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DMP41- a high-precision amplifier based on an inductive-voltage-divider, suitable to safeguard traceability for most mechanical quantities

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Summary:

This paper describes the newest version of the strain gauge precision instrument DMP41 with highest resolution and highest stability for the use in calibration tasks with e.g. force, torque, pressure transducers or load cells. This inductive-voltage-divider-based digital amplifier DMP41 is the world´s most precise amplifier for strain-gauge-based sensors. It has been optimized and got some new version 2020.

Keywords: DMP41, strain gauges, force, torque, pressure, sensors, mechanical calibration systems

Introduction

Since May 2, 2019, definitions based on the universal natural constants apply to all units of measurement in the SI system. With a dispute spanning two centuries, the new definitions for Amperes, Kelvin, and Mole have been set into force at the World Metrology Day 2019 [1]. While Meter and Candela have been already defined using natural constants before, the kilogram artifact, by the new system, is now also replaced. This has far-reaching consequences for the system of metrological traceability of measurements.

Primary quantities of the SI and thus fundamentally affects calibration. A current approach to this in the USA is the strategic “NIST-on-a-Chip”, for which no equivalent concept yet exists in Europe. Still, Germany is famous for its century long history in the field of mechanical engineering. With the brave new world of the many new facets of the internet of things (IoT) we presently see extensive changes in the market and even an ambivalence of new and old in metrology.

We may talk of a “sensorization” in the market, expressed in a much higher quantity of sensors affordable to be employed. The IoT, integrated sensor systems of high complexity, having a lot of wind in its sails. Thus, questions dealing with the nature of metrology, as the representation and the traceability of the measured variables and the measurement uncertainty seem to be not so important anymore [2].

However metrological traceability is defined as property of a measurement result whereby the result can be related to a reference though a documented, unbroken chain of calibration, each contributing to the measurement uncertainty. If you use strain gauges, you have to build up a high-precision measurement chain, consisting of a sensor and a precision amplifer. The following is description of the newest version of the strain gauge precision instrument DMP41 with highest resolution and highest stability [3].

Basic principle of DMP41

The inductive-voltage-divider-based digital amplifier DMP41 is the world´s most precise amplifier for strain-gauge-based sensors and can measure most mechanical quantities, such as force, torque, pressure and any other strain-based pick-up principles.

Figure 1: DMP 41 high-precision instrument

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This newest member of the DMP series, which has been optimized for decades as a reference device in mechanical laboratories of National Metrology Institutes (NMIs) around the world.

In the full paper the new features of the 2020/2021 edition will be shown and explained. Figure 2 is showing its block diagram.

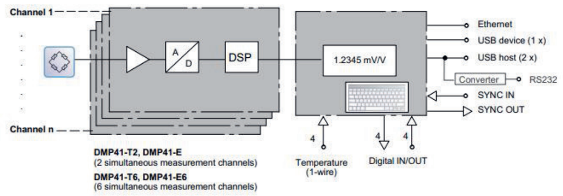

Figure 2: Block diagram of DMP41: a preamplifier is converted into Digital by the ADC; all further data processing happens on the digital side.

Long term stability of the DMP series

Although this paper is mainly about the differences between the DMP41 and the DMP40, all devices of the DMP series have basic design principles in common. The DMP39, DMP40, and DMP41 are all based on an inductive voltage divider, which lays the foundation for the DMP series' outstanding long-term stability.

Such dividers are very accurate because their accuracy is only defined by the ratio of the number of windings, meaning they allow the implementation of amplifiers with much smaller measurement uncertainties than by resistive implementations [4].

This "digitally" defined ratio of windings allows for the instrument's very small deviations. Inductive voltage dividers operate most accurately in the frequency range of 225 Hz, also reducing disturbances. Thus, implementation of the DMP family offers a radically different design to the resistive and generally less accurate designs.

To prove its long-term stability, since the introduction of the first device of the DMP series, the DMP39 in 1980, the long-term stability of a measuring chain consisting of a BN100 calibration unit with Serial Number 010 and the first-ever DMP39 with Serial Number 001 has been monitored over 40 years now. Figure 3 shows the results. The measuring chain did never exceed an error band of +/-2.5 ppm.

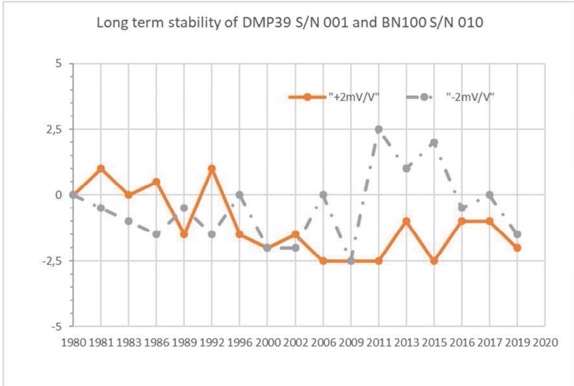

Figure 5: Monitoring of the long-term stability by internal calibration method in a measuring chain, comprising a BN100 calibration unit with S/N 010 and the first-ever DMP39 with S/N 001

Conclusion

It will be shown, that if one uses a high-precision amplifier as DMP41, it will have a significantly lower measurement uncertainty that any strain gauge based sensor, whether it is force, torque, pressure or load cells [5].

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