



TERES-I

Do it yourself (DIY) modular laptop



Open source hardware design running open source software

This document applies for TERES-A64-BLACK and TERES-A64-WHITE

Manual revision 1.5

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1. What is TERES-I?

TERES-I is an open source hardware and open source software do-it-yourself laptop running Linux on a quad core 64-bit ARM processor. It is very light product – weighing less than one kilogram, convenient to carry when traveling. TERES-I has a stylish and elegant shape and an 11.6" LCD screen. You can play videos, browse the Internet, write programs. The laptop's mainboard has an eMMC flash memory loaded with Ubuntu Mate and few basic programs – Internet browser, Open Office, Arduino IDE, IceStorm FPGA Verilog tools, a video player, etc. You can, of course, install additional software from the Ubuntu repositories.

2. Where does the name come from?

Teres I was the first king of the Odrysian Kingdom. This kingdom covered most of what is now present-day Bulgaria. The Odrysian state was the first Thracian kingdom that acquired power in the region, by the unification of more than forty Thracian tribes under a single ruler. This laptop was designed in the city of Plovdiv, Bulgaria, which was originally a Thracian settlement. The golden mask of King Teres I was discovered in 2004 in the Valley of the Thracian Rulers near the city of Kazanlak.



3. What makes this laptop different?

The TERES-I laptop is a completely open source hardware and software product. You don't even need a purchase to access the design files. The CAD files and full source code are available at GitHub and anyone can download, modify and use them for their own needs. It is important to notice that the CAD design tool that we used to make the hardware of TERES-I is also completely free and open source – KiCAD.

The openness of the product puts incredible power and flexibility in the hands of the user. If you want to implement new features, you are free to do it. If you need another processor, more power, more memory, a better LCD, you have everything required to tailor this laptop according to your needs. If you do not like the Linux distribution you have access to the sources and can generate any Linux distribution for your taste. The Android SDK by Allwinner for the A64 chip can be used as another option for operating system.

The laptop is fully modular which means that there are number of possible ways to expand it. We already have several ideas in mind. One of them is to expand the laptop capabilities with an FPGA module so it can act as a digital storage oscilloscope, and a logic analyzer, turning it into a powerful portable laboratory instrument. These FPGA expansion modules are currently work-in-progress and you can follow the development on web site at www.olimex.com

Another advantage is that all the components of the laptop are available for purchase separately, so if a part fails you can replace just the broken part. This lowers the maintenance costs and helps reducing the electronics waste.

There are educational benefits in getting TERES-I – you can assemble it with your children and teach them about electronics or how computers work. Your children might learn about the basic computer components, how are thing assembled together, and in case of trouble can learn to repair it. This may spark an interest in electronics and programming. Assembling the laptop is relatively easy and even small child should be able to do it under adult supervision.

4. Why does open source matter so much?

Open Source gives you freedom. You know everything about the TERES-I laptop.

We provide the hardware design files and schematics. The hardware design is made with open CAD tool. There is nothing hidden. The sources for the Linux distribution and step-by-step compilation instructions are available and easily accessible. You have full access to both the hardware and the software parts and you are able to control every bit of your laptop. You don't even have to purchase anything to access these resources – you can use our work (or parts of it) as a basis for own projects already.

The educational value of such a product is high. Most complex hardware projects are closed and you can only indirectly guess how things are connected or how things are operating in general.

Open source gives guarantee for longevity. It also gives you independence and self-sufficiency – if a problem appears you have the freedom to fix it. You don't have to count only on the availability of the technical support. Proprietary, closed-source products do not come with source code, and you have no access to the board's design layout, you can't easily add the functionality that you want, you can't modify what you don't like, you are not given the opportunity to repair your own product.

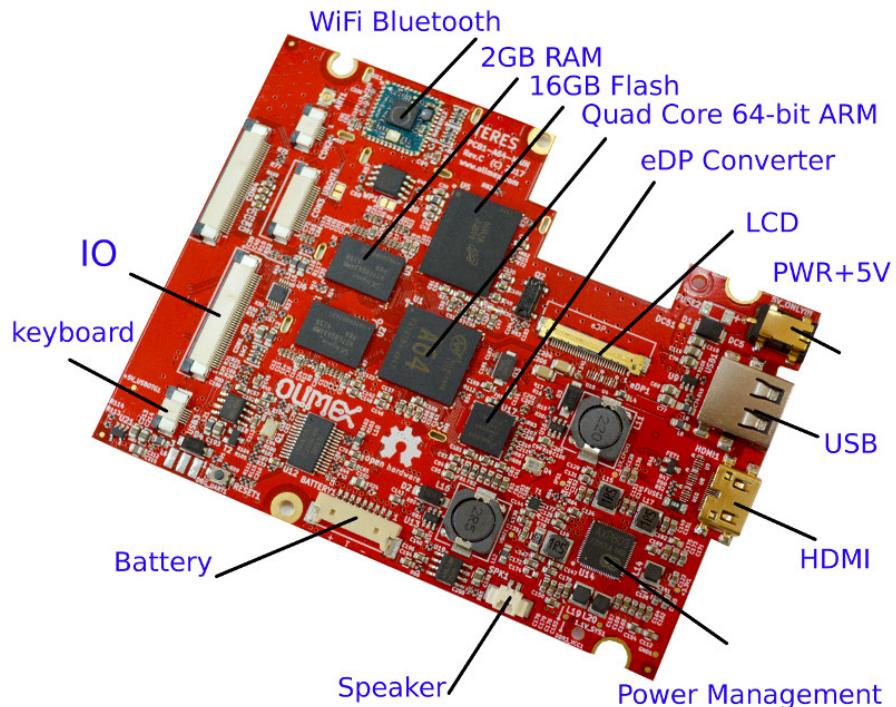
5. Where are the sources?

TERES-I source and design files are available at GitHub: <https://github.com/OLIMEX/DIY-LAPTOP>. The “Hardware” and the “Software” parts of the project are in separate folders, since in future we are planning to release versions of the PCBs with other processors. The current “Hardware” files are in “A64” folder. More to come in future. The “Software” folder contains the scripts for building the official Linux image. Scripts for Android would be added when available.

6. Introduction to the hardware of TERES-I

The TERES-I electronics part consists of five boards. Each of them was designed with KiCAD open source CAD software (<http://kicad-pcb.org/>). You can download KiCAD¹ and open for reviewing or editing each of the PCB files. The schematics are also available as PDF exports for easier viewing.

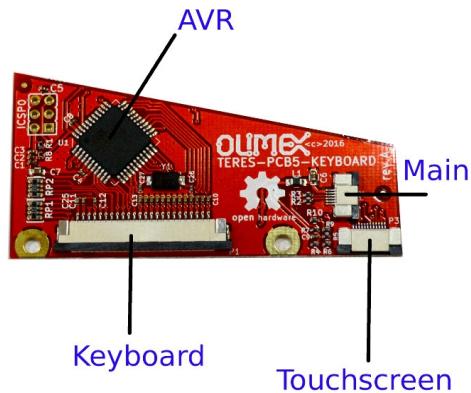
The **MAIN** board (**PCB1-A64-MAIN**) contains the A64 processor, RAM and flash NAND memories, the power management unit, LCD converter, connectors to different interfaces, among others. It looks like this:



We have plans to release extra main boards with different processors and memory configurations in future. These should work with all other existing boards. It is expected newer main boards to have higher laptop speed and better memory performance.

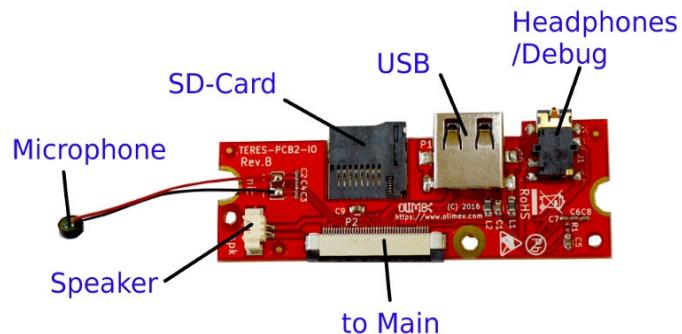
¹ Make sure to download the latest nightly development build. The latest stable release might not be good enough.

The **KEYBOARD** controller board (**TERES-PCB5-KEYBOARD**) has an AVR processor. You can update the firmware of the keyboard/touch controller live on the board itself. It can also be programmed via Arduino. This board handles the keyboard and touch pad interfaces.



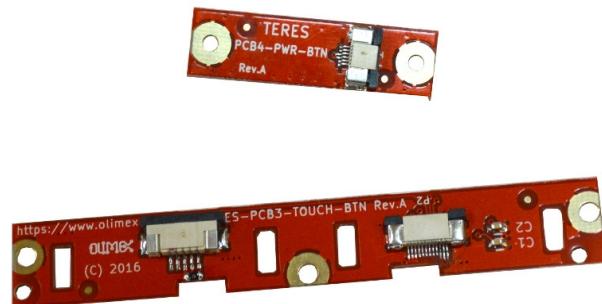
Sources, binaries and update procedures for the AVR firmware are available at GitHub. This keyboard controller board allows you to completely reprogram the keyboard mapping and response according to your own taste. The touch screen parameters can also be changed.

