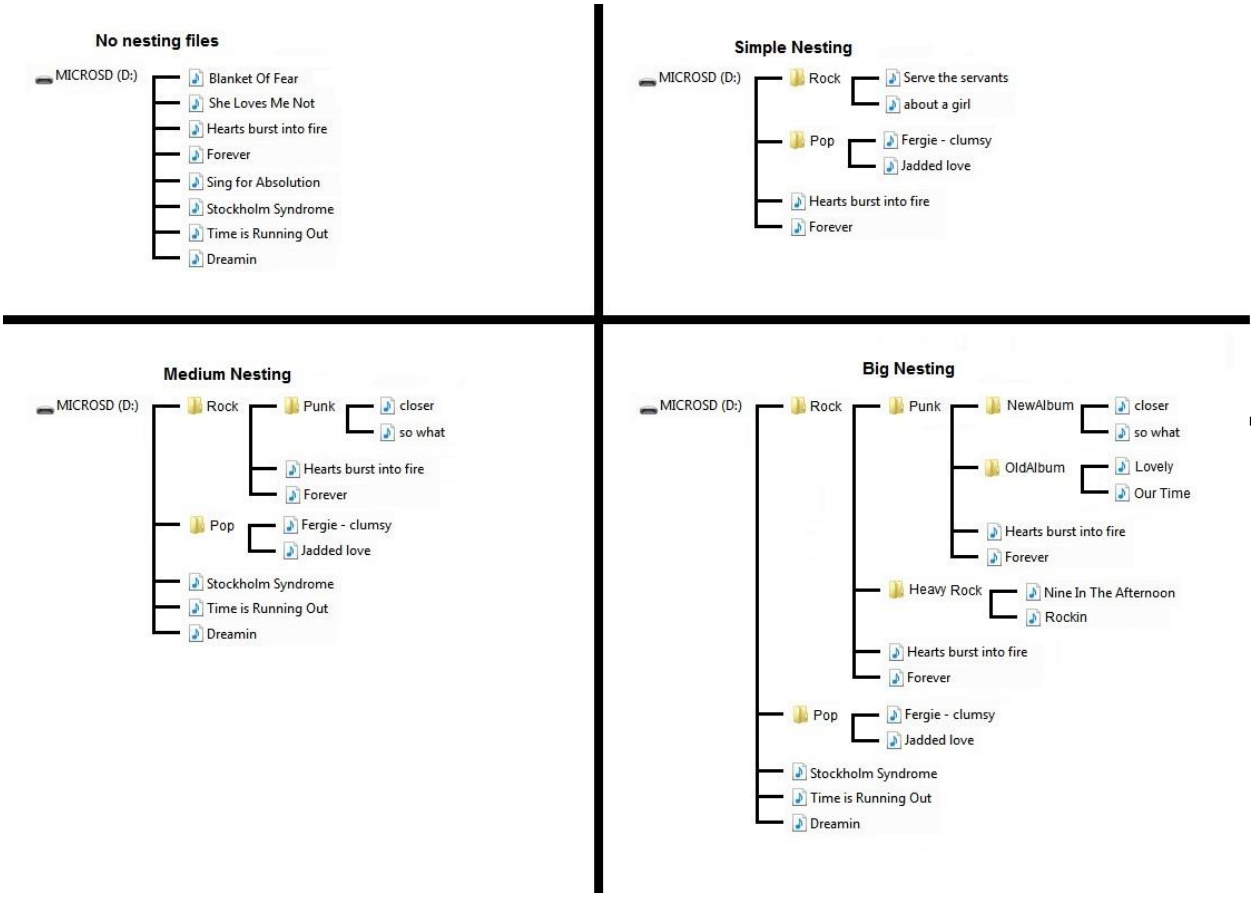
Objects Commands:

- Object Button – **42hex 'B'**
- Object Checkbox – **43hex 'C'**
- Object Switch – **54hex 'T'**
- Object Progress Bar – **50hex 'P'**
- Object Scroll Bar – **53hex 'S'**
- Object Slider – **4Chex 'L'**
- Object Window – **57hex 'W'**

3 Micro SD File/Folder organization

The Smart GPU 2 is capable of managing nested folders, so a complete files and folder organization could be achieved inside the micro SD card. Also the Smart GPU 2 could directly access nested folders for example: "0:/rock/punk/oldies/song.wav".

The next image gives some examples of files/folders organization/nesting that can be achieved and accessed with the Smart GPU 2 processor:



For a detailed information about how to access nest folders please refer to the "SmartGPU2LCD320x240 - Command Set.pdf" file.

4 Micro SD card file management

The Smart GPU 2 is capable of managing files directly in FAT/FAT12/FAT16 or FAT32 file systems without any special program/interface or micro SD rare formats.

A maximum of 32GBs micro SD memory card is supported, allowing storing thousands of full screen images, videos, audio files/songs, and thousands of text files.

The files are fully compatible format with any PC. This section explains how to load and create images (.bmp/.jpg), audio files (.wav) and text (.txt) files to be read with the Smart GPU 2 processor.

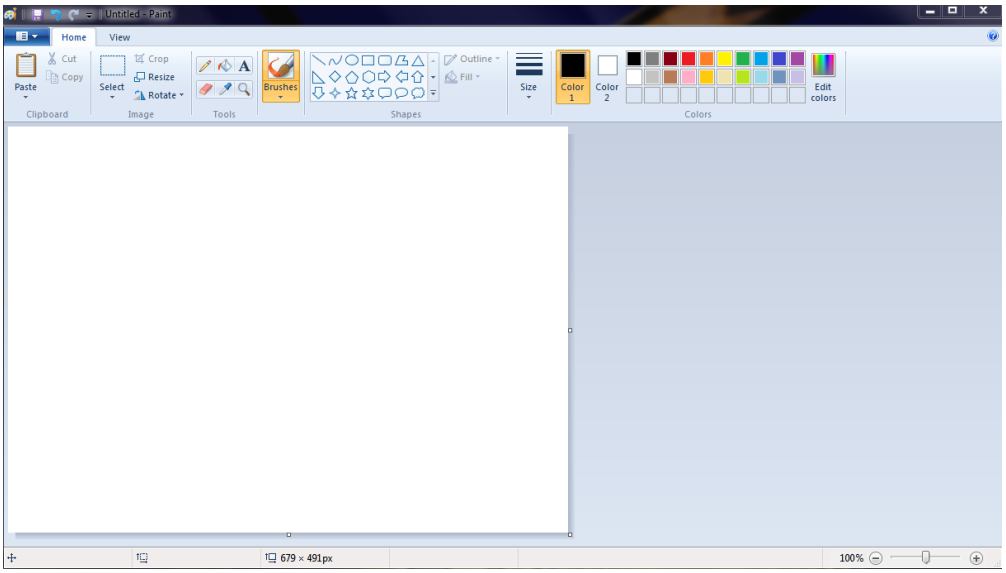
Note that FAT file system could be faster than FAT32 on some micro SD cards.

4.1 Storing Images on the micro SD card

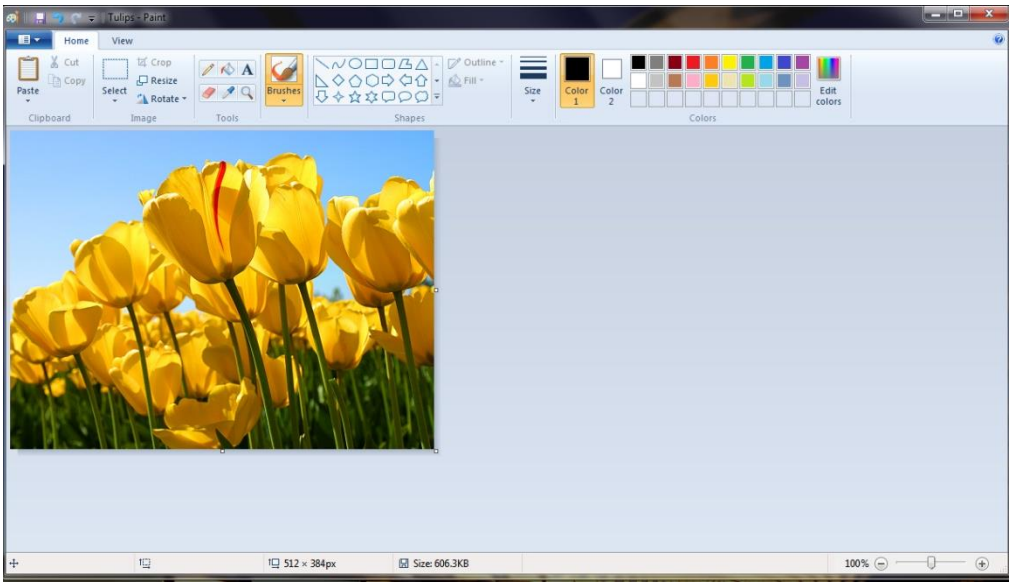
Any image could be prepared to be stored and loaded by the Smart GPU 2, the only requirement is the .bmp extension and desired size.

Any image processing software could convert or "Save As" images as .bmp or .jpg. To keep it simple, in this section the universal and easiest to use: Microsoft Paint software is used.

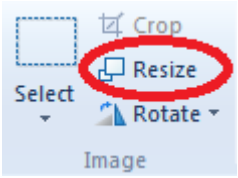
1.- Open the Paint software.



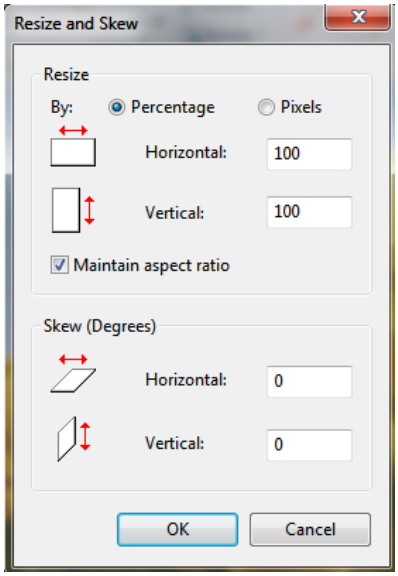
2.- Go to File->Open, and select the desired image, or draw your own creation.



