# A new experience: The desktop video instrument

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Some years ago we received a Lecroy DSO from a nearby research center. They had surplussed a Bruker mass spectrometry system and the device had been part of that system. It didn't tell, but inside the 19" cabinet there was a Lecroy DSO 9350A used as a digitizer. It came without front panel and without monitor, but with the usual GPIB/RS232c interface combo. The photo shows the device wired for use.
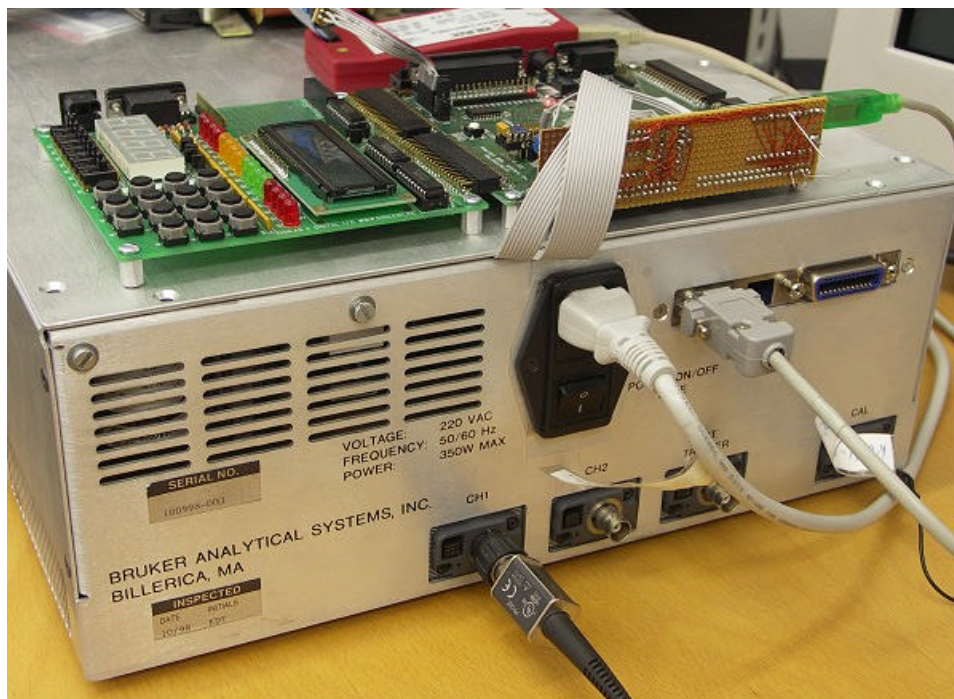

Now, many used Lecroy DSOs and – generally speaking – lots of other computerized high-quality test and measurement equipment from the 90s suffer from a similar problem: The builtin screens are deteriorating over the years and the equipment may become difficult/annoying to use, although still fully functional and reliable. At some point it needs kind of upgrade or repair. During the last two years repair kits showed up that would replace the **bad CRT** by a LCD screen of similar size and resolution, maybe even with colors on screen. Those kits are pricey, around US $ 500 to 2000 when you include the service.

Now when we thought about a solution for our displayless DSO we started with a connection to a PC, using the Lecroy ScopeExplorer tool. What a terrible experience! It took about 20 seconds to update the screen panel, and you have to wait for that update again and again after each and every button press or knob move on the control panel.

Next we wired up a XILINX XC95288XL CPLD and two 512 KByte memories to make a XGA graphics card for the 9350A. This is non-trivial since the Lecroy CRT display is somehow rotated by 90°. It scans bottom up with several KHz and left to right with 50 Hz. So you need a fast random access frame memory to dump video data in one scan direction and at the same time read back frame data in the other scan direction to make this into a standard XGA output. Pixel rate is 48 MHz on the Lecroy side, 66 MHz for XGA analog video. But then you need the XGA display, in addition, finally a somewhat expensive solution. Space and overall size matters. And a flat screen may be noisy and screw up your measurements. XGA screens might become unavailable within some years...

