Measuring harmonics in signal with Analog Discovery 2

In this guide, I will show how to measure harmonics in signal with Analog Discovery using FFT contained in Digilent Waveforms.

Overview

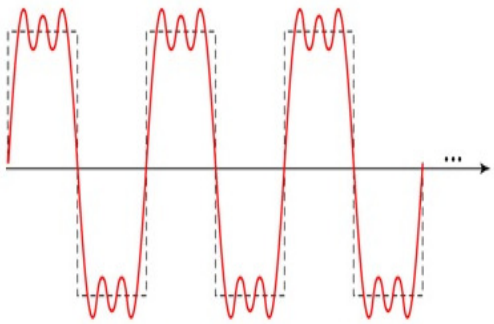
Every **periodic** signal can be described as a sum of sine waves with different *frequencies, amplitudes and phase shifts*. This gives possibility of synthesizing signals with sine waves and analyze all kind of signals to determine sine waves that makes the signal.

Decomposition of signal shape (data in time domain) to sine waves that make the signal (data in frequency domain) is done by **FFT** (Fast Fourier transform). This algorithm is implemented in **Digilent Waveforms**.

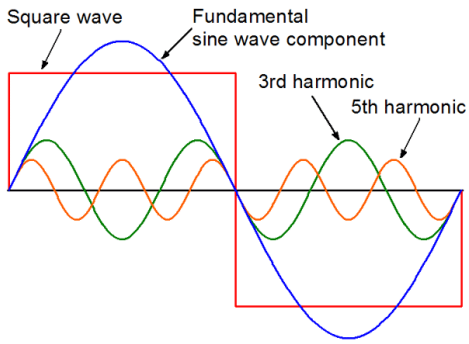
Frequencies of the sine waves are strictly described. Every periodic signal has its own frequency **- base frequency**. It is equal to frequency of the **first** sine wave. Next sine waves in the sum have frequencies *multiplicated* by its index - for example second sine wave has frequency equal to 2 * base frequency.

Index of the sine wave is called a **harmonic**. I will show how to measure amplitudes of harmonics in signal, that is, amplitude of specific sine wave in signal.

Unfortunately, we can't measure **phase** of the sine waves, because phase FFT algorithm is not yet implemented in Digilent Waveforms (it's possible to do this in Waveforms SDK, FFT needs only samples of the signal).

