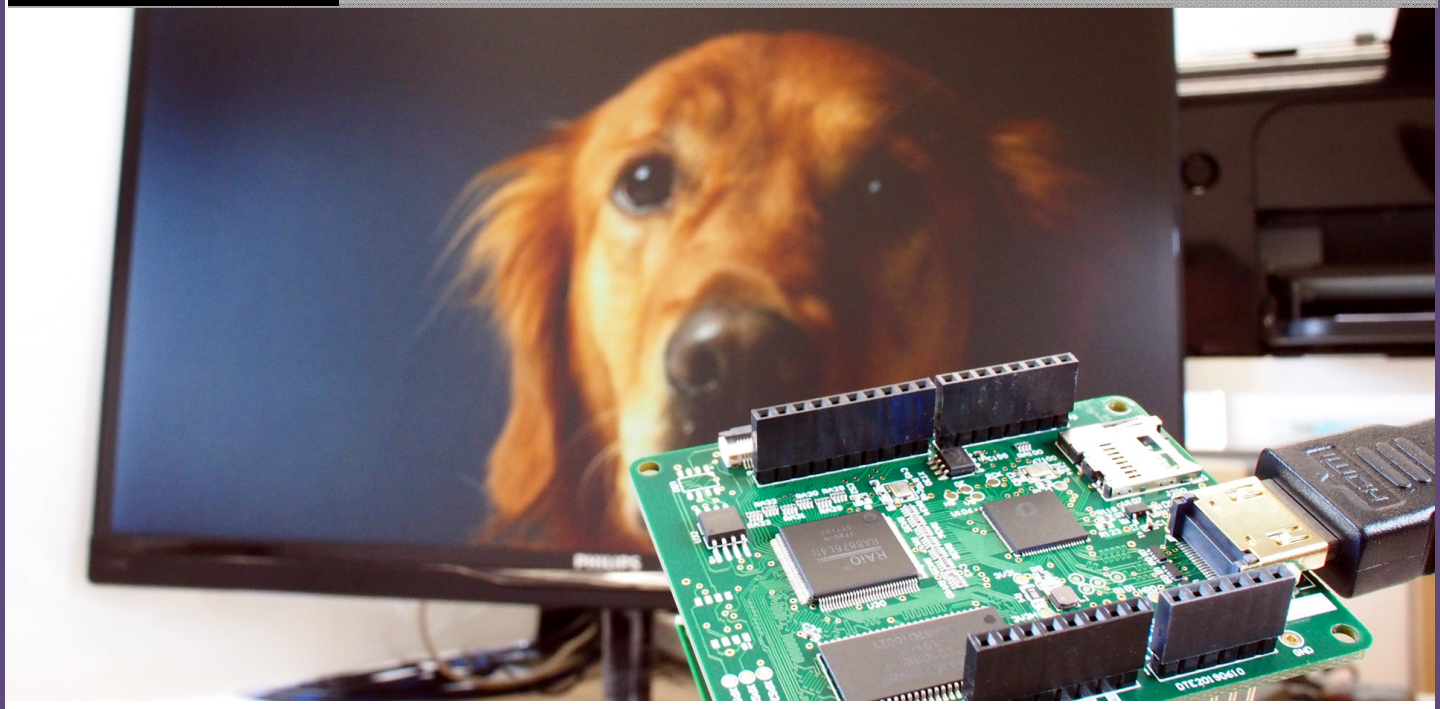
TECHTOYS

GETTING STARTED WITH HDMI SHIELD VERSION 2



BOARD VERSION DTE20190610

by John Leung

Table of Contents

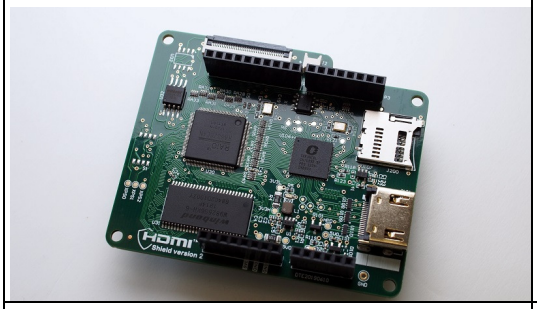
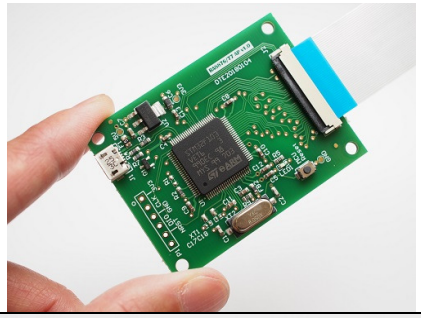
Document versions

Versions	Date
Preliminary draft	28th July 2019
Update for Windows 10 remarks	29th July 2019
Update for a new picture for male to female jumper cables on page 4	4th August 2019

Product description

HDMI Shield is a development board to display high quality graphical contents on high-definition televisions (HDTVs) from memory constrained microcontrollers (MCUs). The supported highest display resolution is 1920x1080 pixels at 60Hz and there is no limitation on the size of TV. In other words, it can be a 15" desktop monitor or a 100" LED TV as long as it comes with a standard HDMI input.

Packing list

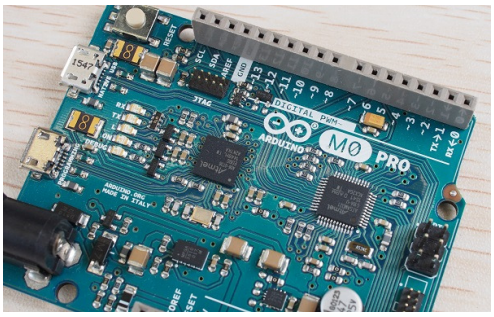
Photo	Item description	Quantity
	HDMI Shield development board - version 2	1
	STM32F103VET6 driver board - use with the AP Software Tool to control RA8876 from a PC	1
	Male to female jumper cables of 2.54mm pitch - connect to your MCU development board	20
	DC power cable of 1.25mm pitch - use it to supply a regulated 5V with current >500mA when USB port not sourcing enough power	1

Equipment and material needed

There are only four extra components required from you to get started. As an electronic engineer you may have them already in your toolbox in most cases.

They are:

- A MCU development board with SPI, 8080, or 6800 output port of **3.3V operation voltage level**. Example is an Arduino M0 PRO (M0) with photo shown in right hand. *Purchase options are available from us for several adapters and an ESP8266 board.*



  There is no minimum benchmark requirement on the MCU speed but we have tested M0 with a slow SPI clock at 12MHz with good results.

  However, there is a maximum SPI input clock limit of 50MHz for RA8876 which is the video generator onboard of the HDMI Shield.

- A HDTV or monitor with HDMI or DVI input. Full audio feature is supported with HDMI. But there is no audio support with DVI and you will have to supply a HDMI-to-DVI adapter for connection.
- A HDMI cable with type A male plug for both ends.

  A purchase option for a compatible cable - Unitek Y-C136K is available from the same web site you have downloaded this document.

- A PC running Windows 7 or above.

Working principle

A LCD controller RA8876 is used to generate RGB video signal in 3.3V voltage level. The RGB signal is supplied to a HDMI encoder chip CH7035B for image processing with parameters configured by either

(1) firmware preloaded inside an I2C serial flash (CH9904) or

(2) initialization sequence embedded in your MCU.

