Fourier Series References 2/28/2021

RECTANGULAR PULSE TRAIN- FOURIER SERIES

http://brewer.ece.gatech.edu/ece3043/Lecture_Notes/spectra.pdf

A rectangular pulse train is similar to a square wave in that it switches between two levels but the duty cycle is not 50%. The duty cycle is the percentage of the time the waveform is in the high state.

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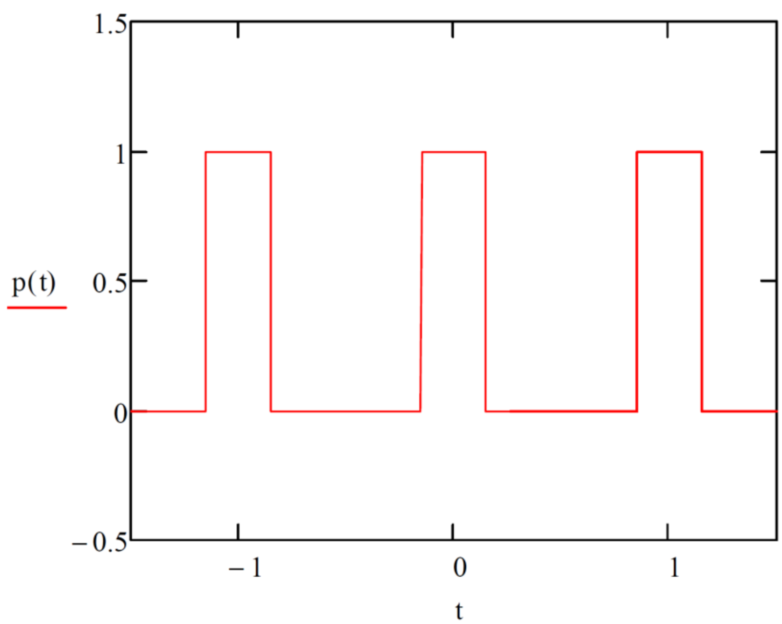
$$x(t) = \begin{cases} A & |t| \leq \frac{\tau}{2} \\ 0 & \frac{\tau}{2} < t < \frac{T}{2} \\ x(t \pm nT) & n \text{ any integer} \end{cases}$$

so the duty cycle is $d = \tau/T$.



Pulse Train with Duty Cycle 0.15.

The Fourier expansion coefficients are

$$c_n = Ad\frac{\sin(\pi n d)}{\pi n d}$$

The expansion coefficient c_n are complex constants which can be determine from $x(t)$ as

$$c_n = \frac{1}{T}\int_{\alpha}^{\alpha+T} x(t)\exp(-jn\omega_p t)dt$$

Thus, the FOURIER Series expansion is

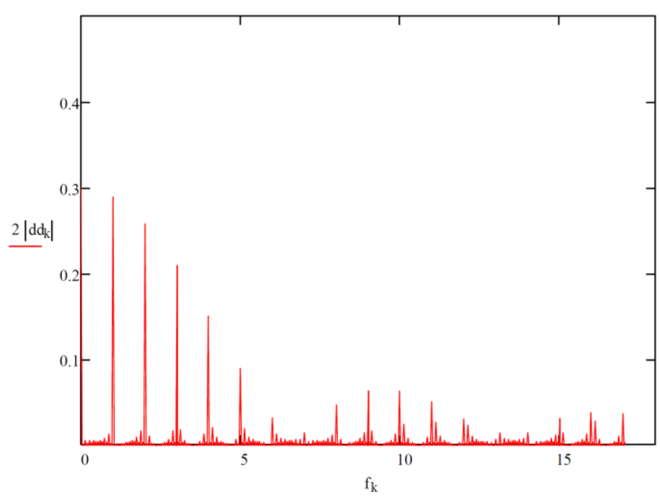
$$x(t) = \sum_{n=-\infty}^{\infty} c_n \exp(jn\omega_p t)$$

where $\omega_p = 2\pi f_p$ and $f_p = 1/T$ is the frequency in Hertz of the periodic function.

Since this is the complex exponential form of the series, the sum is from -infinity to infinity.

Note: The Duty Cycle changes the AMPLITUDE of the frequency components – NOT the frequency spectrum. In this example, the period T = 1 sec. The frequencies are thus

F = [1 2 3 … n …] Hz The amplitudes will be zero if pi*n*d = k*pi where the sine is zero in c_n. Never in this case if d = 0.15. If d=0.5, c_n is zero at 2*k*pi.



