

Electric Motor Monitoring With Your Microlog

Research conducted at the EPRI Monitoring and Diagnostic Center at Eddystone, PA is expanding the use of electronic data collectors, such as your Microlog, and is providing another tool for the plant engineer to use in diagnosing electric motor problems.

The only diagnosis equipment you need in addition to your Microlog data collector is a clamp-on current probe (Figures 1a and 1b) with the proper connector to feed the detected current to the data collector, and a method to accurately determine the RPM while the motor is operating under full load. Note that the motor must be under full or near full load, as determined by an ammeter reading.

If you set *Type:Volts* and *Input:1 mV/EU* in Microlog's *Input Setup* screen in *Analyzer* mode, a good motor will provide a zoomed current spectrum similar to Figure 2.

Figure 3 shows an FFT of the current in a similar motor with four broken rotor bars out of forty-eight and a cut end ring. Note the sidebands at 55.3 Hz and 64.7 Hz that are present in a damaged motor that are not present in a good motor.

These sidebands are created in an AC induction motor, by the rate at which the spinning armature falls behind the rotating electrical field generated by the motor's field windings (referred to as slip frequency).

Microlog's Automatic Zoom Feature

Your Microlog implements the conversion of raw time signals to spectrum displays by a unique approach as compared to other FFT analyzers. The Microlog's FFT process can be set to any maximum frequency less than 20 kHz because a continuously variable anti-aliasing filter is used. Both the filter corner frequency and



Figure 1a. The Model CMSS 6187-1-CE AC/DC Current Clamp Probe.



Figure 1b. The Model CMSS 6187-CE AC/DC Current Clamp Probe.

the clock sample rate are set by the *Maximum Freq:* entry in the *Spectrum Setup* screen in the single-channel Microlog or in the *Measment Setup* screen in the two-channel Microlog (Figure 4).

An additional Microlog feature in these setup screens allows you to specify start frequency (*Start Freq:*), maximum frequency (*Maximum Freq:*), and frequency resolution (*Maximum Freq:/Lines:*) within this interval.

The advantage of this method is that the narrow resolution simply increases the resolution and selects the display scales without the inconvenience of having to set the cursor and zooming in each time data is collected.

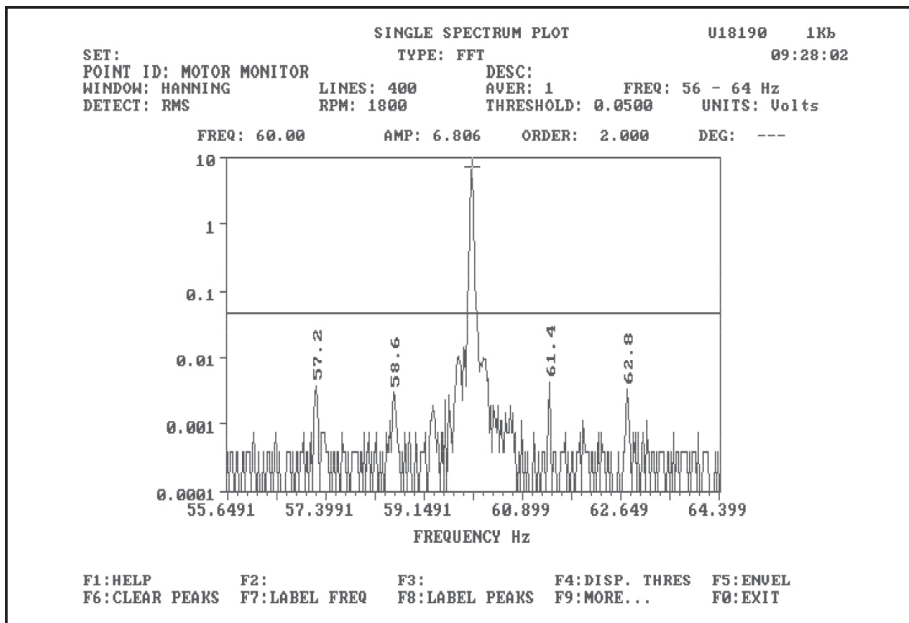


Figure 2. A Current Spectrum for an Undamaged Motor.

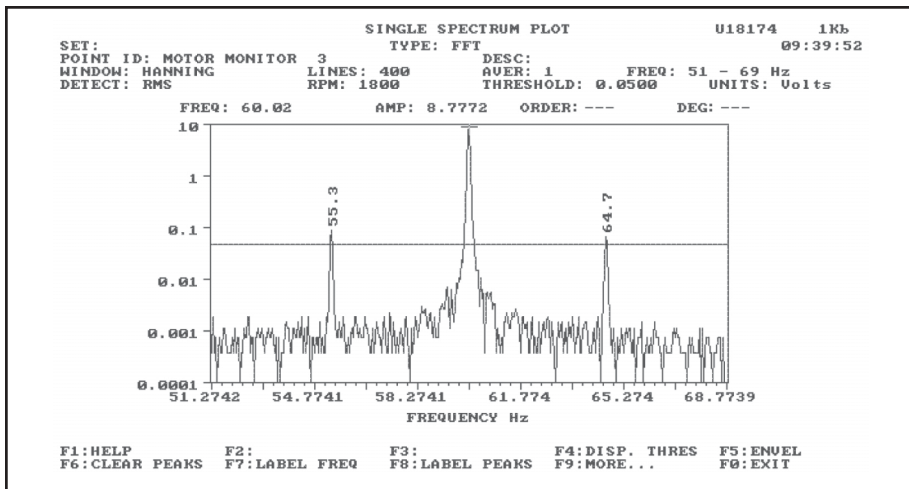


Figure 3. A Current Spectrum for a Damaged Motor.