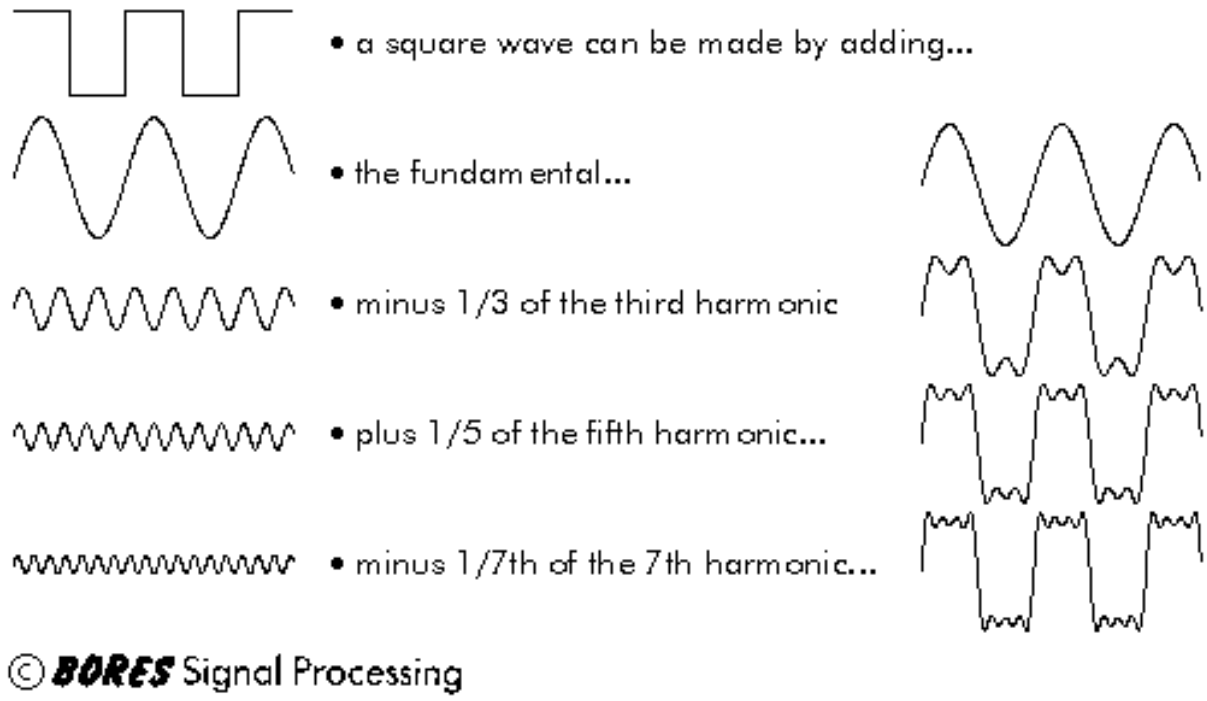


periodic signal (fig. 1)



sine wave frequencies based on harmonics number (fig. 2)

Decomposition of the square wave



source : http://www.bores.com/courses/intro/freq/3_ft.htm (fig. 3)

