Manual for Communication Systems Laboratory (EEE/ECE F311)

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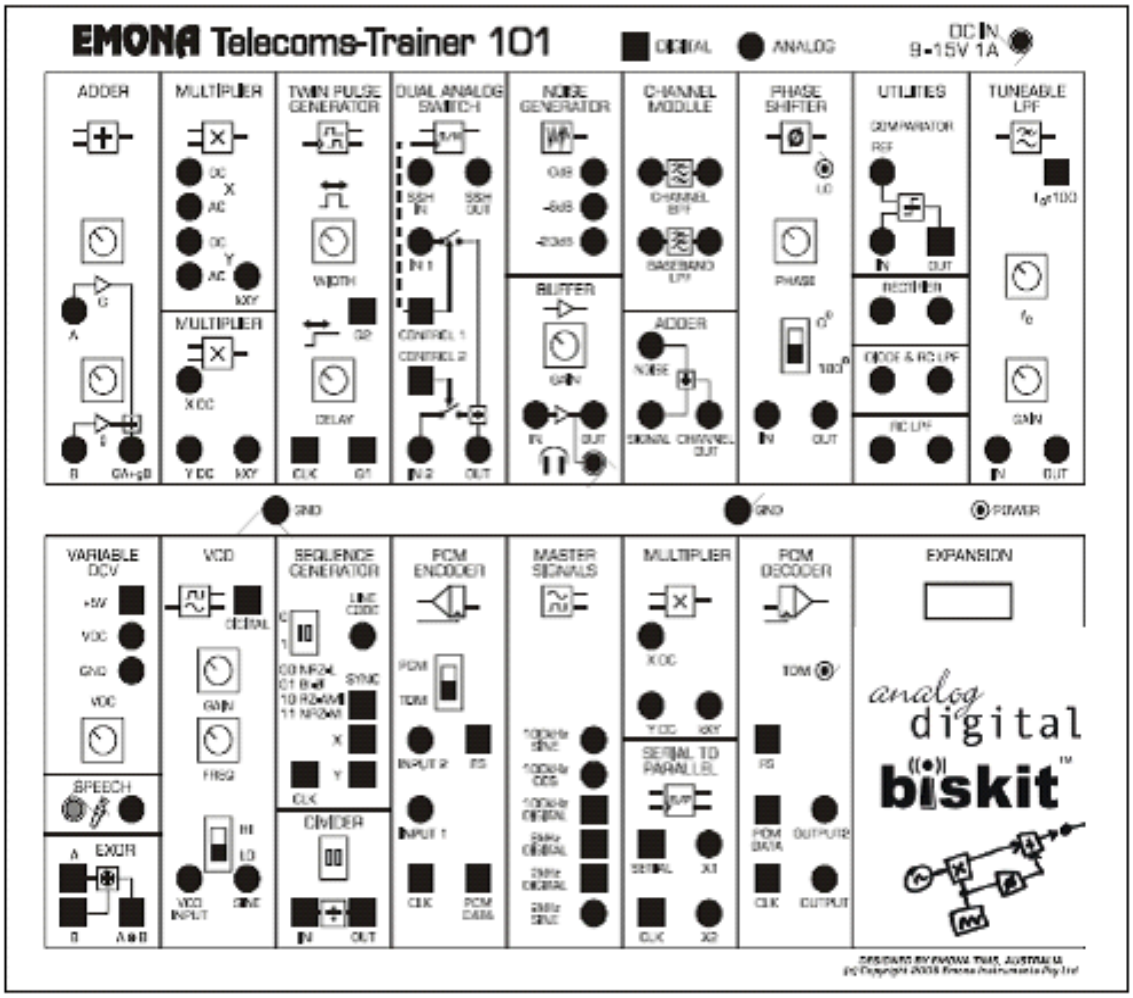
Experiment 2: Studies on Signals and their Spectra using Emona Telecom Trainer Kit

Aim: This experiment is intended to make the student learn to use the Hardware Kit from Emona to generate sinusoidal signals and measure their parameters, in time and frequency domains, using DSO.

Equipment Required: Emona Telecom Trainer Kit 101, DSO, BNC Cables and connecting patch cards.

Pre Learning: One should be familiar with the use of DSO (from Experiment 1). The student should watch the video on the explanation of the Emona kit, prior to attempting this experiment.

