Research & Development

UNIVERSITÀ DEGLI STUDI FIRENZE

Energia power quality maximum saving

Lab Analysis - Joint R&D

Energia Europa owns a state of the art laboratory, jointly managed with the University of Florence: the Smart Energy Lab. The lab is equipped with the most sophisticated equipment available today in terms of the capability to analyze all the parameters that affect the power quality. Thanks to this equipment our engineers, together with the researchers from the department of Information Engineering of the University of Florence, are able to measure and analyze the effects of the E-Power device on the all sorts of loads. Through this analysis we are able to demonstrate the impact of our devices on the loads and carry on a constant experimental activity on new technological solutions.

Our cooperation with universities and research institution does not stop at the Italian borders. We keep an intense joint R&D activity with prestigious international institutions, such as the Polytechnical University in Madrid (Spain), University of Krefeld in Germany and other prestigious research institutes in Germany and Poland.

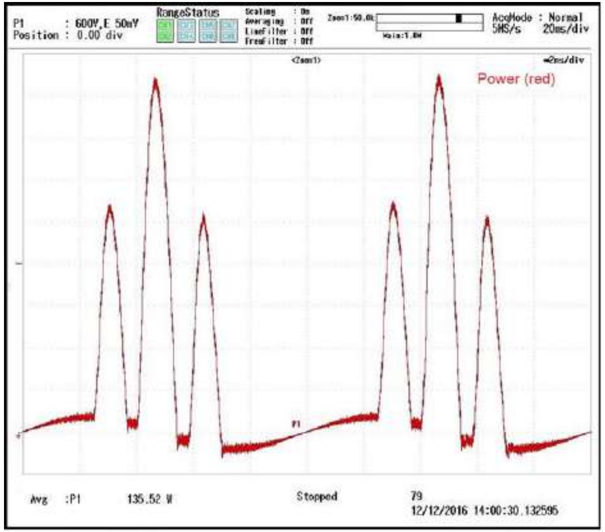
E-Power - How it generates efficiency?

The E-Power system acts and modifies all the parameters that compose the power waveform.

The power waveform of an electrical network or a single load regulated by power electronics is composed of all these parameters.

E-Power generates efficiency by affecting all these parameters, so modifying the power waveform and especially the current waveform which are spoiled by losses and disturbances, it will be possible to recover energy efficiency.

- THDI
- Current Waveform
- Voltage Waveform
- THDV
- Current Form Factor (Irms/I'avg)
- Current Crest Factor (Imax/Irms)
- Ipk
- Smoothing effect di/dt
- Voltage Form Factor (Vrms/V'avg)
- Voltage Crest Factor (Vmax/Vrms)
- Vpk



Lab Analysis

Analysis on the results of the Lab tests that have been conducted on the effects of the E-Power system on Current and Instant Power, with sampling frequency of 5MS/s.

These effects have been measured in Energia Europa's Lab utilizing high precision equipment in conditions which penalize the performance of the E-Power system compared to the real production sites, where losses and disturbances are much greater.

YOKOGAWA
WT1800
Precision
Power Analyzer

YOKOGAWA
PX8000
Precision
Power Scope

12 Measuring Channels
6 Voltage Channels
6 Current Channels

8 Measuring Channels
4 Voltage Channels
4 Current Channels

Current Harmonics Reduction and Reconfiguration

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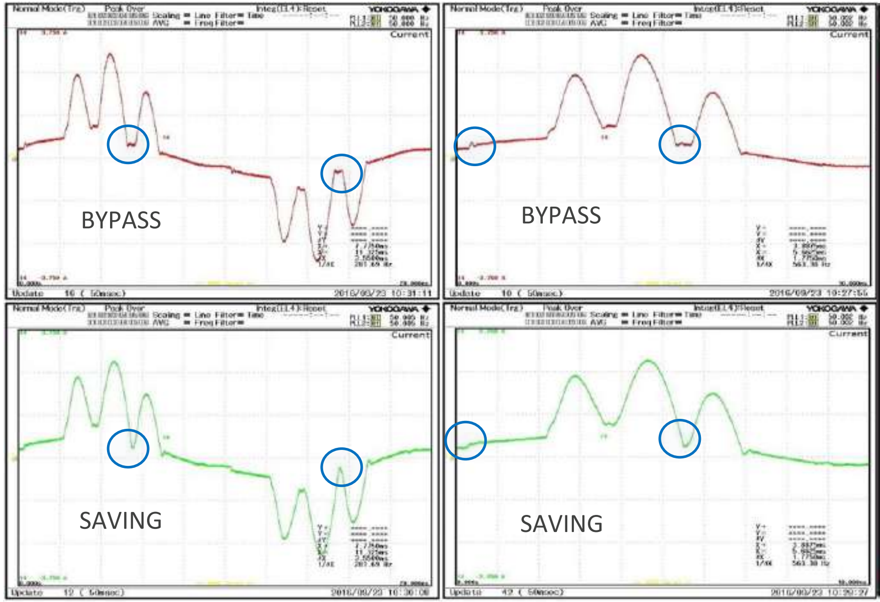
Lab test on non linear loads (switching): modest THD reduction but some key harmonics show significant reduction, like the 5th and the 11th.