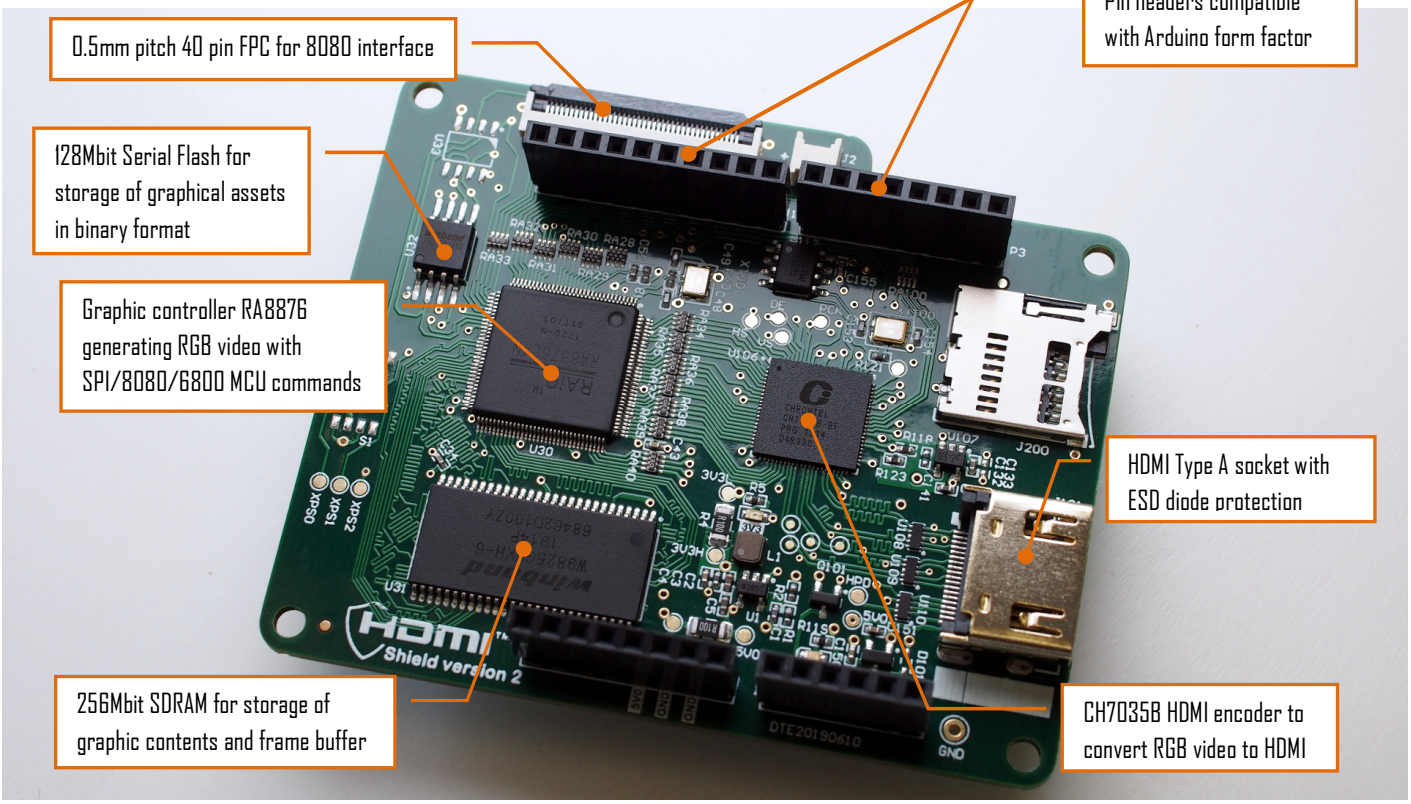
With a HDTV detected, CH7035B will be woken up with frames encoded to some digital packets in a HDMI-compatible format and finally, packets are transmitted to the HDTV.

An SDRAM of 256Mbits is connected to RA8876 for image storage. This memory chip is enough to store up to 17 pages of graphical contents in the resolution 1280x720 of 16 bits width.

With one page reserved for the visible area (*Display Window*), we still have 16 pages as display buffers. Graphical contents copied to an area outside the *Display Window* in SDRAM are not visible. Once the lengthy copying is finished, a single instruction is sent from the MCU to move the whole image from buffer to *Display Window*. Additional features of RA8876 include picture-in-picture, DMA transfer for images preloaded in Serial Flash, and font rendering from embedded character ROM.

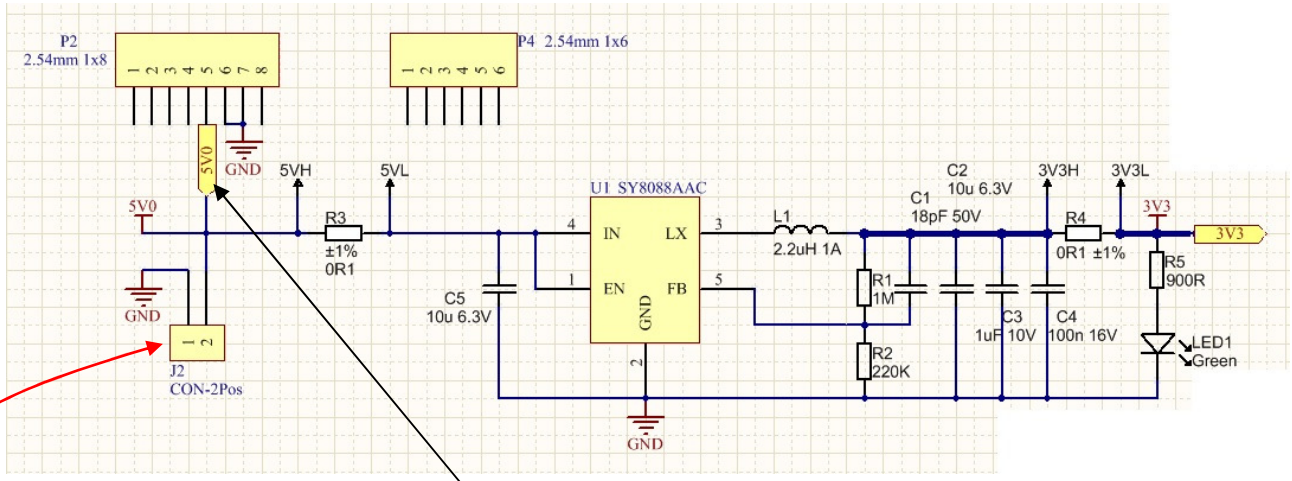
Arduino examples are available at :

https://github.com/techtoys/HDMI-Shield/tree/master/Ra8876_Lite.



Schematic to learn before making a connection with MCU

A step down DC-DC converter chip SY8088AAC on the HDMI Shield is used to generate 3.3V for the whole system. The relevant part of the schematic is shown below:



A single DC supply of 5V @ 500mA to header P2-pin5 is enough for the main power in most cases. This pin matches 5V supply of an Arduino Uno board layout, therefore it would be the USB port from your PC to supply the main power. In this case you may find your USB port slightly overloaded with 5V dropping to 4.8V or below. The overloading will be worsen when the HDMI port is connected. If 5V drops below 4.2V it is recommended to supply a regulated 5V of 500mA or above to J2.

Caution:

Please use a regulated DC supply of 5V for J2 just in case you find 5V from your USB port is over loaded below 4.2V.

Another caution before making a connection is that, there is no voltage level shifter chip onboard of the HDMI Shield. SPI/8080 bus wiring from your host MCU is connected to input of RA8876 and CH7035B directly. As a result, the maximum voltage rating of signal I/O pins of HDMI Shield is the same as that of RA8876 and CH7035B, respectively.

You are advised to study the full schematic for the MCU interface.

It is available from Github at :

https://github.com/techtoys/HDMI-Shield/tree/master/Ra8876_Lite.

