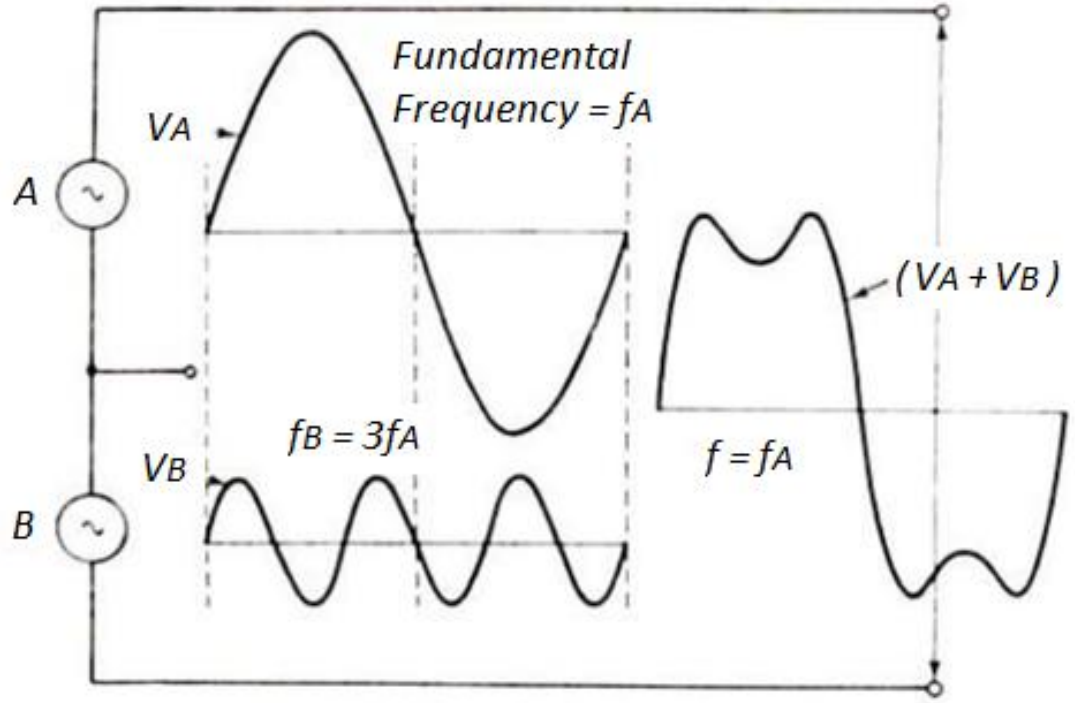
Frequency Synthesis:

Just like an AC signal will superimpose on a DC signal, two AC signals present at the same time will also combine to form a new waveform. When this occurs it is refered to as **Frequency Synthesis.**

