MyDAQ NI ELVISmx – DMM

Connect the red and black test probes that came with your MyDAQ into its banana connectors and use your MyDAQ with **ELVIS DMM** instrument to operate as a digital multimeter to measure the output of the digital function generator just as you did back in week 2's lab. For the Keysight oscilloscope use its measurement utility to measure Cyclic RMS.

WORK SHEET HERE:

$\frac{\text{DMM or myDAQ-SCOPE}}{\text{SCOPE}}(100\%)$

1 kHz Wave (5 Vpp)	Cyclic RMS Key Scope Voltage	Meter Voltage DMM	Meter Voltage myDAQ/DMM	% Difference (vs Scope) DMM	% Difference (vs Scope) myDAQ
Sine:	1.78	1.751	1.77	1.6	.56
Triangle:	1.45	1.427	1.40	1.59	3.57
Square:	2.51	2.379	2.75	5.2	9.56

In particular, does the MyDAQ measurement of sine, square waves and triangular waves behave the same or differently than the digital multi-meter? Why?

ANSWER HERE:

- Yes, they are different for all; most deviation in square
- This might be because MyDAQ has a harder time measuring the sharp rises and falls of a square wave
- Doesn't check as frequently, which is fine for sine because of the predictability, but not for square waves

MyDAQ NI ELVISmx – Oscilloscope

Activate the NI myDAQ in **ELVIS Oscilloscope** instrument. Connect both the myDAQ and the Keysight scopes to the digital function generator. Note that the MyDAQ analog inputs are made through its edge connector and are *differential* (just like an OpAmp), with a non-inverting and an inverting terminal, neither of which is connected to the chassis ground of the MyDAQ. However, the function generator, and many other sources, have *single-ended* outputs, where the negative side of the signal is tied to the chassis ground of the source. Here is the main point: merely connecting the signal source {+lead} to the MyDAQ's {+input} and the signal source {–lead} to the MyDAQ's {–input} **is not enough**. You must add a third wire that connects [a] the MyDAQ's {–input}, [b] the MyDAQ's chassis ground (labeled AGND), and, as a result, also to [c] the signal source's chassis ground. This chassis-ground-to-chassis-ground connection is essential to minimize ground loop noise.

Compare the behavior of the lab bench Keysight and your myDAQ oscilloscopes. Start by setting the MyDAQ oscilloscope time base to 10 ms (you should adjust the time base to values that allow the waveform to be seen clearly). Start by measuring the output of the function generator at about 1 kHz and amplitude of 1 – 10 Vpp looking at both sine and square waves. Increase the frequency of the function generator to 1 KHz, 10 kHz, 99 kHz, 999 kHz and 1999 kHz. Note whether the amplitude of the sine waves and particularly the shape of the square waves remain constant. The digital function generator output is in fact constant over this frequency range, so changes in rise and fall time, and/or amplitude with frequency are the result of frequency limitations in your measuring devices. (The output of the analog function generator varies somewhat over this frequency range.)

WORK SHEET HERE:

Frequency	Oscilloscope RMS Voltages			
kHz	Sine (Key)	Square (Key)	Sine(myDAQ)	Square (myDAQ)
1	1.78	2.51	1.77	2.50
10	1.779	2.50	1.769	2.49
99	1.77	2.49	1.75	2.43
999	1.76	2.43	1.59	1.89
1999	1.75	2.36	0.84	1.12

