بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

(وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيمٌ)

صدق الله العظيم

Tuesday , March, 24 ,2020
9.00 AM

Experiment 4 l

Transformer Regulation

Presenter:

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Contents

- Transformer Regulation

1. Experiment objective
2. Discussion
3. Experiment steps

- Labvolt simulation software

Experiment objectives

- To study the voltage regulation of the transformer with varying loads.
- To plot load regulation curve

What is Voltage Regulation?

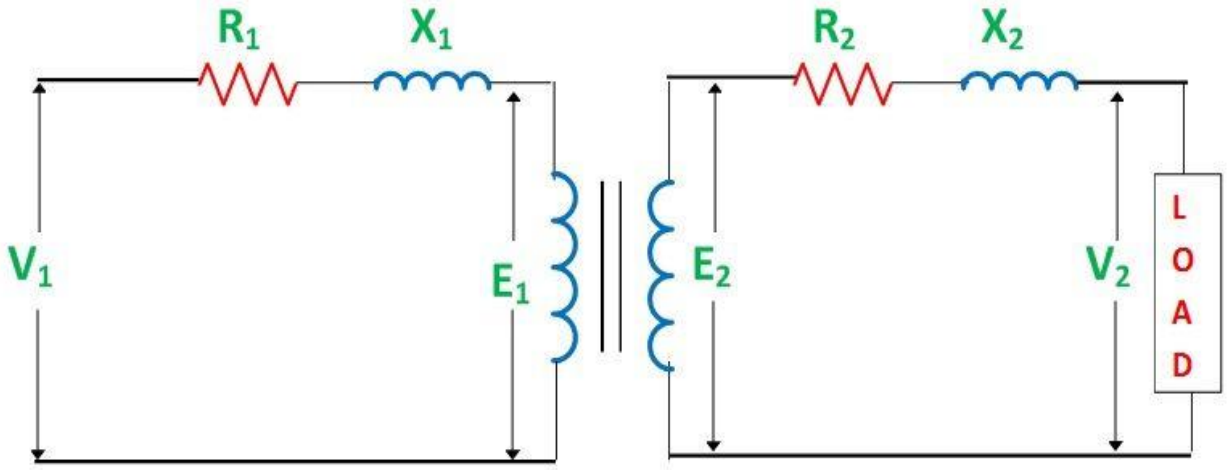
- Voltage regulation is a measure of change in the voltage magnitude between the sending and receiving end of a component.
- Or specifying the influence of load variation on the receiving voltage.
- The variation of terminal voltage depends on the load and its power factor.

It is commonly used in power engineering to describe the percentage voltage difference between no load and full load voltages distribution lines, transmission lines, and transformers.

Electrical Test (2)

Explanation of Voltage Regulation of Transformer

Let us understand the voltage regulation by taking an example explained below:



where,

E_2 – secondary terminal voltage at no load

V_2 – secondary terminal voltage at full load

Electrical Test (2)

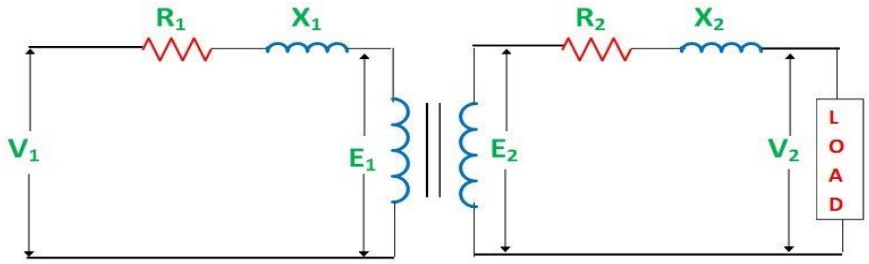
- If the secondary terminals of the transformer are open-circuited or no load is connected to the secondary terminals, the no-load current flows through it.

- If the no current flows through the secondary terminals of the transformer, the voltage drops across their resistive and reactive load become zero.

- If the transformer is fully loaded, i.e., the load is connected to their secondary terminal, the voltage drops appear across it.

The value of the voltage regulation should always be less for the better performance of the transformer.

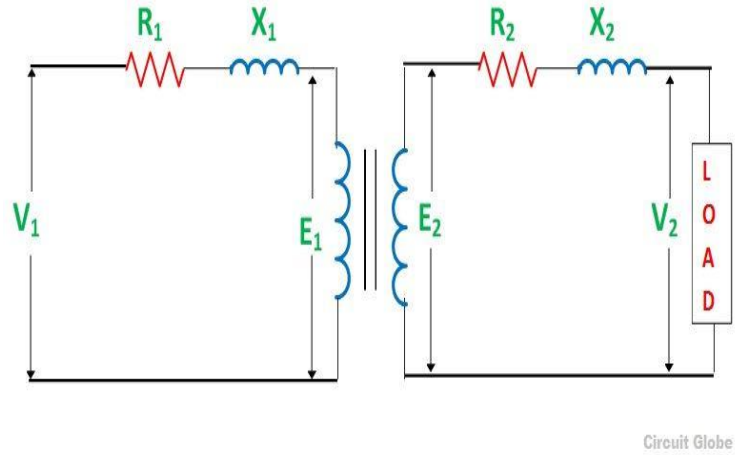
Voltage regulation is equal to zero. This is not practical – and is only theoretically possible in the case for an ideal transformer.