The **IO** board (**TERES-PCB2-IO**) contains the USB connector, headphone/debug connector, SD card, speaker connector and microphone.



The **PWR** button board (**PCB4-PWR-BTN**) handles the keys for powering on and off the laptop.

The **TOUCH** buttons board (**TERES-PCB3-TOUCH-BTN**) contains two buttons for left and right mouse click emulation.



7. What do you get in the package?

Here is the list of items you will receive:

- PCB1 (PCB1-A64-MAIN) – main PCB with A64 processor, 2GB RAM, 16GB eMMC. It is in an ESD protective bag. Please handle with proper anti-static precautions.



- PCB2 (TERES-PCB2-IO) – IO PCB with microphone, connectors for: speaker, USB, SD-card, headphones.



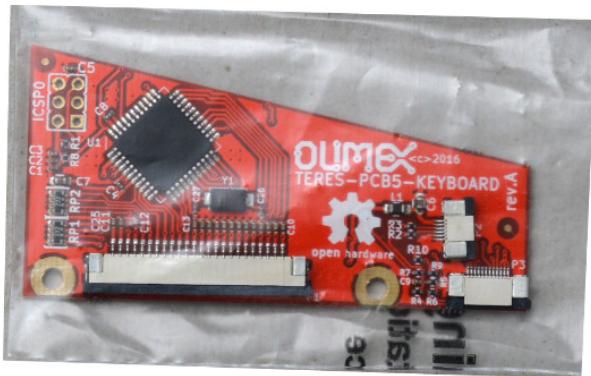
- PCB3 (TERES-PCB3-TOUCH-BTN) – TOUCH two button PCB.



- PCB4 – PWR PCB (PCB4-PWR-BTN) with button for power on/off.



- PCB5 (TERES-PCB5-KEYBOARD) – KEYBOARD PCB with controller of the keyboard and touchpad.



- #005 – Bottom body plastic part, packed in bubble wrap to protect from scratches.



- #006 – Keyboard body plastic assembly.



- #007 – LCD plastic frame.



- #008 – LCD back plastic body.



- #009 – Plastic power button.



- #010 – Plastic touch buttons.



- #011 – Left speaker.



- #012 – Right speaker.



- #013 – Transparent LED pipe.



- #014 – Set of screws: M2x1.5 mm – 4 pcs; M2x3 mm – 9 pcs; M2x4 mm – 17 pcs; M2x5 mm – 12 pcs.



- #015 – LCD 11.6". It has protective foil on top.



- #016 – Left and right hinges.



- #017 – Mat set. There are four rubber pads for the bottom of the laptop, two circular pads for LCD frame screws cover and four self adhesive mats for holding the battery.



- #018 – Magnet for the lid close sensor.



- #019 – Camera.



- #020 – Camera lens.



- #021 – Two dust protectors – big and small.



- #022 – Touchpad cover



- #023 – Touchpad.



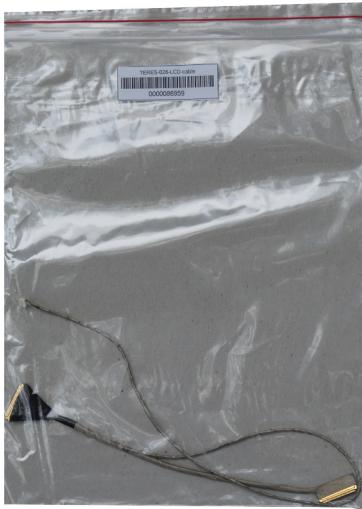
- #024 – LiPo battery 9500 mAh.



- #025 – WiFi/Bluetooth antenna.



- #026 – LCD/camera cable.



- #027 – Flat cable Main-IO.



- #028 – Flat cable Power-Main, Flat cable Main-Keyboard.



AMM ABBE SMC VME

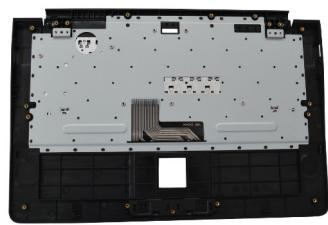
- #029 – Flat cable Touchpad-TouchButtons.



8. How do I assemble my TERES-I?

Prepare your workplace before starting the assembly process – make sufficient room and cover your desk with a soft textile to prevent scratching the laptop's plastic parts. Do not hurry during the assembly. Make sure to read and follow the instructions carefully since disassembling the finished unit to fix mistakes is considerably harder than assembling it.

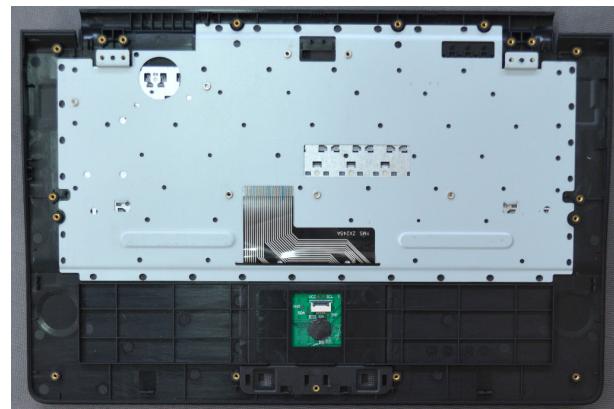
The assembly process begins with the **TERES-006-Keyboard**:



First attach the touchpad **TERES-023-Touch** to the keyboard's body:



The touchpad uses double sided adhesive tape. Remove the protective foil and place it on the top side of the keyboard body like shown in the pictures below:



You must be careful about the orientation of the touchpad connector. The exposed pins of the connector must be pointing UP.

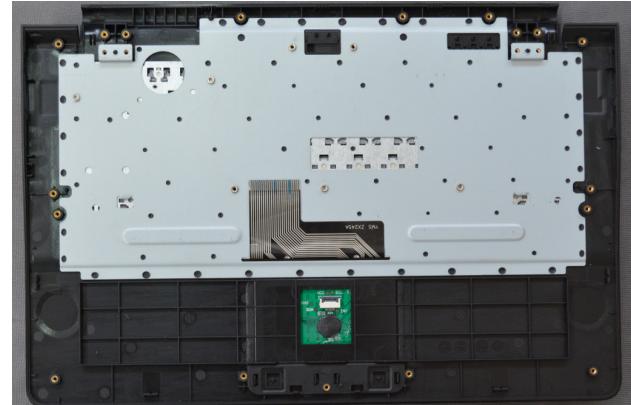


The touchpad snaps very tight to the upper side plastic. You should place it with on an even surface and make sure it is fully inserted.

Next step is to turn over the cover and place on top of the touchpad **TERES-022-Touch-Cover** and **TERES-010-Touch-Btns**:



The final result must look like these pictures:



The next step is to attach the TERES printed circuit boards to the keyboard body. For this purpose use the **TERES-014-Screw-Set**. Note that in this set there are 42 screws of different lengths:

- M2 x 1.5 4 pcs
- M2 x 3 9 pcs
- M2 x 4 17 pcs
- M2 x 5 12 pcs

It is a good practice to first sort all the screws since each screw has its own location and you should put the exact length screw to the exact place as mentioned. All screws have same diameter M2 but different

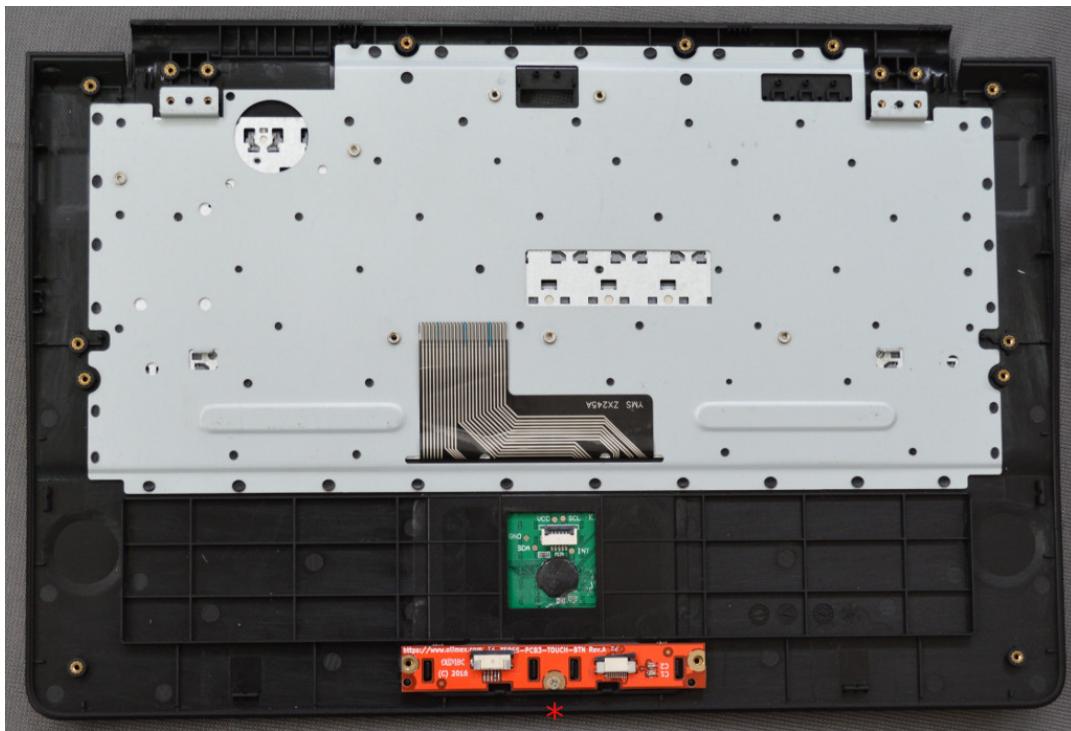
lengths – if you have difficulties determining the size, use a ruler. For example, the M2 x 5 screw would have 5mm length (without the head). Do not mix the lengths of the screws since doing so might damage the plastic parts. Do not screw as tight as possible, since this might break the plastic. Be gentle.

