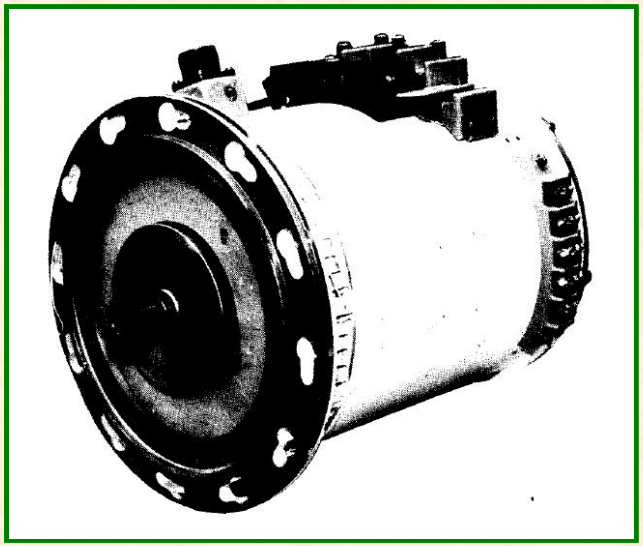
Initial Testing of a P-3C Aircraft Generator Using Electrical Signature Analysis (ESA)



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March 13, 2003

On February 28, 2003, a Preliminary Test Was Performed on a Navy P-3C Electric Generator at NAVAIR (Pax River)

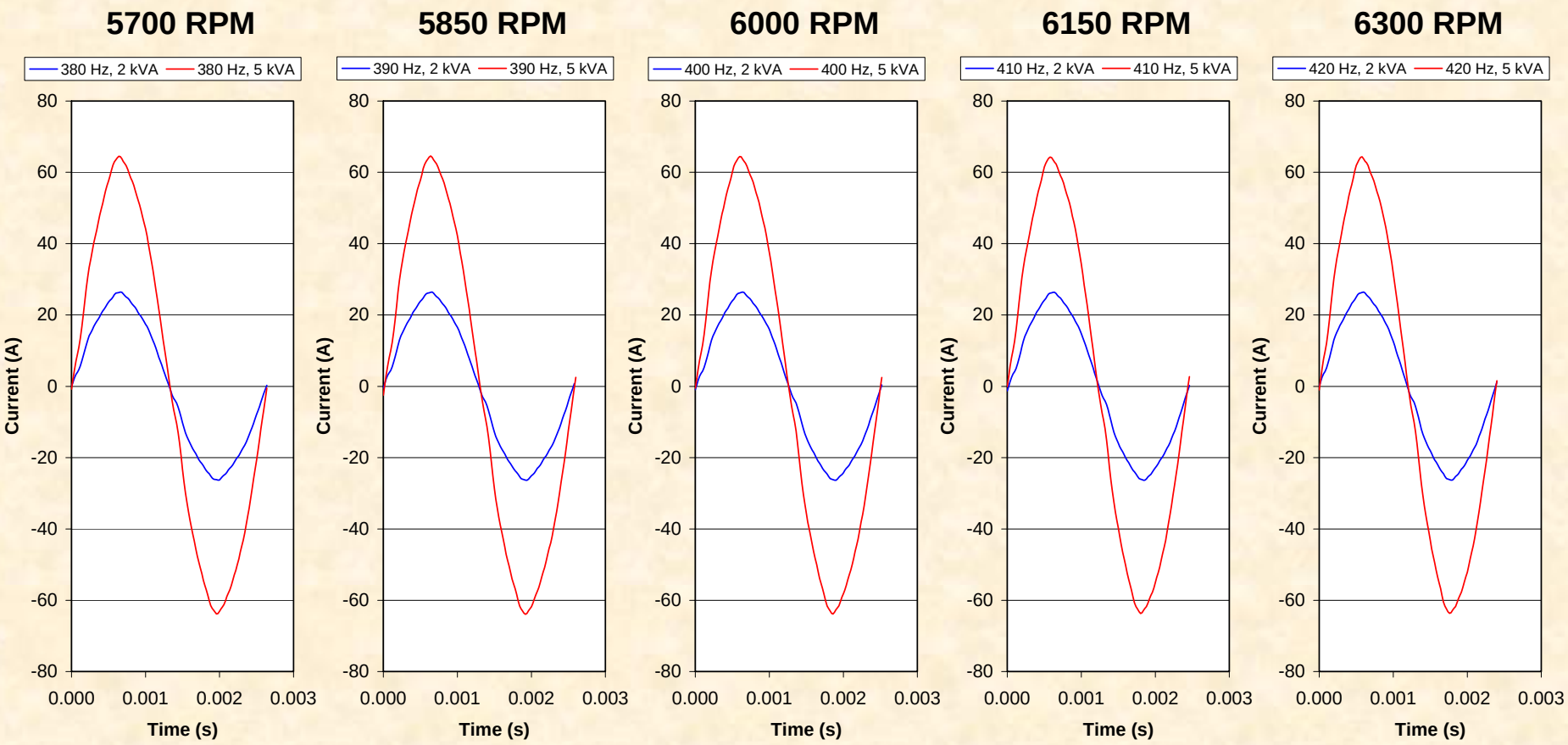
- Participants included NAVAIR personnel and ORNL (D. F. Cox, J. G. Hansen, and D. E. Welch).
- The generator was connected to a constant electrical load. Output current signals were recorded using clamp-on current probes and a digital audio tape recorder.
- The generator is a 3-phase, 400 Hz, 115 VAC, 60 kVA (20 kVA/ph), air cooled machine. According to the ***Product Specification Sheet***, the relationship between operating speed and output frequency is:

Speed (RPM)	Speed (Hz)	Output Frequency (Hz)
5700	95	380
6300	105	420

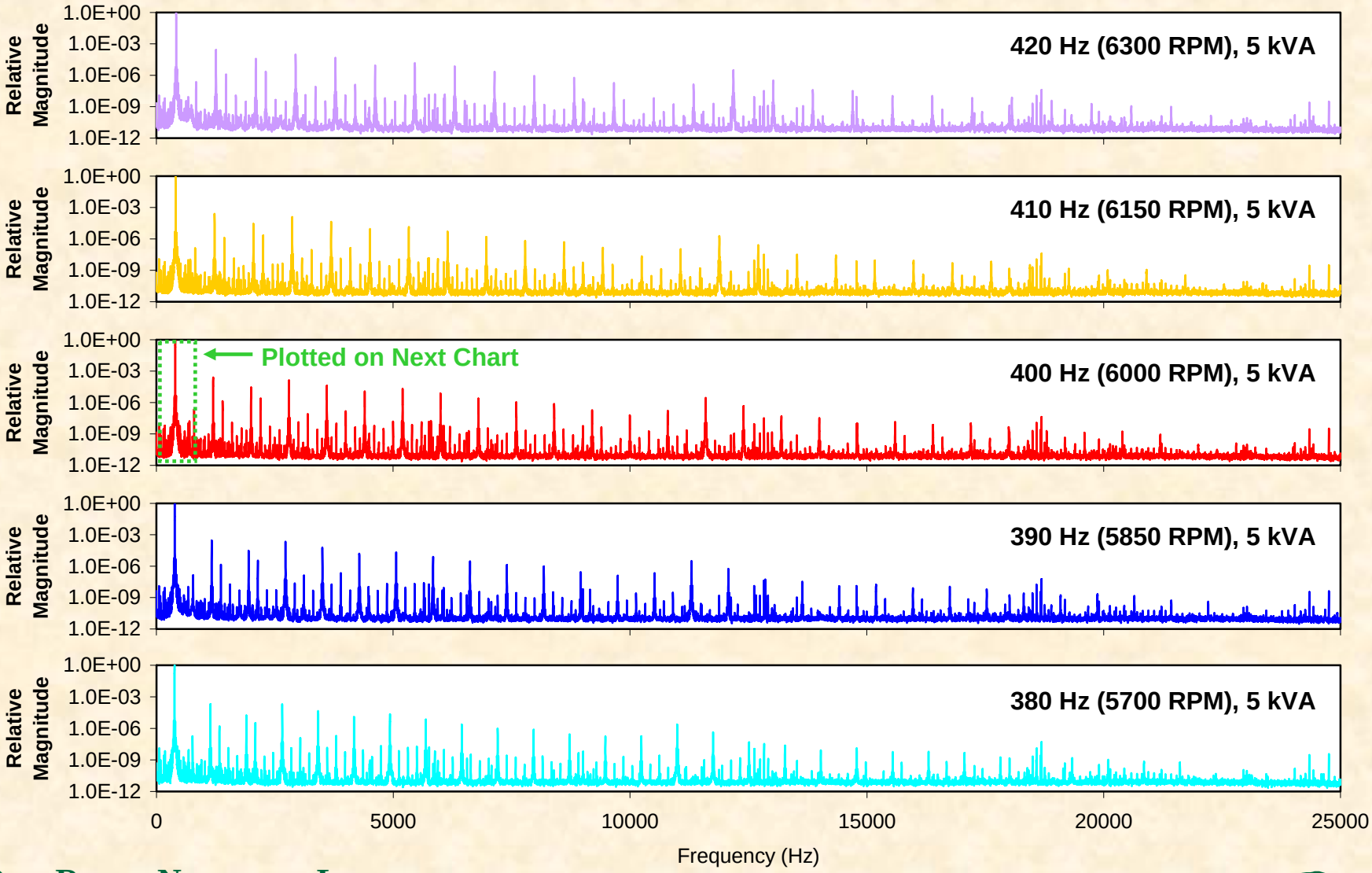
Output frequency is four times the running speed

- During testing, the frequency of the generator's output voltage was varied from 380 Hz to 420 Hz in 10 Hz increments. Running loads were set at 2 kVA/ph (10% of rated), 5 kVA/ph (25% of rated) and 10 kVA/ph (50% of rated).
- Recorded signals were analyzed in Oak Ridge. Due to instrumentation problems, the 10 kVA data was not analyzed.