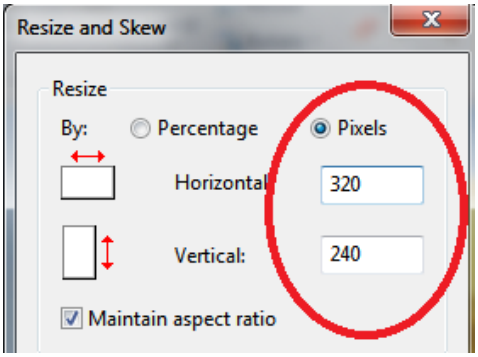
3.-Press on the resize button on the main bar



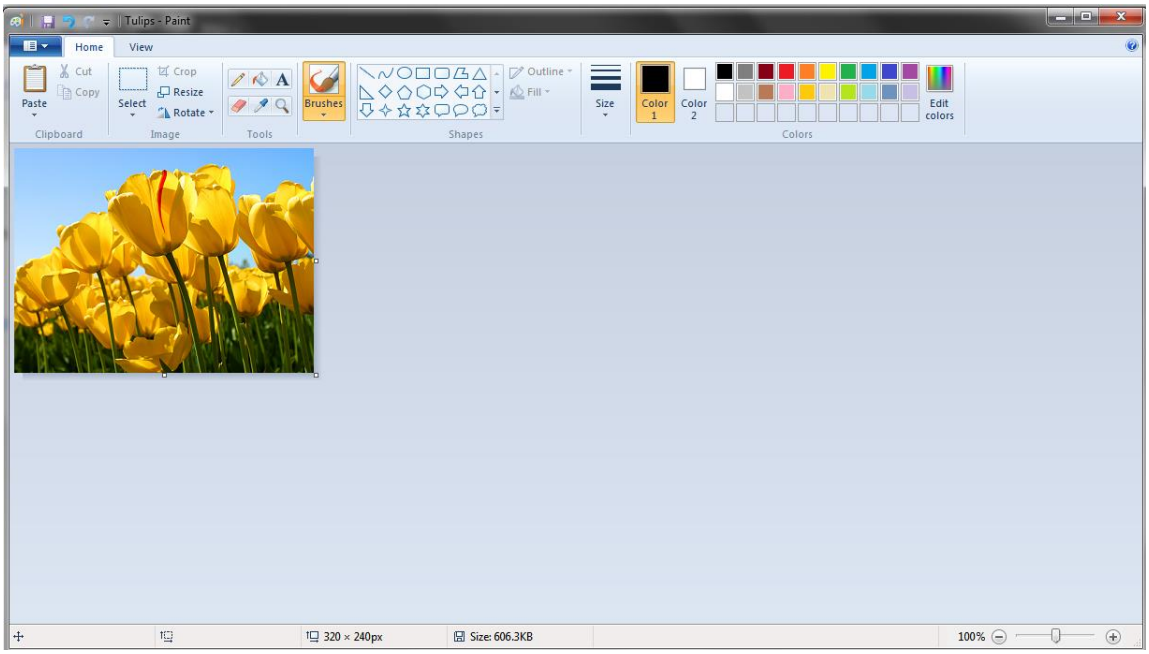
3.1- A new window will pop-up:



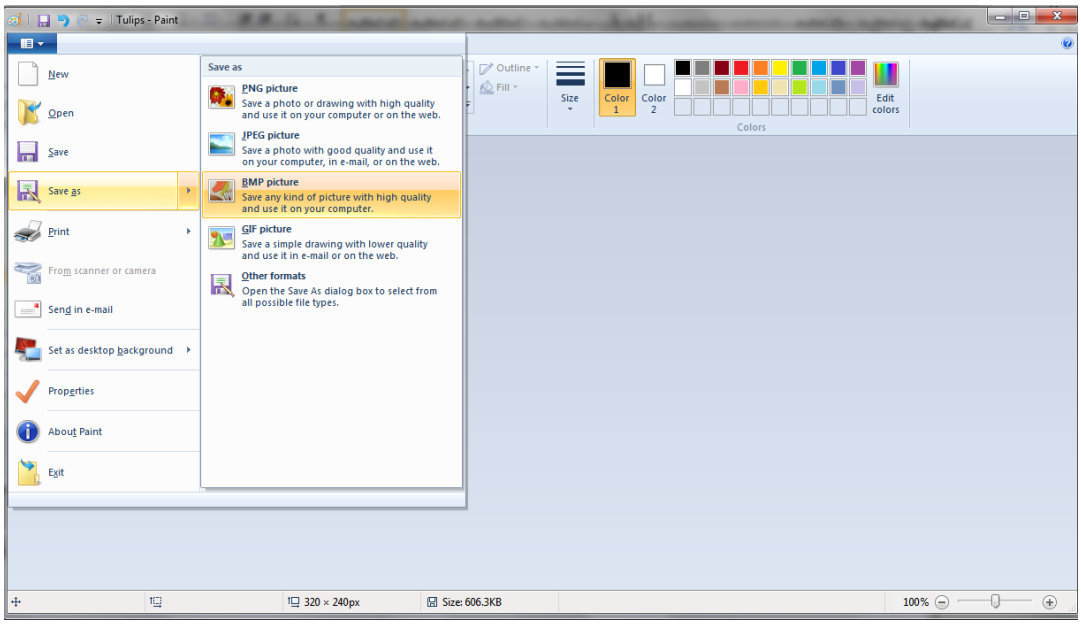
3.2- We only care on the resize section of this new window, now select PIXELS, and then write the size of the image, in this case we create a full screen image (landscape) on the SMART GPU 2, that is 320X240 pixels. ***(Any size under 320x240 could also be chosen if we desire a non-full screen image. In portrait mode we chose 240x320 for a full screen image).***



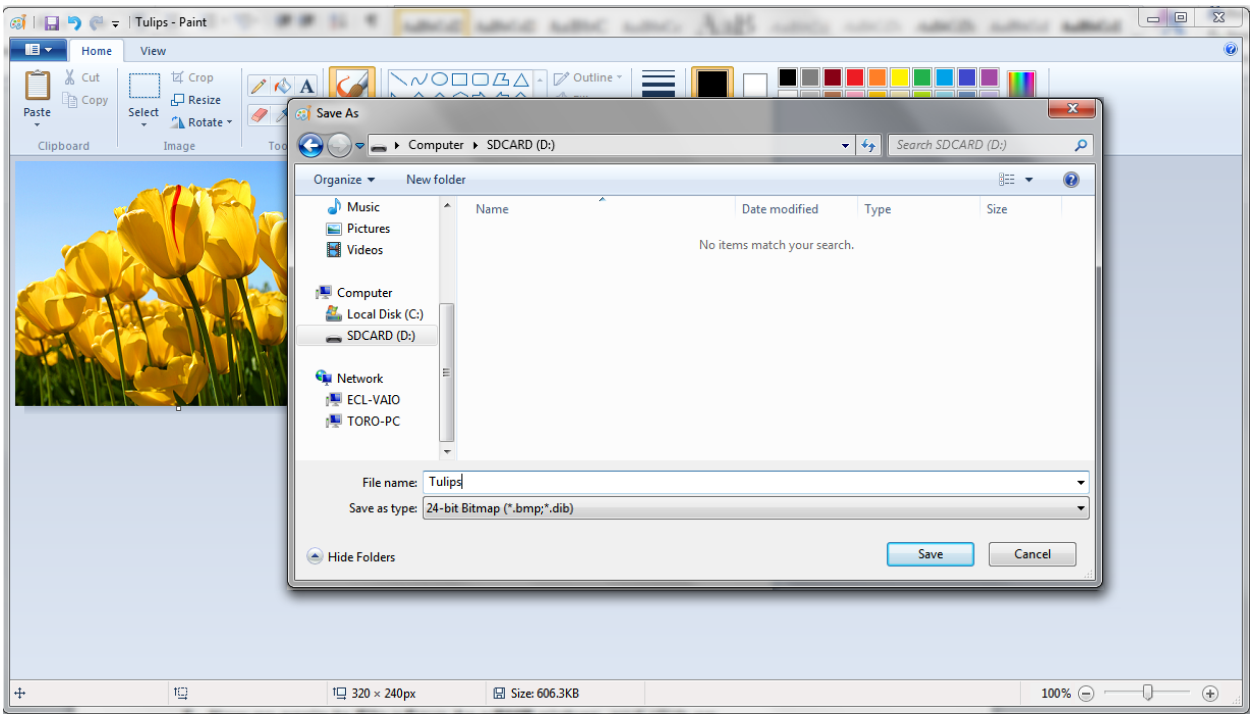
3.3- Press OK button and the image it's now resized.



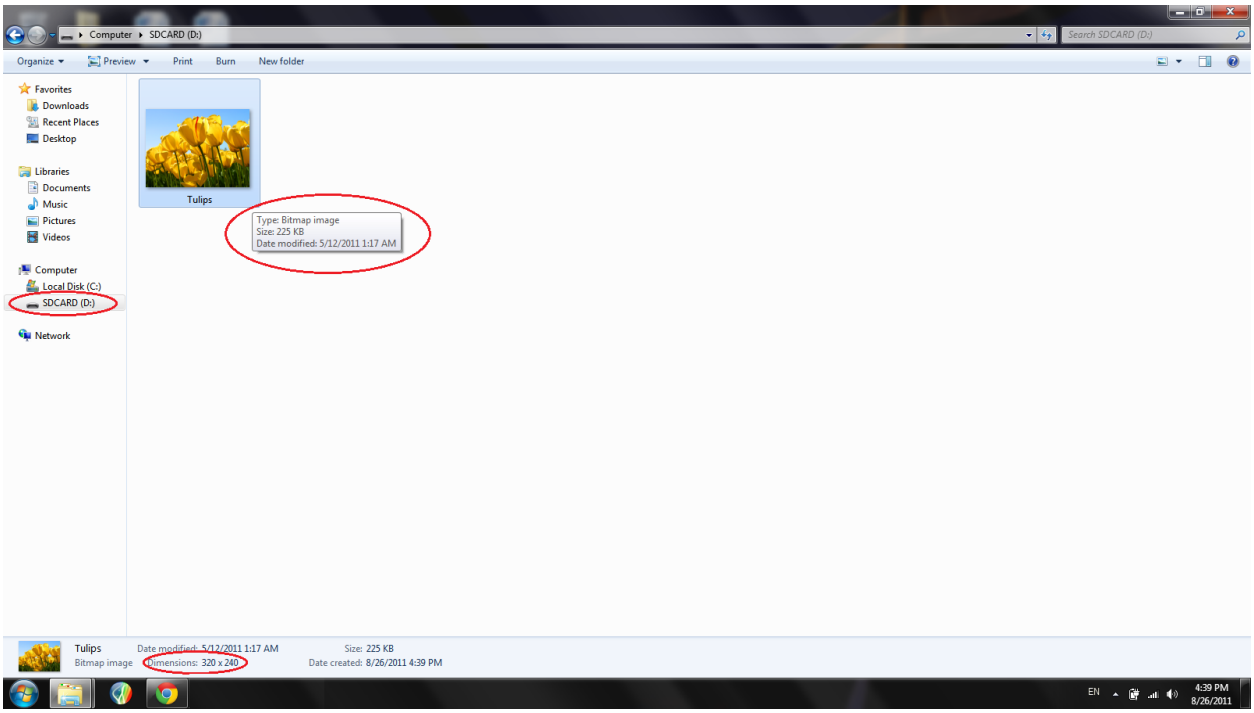
4.- Now go again to File->Save As->BMP or JPG picture, and click.