For the PCB's the M2 x 3 screws must be used.

Next assemble the **TERES-PCB3-Touch** PCB:



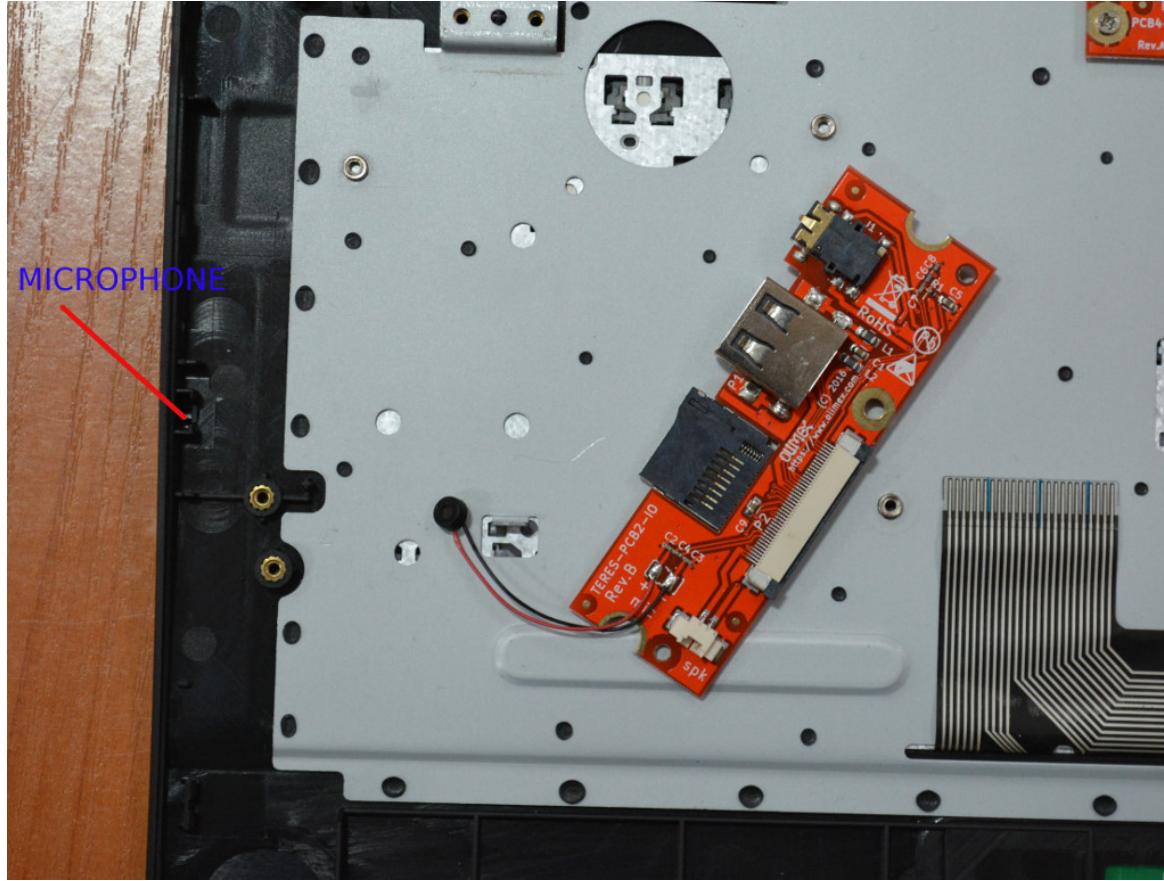
It is shown below, attached to the keyboard body. Note that only the middle screw is used, the other two screws will come later, when fixing the bottom plastic cover:



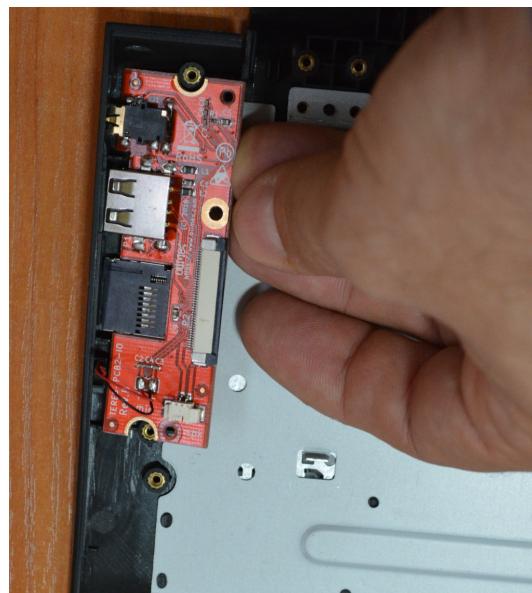
The next PCB to attach is the **TERES-PCB2-IO**:



The PCB2 board has a microphone which has to be placed in the side pocket specially designated for it.



After the microphone is put in place, slip the board at an angle into the side openings for the SD card, USB, and audio connector, then place it down.



Then use one M2 x 3 screw to fix the board:



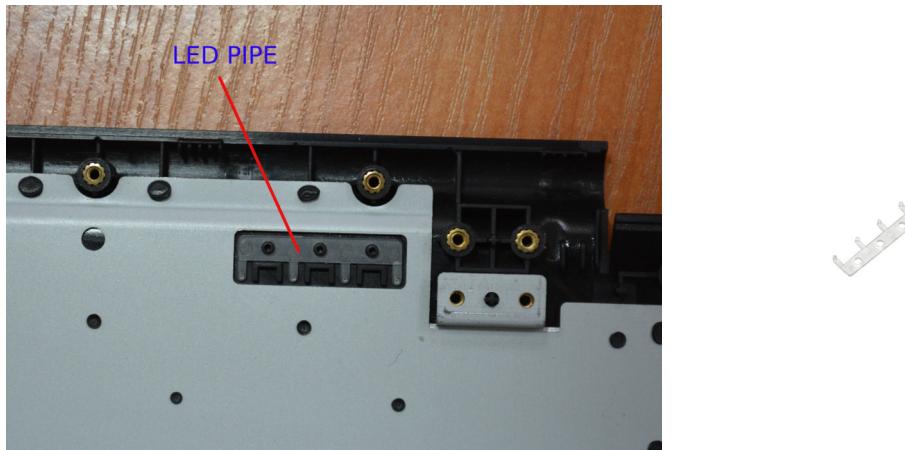
Please make sure that the side connectors are well aligned:



Next you put the PWR button plastic:



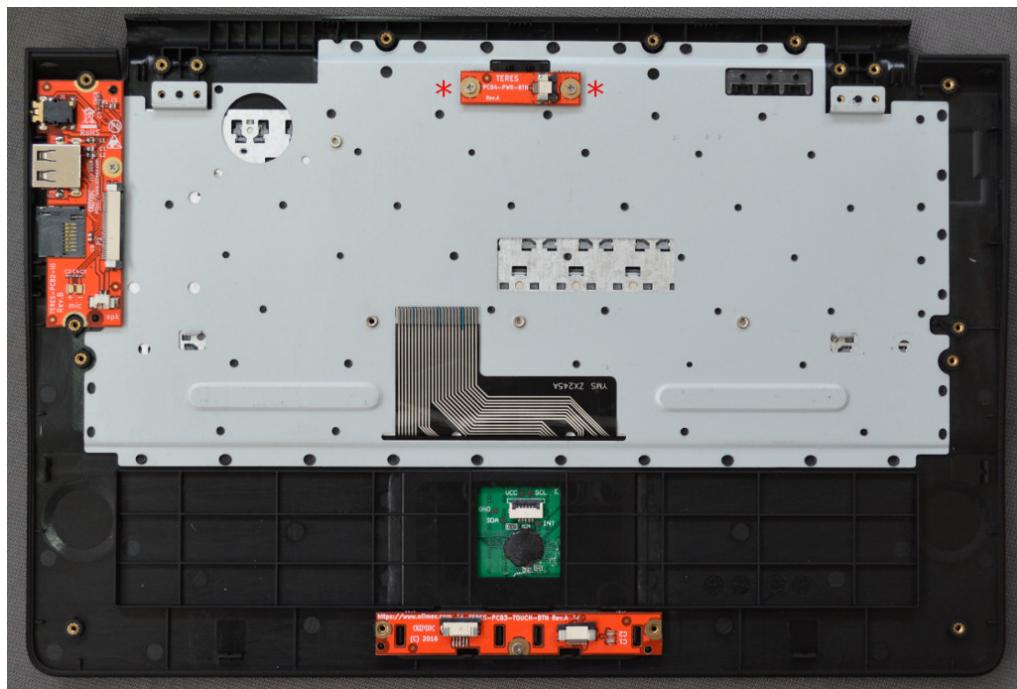
Then the LED pipe:



Next attach the **TERES-PCB4-Btn** (the power button):



The **TERES-PCB4-Btn** is attached with two screws M2 x 3 mm, connector pointing to the right side:

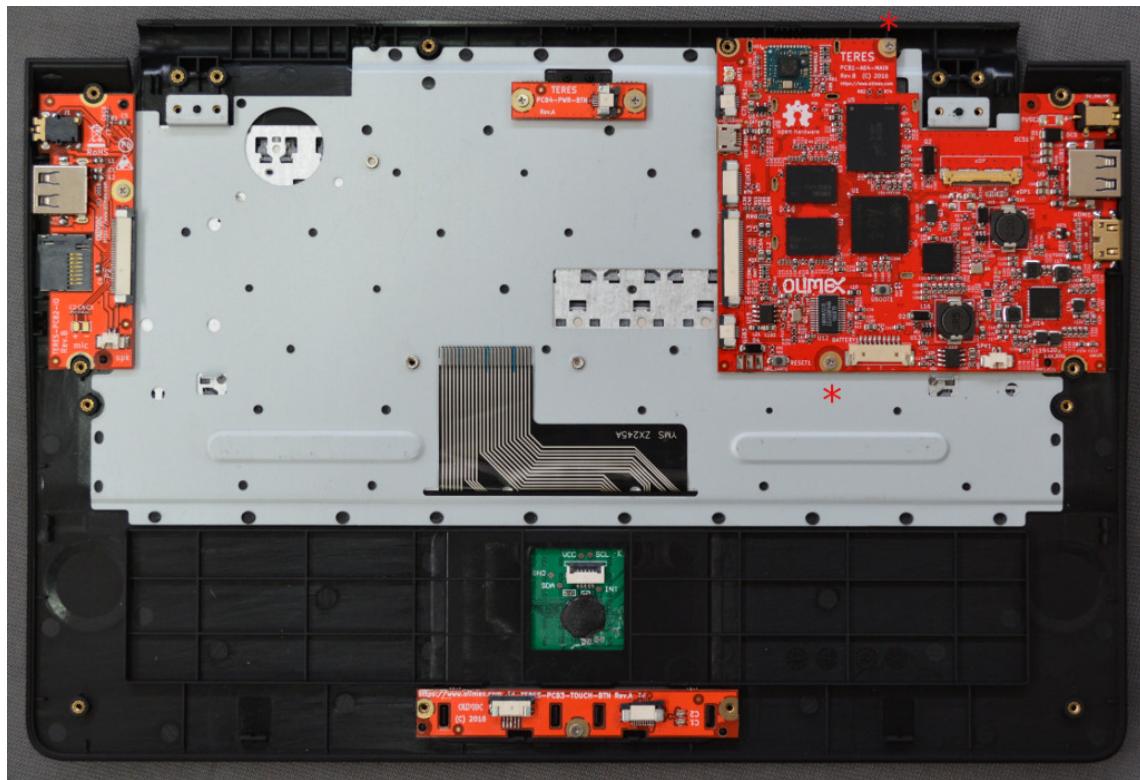


The next step is to assemble the big **TERES-PCB1-A64**:



This is the main board and you should handle it very carefully. Do not bend it, do not drop it, etc. This board is very sensitive to static electricity.

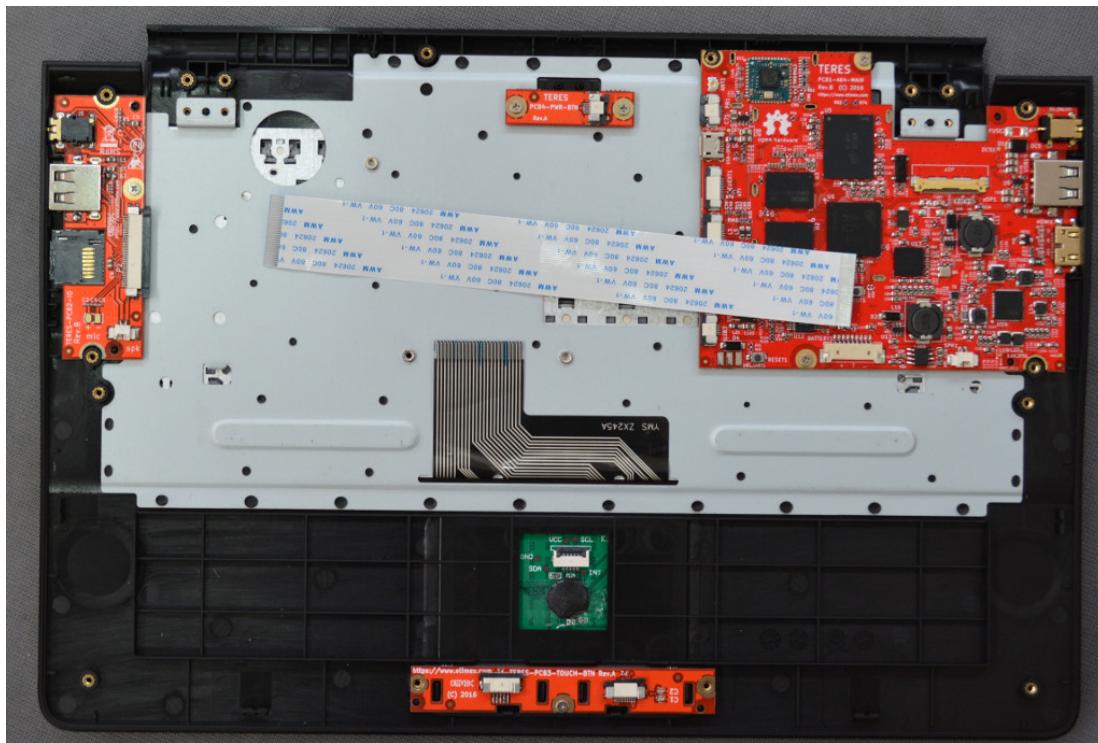
It's a bit tricky to put it in the correct position as you have to slide it right so the connectors enter properly in the side openings. If you succeed you will see all the PCB support nuts from the keyboard body pass exactly through the openings of the PCB. You need to use just two M2 x 3 screws to attach it:



Again, make sure that the side connectors are properly aligned:



Now connect **TERES-PCB2-IO** with **TERES-PCB1-A64**. For this purpose use the Flat Cable **TERES-027-FPC-IO-Main**.



There are two 40-pin connectors on **TERES-PCB2-IO** and **TERES-PCB1-A64**. You have to open the latch – pull the dark plastic of the connector up and insert the FPC cable above it with the contacts up:

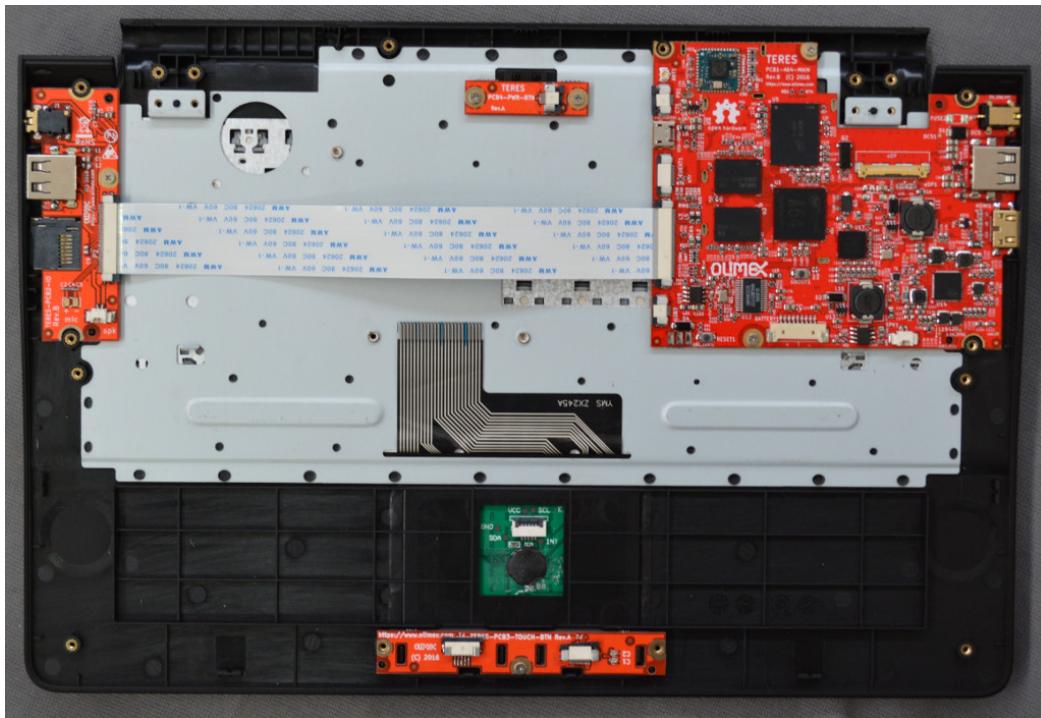


After you have inserted the cable, push the dark plastic back down so it would lock the cable to the connector:

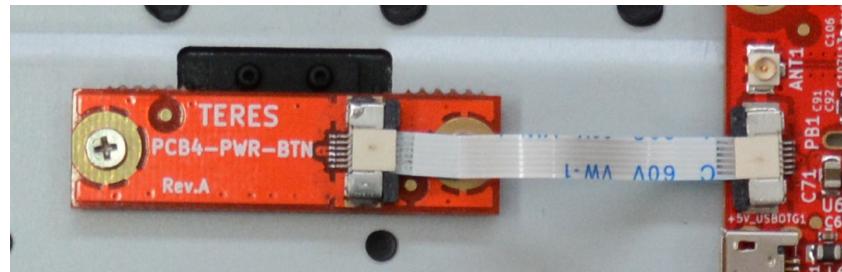


Repeat the same with the **TERES-PCB1-A64**.

Now **TERES-PCB2-IO** and **TERES-PCB1-A64** are connected together:



Do the same for **TERES-PCB4-Btn** and **TERES-PCB1-A64**. Use the small flat cable **TERES-028-FPC-Pwr-Main**. These connectors are similar to the previous ones. You should again disengage the lock (pull the dark plastic up), then insert the flat cable with the contacts pointing UP between the white and dark plastic then push the dark plastic back. Here is the flat cable connected to both connectors:



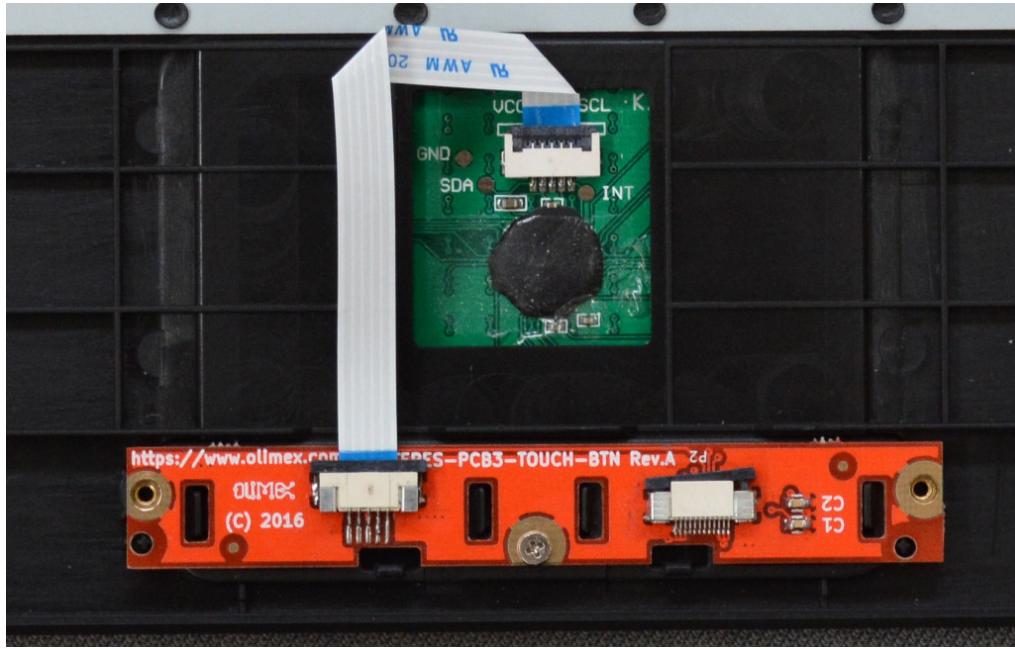
The next step is to connect the touch panel **TERES-023-Touch** to the board with touch buttons **TERES-PCB3-TOUCH**. Use the flat cable **TERES-029-FPC-Touch-Btn**. Note that these connectors are different, the touch panel connector has a hinge and the dark plastic gets opened upside as on this picture:



The flat cable is also inserted with the contacts pointing down and blue back up:

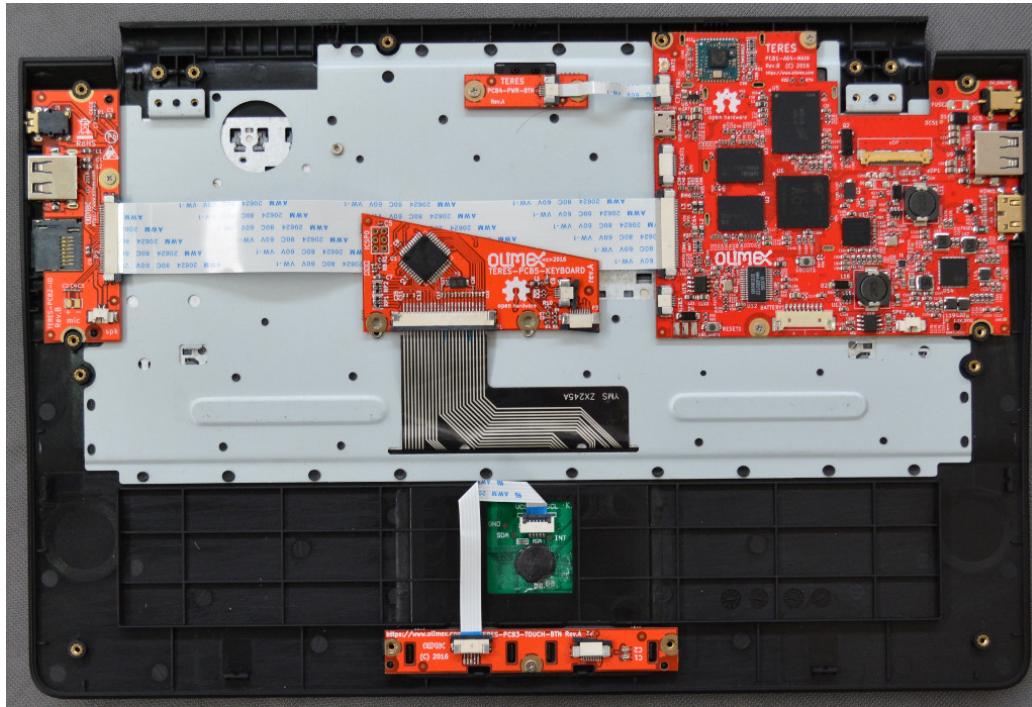


The connector on **TERES-PCB3-TOUCH** is also different so the cable is inserted **below** the dark plastic again with blue back pointing up:



