NVSAGE

The Newsletter of Noise and Vibration

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> "Science without religion is lame, religion without science is blind"
> – Albert Einstein

Foreword

By Krishna Balamurali, Principal Engineer- krishna@nvdynamics.com

Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) the phase II of its implementation by Government of India is likely to bring a sea change to the EV portfolio in the Indian sub-continent.

With over 400 registered EV makers in India and the list growing rapidly, both the right competition and quality requirements stand challenged.

Many start-ups with good seed capital have other high tests and trials, either using most of the ready to use sub-systems or with some of home-grown combinations. While few have put their products already into the market with their existing avatars, the limitations on the milage, battery charging and swap options are holding them all to go full on.

This apart, the very durability of the EVs, particularly of 2 and 3 wheelers are still in their infancy, keeping vehicle weights in check, compromises to the vehicle rigidity, quality of fabrication and overall build quality are all playing into the vehicle Noise, Vibration and Durability issues.

While the EV drive train itself is very compact and less complicated as compared to any IC engine based vehicle, the challenges of achieving better grades of residual noise and vibrations go a long way in establishing the vehicle quality as a whole.

NV Dynamics is working with some of the key EV players in the market in helping them identify the sub-system level NVH issues; we are also formulating a technical package to be offered to any 2 and 3 wheeler EV manufacturer who can implement them to achieve good noise & vibrations.

We will be discussing on the more in the coming days…

Time & Frequency Domains

Aravind Reddy, Engineer - Technical Services

In the previous edition, we discussed on the terms related to Time & Frequency data and aliasing effect, one of the limitations of FFT.

Moving forward, in the current edition lets continue with other limitations of using FFT and how to compensate for the same.

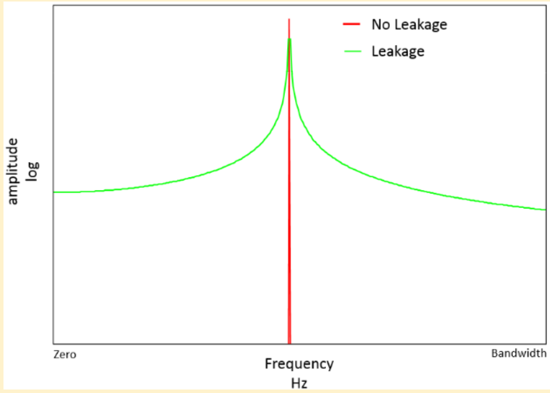


Fig 1

Limitations of FFT

Spectral Leakage

When converting a signal data from time to frequency domain there will be some amount of spectral leakage.

Spectral leakage occurs due to two reasons, which are frequency resolution and frame size.

a. Frequency resolution

Let's say, two sine signals of 3 Hz and 2.5 Hz are processed at 1 Hz resolution (the frequency resolution set to 1 Hz means that the data can only be viewed for every 1 Hz). In the case of 3 Hz sine signal (**Fig 2**) we can see its exact amplitude level as 3 is a multiple of 1, so there is no leakage. Whereas in 2.5 Hz sine signal (**Fig 3**), as 2.5 is not a multiple of 1 we can see some amount of leakage and reduction in the amplitude level.

A signal with leakage has lower amplitude and a broader frequency response than a signal with no leakage (**Fig 1**). This makes it difficult to quantify the signal properly in the frequency domain.

