Introduction

This is not an official firmware release from Seeed Studio. The BenF V3 firmware has been developed to overcome some of the limitations and issues with the official firmware releases. In particular this applies to improved SD card support, a more advanced no loss sampling algorithm and a more intuitive user interface. The firmware is developed on a Seeed Studio DSO Nano V1, but is believed to work equally well with DSO Nano V2. It may or may not work with hardware supplied by other manufacturers.

The firmware is free of charge to individuals in its binary format and is put into the public domain in the hope that it will be useful for others and not only the author. Any use of this firmware is at your own risk. No express or implied warranty is granted for the firmware or related documentation and under no circumstance can the author be held responsible for any direct or consequential damage that may arise from using it.

Background

The DSO Nano project originated as an open source effort. Unfortunately these contributions appear to have been cramped by individuals with limited programming skills and even with the most recent official firmware 2.5e release we're not much further than a pretty enclosure with potential. To release this potential a complete rewrite of the firmware was needed.

A proper digital scope needs a three phase approach to sampling. That is pre-fetch, trigger phase and post fetch. The trigger phase must continue until a trigger is found (forever if need be) while the sampling buffer is continually reused in a round-robin fashion (no samples must be lost or disregarded in this phase). When a trigger condition is met, post fetch will start and when completed all sampled data will be displayed with the trigger point centered on the screen. Unfortunately this is not the way 2.5e and prior versions work. The approach taken with the official DSO Nano firmware is the simplistic single buffer capture followed by trigger search. This makes it more or less unfit for digital analysis (e.g. SPI, I2C, RS-232, RS-485) and also of limited use for signals like electronic ignition (narrow, infrequent pulses) and many (if not most) other real life measuring and fault finding challenges.

Thanks to Seeed Studio however, the current software is open source and based on the 2.5e source release, I’ve rewritten it to fix the more fundamental issues. Fixes and new features include the following:

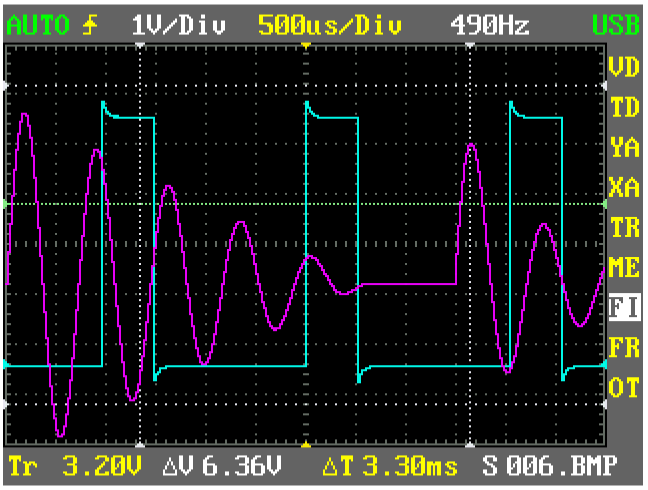
- ✓ Proper three phase sampling (pre-fetch, trigger-fetch, post-fetch) guaranteed never to miss infrequent events
- ✓ More efficient screen update (10-100 times faster than version 2.5e)
- ✓ Eliminate all flickering and stuck pixels
- ✓ Code is re-written to allow full compile time optimization (much faster and compact code all over)
- ✓ A number of overflow bugs have been fixed (calculations for large time/div settings)
- ✓ Scan has been replaced with a proper continues real-time scan mode
- ✓ Configuration profiles can be saved to /restored from SD card or flash (default power on settings).
- ✓ Wave data (reference signals) can be saved/restored from SD cards
- ✓ Screen capture can be saved to SD bitmap files
- ✓ Snapshots of the full DSO sampling buffer can be exported to XML formatted files for further processing
- ✓ A number of issues with incorrect SD card support and file handling in 2.5e have been fixed
- ✓ Files and directories will be created by the DSO Nano as needed without having to preload template files
- ✓ Automatic waveform tuning (FIT mode) can be selected with a dedicated key combination
- ✓ The full sample buffer can be panned left right for further analysis
- ✓ A more relevant collection of data is selected for display on screen
- ✓ A more relevant selection of measurements
- ✓ Simultaneous view of all measurements
- ✓ Use proper ISO abbreviations (e.g. milliseconds is “ms” not “mS”)
- ✓ A completely redesigned user interface (no annoying blinking or color abuse)
- ✓ Support two step full calibration (offset and gain)
- ✓ User selectable grid light intensity level
- ✓ Fine tuning of output frequency to three digits
- ✓ Set duty cycle (PWM) of output frequency from fully-off to fully-on in 1% increments
- ✓ Single button quick select for often used functions

