

SmartScope: Multi-Platform Measuring Instrument

Clever and distinctive USB scope

By Harry Baggen (Elektor Netherlands Editorial)

Most USB oscilloscopes have been designed for use in combination with a Windows or Linux PC. The SmartScope is an exception to this: it works just as well with an Android tablet, an iPad or an OS X system. The software has been designed to make the user interface appear identical across all platforms. We've tried one out on a PC and a tablet.

A fair number of (USB) oscilloscopes have previously been reviewed and tested in Elektor. However, the SmartScope is a measuring instrument that differs significantly from the competition, in both hardware as well as software. Before we take a closer look at the SmartScope, we'll first find out how this project got started.

History

When electronic engineer Riemer Grootjans acquired a number of different USB scopes for use at work and at home, he wasn't very pleased with these devices. He started to think about designing one himself, which would have all the features he expected of a USB scope: versatile, portable, easily extended, and with an intuitive user interface. He started to design the SmartScope along with two of his friends and set up a Kickstarter campaign. Within a month their company (LabNation) achieved over \$300,000 of funding, which was

sufficient to start planning the production of these devices. A lot of hard work was still ahead of them in the following few months. Although the design for the hardware was completed before the Kickstarter campaign, there turned out to be so much demand for a sample buffer in the hardware that they decided to create a completely new design. They succeeded after many sleepless nights, and by the end of 2014, all of their 1500 backers had received their SmartScope (the production started in August 2014).

Hardware

The hardware for the SmartScope consists of a small metal enclosure (for good shielding), with a pair of full-sized BNC connectors on the front for the analog inputs, and a 16-pin header at the back, for the 8 digital inputs of the logic analyzer, 4 digital outputs, and the output of the built-in arbitrary waveform generator (AWG). Also on the back are a mini and

a micro USB connector. The mini-USB is for connecting to a tablet, smartphone or computer, the micro-USB is used to connect an external power supply, or for daisy-chaining several SmartScopes together. This last feature has not yet been implemented, so the SmartScope currently operates with 2 channels.

The printed circuit board contains a powerful Xilinx Spartan 6 FPGA, which takes care of the main tasks (such as processing the received measurement data and creating the AWG signal). The conversion of the input signals is taken care of by an A/D converter with 100 Msamples/channel and a resolution of 8 bits. A RAM chip provides a buffer capacity of 4 Msamples/channel. A PIC controller takes care of the communications with the computer via de USB connection. There are several relays and opamps at the inputs for the range and AC/DC selections. The bandwidth of the analog input section is 45 MHz. This is quite large compared to the sample frequency of 100 Msamples/s. This was done on purpose in order to minimize the attenuation of the input signals as much as possible. The usable input range is up to about 10 to 20 MHz (which is also stated by LabNation).

Software

One of the most important goals that the developers had in mind was that the software should run under almost any operating system, with an identical user interface. This is something they've certainly accomplished. As far as we know, this is the only scope that works on virtually all operating systems: Windows 7/8, Linux, OS X, iOS (jailbroken) and Android 4.0+. It can therefore run on a standard PC or a laptop, but also on a tablet or a smartphone.

The developers also felt that the controls on most USB scopes were somewhat limiting. The user interface is usually some sort of copy of that found on hardware scopes, which has been in existence since the fifties. The whole control panel including the knobs is often simulated on the screen, or pull-down menus are used for all kinds of settings. This was thought to be a bit out of date, and found not to be very intuitive.

The software for the SmartScope had to be different and should make use of modern interfaces such as touchscreens. This didn't appear to be very difficult at first, but it required a lot of thought and hard work before a functional alternative was created. The result is a control surface that reminds you of your first experience with a tablet or smartphone: it is a bit strange to start with, but it soon feels right. It's as if you've given somebody their first tablet: they'll play with it for a bit and after quarter of an hour it looks as if they've been using it all their life. The same happens with the software for the SmartScope. It takes a little bit of time to get used to it, but then it becomes so obvious that you don't want to return to the old-fashioned methods.