Spectra of Pulse Train

which is, of course, a line spectra but the envelope of the spectra has a $\sin(x)/x$

Here the magnitudes are | 2*c_n| for the POSITIVE SPECTRUM. The “wiggles” at the base of the spectrum have to do with the plotting function for the spectrum- numerical noise.

FULL WAVE RECTIFIED SIGNAL – EXPONENTIAL FOURIER SERIES AS IN DSPF BOOK.

Adam Panagos
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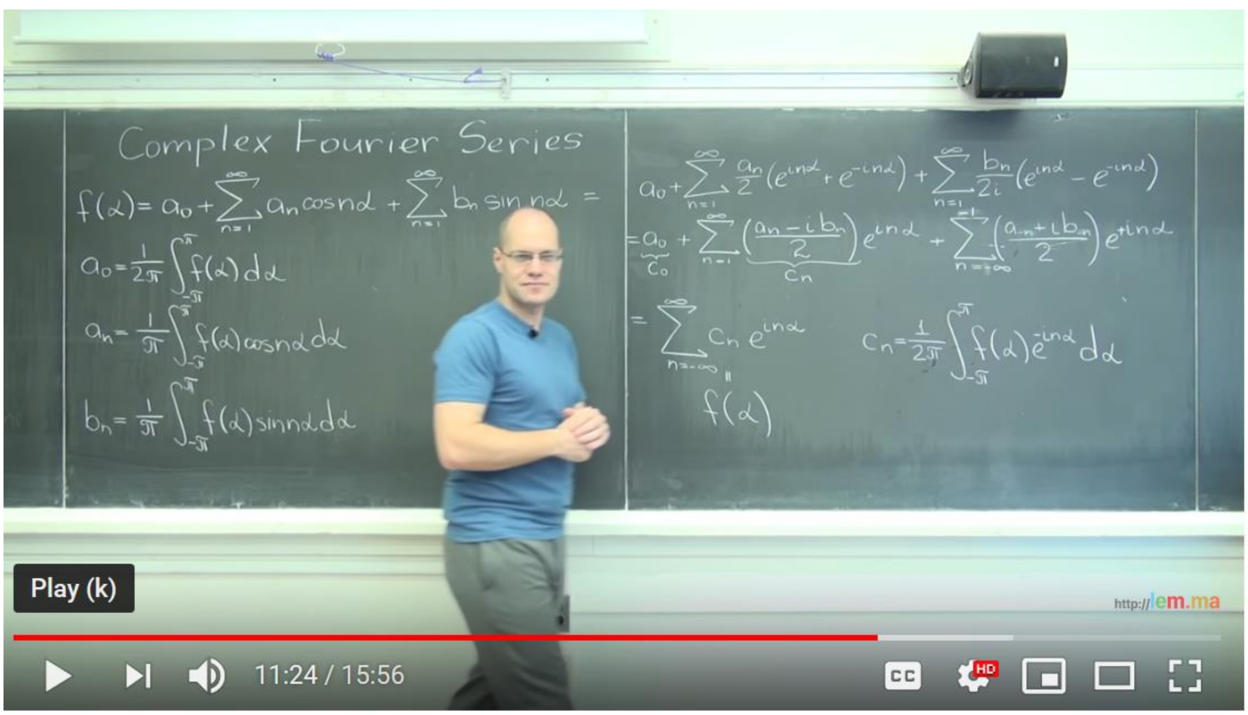
http://adampanagos.org In this video we compute the exponential Fourier (EFS) series of a fully rectified sine wave signal sin(t). This computation involves computing the EFS coefficients Dn by projecting the signal onto the the nth exponential basis signal.

https://www.youtube.com/watch?v=FIKPlRsADL0&list=RDCMUCvpWRQzhm8cE4XbzEHGth-Q&index=2

Complex Fourier Series 38,068 views 15:56

Converts between Trig Series and Complex Series.

https://www.youtube.com/watch?v=Ft5iyapkSqM



Test your Ears – From 100 Hz to 12kHz. Can you hear the difference between a square wave and a sine wave?   5:35

https://www.youtube.com/watch?v=uIuJTWS2uvY

http://www.audiomasterclass.com - A comparison between square waves and sine waves of various frequencies, displayed on an oscilloscope, with commentary.

Taylor series | Essence of calculus, chapter 11   22:20   (e^x at Time 13:30)

https://www.youtube.com/watch?v=3d6DsjIBzJ4

3BLUE1BROWN SERIES S2 • E11

More Exotic:

Understanding the Uncertainty Principle with Quantum Fourier Series | Space Time 14:49

The humble sound wave explains Heisenberg's Uncertainty Principle. PBS Space Time

https://www.youtube.com/watch?v=izqaWyZsEtY