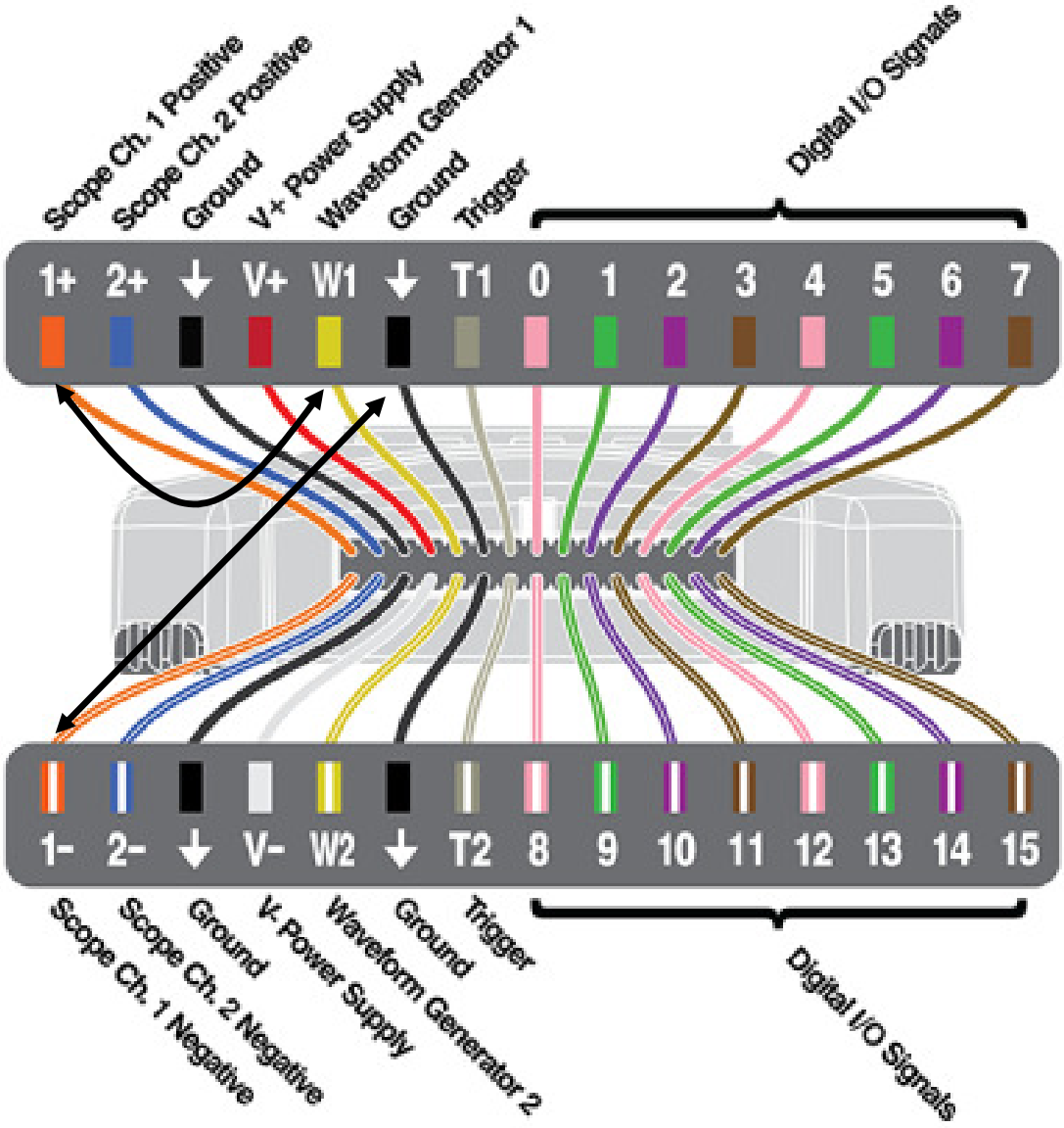
Setup

To run this example, you need **Analog Discovery 2** and **PC**.

Connect **Analog Discovery 2** to your **computer**.

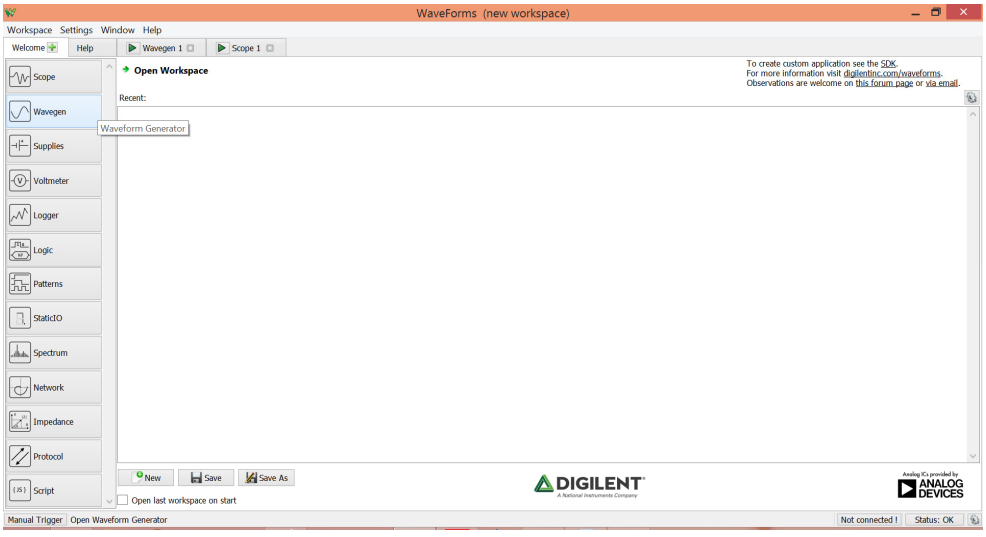
Connect **1+** (oscilloscope positive input) to **W1** (waveform generator output) and **1-** (oscilloscope negative input) to **GND** (ground).