Functionality

The software was installed on a Windows PC and an Android tablet. The Android device needs to be running Android version 4.0 or above, and requires USB-host support. All of the software versions are available from LabNation's website [1]. The Android app can also be found on Google Play. For a tablet you will also need a micro-USB OTG cable (which costs a few dollars) to connect it to the SmartScope. The combination of a

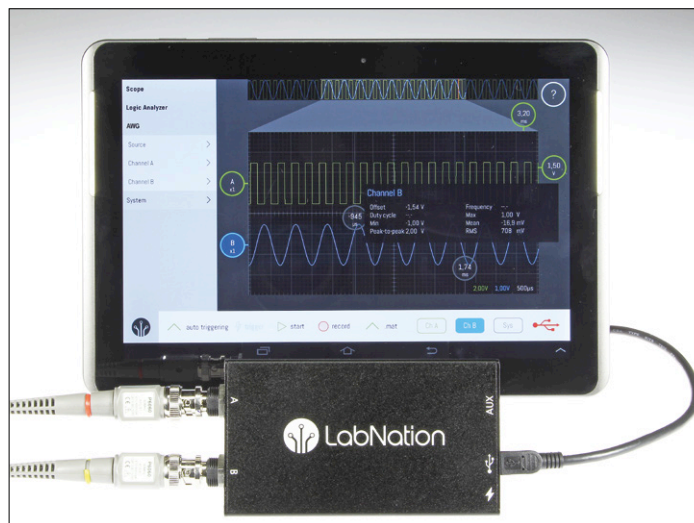


Figure 1. The SmartScope hardware works eminently with a tablet.

tablet and SmartScope creates a very useful mobile measuring instrument, since the scope is powered by the tablet, which means you can use it away from the mains supply.

When the software starts, it first loads the complete 'firmware' for the SmartScope into the FPGA. This takes just a single second. With this method you can be assured that you will always have the most recent version. You won't need a bootloader or flash memory in the device either.

The software looks the same on both systems and always starts in oscilloscope mode (**Figure 2**). On the left is the main menu with all the settings. At the bottom are a few of the most commonly used settings. The rest of the screen is taken up by the scope display with a scale, where the measured signals will be displayed. These are the two analog inputs or the eight digital inputs when in the logic analyzer-mode; when one of the built-in serial decoders is used, the decoded data will also be displayed.

Up to now, there's been nothing really special. What is remarkable is the absence of control knobs and buttons. Instead of using menus and knobs, almost everything is done via mouse clicks or (in case of a touchscreen) by swiping your fingers.

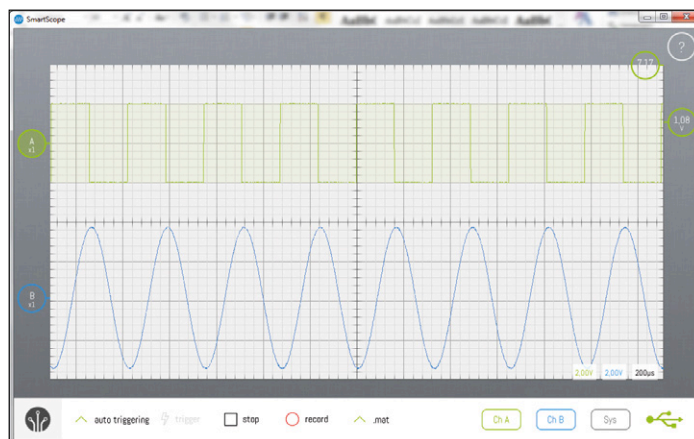


Figure 2. The standard oscilloscope display has very few control elements, as most settings are done via the touchscreen or mouse.

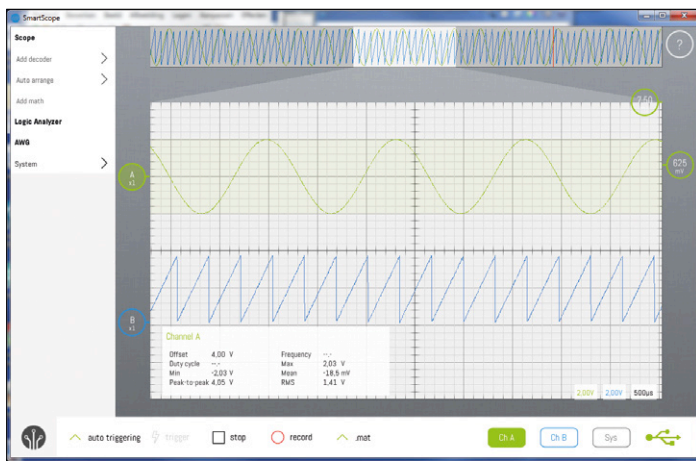


Figure 3. The contents of the hardware buffer can be shown at the top of the display, from where you can select a section and zoom in on it.