5.- A new window pop-up, select any path of the micro SD, give it a name to the image in the File Name field, and click SAVE. ***(Remember that the file name must be up to 250 CHARACTERS, special characters may not work, it's recommended to use only alphanumeric characters).***



6.- Finally check the contents on the microSD card. Safely remove the micro SD card, then insert it on the SMART GPU and call the image!



7.- Follow always the same procedure to load images onto the microSD card!

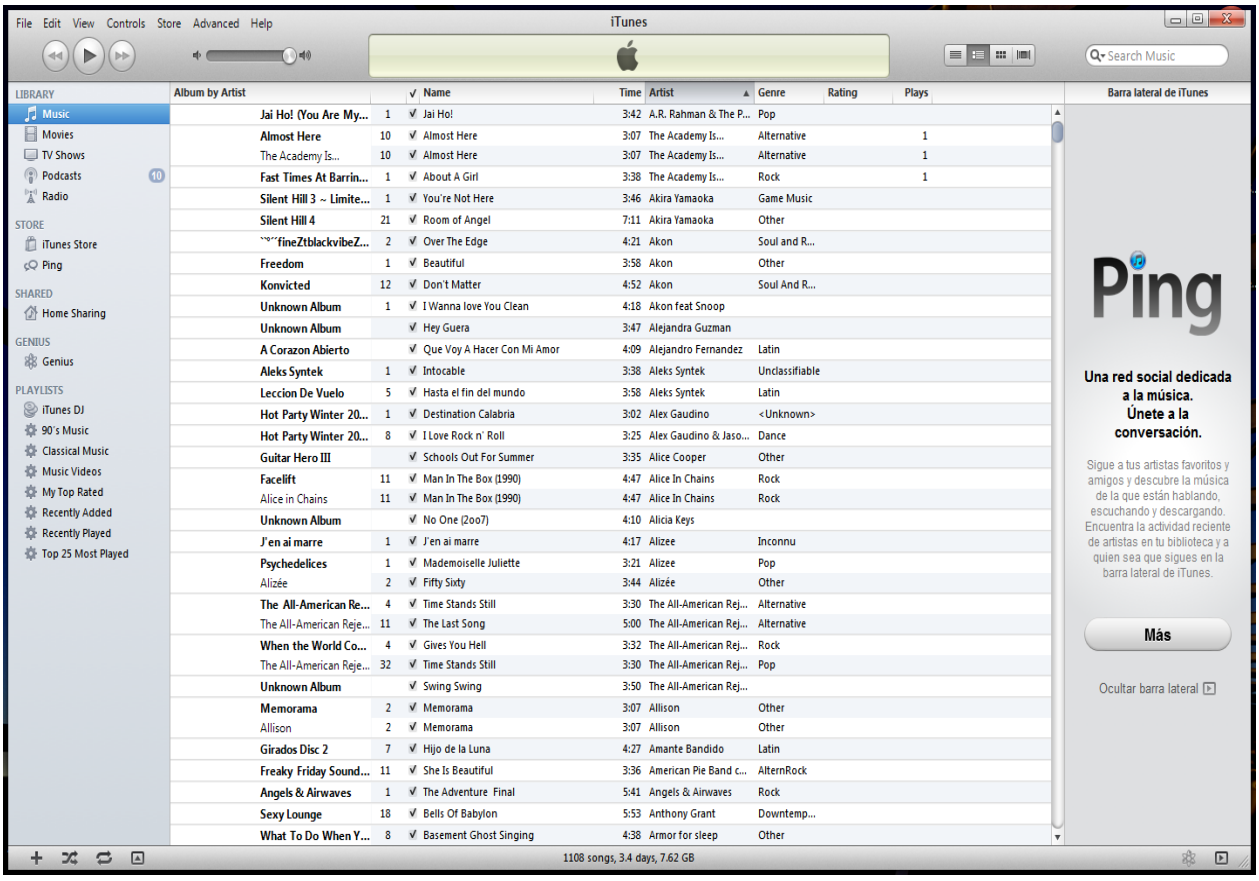
4.2 Storing Songs/Audio files on the micro SD card

Any Song/Audio file could be stored and played by the Smart GPU 2 processor, the only requirement is the .wav extension and WAVE format.

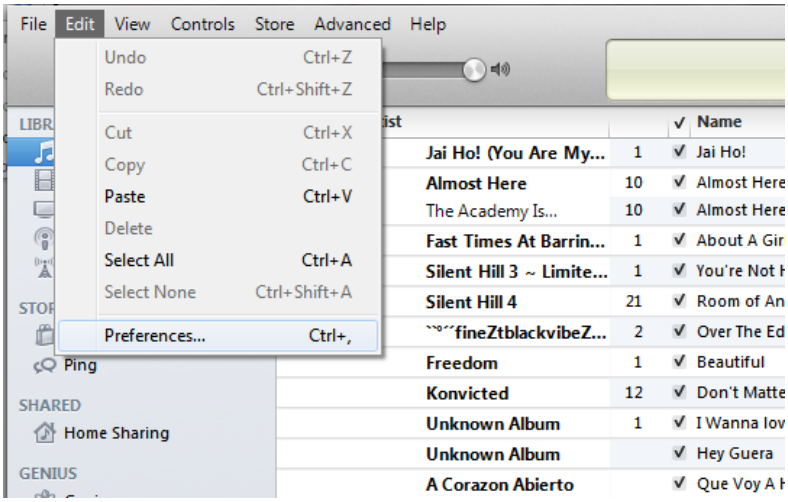
From a music CD, just extract the files/songs in .wav format and place them into the microSD card to be played (see **SmartGPU2-Audio Player-CD Tutorial.pdf**).

For PC stored files with any other extension than .wav, use any Audio processing software to convert .mp3, .wma, .atrac, .mp4, etc. to **.wav** supported format. To keep it simple, in this section it's explained how to convert any file to .wav using the popular apple's iTunes software.

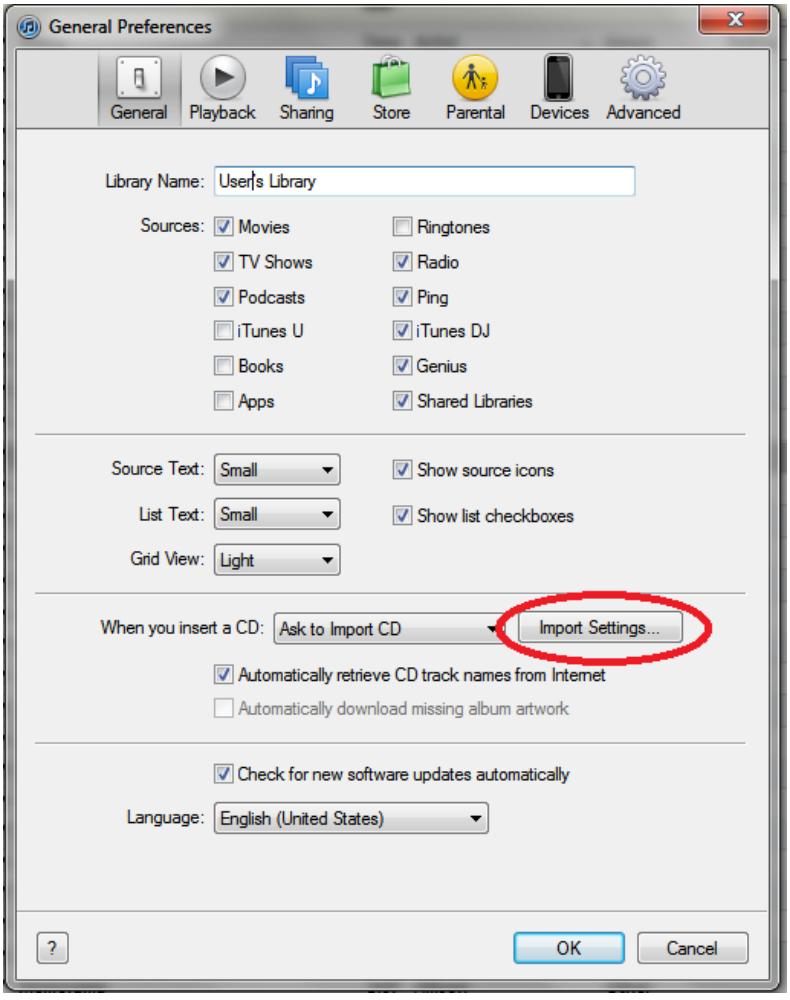
1.- Open the iTunes software.