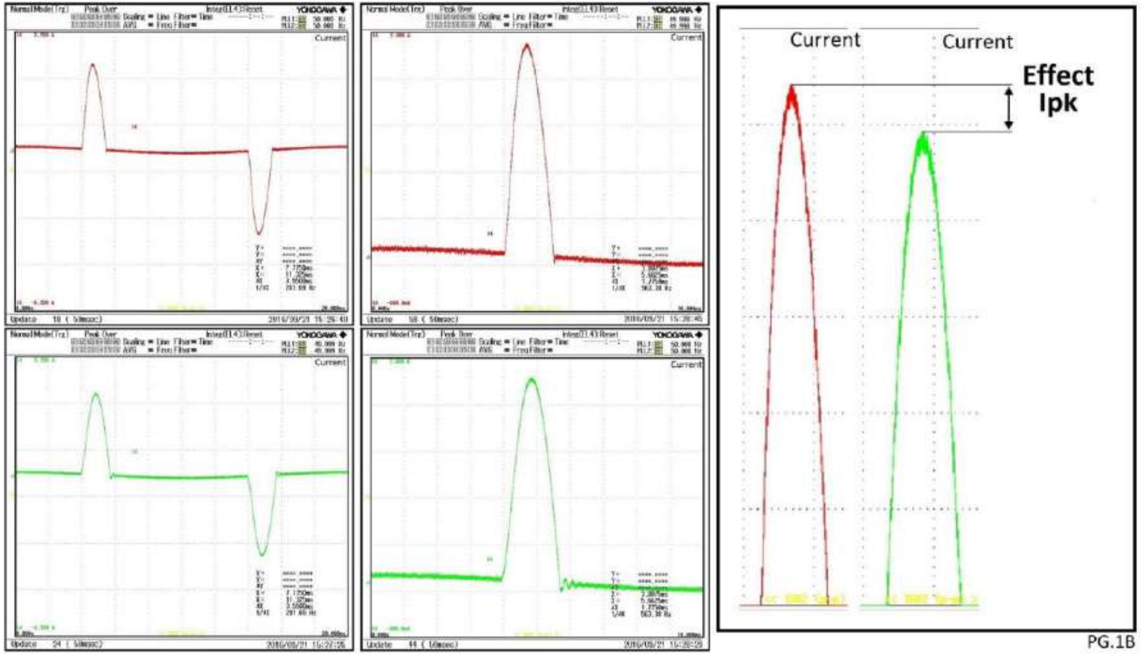


effect on harmonic configuration

Order	I4 [A]	hdf[%]	Order	I4 [A]	hdf[%]
Ithd4	60.461 %		Ithd4	54.342 %	
Total	1.207		Total	1.214	
1	1.032	100.000	1	1.067	100.000
3	0.350	33.934	3	0.356	33.413
5	0.044	4.248	5	0.022	2.027
7	0.039	3.803	7	0.037	3.467
9	0.192	18.590	9	0.181	16.989
11	0.364	35.258	11	0.325	30.461
13	0.280	27.160	13	0.231	21.676
15	0.077	7.489	15	0.060	5.603
17	0.062	5.970	17	0.077	7.198
19	0.053	5.126	19	0.054	5.093
21	0.015	1.500	21	0.015	1.450
23	0.028	2.699	23	0.022	2.049
25	0.016	1.573	25	0.028	2.619
27	0.023	2.225	27	0.021	2.014
29	0.013	1.243	29	0.018	1.668
31	0.009	0.892	31	0.017	1.591
33	0.013	1.265	33	0.012	1.111
35	0.021	2.023	35	0.008	0.709
37	0.011	1.106	37	0.004	0.342
39	0.008	0.746	39	0.006	0.597

Current Peaks Reduction

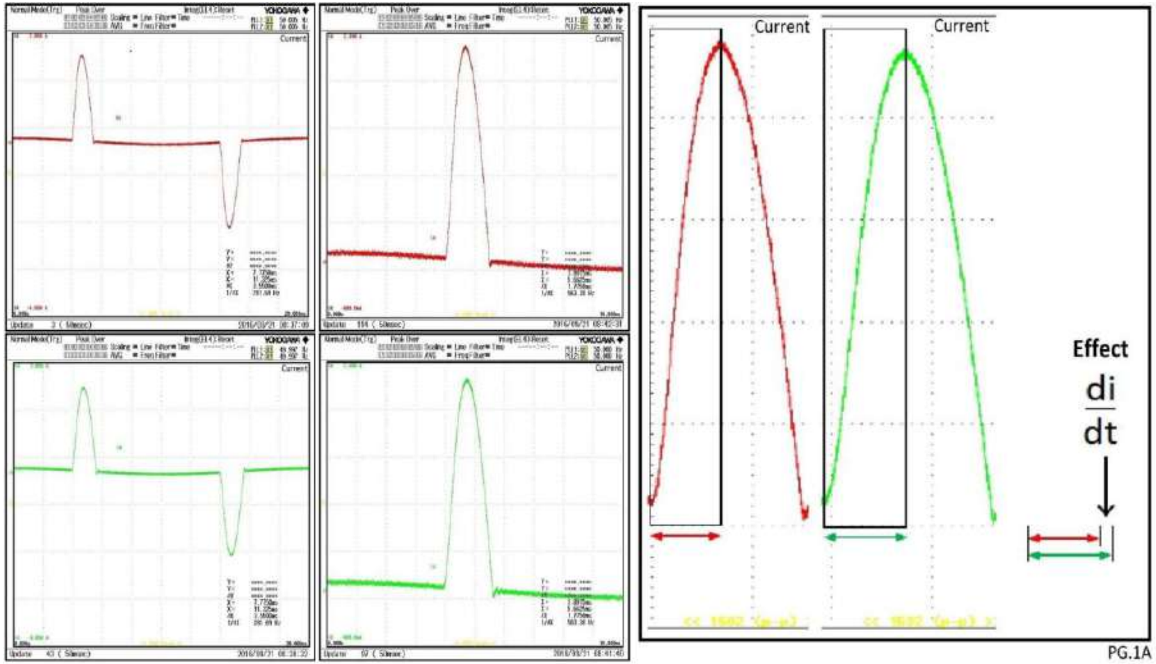
Lab test results on non linear loads (switching): in the Saving mode a significant peak reduction.