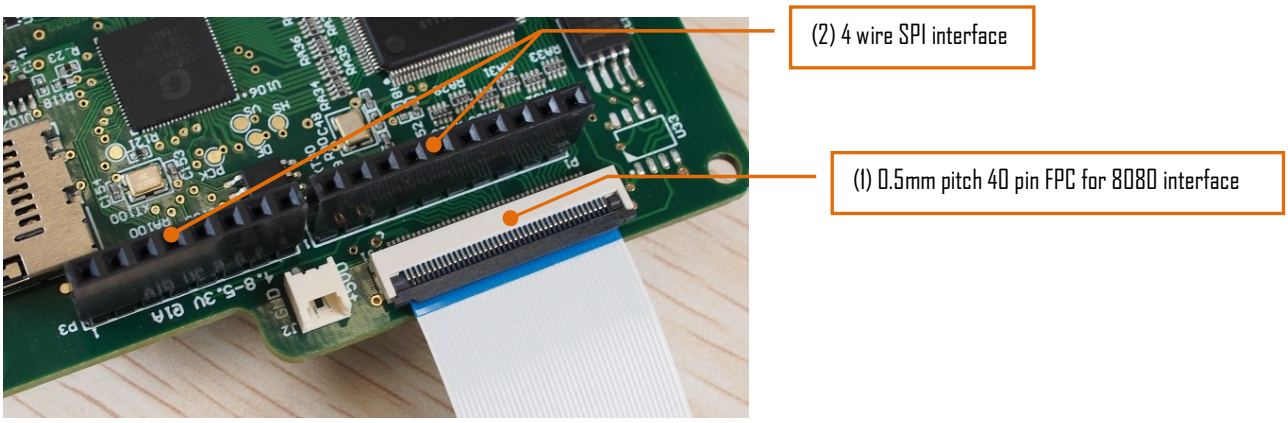
Voltage ratings of HDMI Shield

Parameter	Symbol	Value / V	Remarks
Main power supply	5V0	4.8 ~ 5.3V	5V0 can be measured across resistor R3 on PCB. *Under full operation 5V0 requires a DC current of 484mA.*
Supply voltage range (generated by SY8088AAC onboard)	3V3	3.27 ~ 3.38V	3V3 can be measured across resistor R4 on PCB.
Signal I/O input voltage range RA8876 including SPI/8080 data bus, interrupt input, and reset input	VIN - DB7/SPI_SCK, DB5/SPI_MISO, DB6/SPI_MOSI, DB4/SPI_CS, XnRST, XnINTR	-0.3 ~ 3V3+0.3	VIN for RA8876 are exposed from Arduino pin headers P3, P1 and FPC connector at J1. Please refer to schematic for details.
Signal I/O input voltage range for CH7035B	VDDIO - CH_SCL, CH_SDA, CH_I2S_I2S0, CH_I2S_LRCLK, CH_I2S_SCLK	1.14 ~ 3.5V	VDDIO for CH7035B are exposed from Arduino pin headers P3, P1 and FPC connector at J1. Please refer to schematic for details.
Signal I/O input voltage range for microSD card	VIN	-0.3 ~ 3V3+0.3	SPI bus for microSD shares with RA8876 except SD_CS pin

Host interface for RA8876

(1) 8080 8/16-bit asynchronous parallel bus - this mode is supported with FPC connector at J1

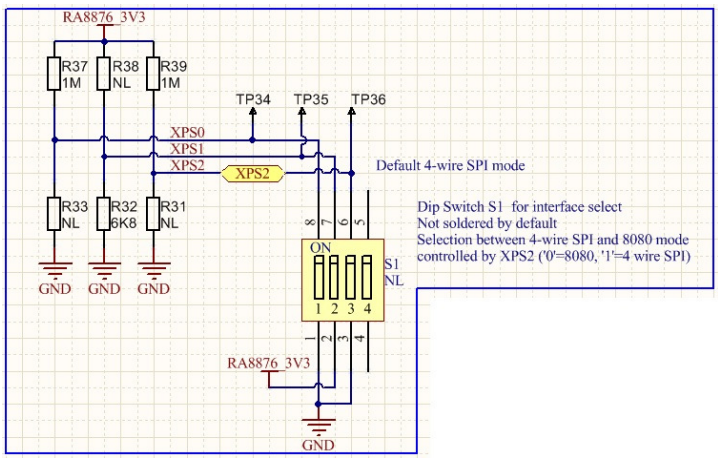
(2) 3/4 wire SPI interface - this mode is supported with 2.54mm pin headers P1 and P3



Different interface mode is selected by XPS[2:0] pins of the RA8876 illustrated by an extract from the data sheet.

XPS[2:0]	I	**Parallel /Serial Host I/F Select** 00X: (parallel host) 8080 interface with 8/16-bits data bus 01X: (parallel host) 6800 interface with 8/16-bits data bus 100: (serial host) 3-Wire SPI 101: (serial host) 4-Wire SPI 11x: (serial host) IIC ***Note*:** If host I/F set as parallel host mode, then XPS[0] pin is external interrupt pin.

On HDMI Shield we have designed a resistor network to select 4-wire SPI as the default interface mode. To switch between 8080 and 4-wire SPI we need to change the state of pin XPS2: '1' for SPI, '0' for 8080. A pull up resistor of 1M Ohm (R39) is soldered to XPS2 and this pin is wired to pin 10 of the FPC connector J1 in parallel. This design allows a simple switch from SPI to 8080 with XPS2 shorted to ground by GPIO operation (this is the case for STM32F103VET6 driver board) or an external jumper to ground. Schematic of the resistor network is shown below. **Just in case you need to change the interface mode to I2C, 6800, or 3-wire SPI mode, you will need to change the positions of the resistor network accordingly.**



Host interface for CH7035B

CH7035B requires only two inputs from the host MCU:

(1) I2C for initialization

(2) I2S for digital audio

I2C and I2S for CH7035B are not mandatory. A serial flash chip CH9904 is onboard of the HDMI Shield. It is used to initialize CH7035B with preloaded firmware when there is no I2C signal detected from the host MCU during power up. The firmware has been fixed to activate the scaling engine inside CH7035B to boost RGB video from 1280x720p @ 60Hz to 1920x1080p @60Hz.

This is the case for STM32F103 MCU host supplied by us. Although the hardware is ready, there is no software for STM to initialize I2C. Two major tasks of the software for STM32F103 are:

(1) initialize RA8876 for 1280x720 @60Hz video output

(2) loop for USB commands from AP Software tool

When the pixel clock of 1280x720 video falls within the safety margin it is boosted by CH7035B for 1920x1080p @ 60Hz HDMI output. Everything is automatic. The disadvantage is that, we need to generate a fixed video format of 1280x720 from RA8876 to satisfy CH7035B. In other words, we need to fix our graphical user interface (GUI) design to fit a resolution of 1280x720.

This '*problem*' can be solved by overriding CH9904 with a foreign initialization sequence sent through I2C. Initialization sequences for different video in/out combinations in `constant arrays` (`videoInOutMap.h`) are provided for this purpose. This file as part of the firmware package for Arduino is available at `./libraries/Ra8876_Lite/src/HDMI`.

Hardware and software setup for Arduino users

The following instructions show you how to install the Arduino driver and finish hardware stack up for several Arduino platforms.

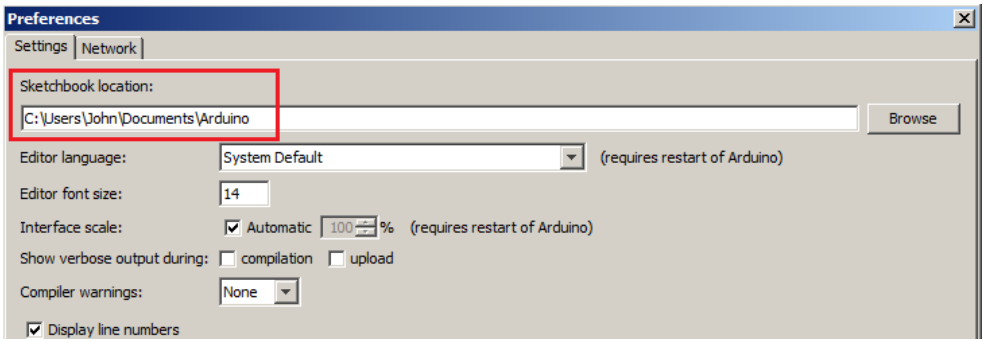
1. Download Arduino library from Github at:

   `https:\\github.com\techtoys\HDMI-Shield\tree\master\Ra8876_Lite`

2. From Arduino IDE click [File] > [Preferences] to open "Preferences" dialog.

   Locate your Arduino library folder path from `Sketchbook location`:

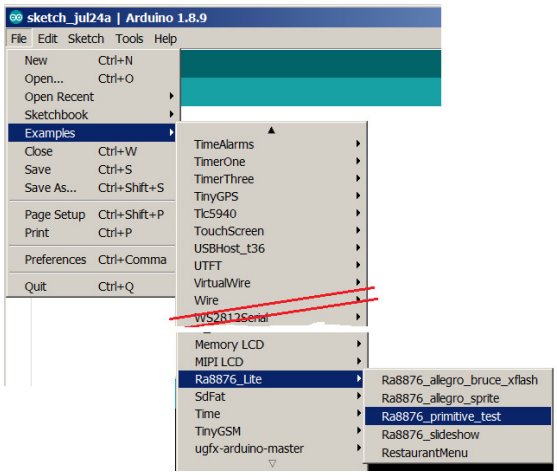
   In my case it is under `C:\Users\John\Documents\Arduino`