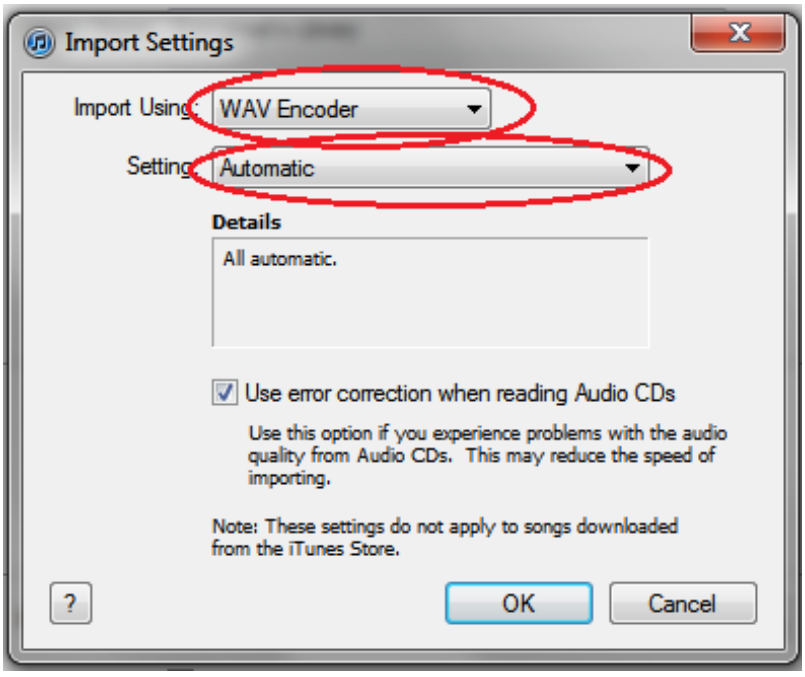
2.- Go to Edit->Preferences, and click.



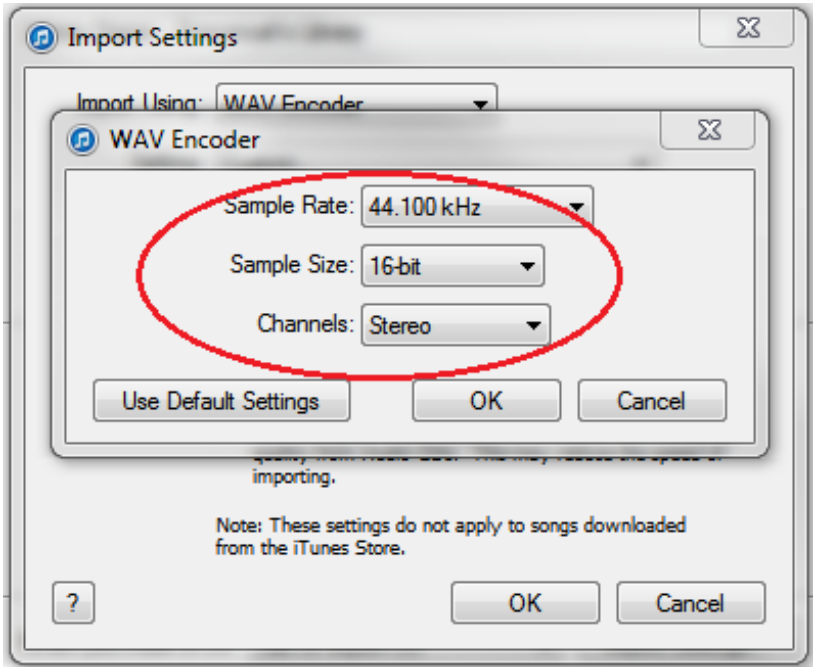
3.-A new Window pops up, then click on the "Import Settings…" box:



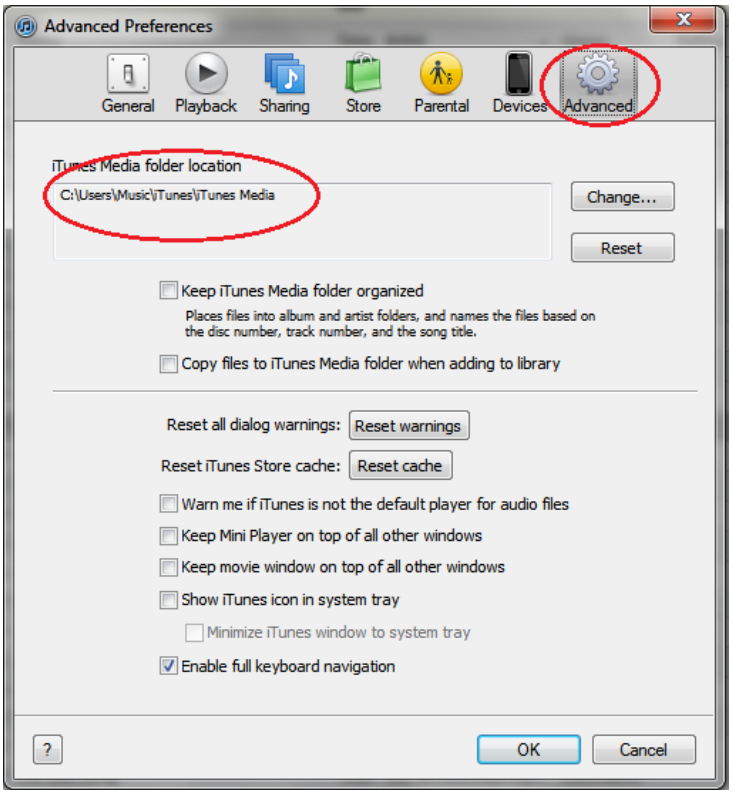
3.1- A new window pops-up, now select "WAV Encoder" and change setting "Automatic" to "Custom", then click OK:



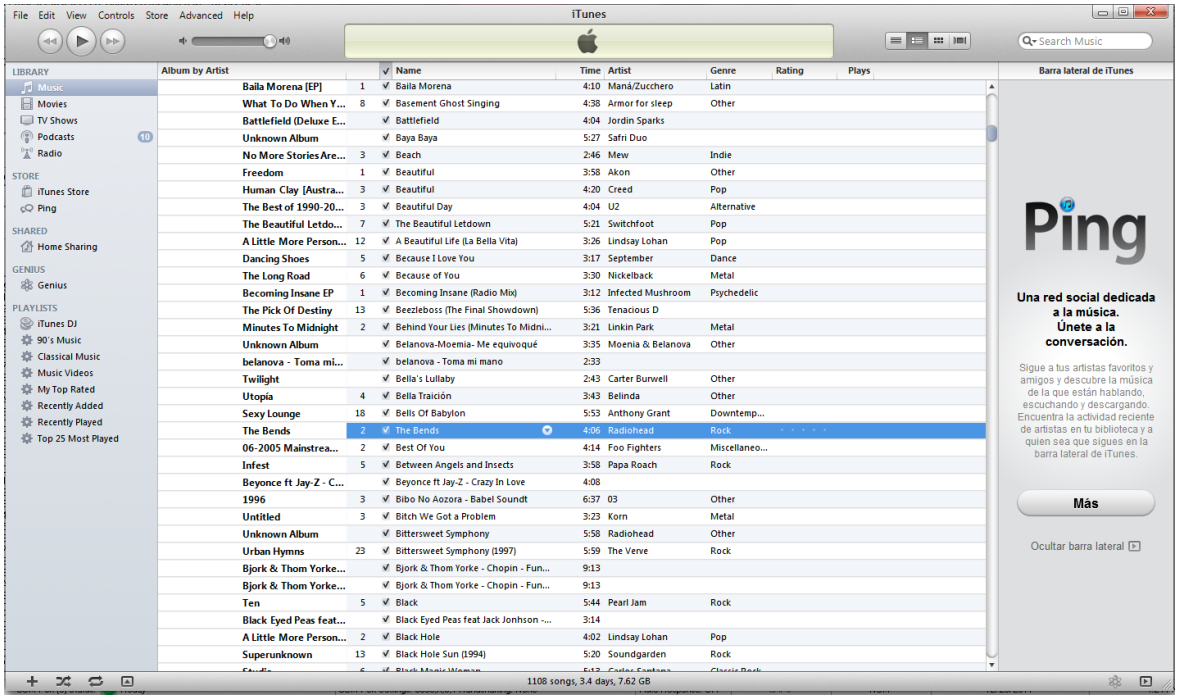
-Select the desired Sample Rate, 8/16 bit Sample Size and MONO or STEREO Audio and click OK. ***The best audio quality is achieved with the 44.100Khz, 16bit, Stereo parameter).***



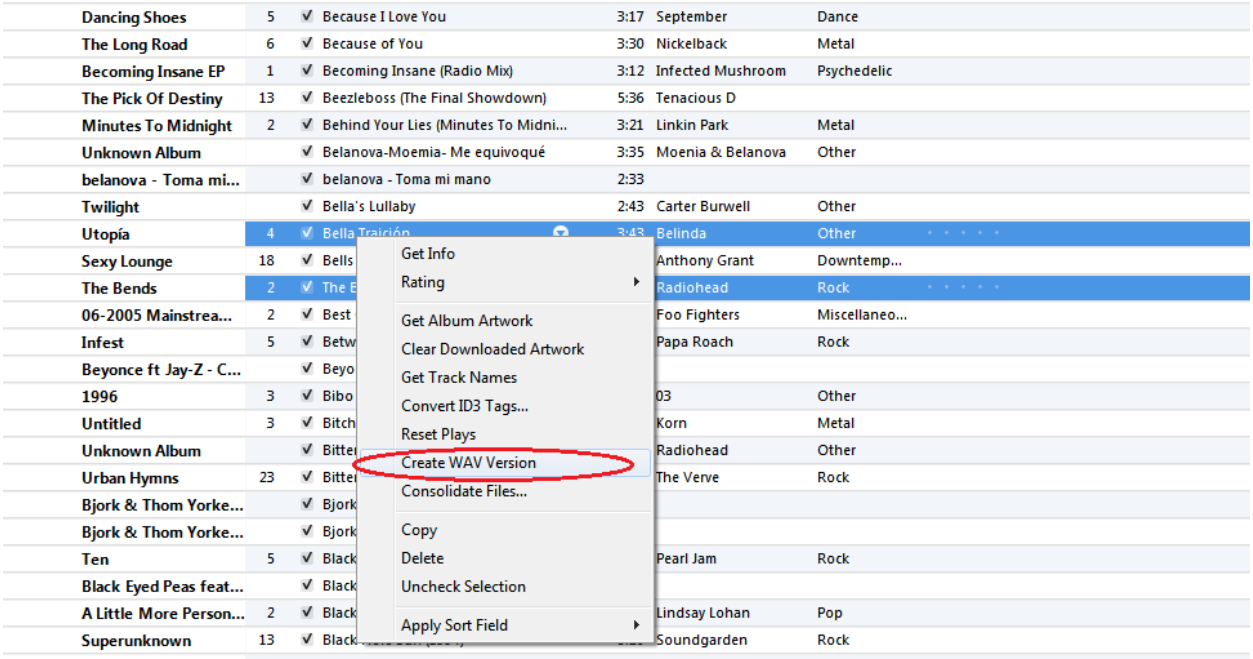
3.2- Now select the "Advanced" tab to visualize the path where converted files/songs will be stored, finally click OK to close the window:



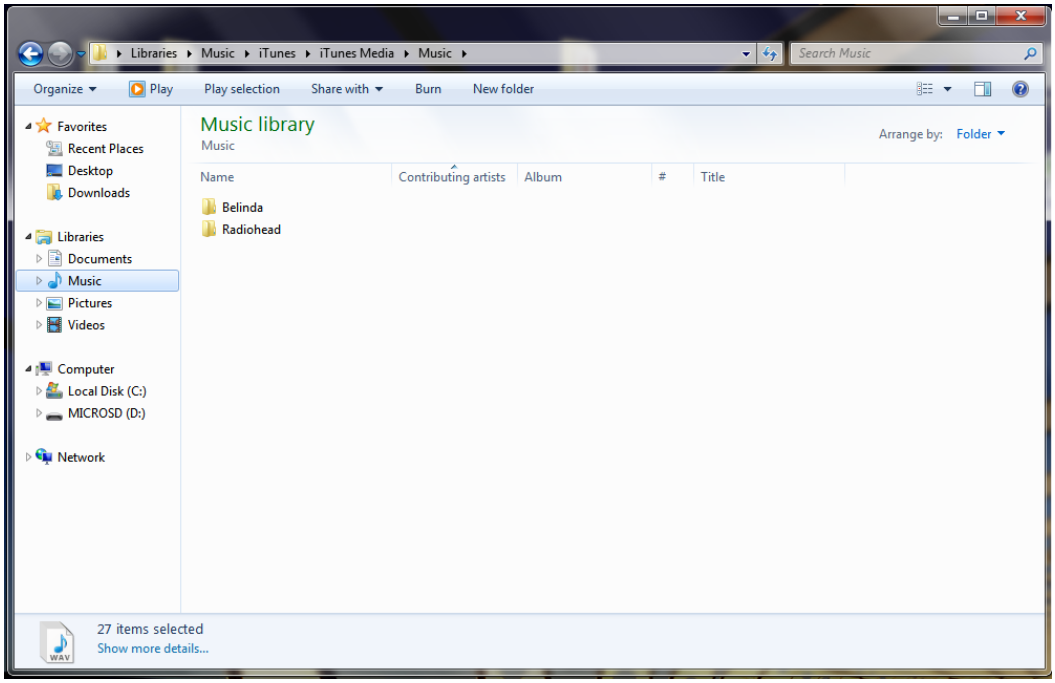
4.- Once again in the main window, select the desired songs to be converted:



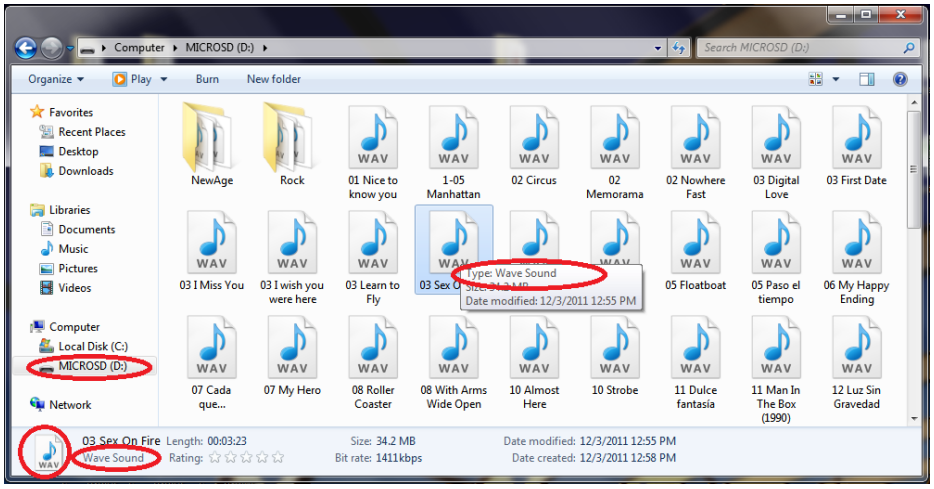
4.1- Once the desired songs are selected, perform right click on the mouse and a new menu will pop-up, click on "create WAV version":



5.- Wait for the files to be converted, then search for them in the iTunes Media Folder previously visualized with the Advanced Preferences Tab. ***User could copy all the files with the folders directly to the microSD card to be sorted by artist/album/year, etc.***



6.- Finally, copy the files to microSD card and check the contents. Safely remove the micro SD card, then insert it on the SmartGPU 2 and play the files!



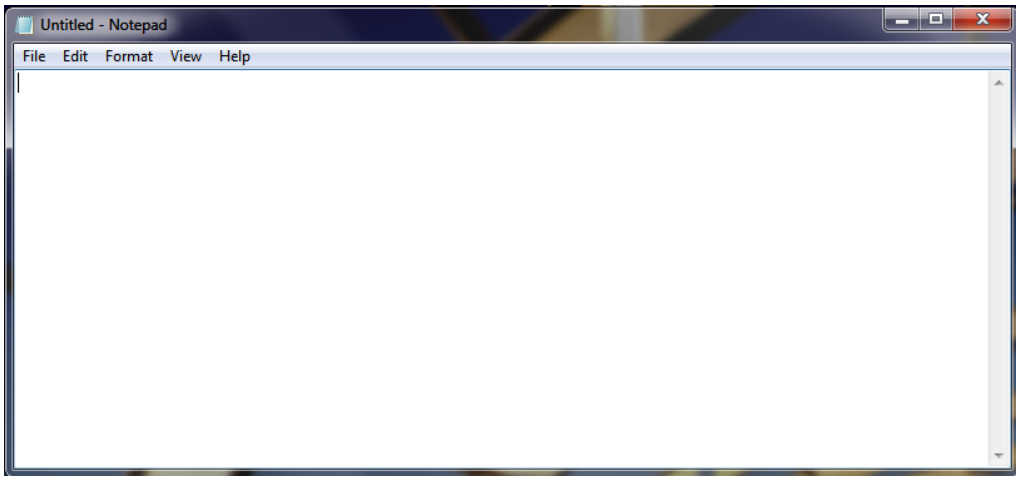
7.- Steps 1-4 must be done only for the first time to setup WAV conversion, once iTunes is configured, user could repeat process from step 4. Follow always the same procedure to load song/audio files onto the microSD card!

4.3 Storing text files on the micro SD card

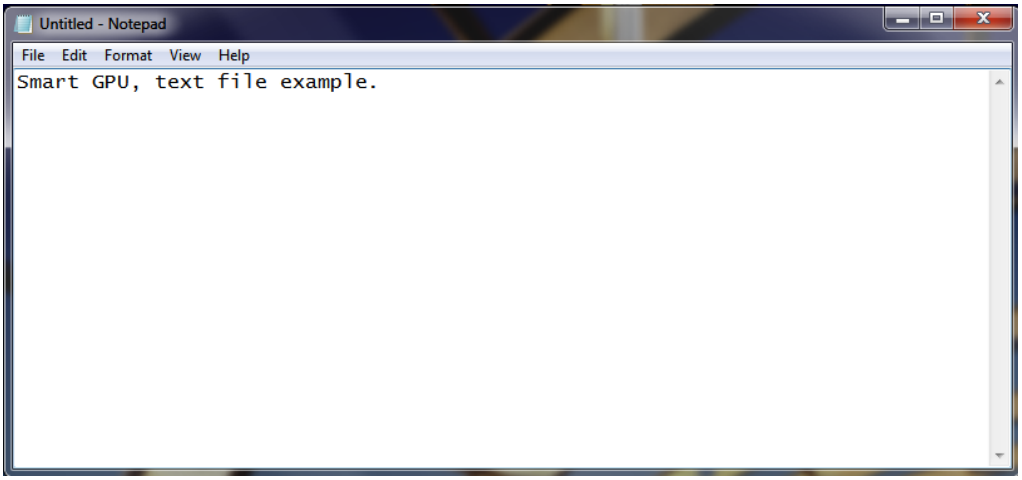
Any text could be prepared to be stored and loaded by the SmartGPU 2, the only requirement is the .txt extension and desired size.

Any text processing software could convert or "Save As" text as .txt. To keep it simple, in this section the universal and easiest to use: Microsoft Notepad software is used.

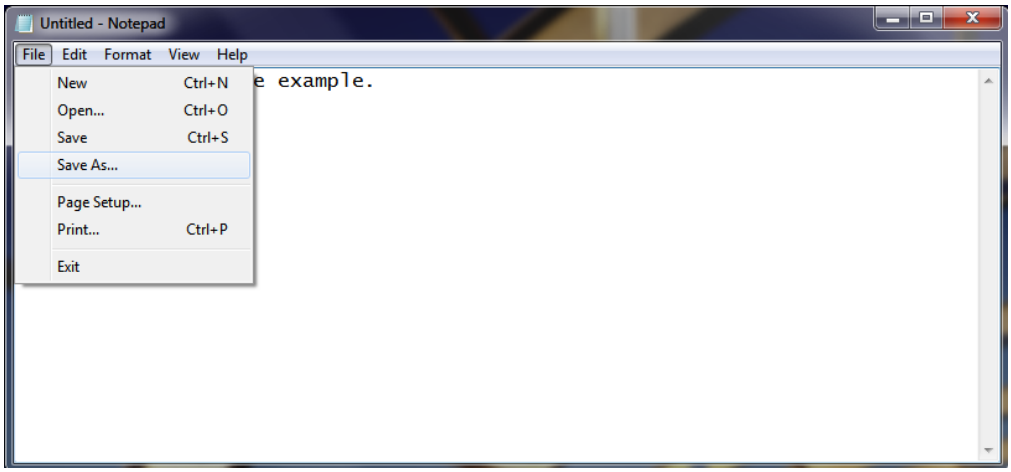
1.- Open the Note Pad software.