Generator Speed and Running Load Determines the Frequency and Magnitude of the Current Waveform

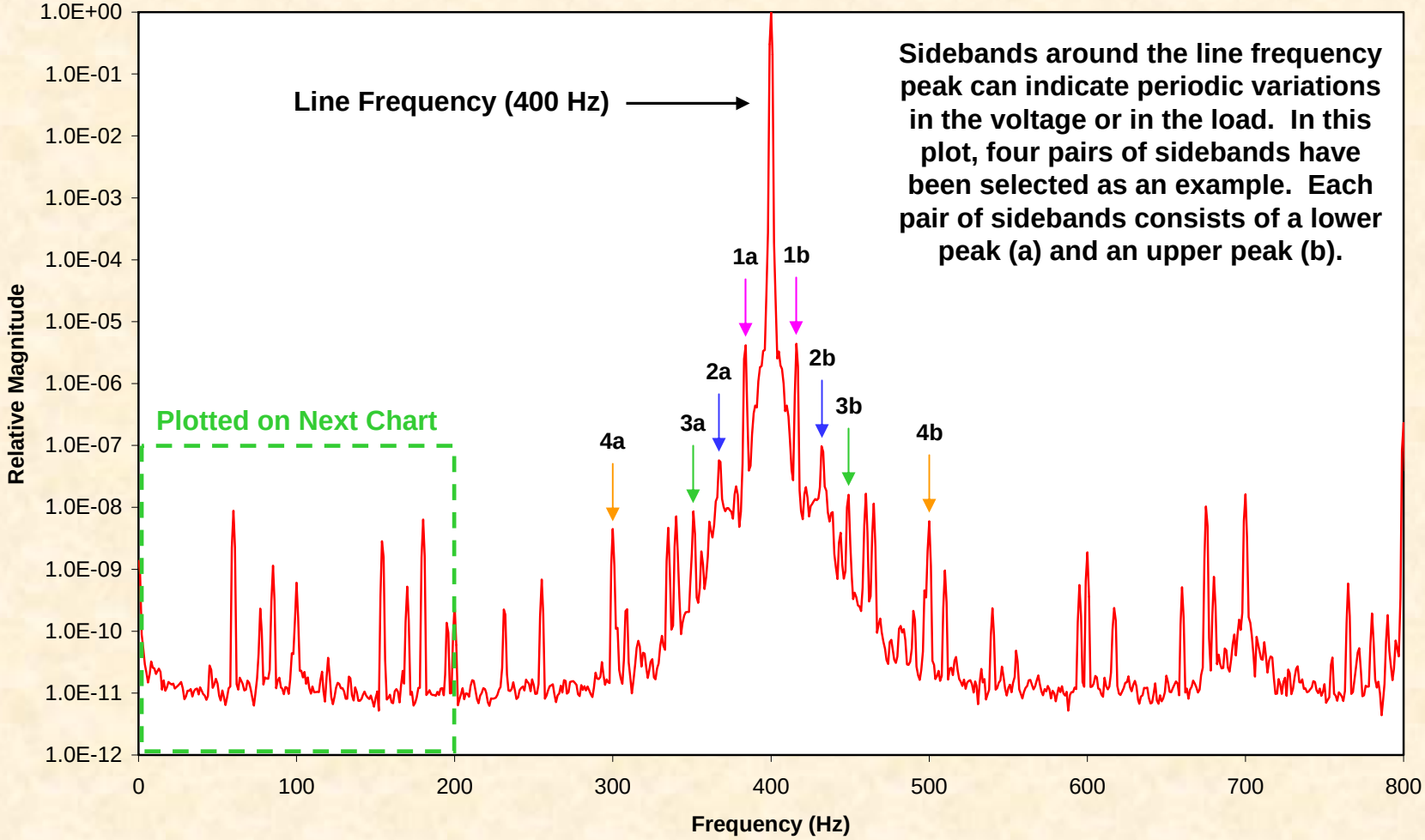


The Electric Current Frequency Spectrum Includes a Large Number Of Peaks That May Provide Useful Diagnostic Information