User Interface

All menu items are available from the right hand side of the display. These are organized in the following main groups:

Main group		Available options
VD	Voltage/Div	Select voltage (y-axis) scale
TD	Time/Div	Select time (x-axis) scale
YA	Y-axis	Set horizontal cursors and ground position
XA	X-Axis	Set vertical cursors, trigger position and buffer usage priority
TR	Trigger options	Choose trigger mode, level, sensitivity and kind
ME	Measurements	Select or display measurements
FI	File options	Options for reading and writing from/to SD cards and Flash memory, show/hide reference
FR	Frequency	Select output frequency and duty cycle (PWM)
OT	Other	Select probe attenuation, options for calibration and grid intensity level adjustment

The following image is an example screen capture showing how the above menu categories appear on the DSO display.



The cyan square wave is a trace of the live input signal and the purple waveform is a static reference waveform.

Information fields on the top and bottom bars include the following:

Field		Information
AUTO	Trigger Mode	NORM, AUTO, SING, SCAN or FIT
ƒ	Trigger Kind	Edge rising or edge falling
1V/Div	Voltage Div	Y-axis scaling
500us/Div	Time Div	X-axis scaling
490Hz	Measure	Measure value
USB	Power	USB or battery level indicator
Tr 3.20V	Trigger Level	Active trigger level
ΔV 6.36V	Delta V1/V2	Voltage between horizontal cursors V1 and V2

ΔT 3.30ms	Delta T1/T2	Time between vertical cursors T1 and T2
S 006.BMP	Info field	Context sensitive information field

Use arrow up/down to move between menu groups. Moving past upper/lower wraps around to the opposite side. Within each group there are one or several sub-commands. As an example YA (Y-axis) have sub commands for V1 Cursor, V2 Cursor and Gnd position. Use the M button to display a popup window with supported sub-commands, up-down to change selection and M to close the popup.

Use left/right to change the setting of the active command within the selected main group. Use either the B button (DSO Nano V2) or a long press of M to show/hide cursors, save/load files or reset to a default value.

When using left/right to select a save to file name, existing files will display with a red color. When selecting a load from file name, choice of name is limited to existing files.

Trigger modes

In NORM trigger mode, the Nano will continuously search for a trigger condition and not update the display unless a trigger is found. In AUTO mode, the Nano will search for a trigger as for NORM, but force a trigger after 100ms if none was found. SING works as NORM, but will not initiate a new capture cycle after a successful trigger. Use R/S to start a new SING cycle.

Choose “Tr. Mode” (Trigger Mode) and press B (or long M) to activate FIT mode. The Nano will then automatically identify the type of waveform and adjust the settings to produce a usable display of the input signal. This is similar in function to the Auto push button found on most scopes. The function will track the input signal and continuously adjust trigger level, vertical sensitivity and horizontal sensitivity in small steps until a stable waveform can be displayed. Press B (or long M) to exit from FIT mode for further manual fine tuning. A stable repeating input signal must be present for this function to work.

Choose AUTO trigger mode and Time/Div greater or equal to 100ms to activate real-time scan. In SCAN mode, the input signal is progressively displayed from left to right in real-time. This mode is useful for observing/trending a slow changing signal such as temperature variations.

Loss of trigger is indicated with the trigger kind (rising/falling) symbol displayed in the color red.

Use menu option “Tr.Kind” (Trigger Kind) to select rising or falling edge trigger, “Tr. Level” to set trigger level and “Tr. Sens” to set trigger sensitivity.

Viewing the full sampling buffer

Panning left/right is possible using menu item XA (X axis) and sub option “Trig Pos” (Trigger Position). With the left/right arrows, you offset the trigger position in steps of 1 horizontal div. When using this technique, you can pan left/right to see the full sampling buffer (more than 10 full screens). When panning left/right, pressing B (or long M) will reset trigger point back to center. Pressing B (or long M) when at center, will alternately show/hide the trigger position axis.). To stop capture, you can use either SING trigger mode or use NORM/AUTO in combination with R/S.