PG.1B

Current Smoothing Effect

Lab test results on non linear loads (switching): the speed of current climbs is slower and the waveform smoother.



Current Harmonics TripleN Effect

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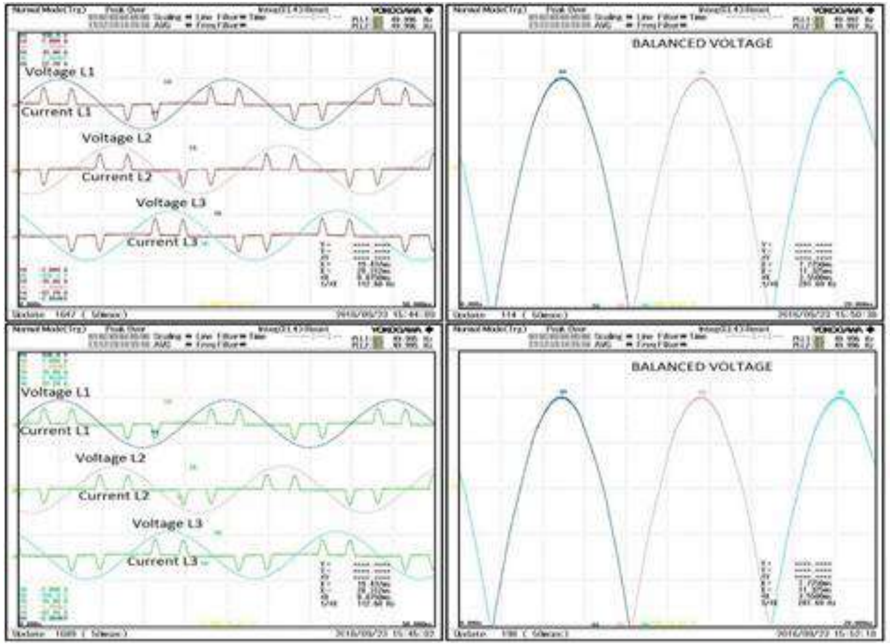
Lab Tests Results on non linear loads (switching): with balanced voltage homogeneous reduction of THD and TripleN harmonics.



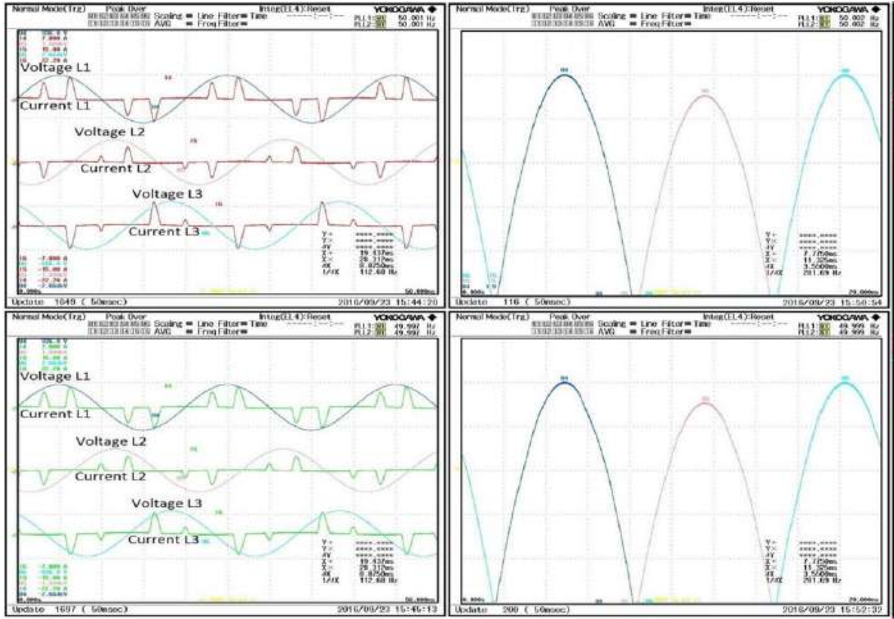
Effect TripleN
BALANCED VOLTAGE

I_{thd4}	158.888		I_{thd5}	160.001		I_{thd6}	160.174	
Order	I_4 [A]	hdf [%]	Order	I_5 [A]	hdf [%]	Order	I_6 [A]	hdf [%]
3	0.003	0.868		0.003	0.945		0.001	0.277
9	0.002	0.569		0.002	0.721		0.001	0.297
15	0.001	0.279		0.001	0.234		0.001	0.448
21	0.002	0.564		0.002	0.506		0.002	0.545
27	0.001	0.456		0.002	0.764		0.002	0.510
33	0.001	0.411		0.001	0.461		0.001	0.327
39	0.001	0.348		0.001	0.292		0.000	0.058