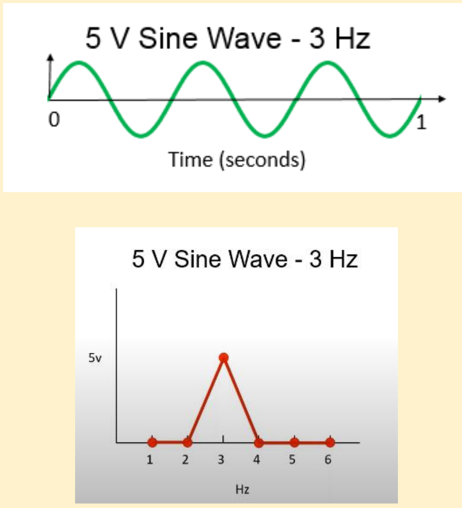


Fig 2

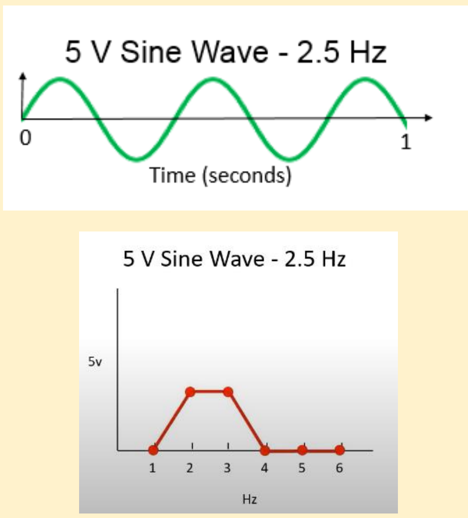


Fig 3

b. Frame Size

The FFT algorithm does not consider the full data for processing, instead considers a small amount of captured data based on the frame size specified and repeats it, in order to perform the Fourier Transform and produce a frequency spectrum.

In **Fig 4** you can see the 'captured signal' (based on the frame size) of a sine wave that is repeated and appended end to end, which is called the 'repeated signal'. If the repeated signal looks like the original sine wave, then the captured signal is periodic. If the signal is periodic the resulting frequency spectrum will have no leakage.

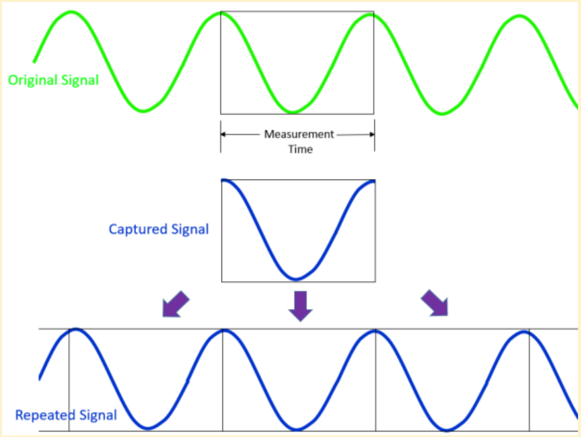


Fig 4

If the frame size or measurement time is changed by a small amount for the same sine signal, as shown in **Fig 5** the 'captured signal' no longer shows a periodic behavior. In the 'repeated signal' you can observe a sudden transition at the end of each captured signal. These sharp transients produce a high, broadband frequency content. So, the resulting spectrum will have broadband response as well as a sinusoidal response as shown in **Fig 1**.

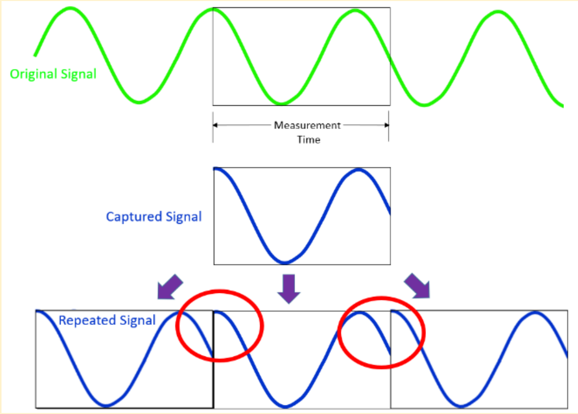


Fig 5

This spectrum leakage can be reduced by applying a window function to the data. Windows are typically shaped functions that start from 0, move to value of 1 and end at 0 again. The window function is multiplied with the non-periodic signal as shown in **Fig 6**. As a result, the value tends to 0 at the start and end of the 'captured signal'. The windowed signal is then repeated and appended end to end.