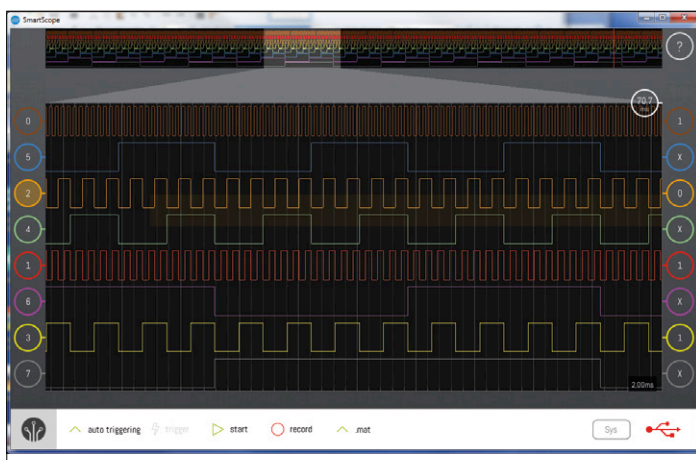


Figure 4. The logic analyzer with its 8 channels. You can easily access the 4 million measurements in the hardware buffer and inspect them in detail. The background is now black to make the waveforms easier to see.

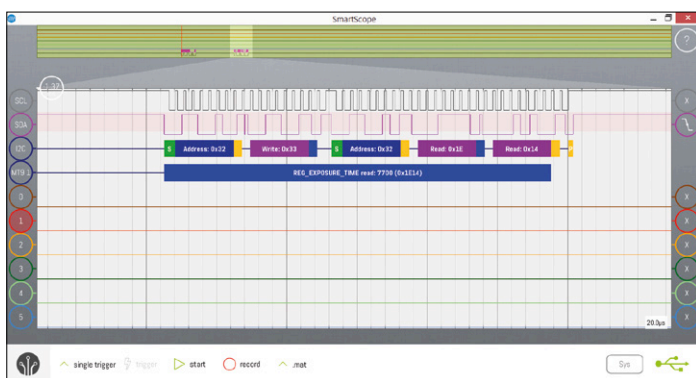


Figure 5. In this screenshot the signals on the I²C bus have been processed by a standard I²C decoder. The results have then been converted by a custom decoder into an easily readable format.

This does take some time to get used to. But once you've found out how to change a setting (such as changing the input gain using a pinch/stretch gesture with two fingers) it soon becomes second nature.

Each signal has an identically colored circle to the left of the grid, which hides a number of functions. When you touch it or click on it with the mouse a small menu appears that lets you set up the AC/DC coupling, triggering, probe attenuation or hide the signal. There is a similar circle at the right of the grid. The menu associated with this lets you select the trigger channel and either the rising or the falling edge for triggering. A status box can be displayed that shows the settings and a lot of detailed information about the signal. When it is no longer required, you can just drag it off the screen.

At the top of the display you can call up the hardware memory buffer. This shows the full contents of the buffer (4 Msamples). From here you can quickly and easily select a section that interests you so you can look at it more closely.

The menu on the left has a section that lets you set up the AWG. At the moment the user can choose from a number of standard wave forms, or import a user-defined signal from a CSV file, which can be stored in Dropbox or a local hard drive. One thing that stands out is that a number of digital decoders are included as standard with the software. It's unusual to see this for products in this price range (you would expect to pay for these as an extra). These decoders are used to unravel different types of digital formats and to display things such as the actual values and addresses of the data. At the time of writing, there are decoders for I²C, 3-wire and 4-wire SPI and UART included with the software, and there are more to follow. It is also possible for users to write their own decoder, and to make it available to the SmartScope community. Such a decoder consists of a single DLL file, which should be added to the SmartScope system folder. This has been set up in such a way that it can work across all platforms without modifications. It's quite possible that some features have not been mentioned, but at least you should now have a good idea what this scope is capable of.