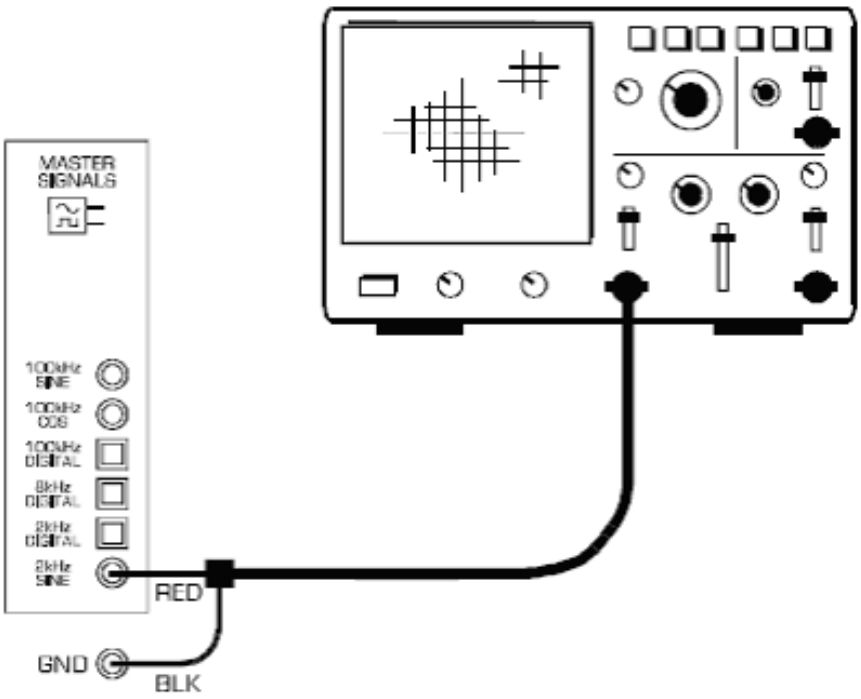
A snapshot of the trainer kit front panel is as shown below.



A. Generation of Signals:

Signal generation is a very basic activity that one would perform while working with communication system experiments. This experiment is intended to make the student learn about the signal generation, measurement of amplitude and frequency of the signal using Digital Storage Oscilloscope (DSO), and Spectral domain measurements using FFT feature of the DSO. Follow the steps given below in sequence to perform the experiment

- Locate the "Master Signals Module" on the Emona kit and the 2Khz sine port on it.
- Connect the BNC cable to BNC port "1" on the DSO and Red lead of the cable to the 2Khz sine port and black lead to the GND port on the kit.
- Press "Autoset" on the DSO and see whether you get a stable waveform on the DSO.If the waveform is not stable, press "Trigger menu" and set the Trigger Source to CH1. You may have to adjust the "Trigger Level" knob, to make the waveform stable.

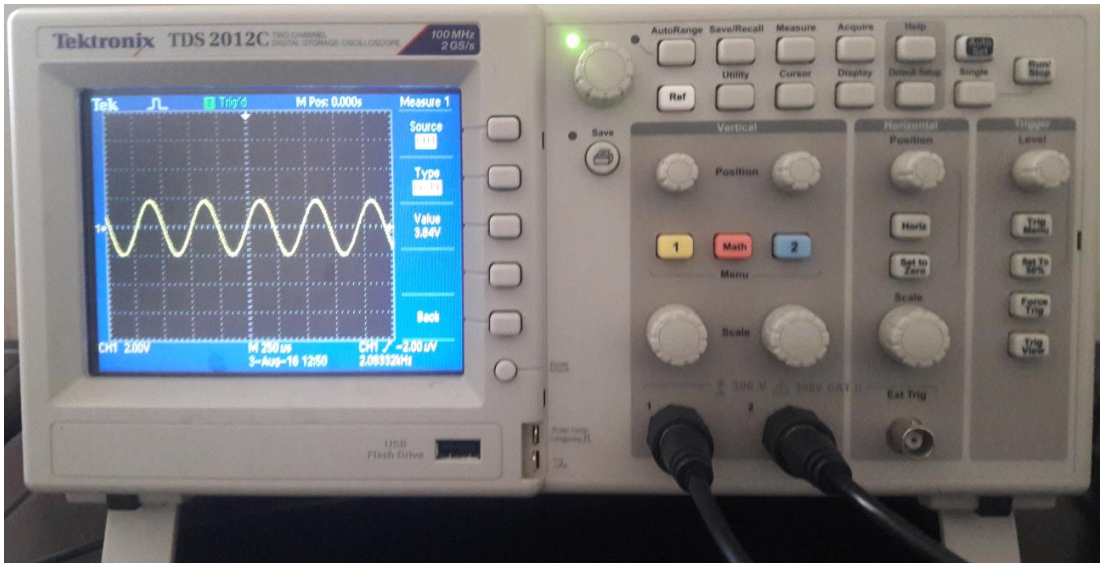


B. Time Domain Measurements on Signals:

In this part, you will measure the amplitude, frequency and the time period of the generated signal. There are two modes in which the measurements can be done: one is the Built-in measurement mode and the other is the Cursor mode. First we will use the measure mode.