As a result of the window function, sharp transients are eliminated and smoothed out, as a consequence of this the broadband frequency of the spectral leakage is also reduced. However, the repeated signal does not match the original signal, there is some amount of reduction in the amplitude values.

Since windows alter the amplitude and frequency content of a signal, there are **correction factors** applied to compensate for the modifications created by applying the window. Also, based on the applications there are various **types of window functions**, that will be discussed in the next edition of NV Sage.

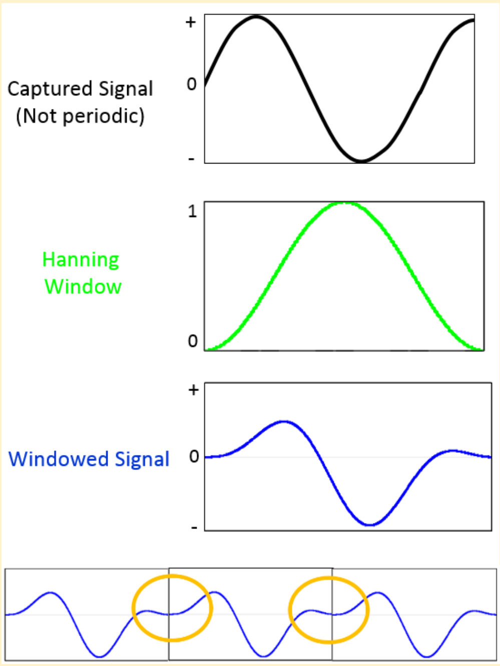
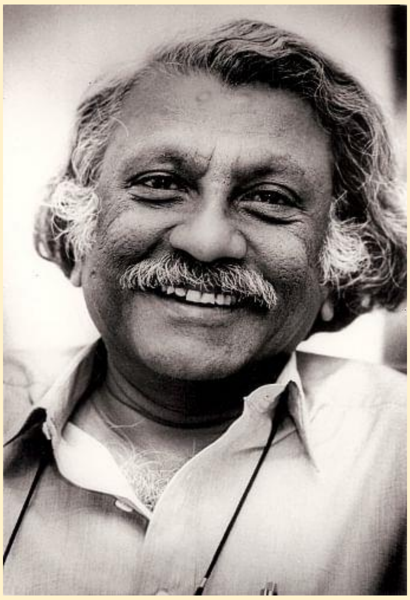


Fig 6

Great Minds & their contribution to the world of science

Venkatraman Radhakrishnan (18 May 1929 – 3 March 2011) was an Indian space scientist and member of the Royal Swedish Academy of Sciences. He ended his career as professor emeritus of the Raman Research Institute in Bangalore, India, of which he had previously been director from 1972 to 1994 and which is named after his father. He served on various committees in various capacities including as the vice president of the International Astronomical Union during 1988–1994. He was also a Foreign Fellow of both the Royal Swedish Academy of Sciences and the U.S. National Academy of Sciences. He was an Associate of the Royal Astronomical Society and a Fellow of the Indian Academy of Sciences, Bangalore. He was closely involved with the construction of the 10.4m tower, millimeter wave radio antenna in the Institute which has been used to study various astrophysical phenomena producing original contributions in pulsar astronomy.



He made important contributions in various other areas. Deuterium abundance in the galaxy, Astrophysical Raman Masers, OH emission from clouds and later on building of the low frequency telescopes at Gauribidanur and Mauritius were some of the hallmarks of his career.

Physics to Know

Otoacoustic emissions (OAEs)

OAEs are sounds that are produced by the linear ear (cochlea) in response to a sound stimulus. These sounds can be measured using specialized equipment, and they are thought to reflect the function of the hair cells in the cochlea.

OEAs can be used to assess the health of the hair cells in the cochlea and to diagnose hearing loss. They are considered to be safe and non-invasive test, so they are often used to test newborns.