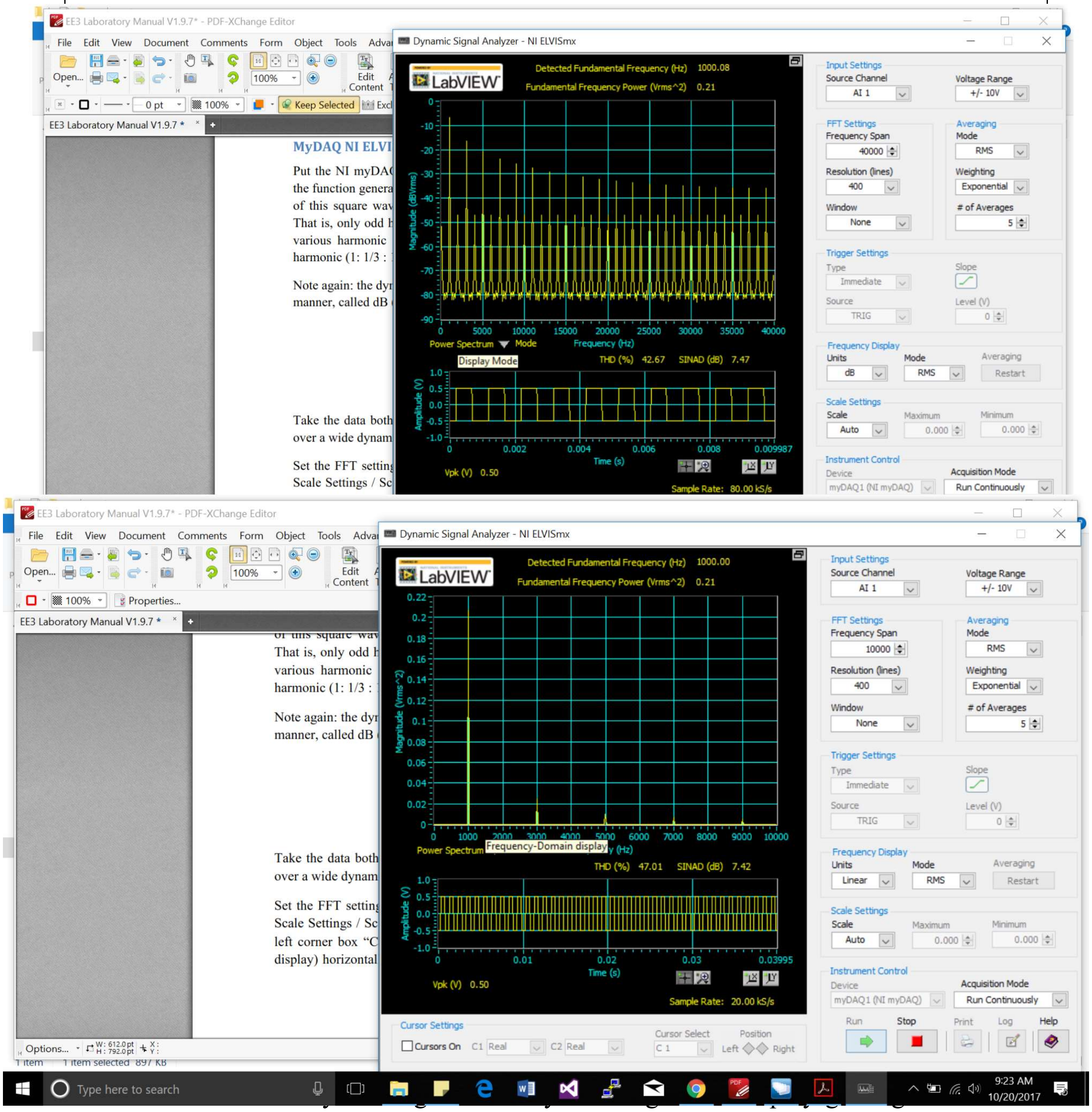
Square wave response requires a higher frequency response from the measuring system than sinusoidal waves. As you will see in the spectrum analyzer experiment, square waves can be thought of as being formed from a fundamental sinusoidal wave whose period is the same as the square wave plus higher frequency components (all odd integer multiples, or *harmonics*, of the fundamental frequency) to make up the sharp rise and flat top asso-ciated with the square wave.

Therefore, as your measuring system goes to its high frequency limit, the sharp rise and fall of the square wave will be lost due to the lack of these higher frequency components being accurately displayed. This is known as the Gibbs phenomenon, which you will have a chance to look at later. Plot the sinusoidal frequency response versus frequency for these two oscilloscopes. Use the Bode plot format with the 1 KHz value as the reference. Plot both oscilloscope curves on the same graph. Then create a second plot for the square wave data.