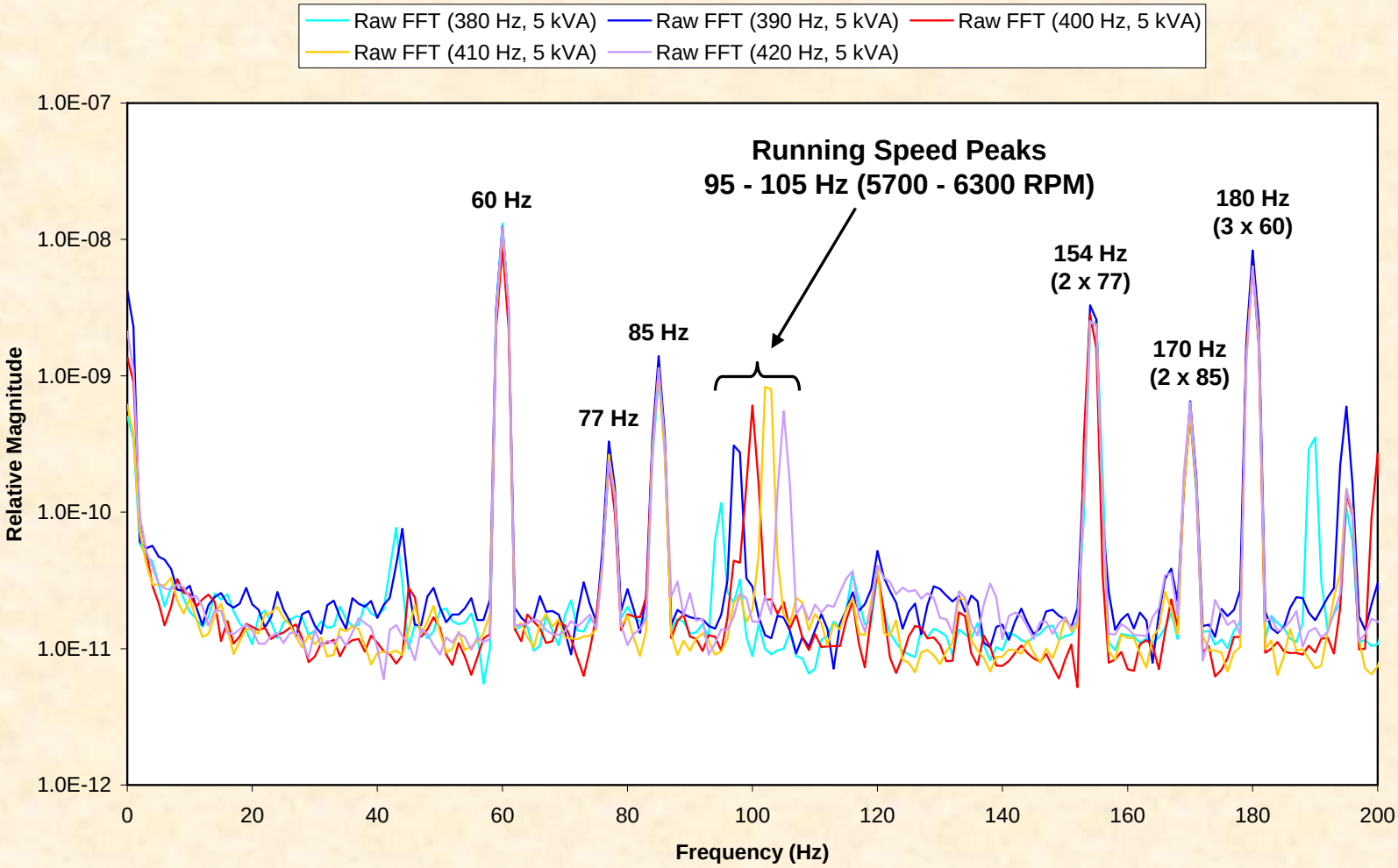


The Spectrum Is Dominated by the Line Frequency, Whose Amplitude Is Modulated by Other Frequencies