Electrical Test (2)

Expression of Voltage Regulation of Transformer

By considering the below circuit diagram, the following equations are drawn



$$\boldsymbol{V_2 = E_2 - I_2 Z_2}$$

$$\boldsymbol{V_2 = E_2 - I_2(R_2 + jX_2)}$$

At no load $I_2 = 0$ so $V_2 = E_2 = \frac{V_1}{a}$ where a is the transformation ratio which equals $\frac{V_1}{V_2}$

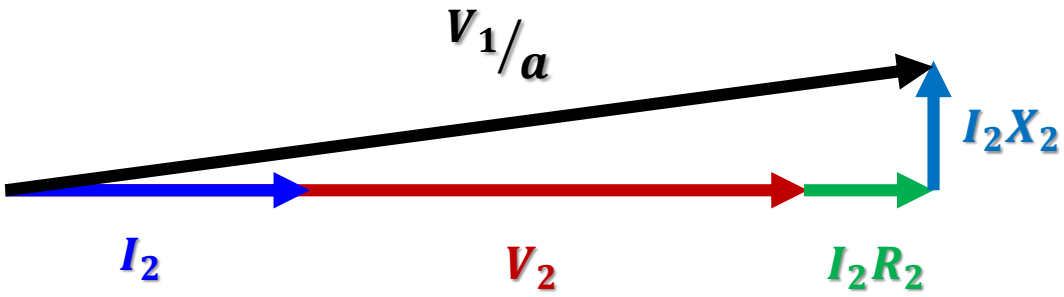
$$\text{Regulation Percentage} = \frac{E_{\text{no-load}} - E_{\text{full-load}}}{E_{\text{full-load}}} (100\%)$$

$$\boldsymbol{VR\% = \frac{V_1/a - V_2}{V_2} \%}$$

Electrical Test (2)

For resistive load (unity PF)

By considering the below phasor diagram,



$$V_2 = E_2 - I_2(R_2 + jX_2)$$

$$VR > 0$$

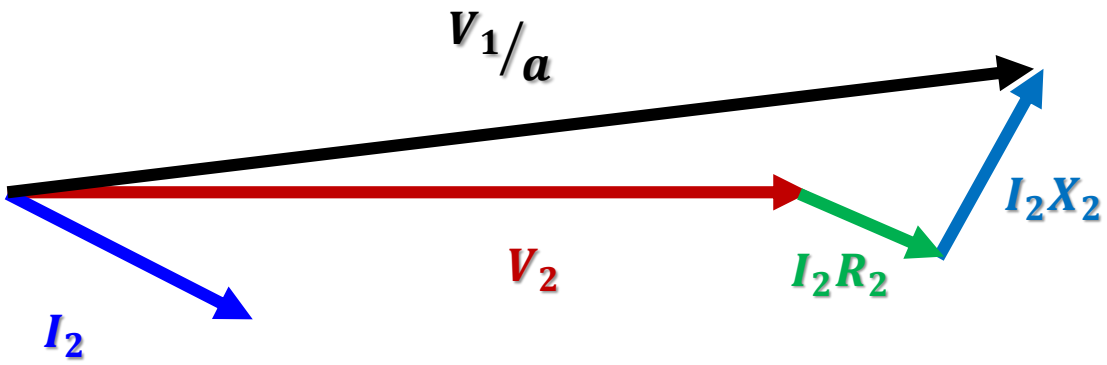
Electrical Test (2)

For inductive load (lag PF)

By considering the below phasor diagram,

$$V_2 = E_2 - I_2(R_2 + jX_2)$$

$$VR > 0$$

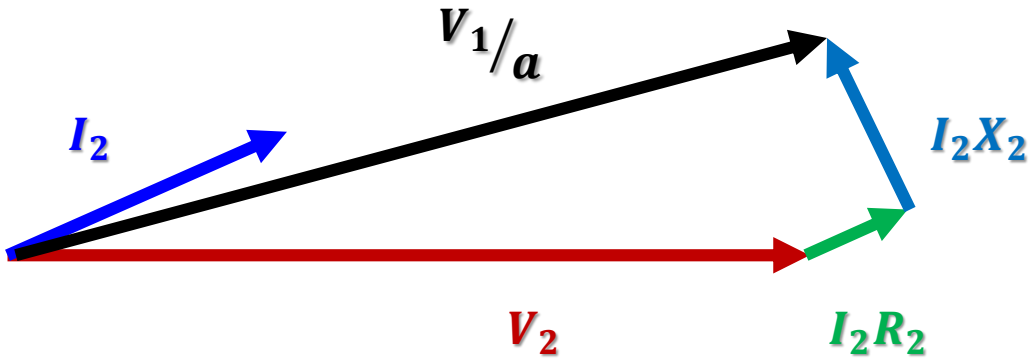


The voltage regulation is a larger number than it was with a resistive load.

Electrical Test (2)

For Capacitive load (lead PF)

By considering the below phasor diagram,



$$V_2 = E_2 - I_2(R_2 - jX_2)$$

$$V_2 = E_2 - I_2R_2 + jI_2X_2$$

$$VR < 0$$

If the secondary current is leading, the secondary voltage can actually be higher than the referred primary voltage.

If this happens, the transformer actually has a negative voltage regulation.