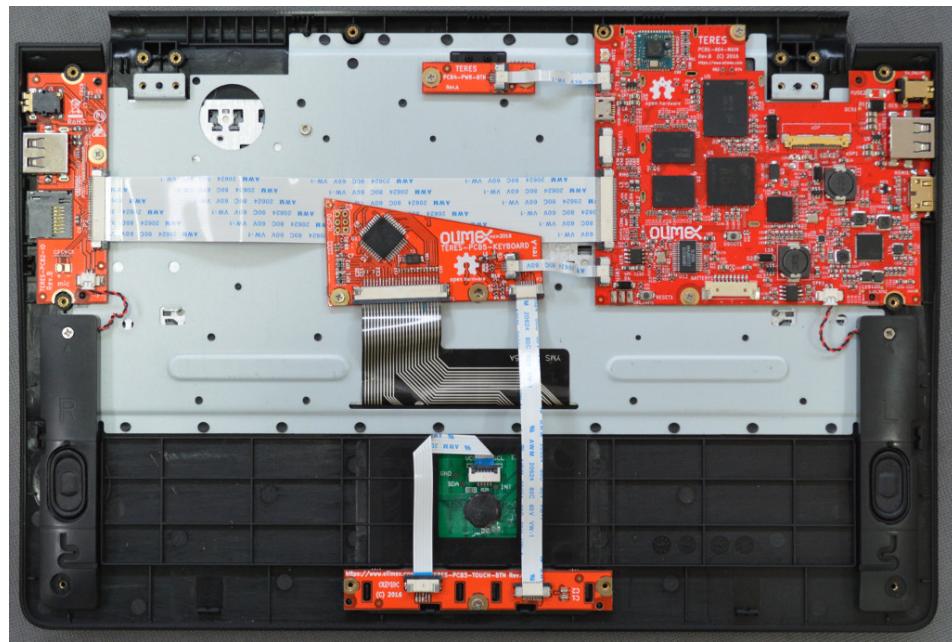
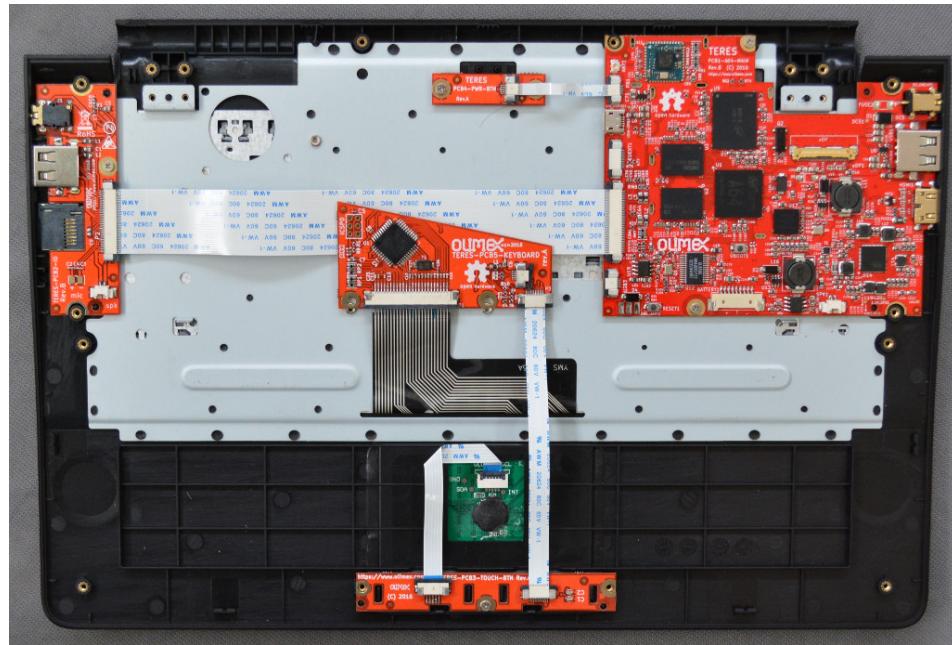
You have to bend the cable twice. Do not bend at a very sharp angle and don't bend it too hard, else it might break!

The next step is to attach the **TERES-PCB5-KEYBOARD** to the keyboard flat cable as shown on the picture below. Note that the cable goes under the black sliding plastic of the connector:



Do not assemble the keyboard PCB to the plastic base yet.

The next step is to connect **TERES-PCB5-KEYBOARD** with **TERES-PCB3-TOUCH**. Use **TERES-031-FPC-Kbd-Btn** flat cable for this purpose. The cable is inserted with contacts up above the black plastic of the connector, the same as the power button and main board cables:



Next connect **TERES-PCB5-KEYBOARD** with **TERES-PCB1-A64** via one left over **028-FPC-Pwr-Main** cable. Attach **TERES-PCB5-KEYBOARD** to the plastic body using just one M2 x 3 screw. Note that only the left screw is placed. The right screw will come when attaching the bottom plastic.

The final assembly step is to attach the left and right speakers. Look at the bottom side you will notice that Right speaker is assembled at the left hand side, and Left speaker – at the right hand side.

For this purpose use M2 x 4 screws and only the upper one is screwed. The speaker connectors should be inserted in **TERES-PCB2-IO** and **TERES-PCB1-A64** boards.

Now continue with LCD frame assembly using the **TERES-008-LCD-Back** as base:



First attach the metal hinges to the **TERES-016-Hinge-Set** using 8 pcs M2 x 4 screws:



Next attach **TERES-026-LCD-cable** to the **TERES-015-LCD11.6"** panel:



With M2 x 1.5 screws assemble the LCD to the plastic. Note that only 4 screws are used!



Connect the **TERES-019-Camera** to the four pin connector of the **TERES-026-LCD-cable**. There are two holes in the camera board which attach to two pins to the plastic body.



Leave the cable of the camera hanging for now.

On the other side attach **TERES-025-WiFi-Antenna** with double sided adhesive tape to the plastic body (the cable path and fit would be described on the pages):



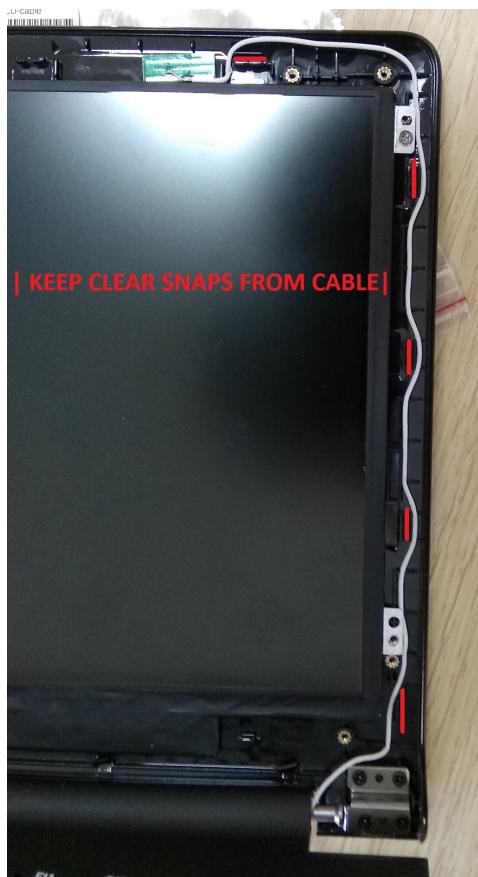
Now comes the most frustrating and time consuming task of the assembly – routing properly the camera and antenna cables to the bottom of the back LCD panel. If you do it correctly the LCD frame that has to be placed over it will snap firmly and there would be no gaps. If you don't do it properly, the two plastic parts will have gaps in between and it is possible to break the plastic locks that hold the back and the front together. If this occurs you would probably need to purchase replacement parts.

Follow the wiring shown on the pictures below for the correct path of the camera and antenna cables. Pay attention on how the cables go around the plastic locks and hinges! It is incredibly important to keep the same layout else the LCD front cover will **NOT** snap properly later.

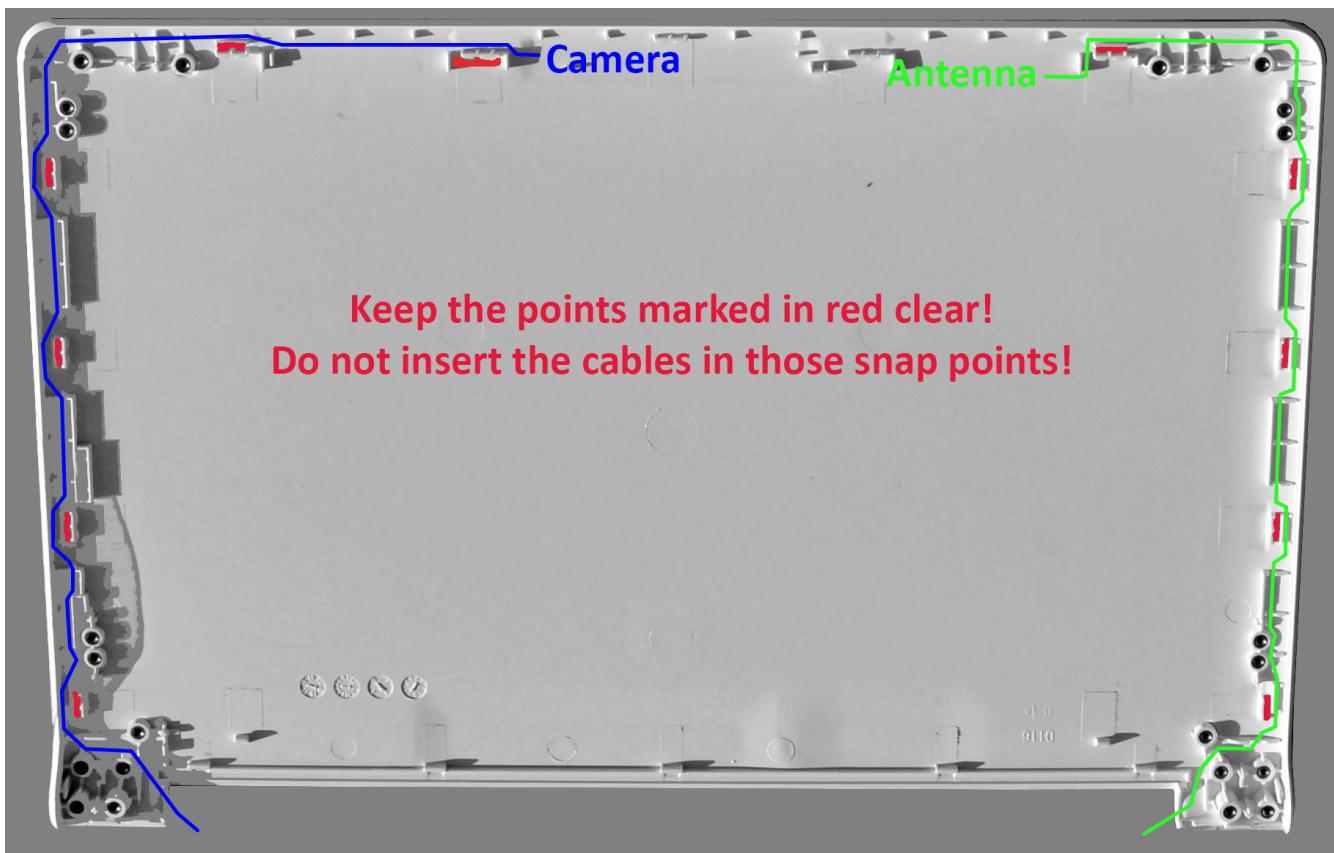
Take your time to inspect the two plastic parts so that you are aware how they snap. This would help you avoid putting the cable between the snap points.