Example: 400 Hz, 5 kVA

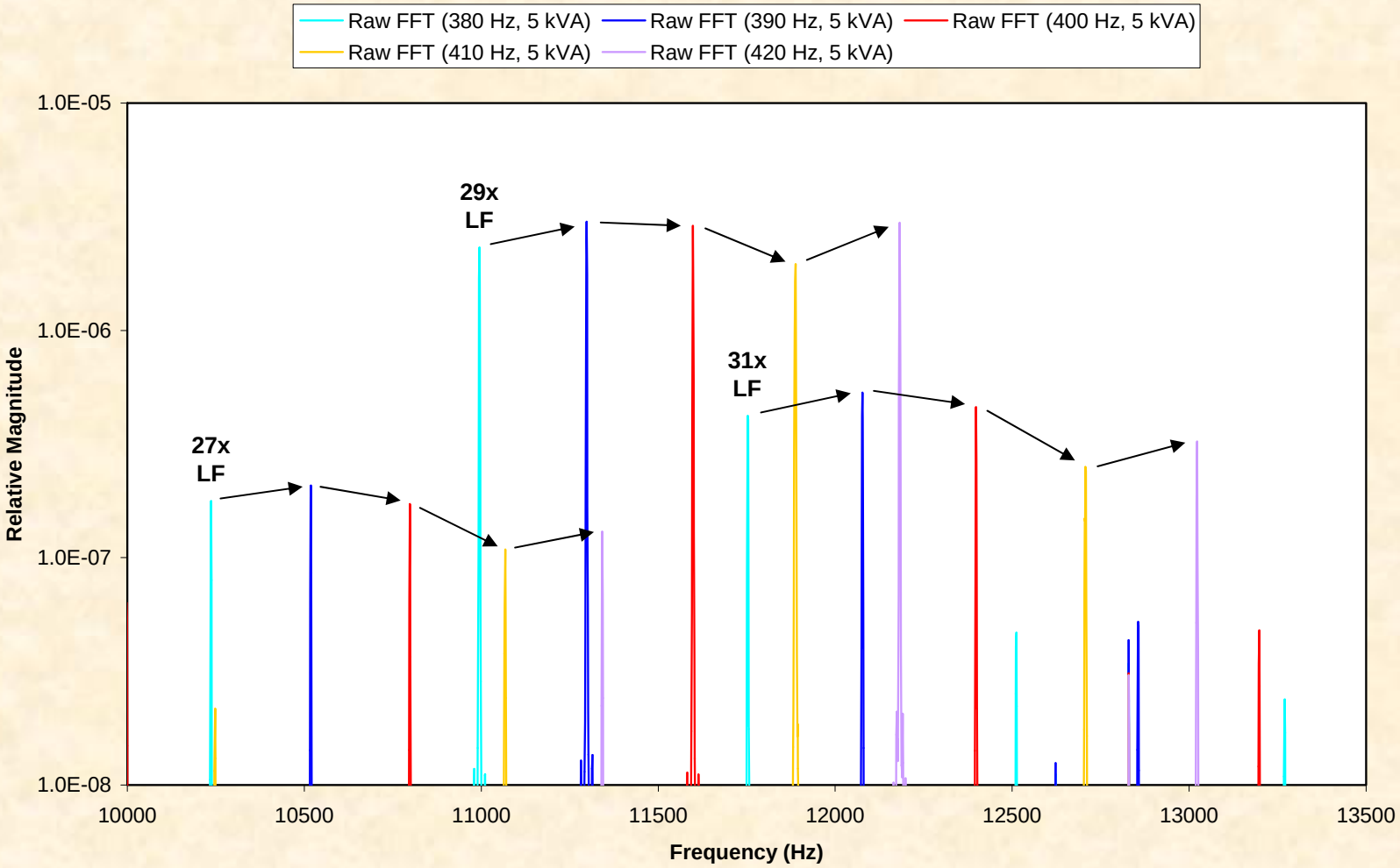


Some Spectral Components Are at Fixed Frequencies And Others Are Dependent on Generator Speed

