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# Capturing video signal from ZX Spectrum using STM32F4.

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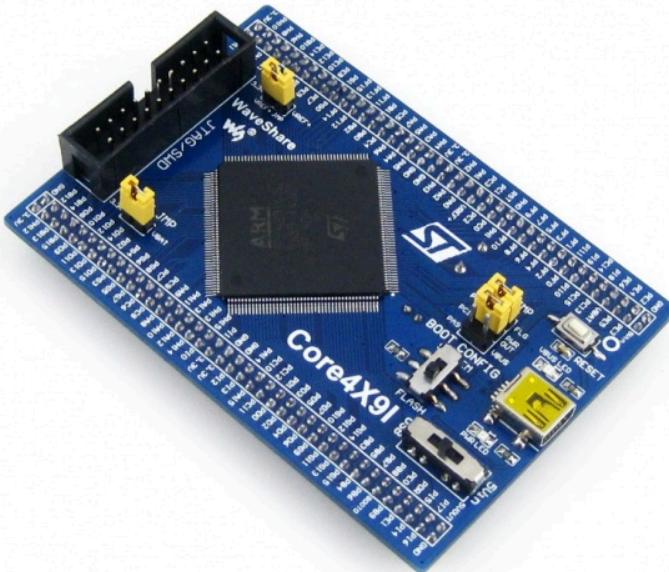
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I have a ZX Spectrum. I wanted to get a color image from it. I don't have a TV with a suitable SCART connector, and buying any adapters isn't an option. :) So, I decided to build my own converter based on the STM32F429, capable of generating a VGA video signal. This was done primarily for self-education.

I once bought a Chinese Core429I module based on the STM32F429.

for we.eeasyelectronics.ru



This module has a certain drawback: the connector pin pitch is 2 mm, which differs from the 2.54 mm pitch connectors typically found on development boards.

Since I was buying this module anyway for experimenting with video signal generation on a microcontroller, I built a special development board containing a VGA connector, an R-2R DAC connected to the LTDC controller pins, a DCMI bus

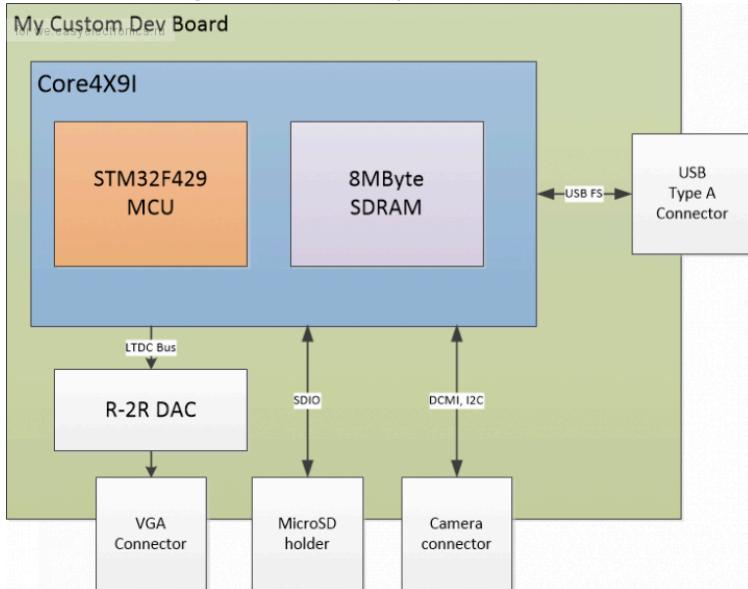
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connector (for connecting a video camera), and several debug connectors.

The structural diagram of this development board:

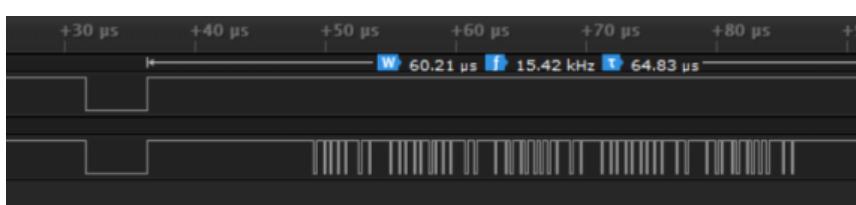
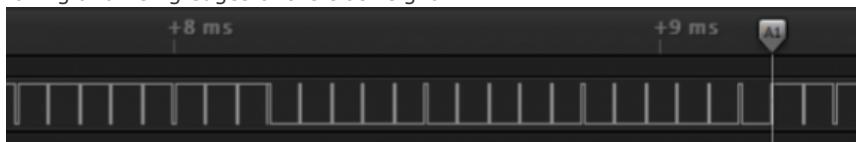


I successfully generated a VGA video signal (16-bit 640x480) using this board, and a video camera based on the OV7670 sensor, connected to the controller, also worked successfully. If anyone is interested in code samples, [they are available here](#).