Electrical Test (2)

Experiment steps

INSTRUMENTS AND COMPONENTS :

- Transformer Module
- Power Supply Module (0-220/380 V ac)
- AC Metering Module (250/250/250 V)
- AC Metering Module (0.5/0.5 / 0.5 A)
- Resistance Module
- Inductance Module
- Connection Leads

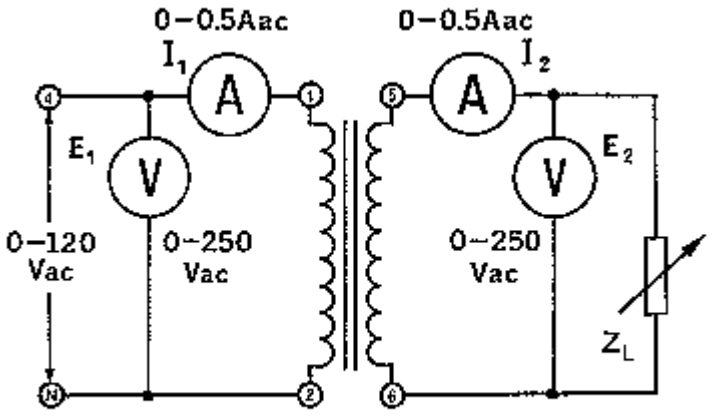


Fig 3-3

Electrical Test (2)

Experiment steps

Install the Power Supply, data acquisition module, Single-Phase Transformer, Resistive Load, Capacitive Load, and Inductive Load modules in the EMS Workstation.

Make sure that the main switch of the Power Supply is set to the O (OFF) position, and the voltage control knob is turned fully counterclockwise. Set the voltmeter select switch to the 4-N position, then make sure that the Power Supply is connected to a three-phase wall receptacle.

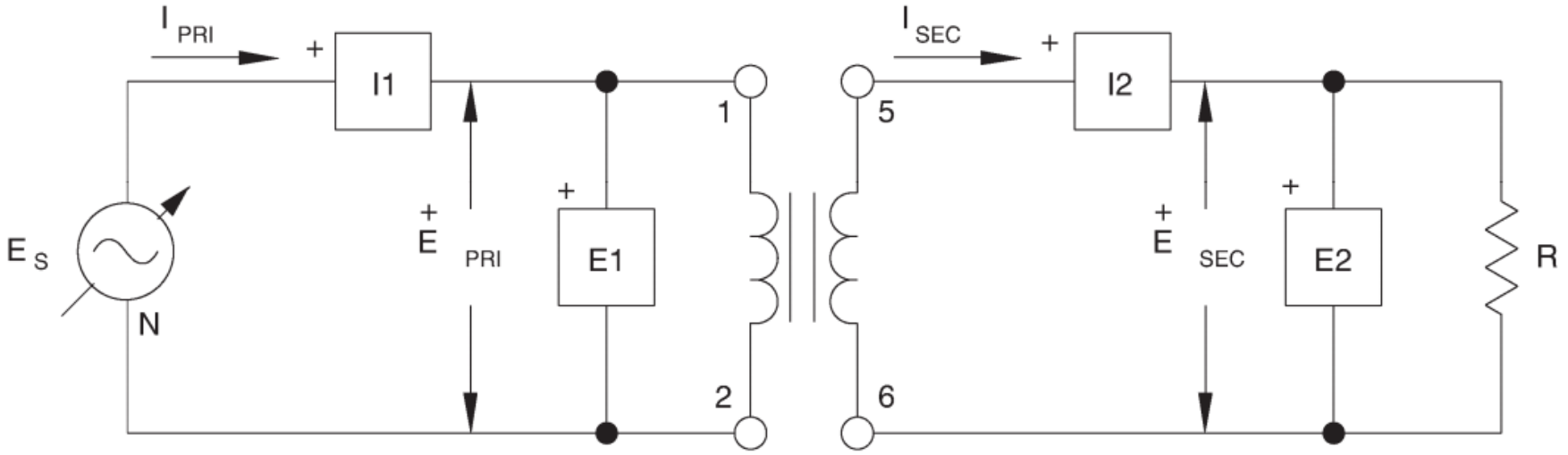
Make sure that the data acquisition module is connected to a USB port of the computer.

Connect the POWER INPUT of the data acquisition module to the 24 V - AC output of the Power Supply. Set the 24 V - AC power switch to the I (ON) position.

Electrical Test (2)

Experiment steps

- Set up the transformer loading circuit shown in Figure 7-10. Make sure that all switches on the Resistive, Capacitive, and Inductive Load modules are open, and connect meter inputs E1, E2, I1, and I2 as shown in the figure. Different load values will be used to examine how the secondary (load) voltage changes as transformer loading changes.



Electrical Test (2)

Experiment steps

Local ac power network		E_S (V)	R (Ω)
Voltage (V)	Frequency (Hz)		
120	60	120	∞
220	50	220	∞
220	60	220	∞
240	50	240	∞

Local ac power network		R, X_L, X_C (Ω)	R, X_L, X_C (Ω)	R, X_L, X_C (Ω)	R, X_L, X_C (Ω)	R, X_L, X_C (Ω)
Voltage (V)	Frequency (Hz)					
120	60	1200	600	400	300	240
220	50	4400	2200	1467	1100	880
220	60	4400	2200	1467	1100	880
240	50	4800	2400	1600	1200	9600

Electrical Test (2)

Experiment steps

Plot the regulation curve with output voltage vs output current for each type of the transformer load

