



Applications of:
Practical
Harmonic
Analysis

So, what is Practical Harmonic Analysis?

- ❖ **Harmonic Analysis** is a mathematical procedure for describing and analyzing phenomena of a periodically recurrent nature. Many complex problems have been reduced to manageable terms by the technique of breaking complicated mathematical curves into sums of comparatively simple components.
- ❖ Many physical phenomena, such as sound waves, alternating electric currents, tides, and machine motions and vibrations, may be periodic in character. Such motions can be measured at a number of successive values of the independent variable, usually the time, and these data or a curve plotted from them will represent a function of that independent variable.

So, what is Practical Harmonic Analysis?

- ❖ Generally, the mathematical expression for the function will be unknown. However, with the periodic functions found in nature, the function can be expressed as the sum of a number of sine and cosine terms. Such a sum is known as a Fourier series, after the French mathematician Joseph Fourier (1768–1830), and the determination of the coefficients of these terms is called harmonic analysis. One of the terms of a Fourier series has a period equal to that of the function, $f(x)$, and is called the fundamental. Other terms have shortened periods that are integral submultiples of the fundamental; these are called harmonics.

So, what is Practical Harmonic Analysis?

- ❖ In 1822 Fourier stated that a function $y = f(x)$ could be expressed between the limits $x = 0$ and $x = 2\pi$ by the infinite series that is now given in the form:

$$f(x) = \frac{1}{2}a_0 + \sum_{k=1}^{\infty} (a_k \cos kx + b_k \sin kx), \quad (1)$$

So, what is Practical Harmonic Analysis?

- ◆ Provided the function is single-valued, finite, and continuous except for a finite number of discontinuities, and where:

$$a_k = \frac{1}{\pi} \int_0^{2\pi} f(x) \cos kx \, dx$$

$$b_k = \frac{1}{\pi} \int_0^{2\pi} f(x) \sin kx \, dx$$

So, now that we know the definition, here are the Applications:

Power Systems

- ❖ Power systems: Practical harmonic analysis is widely used in power systems to analyze and monitor harmonic distortion, voltage fluctuation, and power quality issues. It helps to detect and mitigate power quality problems caused by nonlinear loads, such as variable frequency drives and LED lighting.