Use sub option “Buff Pri” to switch between equal buffer priority mode and post trigger priority mode. In equal priority mode, an even split is used for waveform data before and after the trigger. In post trigger priority mode, maximum buffer capacity will be used for data after the trigger.

Changing buffer priority mode will reset trigger position back to center.

Profiles and power on defaults

Preferences can be saved to a micro-SD card for recall or to flash memory to act as power on defaults. First, use the various menu options to configure DSO Nano any way you prefer. Then choose menu FI and sub-option "Save Pro". Choose profile zero (S Flash) and press B (or long M). This will save all active settings to DSO internal flash memory for use as power on defaults. Profiles other than zero (e.g. S 001.CFG) will be saved to SD card and can be recalled with sub-option "Load Pro".

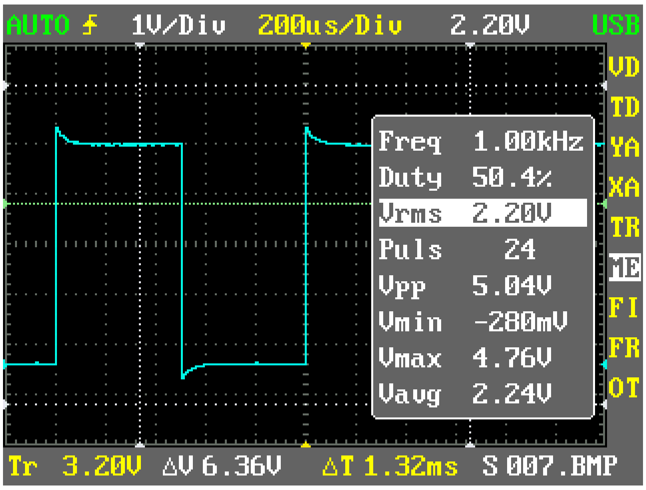
Measurements

The following is a list of the measurements you can obtain directly from your Nano:

Name	AC/DC	Description
Freq	AC	Input frequency measured in Hz
Duty	AC	Duty cycle as a percentage of high vs. full period relative to **Vavg**
Vrms	AC	Root-mean-square voltage relative to **Vavg**
Puls	AC	Pulse count (count of low to high transitions)
Vpp	AC+DC	Voltage difference between **Vmax** and **Vmin**
Vmin	AC+DC	The minimum input voltage relative to ground
Vmax	AC+DC	The maximum (peek) input voltage relative to ground
Vavg	AC+DC	Average voltage

Measurements **Freq**, **Duty** and **Vrms** will only be calculated for AC input (a minimum of one full cycle). For signals with multiple cycles, calculations will be averaged across all full cycles. Partial cycles at the beginning and end of the captured waveform will be omitted from calculations.

Below is an example screen image of a 1.00 kHz square wave input signal with its associated measurements:



The highlighted/selected measurement (**Vrms**) is duplicated on the top bar for reference when the popup is closed.

Select menu ME and press B (or long M) to save a screen capture to your micro-SD card with overlaid measurements.

Frequency Generator

Output frequency can be set to three digits of precision in the range from 10Hz to 1MHz using menu FR and sub option "Freq Out". Press B (or long M) to cycle between 1, 2 and 3 digits of precision. Press left or right to alter the highlighted digit.

Duty cycle (pulse width modulation) can be set with sub option "Freq Duty" in steps of 1% from fully off to fully on. Press B (or long M) to reset duty cycle back to the default 50%.

Calibration

First choose the range you want to calibrate. Then select **Vavg** as active measurement. Apply ground level to the input probes and choose menu group OT and sub option "Cal Offs" to calibrate ground offset. Use left/right arrow until you have a zero **Vavg** voltage reading. Then apply a known voltage reference to the input probes and use sub option "Cal Gain" to calibrate gain. Use left/right arrow until you have a **Vavg** voltage reading that match your input voltage reference. Gain calibration is applied as a percentage of full scale in steps tuned to the actual dynamic range of the active V/Div selection. Pressing B (or long M) will reset calibration to factory default for the active range and calibration type (offset or gain).

For a full calibration, you must repeat the above steps for the remaining ranges. Use "Save Cal" to save calibration data to FLASH. Calibration data saved to FLASH will automatically be restored when you power on your Nano.