The photo shows the digital video connector on the Lecroy CPU board, probing the existing digital video signals with short wires. The additional socket was glued onto the Lecroy ASIC. It contains twelve bits of video data plus HSync, VSync, pixel clock and power plus several ground connections.
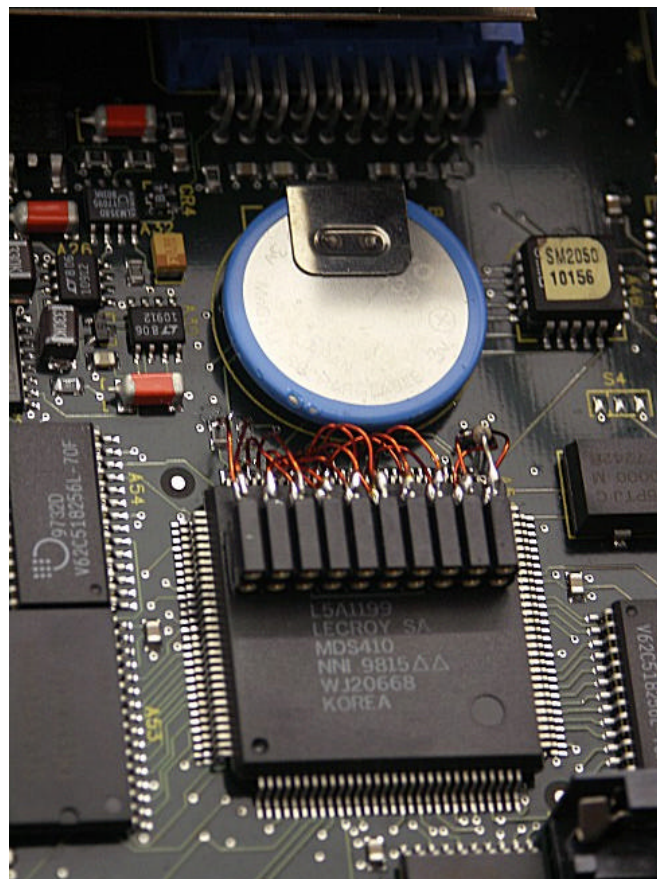

Anyway, we learned that the 9350A works with **screen colors** internally and we were able to get those colors onto the XGA screen by taking the proper signals from the CPU board. So this became more interesting.

Then we had to do some more work with FPGAs and USB and we decided to get the Lecroy screen as a video into a Windows XP desktop panel. Some obvious preconditions were:

- Don't use USB II with a high continuous data rate and CPU load,

- get the color image and
- get it as video with several frames per second.

These requirements can be fulfilled with a good image compressor that we wrote in Verilog for a Xilinx Spartan FPGA and first realized on a Digilent DIGILAB IIE board. That FPGA has enough pins and speed to connect the digital video from the Lecroy CPU board. We added a USB FIFO chip and a fast 32 KBytes SRAM. The SRAM is used in DMA mode as a FIFO to adapt the video compressor output data rate of up to 48 MBytes per second down to the compressed video data stream of about 300 to 500 KBytes pre second. Here we are talking about a lossless compression with a compression factor of about 100. Of course the output data rate depends on the complexity of the screen image. The quoted data rate is for a constant 12.5 fps, that is we transfer 1 out of 4 frames. The compressor and its data protocol implements a **throttle** mechanism, so it can reduce data rate without loosing frame sync. This will happen when the data rate exceeds about 800 to 1000 KBytes per second, which is the physical limit of the USB connection. Power consumption of the FPGA and USB circuitry is negligible considering the power consumption of a Lecroy 93xx DSO. The image shows the FPGA development setup. The red box at the bottom is a Xilinx USB II Platform Cable (JTAG). Power and clock are taken from the Lecroy DVI connection.
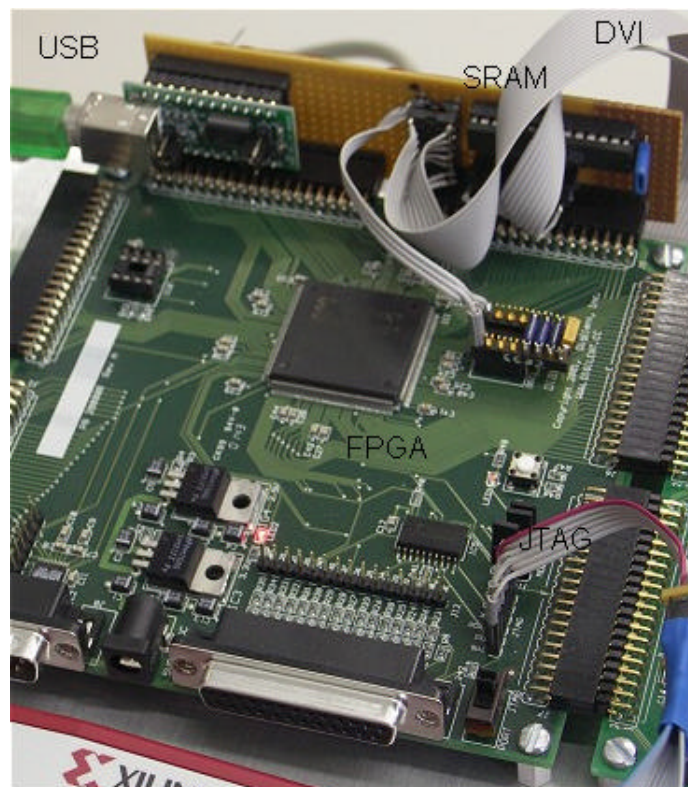
Then we wrote a small Win32 application to receive and uncompress the video stream and display it into a desktop window. Average continous CPU load is about 3% on a 3GHz Intel P4 machine, as displayed in the Windows XP Task Manager panel. On a more recent PC that would reduce even more, maybe to less than 1%.

