VIBRATION SENSOR WITH TWO-WIRE INTERFACE AND BIAS USED FOR MEASURE TEMPERATURE

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Abstract: A sensor with integrated mechanical transducing and temperature monitoring capability is described. The sensor includes housing containing a transducer, a temperature sensor with associated bias, a summing circuit, and a two-wire cable connector. The transducer is operable to output a dynamic transducer waveform that corresponds to dynamic mechanical perturbations sensed by the transducer. The temperature sensor is operable to output a quasi-static temperature waveform that corresponds to temperatures sensed by the temperature sensor. The summing circuit is operable to combine the transducer waveform and the temperature waveform into a composite modulated voltage bias output signal or modulated current bias output signal. The two-wire cable standard connector is accessible on an outside of the housing and is connectable to a two wire cable that delivers power to the sensor from a power source and delivers the composite output signal from the sensor to a remote data acquisition circuit.

Key words: Vibration, temperature, sensors, two wire interface

Introduction: The present paper describes sensors with vibration transducing capability, in particular the piezoelectric or MEM transducer with an integrated preamplifier and a two-wire interface connected via a cable to a constant current IEPE/ICP® (ICP is an abbreviation of "integrated circuit piezoelectric", and is a registered trademark (no. 1,603,466 in the USA) of PCB Group, Inc. There is a similar non-proprietary standard called IEPE, which stands for "integrated electronics piezoelectric.) [1] or constant voltage CLD (Current Line Drive) [2] power source for power input, and to a data acquisition circuit for signal output.

Such piezoelectric (or MEMs) based transducers used for detection of vibrations and other dynamic physical parameters are often installed at locations that are remote from monitoring equipment that evaluates the sensor output. To overcome the noise and interference inherent in such environments, line drive piezoelectric sensors have been developed that combine a piezoelectric transducer and a built-in preamplifier that transforms the high impedance charge mode output of the transducer into a low impedance voltage or current output signal. A two-wire interface and associated two-wire cable (such as a coaxial cable or two wire cable) connects the sensor to a remote constant current or constant voltage power source for power input, and to a remote data acquisition circuit for signal output. The two-wire cable may be as long as several hundred meters. In some piezoelectric sensor designs, the sensor is powered by a constant current power source and the sensor's output is a modulated bias

voltage signal. In other piezoelectric sensor designs, the sensor is powered by a constant voltage power source and the sensor's output is a modulated bias current signal.
Line drive piezoelectric sensors as described above are designed to measure only a single parameter, such as vibration. If an additional parameter needs to be measured, such as temperature in situations where both parameters are need to be monitored at the same measurement location, a separate output and lengthy cable connection to a remote unit are required. This redundancy adds design complexity and expense.
Bellow the integrated sensor is proposed that combines mechanical transducing with temperature monitoring [3].

Description: The presented sensor includes housing containing a transducer, a temperature sensor, a summing circuit, and a two-wire cable connector. The transducer is operable to output a dynamic transducer waveform that corresponds to dynamic mechanical perturbations sensed by the transducer. The temperature sensor is operable to output a quasi-static temperature waveform that corresponds to temperatures sensed by the temperature sensor. The summing circuit is operable to combine the transducer waveform and the temperature waveform to generate a composite bias-modulating output signal. The two-wire cable connector is accessible on an outside of the housing and is connectable to a two wire cable that delivers power to the sensor from a remote power source and delivers the composite output signal from the sensor to a remote data acquisition circuit.
The Figure 1 shows a schematic diagram of the sensor with combination of a constant current power source and a data acquisition circuit.
The Figure 2 shows a schematic diagram of the sensor with combination of a constant voltage power source and a data acquisition circuit.

