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Calibration of Digital Dynamic Pressure Sensors

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Summary:
In dynamic pressure measurement phenomena, dynamic pressure calibration of the measurement chain including a pressure sensor, signal conditioning amplifier and data acquisition part is required. Some applications show time-invariant static characteristics, so certain types of transducers can be used to measure such static time-invariant value of pressure. The aim of this study is to modify and realise dynamic calibration methods for digital sensors inside calibration facilities and calibrating a dynamic digital sensor by using the newly developed dynamic calibration system

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Keywords: Dynamic, pressure, calibration, digital, sensor, DTI

Introduction

Traceability for digital sensors in dynamic measurements and practical MEMS calibration services is currently completely lacking NMI-level or accredited calibration services. This is a consequence of the lack of adequate technical set-ups and procedures as well as normative standards [1]. If pressure value is changing by time or in other saying if it is time-dependent, it is defined as dynamic because it varies significantly in a short period of time demanding a dynamic calibration.

Dynamic Calibration System

National Metrology Institute of Turkey (TUBITAK UME) has developed a measurement standard based on dropping mass principle for dynamic calibration machine of pressure transducers. It uses conservation of energy which is the well-known basic physical law. (see Fig. 1). Drop mass system transfers the produced kinetic energy by free dropped mass to the sensor under test. The system can create a half-sinus signal with a width of around 5 ms for calibration of dynamic pressure transducers up to 500 MPa in hydraulic media with relative uncertainty 2% [2].

TUBITAK UME has a drop mass system with a measurement range from 50 MPa to 500 MPa. The distance between dropping mass and the piston is adjustable from 5 mm to 300 mm. There are piezoelectric based reference pressure sensors up to 500 MPa. The dynamic calibration system is able to produce a triggering signal from built-in PLC (programmable logic controller)for some purposes. In the measurement, it is planned to use the triggering signal to the trig DTI module.

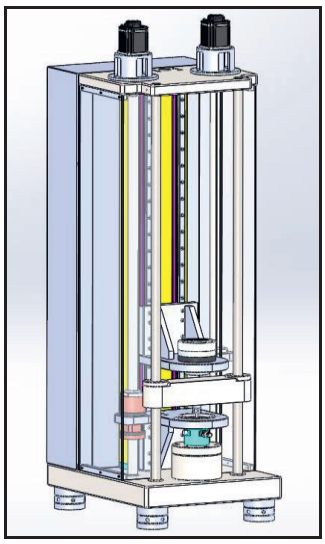

Fig. 1. Design of Dropping mass dynamic calibration system

In order to obtain testing pulse pressure, it uses a dropping mass on to a piston, increasing the pressure in the hydraulic medium by up to some hundreds of MPa in order to perform a quick and accurate check and calibration of high-pressure dynamic sensors. (see Fig. 1,2). The pulse amplitude level is adjusted by changing the dropping height of the dropping mass [3].

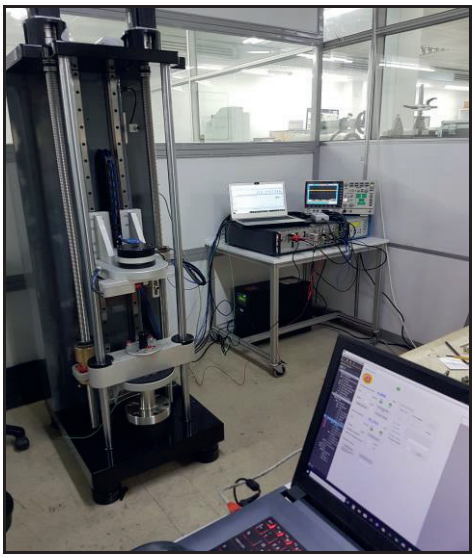

Fig. 2. Dropping mass dynamic calibration system

Calibration of Digital Pressure Sensors

The challenge in dynamic calibration is that traditionally, dealing with analogue signals, the timekeeping was managed by the calibration system. Such centralized time management was the enabling technology for synchronous sampling and hence, calibration of phase-response. The autonomous timing of digital sensors is currently impeding the phase response characterization and requires new concepts for the full characterization of the dynamic response of sensors with digitally pre-processed output are needed.

In the dynamic calibration system, there is a vessel equipped with a piston-cylinder unit, reference and test sensor. Glycerol is used as a pressure transmission media. The vessel has two ports usually used for the device under test DUT (port1) and reference pressure sensor (port 2). Pressure vessel and measurement set-up for calibration of the digital pressure sensor (see Fig. 3).

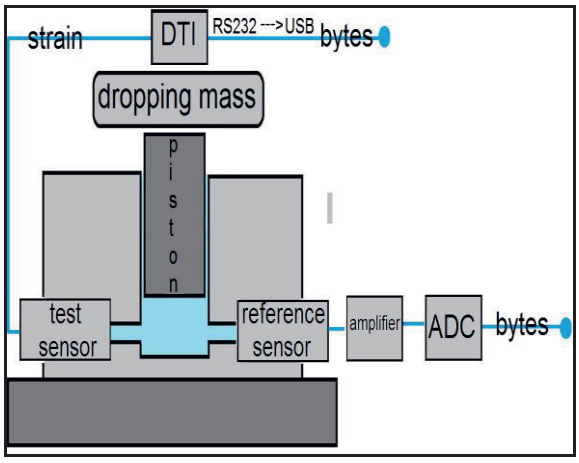

Fig. 3. Pressure vessel and measurement set-up for calibration of a digital pressure sensor

As DUT HBM P3TCP 10kbar transducer sensor together with the digital transducer interface (DTI) module.
Measurement intensities will be up to 500 MPa. One additional precondition for the DTI module is a trigger pulse/step provided by PLC on the dynamic pressure calibration system in order to start the acquisition. Since the transducer has a mounting thread of 20x1.5 mm we needed to modify our measurement system that is given in Fig. 2.
The DTI module is a very small circuit board which provides the equivalent to a bridge amplifier joint with an ADC. It needs an external trigger and once it receives that it starts sampling immediately with 20kS/s for 190 ms. After that, we read out the buffer and gather the samples. The trigger is a rising edge of ca. 3V which can be generated/adapted by an oscilloscope with an external trigger output. A measurement protocol is going to be used for the measurement. (see Tab. 1).

Tab. 1: Measurement protocol

Nominal pressure (MPa)	Reference pressure (MPa)	DUT pressure (MPa)
50	The output of the reference pressure sensor will be given for corresponding pressures	The output of the reference pressure sensor will be given for corresponding pressures
100		
200		
300		
400		

References

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