Application Note

Shaft Eccentricity Measurements with the VM600

By Marcel de Boer • SKF

What is eccentricity monitoring?

Shaft eccentricity is a measurement of the mechanical, thermal or gravity bow of a rotor assembly at slow roll speeds (→ **fig. 1**). This bow must be minimized prior to operation of a large machine train to prevent vibration and possible machine damage caused by rotating parts of the rotor assembly contacting stationary parts of the machine case. This contact of rotating and stationary parts is referred to as "radial rub occurrence".

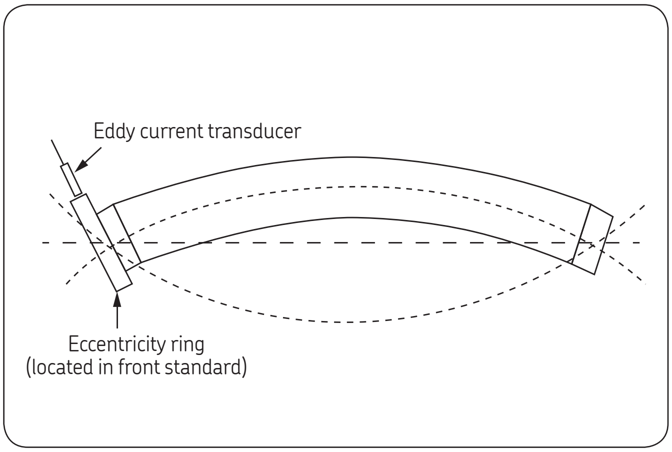


Figure 1. Shaft eccentricity.

Why measure eccentricity?

Rotor bow

During normal machine operation, the rotor assembly is constantly rotating at high speed. This high speed rotation equalizes the effects of gravity and thermal forces acting on the rotor assembly. However, as soon as the rotor assembly comes to rest, these forces no longer apply equally to all sides of the assembly. With the rotor assembly in a stationary position, gravity acts upon the rotor causing the center to bow, similar to how a thin piece of wood bows when placed between two mountings. As displayed in **fig. 2**, machine bearings support the rotor assembly span between them. This condition is normally a problem on a machine that has been stationary for some time (for example, as a result of machine outage).

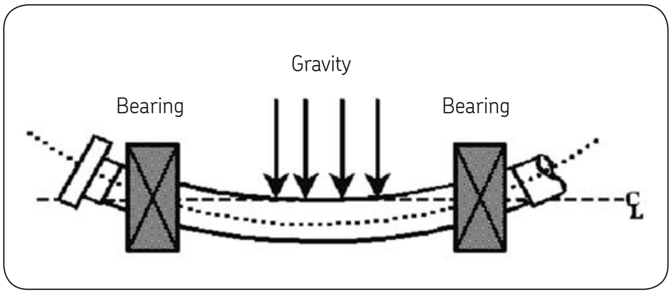


Figure 2. Bearings supporting the rotor assembly.

Thermal forces act on a rotor assembly when the rotor is shut down from its operating condition. In a shutdown condition, heat is trapped in the upper machine casing, creating a thermal differential across the assembly (for example, the top of the rotor assembly becomes hotter than the bottom). As displayed in **fig. 3**, this temperature differential causes the rotor assembly to bow towards the greater heat source (upwards in this case). This example is similar to placing a torch or other heat source on one side of a piece of flat steel. The steel will bow toward the torch, or heat source.

The degree of the bow is reflected as mechanical eccentricity at the two shaft ends (→ **fig. 1**). A key Turbo Supervisory Instrumentation (TSI) measurement for monitoring shaft bow uses an eddy current probe targeted on an “eccentricity ring” to measure eccentricity.