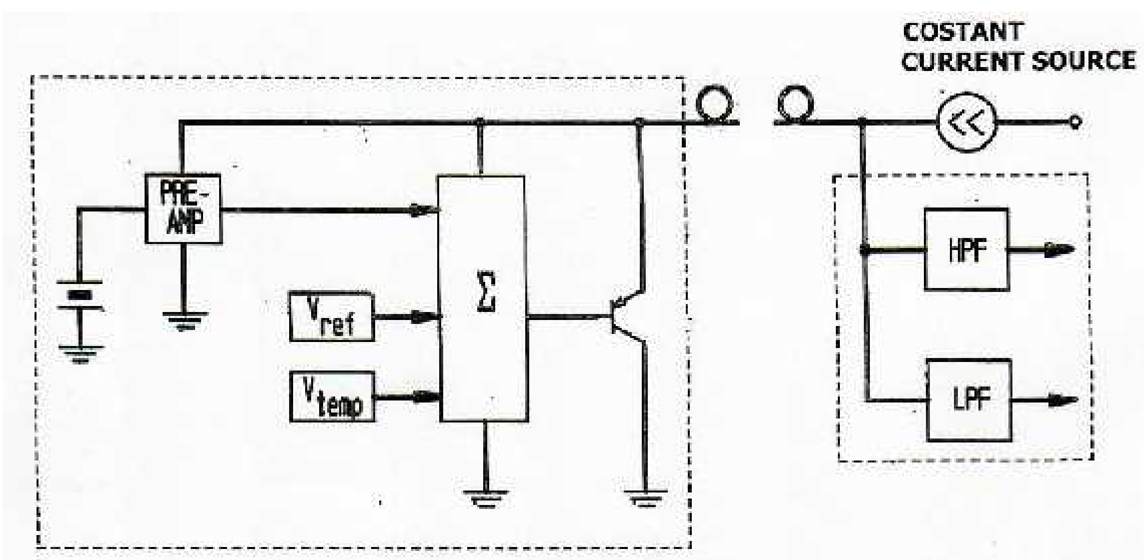

Figure 1 IEPE vibration sensor included charge amplifier, reference voltage source, temperature sensor, summarize circuit and voltage repeater, where DC part of bias voltage consist of constant voltage and voltage proportional to temperature, and AC part of voltage proportional to vibration signal.

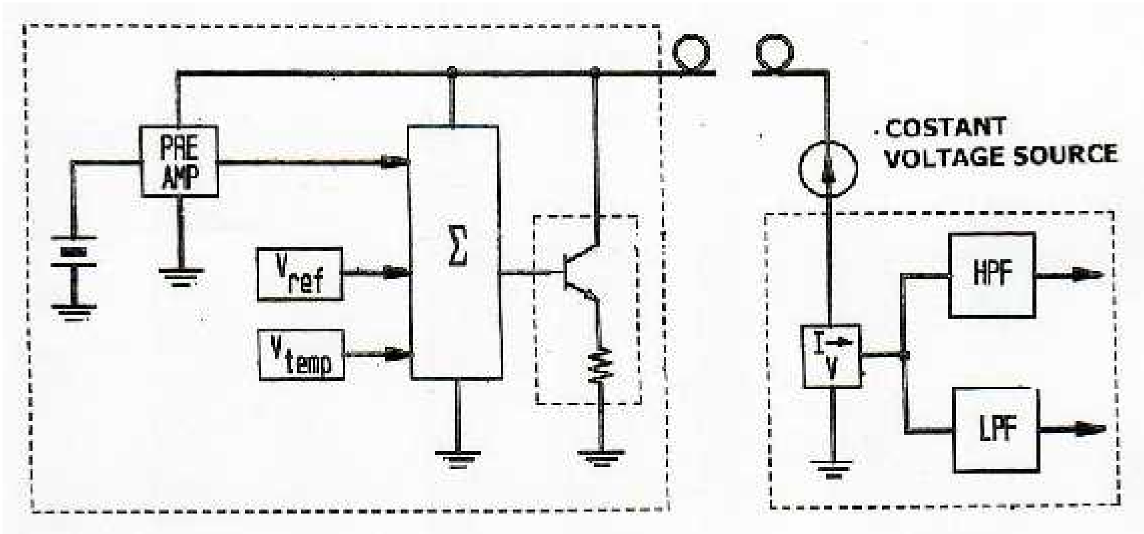

Figure 2 CLD vibration sensor included charge amplifier, reference voltage source, temperature sensor, summarize circuit and voltage to current transmitter, where DC part of bias current consist of constant current and current proportional to temperature, and AC part of current proportional to vibration signal.

The summing amplifier outputs a time-varying voltage output embodying a composite waveform that represents a summation of the transducer waveform and the temperature waveform, with direct current bias provided by the reference voltage from the voltage reference source. Unlike the dynamic transducer waveform, which tends to vary relatively rapidly, the temperature waveform output by the temperature sensor will normally be quasi-static in nature. The temperature waveform will be time-varying, but of relatively low frequency compared to the frequency of the transducer waveform.

Testing results: On the Figure 3 and Figure 4 the testing results of the described sensor are provided. The sensor typical specification is placed in the Table 1.

Table 1. Sensor technical specification

Name	Value
Nominal sensitivity, mV/g	100
Frequency range with +/-3 dB , Hz	2...10000
Dynamic rang, g pk	0...50
Sensitivity tolerance, %	<+/-5
Cross exes sensitivity, %	<3
Non-linearity, %	<1
Nominal bias voltage at 20 Degree C, V	12
Bias voltage tolerance at 20 Degree C, V	<+/-0,1
Nominal bias voltage temperature coefficient, mV/Degree C	25
Temperature measuring range, Degree C	-40...+120
Temperature measurement accuracy, Degree C	<+/-4
Working temperature range, Degree C	-55...+125

Interface	2-wire IEPE
Nominal power voltage, V	24 +/-10%
Constant current range, мA	2...8

