Vibration related Formulas

Frequency and Period:

- Frequency = 1/Period = $\frac{1}{T}\ \frac{Cycles}{Second}$ or Hz
- Period = T = $\frac{Second}{Cycle}$

Data Sampling:

- *Tmax* (no overlap) = $\frac{(60)(\#FFT\ Lines)}{Fmax\ (CPM)} = \frac{(60)(Sample\ Size)}{(2.56)(Fmax)}$
- *Tmax* (sec) (with overlap) = $\frac{(60)(\#FFT\ Lines)}{Fmax\ (CPM)}$ + ((NO. Samples with overlap) * (1- overlap %)) * $\frac{(60)(\#FFT\ Lines)}{Fmax\ (CPM)}$)
- # Revolutions = $\frac{(\#FFT\ Lines)(RPM)}{Fmax}$
- *Fmax* (CPM) = $\frac{(\#FFT\ Lines)(RPM)}{\#Revolutions}$

Where:

- *Fmax* = Maximum Spectral Frequency (CPM)
- *Tmax* = Sampling period in sec to capture one data sample
- Revolutions = # Revolutions captured in the Time Domain. # Revolutions controlled by Accurex bases on component speed.
- Sample Size = Number of Analog to Digital Conversions used to construct the Time Waveform.

#Lines	#Samples
100	256
200	512
400	1024
800	2048
1600	4096
3200	8192
6400	16,384
12,800	32,768

Data Sampling Examples:

Accurex LF Spectrum: 800 lines with an Fmax of 12,000 cpm.

Collection time (one sample): $Tmax = \frac{(60)(800)}{12,000}$ = 4 seconds

Collection time 4 samples with 75% overlap:

$$Tmax = \frac{(60)(800)}{12,000} + ((3*(1-.75))*\frac{(60)(800)}{12,000})$$

$$= 4 + 3 = 7 \text{ seconds}$$

Accurex constructed Time Waveform # Revolutions:

Whereas revolutions are equal to:

revolutions = (#Signal Points X CPM)/(Sampling Frequency in CPM)

Example:
revolutions = (128,000 X 120)/(600,000 X 2.56)
revolutions = 15,360,000/1,536,000
revolutions = 10

Shaft Speed RPM	Sampling Frequency	FMax	# Signal Points	Shaft Revolutions in Waveform	Time for 1 Sample (sec.)	Resolution (cpm)
< 59	25.6k Hz	600,000 CPM	512k	19.6 or less	20	1.17
59-117	25.6k Hz	600,000 CPM	256k	9.83-19.5	10	2.34
118-120	25.6k Hz	600,000 CPM	128k	9.83-10.0	5	4.7
121-234	51.2k Hz	1,200,000 CPM	256k	10.083-19.5	5	4.7
235-468	51.2k Hz	1,200,000 CPM	128k	9.79-19.5	2.5	9.4
469-899	51.2k Hz	1,200,000 CPM	64k	9.77-18.179	1.25	18.75
900-1899	51.2k Hz	1,200,000 CPM	32k	9.375-19.78	.625	37.5
1900-3999	51.2k Hz	1,200,000 CPM	16k	9.9-20.83	.3125	75
4000-7500	51.2k Hz	1,200,000 CPM	8k	10.42-19.53	.1563	150
>7500	51.2k Hz	1,200,000 CPM	4k	9.77 or greater	.078	300
Eagle						
469-899	12.8k Hz	300,000 CPM	16K	9.77-18.179	1.25	18.75
900-1899	25.6k Hz	600,000 CPM	16K	9.375-19.78	.625	37.5
1900-3999	25.6k Hz	600,000 CPM	8K	9.9-20.83	.3125	75

Vibration Amplitude = $\frac{Dynamic\ Force}{Dynamic\ Resistance}$

RMS vs Peak vs Peak-to-Peak:

- Peak-to-Peak Vibration = 2 times Peak Vibration
- Peak Vibration = 0.5 X Peak-to-Peak Vibration
- Peak Vibration = 1.414 X RMS Vibration
- RMS Vibration = .707 X Peak Vibration

CPM/Hz Conversion:

- CPM = $Hz * 60$
- Hz = $\frac{CPM}{60}$

Frequency Resolution, Bandwidth, Separating Frequency

- Frequency Resolution = $\frac{Frequency\ Span}{\#\ FFT\ Lines}$
- Separating Frequency (difference between two frequencies to be identified) = $\geq$ 2 * Frequency Resolution * Window Noise Factor
- Required #FFT Lines = $\frac{2 * Window\ Noise\ Factor * Frequency\ Span}{Separating\ Frequency}$

Where:

- Window Noise Factor =
  - 1.0 for Uniform or Rectangular Window
  - 1.5 for Hanning Window (Used in Data Collection)

Approximates of Rolling Element Bearing Defect Frequencies

- Approx BPFI = (Nb/2 + 1.2) X RPM
- Approx BPFO = (Nb/2 - 1.2) X RPM
- Approx BSF = ½(Nb/2 – 1.2/Nb) X RPM
- Approx FTF = (1/2-1.2/Nb) X RPM

Where: Nb = Number of Rolling Elements

Blade Pass Frequency:

- BPF= # Blades * RPM

Gear Mesh Frequency:

- # Gear Teeth * # Gear RPM

Induction Motors:

- N_s = Synchronous Speed = $\frac{120\ Fl}{Poles}$
- F_s = Slip Frequency = N_s – RPM (Actual)
- F_p = Pole Pass Frequency = F_s * #Poles
- RBPF = Rotor Bar Pass Frequency = #Rotor Bars * RPM
- F_l = Line Frequency

Belt Frequencies:

Flat or V Belt:

- Belt Speed = $\frac{3.142 * Pulley\ RPM * Pulley\ Pitch\ Diameter}{Belt\ Length}$

Timing Belt Frequency:

- Pulley RPM * # Pulley Teeth

dB Conversions:

Calculate dB from ratio:

- 20Log(ratio) = dB

Calculate ratio from dB:

- 10^(dB/20) = Ratio