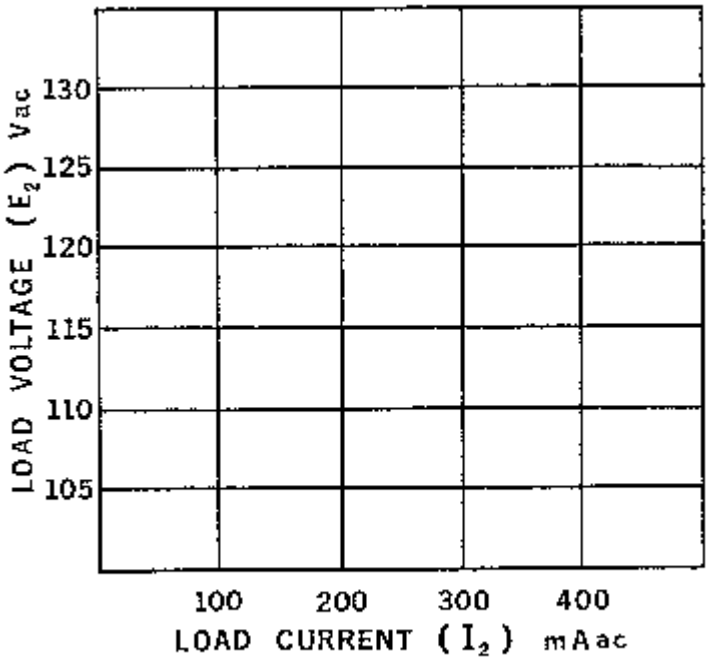
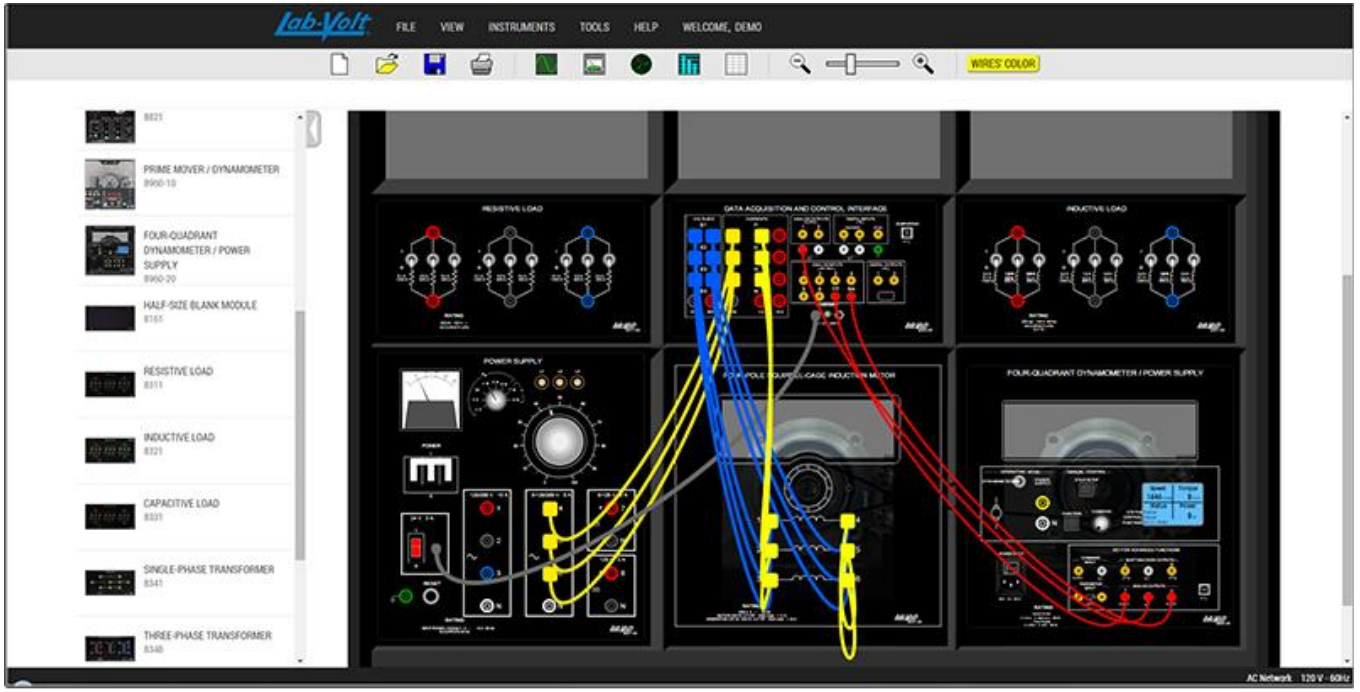


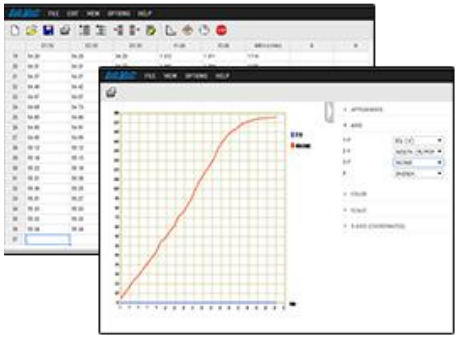
Fig 3-4

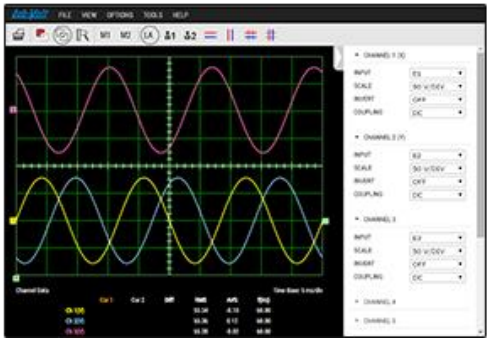
Electrical Test (2)

