Measuring Low-Frequency Bearing Currents with PEM's RCTi & LFR Rogowski sensors

Low-frequency bearing currents silently damage critical rotating machinery through continuous electrical stress at power frequency.

PEM's Rogowski sensors - **RCTi/25** for permanent installation, or battery powered **LFR015** for troubleshooting - provide purpose-built detection with high SNR at power frequencies, enabling early warning protection for hydroelectric generators, turbogenerators and large industrial motors before catastrophic failure occurs.

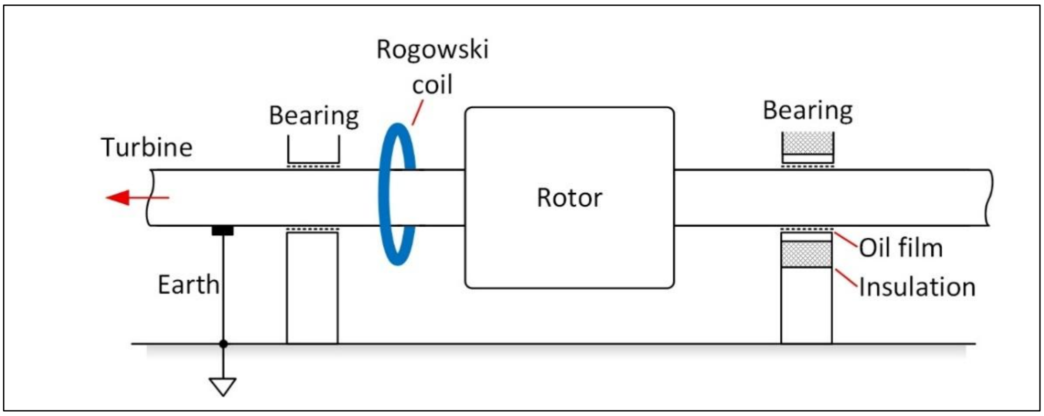


Figure 1. Rogowski coil positioned around a generator's shaft

About Low-Frequency Bearing Currents

Low-frequency bearing currents are parasitic electrical currents that flow through machine bearings at power frequency (50/60 Hz) and related harmonics. Unlike high-frequency bearing currents associated with variable frequency drives (VFDs), low-frequency bearing currents originate from electromagnetic asymmetries, residual magnetisation and other machine-specific phenomena.

These currents are characterised by:

- Fundamental frequency components at 50/60 Hz
- Harmonics at 100/120 Hz (2nd), 150/180 Hz (3rd), up to 2kHz.
- Amplitudes ranging from 100mA to 20A (depending on machine size)
- Sinusoidal or quasi-sinusoidal waveforms
- Continuous or intermittent presence during normal operation

Spectral Signature

- Dominant peaks at power frequency (50/60 Hz)
- Strong presence of low-order harmonics (especially 3rd, 5th, and 7th)
- Harmonic content typically declines rapidly above 1 kHz
- May show sidebands related to rotational speed
- Often correlates with machine loading patterns

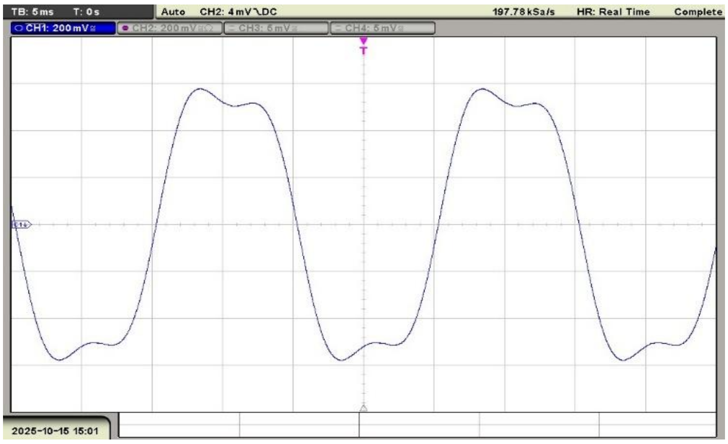


Figure 2. Distorted 50Hz power waveform

Waveform Features

- Quasi-sinusoidal pattern following power frequency
- Amplitude modulation related to mechanical loading
- Typically continuous rather than impulsive
- Often shows phase relationship to stator currents
- May exhibit distinctive phase shifts between measurement points