The most important part is to avoid putting the cable in the places marked with red!! Those are the points where the top plastic snaps into the back panel.

The **TERES-025-WiFi-Antenna** should follow this path:



On the next page you can see the suggested path for both cables (common sense also helps).



If you have problems use scotch tape to keep the cable in the suggested path.

Before closing the plastic front and back remember to place the **018-Magnet** in the specially provided gap on the left side of the LCD panel:



Now place the panel. If you did the wiring correctly, the panel will snap tightly. You will have something like this:



If the panel doesn't snap properly and you have to remove the cover to re-do the wiring, please, be patient else the plastic locks can break. You can use a credit card or other similar card as a lever to separate the bottom and top parts of the display.

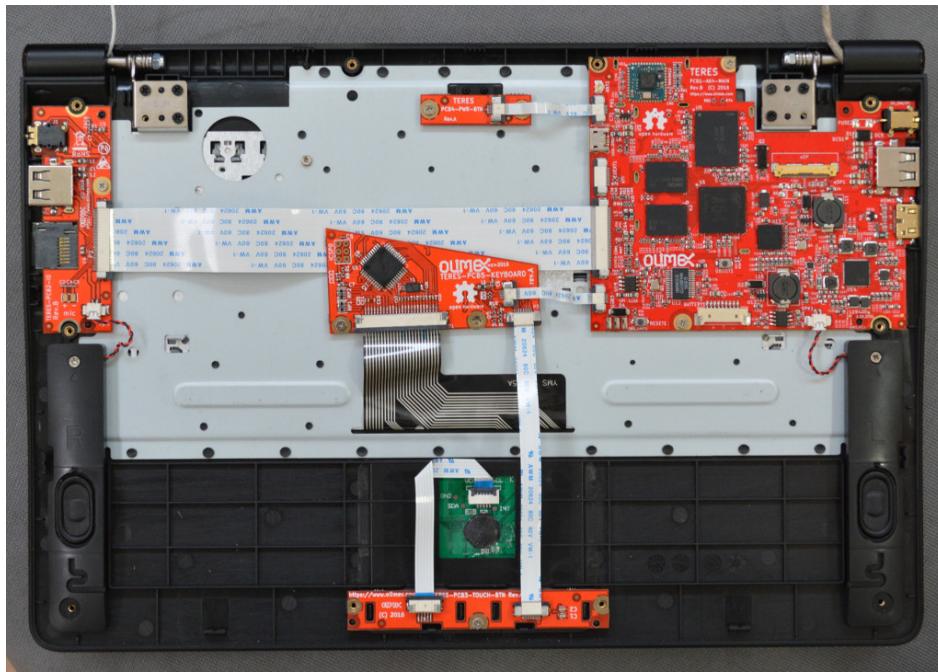
Then fix the upper corners with M2x3 mm screws like this:



Now place the **TERES-020-Camera-Lens** above the camera sensor and rubber mats over the two screws:

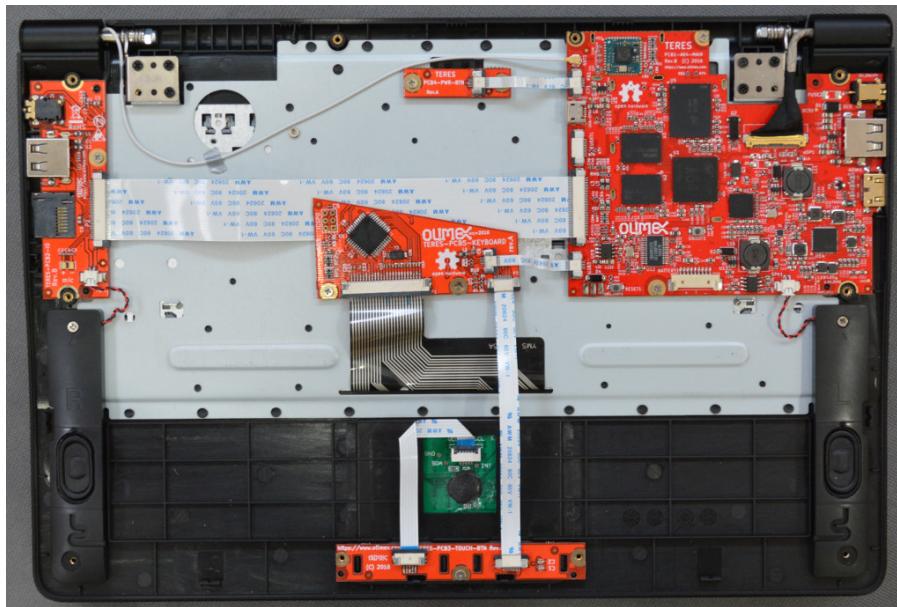


Now assemble the LCD part with the keyboard body. Use 6 screws M2 x 4 mm for this purpose:

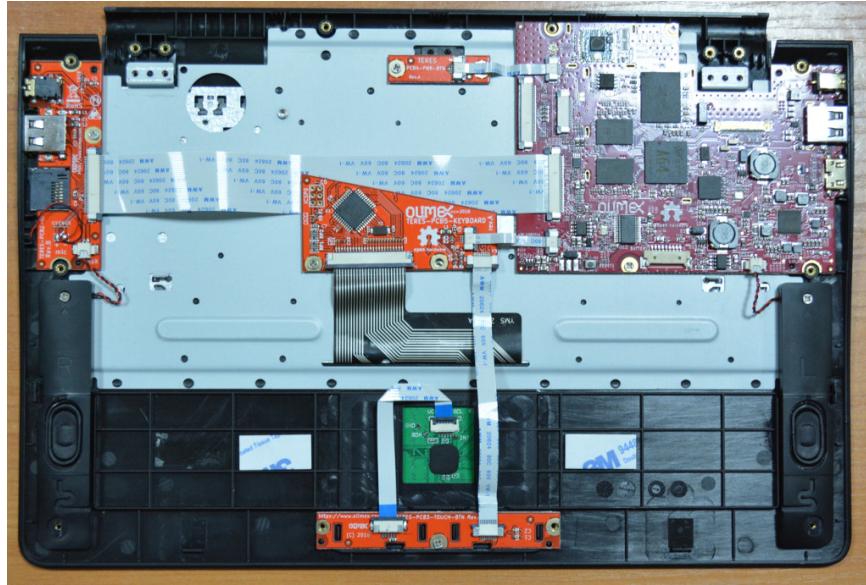


Note that there are four places on the hinges but only three get assembled with screws. The fourth hole should be left empty; the extra screw will come from the bottom plastic body attachment. The places where you have to put screws are stamped at the metal hinges with arrows.