Labvolt simulation

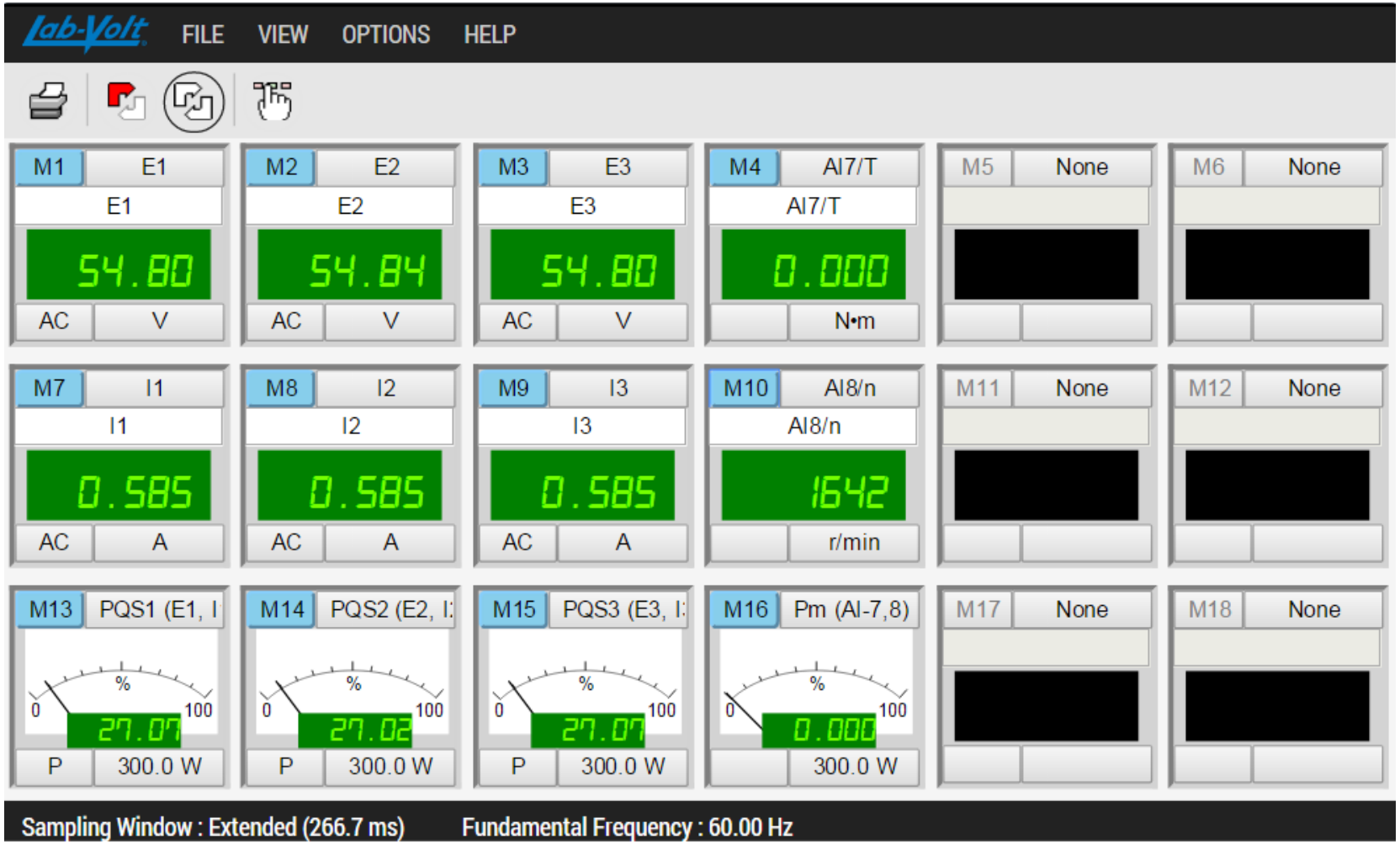
Electrical Test (2)







Electrical Test (2)



Electrical Test (2)

Lab-Volt FILE EDIT VIEW OPTIONS HELP

	E1 (V)	E2 (V)	E3 (V)	I1 (A)	I2 (A)	I3 (A)	G	H
1	0.384	0.660	0.752	0.013	0.022	0.025		
2	0.737	1.263	1.440	0.025	0.042	0.048		
3	1.134	1.945	2.216	0.038	0.065	0.075		
4	1.549	2.658	3.025	0.052	0.090	0.102		
5	1.912	3.280						
6	2.323	3.985						
7	2.721	4.672						
8	3.094	5.307						
9	3.480	5.974						
10	3.881	6.658						
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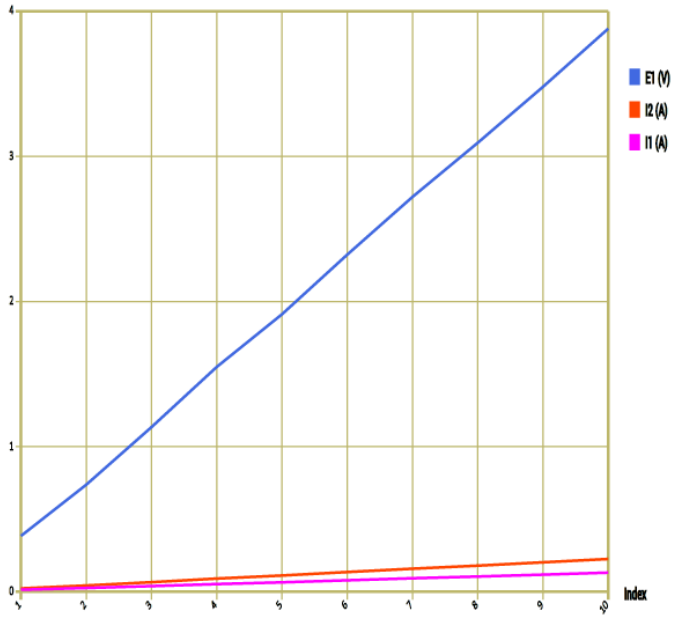
Lab-Volt FILE VIEW OPTIONS HELP



