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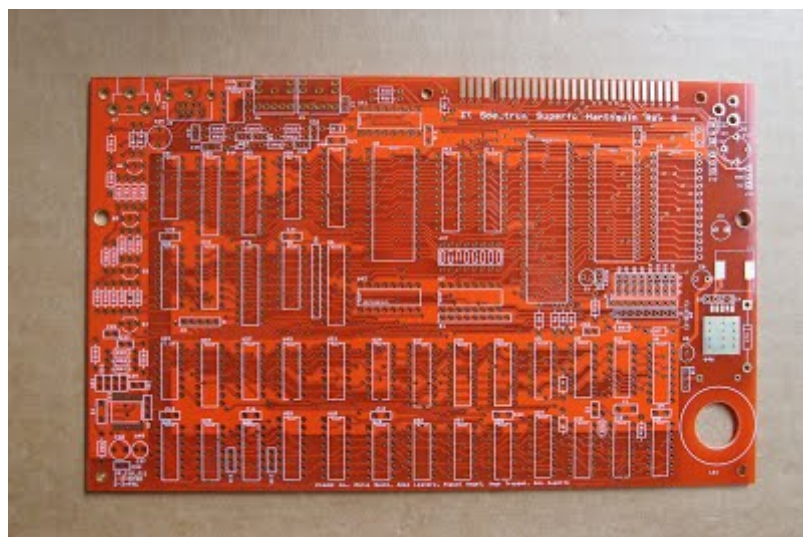
# Building ZX Spectrum Clone - Harlequin - Part 1

posted Mar 1, 2016, 2:16 AM by Sergey Kiselev [ updated Mar 2, 2016, 8:42 PM ]

[ZX Spectrum](#) was a very popular (well, at least in Great Britain and Spain) home computer released in 1982 by Sinclair Research Ltd. And while towards the end of 1980's its popularity declined in the West (due to availability of better computers), various [ZX Spectrum clones](#) became immensely popular in Soviet Union. They were manufactured by quite a few factories, as well as built by hobbyists. Several of my friends had one of these ZX Spectrum clones back then, and I was thinking about building my own (and even started to collect components for it). But somehow that didn't work out, and soon enough I've got an IBM PC/XT compatible, which shortly was upgraded to an AT-386 machine. As you might know I designed and built [quite a few computers](#) already, but every now and then I have a thought of building one of these 8-bit home computers from 80's (be that ZX Spectrum or MSX). Now might be the right time to build the ZX Spectrum...

## Design and PCB

There is one particular roadblock to building ZX Spectrum compatible computer: It uses a proprietary chip, so called "ULA" (basically a programmable logic). To get around, ZX Spectrum clones normally implement ULA functionality using regular logic ICs, but none of them are 100% compatible with the original. Several years ago [Chris Smith](#) reverse engineered the ULA, implemented a ZX Spectrum clone (Harlequin), and wrote [a book](#) about it. And several other folks designed [the board](#) (in Spanish, use [Google Translate](#)) based on this work. I came across a fellow selling Harlequin PCBs on eBay for a reasonable price of \$23 a piece, and bought one.



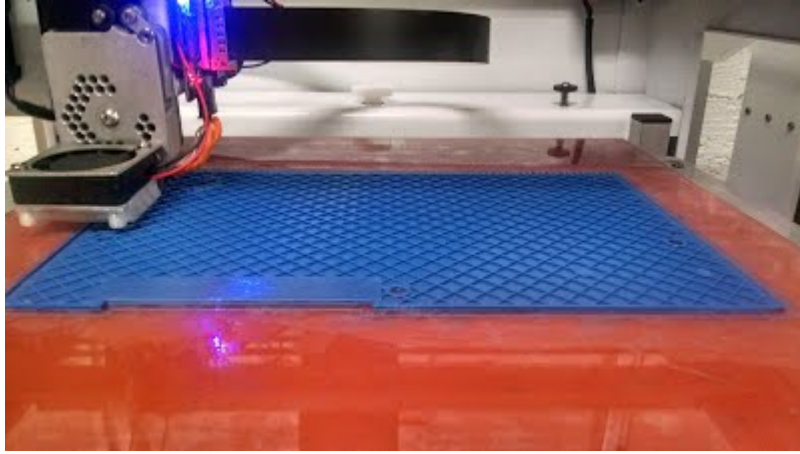
The PCB is a very good quality, with what appears to be ENIG finish. It is also the latest Rev G. of the Harlequin. So I hope it will work nicely without mods.... Actually I do plan to modify the video output circuitry to have S-Video output using [this mod](#). It also quite possible that my flat screen TVs only support NTSC format, so I might do some other modifications as well. Thankfully it seems that this revision of the board has some jumpers to enable NTSC support. We'll see how it works...