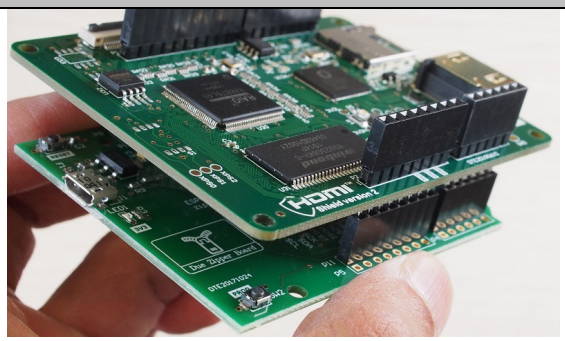
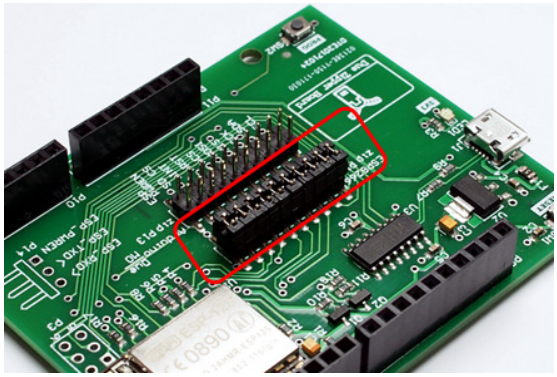
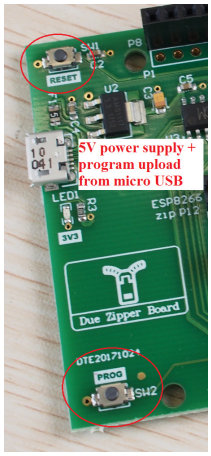
3. Install the library folder `Ra8876_Lite` by copying it to the library path `\libraries`

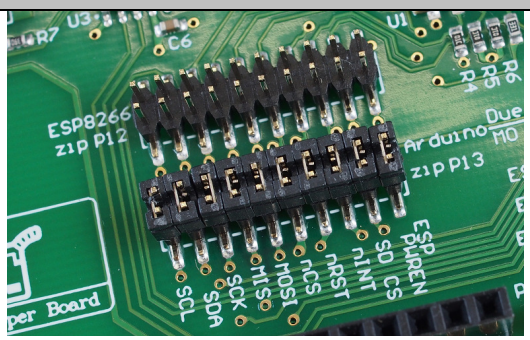
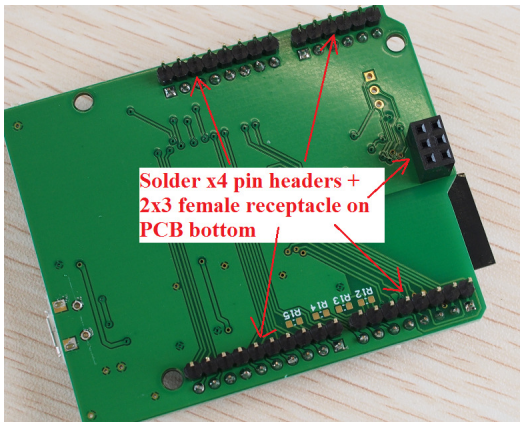
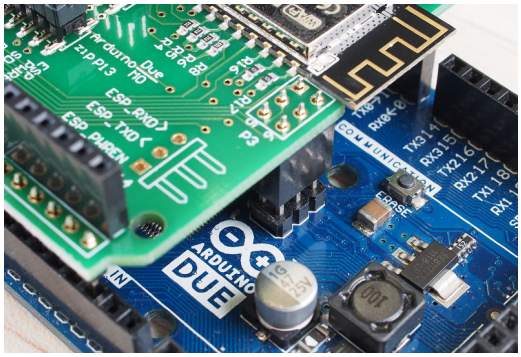
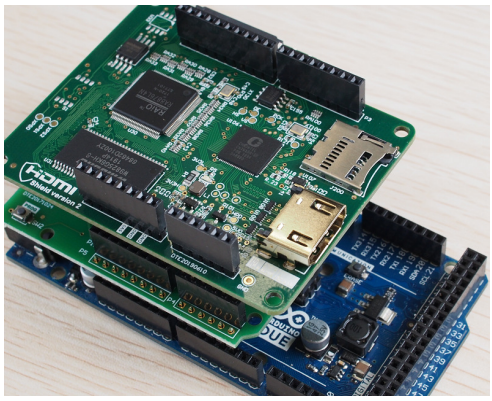
4. Restart Arduino IDE you will see a new option from [File] > [Examples] > [Ra8876_Lite].

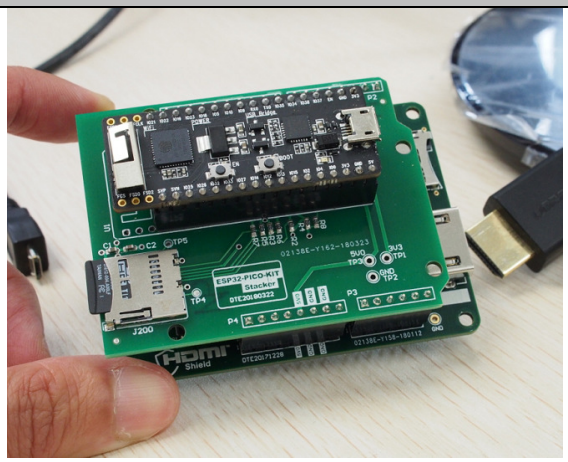
   This shows a successful library installation.

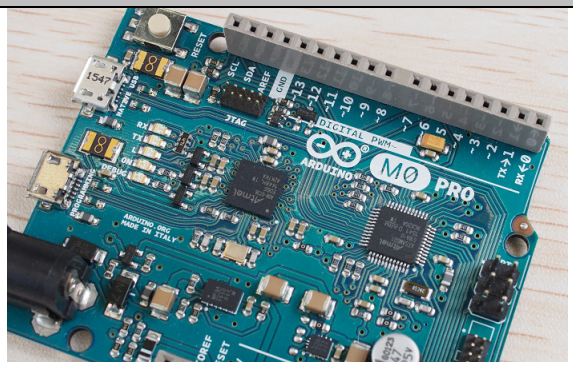
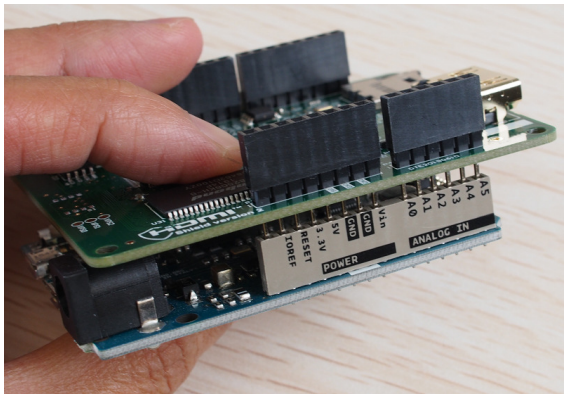


Six platforms have been tested . Tables below illustrate the setups.