1. I. Measure Mode Procedure: (Old DSO) (Model No. TDS 2012C)

- Press “Measure” button on DSO.
- Press the topmost button, located on the display panel border. It should be set to CH1 by pressing it. (If required repeatedly).
- To measure peak to peak voltage of the displayed waveform, press the second button from top repeatedly to till the “Type” display shows “Pk-Pk”. The value of the peak to peak voltage gets displayed just below the “Type” display. Tabulate the measured value in Table1.
- To measure frequency of the displayed waveform, press the second button from top repeatedly to till the “Type” display shows “Freq”. The value of the frequency of the signal gets displayed just below the “Type” display. Tabulate the measured value in Table1.
- To measure time period of the displayed waveform, press the second button from top repeatedly to till the “Type” display shows “Period”. The value of the time period of the signal gets displayed just below the “Type” display. Tabulate the measured value in Table1. Check whether the frequency and time period values are consistent with each other.
- Following steps, similar to above, measure the minimum voltage, maximum voltage, mean voltage, RMS voltage of the signal.



1. II. Measure Mode Procedure: (New DSO) (Model No. TBS 1102B-EDU)

- Press “Measure” button on DSO.
- Press the second topmost button, located on the display panel border. It should be set to CH1 by pressing it. (If required repeatedly).
- To measure peak to peak voltage of the displayed waveform, select the “Peak-Peak” option from "Measurement " menu by rotating "Multipurpose" knob located on DSO. Once you select the required option press the multipurpose knob. The value of the peak to peak voltage gets displayed on the bottom of the display panel board. Tabulate the measured value in Table1.

- To measure frequency of the displayed waveform, select the “Frequency” option from "Measurement " menu by rotating "Multipurpose" knob located on DSO. Once you select the required option press the multipurpose knob. The value of the frequency gets displayed on the bottom of the display panel board. Tabulate the measured value in Table1.
- To measure time period of the displayed waveform, select the “Period” option from "Measurement " menu by rotating "Multipurpose" knob located on DSO. Once you select the required option press the multipurpose knob. The value of the Period gets displayed on the bottom of the display panel board. Tabulate the measured value in Table1.
- Following steps, similar to above, measure the minimum voltage, maximum voltage, mean voltage, RMS voltage of the signal.

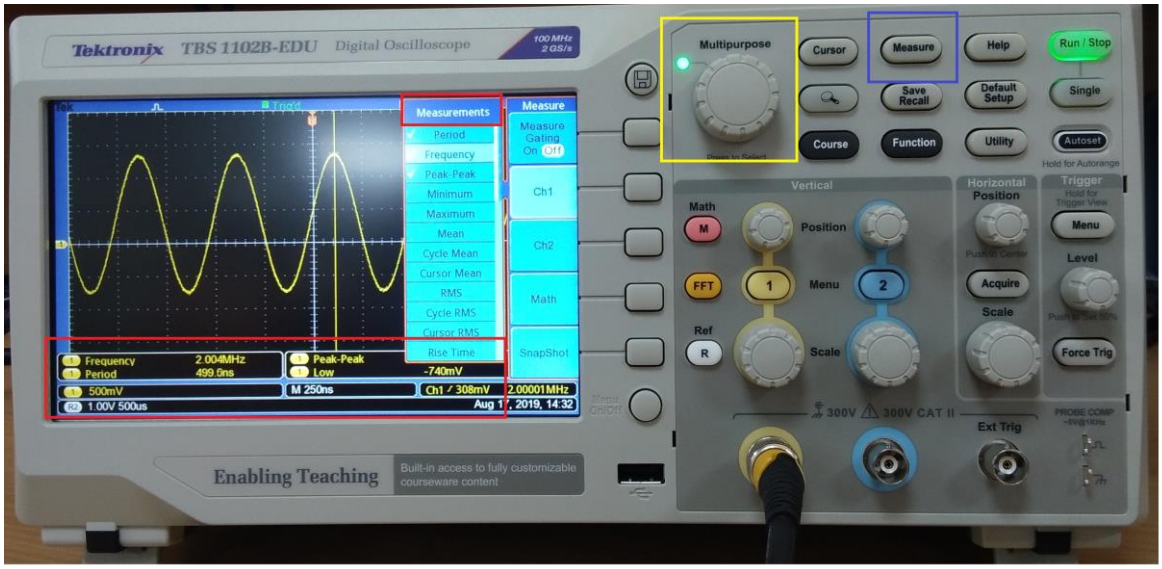
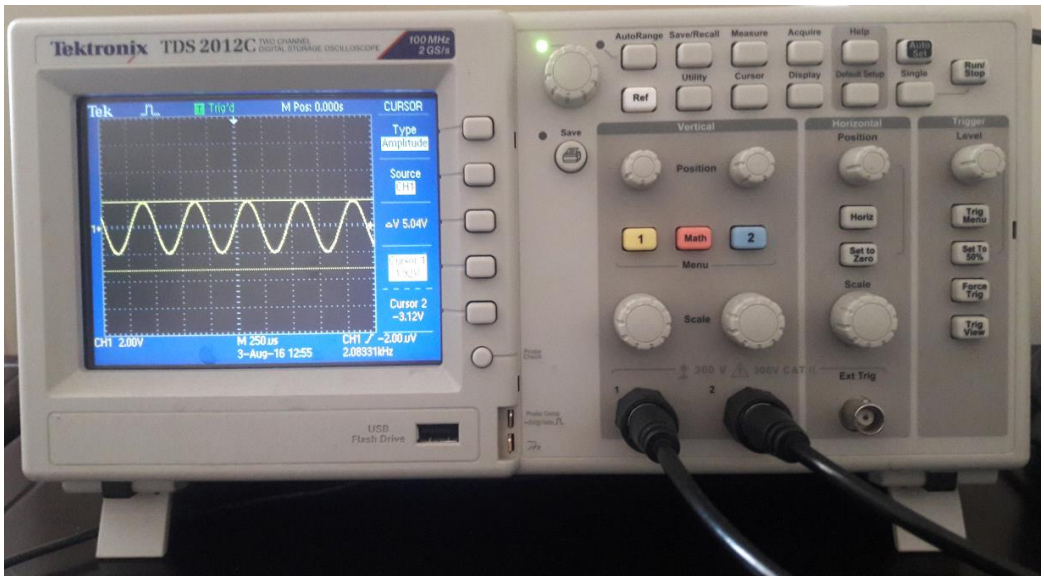