## Bill of Materials

It took me several hours to build the BOM based on the schematic and the PCB layout. So here is the link to the [project BOM](#) on Mouser for your enjoyment.

## Case

What could be better than a 3D printer? Well, it turns out - a free 3D printer. Last week I've got access to several pretty nice [Type A Machines Series 1 Pro 3D printers](#) at [TechShop San Francisco](#) and took advantage of them by printing this [ZX Spectrum case](#) I found on the Thingiverse. After 10 or so hours of printing I had the case ready:



Now, it looks like the case is modeled very closely to the original injection molded ZX Spectrum case, and it is not quite optimized for 3D printers. To print it successfully I had to trim the standoffs on the top part, to reduce the amount of support material, and to make sure that the part lays flat on the 3D printer bed. If modifying the case model, I'd also reduce the wall thickness to 2-3 mm or so... Also it appears that mounting holes in the PCB do not quite align with the holes and standoffs in the printed case. It is not a huge problem. I'll enlarge the holes with a file.

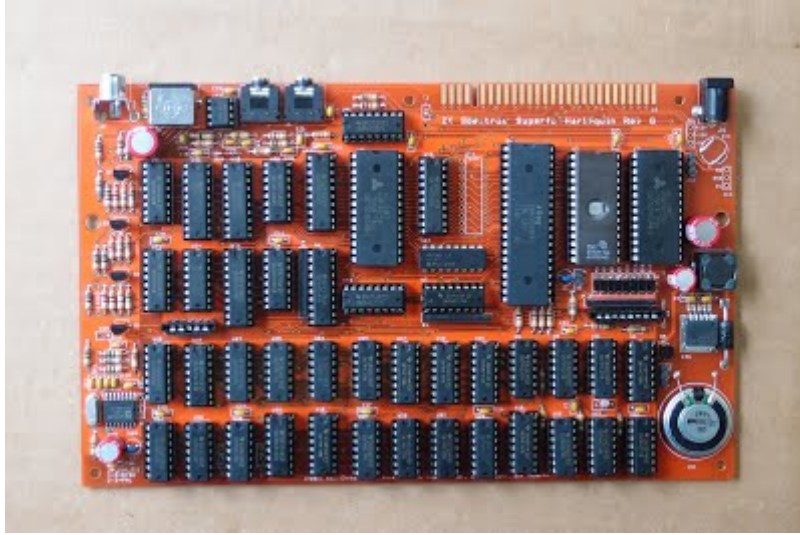
## Keyboard

I considered several possibilities for obtaining a keyboard:

1. Making an adapter for PS/2 keyboard (rejected, because it would be too bulky, and not quite original look and feel)
2. Making a complete keyboard using good mechanical switches (expensive, but I might come back to this later)
3. Buying a ZX Spectrum replacement keyboard. I ended up getting [this keyboard](#). While it is not very cheap, it is still cheaper than the previous option. And while it looks like a membrane keyboard, it is not. It uses tactile switches, and it actually feels pretty good.

## Putting it all together

It took me quite some time to solder all the components to the PCB (yeah, that's a lot of components). As usual I started with soldering SMD parts - the AD724JR, the LM2596, and the inductor. Next I soldered all the low profile components (resistors, diodes, quartz crystals). Next - ceramic capacitors, IC sockets, electrolytic capacitors, and connectors. The speaker was soldered the last, after I cleaned the flux with isopropyl alcohol (it is probably not a good idea to get the speaker wet... who knows). Unfortunately I ran out 20-pin sockets (reordered, should get any time now), so that is the only component missing for my build. I decided not to install diode bridge at the power input, and soldered two pieces of wire instead. Modern power bricks are regulated switching mode power supplies anyway, and they provide DC output.