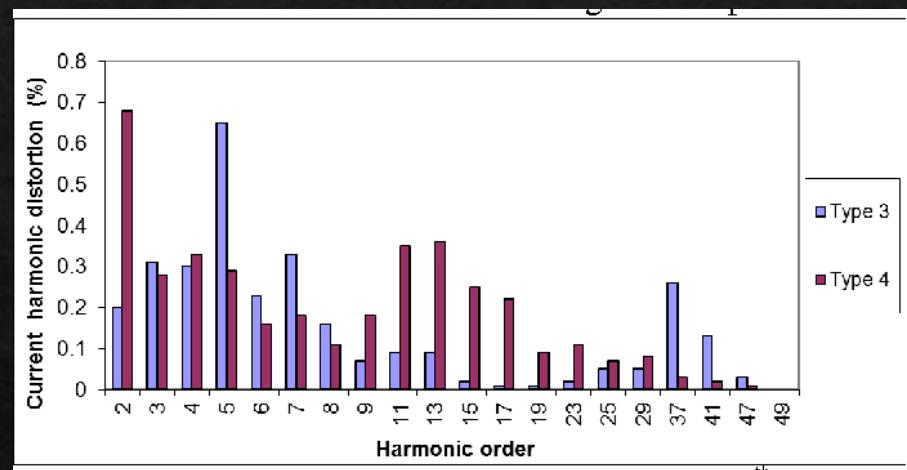
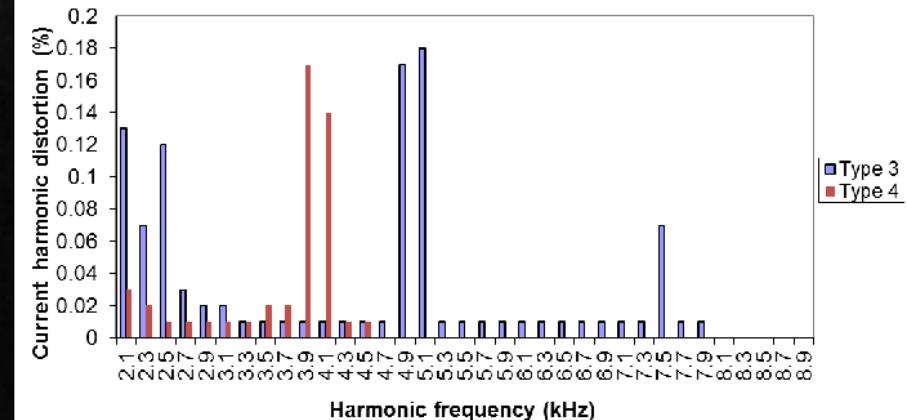
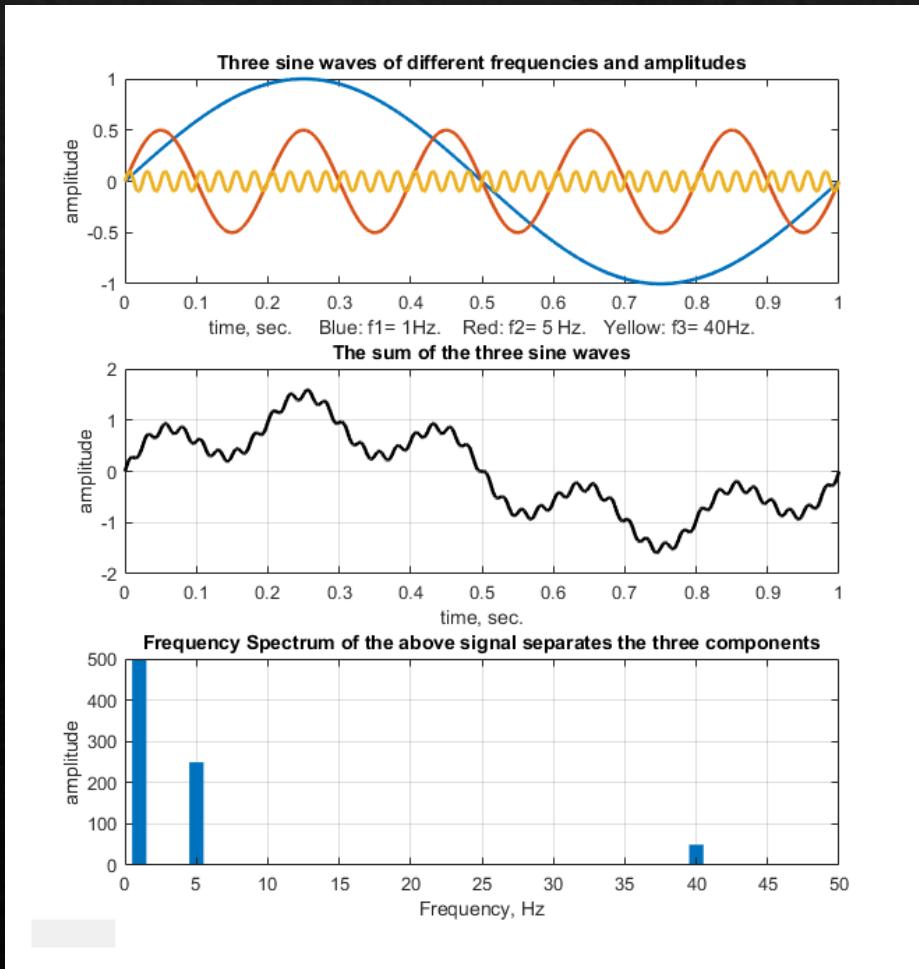


Fig. 1. Most significant integer harmonic currents up to the 50th order for type 3 and 4 turbines



Signal Processing



- ❖ Signal processing: Practical harmonic analysis is used in signal processing to analyze and filter periodic signals, such as audio and video signals. It helps to remove unwanted noise and interference from signals, and to identify the frequency components of a signal.