Table1. Amplitude and Frequency Measurements on Sinusoidal Signals Using DSO

Signal	Measurement Procedure	Voltage Measurements					Time Period & Frequency	
		Voltage	Min	Max	Mean	RMS	Time Period	Frequency
2KHz Sine Wave	Built-in Method							
	Cursor Method							
100 KHz Cosine Wave	Built-in Method							
	Cursor Method							

2. Cursor Mode Procedure for Amplitude Measurements:

- Press “Cursor” button on the DSO.
- Press the topmost button, located on the display panel border. It should be set to ‘Amplitude” by pressing it repeatedly, if required**. (Model No. TDS 2012C) OR** Press the "type" button located on the display panel border. Select "Amplitude" option by by rotating "Multipurpose" knob located on DSO**. (Model No. TBS 1102B-EDU)**



- Set the “Source” to CH1, by using corresponding button. You will notice two Yellow horizontal cursors appear on the screen. You will also notice that light near the rotating knob is glowing. Rotate the knob to notice that one of the cursor’s position changes and at the same time, on the screen, highlighted ‘Cursor1” value is changing. The value is the voltage corresponding to the Curso1 position in the vertical direction.
- Press the button corresponding to “Cursor 2”, which is not highlighted. Now this represents the voltage value corresponding to the Cursor 2 position in the vertical direction. It changes when you rotate the knob.
- Now measure peak to peak value of the signal, by appropriately positioning the cursors and noting the **Δv** value on the screen. Tabulate this value in Table 1 and compare with earlier entries. Comment on the discrepancies if any.
- Follow the same procedure as above to measure other amplitude parameters and tabulate in table 1.

3. Cursor Mode Procedure for Time Period Measurements

- Press the topmost button, located on the display panel border. It should be set to ‘Time” by pressing it repeatedly**. (Model No. TDS 2012C)** OR Press the "type" button located on the display panel border. Select "Time" option by rotating "Multipurpose" knob located on DSO**. (Model No. TBS 1102B-EDU)**

- Set the “Source” to CH1, by using corresponding button. You will notice two Yellow Vertical cursors appear on the screen. You will also notice that light near the rotating knob is glowing. Rotate the knob to notice that one of the cursor’s position changes and at the same time, on the screen, highlighted ‘Cursor1” value is changing. The value is time value, corresponding to the Cursor1 position in the horizontal direction.
- Press the button corresponding to “Cursor 2”, which is not highlighted. Now this represents the time value corresponding to the Cursor 2 position in the horizontal direction. It changes when you rotate the knob
- Now measure time period of the signal, by appropriately positioning the cursors and noting the **Δt** value on the screen. Notice that the corresponding frequency is also displayed as 1/ **Δt.** Tabulate these values in Table 1 and compare with earlier entries.
- Comment on the discrepancies if any.