Next, I wanted to connect a ZX Spectrum to this board.

The Spectrum transmits color video signals over four digital lines: three lines for color and one sync line (containing standard TV vertical and horizontal sync signals). This is what the sync signal looks like ([the vertical blanking pulse](#)

is in the center ): And here's what the sync line and one of the color lines look like: An important question is which interface to use to capture this data. DCMI was an option, but it requires an external clock signal, which would have to be output from the Spectrum. I didn't like this option, so I decided to try capturing data using a combination of a timer, DMA, and GPIO. In this case, to capture data to RAM, you need to configure the DMA module to copy data from the GPIO to RAM, using a signal from one of the timers as a trigger. One important feature of the STM32F4 controllers is worth noting: the controller has two DMA modules, and only the DMA2 controller has access to the peripheral modules located on the AHB1 bus. The GPIO modules are connected to the AHB1 bus. Therefore, only DMA2 can be used for data capture. Data transfer requests for this DMA can be generated by only two timers—TIM1 and TIM8. I decided to use the latter. The selected timer must be synchronized with the Spectrum's clock signal. To achieve this, I connected this signal to the channel 1 input of TIM8, and the timer itself is configured to operate in "Gated" mode. This means that the timer only operates when the clock line is high (that is, when data is to be captured). Furthermore, this timer is configured to generate interrupts on the falling and rising edges of the clock signal.



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A negative-edge interrupt resets the TIM8 timer (it's already stopped by this point due to "Gated" mode). This ensures that the timer always starts counting from 0 after the rising edge of the clock

signal appears. Positive-edge interrupts are used to detect frame pulses. This is done by measuring the time between the rising and falling edges of the clock signal—during frame pulses, this time becomes short.

I use a separate timer to measure this time.

The program logic analyzes this time to determine the number of the currently captured line, which is crucial for correctly displaying the image on the screen.

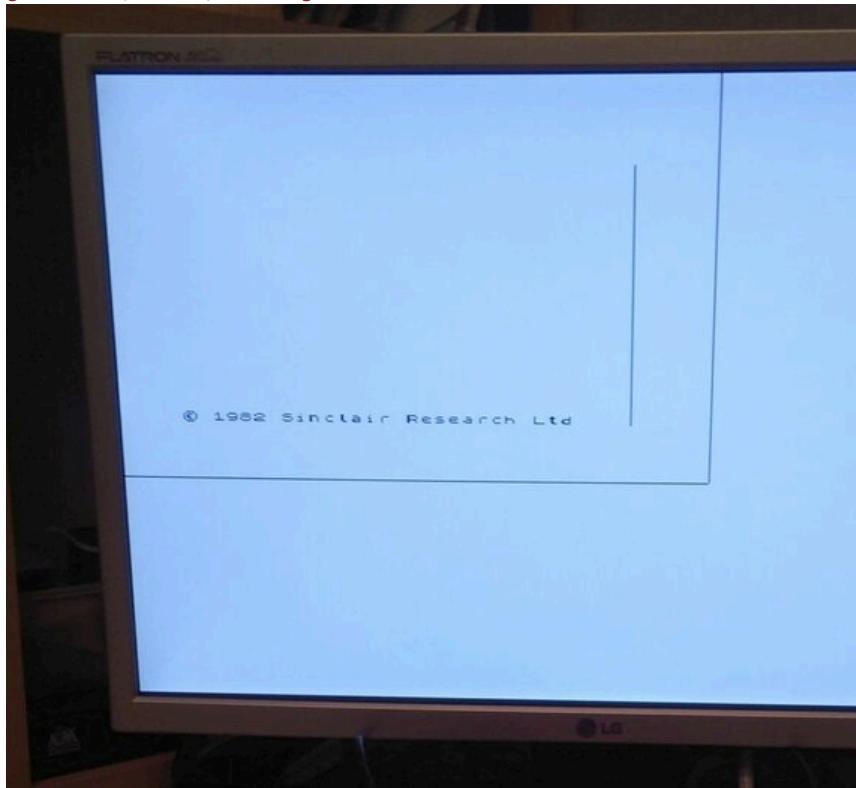
Double buffering is used to display the captured signal on the screen: while the signal from one line is being captured using DMA in RAM, data from the previously captured line is copied to the video buffer by the main program. This requires recoding the captured data to the required pixel color.