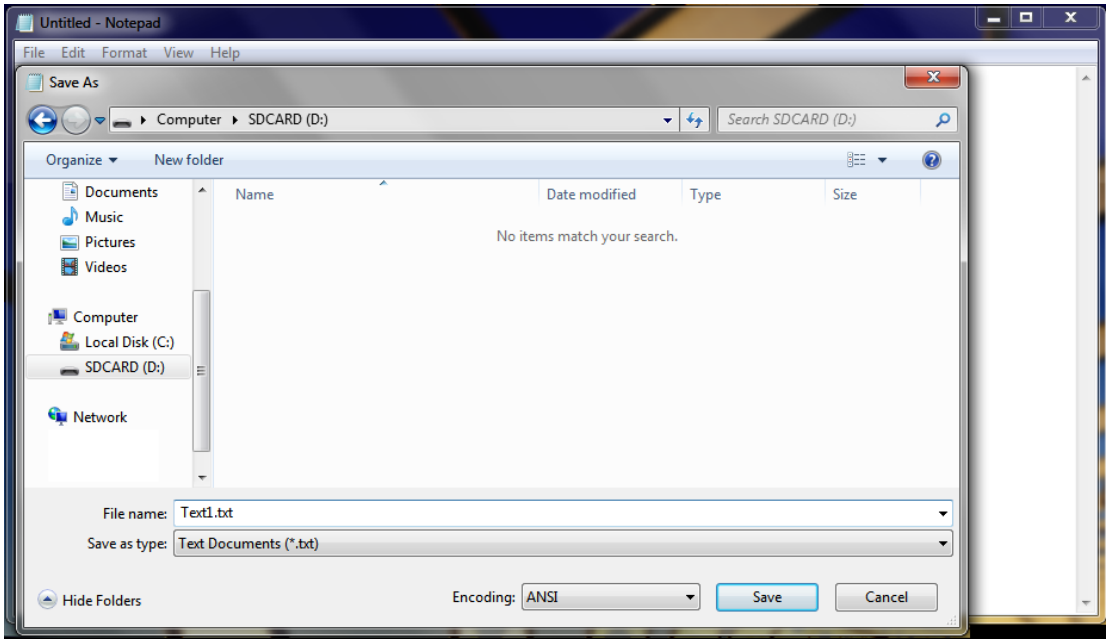
2.- Go to File->Open, and select the desired text file, or write your own text.



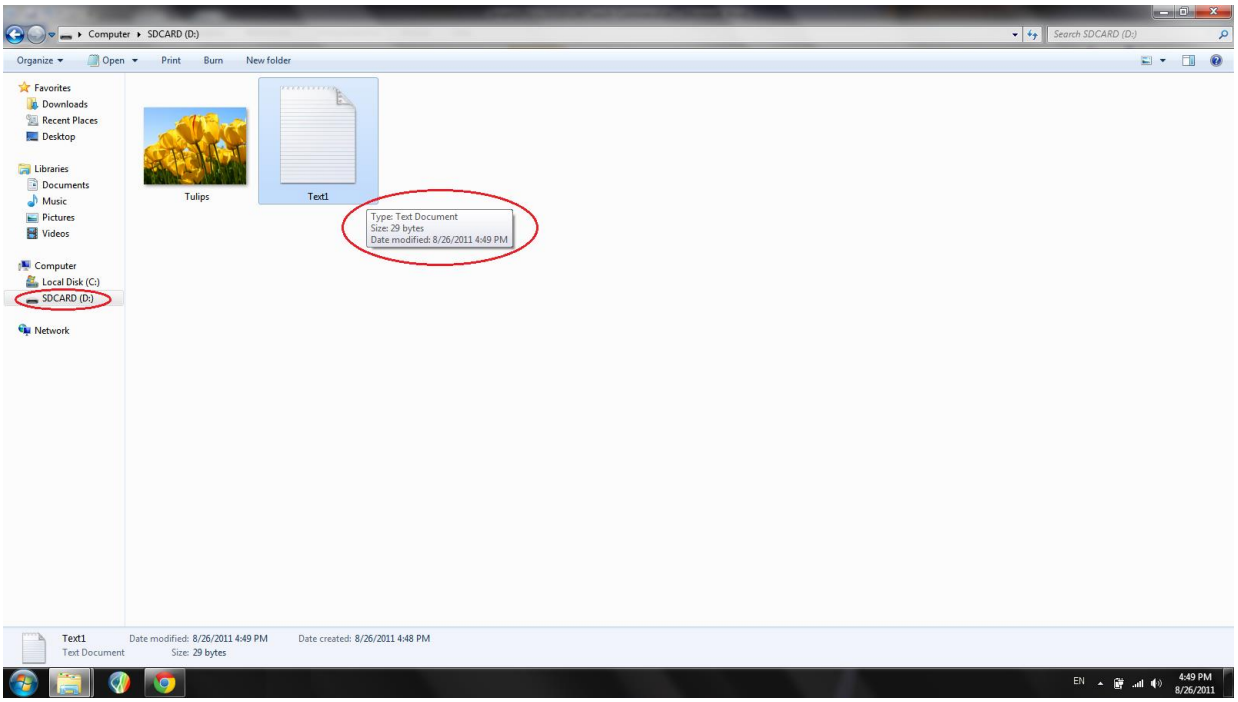
3.- Go to File->Save As, and click on.



4.- A new window pop-up, select any path of the microSD card, give it a name to the text file, be sure that the ".txt" extension is selected and click SAVE. ***(Remember that the file name must be up to 250 CHARACTERS, special characters may not work, it's recommended to use only alphanumeric characters).***



5.- Finally check the contents in the microSD card. Safely remove the micro SD card, then insert it on the SMART GPU 2 and call the text file!

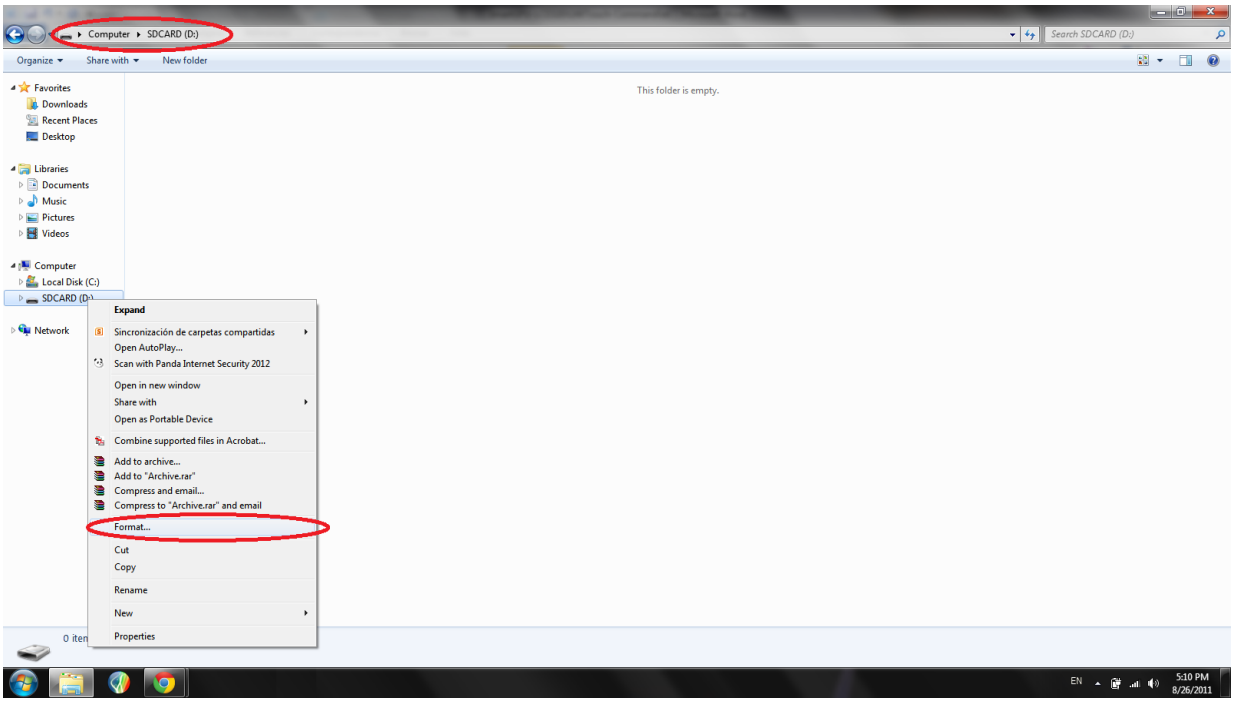


6.- Follow always the same procedure to load text files onto the microSD card!

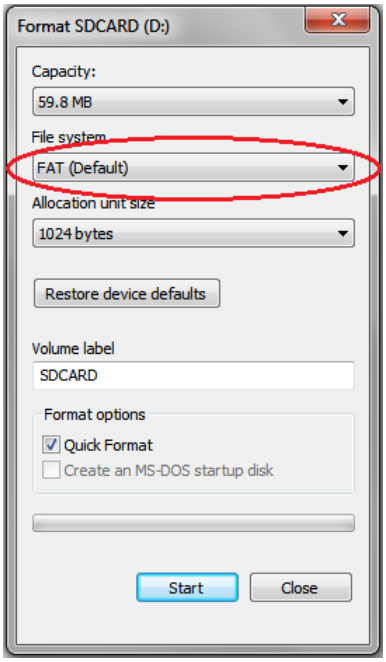
4.4 Formatting the micro SD card for first use

It is recommended but not necessarily to format the micro SD card for first use, in this section a format to new micro SD card to FAT format is explained.