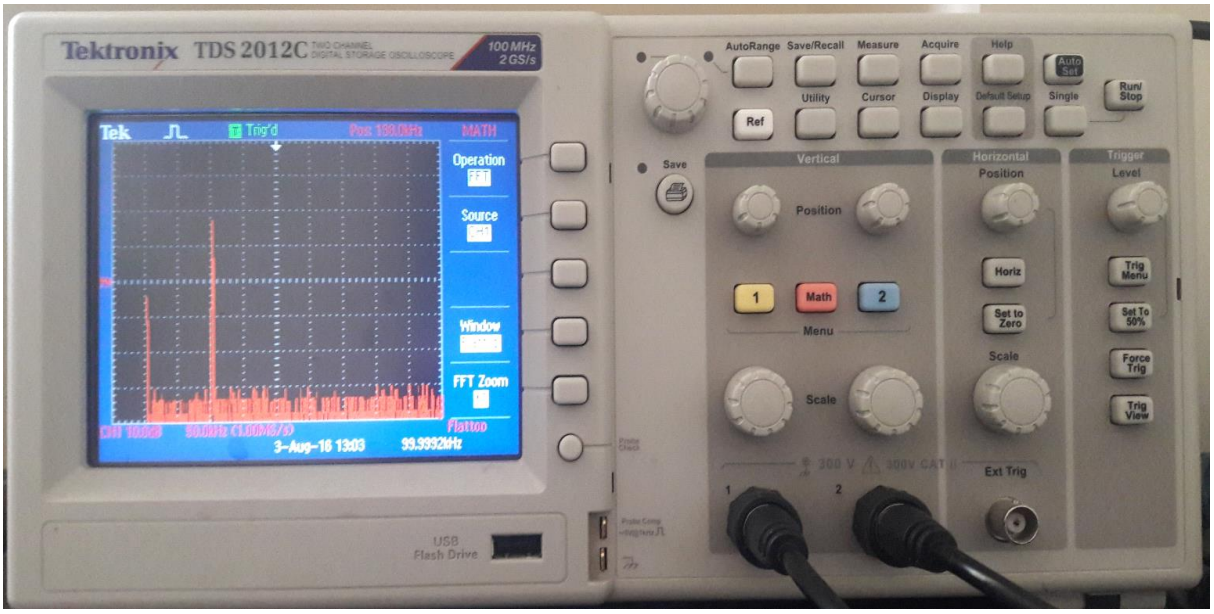
Advise: It is advisable to generate 100 KHz cosine wave from the Master signal module and perform the measurements as done on 2 KHz signal.

C. Study of Spectral Properties of Signals Using DSO.

This experiment is intended to make the student learn about the Spectral domain measurements using FFT feature of the DSO.

i. Old DSO (Model No. TDS 2012C)

- Generate a Sinewave signal of 100 Khz, using “Master Signals Module” and connect to Channel 1 of DSO. Use “Autoset” to obtain stable waveform on the DSO.
- How many cycles of sine wave you observe on the screen? What is the time period of the signal? Does the display indicate the frequency to be 100 KHz? What is the RMS voltage of the signal, as displayed on the screen? Tabulate the RMS Voltage, frequency and the period of signalin Table 2.
- To measure the spectral domain features of the generated signal, we need to use the FFT feature of the DSO. Follow the steps given below to use FFT feature.
    - Press ‘MATH” button on the “Vertical” panel on the DSO.
    - Press the topmost button, located on the display panel border. It should be set to ‘FFT” by pressing it repeatedly.
    - Set the “Source” to “CH1”, by using corresponding button.
    - Set the “Window” to “Flattop”, by using corresponding button.
    - Set the “FFT Zoom” to “X1” by using corresponding button.
    - Using the “Horizontal” “position” knob, bring the peak of the displayed part on the screen to approximately middle of the screen and in between any two of the grid lines.

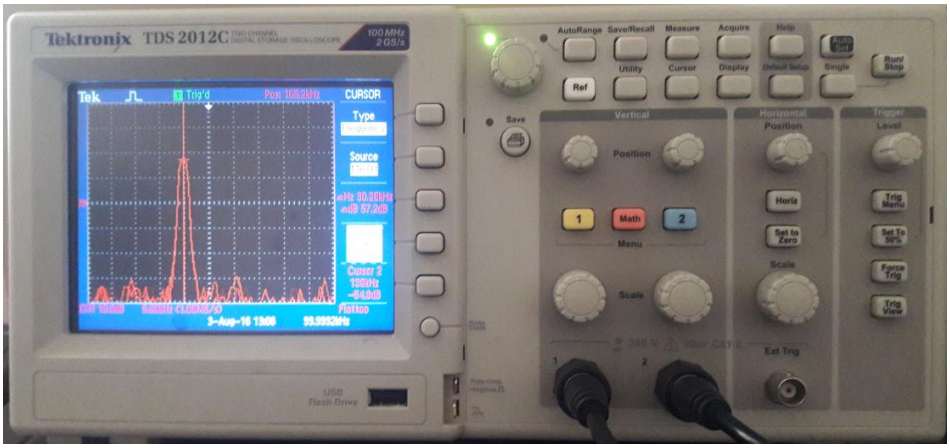


- Why do you see a single thin large vertical line at one position and low level fluctuating vertical lines at other places on the screen? Does this have any relation to Fourier Transform of a sinusoid signal?
- To measure the position of the large vertical line on the horizontal axis, use cursor method. Press the cursor button. For using cursor mode, make sure that the "Source" is in "MATH" mode.To measure the location of the peak, Change the "Type" to Frequency. It means that the horizontal axis is representing Frequency. Do you know the reason?
- Activate "Cursor 1" and align the position of the cursor with the position of large thin line. Note the position, as displayed in the highlighted "Cursor 1" and tabulate in Table 2. Is it close to 100 Khz? Do you see that the Time Domain measurement and frequency domain measured values are matching?