Once we had that, we implemented our own **control panel** next to the screen video. Our control panel is based on a digital image of a real Lecroy 93xx DSO control panel, plus some special alpha-blending software for the visual feedback. The control panel software supports the onscreen menu buttons, and it corrects the channel 2 errors in ScopeExplorer that happen with two channel 93xx scopes. Now i can operate the control panel buttons with the left mouse button and turn the knobs using the mouse wheel. I can also turn the knobs using mouse clicks on arrows, as in ScopeExplorer. The virtual knobs won't break anymore!

The image shows the Win32 application panel, which is much larger on screen and which shows the DSO screen with each pixel and in color. Note the hilited trace 1 zoom section (in the red trace). The Lecroy video ASIC uses intensities also for curve smoothing.
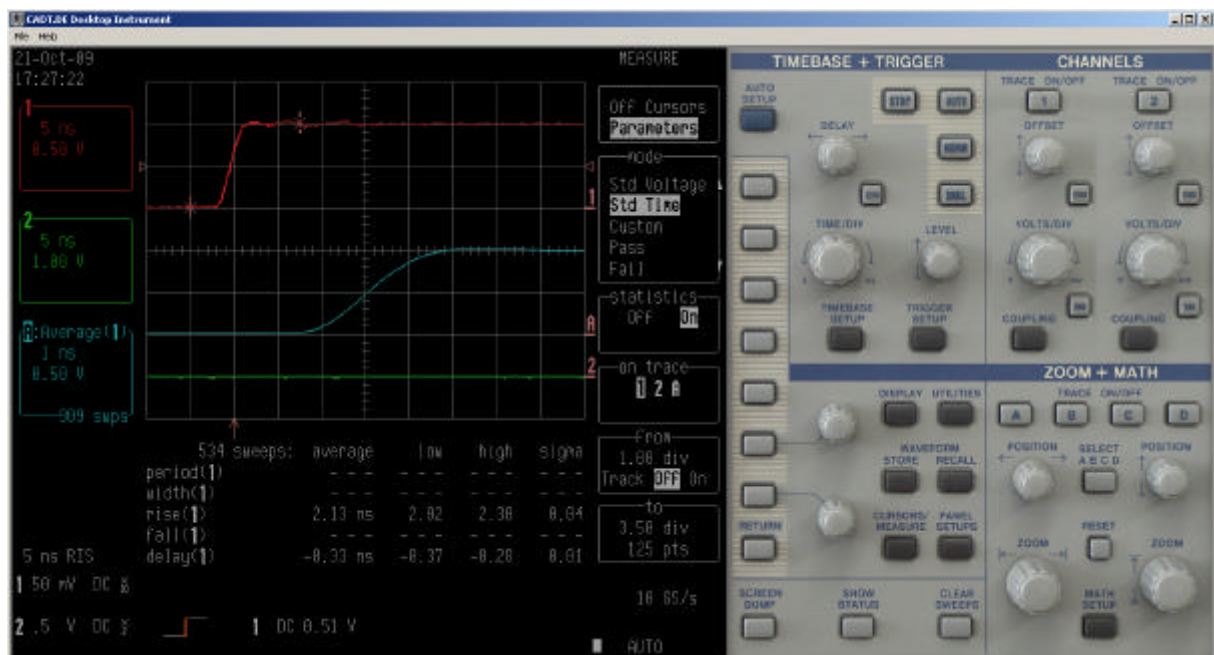
We have a screen recorder digital video that we can provide on request. That video also demonstrates the mouse visual feedback in the control panel. It is much more impressive than a still image.

Now our intial problem solving approach has turned into something completely different: An innovative solution that we may call **desktop video instrument**. It gives me a completely new user experience. Somehow the scope moved „inside" my everyday workstation, with its two large screens, with its two CPUs, its RAID disks, its DVD Burner etc. With a mouse click i can get color screen captures – either as still image or as video.

And this solution is simple and easy to integrate into any Lecroy 93xx scope and – more generally speaking – into many other devices. For example we have a very nice HP 8560A spectrum analyzer with builtin tracking generator which should get a similar USB interface as soon as possible. For the Lecroy 93xx, we found a good place for the FPGA video compressor/USB board is the UART chip socket. We can even use the FPGA to replace that old UART by something with a FIFO. The old

UART doesn't handshake well with a modern computer, because it lacks the buffers. Of course we can also integrate a direct data path from the video USB device to the UART socket, simulating the UART for the Lecroy M68K CPU. Then the video data stream and the automation data run through the same physical USB connection. With the help of a little extra logic even the FPGA configuration data stream can be sent through the same USB connection. That means the same simple hardware can be used for various video standards. And finally our Win32 application should become an automation server that accepts commands, transmits them to the DSO and returns results.

Cost estimate for our new automation interface including digital video:

About € 200 for a Lecroy 93xx DSO. The upgrade involves engineering mods in the CPU board (DVI connection). All previous device functions fully persist with the upgrade. When the upgrade is removed, only the CPU board mods and the USB connector hole remain, as visible in the images above. If interested, please communicate to dieter@cadt.de. We may provide a kit or apply the upgrade in our lab.