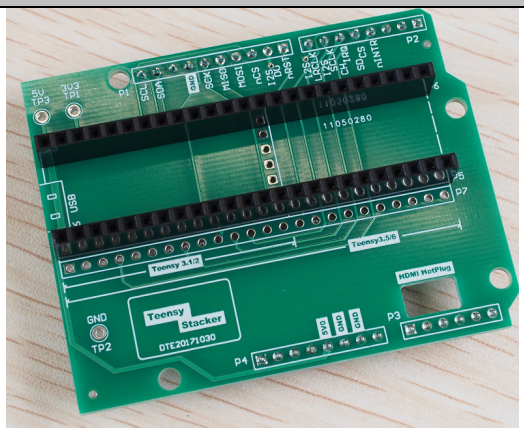
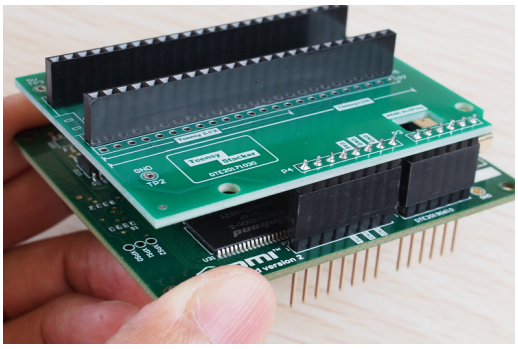
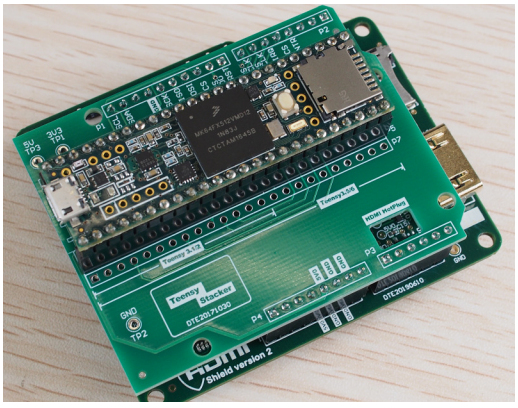
Arduino board	How "stack up" is done	Descriptions
Espressif ESP8266 WiFi SoC Our part number: **DueZipper_DTE20171024**	  	**ESP8266** host board (**DueZipper**) is provided as an optional item from our web store. Its schematic is available at Doc 06 from the same web page you have downloaded this user guide. This board serves dual purposes: (1) **ESP8266** host board (2) Adapter board for **Arduino** DUE If **ESP8266** is used please make sure all jumpers are set to P12 (red square on photo) on the PCB of **DueZipper**. The micro USB port on **DueZipper** provides 5V power supply for the whole system and upload programs to **ESP8266**. Please notice that is no automatic upload mechanism. You need to follow this procedure to upload a program to ESP8266: 1. Connect a micro USB cable 2. From **Arduino** menu click [Tools]>[board]>[Generic ESP8266 module] 3. Select [Flash Mode] > DIO [Flash Size] > 4M(1M SPIFFS) [Crystal Frequency] > 26 MHz [Flash Frequency] > 40MHz [CPU Frequency] > 80MHz [Upload Speed] > 115200 [Port] > your serial port enumerated in Windows Finally, press and hold PROG button and click RESET button to put **ESP8266** into **bootloader** mode. From **Arduino** menu click [Sketch] > [Upload]

Arduino board	How "stack up" is done	Descriptions
Arduino DUE **DueZipper_DTE20171024** as an adapter board		**DueZipper** board is used as an adapter for **Arduino DUE** when all jumpers are set to position P13 on PCB.
		We will have to solder four pin headers together with 1 piece 2x3 female receptacle on the bottom side of the PCB with photo shown on the left column.
		Now align the 2x3 female receptacle you have just soldered to the pin header in the middle of the **Arduino DUE** platform. Push to close it firmly.
		Finally, install **HDMI Shield** on top **DueZipper** to complete the stack up. Connect a micro USB cable to Debug Port of **DUE**. This port provides 5V for the whole system and uploads programs for **DUE**.

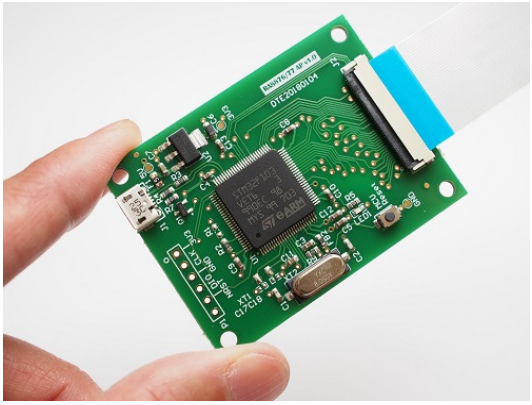
Arduino board	How "stack up" is done	Descriptions
ESP32-Pico-Kit **ESP32-PICO-KIT Stacker_DTE20180322** as an adapter board		A low cost adapter board is available from us with the part number **ESP32-PICO-KIT Stacker_DTE20180322.** This board is an optional item. Remarks: ESP32-Pico-Kit is NOT included. We only sell the adapter board. This adapter provides a bridge for ESP32-PICO-Kit to fit an Arduino UNO form factor and a micro SD card socket (J200) is also on the PCB with connections wired to a different SPI port of ESP32. Connections are listed as follows: **VSPI for RA8876** RA8876-CS < GPIO5 RA8876-RESET < GPIO10 RA8876-MOSI < GPIO23 RA8876-MISO > GPIO19 RA8876-SCK < GPIO18 RA8876-INT > GPIO35 **HSPI for micro SD** SD-CS < GPIO15 SDCARD-MOSI < GPIO13 SDCARD-MISO > GPIO4 SDCARD-SCK < GPIO14 MicroUSB port on the ESP32-Pico-Kit is used to supply 5V power for the whole system and uploads a program to ESP32.

Arduino board	How "stack up" is done	Descriptions
Arduino M0 PRO	  	No adapter board is required. Simply stack HDMI Shield on Arduino M0 PRO is OK. Caution: There is no SD card feature available for M0 PRO.

Arduino board	How "stack up" is done	Descriptions
Intel Genuino 101	 	No adapter board is required.

Arduino board	How "stack up" is done	Descriptions
Teensy 3.2 and 3.5 **TeensyStacker_DTE20171030** as an adapter board	  	**Teensy Stacker DTE20171030** is provided as an optional item from our web store. Its schematic is available at Doc 07 from the same web page you have downloaded this user guide. Connections are listed as follows: **SPI for RA8876** RA8876-CS < D20 RA8876-RESET < D8 RA8876-MOSI < D7 RA8876-MISO > D12 RA8876-SCK < D14 RA8876-INT > D2 **micro SD shares the same SPI as RA8876** SD-CS < D10 SDCARD-MOSI = RA8876-MOSI SDCARD-MISO = RA8876-MISO SDCARD-SCK = RA8876-SCK

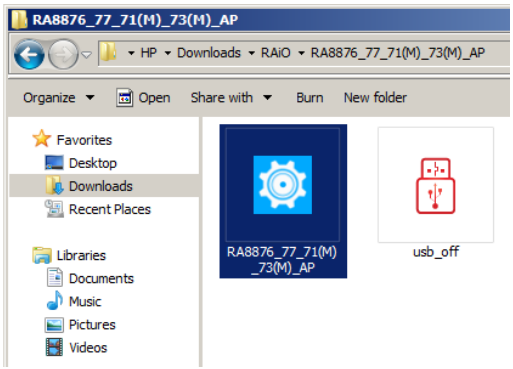
Hardware and software setup for STM32 users



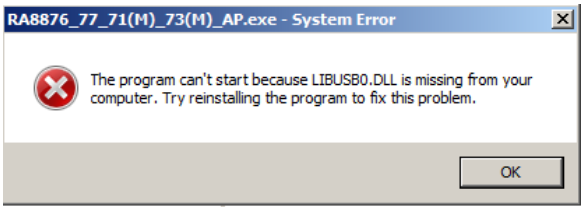
Procedures for Windows 7

Download AP Software tool with user guide from RAiO web site at
http://www.raio.com.tw/en/Support_RA887677.html

By unzipping the tool you will find an application RA8876_77_71(M)_73(M)_AP.exe



Double click on it the first time you will see an error like this.



Go to our web site to download the driver.

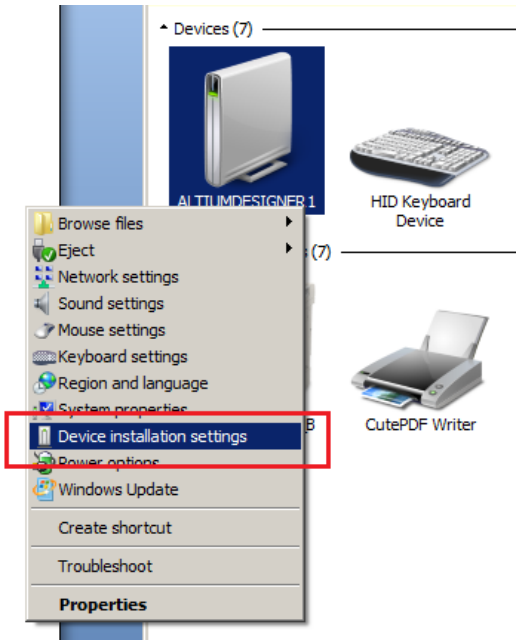
			Document & Software
Doc 01	User's Guide (read me first)		
Doc 02	Schematic for AP connections		
Doc 03	Pinout diagram		
Doc 04	Schematic of STM32F103VET6 AP board		
Doc 05	STM32F103VET6 USB Driver	285 KB	
Doc 06	Schematic of Due Zipper Board		
Doc 07	Schematic of TeensyStacker board		
Doc 08	Arduino library on GitHub		