We will play waveforms by **WaveGen** and observe shapes of the signal and measure harmonics (FFT) using **Scope.**

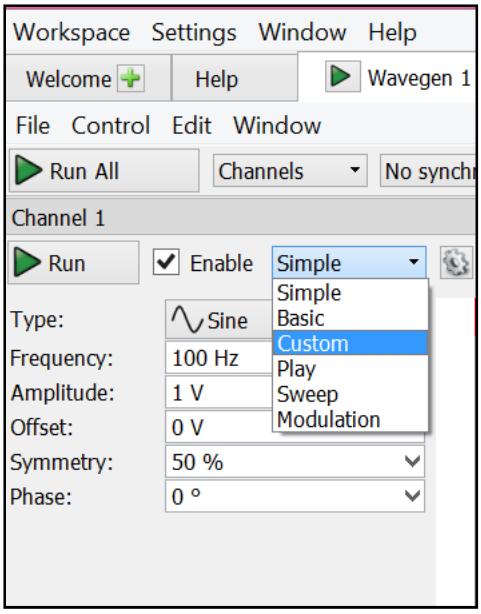


Analog Discovery 2 connections (fig. 4)

Waveform generator

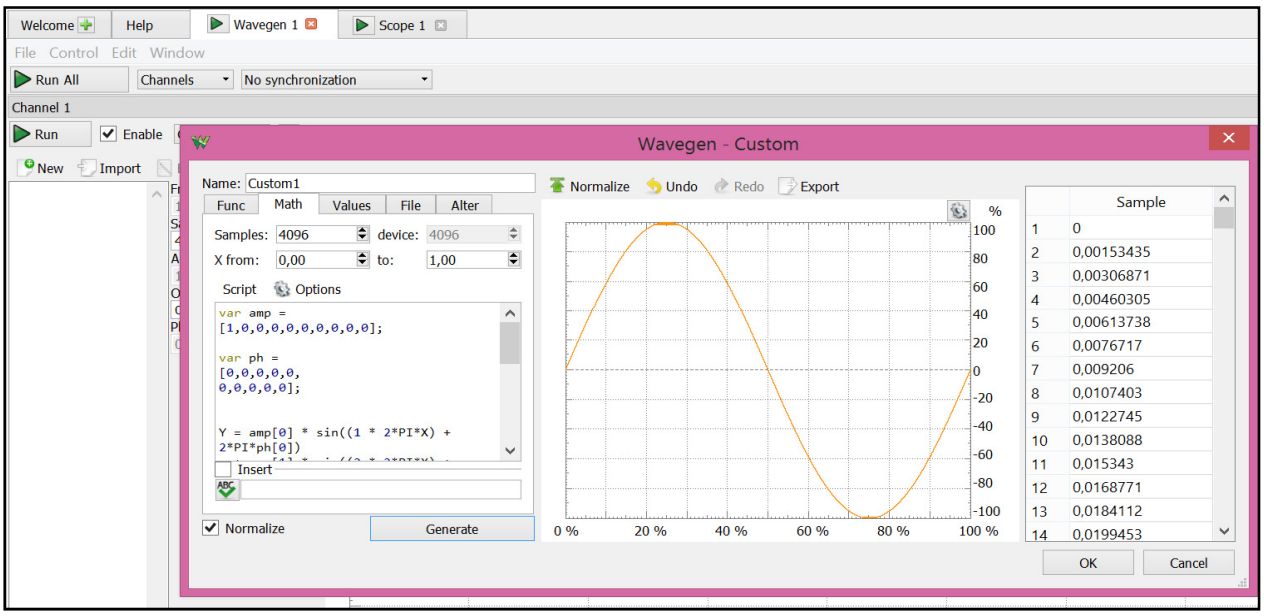


1. To launch **Waveform generator**, click on the **Wavegen** button.



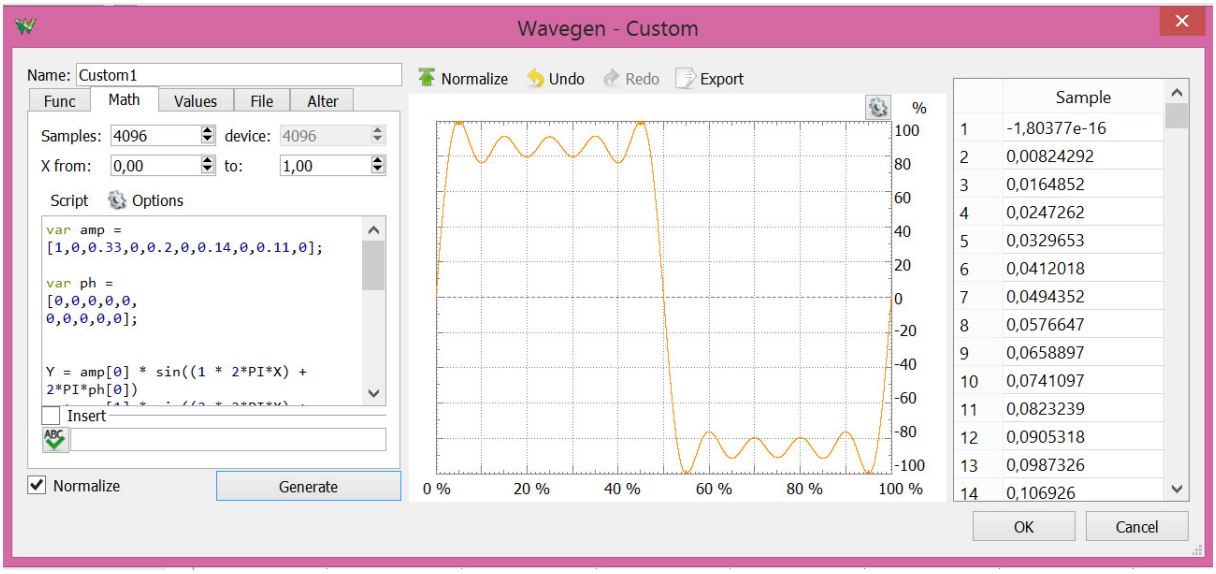
2. Switch to the **custom** mode - we will implement **additive generator**.

3. Click on **New**, paste code listed on **fig. 5** to the script field. By modifing **amp** and **phase** values we will generate diffirent shapes of signals. If you click **generate** button, you will see generated shape.