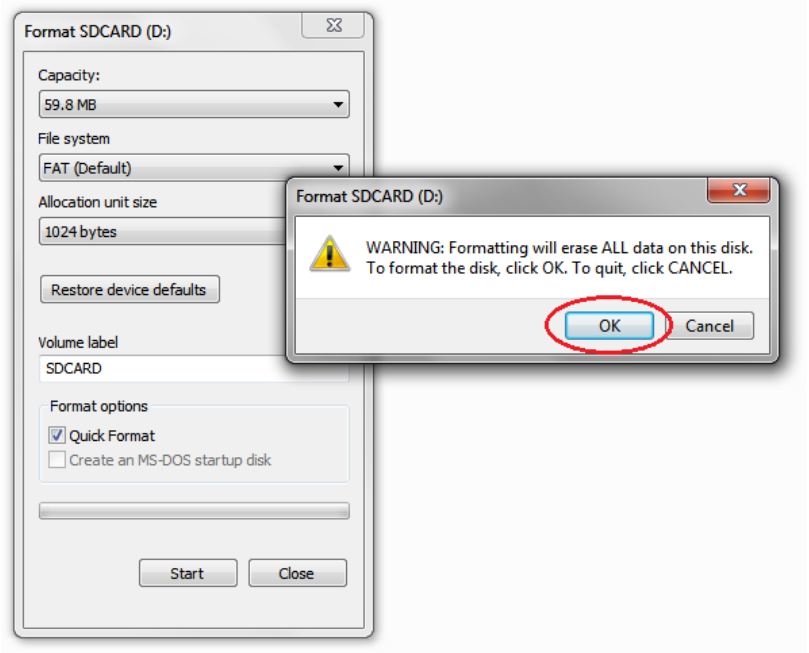
1.- Open a new explorer window, right click on the microSD card and a menu appears, select "FORMAT…" and click. ***(Note that formatting a micro SD card will erase all the contents of it).***



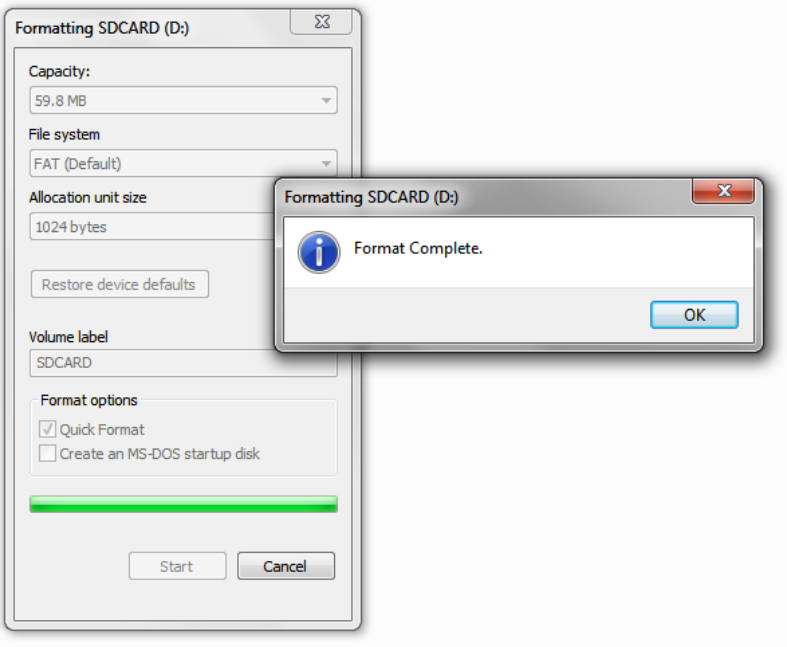
2.- A new window will pop-up, choose FAT(default) or FAT32 on the File System menu, and click start.



3.- Click OK on the new window and wait to the PC to perform the format.



4.- Now the microSD card is ready to load images, songs and text!

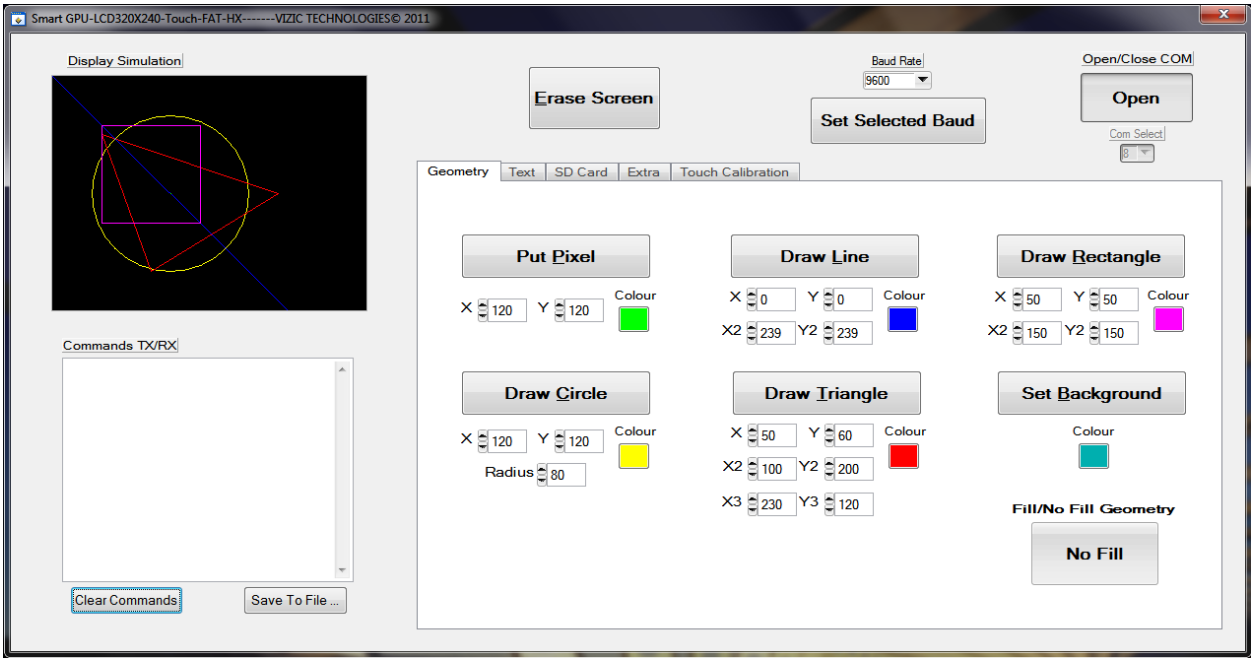


5 Development software tools

In order to make even easier the learning about how to communicate with the Smart GPU 2 processor, FREE software could be downloaded and used in any PC.

This software simulates most of the functions of the Smart GPU 2 chip by connecting it to the PC through the USB-UART SX Bridge, this connection enables real live graphics processing.

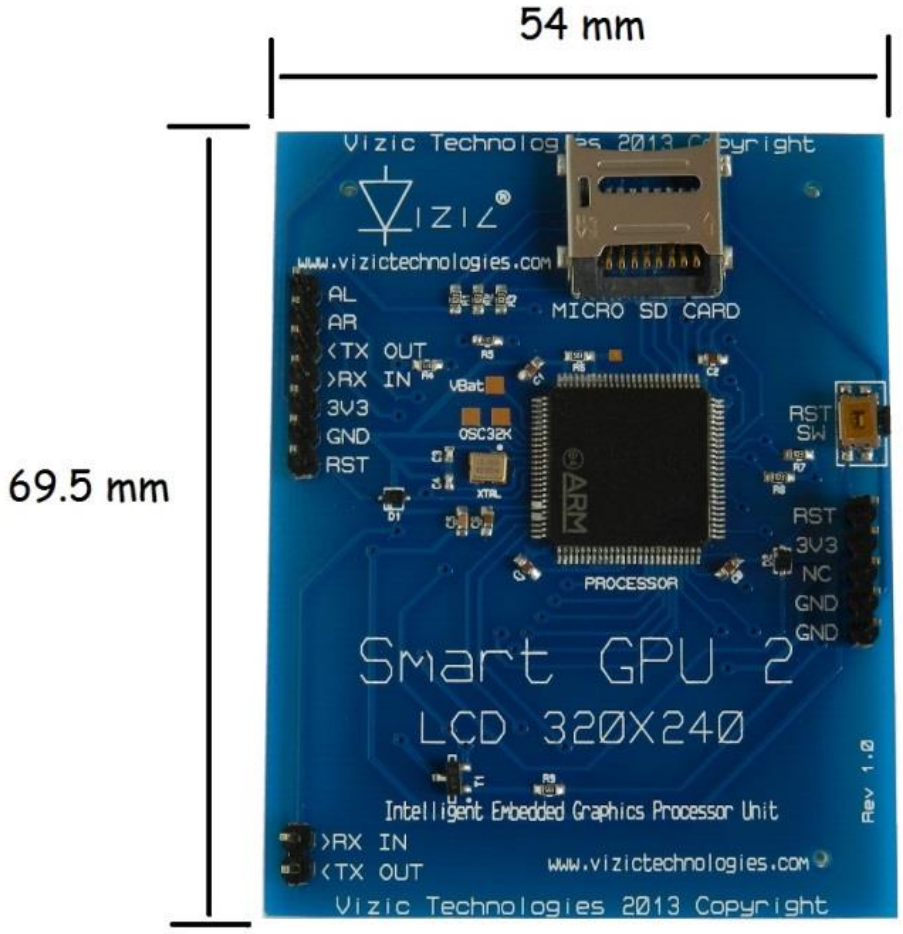
This software greatly reduces the time of learning the commands, and helps the user to understand how commands are created as it shows the sent and received commands by the PC<->Smart GPU 2 processor.



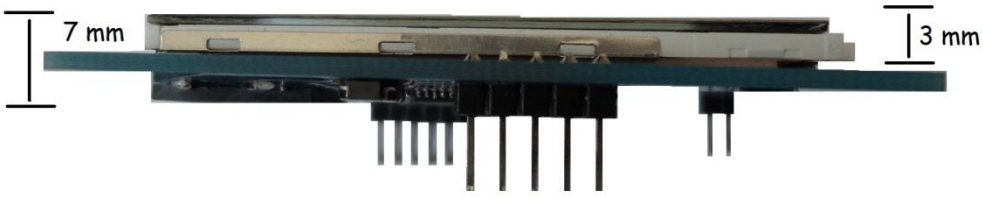
For detailed information about this software and how to use it, please refer to the "SMARTGPU2-PCsimulation.pdf" sheet that could be downloaded in the web site.

For detailed information about the USB-UART SX Bridge, please visit our web site.

6 Mechanical dimensions



All units in mm.



All units in mm.

