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High Temperature Acoustic Emission Transducer Pencil Test

1. Scope of the Technical Note

Various industries, including power generation, aerospace, and oil and gas, demand high-temperature acoustic emission transducers for structural health monitoring. The challenge for high temperature operation is maintaining sensitivity in the sensors, where typical piezo-crystals used fail at temperatures ~180 °C or materials like quartz exhibit inherently low sensitivity and require charge to voltage conversion or substantial amplification to overcome cable length resistance and impedance mismatch. This is typically achieved by using integrated electronics (IEPE) which are also temperature limited, or by using long waveguides to achieve a standoff from the component surface temperature which acts to further decrease sensitivity.

This technical note explores the suitability of Ionix's HotSense platform for acoustic emission (AE) transducers for such applications, without the need for waveguides or IEPE electronics due to its high sensitivity across a wide temperature range, by the application of a standard pencil break test conducted at 350 °C. The outcomes demonstrate that the HotSense AE transducer exhibits outstanding sensitivity at this temperature, maintaining a performance level similar to that at room temperature.

Highlights:

- ► Successful pencil break tests conducted at 350 °C, demonstrate the AE transducer's functionality at elevated temperatures without IEPE or waveguides.

- ► The transducer consistently maintains a performance level comparable to that observed at room temperature, showcasing its reliability across varying temperature conditions.

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2. Methodology

- A prototype HotSense AE transducer, constructed with Ionix HPZ 580 piezo-crystal was assembled within a titanium enclosure, with components chosen based on availability rather than application-specific design.
- The AE transducer was coupled to a 200 mm length titanium rod, to act as the component under test, using a silver foil with compression from a top loaded bolt.
- Both the transducer and testing rod were placed inside an oven, with the bottom of the testing rod protruding through a port for access to the pencil.
- The AE transducer was connected to 2 m of coaxial cable into a wide-band 20 dB pre-amplifier and then linked to an oscilloscope.
- An initial pencil break test (PBT) (Hsu-Nielsen, Pencil lead break AE test, ASTM E976-94) was conducted when the oven was at ambient temperature, with the snap point at the bottom of Ti rod.
- The AE transducer was heated from 27 ˚C to 350 ˚C and left to dwell for 3 hours.
- Another pencil test was carried out when the oven stabilized at 350 °C.
- Data, captured in oscilloscope screenshots and waveforms, underwent further FFT analysis to examine the frequency domain content.

Figure 1 – Photograph of AE transducer coupled to a 200 mm length Ti rod

Figure 2 – Transducer and testing rod were placed inside an oven, with the bottom of the testing rod protruding through a port

3. Results

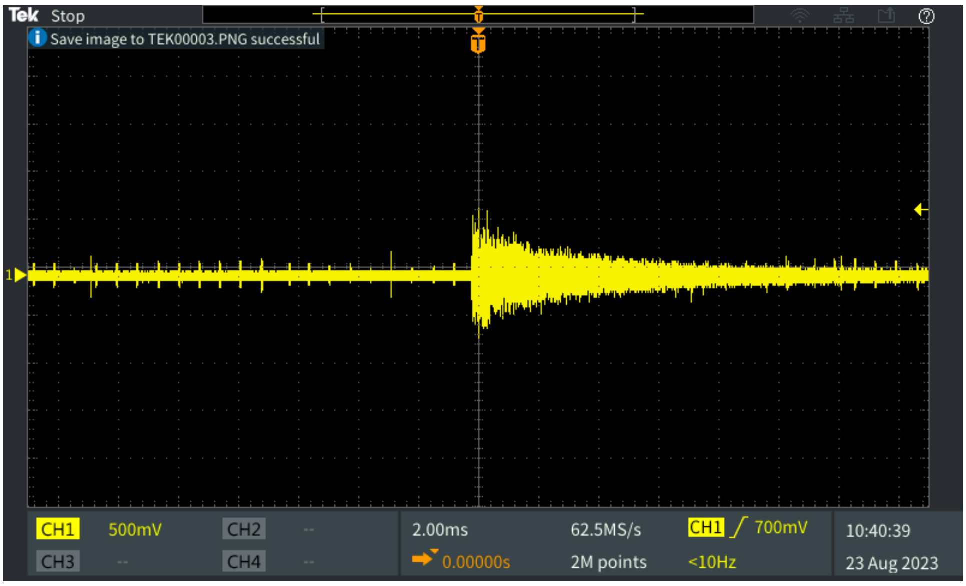

Figure 3 – Oscilloscope screen shot for room temperature pencil test, Peak-Peak Voltage magnitude 1.3 V