Table2. Time & Spectral Domain Measurements on Sinusoidal Signals Using DSO

Signal	Measurement Procedure	Frequency		RMS Voltage & Power		Power from FFT Mode Measurement (dB)
		Time Domain	Frequency Domain	RMS Voltage(V_{rms})	Power in dB = $20*\log_{10}(V_{rms})$	
100 KHz Sine Wave	Measured by DSO					
	Measured Using Cursors					

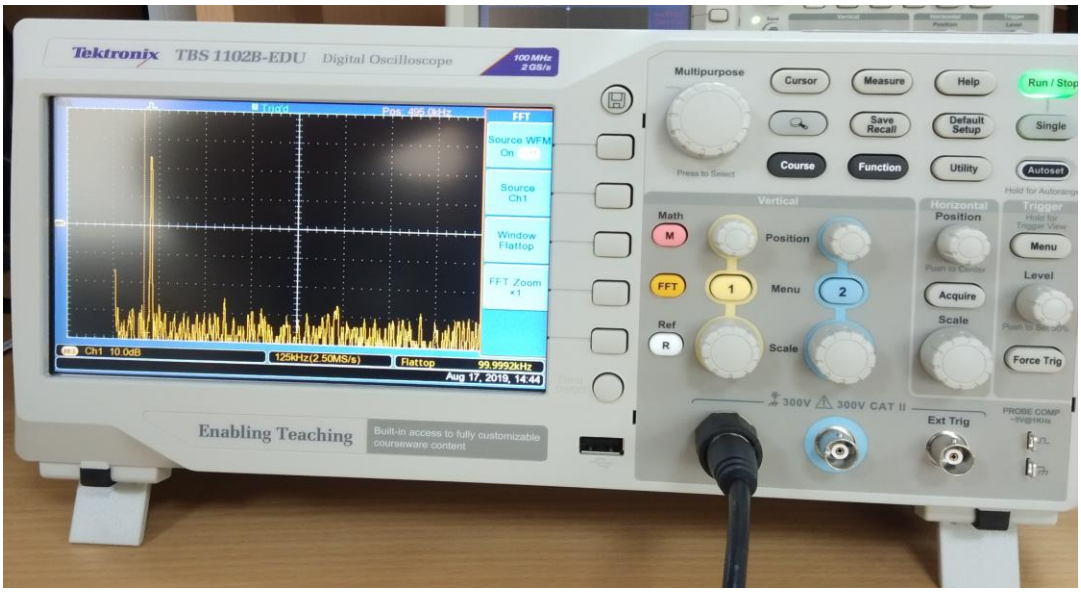
- You also notice that there is a small horizontal line coinciding with the peak amplitude and the CH1 measurement shows some value in “dB”. Tabulate in Table 2.
- How do you relate the RMS voltage you measured in time domain to the peak value you measured now?
- You might have observed that the display is a very thin line. To have a better view, it is advisable to zoom and see. For this, Go to “MATH” mode by pressing MATH button, and change the “FFT ZOOM” to X2. You may have to use the “position knob” to bring the peak to be within the display window.
- Again go to Cursor mode and measure the frequency and amplitude value of the spectral peak. Do you see any discrepancy with respect to “X1” zoom?
- You can further zoom by changing the “FFT ZOOM” to X5. For this, Go to “MATH” mode by pressing MATH button, and change the “FFT ZOOM” to X5. You may have to use the “position knob” to bring the peak to be within the display window. Again go to Cursor mode and measure the frequency and amplitude value of the spectral peak. Do you see any discrepancy with respect to “X1” and “X2” zoom ?



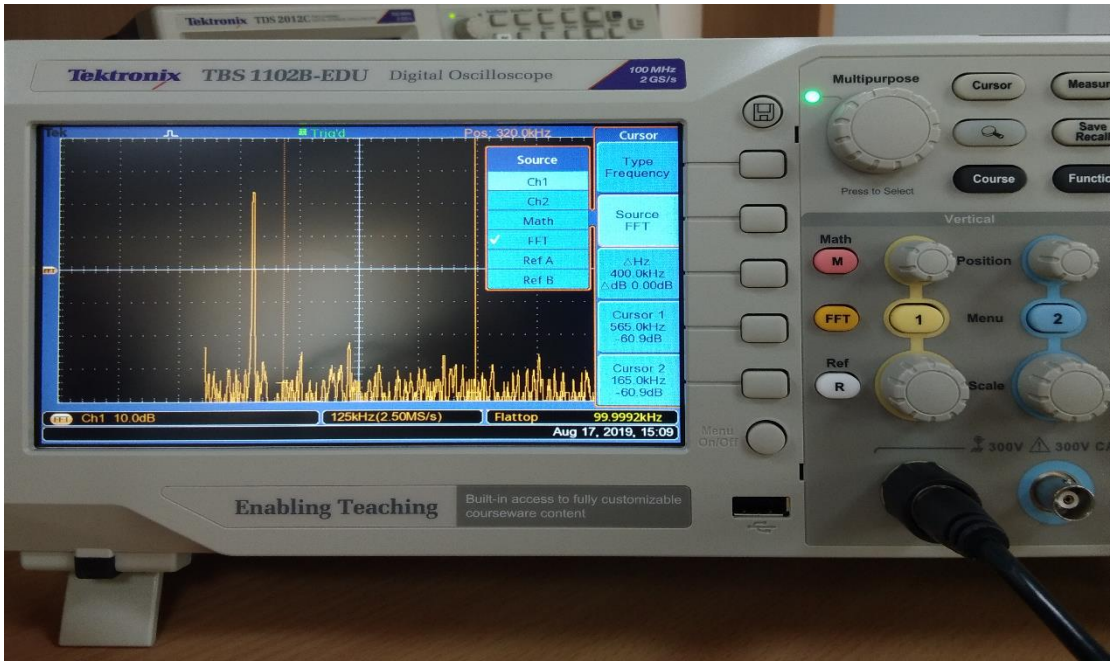
- You can further zoom by changing the “FFT ZOOM” to X10 and go to Cursor mode and measure the frequency and amplitude value of the spectral peak. Do you see any discrepancy with respect to “X1” , “X2” and “x10” zoom ?
- One can further zoom the picture by rotating the “Scale” knob to the left side on “Horizontal” panel. If the peak position moves away from center, use the “Horizontal” position knob to bring it back to the center. Check whether the measurements are consistent for different zoom conditions.
- One can make the amplitude measurements using cursors also. For this, change the “Type” to “Magnitude” Activate “Cursor 1” and measure the peak amplitude. Compare these measured values with previous measurements.