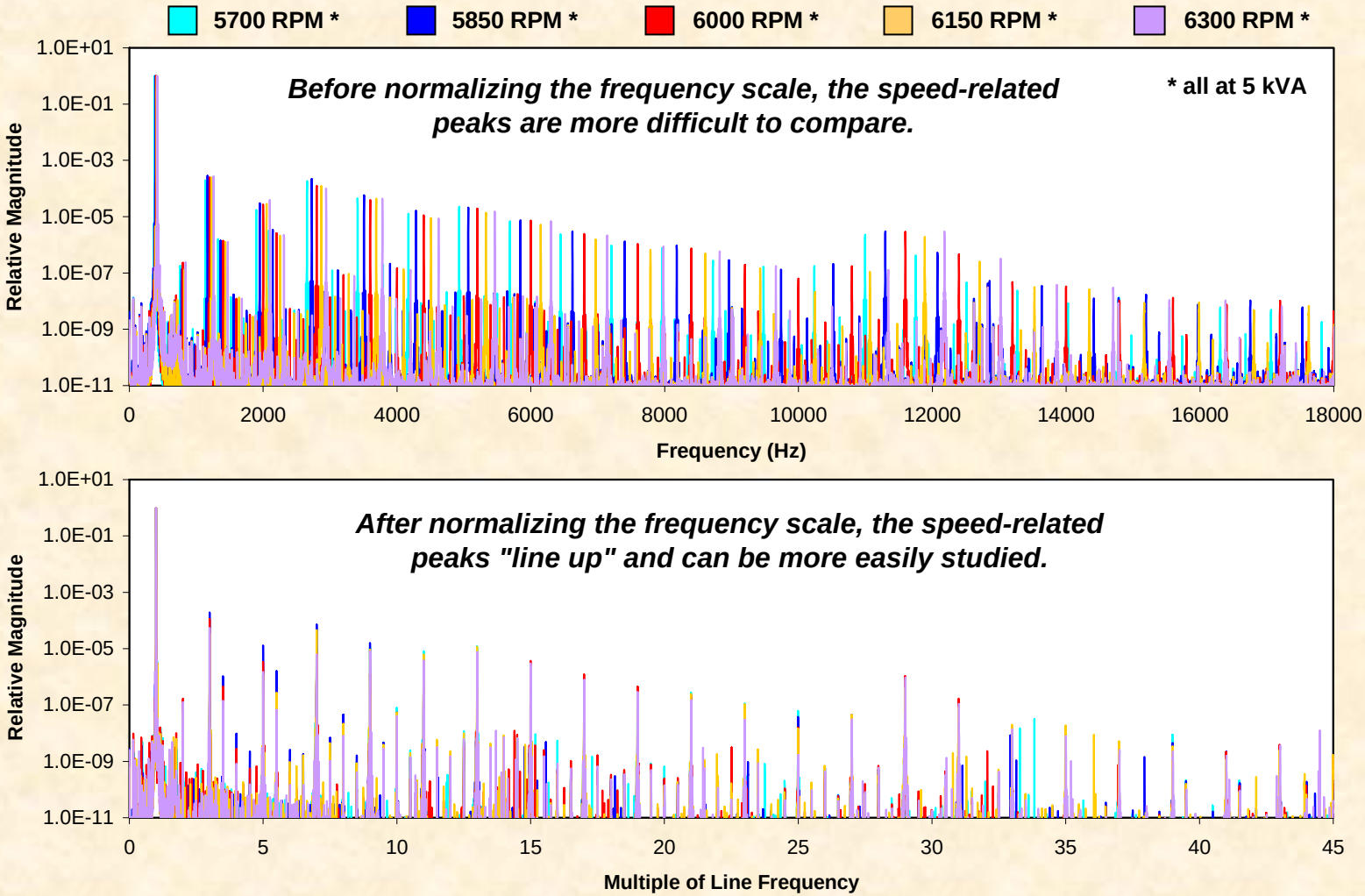


Line Frequency (LF) Harmonics Are Found Throughout the Spectrum and All Contribute Towards the Electrical "Signature" of the Generator

Example: 27x, 29x, and 31x Line Frequency Peaks

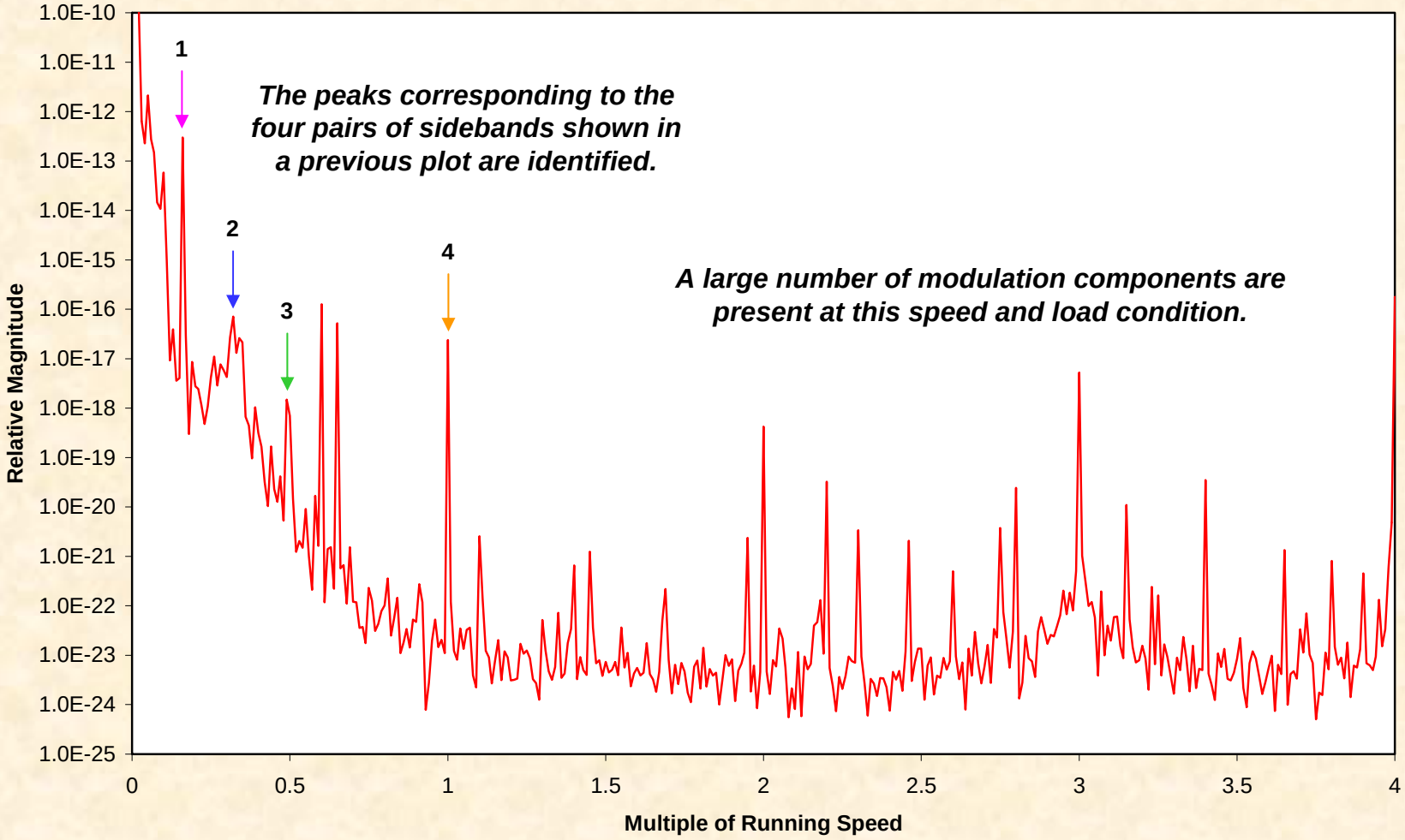


The Spectra From the Five Speed Conditions Can Be Compared After Converting the Frequency Scale To Multiples of Line Frequency