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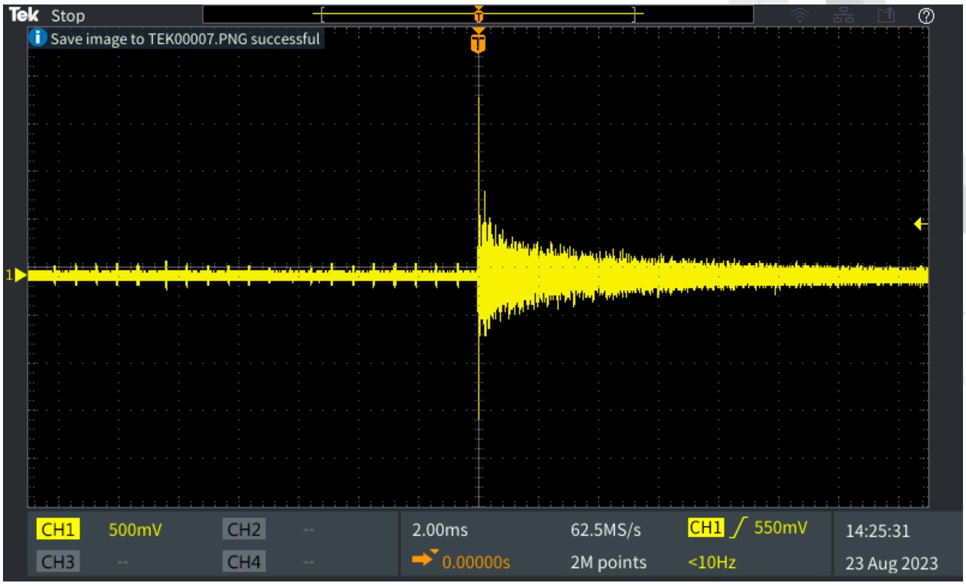

Figure 4 - Oscilloscope screen shot for high temperature pencil test at 350 °C, Peak-Peak Voltage magnitude 1.5 V

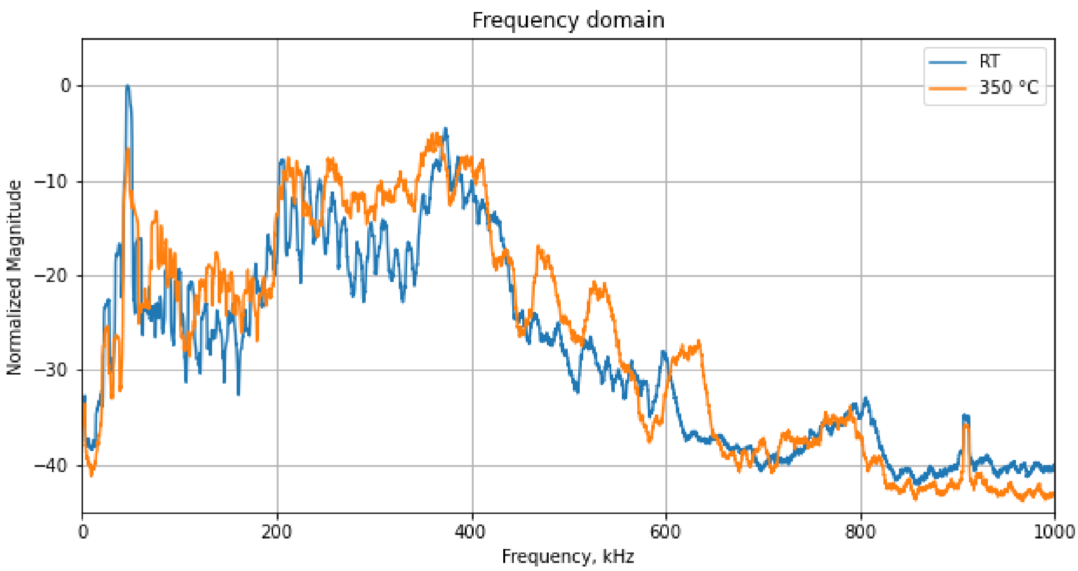

Figure 4 – FFT of room temperature and high temperature captured pencil test signal, moving average used to filter out unwanted noise, the two signals are normalized in magnitude for comparison purpose.

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4. Conclusions

- A pencil break test was conducted, with the acoustic emission waves traversing a 200 mm length titanium rod and subsequently being collected by the AE transducer at both room temperature and 350 °C.
- The AE transducer exhibited consistent broadband performance in both signal magnitude and frequency content, demonstrating its reliability across temperature variations, without integrated amplification or waveguides, across appreciable cable lengths.
- HotSense has been shown to be capable of Acoustic Emission testing for high-temperature applications, affirming its effectiveness in maintaining comparable performance under elevated temperatures.

HotSense Technical Note	
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