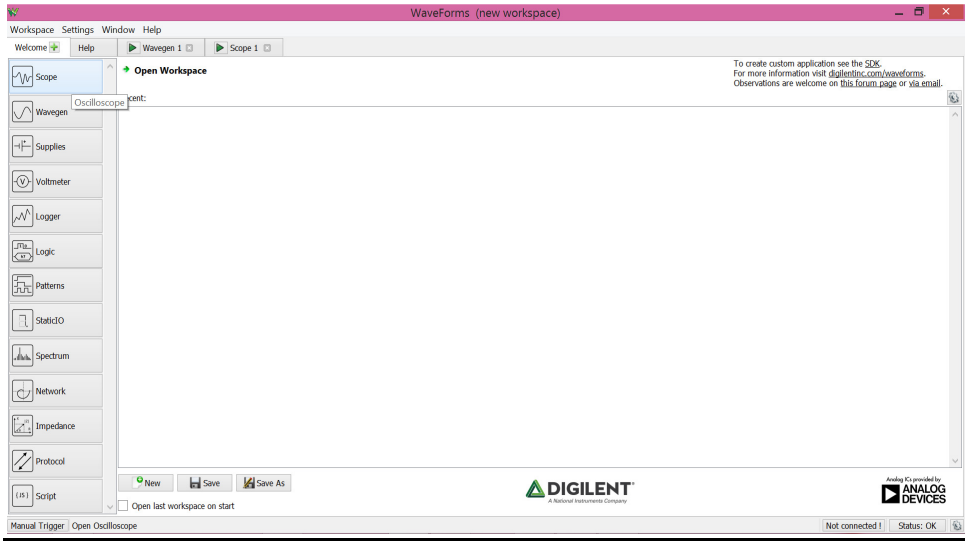

```
var amp = [1,0,0,0,0,0,0,0,0,0];        //amplitude values from 0 to 1 (0-100%)
var ph =  [0,0,0,0,0,0,0,0,0,0];        //phase values from 0 to 1 (0-360 degrees)

Y = amp[0] * sin((1 * 2*PI*X) + 2*PI*ph[0])
+ amp[1] * sin((2 * 2*PI*X) + 2*PI*ph[1])
+ amp[2] * sin((3 * 2*PI*X) + 2*PI*ph[2])
+ amp[3] * sin((4 * 2*PI*X) + 2*PI*ph[3])
+ amp[4] * sin((5 * 2*PI*X) + 2*PI*ph[4])
+ amp[5] * sin((6 * 2*PI*X) + 2*PI*ph[5])
+ amp[6] * sin((7 * 2*PI*X) + 2*PI*ph[6])
+ amp[7] * sin((8 * 2*PI*X) + 2*PI*ph[7])
+ amp[8] * sin((9 * 2*PI*X) + 2*PI*ph[8])
+ amp[9] * sin((10 * 2*PI*X) + 2*PI*ph[9]);
```