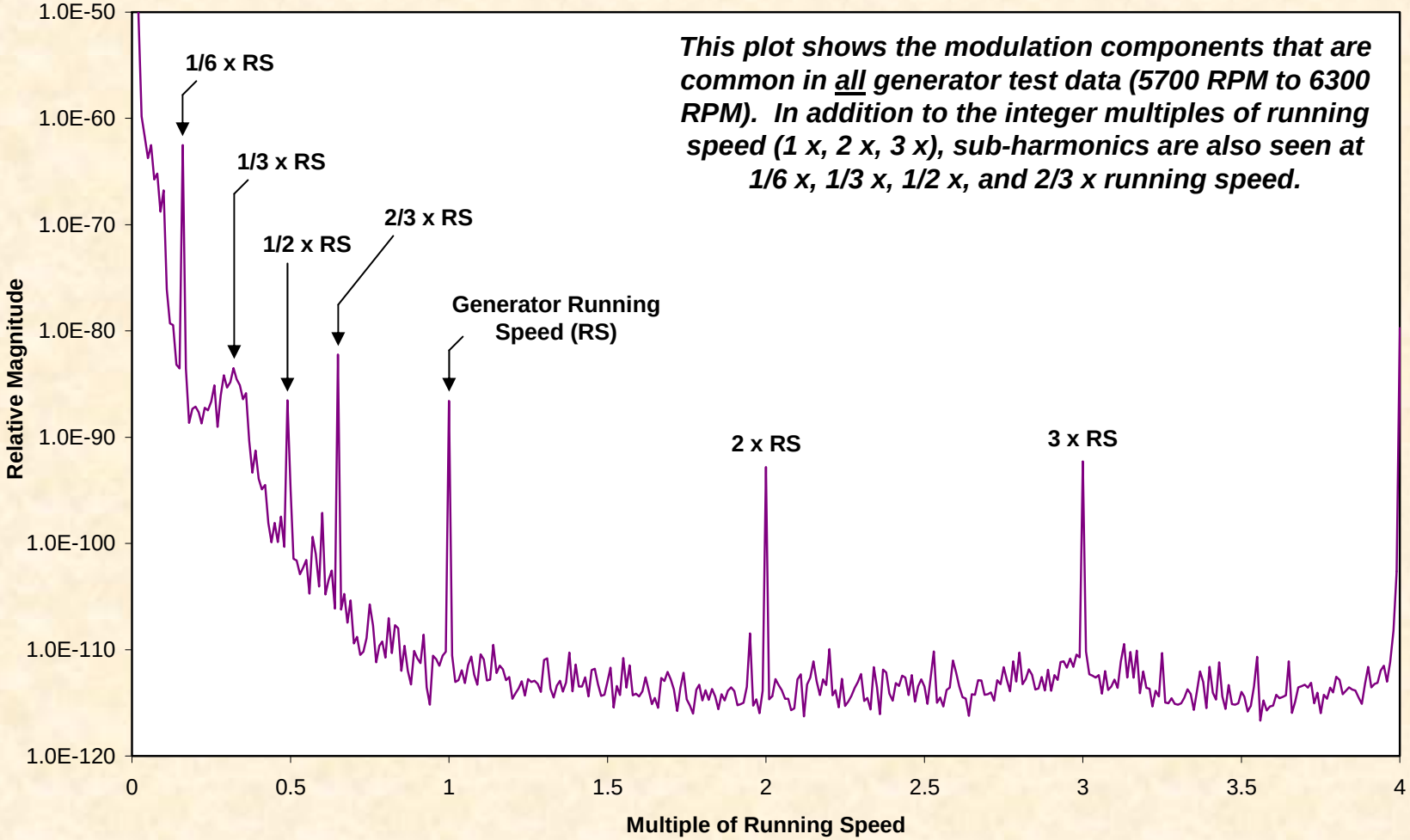


By Demodulating the Current Signal, the Modulation Frequencies Can Be Studied Directly and Related to Generator Running Speed

