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Performance comparison of single element piezoresistor with a half-active Wheatstone bridge for miniaturized pressure sensors

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Abstract: In recent years, miniaturized piezoresistive pressure sensors have been extensively explored, especially for biomedical applications. Typically, the electromechanical transduction of a measurand into an equivalent electrical signal is accomplished by a fully active Wheatstone bridge (WSB). Even though, a fully active WSB has advantages in terms of improved sensitivity and noise cancellation, still it suffers from a major limitation in terms of area, especially for applications like cardiac catheters that demand ultra-miniaturized pressure sensors. Hence for miniaturized sensor design, half active WSB or single element piezoresistor is deployed by various researchers. In this paper, performance of a single element piezoresistor (3TP-1) is compared with a half-active WSB configuration and other single element piezoresistors such as four terminal piezoresistor (4TP), multi-terminal piezoresistor (MTP**)** and another three terminal piezoresistor (3TP-2) for area constrained applications. Investigation of the 3TP-1 is carried out by using a finite element method (FEM) based numerical simulation tool IntelliSuite® (version 8.7). Simulation results show that compared to a half-active WSB, the 3TP-1 has 35% better performance in terms of output voltage. Furthermore, it is found that compared to other single element piezoresistors, the 3TP-1 is more suited for realizing ultra-miniaturized pressure sensors both in terms of area and performance.

Keywords: Piezoresistive pressure sensor, single element piezoresistor, multi-terminal piezoresistor, Wheatstone bridge, catheter.

1. Introduction

Over the years, Microelectromechanical systems (MEMS) based pressure sensors have found versatile applications ranging from aerospace [1] to biomedical fields [2]. Compared to other devices like accelerometers [3], biosensors [4], gyroscopes [5], temperature sensors [6], etc., pressure sensors occupy a major share of MEMS market [7]. In recent times, much focus has been on developing ultra-miniaturized pressure sensors for biomedical applications, especially for cardiac pressure sensing [8]. In such high performance sensors, the electromechanical transduction of measurand into an equivalent electrical signal can be accomplished by optical [9], piezoelectric [10], capacitive [11], and piezoresistive [12] readout technique. Among the various readout techniques, piezoresistive sensing technique has