Digital X-Ray: Gadgets inspector

Good news, everyone!

Reception of the previous article was rather positive, I have been planning to continue writing for a long time, and Christmas Holidays gave me such an opportunity at last.

This time I would like to tell you about the experience concerning our development of a portable system for X-ray inspection of PCB and different electronics/gadgets.

What is our aim then? We already have premium X-ray detectors, they are actively used for non-destructive testing of welding, ceramics, composites and in scientific research (for example, in St. Petersburg State Electrotechnical Institute LETI or in the Joint Institute of Nuclear Research in Dubna).

The next step is to take a closer look at the market of ready-made/turn-key X-ray imaging systems. Here we can see two directions – X-ray inspection of electronics and tomography. In both cases you need to get maximum resolution and low noise level in X-ray imaging, and our products perform this task perfectly.

Let's start with X-ray inspection of electronics as tomography is quite another world.

Why do we need X-ray inspection of electronics?

Possible variants, underline the appropriate answer:

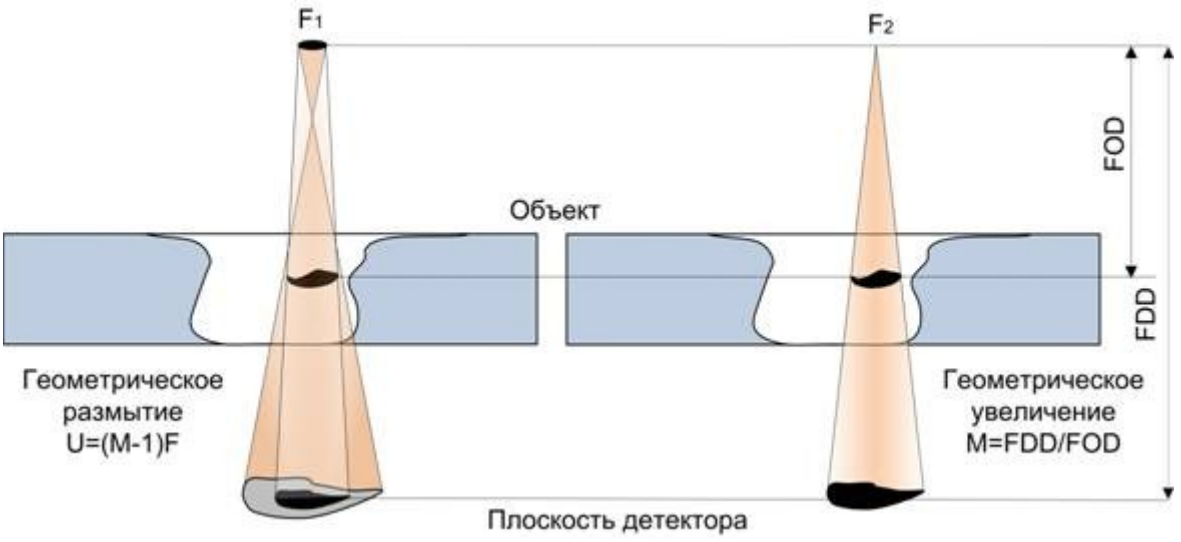
- The craftsmanship at PCB mounting was poor
- Engineers made a blunder with mode at automatic brazing
- BGA microcircuits don't work (mainly memory)
- PCB did not start, perhaps because of short circuit
- Counterfeit integrated circuits (without contacts or just a replica, there is a related article on Habr)
- Poor contact of hot elements and the radiator
- Any other surprise from a Chinese factory
- Reluctance to disassemble the complete product
- Big Brother is watching you and makes a hardware tap

OK Google, how can I perform X-ray inspection of electronics without sms and registration?

- Architecturally the scheme is rather simple – we need a detector (we have it), a source of X-ray radiation (we've found it), a positioning system or something for automatic feed of object of inspection (we'll make it). We pack it everything in a lead shielded cabinet, install software and voila – the system is ready.

  There are many sources of X-ray radiation manufactured in the world, also in Russia. They differ in anode voltage, power, focus size, X-ray beam cone angle etc. We are interested in the class of **microfocus** sources only, when X-ray beam comes from a very small spot (focus). The diameter of this spot must be about several microns, it allows working in geometric magnification mode. The smaller focus is – the less blurring on the border of X-ray projection of our object and higher magnification we can make. In the limit we get X-ray microscopy 5000x and even more.

  For illustration purposes:



Object Geometric blurring U=(M-1)F Detector plane Geometric magnification M=FDD/FOD

Microfocus X-ray source

On the whole it's not *penis canina*. A micron sized spot (5-30 µm) can't adopt large heat rate required for X-ray inspection of metal cases and working in video mode (shot exposition in milliseconds) even on a tungsten anode.