Before installing this driver you will have to stop Windows 7 automatically installing drivers

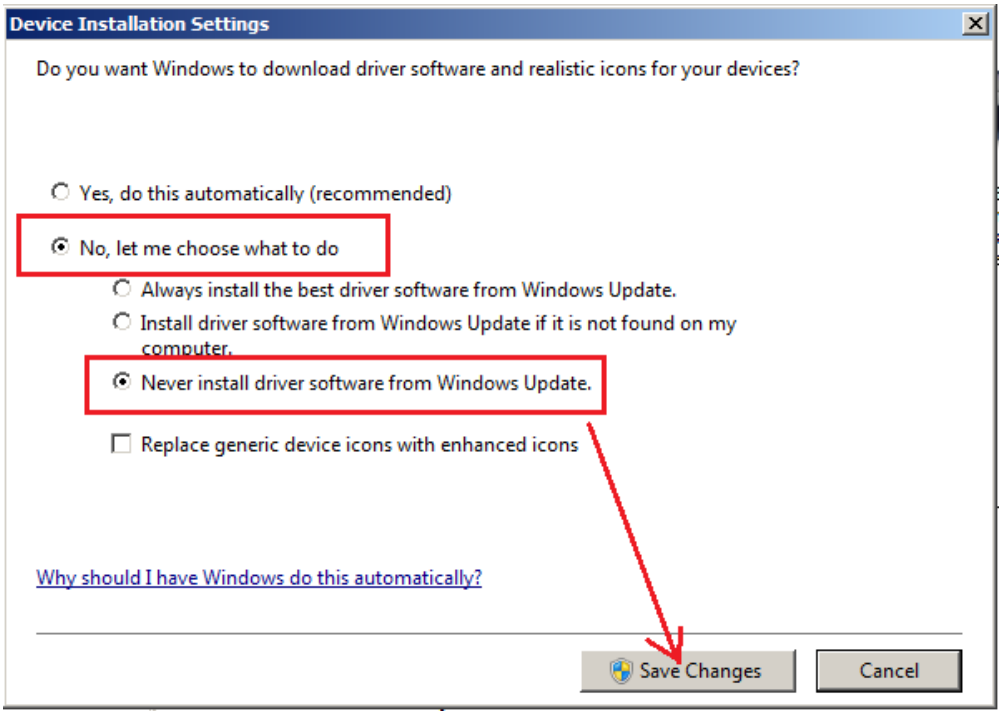
Steps similar to procedure described in

https://support.microsoft.com/zh-hk/help/2500967/how-to-stop-windows-7-automatically-installing-drivers

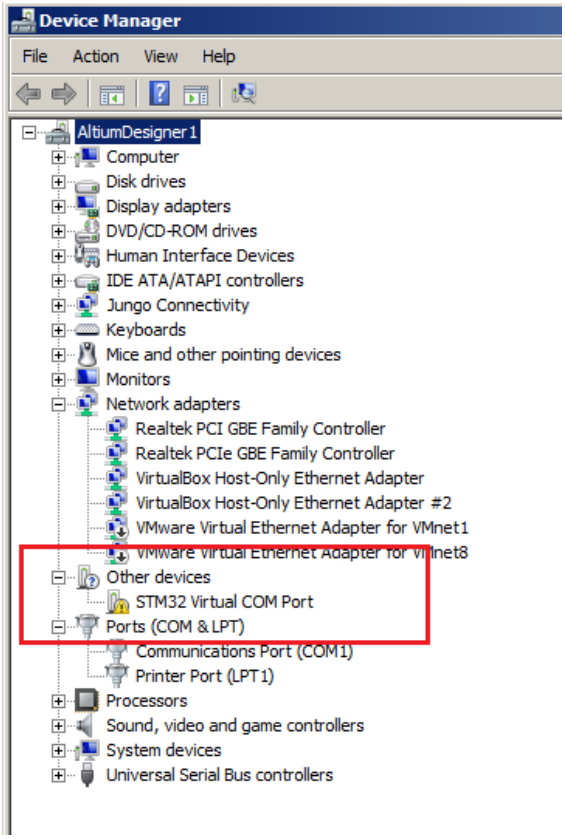
Go to **Control Panel ►Devices and Printers**, right click on computer icon then click **Device installation settings**



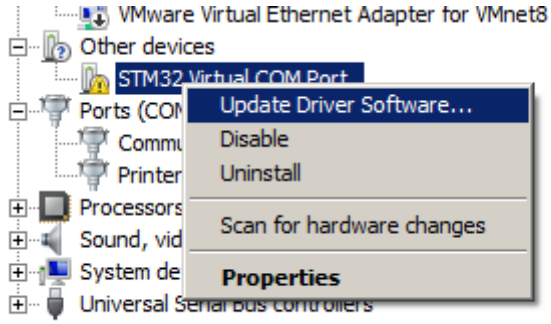
A new window pops up asking you whether you want Windows to download driver software. Click to select **No, let me choose what to do**, select **Never install driver software from Windows update**, and then click **Save Changes**. Click **Yes** for the next window. You may restore the original settings afterwards.



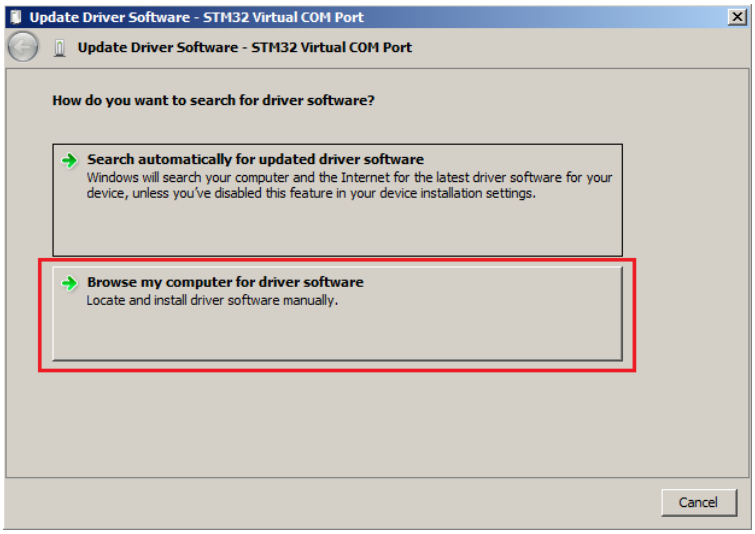
Connect STM32F103VET6 driver card to your PC. From Device Manager you will see a new device with driver not successfully installed, because you have stopped PC from automatic driver installation in last step.



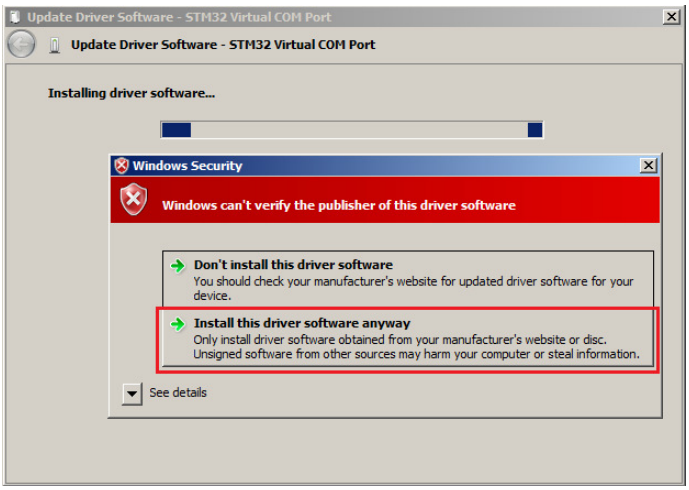
Right click on it to select **Update Driver Software**



Select **Browse my computer for driver software** in next step.