I_{thd4}	148.935		I_{thd5}	149.963		I_{thd6}	149.805	
Order	I_4 [A]	hdf [%]	Order	I_5 [A]	hdf [%]	Order	I_6 [A]	hdf [%]
3	0.001	0.439		0.002	0.637		0.000	0.084
9	0.000	0.099		0.002	0.558		0.002	0.499
15	0.001	0.351		0.000	0.079		0.001	0.167
21	0.001	0.464		0.001	0.475		0.001	0.444
27	0.002	0.555		0.002	0.538		0.001	0.266
33	0.000	0.096		0.001	0.312		0.001	0.253
39	0.001	0.295		0.000	0.114		0.001	0.247

Current Harmonics TripleN Effect

Lab tests results with non linear loads (switching): with unbalanced voltage higher reduction of THD and TripleN Harmonics, and balancing effects on the 3 phases current.

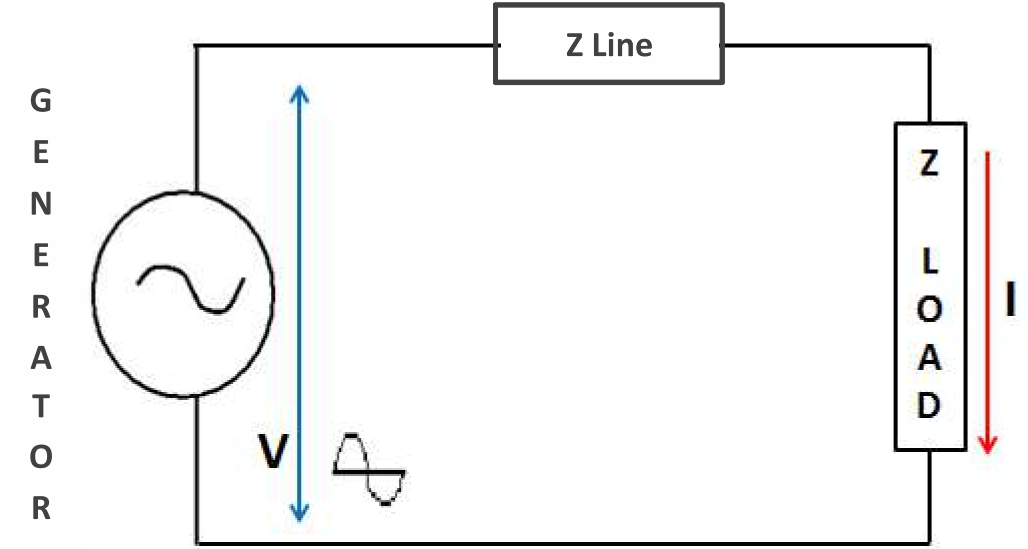


Effect TripleN
UNBALANCED VOLTAGE

Order	I_{thd4} 153.333		I_{thd5} 199.873		I_{thd6} 162.632	
Order	I_4 [A]	hdf [%]	I_5 [A]	hdf [%]	I_6 [A]	hdf [%]
3	0.114	27.543	0.127	66.116	0.236	67.723
9	0.112	26.918	0.103	53.692	0.186	53.340
15	0.090	21.549	0.066	34.488	0.113	32.457
21	0.054	13.116	0.034	17.446	0.056	15.958
27	0.030	7.283	0.021	10.766	0.024	6.990
33	0.022	5.245	0.016	8.407	0.009	2.586
39	0.011	2.677	0.009	4.693	0.004	1.210

Order	I_{thd4} 142.874		I_{thd5} 179.671		I_{thd6} 151.562	
Order	I_4 [A]	hdf [%]	I_5 [A]	hdf [%]	I_6 [A]	hdf [%]
3	0.109	26.148	0.114	54.686	0.220	62.095
9	0.098	23.479	0.086	40.907	0.161	45.372
15	0.069	16.454	0.046	21.794	0.085	24.062
21	0.036	8.557	0.020	9.734	0.041	11.631
27	0.023	5.546	0.019	9.111	0.023	6.351
33	0.015	3.506	0.012	5.969	0.006	1.566
39	0.006	1.493	0.002	1.097	0.004	1.149

Energy Shifting and Line Losses



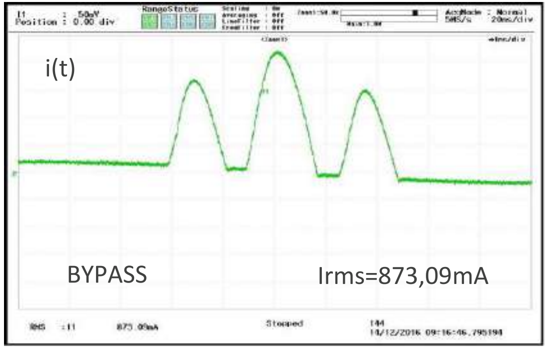
Power Losses Effect Analysis on the line (PX8000)