APPEARANCE

AXIS

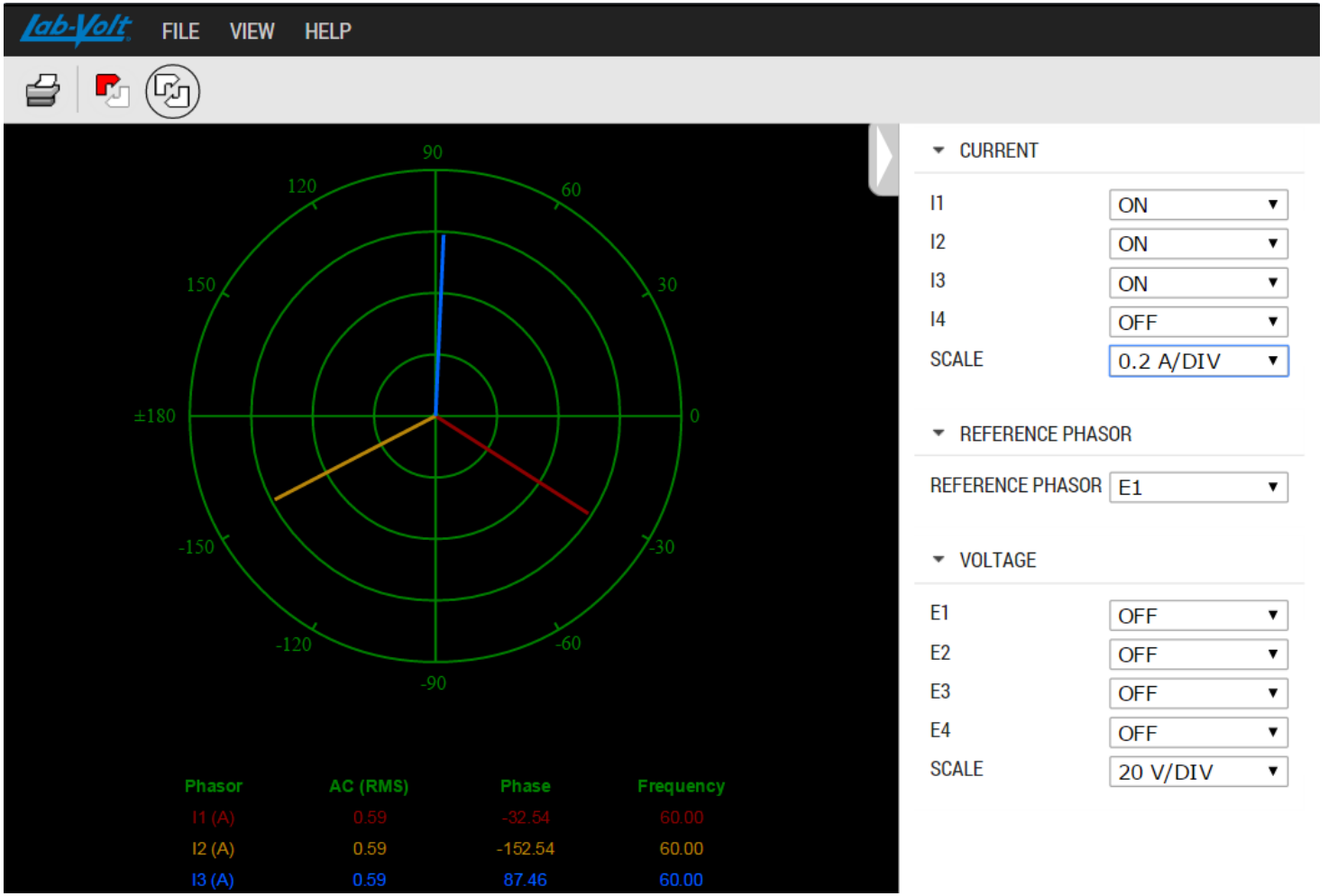
1-Y	E1 (V)
2-Y	I2 (A)
3-Y	I1 (A)
X	INDEX