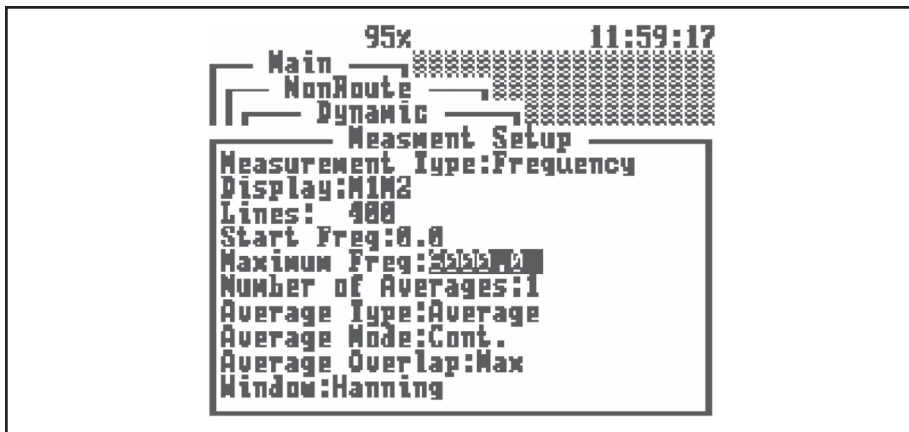


Figure 4. The Maximum Freq Field in the Measment Setup Screen of the Two-Channel Microlog.

NOTE: In order to apply this technique in the ROUTE mode, you must save this “ f_{start} and f_{max} ” setup and upload it to the PRISM² database (it is not possible to set the proper start and maximum frequencies in the PRISM² POINT SETUP TABLE). Then you can duplicate this unique POINT set up or as many motors as desired. The next step would then be to change the duplicated ID to the proper ID for each motor.

Diagnosing Open Rotor Bars – An Application

The Microlog lends itself to this measurement application to identify the symptoms of open rotor bars in a squirrel cage AC motor without the need of further software.

An induction motor rotor open can be diagnosed by measuring the sideband amplitudes around the excitation frequency. The sidebands are spaced at number of poles x slip frequency in Hz.

$$\begin{aligned} \text{sidebands} &= 2 \times \left[\frac{\text{Sync} - \text{Sact}}{\text{Sync}} \right] \times L.F. \\ &= 2 \times \frac{\text{Slip}}{\text{Sync}} \times L.F. \end{aligned}$$

$$\begin{aligned} \text{Sync} &= \text{Synchronous rotation (CPM)} \\ &= \frac{60 \times L.F.}{P/2} \end{aligned}$$

$$\text{Sact} = \text{Actual rotation (cpm)}$$

$$P = \text{Number of poles}$$

$$L.F. = \text{Power line frequency}$$

$$\text{Slip} = \text{Sync} - \text{Sact}$$

If the sideband amplitudes are greater than 0.5% of the center frequency peak then there is concern that the motor is developing a rotor problem.

Normally slip is a small percentage of synchronous speed. In order to identify these sidebands, more FFT resolution than usual is required for data logging procedures. Because the sidebands are so closely spaced



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to the power line frequency, we must zoom in on a narrow frequency range. The required zoom is automatically preset with the selection of **Start Freq.**, **Maximum Freq.**, and **Lines.**:

Suppose we have an 1,800 Hz motor with 2% slip under full load.

$$\begin{aligned} \text{slip} &= N_s - N_a \\ \% \text{ slip} &= \frac{N_s - N_a}{N_s} \times 100 \end{aligned}$$

where

$$\begin{aligned} N_s &= \text{synchronous speed} \\ N_a &= \text{actual speed} \end{aligned}$$

In our example,

$$\begin{aligned} \text{slip} &= 0.02 (1,800) \\ &= 36 \text{ RPM or } 0.6 \text{ Hz, and} \\ \text{number of poles slip} &= 2.4 \text{ Hz} \end{aligned}$$

If **Maximum Freq.** (f_{\max}) is set at 65 Hz (3,900 RPM), **Start Freq.** (f_{start}) at 55 Hz (3,300 RPM) and **Lines:**400, then the frequency resolution needs to be

$$\frac{65 - 55}{400} = 0.025 \text{ Hz/line (1.5 RPM/line)}$$

In order to accomplish this zoom, the Microlog automatically selects a 1,600 line resolution to provide 400 lines between f_{start} and f_{\max} , as shown.

Using the proportion,

$$\begin{aligned} \frac{f_{\max} - f_{\text{start}}}{400} &= \frac{f_{\max}}{\text{number of lines}_{\text{new}}} \\ \text{number of lines}_{\text{new}} &= 400 \frac{f_{\max}}{f_{\max} - f_{\text{start}}} \\ &= 400 \frac{65}{10} \\ &= 2,600 \text{ lines} \end{aligned}$$

The lower Microlog binary number line resolution is 1,600, so

$$\begin{aligned} f_{\text{start}} &= f_{\max} \left(\frac{1,600 - 400}{1,600} \right) \\ &= f_{\max} \left(\frac{1,200}{1,600} \right) = 65 \left(\frac{1,200}{1,600} \right) \\ &= 48.75 \end{aligned}$$

The f_{start} frequency Microlog displays will be 48.75 (the nearest line resolution) rather than 55 Hz as selected.

The overall value accurately approximates the line frequency load current since the sideband contribution is very small. The cursor is first positioned on the lower sideband. If the sideband amplitude is greater than 0.5% of the overall RMS level then there is some concern of a rotor problem that should be further investigated.