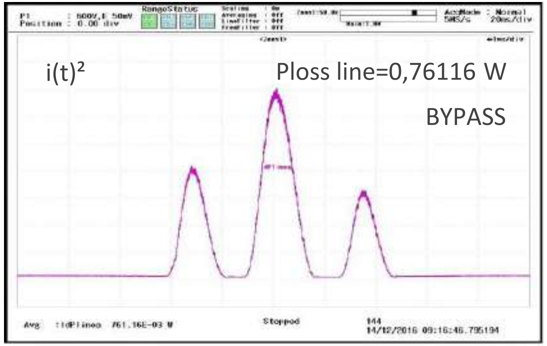
To simplify the analysis on the effects of the line it is empirically hypothesized that the line itself is purely resistive with R=1Ω

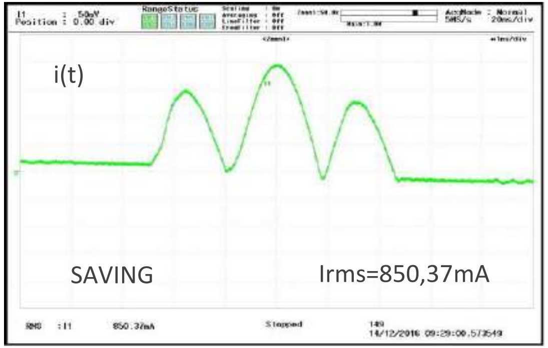
Power losses on the line are directly proportional to the square of the instantaneous current i(t)

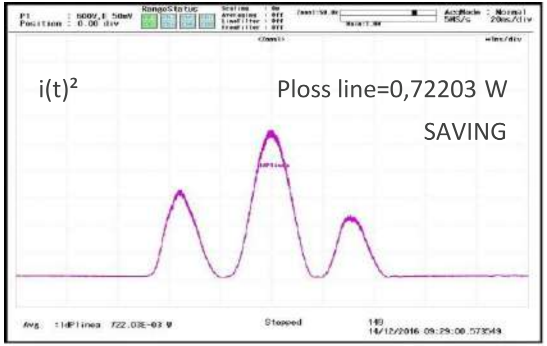
$$Ploss\ line(t) = R * i(t)^2 = 1 * i(t)^2 = i(t)^2$$

Energy Shifting and Line Losses





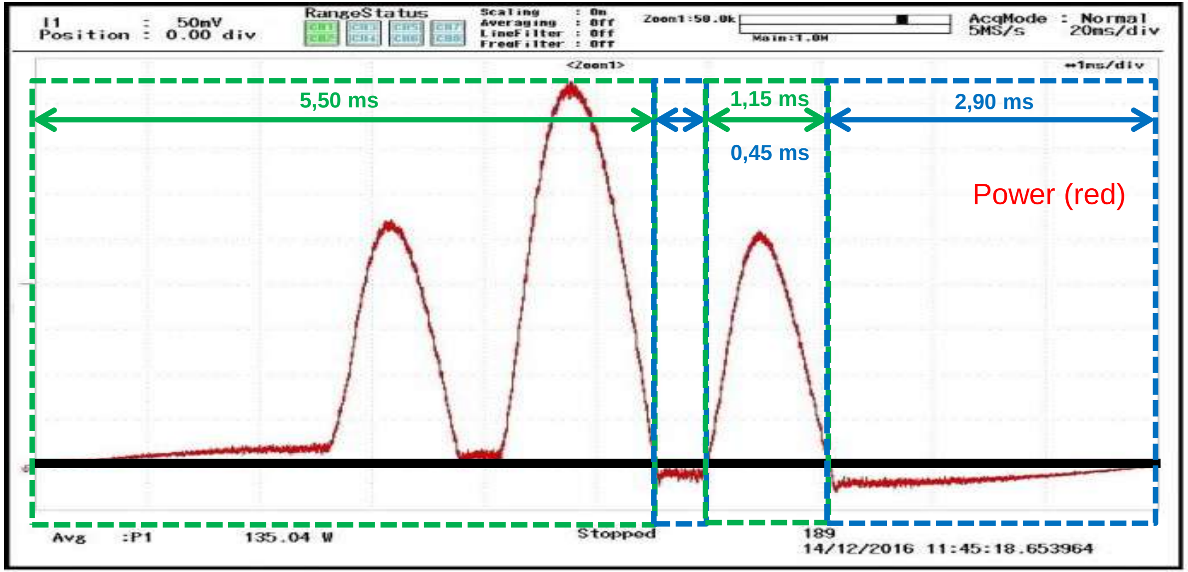


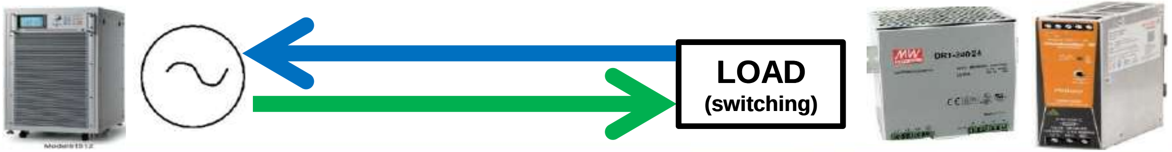


Power Losses Effect Analysis on the line (PX8000)

If it improves the waveform of the current and decrease the power losses, improves the energy transmission performance and produces an economic advantage.