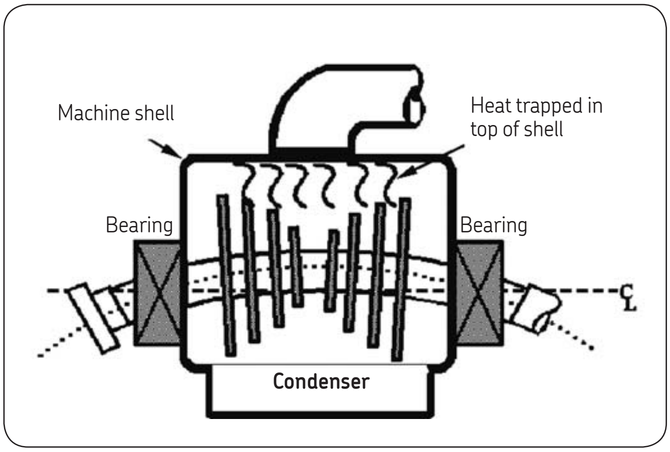


Figure 3. Bowing due to temperature differential causes.

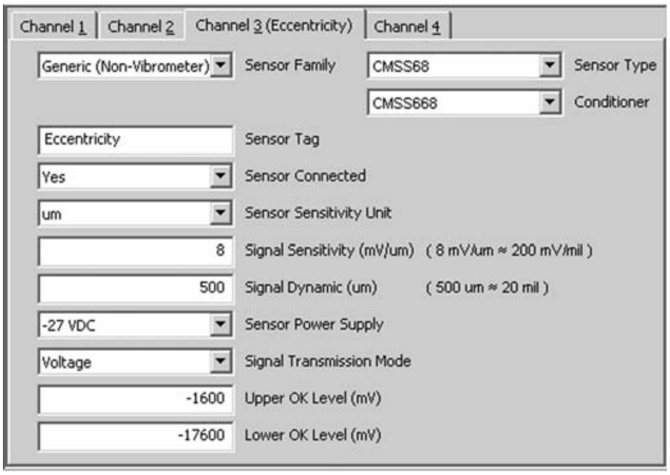
Eccentricity with the VM600

In the VM600 system, the MPC-4 protection module is the signal-conditioning card used for monitoring eccentricity. The following section provides information regarding the module’s configuration. For typical eccentricity measurements, the following description should be used in conjunction with the VM600 User Manuals for proper system configuration.

The VM600’s MPC-4 card accepts up to four dynamic input signals and up to two speed inputs simultaneously through its terminal strip connector. Each channel can be independently configured via hardware solderless jumpers and programming for any kind of AC or DC voltage or current based signal. For the purpose of this document, only the eccentricity configuration is discussed.

Sensor input

Analog sensor inputs are conditioned and converted to signals based on the full range display selected when programming with MPS-1 software. When measuring eccentricity, a standard eddy current probe with a 2 mm *(80 mils)* range is typical. An example “sensor input screen” is shown in **fig. 4**. The MPC-4 microprocessor performs probe “OK” checks and compares the signals to programmed alarm setpoints. The results of these comparisons display on the module’s front panel LED.



Generic (Non-Vibrometer) Sensor Family
CMSS68 Sensor Type
CMSS668 Conditioner
Eccentricity Sensor Tag
Yes Sensor Connected
um Sensor Sensitivity Unit
8 Signal Sensitivity (mV/um) (8 mV/um ≈ 200 mV/mil)
500 Signal Dynamic (um) (500 um ≈ 20 mil)
-27 VDC Sensor Power Supply
Voltage Signal Transmission Mode
-1600 Upper OK Level (mV)
-17600 Lower OK Level (mV)

Figure 4. Input configuration.