Files on SD cards

Configuration profiles (preferences), reference waveforms, screen capture bitmaps and snapshots of the full DSO sampling buffer can be saved to files on micro-SD cards. Profiles and reference waveforms can be read back. The files are laid out on the card as follows:

Directory	File	Content
IMAGE	IMAGExxx.BMP	Screen capture
PROFILE	FILExxx.CFG	Configuration files
REFWAV	FILExxx.DAT	Reference waveforms
BUFFER	FILExxx.XML	Sample buffer export files

The x characters represent sequential numbers in the range 001 to 999 within each category.

When powering on the Nano, naming of new files will start with the first available number (highest file number on the card plus one) within each category. If you select an existing file, the file will be overwritten without warning. Files can only be read back when properly named and located in their respective subdirectory.

Installation

The procedure to upgrade firmware is described in the manual that came with your DSO Nano. A copy of this manual (PDF file) can also be downloaded from the Seeed Studio product pages. You need to follow the steps in this procedure carefully and upload both the **DSO BenF APP v3.xx.dfu** and **DSO BenF LIB v3.xx.dfu** files. The order of upload (LIB or APP) is not significant.

Micro-SD cards must use either the FAT16 or the FAT32 file system (NTFS and exFAT is not supported). High capacity SD cards (SDHC) are not supported. SD cards must support the SPI access protocol. I'm using a 2GB SanDisk card supplied by Seeed Studio that works well with the new V3 firmware. The FAT16 file system appears to be more responsive on Windows XP (e.g. when doing a directory refresh after writing a new image file to the card). This may or may not be the case on other platforms.

SD cards that have previously been formatted with the original Seed Studio firmware must be reformatted prior to use. The "sdformatter" utility (use Google to find a download site for ver. 2.xx) can be used to fully initialize a card to a known compatible format.

XML export files

Below is a condensed copy of an exported XML file showing 5 sample points around the trigger position. The Profile section includes information items documenting the active configuration at the time of export. There are also three numeric items in this section, namely triggerIndex, sampleCount and timeRange. The sampleCount item is the total number of sample points included in the file (currently 4098 in the V3 firmware), timeRange is the time interval in seconds between the first (0) and last (4097) sample, triggerIndex is the index of the trigger sample point. Time between individual samples can be calculated as timeRange / sampleCount.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<Document>
<Profile>
 <triggerMode>NORM</triggerMode>
 <triggerKind>EdgeRising</triggerKind>
 <triggerLevel>3.76V</triggerLevel>
 <triggerSensitivity>200mV</triggerSensitivity>
 <attenuation>x1</attenuation>
 <voltageDiv>1V</voltageDiv>
 <timeDiv>200us</timeDiv>
 <firmware>V3.40</firmware>
 <fileNumber>S003</fileNumber>
 <triggerIndex>1420</triggerIndex>
 <sampleCount>4098</sampleCount>
 <timeRange>32.784e-3</timeRange>
 </Profile>
<Point>
 <seq>1418</seq>
 <val>-40.000e-3</val>
 </Point>
<Point>
 <seq>1419</seq>
 <val>-40.000e-3</val>
 </Point>
<Point>
 <seq>1420</seq>
 <val>5.280</val>
 </Point>
<Point>
 <seq>1421</seq>
 <val>5.200</val>
 </Point>
<Point>
 <seq>1422</seq>
 <val>5.160</val>
 </Point>
</Document>
```

Each individual sample point is placed in a Point section. The seq item is the sequential number of the sample point in the range from 0 (first point in time) to sampleCount – 1, val is the measured voltage of the sample point.

Reference waveform files

Reference waveform files ("FILExxx.DAT") have a size of 302 bytes with the following layout:

```
typedef struct _ReferenceType {
  unsigned char  Signature[2];    // 2 byte signature field
  unsigned char  Ref_Buffer[300]; // 300 byte waveform
} ReferenceType;
```

The full DSO Nano screen is 320x240 pixels and the area used for waveform display is 300x200 pixels (grid size is 25x25). Values in "Ref_Buffer" represent y-axis absolute screen coordinates with a valid range from 20 to 219 (20 being bottom). Index within the buffer represents waveform relative x-axis coordinates with a range from 0 to 299 (zero being left).

A value of 255 in Ref_Buffer is interpreted as "no value". Values 0 to 19 and 220 to 254 are reserved.

The Signature field is currently unused. Values in this field will be zero on output from the DSO Nano (V3 firmware) and should be set to zero in files created for import to the Nano.