Energy Shifting and Line Losses

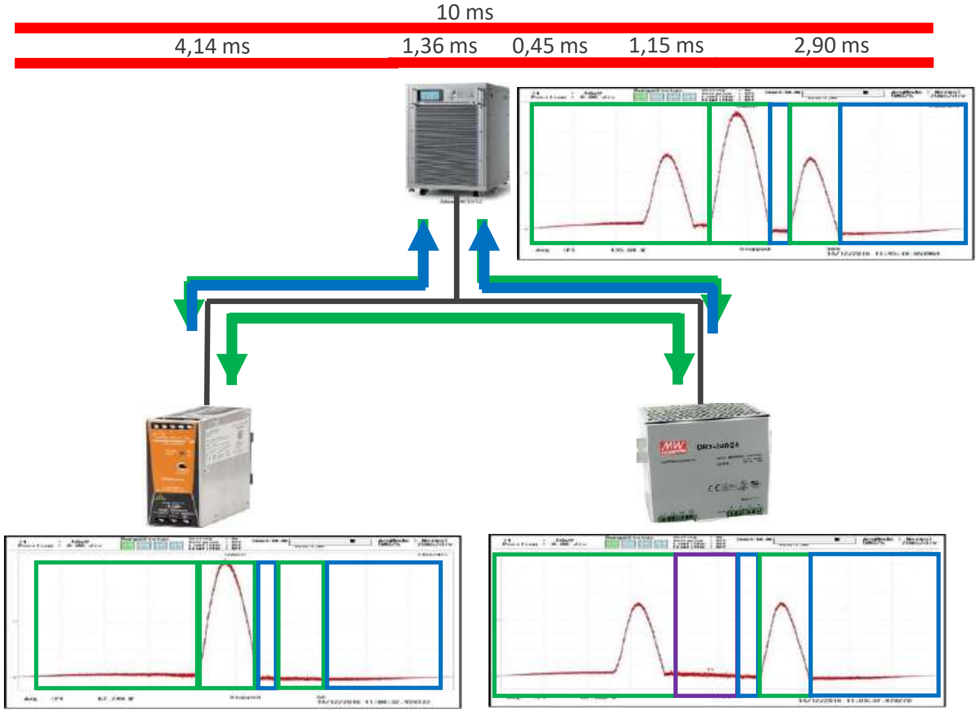




The image shows the energy shifting between generator and load measured on instantaneous power.
The red curve above the zero line shows the *Instantaneous Power [Watt]* supplied by the *Generator* and absorbed by the *Load*, while the curve below the zero line shows the *Instantaneous Power [Watt]* returned from the Load towards the *Generator*.

An electrical network composed by a multiplicity of loads, that is gradually extended, increases this “shifting” of energy.

Energy Shifting and Line Losses



Respect to the previous one, the image on the left, goes into greater detail on how two *Loads* (switching) supplied by a single Generator, exchange energy between them.

An electrical network composed by a multiplicity of *Kirchhoff nodes* could greatly amplify the losses on the line, due to a shifting of energy that is not transformed into work, but which is dissipated due to *Joule effect*.

This leads to poor *Power Quality* and lower system performance.

Energy Shifting and Line Losses

The result of the instantaneous power transmission described before is quantified as follow.

It is possible to notice that the overlapping effects, valid for linear systems, is not equally valid for distorted systems, in fact, the *Power Transmitted₁*, added to the *Power Transmitted₂* does not result in the *Power Transmitted₃*.

Moreover, it was possible to measure the effect of the E-Power system on the reduction of the energy exchange between the loads, useful for improving the efficiency of the energy transmission and producing a consequent economic advantage.

BYPASS		E-POWER	
P. Transmitted$_1$ =	78,397W	P. Transmitted$_1$ =	76,563W
P. Line Losses =	0,41416W	P. Line Losses =	0,39126W
P. Active=	67,749W	P. Active =	67,411W

BYPASS		E-POWER	
P. Transmitted$_2$ =	76,428W	P. Transmitted$_2$ =	74,590W
P. Line Losses =	0,33466W	P. Line Losses =	0,31776W
P. Active =	67,166W	P. Active =	67,096W

BYPASS		E-POWER	
P. Transmitted$_3$ =	151,04W	P. Transmitted$_3$ =	147,06W
P. Line Losses =	0,76332W	P. Line Losses =	0,72105W
P. Active =	135,04W	P Active =	134,79W

	BYPASS	E-POWER
P Transmitted$_1$ + P Transmitted$_2$ =	154,825W	151,153W
P Transmitted$_3$	151,040W	147,060W
Shifting Reduction =	3,785W	4,093W

Energy Shifting and Line Losses

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Lab tests with non linear loads (mixed loads A): the instantaneous power curve is modified and lowered when the E-Power is in Saving mode (green curve), resulting in a reduction of the losses.

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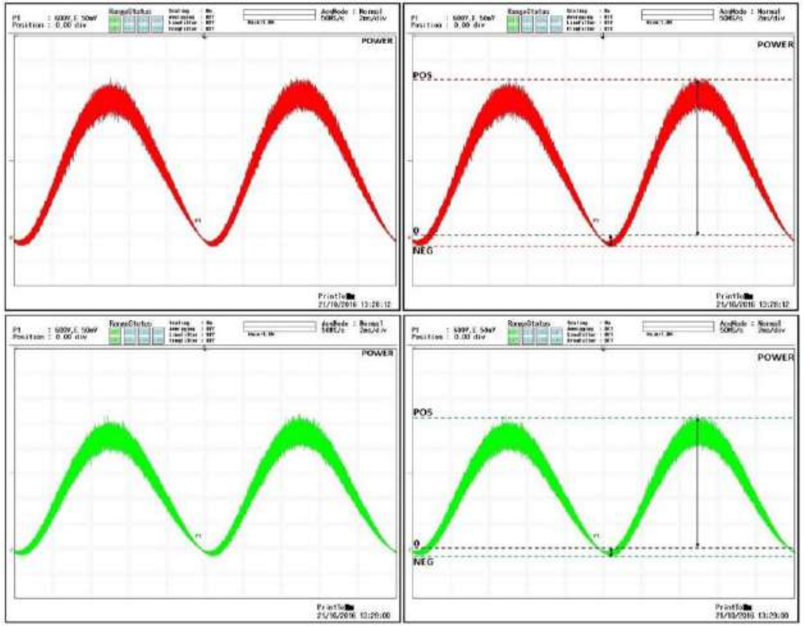