ii. New DSO (Model No. TBS 1102B-EDU)

- Generate a Sinewave signal of 100 Khz, using “Master Signals Module” and connect to Channel 1 of DSO. Use “Autoset” to obtain stable waveform on the DSO.
- How many cycles of sine wave you observe on the screen? What is the time period of the signal? Does the display indicate the frequency to be 100 KHz? What is the RMS voltage of the signal, as displayed on the screen? Tabulate the RMS Voltage, frequency and the period of signalin Table 2.
- To measure the spectral domain features of the generated signal, we need to use the FFT feature of the DSO. Follow the steps given below to use FFT feature.
    - Press ‘FFT” (yellow color button) button on the “Vertical” panel on the DSO
    - Set the “Source” to “CH1”, by using corresponding button.
    - Set the “Window” to “Flattop”, by using corresponding button.
    - Set the “FFT Zoom” to “X1” by using corresponding button.
    - Using the “Horizontal” “position” knob, bring the peak of the displayed part on the screen to approximately middle of the screen and in between any two of the grid lines.



- Why do you see a single thin large vertical line at one position and low level fluctuating vertical lines at other places on the screen? Does this have any relation to Fourier Transform of a sinusoid signal?
- To measure the position of the large vertical line on the horizontal axis, use cursor method. Press the cursor button. For using cursor mode, make sure that the “Source” is in “FFT” mode.To measure the location of the peak, Change the “Type” to Frequency. It means that the horizontal axis is representing Frequency. Do you know the reason?



- Activate "Cursor 1" and align the position of the cursor with the position of large thin line. Note the position, as displayed in the highlighted "Cursor 1" and tabulate in Table 2. Is it close to 100 Khz? Do you see that the Time Domain measurement and frequency domain measured values are matching?

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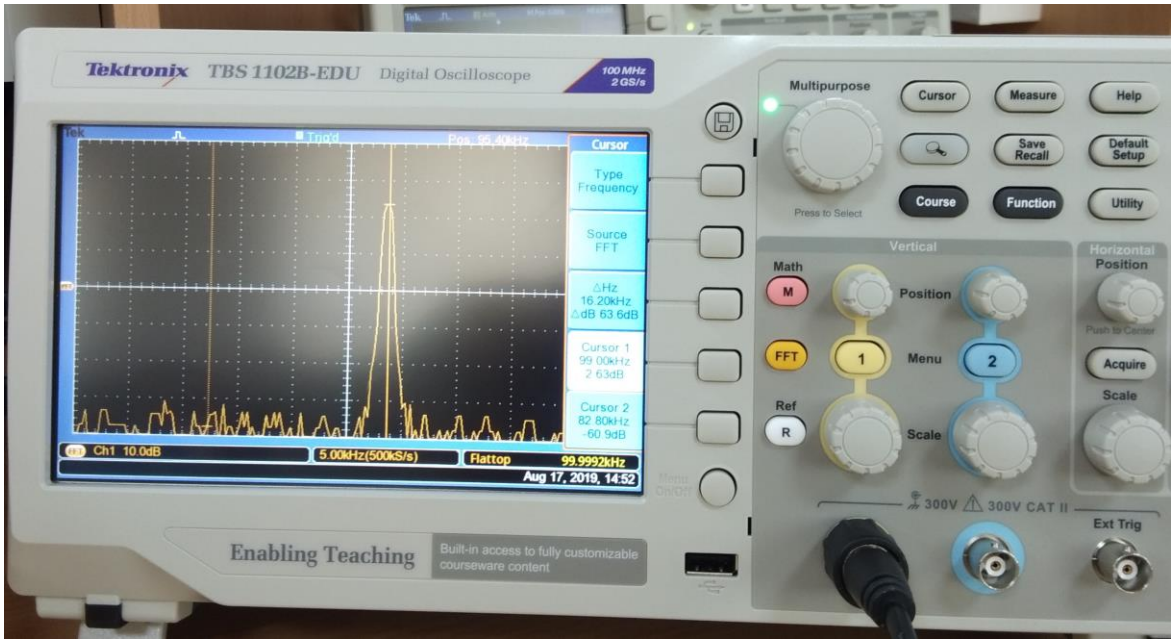
		Time Domain	**Frequency Domain**	**RMS Voltage (V_{rms})**	**Power in dB = $20*\log_{10}$ (V_{rms})**	
100 KHz Sine Wave	**Measured by DSO**					
	Measured Using Cursors					