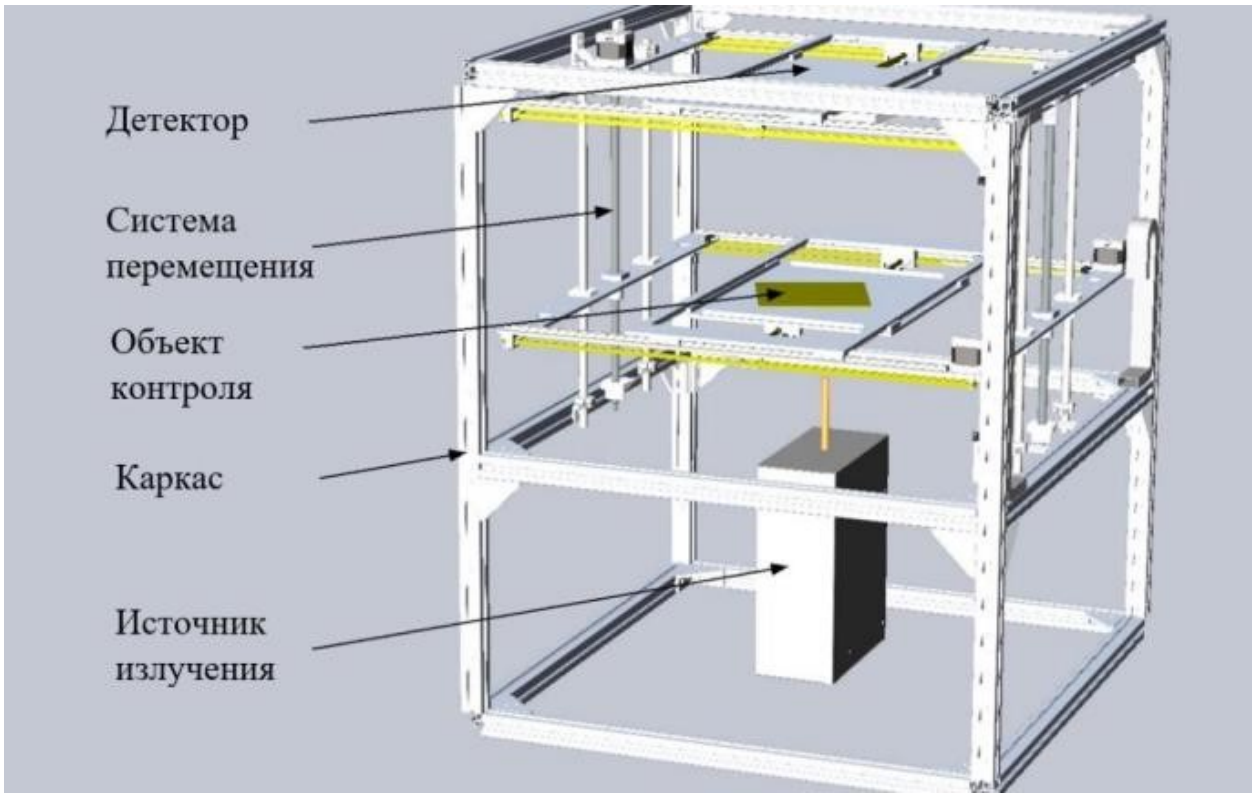
There are many solutions to this problem: diamond substrates, titanic anode cooling systems, X-ray tubes with liquid-metal anode (cost an arm and a leg).

We have chosen a Russian X-ray tube with focus 15-30 µm and water cooling system of anode so that not to make the total price of the system too high. The value of it's geometric magnification coefficient is not large (up to 50x), the power is rather low too (up to 10 W) but that's enough to solve routine tasks.

Positioning system

We need to position the object of inspection under X-ray (XY axes), to play around with magnification (Z axis), so you'd better have an opportunity to look at the object at an angle or turn it by an angle (AB axes). There should be 5 axes in total.

A three-dimensional model looks something like this:



It looks familiar, doesn't it? Essentially it is a 3D printer with 5 axes in CoreXY geometry.

Thanks to science, there is a great number of devotees of 3D printing and there are open projects on electronics and embedded software for them. We've made a prototype on RAMPS + GRBL software with (~~in~~) significant changes.

Peculiarities of work with the Chinese market

I strongly recommend to make own PCB layout and control assembly of new versions of control boards and stepping motor drives. The parts/PCBs bought on Aliexpress can let you down any moment. As for the drivers, common A4988 we had at hand were enough for us but you can also consider more powerful ones on TB6600 boards or their analogs.

As far as the linear guideways are concerned – you can take any branded one, Hiwin, for example, all the rest – in the lap of the gods.

Many components for 3D printers and CNC sold in our country are also bought on Aliexpress. You'll have no guarantees. My own experience – curved guideways, manual cleansing of guideways' carriages, greasing, stepping motors with different turning number and dimensions, different models of bushings and nuts provided that the part numbers are the same – all this is an integral part of working with no-name brands. But it's cheap, indeed. Of course, we've altered everything.

Software

We used OEM software for work with X-ray images for the start as there are some partner development companies for our detectors with the features we need.

We used UGS utility fork for control of the positioning system with some alterations.
The next step is development of our own software best oriented to electronic control and automation of analysis on neural networks.

Summary

We've assembled and launched MVP, adjust and manufacture the series. It's really a wonder that we successfully solve most routine tasks provided that our prices are 50% of our closest European/Japanese colleges' prices.

P.S. If you are interested in what we are doing – don't hesitate to write to us. We'll hire a team for this project. Desktop, Qt, openCV, Linux and – to top it off – Elbrus support optionally.