Damage Mechanisms

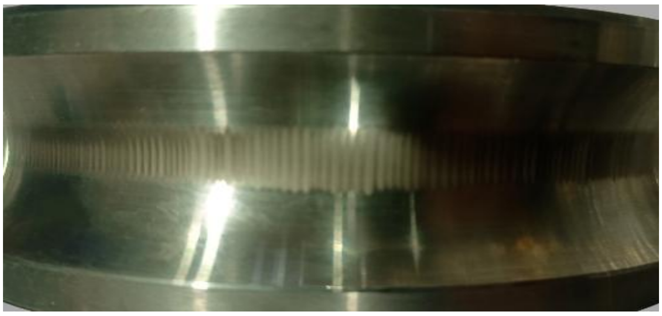
The damage pattern differs substantially from high-frequency bearing current damage:

- **Thermal Degradation**: Resistive heating within bearing components
- **Lubricant Breakdown**: Accelerated oxidation of lubricants
- **Surface Fatigue**: Electrical stress contributing to material fatigue
- **Uniform Wear**: More generalised wear patterns compared to fluting from high-frequency currents
- **Cumulative Effect**: Progressive damage over extended operating periods

This damage often remains undetected by conventional vibration monitoring until advanced stages, making early electrical detection crucial for asset protection.

Technical Difficulties

- **Low Magnitude**: Currents are often below 1A during normal operation
- **Large Physical Size**: Machine dimensions complicate sensor placement
- **Power Frequency**: Measurements at 50/60 Hz face interference from surrounding equipment
- **Limited Access**: Operational machinery restricts measurement point access
- **Non-Invasive Requirement**: Measurement must not alter circuit characteristics



Picture 1 Bearing Fluting (courtesy of **3Phi Reliability**)

RCTi/25 | LFR015: Technical Specifications

Core Technology

Both the RCTi/25 and LFR015 utilise optimised Rogowski coil technology to maximise the SNR at power frequency and higher order harmonics for low frequency bearing current measurements:

- **Measurement Principle**: Air-core inductive sensor that produces an output voltage proportional to the rate of change (derivative) of the measured current
- **Signal Conditioning**: Precision integrator circuit that is bandwidth limited to provide improved SNR at power frequencies up to 200th harmonic, produces a voltage output proportional to the measured current.
- **Noise Rejection**: Common-mode rejection techniques and specialised shielding.
- **Physical Design**: Flexible, lightweight coil structure with uniform winding distribution for good overall accuracy.

Physical Specifications

Coil and cable

Parameter:	Available Options:
Coil circumference	500mm, 700mm, 1000mm, up to 7000mm
Coil cross-section	8.5mm (14mm with robust removable silicone sleeve)
Coil insulation	2kV peak
Cable length	2.5m up to 30m
Coil cable ingress rating	IPX8
Coil cable disconnect 'option'	LEMO self-latching in line cable connection. Robust connector with excellent EMI protection IP50 Ingress rating

Electronics enclosure

Parameter:	Available Options:
Power supply	+10.8 to 26.4Vdc, 1W
Operating Temperature	-20°C to +70°C
Storage Temperature	40°C to +85°C

**RCTi - **DIN rail mount plastic enclosure
IP20 ingress rating
Output & power cabling via rising clamp screw terminals

RCTi / IRF - Panel mount diecast aluminium
IP65 ingress rating
High EMI shielding
Output cable – double screened BNC cable with plug
Power supply cable – screened twisted pair cable

LFR - The sensor can also be supplied as a battery powered probe, the LFR015/1.5, for troubleshooting applications where permanent installation is not required.

Performance Specifications

Parameter	Specification	Notes
(-3dB) Frequency Range	4 Hz to 40 kHz	Bandwidth limited to provide improved SNR at power frequencies up to 200th harmonic
Sensitivity	200 mV/A	
Measurement Range	30A	Highly linear response
Output Noise (typ.)	4mV rms	With coil closed and no current, (Main Noise frequency 4Hz)
Accuracy (typ.)	±1% of reading	See RCTi technical notes
Phase Error	<10° (50/60 Hz)	
Typ. Coil Temp. Coefficient	<-0.02%/°C	For ambient temperatures -20°C to +70°C

Certification & Compliance

- Electromagnetic Compatibility: EN 61326-1:2013
- Safety: EN 61010-1:2010
- Environmental: RoHS and REACH compliant
- Quality: ISO 9001:2015 certified manufacturing

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