ANSWER HERE:

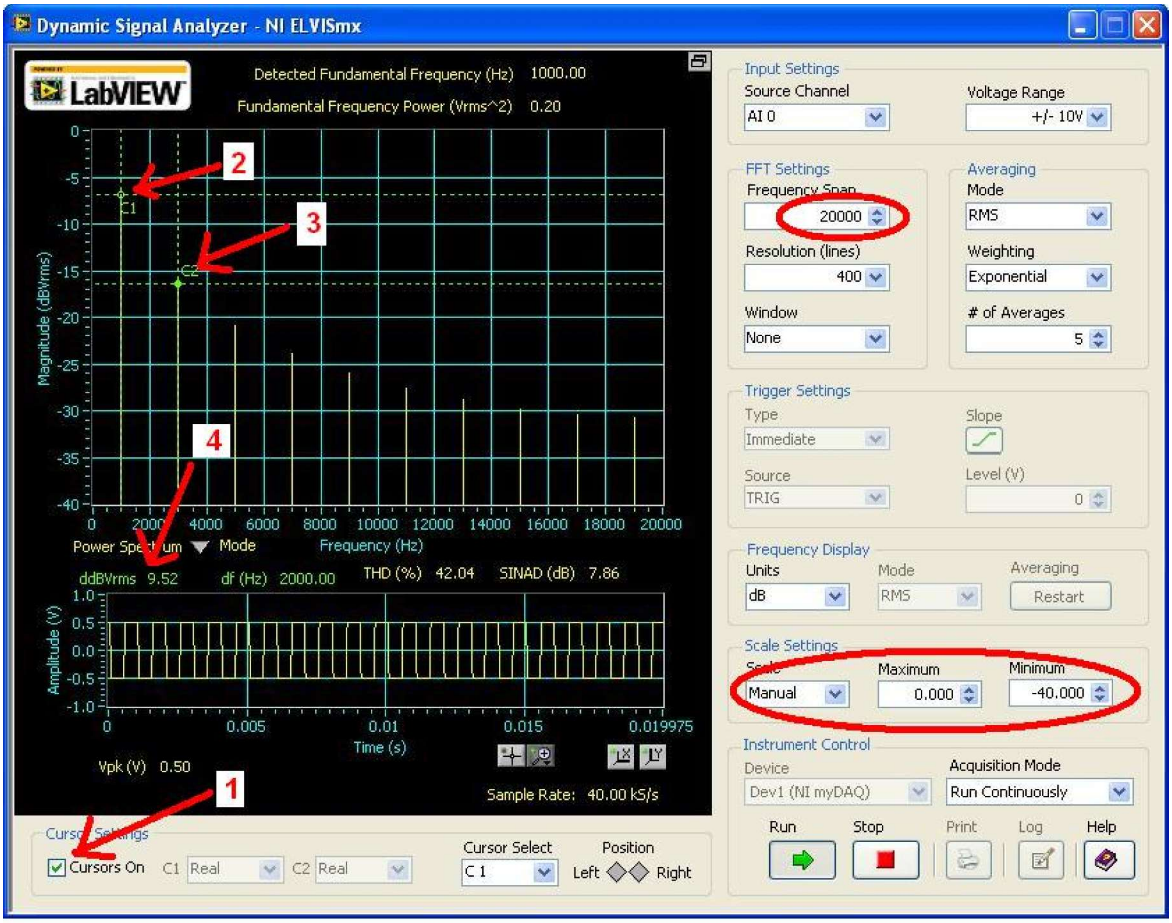
We define the upper frequency response of a system to be the point at which the amplitude decreases to 70.7% (-3 dB). Using this criterion, can you estimate the frequency response of the myDAQ and the Keysight oscilloscopes? Discuss.