Example: 400 Hz, 5 kVA

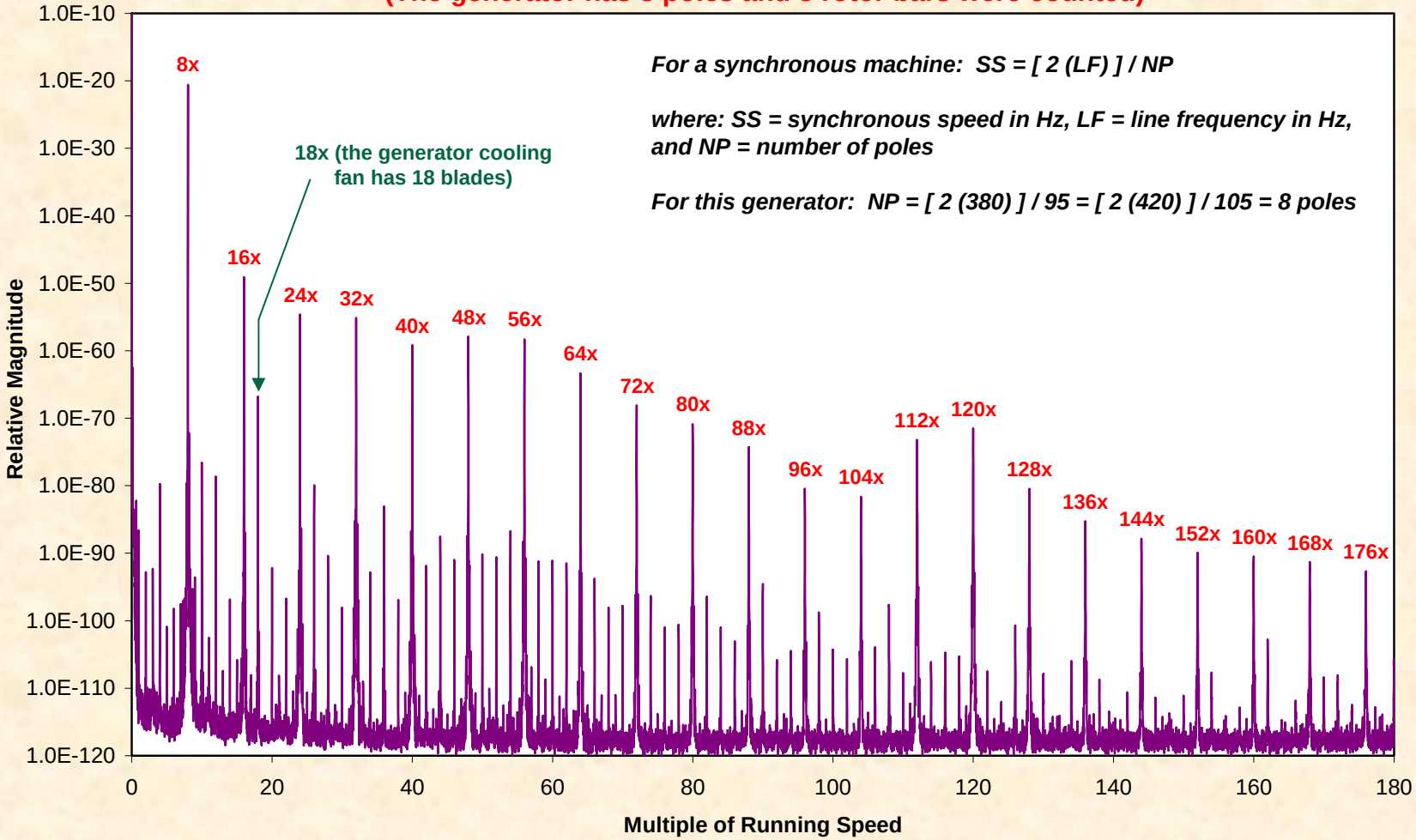


A Composite Spectrum Was Created From Data Taken at All Generator Speeds, and Used to Identify Potentially Useful Diagnostic Components



The Composite Spectrum Reveals a Large Number Of Peaks That Have Potential Diagnostic Value

The most dominant peaks are at multiples of 8 times generator speed.
(The generator has 8 poles and 8 rotor bars were counted)



Conclusions:

- The P-3C generator output current signals can be easily obtained using clamp-on current probes.
- The current frequency spectrum contains numerous elements that likely reflect the condition of the generator, including its many subcomponents. Even with a constant load, amplitude modulations are present at integer and fractional harmonics of running speed. For example, strong modulations are observed at eight-times running speed, which matches the number of generator poles and the number of counted rotor bars. Additional generator testing will identify the source of each modulation and the sensitivity to component degradation.
- Since the frequency of the output AC voltage is directly related to the generator running speed, the generators speed can be directly monitored.
- The frequency of some spectral components do not vary with the speed of the generator. Further testing will identify their source and how they can be best utilized for generator diagnostics.
- This initial test was performed while the P-3C generator was connected to a constant electrical load. Under these conditions, the current signature is dominated by the generator output voltage signature characteristics. When a device having a variable load is powered by the generator, the characteristics of the load will also be present in the generator current signature.
- Based on this initial test, ESA was judged to be a viable monitoring technology for the P-3C generator. Generator ESA methods can be developed and packaged as a stand-alone instrument, or incorporated in the portable ESA system that has already been developed for fuel pump condition monitoring.