COLOR

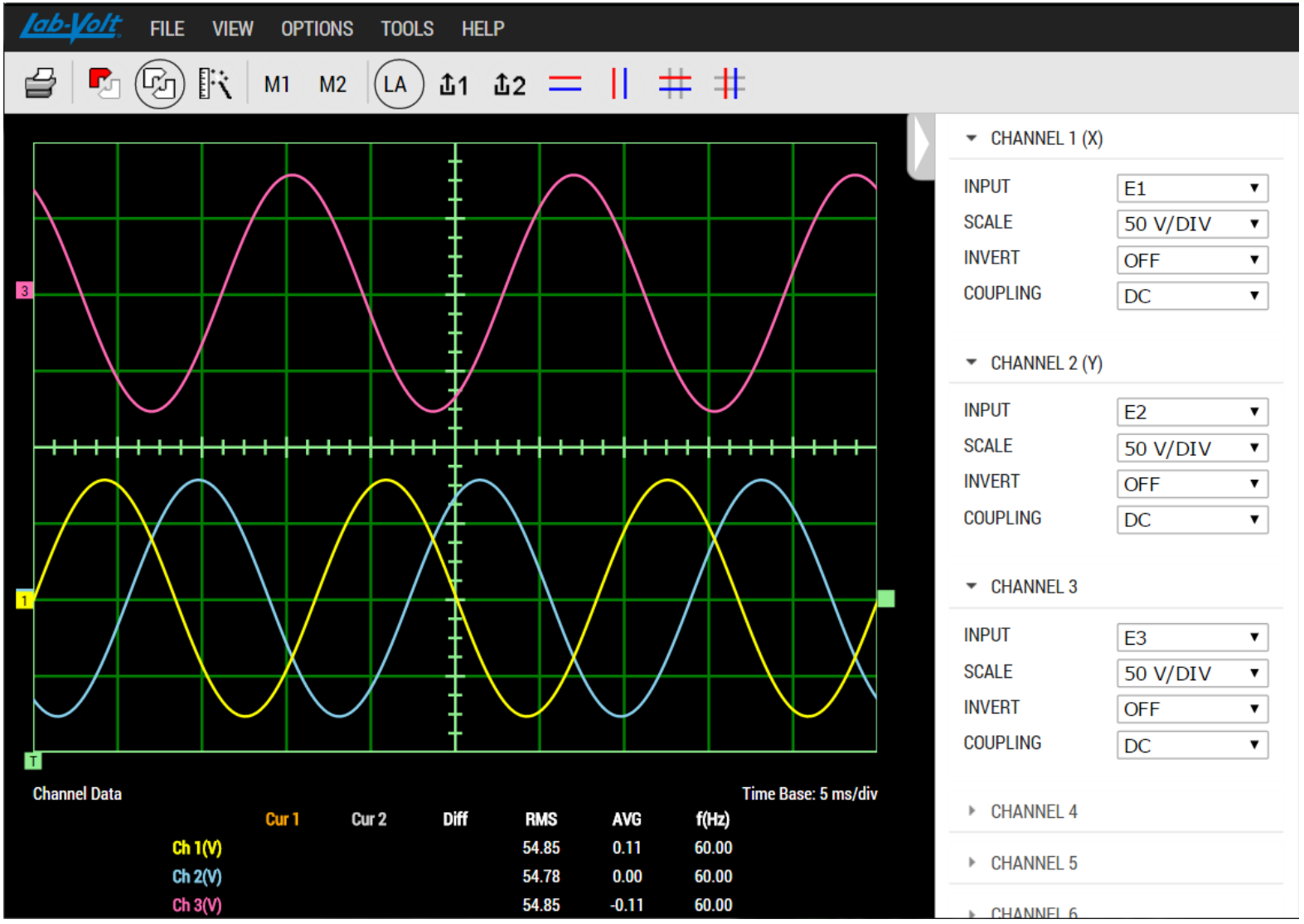
SCALE

X-AXIS (COORDINATES)

Electrical Test (2)



Electrical Test (2)



Electrical Test (2)

Labvolt simulation

Electromechanical Systems Simulation Software (LVSIM®-EMS)

https://www.labvolt.com/solutions/6_electricity_and_new_energy/98-8970-00_electromechanical_systems_simulation_software_lvsim_ems?fbclid=IwAR3KoaqulV8jn3MeFgkcL5TfA7dpUDjYL1jKu-z8Jk_S_j1yTnxxYTUKCTc

LVSIM- EMS 371

https://www.labvolt.com/downloads/LVSIMEMS371.zip

LV SIM EMS 42300
https://www.labvolt.com/downloads/LVSIMEMS42300.zip

Security Device Drivers (Windows 8 compatible)

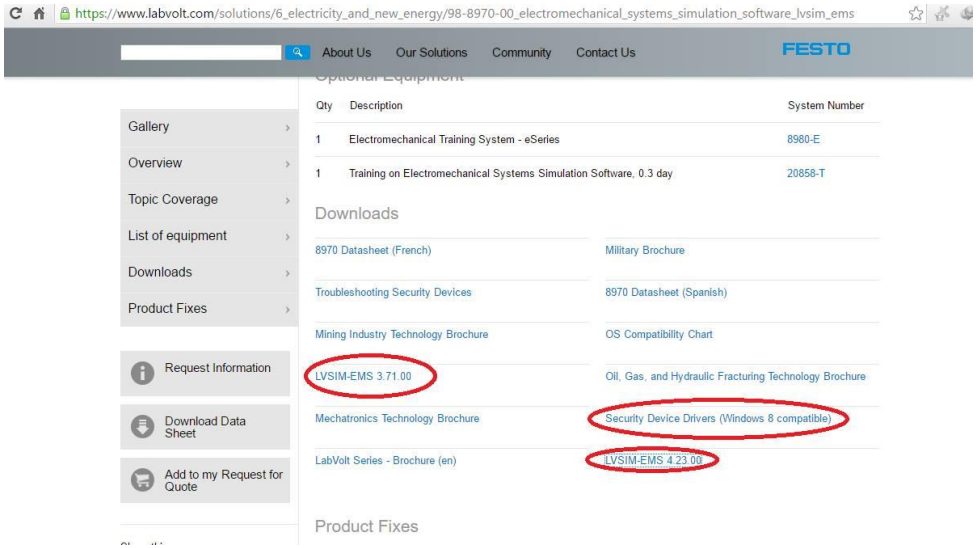
https://www.labvolt.com/dow…/Sentinel_LDK_Run-time_setup.zip

Electrical Test (2)

Labvolt simulation

All program

https://drive.google.com/drive/folders/1EadUFBf25na2b85EVjxCxaXjg1fwhiIN?usp=sharing