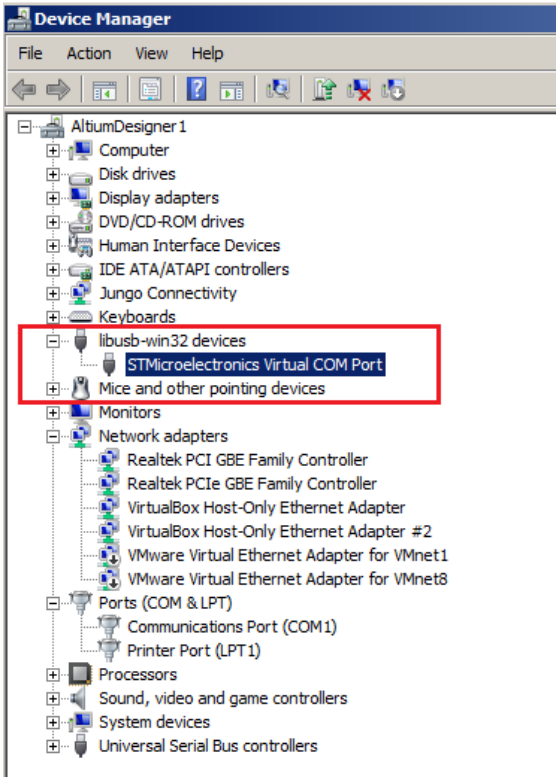
Browse to the top folder level **\STM32F103_USB_DRIVER** with **Include subfolders** option checked. Windows Security warning should be ignored. Click **Install this driver software anyway**.



Wait until driver installation finished.

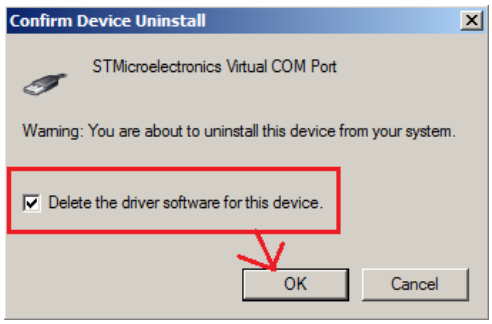
Turn back to **Device Manager**.

A new device **libusb-win32 devices** with **STMicroeletronics Virtual COM Port** will be available. This is the signature for a correct driver having installed.



Caution:

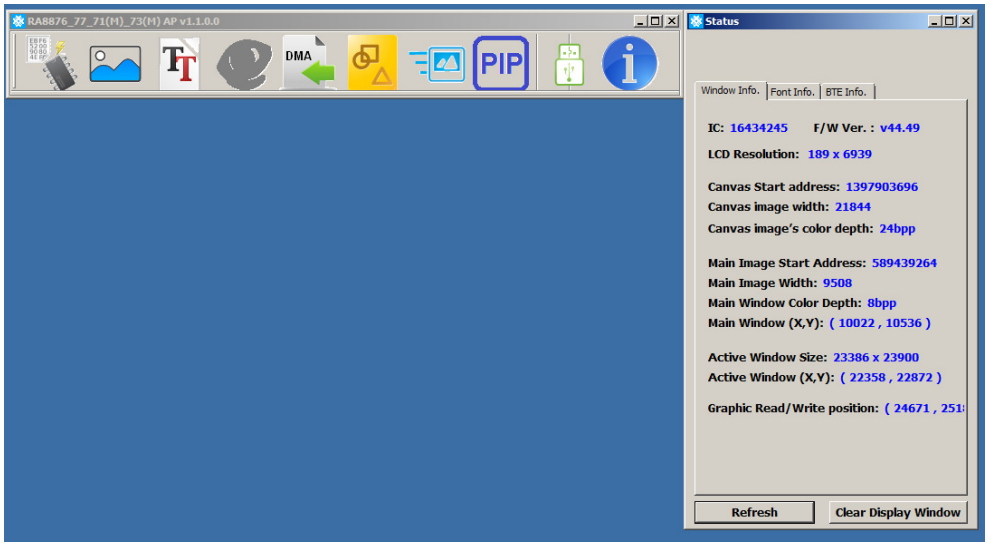
If your PC happens to have installed a Virtual COM Port under **Ports(COM & LPT)**, you will have to uninstall that driver with the option **Delete the driver software for this device** checked and start all over again.



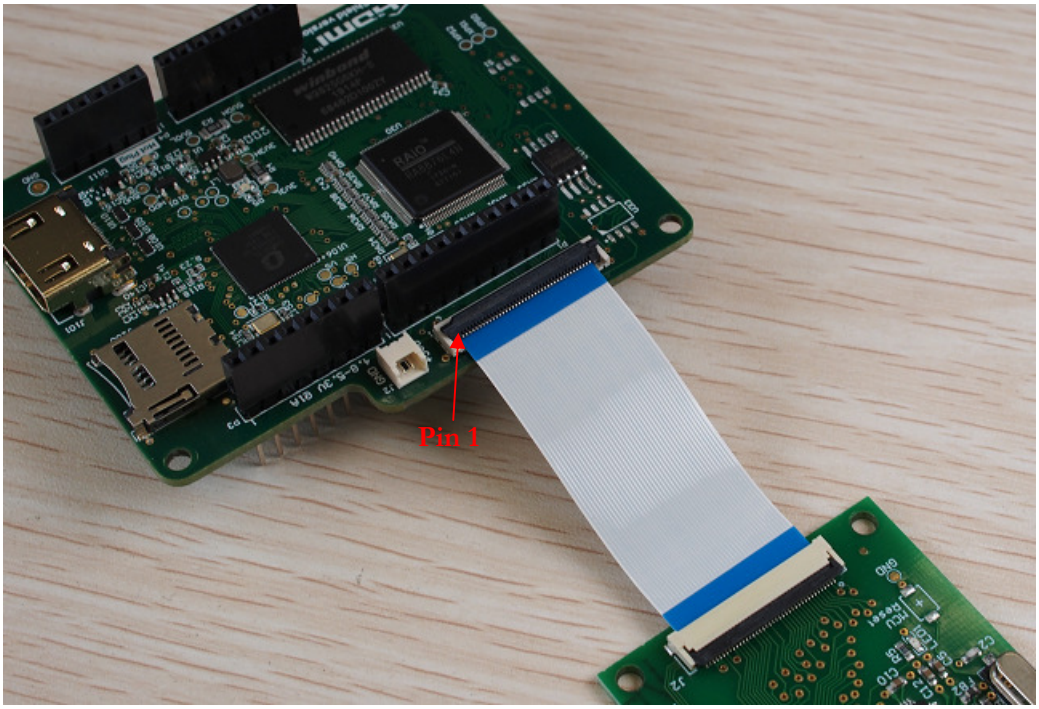
The correct USB driver for STM32F103VET6 card should be categorized under a new **libusb-win32 devices** like screen shot on last page.

Double click the application RA8876_77_71(M)...AP once more, an application user interface like this with a status window at the right will be shown.

This finishes the installation procedure. Quit the application for now.



Unplug the STM32F103VET6 card from PC. Connect HDMI shield to it following the picture below.



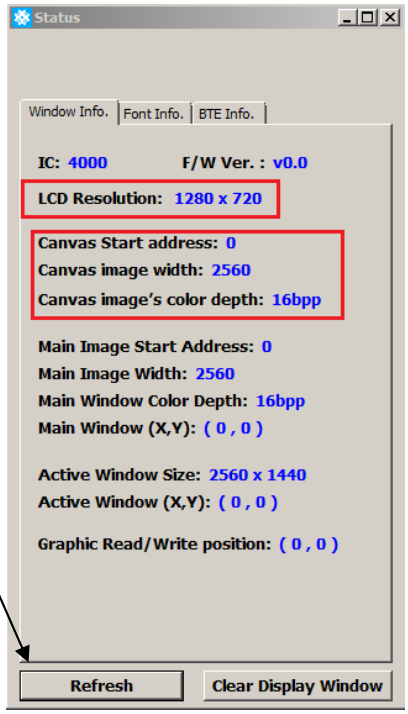
Close FPC connector by pressing it to lock.

Connect HDMI Shield to your HDTV or monitor of 1080p with a HDMI cable.