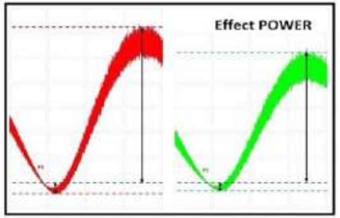

PG.2A

Energy Shifting and Line Losses

Lab tests with non linear loads (mixed loads B): the instantaneous power curve is modified and lowered when the E-Power is in Saving mode (green curve), resulting in a reduction of the losses.

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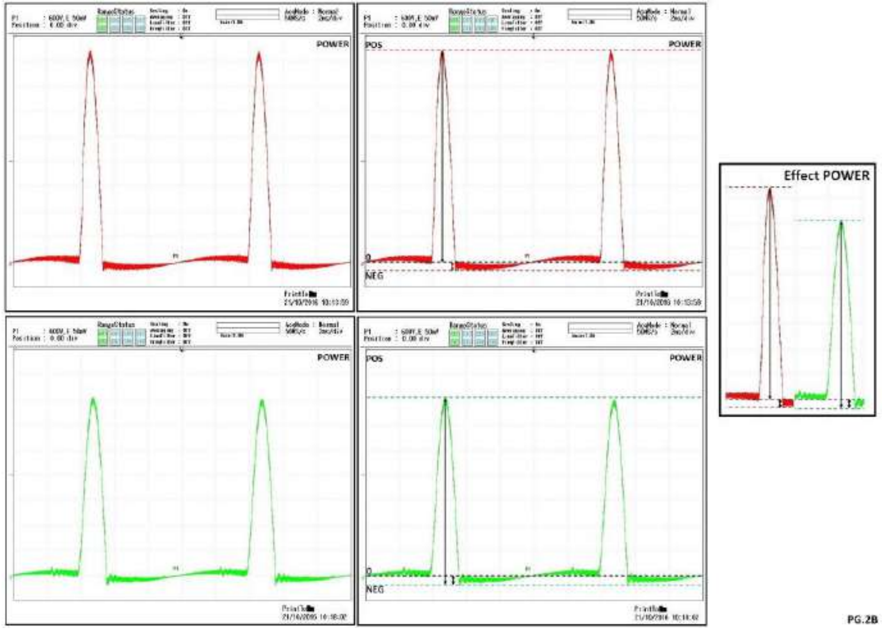
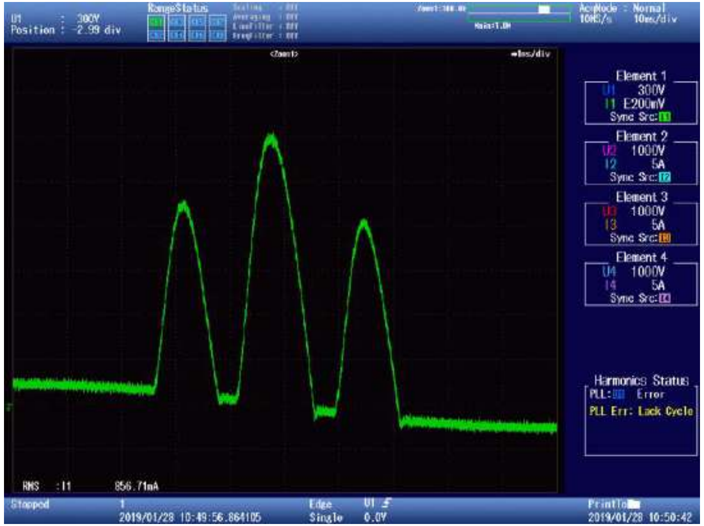
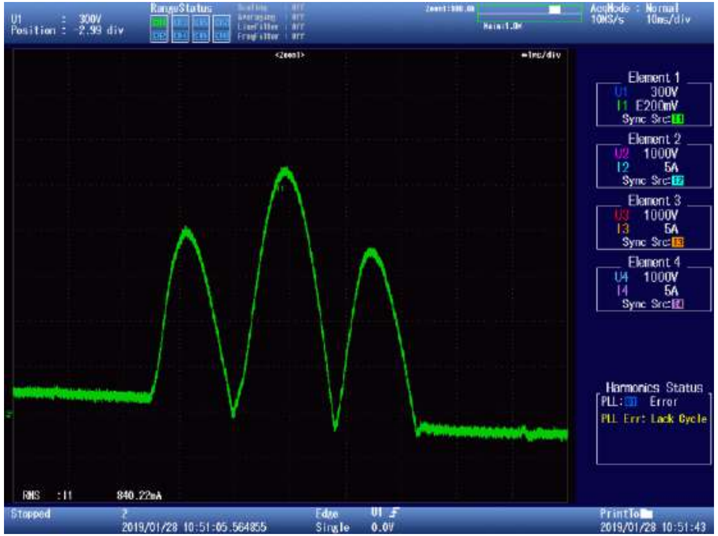


Improvement of the current waveform

Lab tests with non linear loads (switching): the current waveform is improved with the E-Power system in Saving mode, producing a positive effect on loads and electrical lines.