الخطوات

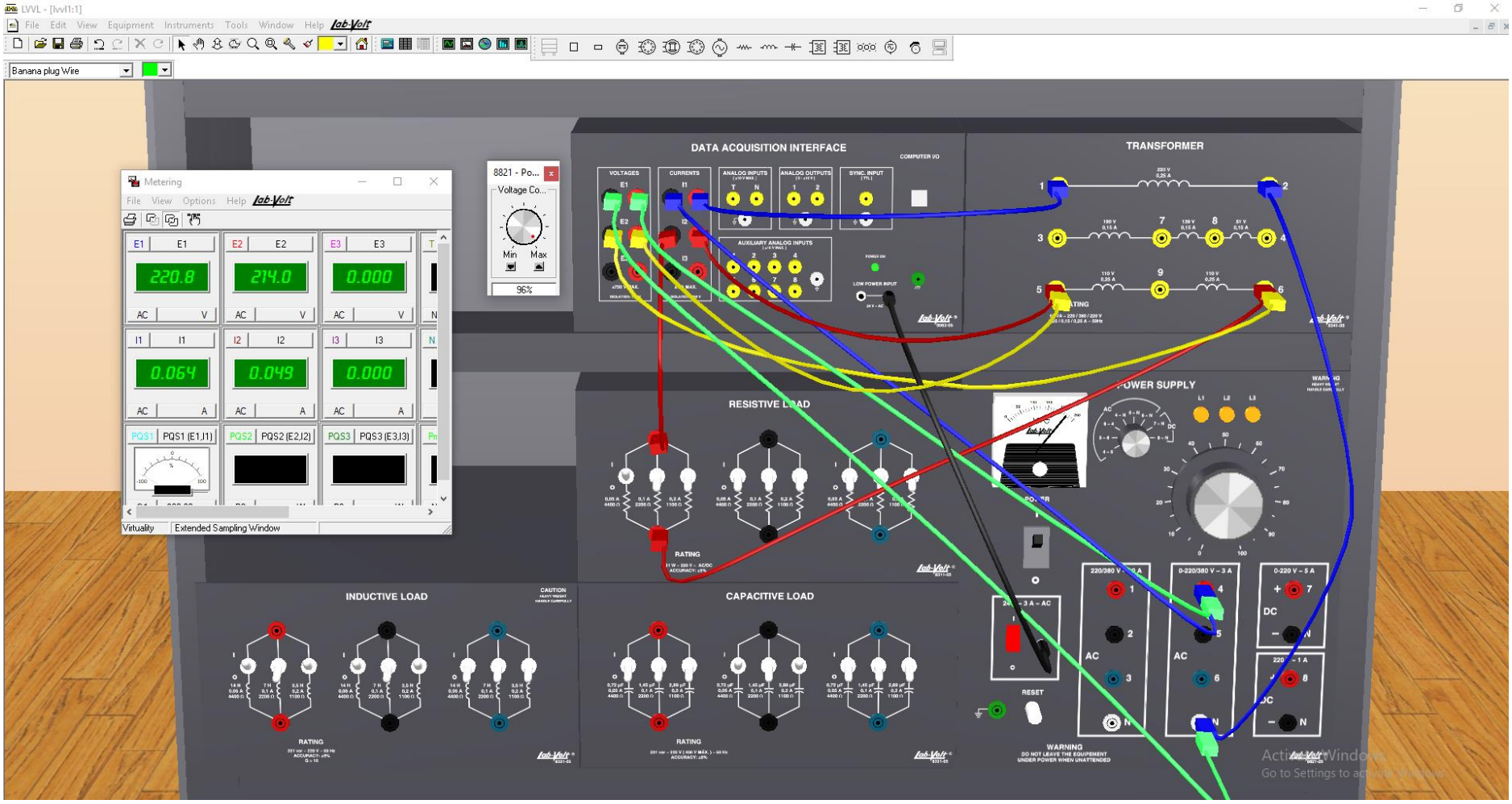
1- ازالة نسخة البرنامج الموجودة علي الجهاز

2- تثبيت برنامج Security Device Drivers

3-اعادة تثبيت الرنامج

#ملحوظة / قد لا تتوافق هذه الخطوات مع كل الاجهزة

Electrical Test (2)



Electrical Test (2)

Quiz

1. A transformer can have zero voltage regulation at _____
   a) Leading power factor
   b) Lagging power factor
   c) Unity power factor
   d) Zero power factor

2. Negative voltage regulation indicates _____
   a) Capacitive loading only
   b) Inductive loading only
   c) Inductive or resistive loading
   d) Cannot be determined

3. A good voltage regulation of a transformer indicates _____
   a) output voltage fluctuation from no load to full load is least
   b) output voltage fluctuation with power factor is least
   c) difference between primary and secondary voltage is least
   d) difference between primary and secondary voltage is maximum

Electrical Test (2)

Quiz answer

1. Answer: a
Explanation: At leading power factor the voltage regulation is given by I*(Rcosφ- Xsinφ). Thus, at a particular condition of angle φ we may get zero voltage regulation. While in lagging power factor case we have + sign in the above formula.

2. Answer: a
Explanation: The sign -ve arises in the voltage regulation calculations when, the load connected to the transformer is leading in the nature. The only condition when we'll get negative voltage regulation when second term is higher than first term.

3. Answer: a
Explanation: Voltage regulation is defined as rise in the voltage when the transformer is thrown off from full load condition to no-load condition. Thus, least voltage regulation means output fluctuations depending on the load are very less.

Electrical Test (2)

Feedback

Email: hossam.herzallah7@gmail.com

Email subject: Transformer regulation Feedback

Electrical Test (2)

Reference

- Chapman, Stephen. Electric machinery fundamentals. Tata McGraw-Hill Education, 2005.
- Theraja, B. L. (1997). A Textbook of Electrical Technology (Volume-ii). Ram Nagar.
- https://www.electrical4u.com/electrical-engineering-articles/transformer/
- https://circuitglobe.com/what-is-voltage-regulation-of-a-transformer.html


Thanks