waveform generator code (fig. 5)

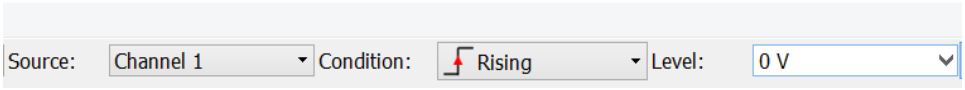


composite square wave (fig. 6)

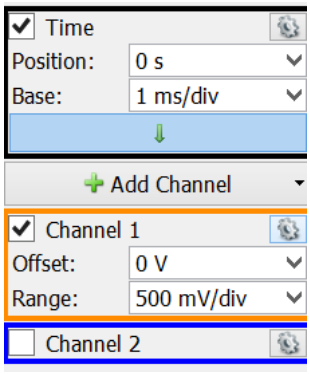
Oscilloscope



1. To launch **Oscilloscope**, click on the **Scope** button.



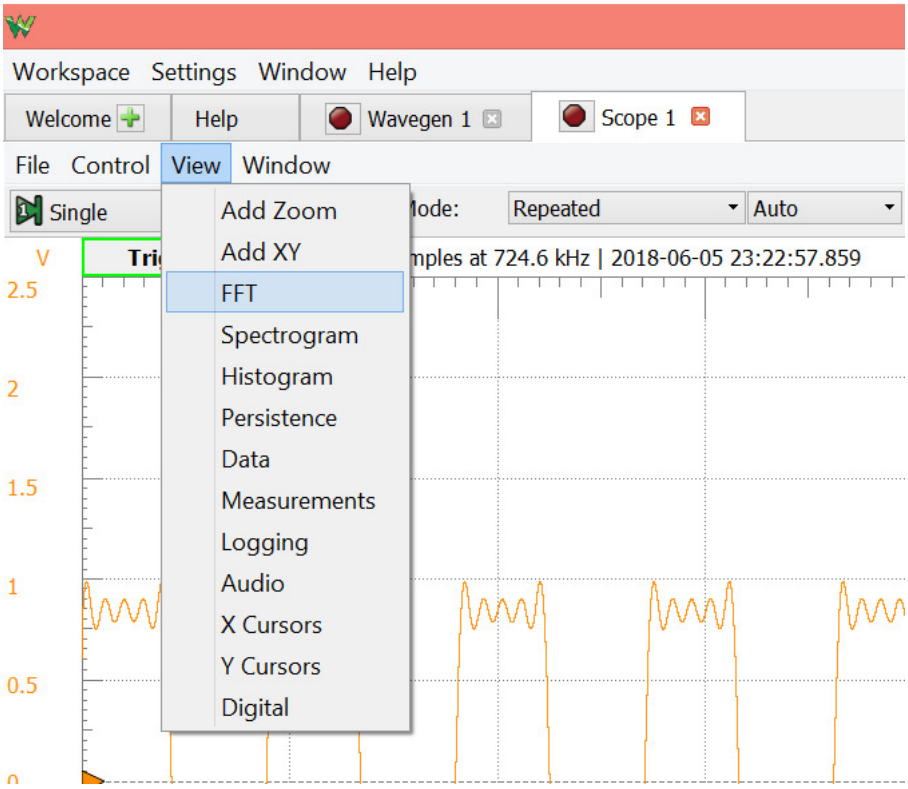
2. **Trigger** options :
source - Channel 1,
condition - rising,
level - 0V