ANSWER HERE:



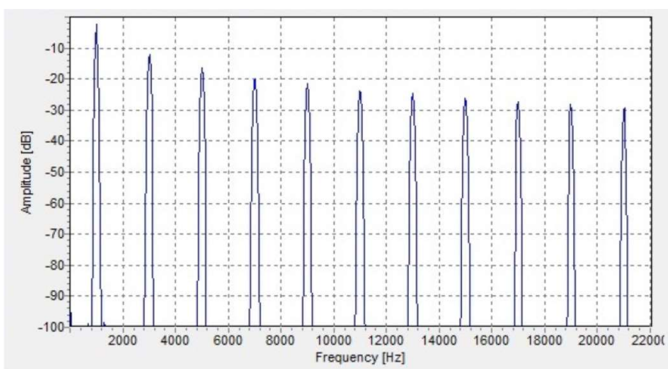
over a wide dynamic range and is therefore commonly used in engineering.

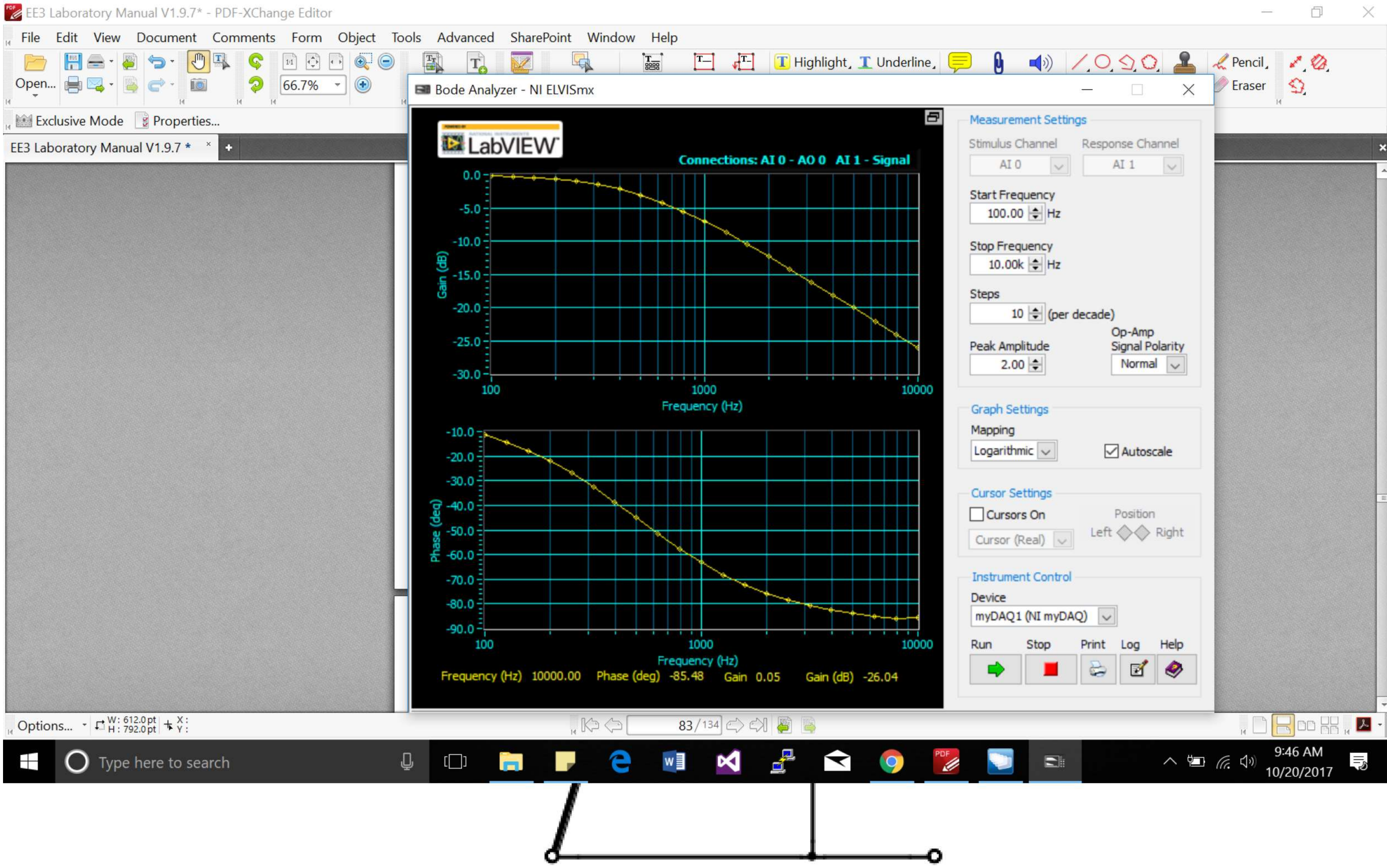
Set the FFT settings / Freq Span to 20 kHz, Frequency Display / Units to dB, and set the Scale Settings / Scale to Manual (Max = 0, Min = -100). Click Run, then click the lower-left corner box “Cursors On,” drag the dashed vertical green line (on the left side of the display) horizontally until it snaps onto the first harmonic, then drag the remaining second dashed vertical line to snap respectively on each of the higher harmonics – one by one. Each time (snapped onto each of the higher harmonics) note and record the value on the left middle indicator in green as ddBVrms (delta dB).