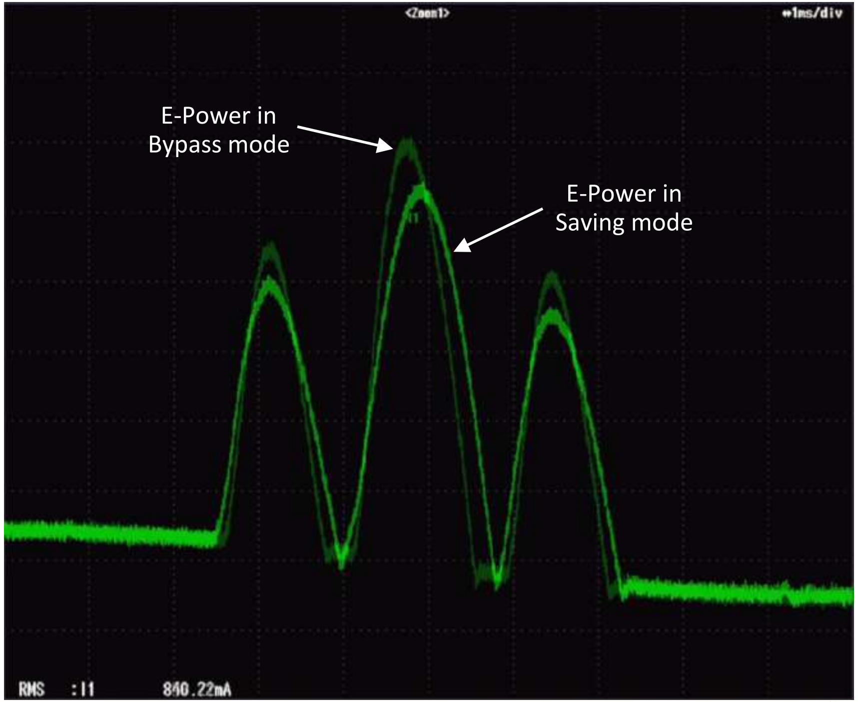
E-Power in Bypass mode



E-Power in Saving mode

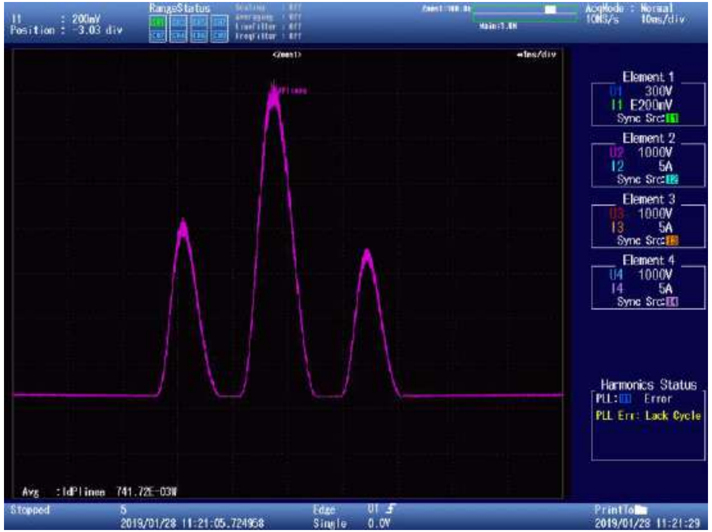
Improvement of the current waveform

Lab tests with non linear loads (switching): comparison of the current waveforms previously seen.

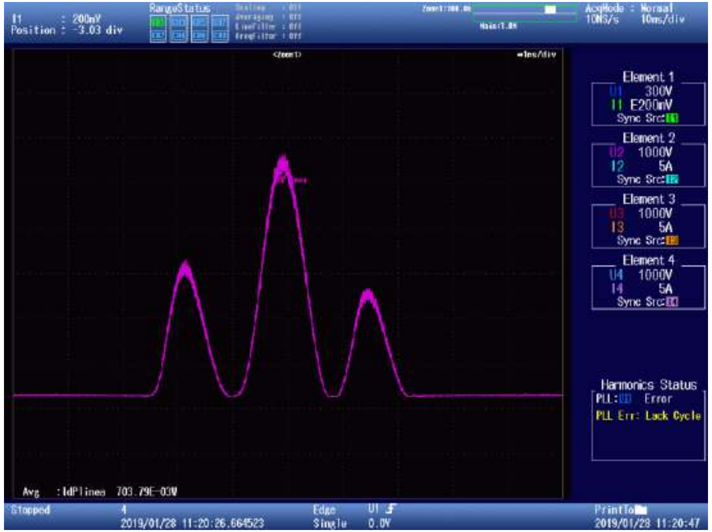


Reduction of Line Losses

Lab tests with non linear loads (switching): the power waveform is improved with the E-Power system in Saving mode, reducing the line losses.



E-Power in Bypass mode



E-Power in Saving mode

Reduction of Line Losses

Lab tests with non linear loads (switching): comparison of the power waveforms previously seen.