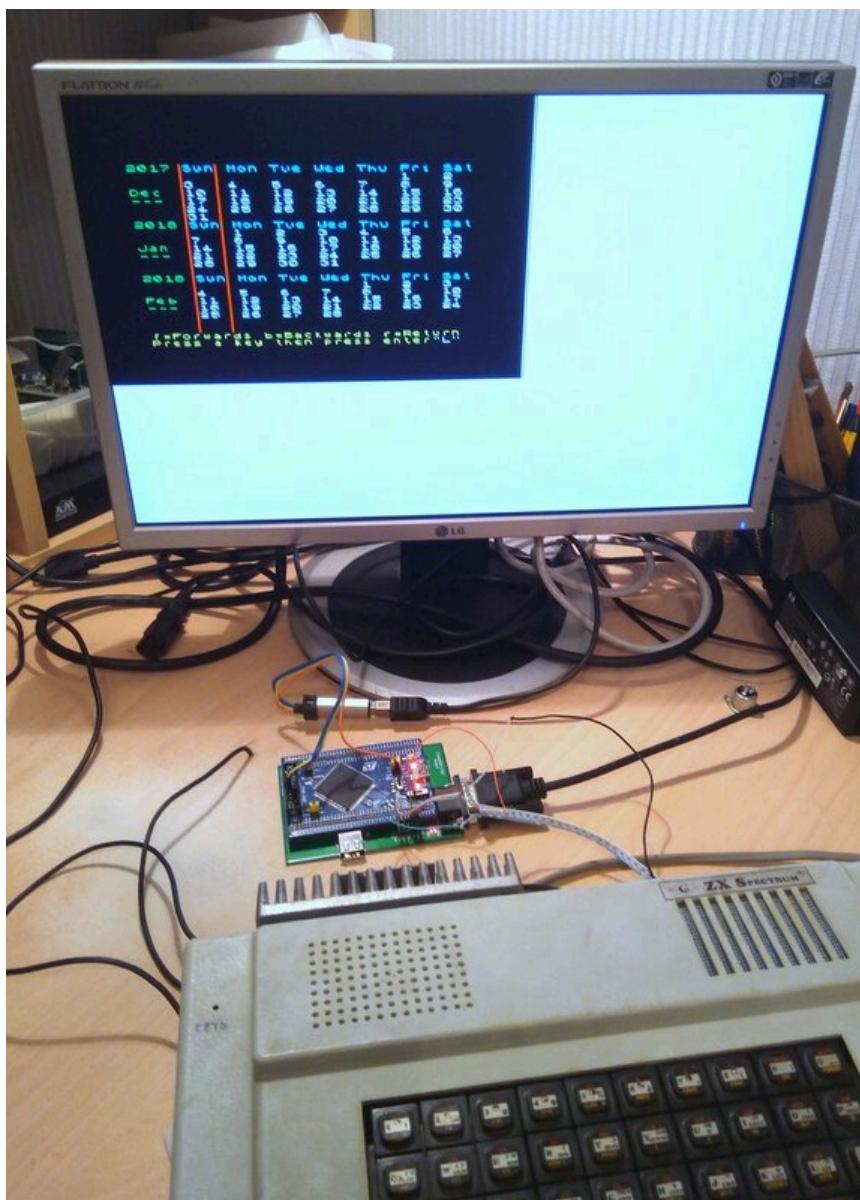
Photos of the converter in action:

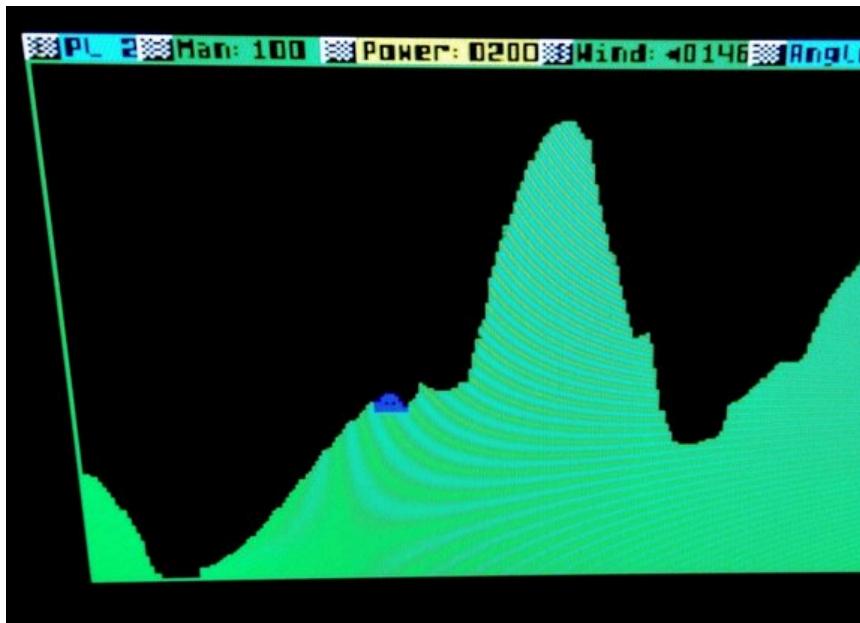
ZX Spectrum loading screen: General view of the design: Loading Tetris:

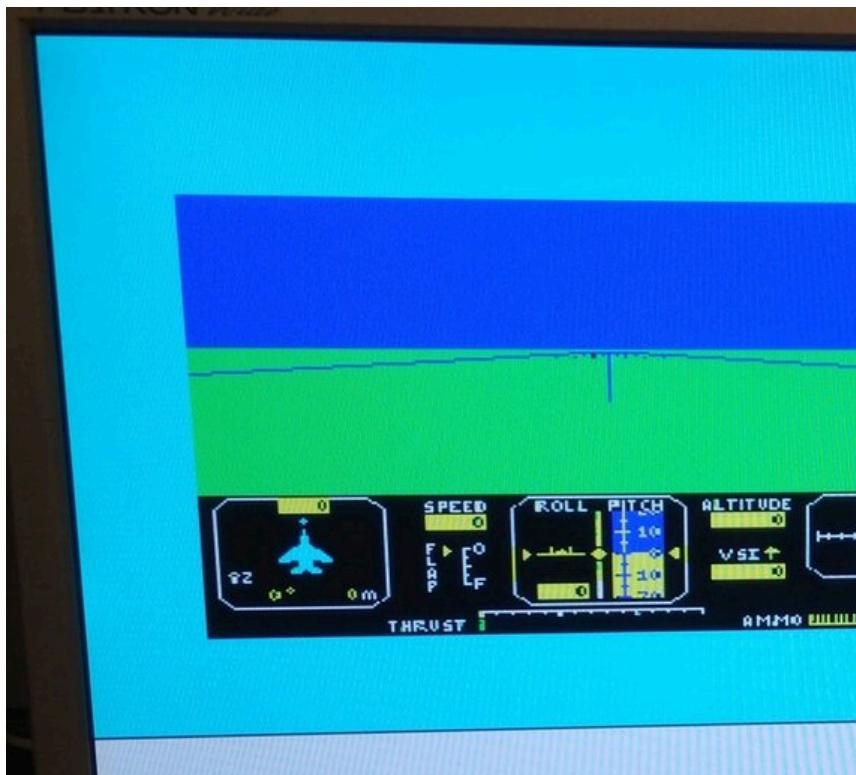
Scorched Earth: Fighter Pilot: Project source code:

[github.com/iliasam/zx\\_to\\_vga](https://github.com/iliasam/zx_to_vga)









STM32 , stm32f429 , ltdc , zx spectrum

+1 March 18, 2018, 6:06 PM **citizen**

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The Spectrum generates color signals. What prevented them from being fed directly to the monitor?

0

**BigLeha**

March 19, 2018, 1:14 PM

The frequencies of the spectrum and VGA monitor do not match.

0

**citizen**

March 19, 2018, 1:50 PM

答复

It is not possible to view photos of the converter in operation.

0

**Aneg**

March 19, 2018, 1:15 PM

I don't quite understand, the last 5 photos aren't displayed at all?

0

**citizen**

March 19, 2018, 1:51 PM

答复

Yes, that's exactly it(

0

**Aneg**

March 19, 2018, 5:29 PM

答复

I checked it in several browsers, and using Opera VPN – it works everywhere.

0

**citizen**

March 19, 2018, 9:44 PM

答复

0

His Yandex is blocked.

**Satellite**  
March 19, 2018, 11:55 PM

↓

0

And in general, it's better to upload the thumbnails directly here.

**VGA**  
March 20, 2018, 3:30 AM

↓

0

The Spectrum window is being centered on the monitor. Is it difficult to move it?

**Sikorski**  
September 2, 2018, 12:47 PM

0

In principle, no, but I like it better this way.

**citizen**  
September 2, 2018, 5:47 PM

↓

0

*The block diagram of this debug board:*

How much did the eight-meter drama cost you?

**VGA**  
September 30, 2018, 4:38 AM

0

*At one time, I bought a Chinese Core429I module based on STM32F429*

The board currently costs around \$30.

**citizen**  
September 30, 2018, 12:24 PM

↓

0

Does it already have SDRAM? You can't see it in the photo, is it underneath?

0

**VGA**  
September 30, 2018, 5:08 PM

↓

0

Yes, it is sealed at the bottom.

0

**citizen**  
September 30, 2018, 5:15 PM

↓

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