3. **Time** options :
position : 0s
base : 1ms/div

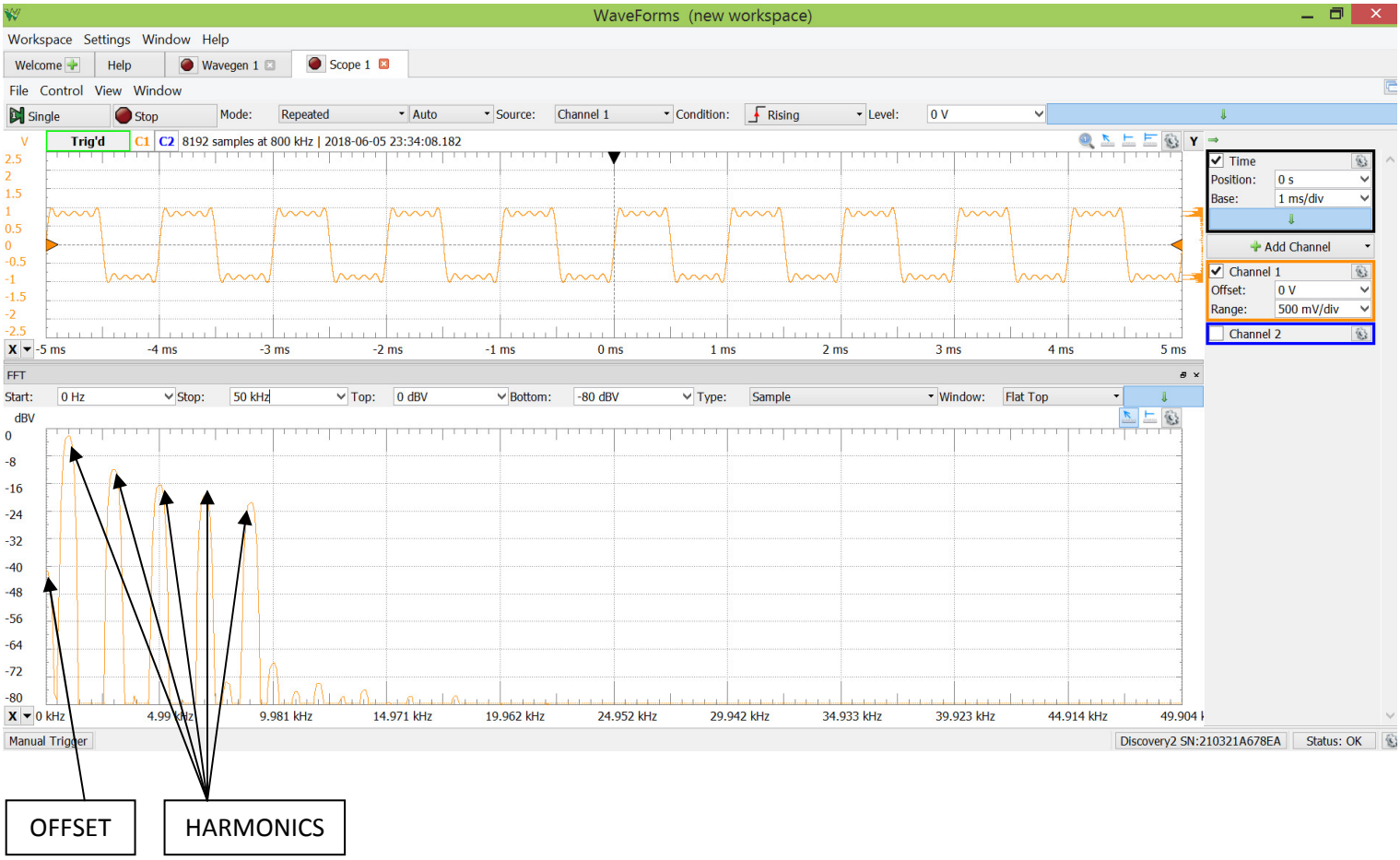
4. **Unclick** Channel 2

5. **Channel** options :
offset : 0V
range : 500mV/div
Click on the sprocket wheel button and unclick **Noise** checkbox.



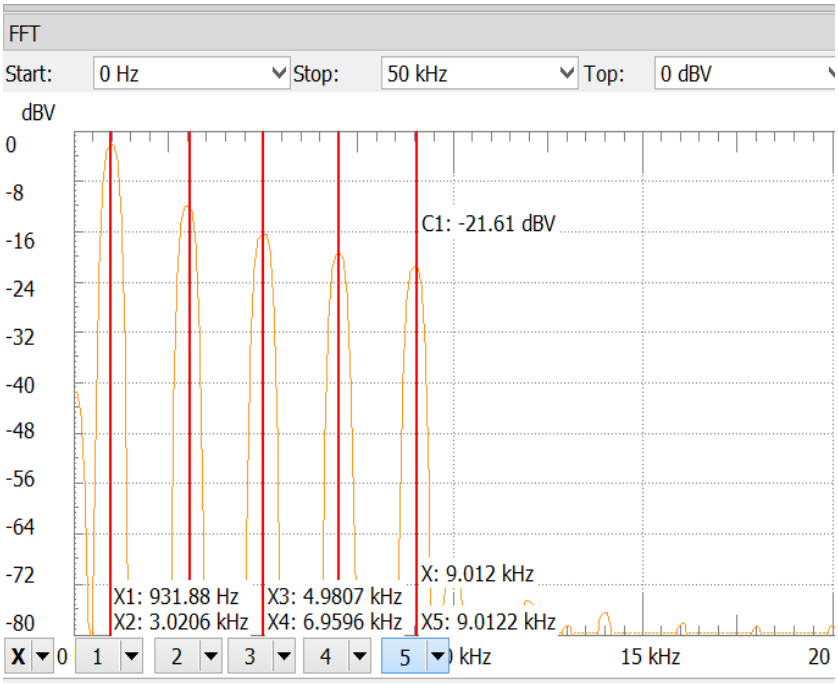
6. Click on **View->FFT** to show FFT window

7. **FFT** options :
Start : 0Hz,
Stop : 50kHz,
Top : 0dBV,
Bottom : -80dBV



Measurements

The setup is done, so we can take some measurements.



FFT of composite square wave (fig. 7)

```
var amp =
[1,0,0.33,0,0.2,0,0.14,0,0.11,0];
//amplitude values from 0 to 1
(0-100%)
```

square wave amplitude values

Frequency [kHz]	Harmonic	Level [dBV]	Voltage [V]	Compared to Base frequency [%]
1	1	-2,4	0,76	100,00%
3	3	-12,0	0,25	33,11%
5	5	-16,5	0,15	19,72%
7	7	-19,5	0,11	13,96%
9	9	-21,6	0,08	10,96%

Results of FFT. Compare with amplitude values from WaveGen.

Examples of the other waveforms