- You also notice that there is a small horizontal line coinciding with the peak amplitude and the CH1 measurement shows some value in "dB". Tabulate in Table 2.
- How do you relate the RMS voltage you measured in time domain to the peak value you measured now?

- You might have observed that the display is a very thin line. To have a better view, it is advisable to zoom and see. For this, press FFT button, and change the “FFT ZOOM” to X2. You may have to use the “position knob” to bring the peak to be within the display window.
- Again go to Cursor mode and measure the frequency and amplitude value of the spectral peak. Do you see any discrepancy with respect to “X1” zoom ?
- You can further zoom by changing the “FFT ZOOM” to X5. For this, press FFT button, and change the “FFT ZOOM” to X5. You may have to use the “position knob” to bring the peak to be within the display window. Again go to Cursor mode and measure the frequency and amplitude value of the spectral peak. Do you see any discrepancy with respect to “X1” and “X2” zoom?



- You can further zoom by changing the “FFT ZOOM” to X10 and go to Cursor mode and measure the frequency and amplitude value of the spectral peak. Do you see any discrepancy with respect to “X1” , “X2” and “x10” zoom ?
- One can further zoom the picture by rotating the “Scale” knob to the left side on “Horizontal” panel. If the peak position moves away from center, use the “Horizontal” position knob to bring it back to the center. Check whether the measurements are consistent for different zoom conditions.
- One can make the amplitude measurements using cursors also. For this, change the “Type” to “Magnitude” Activate “Cursor 1” and measure the peak amplitude. Compare these measured values with previous measurements.

D. Study of Spectral Properties of Signals Using DSO. (Two Frequencies)

- Generate a composite signal consisting of 2 tones with amplitudes and frequencies (0.75V, 100KHz) and (1.5V, 75KHz), respectively. For this follow the steps below:

	• For generating composite signals, one can use the Adder module of Emona kit. • Locate the Adder module and turn its ***G*** control (for ***Input A***) half way through its rotation. Using the available patch cords, connect 100KHz sine wave signal from the Master Signal Module to the input port 'A". Connect the output of the adder module to Channel 1 of DSO. Obtain a stable waveform on the DSO. Vary the ***G*** control and adjust the signal voltage to 1.5V peak to peak. • Next we need to generate 75 KHz sine wave. Since the master signal module does not have a provision to generate a fixed 75 KHz, signal, we need to use VCO (Voltage Control Oscillator) module for this purpose. • Locate the VCO block on the Emona Kit. Put the Switch to "HI" position. Turn the VCO module's Frequency Adjust control to half way through its rotation.Adjust the Gain knob to be in midway in its rotation. • Connect VCO sine wave output to the B input of the adder module. Vary the Adder module's ***g*** control half way through its rotation. Disconnect input A. Measure the frequency of the signal, at the output of the adder module.Turn the VCO module's Frequency Adjust control to get a 75 KHz sine signal. Now, vary the ***g*** control and adjust the signal voltage to 3.0 V peak to peak. • Is the display stable? • Connect the Channel 2 of DSO to 100KHz sine port on Master signal module. Press the trigger menu and set the trigger source to CH2. Adjust the trigger "Level" to get a stable signal waveform in channel 2. • Go to FFT mode and observe the spectrum on the screen. Use the Horizontal Position knob to bring the spectral peaks to visible region of the screen. You may use the "Window" as "Flattop". Using the combination of Horizontal position and scale knobs, try to get 2 distinct peaks on the screen. • Using cursor mode, measure the frequency and magnitude of each of the peaks. Verify their correspondence to the sine waves with parameters (0.75V, 100KHz) and (1.5V, 75KHz).

Table2. Time & Spectral Domain Measurements on Sinusoidal Signals Using DSO

Signal	Measurement Procedure	Frequency		RMS Voltage & Power		Power from FFT Mode Measurement (dB)
		Time Domain	Frequency Domain	RMS Voltage(V_{rms})	Power in dB = $20*\log_{10}(V_{rms})$	
Composite Signal	Measured by DSO					
	Measured Using Cursors					

E. Conclusions.

What is the learning you gained through this experimentation?