7 Specifications and ratings

Main LCD panel

Item	Standard Value
Display Type	240*(R、G、B)*320 Dots
LCD Type	a-si TFT，Positive，Transmissive type
Screen size(inch)	2.4" (Diagonal)
Viewing Direction	12 O'clock
Color configuration	R.G.B. vertical stripe
Backlight Type	White LED B/L

Mechanical Specifications

LCD panel

Item	Standard Value	Unit
Active Area	36.72（W）*48.96（L）	mm

Touch panel

Item	Standard Value	Unit
Outline Dimension	42.32(W)*59.03(L)	mm

Absolute Maximum Ratings

Module

Item	Symbol	Condition	Min.	Max.	Unit
System Power Supply Voltage	VCC	-	2.7	3.4	V
Input Voltage	V_{IN}	-	-0.3	VCC+0.3	V
Operating Temperature	T_{OP}	-	-20	+70	℃
Storage Temperature	T_{ST}	-	-30	+80	℃
Storage Humidity	H_D	Ta < 40°C	20	90	%RH

CHIP processor:

Absolute maximum ratings

Stresses above the absolute maximum ratings listed in *Table 7: Voltage characteristics*, *Table 8: Current characteristics*, may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 7. Voltage characteristics

Symbol	Ratings	Min	Max	Unit
V_{DD}–V_{SS}	External main supply voltage	–0.3	3.4	V
V_{IN}(2)	Input voltage on five volt tolerant pin	V_{SS} – 0.3	V_{DD} + 4.0	
	Input voltage on any other pin	V_{SS} – 0.3	3.4	

2. V_{IN} maximum must always be respected. Refer to *Table 8: Current characteristics* for the maximum allowed injected current values.

Table 8. Current characteristics

Symbol	Ratings	Max.	Unit
I_{IO}	Output current sunk by any I/O and control pin	25	mA
	Output current source by any I/Os and control pin	– 25	
$I_{INJ(PIN)}$(2)	Injected current on five volt tolerant pins(3)	-5/+0	
	Injected current on any other pin(4)	± 5	

2. Negative injection disturbs the analog performance of the device.
3. Positive injection is not possible on these I/Os. A negative injection is induced by $V_{IN}<V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to *Table 7: Voltage characteristics* for the maximum allowed input voltage values.
4. A positive injection is induced by $V_{IN}>V_{DD}$ while a negative injection is induced by $V_{IN}<V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to *Table 7: Voltage characteristics* for the maximum allowed input voltage values.

Backlight & LED Characteristics

LCD Module with LED Backlight

Maximum Ratings

Item	Symbol	Conditions	Min.	Max.	Unit
Forward Current	IF	Ta =25°C	-	60	mA
Forward Voltage	VF	Ta =25°C	-	3.2	V
Power Dissipation	PD	Ta =25°C	-	192	mW

Electrical / Optical Characteristics

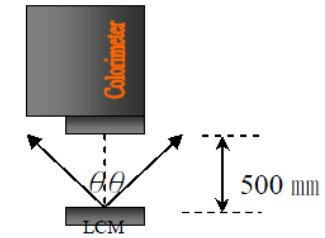
Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Voltage	VF	IF=60mA VF=3.2 V 4 white leds Ta =25°C	2.9	3.2	3.4	V
Average Brightness (Without LCD)	IV		3600	-	-	cd/m^2
Color of CIE Coordinate (without LCD)	X		-	-	-	-
	Y		-	-	-	
Color	White					

Optical Characteristics

TFT LCD panel VCC=2.8V, Ta=25℃

Item		Symbol	Condition	Min.	Typ.	Max.	unit	
Contrast ratio		CR	Ta = 25℃ θX , θY = 0°		500	-	-	Note3
Color of CIE Coordinate （With B/L）	White	X		0.275	0.305	0.335	-	Note1
		Y		0.229	0.329	0.359		
	Red	X		0.579	0.609	0.639		
		Y		0.302	0.332	0.362		
	Green	X		0.270	0.300	0.330		
		Y		0.536	0.566	0.596		
	Blue	X		0.112	0.142	0.172		
		Y		0.082	0.112	0.142		
Average Brightness Pattern=white display （main）		IV	-	-	-	-	cd/m^2	Note1
Uniformity		△B	-	-	-	-	%	Note1

Note1:
1：△B=B(min) / B(max) ×100%
2：Measurement Condition for Optical Characteristics:
a：Environment: 25℃±5℃ / 60±20%R.H，no wind，dark room below 10 Lux at typical lamp current and typical operating frequency.
b：Measurement Distance: 500 ± 50 ㎜ ，(θ= 0°)
c：Equipment: TOPCON BM-7 fast，(field 1°) ，after 10 minutes operation.
d：The uncertainty of the C.I.E coordinate measurement ±0.01，Average Brightness ± 4%



Colorimeter=BM-7 fast

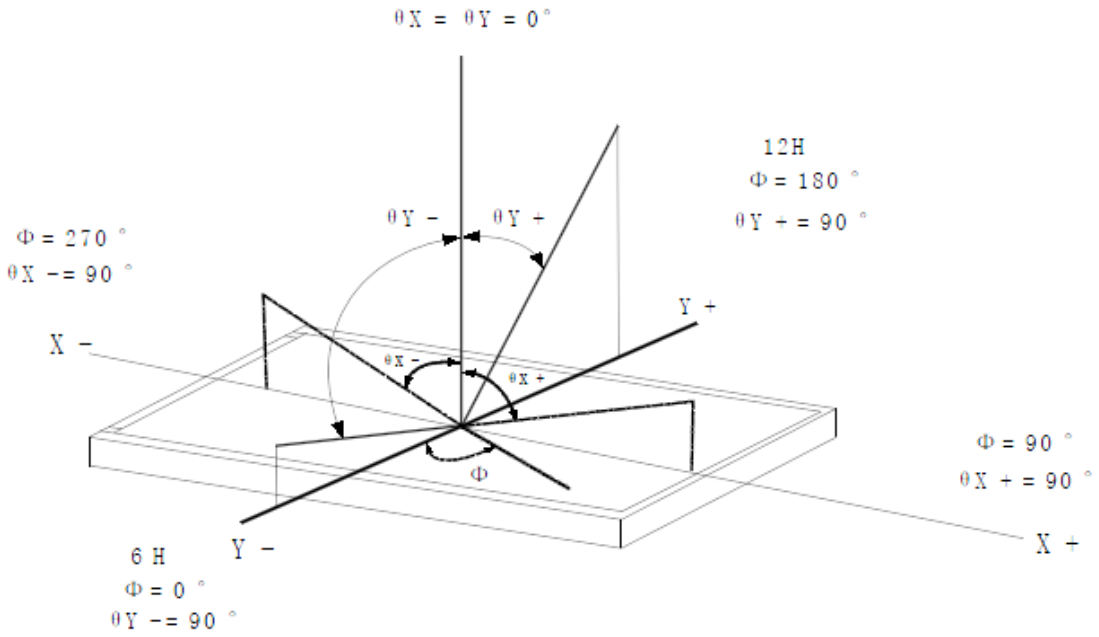
Note3: Definition of contrast ratio:

Contrast ratio is calculated with the following formula

$$\text{Contrast ratio (CR)} = \frac{\text{Photo detector output when LCD is at "White" state}}{\text{Photo detector output when LCD is at "Black" state}}$$

Note4: Definition of viewing angle:

Refer to figure as below:



PRECAUTION RELATING PRODUCT HANDLING

SAFETY

If the LCD panel breaks , be careful not to get the liquid crystal to touch your skin.
If the liquid crystal touches your skin or clothes , please wash it off immediately by using soap and water.

HANDLING

Avoid any strong mechanical shock which can break the glass.
Avoid static electricity which can damage the CMOS LSI—When working with the module , be sure to ground your body and any electrical equipment you may be using.
Do not remove the panel or frame from the module.
The polarizing plate of the display is very fragile. So , please handle it very carefully, do not touch , push or rub the exposed polarizing with anything harder than an HB pencil lead (glass , tweezers , etc.)
Do not wipe the polarizing plate with a dry cloth , as it may easily scratch the surface of plate.
Do not touch the display area with bare hands , this will stain the display area.
Do not use ketonics solvent & aromatic solvent. Use with a soft cloth soaked with a cleaning naphtha solvent.
To control temperature and time of soldering is 320 ± 10℃ and 3-5 sec.
To avoid liquid (include organic solvent) stained on LCM

STORAGE

Store the panel or module in a dark place where the temperature is 25℃ ± 5℃ and the humidity is below 65% RH.
Do not place the module near organics solvents or corrosive gases.
Do not crush , shake , or jolt the module.

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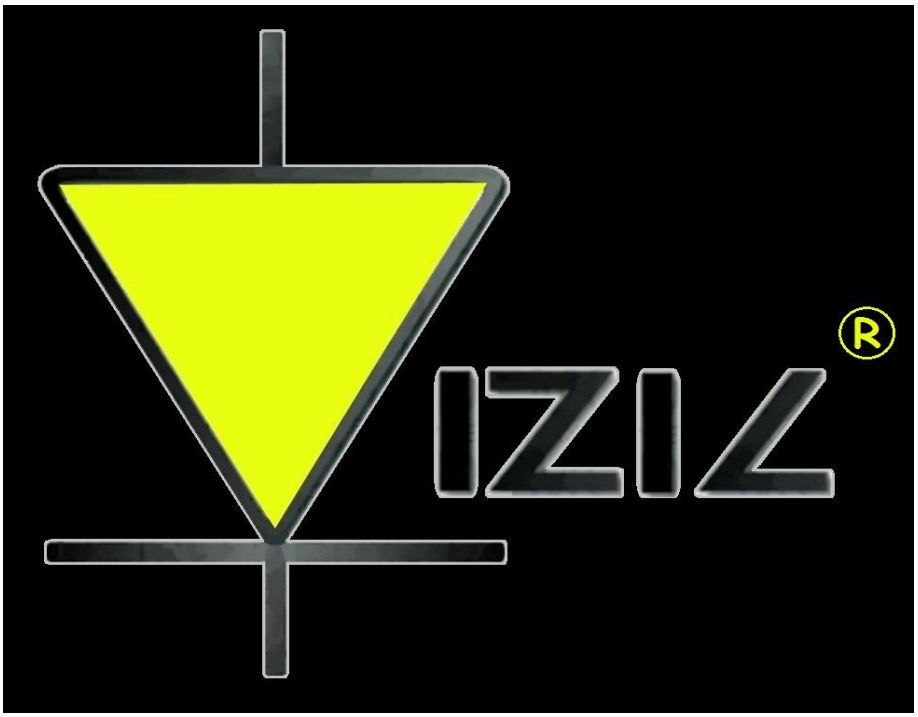

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