Dynamic Signal Analyzer - NI ELVISmx
LabVIEW
Detected Fundamental Frequency (Hz) 1000.00
Fundamental Frequency Power (Vrms^2) 0.20
Magnitude (dBVrms)
C1
C2
1
2
3
4
Power Spectrum
Mode
Frequency (Hz)
ddBVrms 9.52
df (Hz) 2000.00
THD (%) 42.04
SINAD (dB) 7.86
Amplitude (V)
Time (s)
Vpk (V) 0.50
Sample Rate: 40.00 kS/s
Cursor Settings
Cursors On
C1 Real
C2 Real
Cursor Select
C 1
Position
Left
Right
Input Settings
Source Channel
AI 0
Voltage Range
+/- 10V
FFT Settings
Frequency Span
20000
Resolution (lines)
400
Window
None
Averaging
Mode
RMS
Weighting
Exponential
# of Averages
5
Trigger Settings
Type
Immediate
Slope
Source
TRIG
Level (V)
0
Frequency Display
Units
dB
Mode
RMS
Averaging
Restart
Scale Settings
Scale
Manual
Maximum
0.000
Minimum
-40.000
Instrument Control
Device
Dev1 (NI myDAQ)
Acquisition Mode
Run Continuously
Run
Stop
Print
Log
Help

WORK SHEET HERE (SQUARE WAVE ANALYSIS):

n Harmonic	20 log(Vn / V1)=dBn-dB1 Ratio, in dB (n-th / 1st)	20log(1/n), n=odd; -inf, n=even Theory .
1	0	0
2	-80	-infinity
3	-9.49	-9.54
4	-80	-infinity
5	-13.80	-13.98
6	-80	-infinity
7	-16.53	-16.9
8	-80	-infinity
9	-18.42	-19.08
10	-80	-infinity





Note that the AO subsystem drives the filter, and the AI subsystem measures both the input to and output from the filter.

Start the Bode Analyzer and set it up to take 20 measurements starting at 100 Hz and ending at 10 KHz. Take a screen shot (NOT a photograph!) of the result. Calculate:

The theoretical cutoff frequency (-3 dB point) of the filter _________ Hz

The cutoff frequency as measured by the Bode Analyzer 501.19 Hz

The % difference, using theoretical as the reference.

Offer a list of the causes of the difference. ____

____

____

Four optional, but informative experiments:

1. If the function generator has a symmetry adjustment, then with the function generator set on "triangular output" adjust the wave to be non-symmetrical as seen on the scope. Compare the harmonic structure to the symmetrical waveform.

2. Select a sinusoidal output on the function generator. Use the NI myDAQ to analyze the spectrum. What do you observe? Can you explain the result?

3. Set the function generator to sine wave and observe the spectrum on both linear and logarithmic scales. Is the sine wave generator making perfect sine waves? What do you observe?

   Try this experiment with both an external function generator and the internal myDAQ. Is there a difference? Why?

4. Connect the external digital function generator to the Keysight oscilloscope and generate a square wave. Zoom in on the corner of a square wave where the voltage drops from high to low or rises from low to high. What do you observe?

   Does the "curving" get better or worse as you change the frequency of your square wave? This imperfection in generating square waves is known as Gibbs phenomenon.