Outputs

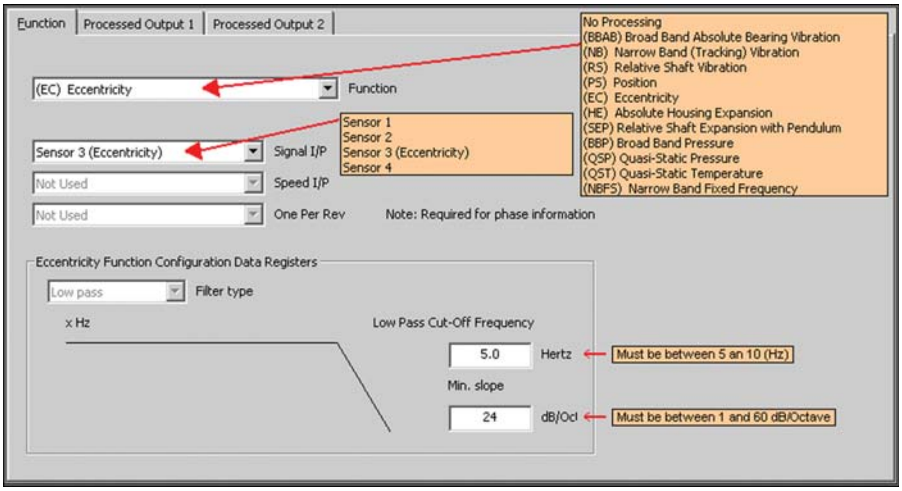
If input signal levels exceed the programmed setpoints, the module’s microprocessor can activate individual channel or common rack relays. Conditioned input signals are also converted to either a 4 to 20 mA or 0 to 10 V DC proportional analog output, and are available at the rear terminal strip connector for interface to an external recorder or as a process variable input to another system.

In addition to being processed internally, the original unprocessed analog sensor input signals are active buffered and available at the rear terminal strip and on the internal VM600 raw bus.

If the VM600 is also equipped with Vibrometer’s Condition Monitoring Card (the CMC-16), it is recommended that the eccentricity measurement be recorded by the CMC-16 by means of the DC processed output of the MPC-4 card. This avoids differences in the measured results, as the CMC-16 card uses different filtering techniques that will influence the result of the eccentricity measurement.

Processing

The eccentricity measurement is only valuable as an indicator of possible rotor bow at slow speed (slow roll), and occurs at speeds below 600 r/min (10 Hz). Above this speed, either the rotor bow has been “rolled out” or the machine has wrecked itself. As the speed increases, the mechanical eccentricity at the shaft ends reduces to the level where it is indistinguishable from shaft radial vibration (as measured on the eccentricity ring). Hence, when measuring eccentricity, a software selectable low pass filter is applied that is between 5 and 10 Hz. This results in an operating area from 1 r/min (0,017 Hz) up to any speed between 300 and 600 r/min (5 and 10 Hz).



(EC) Eccentricity — Function
Sensor 3 (Eccentricity) — Signal I/P
Not Used — Speed I/P
Not Used — One Per Rev — Note: Required for phase information

Eccentricity Function Configuration Data Registers
Low pass — Filter type
Low Pass Cut-Off Frequency
5.0 Hertz ← Must be between 5 an 10 (Hz)
Min. slope
24 dB/Oct ← Must be between 1 and 60 dB/Octave

Figure 5. Function configuration.

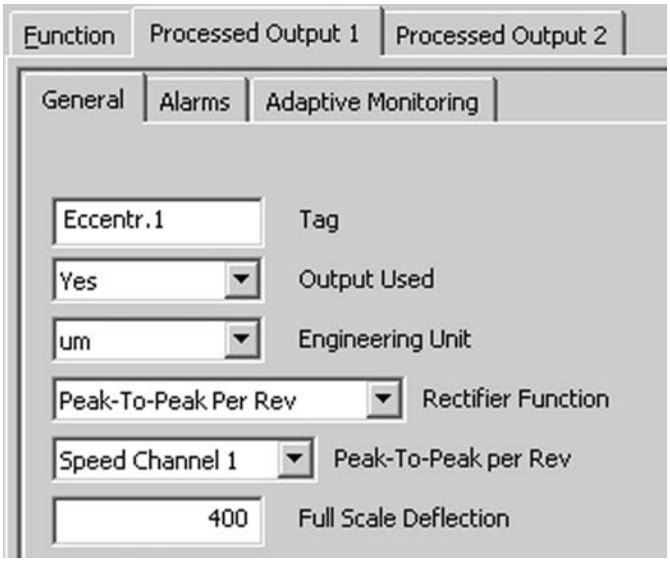
Processing configuration

Set up the eccentricity processing as follows, choosing between:

- Processed Output 1, which is pk-pk per revolution, or
- Processed Output 2, which is true pk-pk

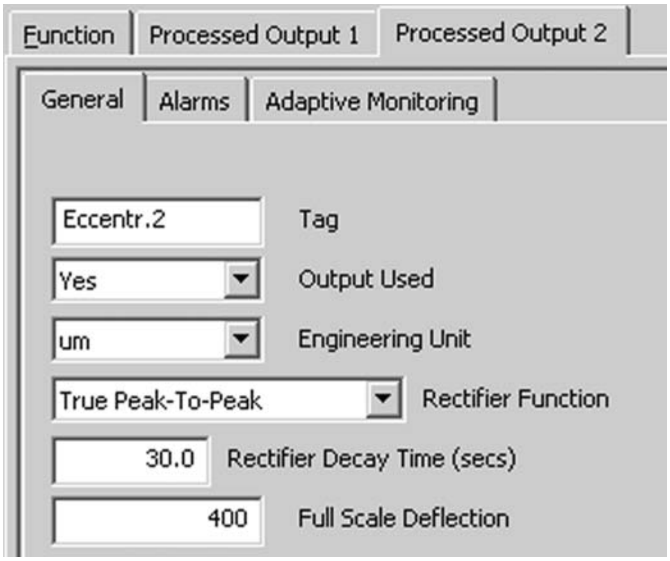
If eccentricity is determined by Processed Output 2 (true pk-pk with a rectifier time of 30 seconds), the pk-pk value will be measured over 30 seconds, and will be more stable than a pk-pk per revolution measurement (Processed Output 1).

As described in **figs. 5** through **7**, processing will produce the results shown in **fig. 8** in a live MPS display.



Eccentr.1 — Tag
Yes — Output Used
um — Engineering Unit
Peak-To-Peak Per Rev — Rectifier Function
Speed Channel 1 — Peak-To-Peak per Rev
400 — Full Scale Deflection

Figure 6. Processed Output 1 configuration.



Eccentr.2 — Tag
Yes — Output Used
um — Engineering Unit
True Peak-To-Peak — Rectifier Function
30.0 — Rectifier Decay Time (secs)
400 — Full Scale Deflection

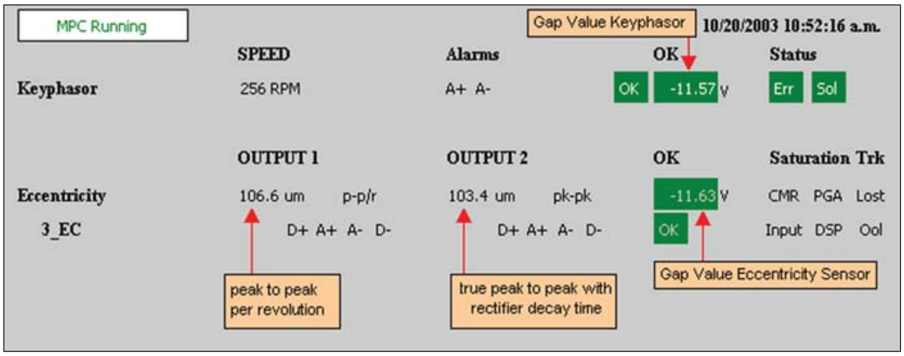
Figure 7. Processed Output 2 configuration.

Installation considerations

Considerations during eccentricity measurement installation are those of all TSI measurements:

- Is the sensor system capable of measuring the expected movement?
- Is the full scale of sufficient amplitude, even if a machine problem develops?
- What alarm values are to be used for the protection system?
- Did you choose the proper location and account for thermal expansion of the rotor?
- Mechanically, have you installed the sensor correctly for the desired measurement?
- Electronically, have you wired the system to the protection system properly?
- Did you configure the protection system properly, including alarm set points?

Consult installation and service documentation for more detail.



Gap Value Keyphasor

peak to peak per revolution

true peak to peak with rectifier decay time

Gap Value Eccentricity Sensor

Figure 8. Displayed output.

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