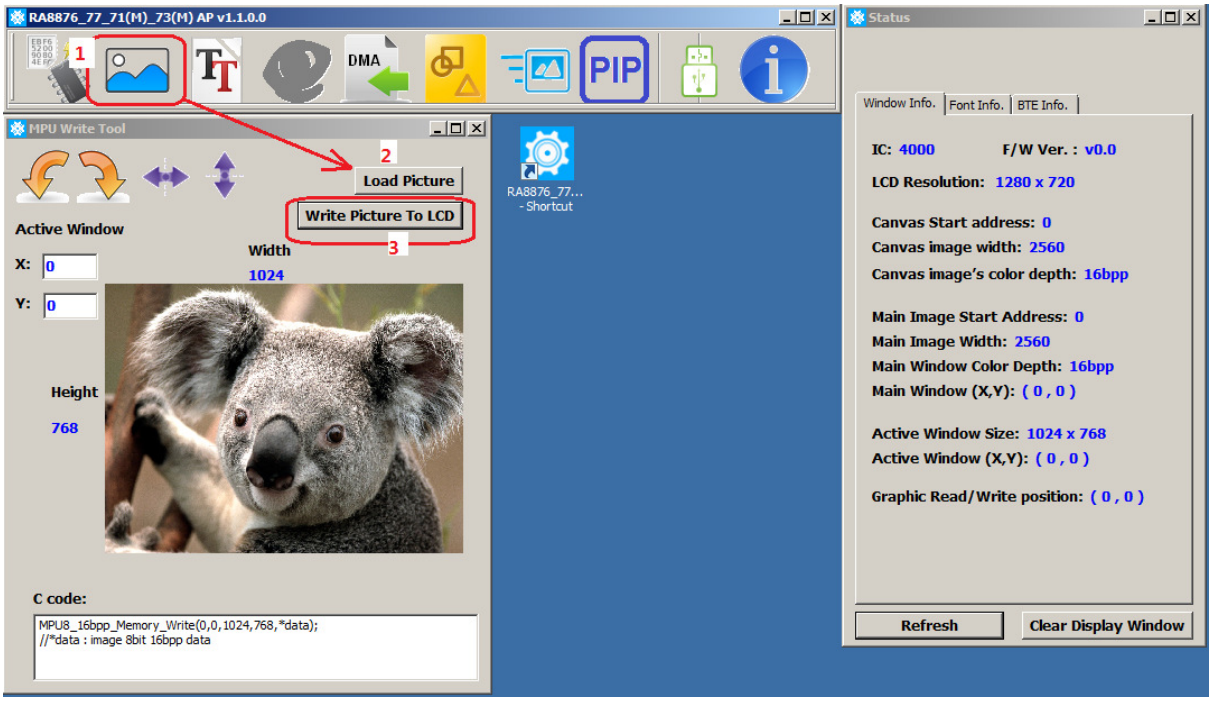
Finally connect the microUSB port to your PC. A single 5V supplied from the USB port should be enough to power the STM32 + HDMI Shield.

Run RA8876_77_71(M)...AP again you will see your monitor/TV is displaying something like this. This is normal because the SDRAM as frame buffer has not been initialized for anything yet.

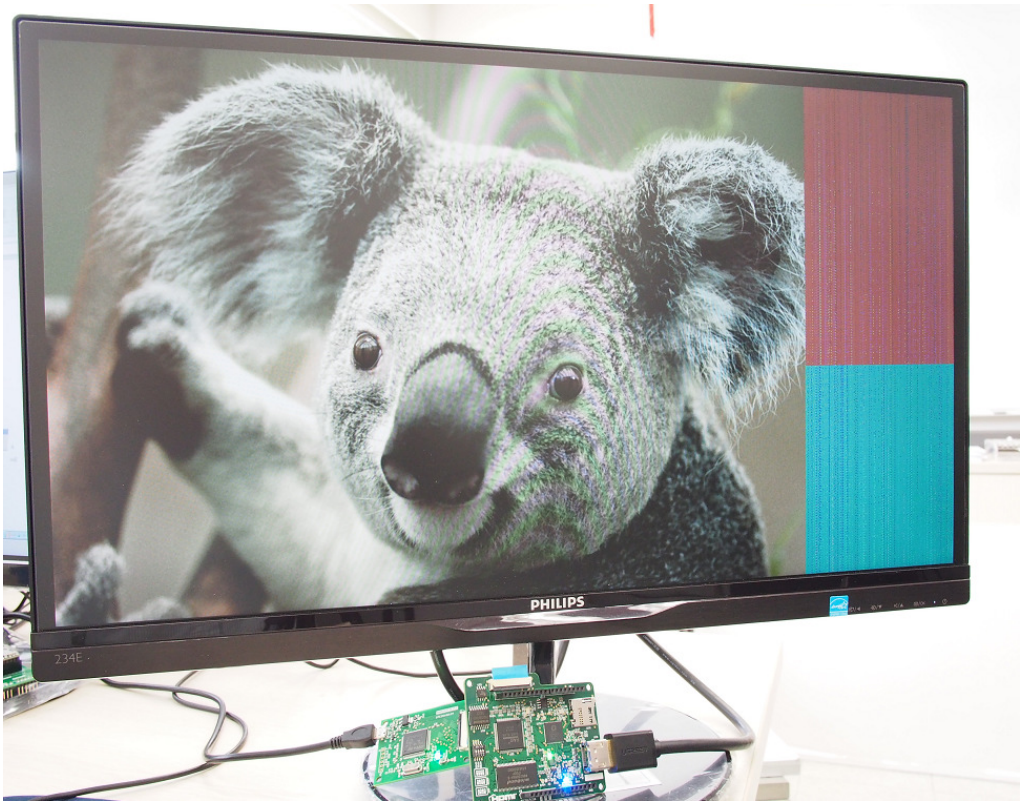
Now take a look at the Status Window you will see the LCD Resolution is 1280 x 720 with Canvas image width 2560 in 16bpp. If not, click **Refresh** button .



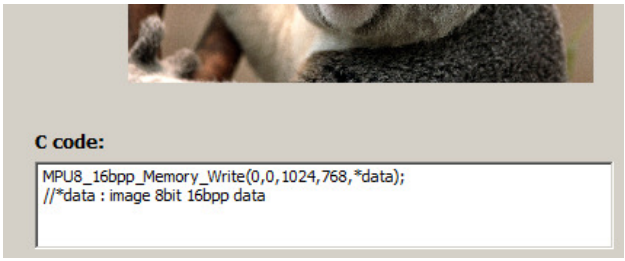
From the top menu click on **MPU Write Tool > Load Picture. B**rowse to any bmp or jpeg from your PC > click **Write Picture to LCD button**.

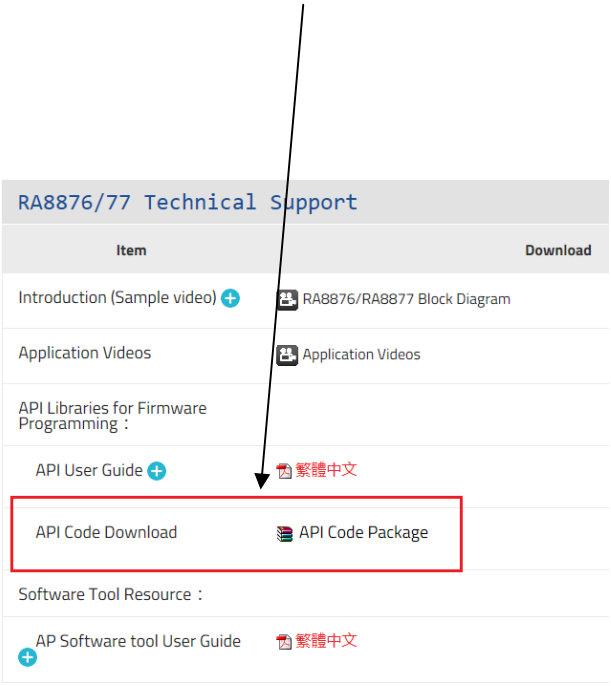


You will see the monitor refreshed with the picture you have chosen.



Look closely to the **C Code window** you will find the relevant function that actually wrote pixels to main window of RA8876. Full source code can be obtained from the same RAiO website you have downloaded the AP Software tool.





Remarks for Windows 10

Reference: https://ph.answers.acer.com/app/answers/detail/a_id/38288/~/windows-10%3A-disable-signed-driver-enforcement

Windows 10 enforces driver signatures by default. This can be disabled to install drivers that are not digitally signed. Use the following steps to disable driver signature enforcement.

1. Click the **Start** menu and select **Settings**.
2. Click **Update and Security**.
3. Click on **Recovery**.
4. Click **Restart now** under **Advanced Startup**.
5. Click **Troubleshoot**.
6. Click **Advanced options**.
7. Click **Startup Settings**.
8. Click on **Restart**.
9. On the Startup Settings screen press 7 or F7 to disable driver signature enforcement.

Your computer will restart and you will be able to install non-digitally signed drivers. If you restart your computer again the driver signature enforcement will be re-enabled.