Here is how the board and the keyboard look in the case (note that mounting holes are not quite aligned, and one 74HC245 IC is missing...):



To be continued... Read [part 2 here](#)



 <a href="#">Bare PCB.jpg</a> (1080k)	Sergey Kiselev, Mar 1, 2016, 2:16 AM	v.1	↓
 <a href="#">Board - Almost Populated.jpg</a> (1062k)	Sergey Kiselev, Mar 1, 2016, 2:16 AM	v.1	↓
 <a href="#">Case - 3D Printing.jpg</a> (794k)	Sergey Kiselev, Mar 1, 2016, 2:16 AM	v.1	↓
 <a href="#">Case - Printed.jpg</a> (697k)	Sergey Kiselev, Mar 1, 2016, 2:16 AM	v.1	↓
 <a href="#">Case - With boards.jpg</a> (858k)	Sergey Kiselev, Mar 1, 2016, 2:16 AM	v.1	↓

## Kommentare

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## Building ZX Spectrum Clone - Harlequin - Part 2

posted Mar 2, 2016, 6:26 PM by Sergey Kiselev [ updated Mar 3, 2016, 8:40 PM ]

Read [part 1 here](#)

### Board Bring-Up

Yesterday evening I received the missing IC socket, soldered it to the board, plugged that 74HC245 IC, connected the keyboard, and quickly moved to test the board. For testing purposes I used this [Diag ROM](#). During the initial power on no magic smoke escaped, and it all looked pretty good. My oscilloscope was showing the right CPU clock frequency, it appeared that CPU is fetching the instructions, and it was some kind of signal on the video output. So I decided to connect the board to the TV... Well, the board appeared to be dead: I didn't get any picture, and it didn't generate any sounds either. It turned to be a few simple mistakes - I plugged it into an Audio input instead of the Composite, and I forgot to install jumpers one connecting the speaker, another one connecting A14/PGM signal to the EPROM :-). That was soon corrected, and I proceeded with the testing.

### Upper RAM Issue

This time Diag ROM started properly, and I've got the picture on the TV, and some beeps sounded through the speaker. While performing the upper RAM test Diag ROM reported errors at address \$FFDC, I repeated the test, this time the error was elsewhere but still within the last 256 bytes of memory space (addresses \$FFxx). I tried swapping out and replacing the SRAM chip, which didn't help. So I am still puzzled, perhaps there is something wrong with the address decode / chip select logic?! (I have to go back and check the schematic) Any ideas?

*Update: I have tested my board using [System Test ROM](#) and [ZX Spectrum Diagnostics](#) and these programs found no problems with upper RAM whatsoever... So it must be a bug in the Diag ROM.*



### Defective Video Input?

Other than the issue above it appeared that the Diag ROM was working OK, except that the picture on the TV was black and white.





I worried that I've done something wrong with setting up the board to work in NTSC mode. I checked the signals on the relevant pins on AD724JR video encoder, and they all looked good. I hooked up my oscilloscope, and it showed perfect (as far as I can tell) composite color signal. I checked the video timing - it looked OK too. After several minutes of confusion, searching the Internets, etc., I've decided to try another video input on the TV. It worked just fine this time:





## ZX Spectrum ROM

I did a few more tests and finally I replaced the Diag ROM with the ZX Spectrum ROM. It booted up happily. And I even ran a small BASIC program (oh boy, now I need to recall how to program this thing):



To be continued...



 TV Picture - Color.jpg (500k)	Sergey Kiselev, Mar 2, 2016, 6:26 PM	v.1	
 TV Picture - Monochrome.jpg (475k)	Sergey Kiselev, Mar 2, 2016, 6:26 PM	v.1	
 TV Picture - Sinclair ROM.jpg (415k)	Sergey Kiselev, Mar 2, 2016, 6:26 PM	v.1	
 TV Picture - Upper RAM error.jpg (504k)	Sergey Kiselev, Mar 2, 2016, 6:26 PM	v.1	

## Kommentare

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