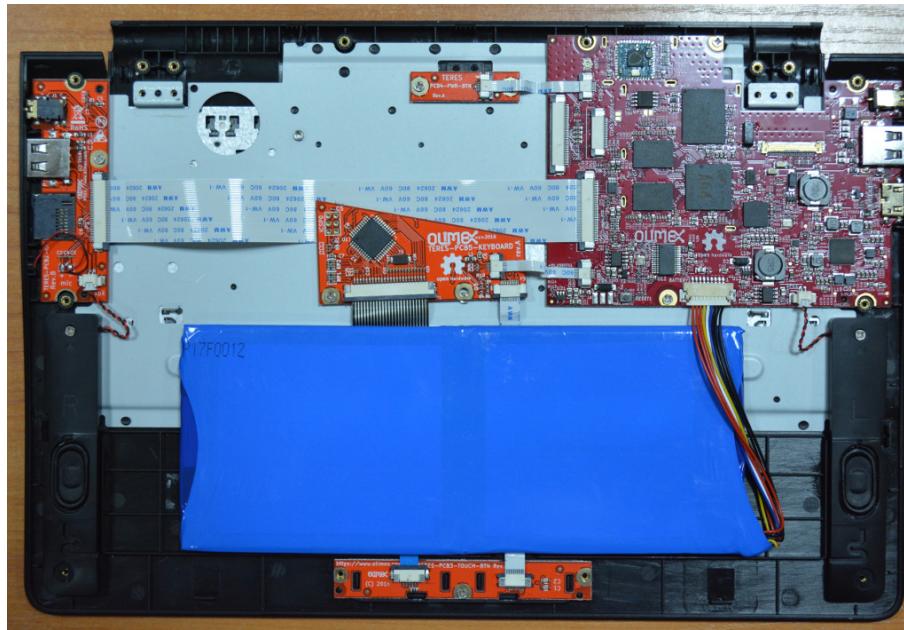
Next connect the WiFi antenna cable and LCD cable to **TERES-PCB1-A64**:



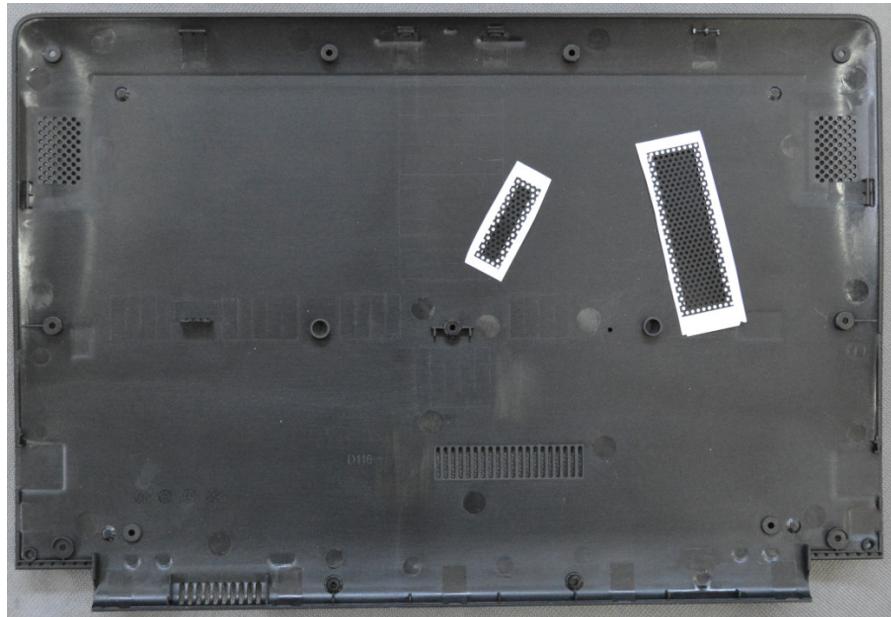
The next step is to attach four double adhesive mats that would hold the LiPo battery in place:



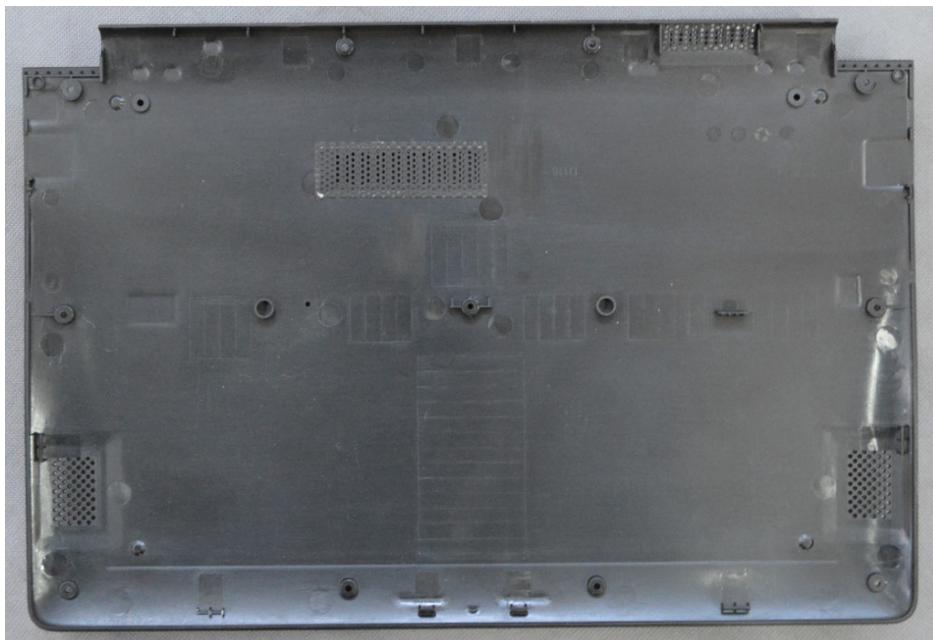
Attach the battery and plug the battery connector to the PCB1. Mind the orientation of the cable and polarity! Red cables should go to the left side.



Next put the **TERES-021-Dust-Protectors** at the openings of the bottom plastic **TERES-005-Bottom**:



In the next image, you see the dust covers placed over the two openings:



Next assemble the bottom plastic using 12 of M2 x 5 screws:



The final step is to attach the rubber mats to the four locations at the bottom:



The assembly is now complete. Now press the PWR button and the laptop will boot:



Congratulations! You assembled your own laptop TERES-I!

9. Updating the image

Once the Linux boots, connect to the Internet (either via the on-board WIFI adapter or using Ethernet cable). You might use the graphical network manager or edit the configuration files via command line. Then open a console terminal (press ALT+CTRL+T) and type:

```
sudo apt update
```

Insert your password if prompted and wait until each of the commands succeeds.

If you decide to completely re-write the image at the eMMC memory, then follow the advice in the next chapter.

10. Installing a fresh official image to TERES-I

In certain cases you might want to update the Linux on the eMMC memory (if the eMMC got corrupted; or if the original installation got damaged; or if there are no other means to update to the latest software release; etc). The typical way of installing the operating system of TERES-I is via a micro SD card (there is a micro SD card slot at the right side of the TERES-I). You would also need SD card writer. Note that the whole procedure takes considerable amount of time and requires good internet connection. The procedure is as follows:

1. Download and extract the latest image provided by Olimex. A download link for the torrent with the latest image is available at the “SOFTWARE” section of the product's page. It looks like this:

The screenshot shows the product page for the TERES-A64-BLACK. At the top, there are links for 'Swag' and 'Retired'. Below that is a 'Products Price List'. The main content area has sections for 'FEATURES' and 'DOCUMENTS'. The 'FEATURES' section lists hardware specifications: Quad Core Allwinner A64 64-bit Cortex-A53 processor, LCD 11.6" 1366x768 pixels, 2GB DDR3L memory, 16GB eMMC flash memory, WiFi 150Mb, BLE 4.0, Camera, HDMI, 2 x USB, Built-in stereo audio, 3.5mm audio jack (stereo out, microphone in), and Batterv 9500mAh. An arrow points from the 'FEATURES' section towards the 'DOCUMENTS' section. The 'DOCUMENTS' section includes links to 'TERES-I manual and assembly instructions' and 'PCB CAD files on GitHub'. Below these are sections for 'HARDWARE' (PCB CAD files on GitHub) and 'SOFTWARE' (Linux build scripts on GitHub and a highlighted 'Torrent with official Ubuntu Mate image'). A pink oval highlights the 'Torrent with official Ubuntu Mate image' link. The 'NOTICE' section at the bottom contains a link to 'Evaluation Board/Kit Important Notice'.

2. Remember to extract the image from the archive.
3. Download the img file to a micro SD card (8GB or bigger) using a micro SD card writer hardware. If you don't know how, use free software like “Etcher”: <https://etcher.io/> - it has builds for Linux,

Windows, and MacOS. Download the installer for your operating system and start the software. Select the image that you extracted. Then point to the drive of the micro SD card. It looks like this:



3. Insert the card in the laptop and start the laptop from the power button, it would boot from the micro SD card.
4. You would be asked for username and password in a command line. The username is olimex and the password is also olimex.
5. Once you login execute the eMMC install script, that would move the files from the card to the built-in eMMC memory inside. Type:

```
sudo install_emmc.sh
```

You would be asked for confirmation and then you would be prompted to select the emmc drive. Select the defaults and wait until the install script completes (it might take up to 15 minutes).

7. Remove the card, so TERES-I can now boot from the fresh image on the eMMC memory.

11. Building the software

Follow the build instructions at the following GitHub location (or download readme.md text file that contains the description):

<https://github.com/OLIMEX/DIY-LAPTOP/tree/rel3/SOFTWARE/A64-TERES/scripts>

12. What's next?

This is a work-in-progress product. We are currently working on a set of extension boards that can turn each TERES-I into a portable lab – a digital storage oscilloscope and logic analyzer.

We are designing new main boards with newer and more powerful processors with more RAM and NAND flash (the trade-off would be a shorter battery life, of course).

Being OSHW we expect community members to release their own ideas, software and hardware projects and designs compatible with the TERES-I.

13. Community links