In practice

We've now come to the stage where we connect the device and start using it in earnest. The PC version of the software was tried out first, and it took a while to get used to it. To start with, we regularly found ourselves looking up instructions from the Help, or tried to discover where a particular function was. It will take some time before you'll be able to operate the software like a pro. However, with the tablet versions things progressed much more quickly. You'll soon find out that the program was developed for use with a touchscreen. In this case, it took only several minutes to find out how to operate it, and it was also much easier to try things out.

In both cases it was noticeable how quickly the scope responded. You get the same experience as if you were using a 'standard' scope. It is often the case that USB scopes experience a delay between the scope hardware and the processing and displaying of data on the computer. You don't notice any delay with this device, so that's a job well done by LabNation. The time and voltage scales can be adjusted via pinch/stretch gestures with your fingers or with the scroll wheel of your mouse. The scale is updated immediately, going to the next, rounded,

▶ The built-in hardware buffer is unique in this price range

value. It is even possible to set a different voltage scale for each analog input signal.

The panorama bar is a very useful feature, which can be made to appear at the top of the display. This shows all of the 4 million samples stored in the hardware memory. From here you can select any section using touch or the mouse, which will then be displayed on the main scope screen. The complete contents of the memory can also be exported and stored in a file. The AWG can create several waveforms as standard, which have a number of adjustable parameters. The slide controls for these are quite small, which makes it difficult to adjust the values to a precise figure, especially for the frequency. An extra (numerical?) input method would be a welcome addition here. You can create your own waveforms by putting values into a CSV file, but this is not a very user-friendly method. The developers have indicated that they're continually adding to the functionality, so this is one area that should see some improvement in the future.

The logic analyzer is just as easy to control as the scope section. Many electronic engineers rarely use these functions on a standalone device because the operation is so tricky. However, it's a piece of cake in this case. You can set an 8-bit trigger word by clicking/touching the circles on the right of the display. Further development of this section is planned for the future as well.

The digital decoders in the SmartScope can be used on both analog signals as well as digital signals to decode various protocols. Some of the more popular ones have already been included. A small test with an I²C bus quickly revealed how useful these decoders are. Without too much effort, you'll be able to see the values or addresses on the screen. It is even possible to set up two decoders in series, where the second one processes the results produced by the first decoder. An example of this is shown in **Figure 5**, where the data in the hardware buffer has first been decoded by the standard I²C decoder. Its output is then processed further by the second

decoder, which displays the results in an easily readable format: It shows the register number followed by the value of the next two bytes, combined as a word.

Conclusion

Although the specifications and features of the SmartScope at first appear similar to other devices in this price range, it soon becomes apparent that it has several features that none of the others has, such as the built-in hardware buffer and the digital decoders. This instrument provides you with an extensive measurement arsenal: Not only do you get two analog inputs, but there also eight digital inputs, four programmable digital outputs and last but not least, the AWG. When you consider the number of accessories that are included as standard (two probes, connection cables for the AWG and digital inputs/outputs, test clips and a USB cable) it becomes clear that the SmartScope is a successful measuring instrument that is certainly worth its €230 price tag (\$/£ pricing is conversion dependent).

The software is unique in that it can run on virtually any platform. The interface does take some time to get used to, and may not appeal to everybody, but we're certain that it will become better, more flexible and extensive in the future. The people at LabNation are continuously developing the software, and several items were added or improved during the time we evaluated the scope.

The best way to control the SmartScope is with a touchscreen, since that is much more preferable than a mouse. However, since electronic engineers can't do without their laptop or PC, my choice is easy. I'm going to my boss and ask if there's room in the budget for a Windows 8 laptop with a touchscreen. This seems to me the ideal combination for use with the SmartScope! ◀

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Since the SmartScope is so versatile and has such a good price/quality ratio, we've decided to make this instrument available via the Elektor Store, see www.elektor.com.

Web Links

[1] www.lab-nation.com