Music

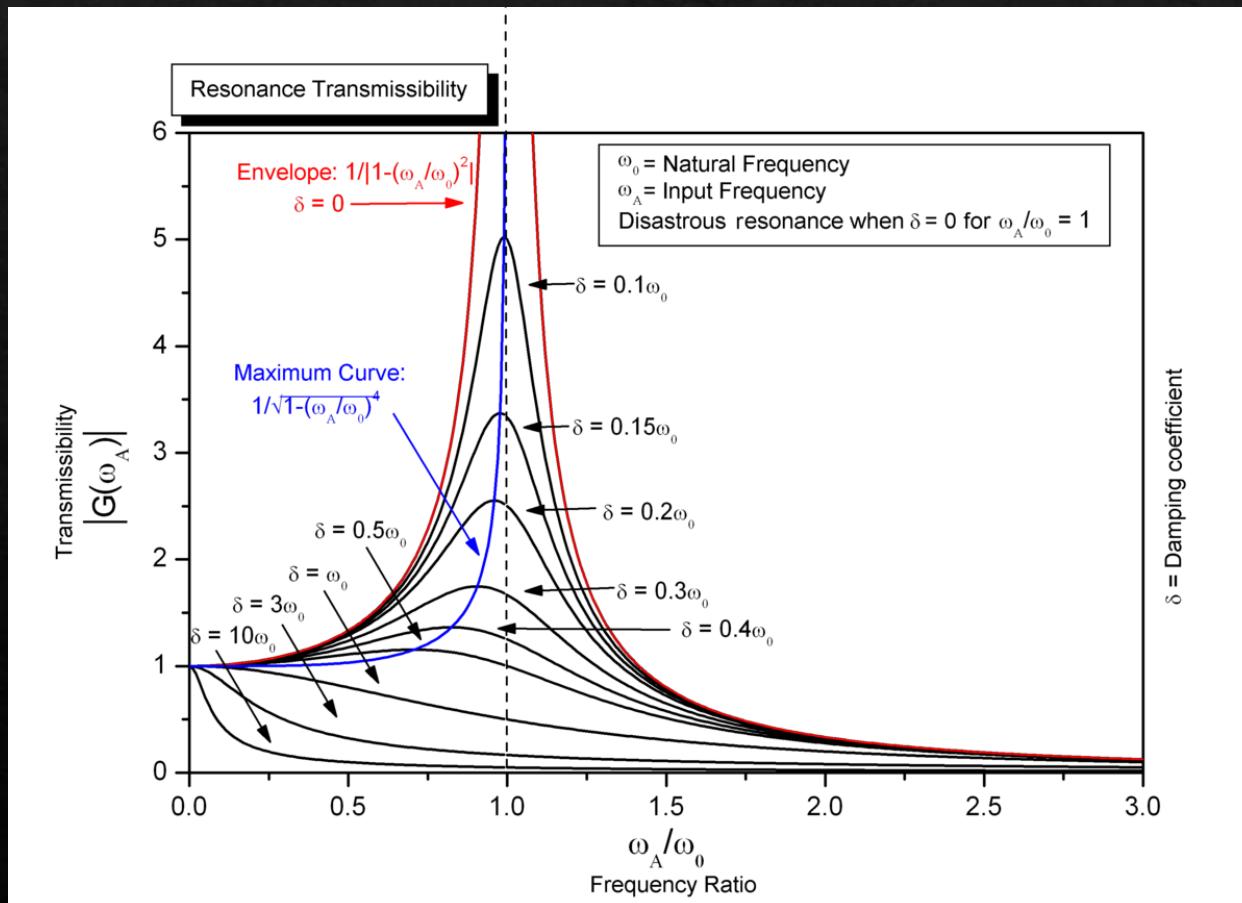
- ❖ Music: Practical harmonic analysis is used in music to analyze and understand the harmonic structure of a musical piece. It helps to identify chords, melodies, and harmonic progressions, and to study the relationship between different musical elements.