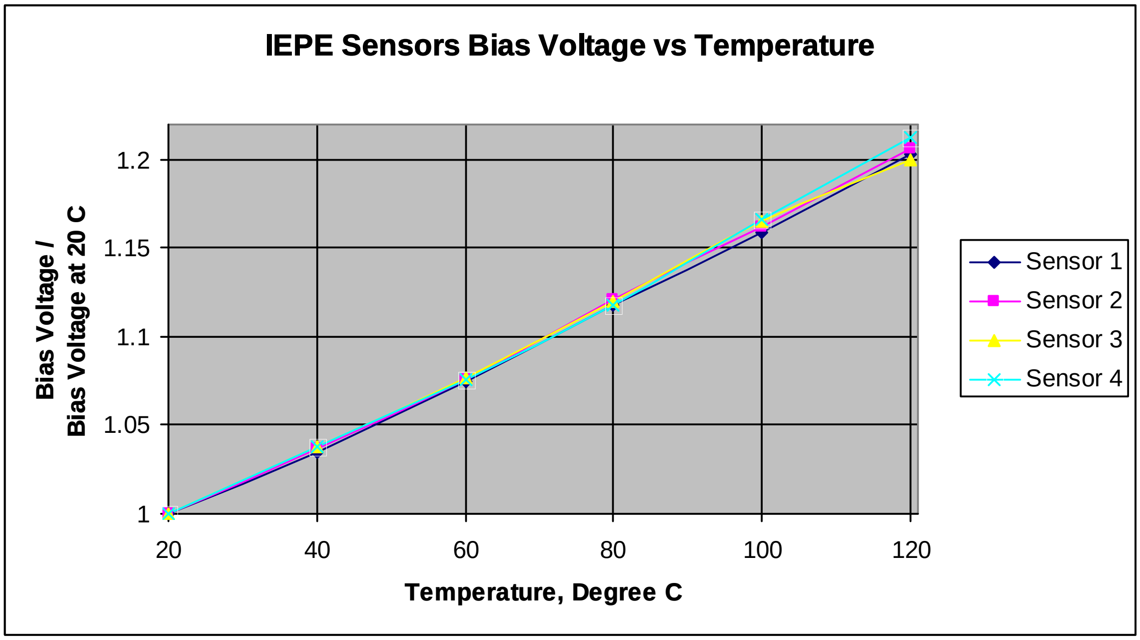

Figure 3. Designed IEPE sensor Relative Bias voltage vs Temperature

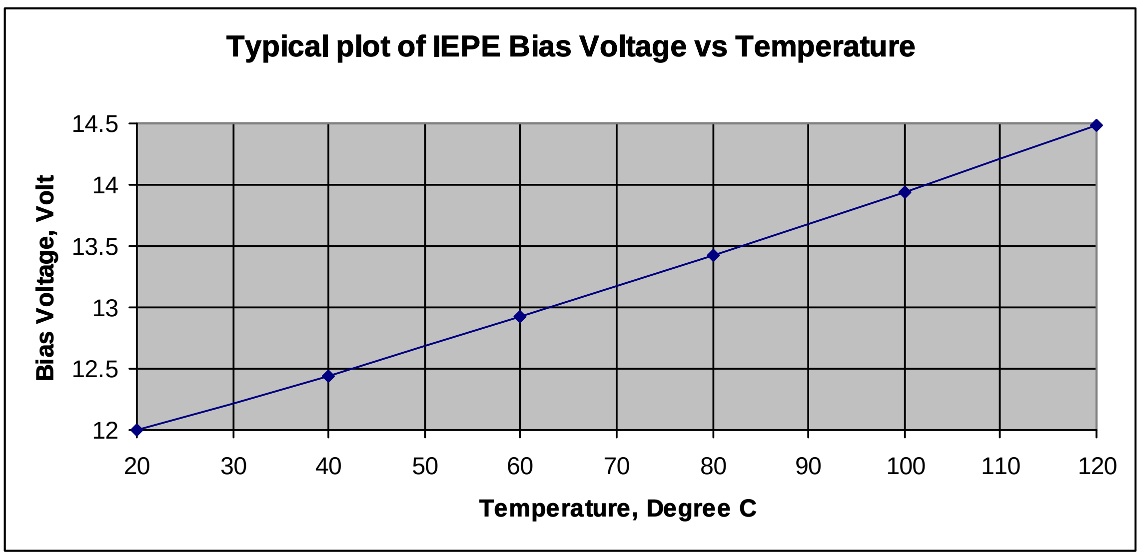

Figure 4. Typical IEPE designed sensor Absolute Bias Voltage vs Temperature

Conclusion:

This paper introduced a vibration sensor with two wire output and possibility to measure acceleration and temperature without requiring any additional third wire. It is done by making bias of the sensor accurately linear increasing follow to the temperature. The sensor could be used by usual way with two wire caballing and to measure the temperature additionally to acceleration no any changes required in the installation procedures. We presented the sensor testing results and typical specification. These sensors practically would be not expensive than common accelerometers and it is might be important then user have a possibility to decide of measuring temperature at any time after installation and just for particular channels without any additional equipment or action.

References:

[1]IEPE Standard http://www.mmf.de/iepe_standard.htm
[2]V. Petrovich, G. Zusman "Apparatus for vibration measurement", Pat. USSR 1545090, Jan 20, 1987, published Feb. 23, 1990.
[3]G. Zusman "Two wire electronics interface sensor with integrated mechanical transdusing and temperature monitoring", USA Pat. Application 14/821,727. Published Feb. 9, 2017