Harmonic Propagation in Electric Power System

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Motivation and Objective

•Our previous work [1,2]

• Rapid deployment of power-electronically controlled equipment in electric power systems creates major problems with harmonic pollution.

• Need to identify sources of harmonics and their effects.

• Need to design filters for differentiated quality of service to meet broad range of customer needs.

Mathematical background

Instantaneous voltage and current can represented by the Fourier series as following:-

$$v(t) = \sum_{h=1}^{\infty} \sqrt{2} V^{h} \sin(hwt + \Theta^{(h)})$$

$$THD_{v} = \frac{\sqrt{\sum_{h=2}^{\infty} (v^{(h)})^{2}}}{v^{1}}$$

Where:-
V^h is the RMS values for h-th order of harmonic voltage.
THD is the total harmonic distortion.

Methods

➢Use Matlab to simulate the harmonic propagation in simple power systems.

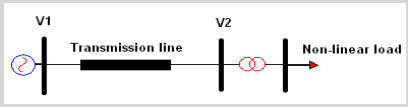
➢Study propagation of total harmonic distortion using various parameters (firing angle, length of transmission line and the type of transformer connections).

➢Expand the system and connect another load to study the effect of the non-linear load on linear one.

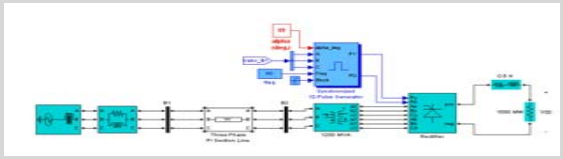
Previous work

[1] Nermeen Mahmoud, Marija Ilic ,*"Novel Technique for Classification of Power Quality Events"* , to be submitted in 2008.
[2] Nermeen Mahmoud, Marija Ilic ,*"Diagnosis the Causes of Voltage Sag Disturbance"*, to be submitted in 2008 .

Two bus system with non-linear load

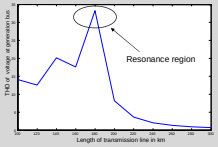


A 1000-MW resistive load is connected to the DC side through a 0.5 H smoothing reactor; the conversion from AC/DC is done using a rectifier built up from two 6-pulse thyristor bridges connected in series. The converter is connected to the system with a 1200-MVA three-phase transformer (three windings).



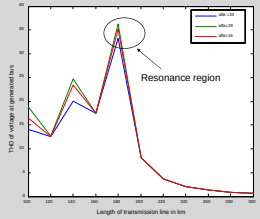
Dependence of the harmonic propagation on transmission line length

At firing angle= 19°



Dependence of the harmonic propagation on firing angle

At the same non-linear load

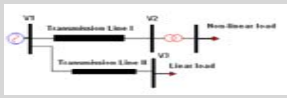


Dependence of the harmonic propagation on firing angle

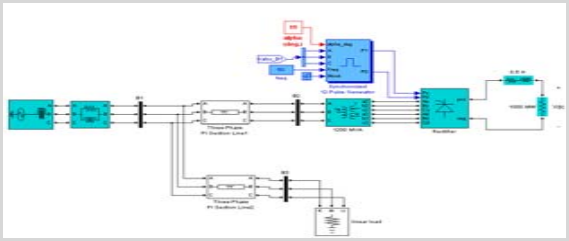
Change the transformer connection from Y to Δ1 and Δ11 The table below explain how the THD of the voltage at generator will change.

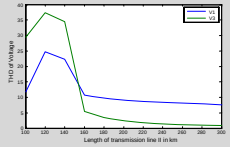
	Y	Δ1	Δ11
THD	16.55%	18.96%	14.03%

Three bus system with linear and non-linear loads



The effect of different length of the transmission line2 on the THD voltage of generator and linear load buses





Conclusions

1. As the firing angle increases by one degree, the THD of generated voltage will increase by 13.98%.
2. Transmission line will act as low-pass filter to harmonic except in the resonance region.
3. Linear load will be affected by the presence of non linear load even if they are not located at the same bus.
4. Change of transformer connection to Δ11 will decrease the THD at generator bus by 15.22%.

Future work

1) Study the harmonic distortion of different non-linear loads (motors, arc furnace and saturable devices) .

2) Design filters to ensure the implementation of pre specified quality of service.

3) Develop new filters for implementing differentiated quality of service for different types of loads in more complex power systems.

Acknowledgments

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