The computation of the PQ indices on the implemented system along with the RLC load is identified before any disturbance, during the sag voltage, during the harmonic distortion and after these disturbances. These measures are displayed in the table below (Table 1) to clearly analyze how the parameters are affected by each disturbance.

Table I. Comparison Table of the values of power quality indices at each time.

	Before Disturbances	During Sag	During Harmonic	After Disturbances
Vrms (V)	70.5346	28.2843	95.38	70.71
THDv (%)	0	0	90.69	0
TIFv	0	0	237.607	0
VT	0	0	22662.9	0
Distortion Factor	1	1	0.183211	1
Displacement Power Factor	0.066284	0.06572	0.06567	0.06626
True Power Factor	0.066284	0.06572	0.01203	0.06626

Table I indicates that the RMS value is affected by all types of disturbances. When no disturbance occurs, the RMS voltage is almost 70.7 V ($Vp\sqrt{2}$= 100√2=70.7). This RMS value decreases in the case of a sag voltage (28.28 V) and increases in the case of a swell voltage or harmonic distortion (95.38V).

The crest factor, in a normal signal, free of harmonics, is equal to almost 1.414 and this index varies with the variation of the RMS and peak voltages.

However, THD, DIN, TIF, VT, and IT are only affected in the presence of harmonics. Otherwise, they are equal to zero. The harmonic plot in a normal signal only contains the fundamental component. Whereas, the harmonic plot of a distorted signal shows the fundamental component along with the 3rd, 5th and 7th order harmonics. In this case, the THD, DIN, TIF, VT and IT will highly increase.

The distortion power factor related to the total harmonic distortion is equal to one in a signal free of harmonics. Hence, this factor decreases to 0.18321 during the presence of harmonic distortion.

While the displacement power factor remains the same even with the presence of harmonics, the true power factor gets smaller as harmonics are added and becomes less than the displacement factor. Both TPF and DPF are equal in non-harmonic situations.

6. Conclusion

In their field work, electrical engineers might face a lot of problems while dealing with power quality. All new technologies related to nonlinear devices and renewable energy sources generate a huge amount of quality disturbances.

This virtual lab was designed to enhance the knowledge of the EE on power quality problems, for them to be aware of all the issues and to be able to handle and manage all the situations properly in their future career as electrical engineers with regards to power quality standards and practice guides. Each PQ problem such as voltage sag, voltage swell, harmonics and unbalance were tackled in this virtual lab by measuring and analyzing all the PQ indices discussed earlier in the paper.

This tool is considered as a teaching and training tool, to be applied in lab activities after teaching, learning and discussing the power quality generalities and concepts. A laboratory manual with several experiments was developed to meet the learning objectives related to power quality.

This lab was built using NI LabVIEW/Multisim, an accessible learning tool. The EE will be able to investigate the effects of the desired power quality issue on different types of loads designed using Multisim.

Moreover, it is important to mention that this eco-friendly and cost-efficient virtual lab can be considered as a foundation because it can always be updated and developed for future objectives where more issues can be tackled and more experiments can be added to always keep EE fully informed on all the updates related to power quality.

Acknowledgement

The authors acknowledge the University of Balamand and especially the supervisors for their guidance, help, expertise, and support during the project.

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