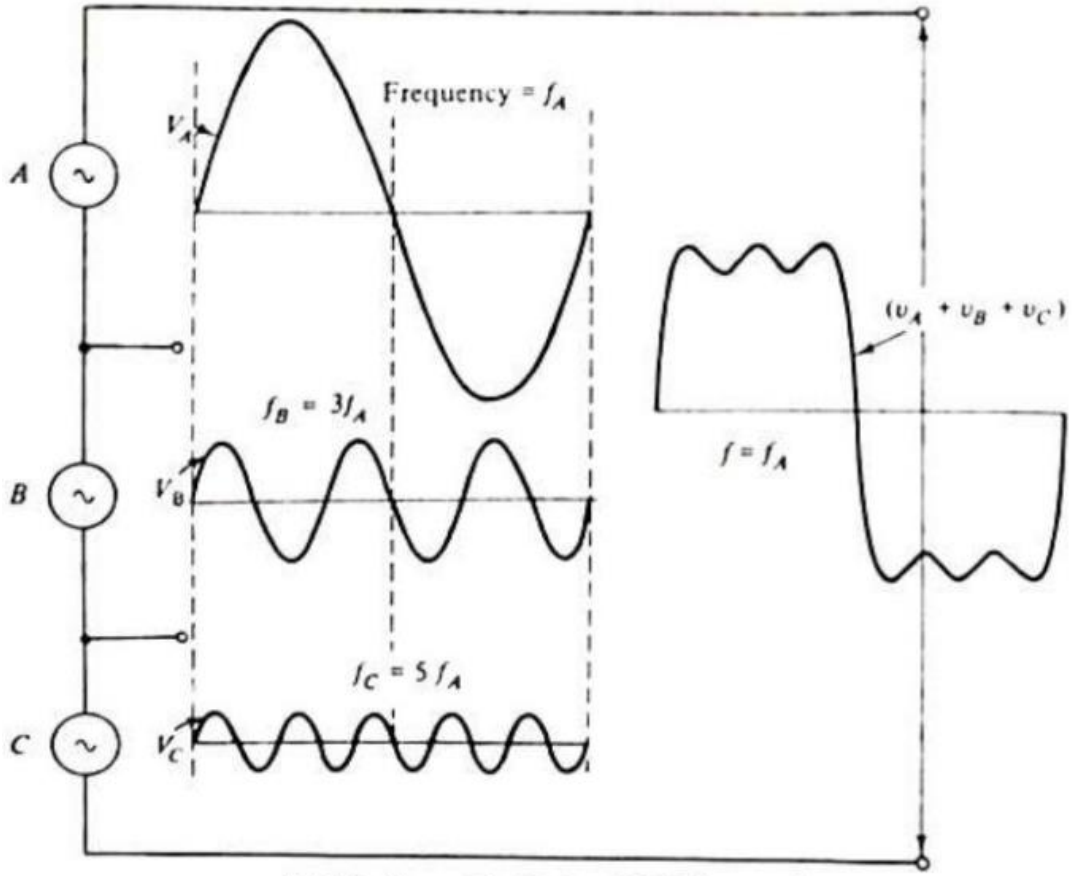
- **synthesis** noun : the composition or combination of parts or elements so as to form a whole – Merriam Webster
- **Frequency Synthesis** is the process of combining multiple sine waves to produce a new desired waveform
- **Perfect Square Waves** are comprised of an infinite number of odd harmonic sine waves
- **Sawtooth, Exponential, and Triangle Waveforms** are comprised of a combination of odd and even harmonic sine waves.
- **Harmonics**
    - A harmonic is a multiple of the fundamental
    - Harmonics are numbered according to their ratio to the fundamental
    - The number of harmonics is infinite; however, the amplitude of each harmonic will successively decrease as frequency increases.

Harmonic number	Frequency	Amplitude
Fundamental	f	V
2nd Harmonic	2f	1/2V
3rd Harmonic	3f	1/3V
4th Harmonic	4f	1/4V
5th Harmonic	5f	1/5V
7th Harmonic	7f	1/7V
100th Harmonic	100f	1/100V

- **Frequency Synthesis Waveform Example**



(a) Fundamental and third harmonic



(b) Fundamental, third and fifth harmonic

- **Harmonic Analysis** is the converse of frequency synthesis
    - **Fourier Analysis** is the mathematical function by which waveforms can be analyzed to determine their harmonic content.
    - Suppose that a square wave with a frequency of 1Khz (Fundamental) is applied to an amplifier with an upper frequency limit of 15Khz. This amplifier will not pass harmonics of 1Khz (the fundamental) beyond the 15^{th} harmonic. If the Square wave applied was changed to 5Khz (fundamental), only the first, second, and third harmonic would be passed.
        - $\boldsymbol{Bandwidth} = \#of\ Harmonics \times Fundamental$
        - $\boldsymbol{\#of\ Harmonics} = \frac{Bandwidth}{Fundamental}$
        - $\boldsymbol{Fundamental} = \frac{Bandwidth}{\#of\ Harmonics}$
- **Fourier Series Examples:** https://www.falstad.com/fourier/e-index.html

References:

- Bell, D. A. (1997). *Solid state pulse circuits*. Sarnia, ON: David A. Bell.
- Synthesis Merriam Webster. (n.d.). Retrieved from https://www.merriam-webster.com/dictionary/synthesis.