The image displays two musical diagrams. The top diagram, labeled 'C major', shows a treble clef staff with seven chords: C, Dm, Em, F, G, Am, and Bdim. Below the staff, Roman numerals I through VII indicate the chords. The bottom diagram, labeled 'D major', shows a treble clef staff with seven chords: D, Em, F[#]m, G, A, Bm, and C[#]dim. Below the staff, Roman numerals I through VII indicate the chords. Both diagrams use standard chord notation with three-note chords shown as stacked horizontal bars.

C major	C	Dm	Em	F	G	Am	Bdim
	I	ii	iii	IV	V	vi	vii°

D major	D	Em	F [#] m	G	A	Bm	C [#] dim
	I	ii	iii	IV	V	vi	vii°

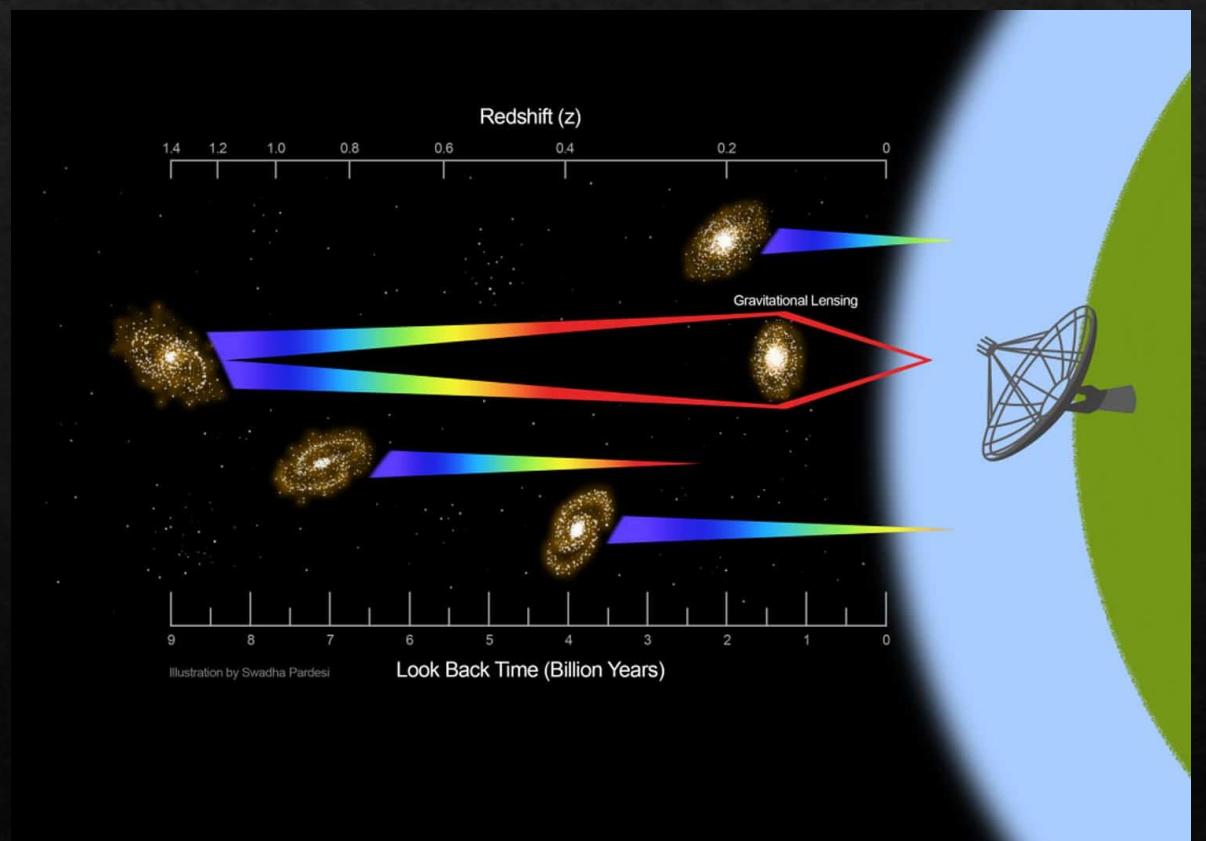
Mechanical Systems



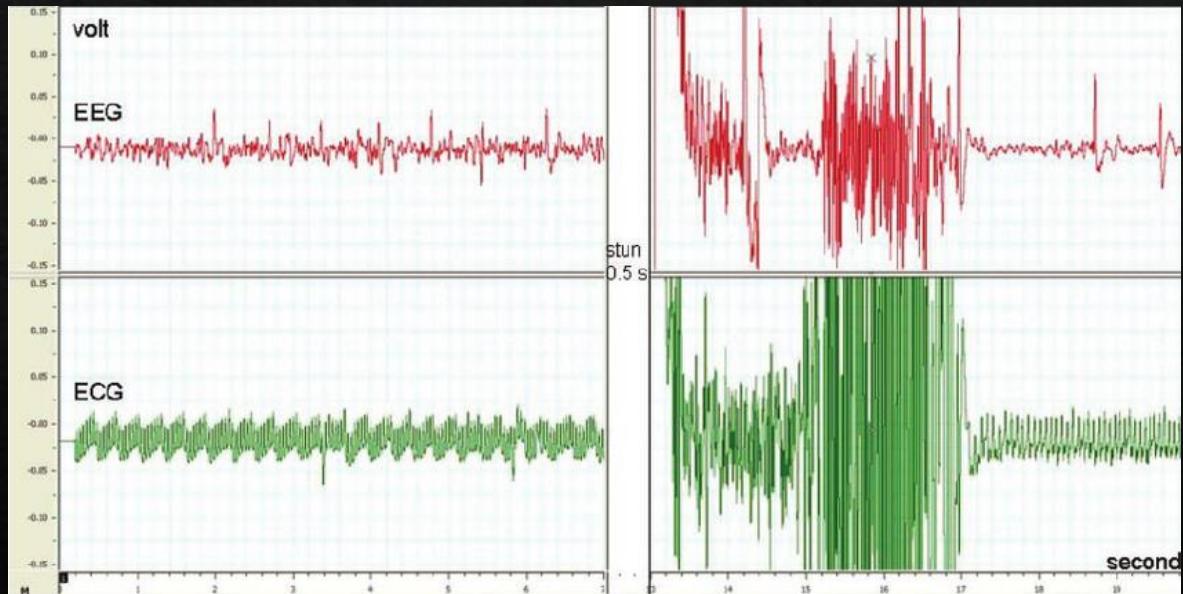
- ❖ Mechanical systems: Practical harmonic analysis is used in mechanical systems to analyze and monitor vibrations and resonances. It helps to identify and mitigate problems caused by structural resonances, such as excessive noise and vibration.

Astronomy

- ❖ Astronomy: Practical harmonic analysis is used in astronomy to analyze and understand the periodic behavior of astronomical objects, such as stars and planets. It helps to identify the frequency components of astronomical signals, and to study the dynamics of celestial objects.



Medical Diagnosis



- ◊ Medical diagnosis: Practical harmonic analysis is used in medical diagnosis to analyze and classify the periodic behavior of physiological signals, such as electrocardiograms (ECGs) and electroencephalograms (EEGs). It helps to detect and diagnose abnormal heart rhythms and brain activity patterns.

Overall, Practical Harmonic Analysis is a powerful tool for analyzing and understanding periodic signals and systems, and it has numerous applications in various fields.

Thank you!

By Team 7:

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