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Integrated Readout Circuit Using Active Bridge For Resistive-based Sensing

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Abstract

An integrated Readout Interfacing Circuit (ROIC) for resistive-based sensors using SILTERRA CMOS 0.13 μm technology that reads resistance shift and converts it to voltage was designed. In conventional practice, resistive-based sensors are interfaced with Wheatstone bridge to transform the sensor signal to voltage. Due to low sensitivity of Wheatstone bridge, the output voltage of shifted resistance is not significant. The objective of this project is to propose an integrated interfacing circuit using Wheatstone bridge with improved sensitivity. The project scope focuses on integrated circuit design of readout circuitry for resistive-based sensors. An active bridge, a modification of standard Wheatstone bridge using active components was used as ROIC. The sensitivity of the circuit is defined as percentage change in output voltage of the circuit to the changes in resistance of the sensor. Results show that, the active bridge circuit is almost four times more sensitive compare to conventional bridge circuit. The sensitivity improvement would allow any resistive-based sensors to be integrated with ROIC to produce more significant output voltage of shifted resistance.

Keywords: Integrated Circuit, Readout Interfacing Circuit; Resistive-based Sensor; Sensitivity

1. Introduction

Nowadays, robotics tactile sensor systems become more important, due to the demand for collision safety and reactive control in unstructured environments. Based on readings, there are three major classes that can measure principle of the tactile sensor cells which are optical, capacitive and resistive effects¹. Resistive are some of the common sensor because of relatively inexpensive to manufacture and easy to

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interface with signal conditioning circuit². A resistive-based sensor is a category of sensors that acquire information through physical or environmental change. The measured characteristics can be properties such as temperature, vibration, shape, and normal forces. Tactile sensor may also measure one or more of these properties.

Read-out Interfacing Circuit (ROIC) refers to the integrated circuit that is specifically used reading detectors of a sensitivity that is very low. Discrete circuit may not be useful as noise may be large enough to cover up whole signal. Voltage dividers and Wheatstone Bridge followed by differential or instrumentation amplifier are common conditioning circuit for resistive sensor in which an output signal is obtained^{3,4}. Therefore, a voltage-mode Wheatstone bridge (VMWB) is employed for firstly interfacing resistive sensors in analog system. It is used to compare the signal to some set point value. The conventional Wheatstone bridge as the main topologies for resistive sensors offers an attractive for measuring small resistance and widely used in^{2,5}. A. De Marcellis et al⁶, present a new approach based on current signals, suitable for the detection of very low variations of resistive sensors in a Wheatstone bridge configuration.

One of the paper shows discussion on the force-balance Wheatstone bridge when interface with resistive-based sensor⁷. The project scope of this paper is comparing the sensitivity of balance Wheatstone bridge with voltage divider that to be used as conditioning circuit for resistive sensor. Due to low power supply rejection ratio (PSRR) of voltage divider, the Wheatstone bridge is used to interface with that sensor.

This project will focus on designing an integrated readout interfacing circuit (ROIC) for resistive-based sensing. The circuit design acts as conditioning circuit for easy interface with microcontroller. The topology of the op-amp was studied in order to have an operational amplifier with high gain⁸. The circuit design acts as conditioning circuit for easy interface with microcontroller. It is used to extract the resistive changes of sensor and convert it to the voltage value. Besides that, two types of Wheatstone bridge are comparing in term of sensitivity of the circuit. The bridge circuits that give highest sensitivity will be used as sub-circuit of the ROIC.

2. Methodology and Design Architecture

The conventional Wheatstone bridge is widely used as its technique offers an attractive alternative for measuring small resistance. Fig. 1 (a) shows the used bridge configuration suitable for sensor applications, which relate the bridge resistance values to the bridge output voltage. The design is used to convert the variation resistance value of the sensors into a voltage value. In this configuration, IN is the excitation voltage, R1, R2 and R4 is the value of the fixed bridge resistor and the variable resistor, R3, where the element varying bridge produces the change in voltage output.

Major problem encountered in the bridge circuit is low sensitivity due to the large excitation voltage for sufficient full-scale output voltage. This leads in power dissipation and the possibility of error due to sensor self-heating. Therefore, ROIC based on the Wheatstone bridge with modification using operational amplifier to increase the sensitivity of the conventional bridge circuit has been proposed. Fig. 1 (b) shows the architecture of an active bridge. A buffer is employed in the arm AB to provide isolation from the adjacent arm AD and also to make the circuit more sensitive.

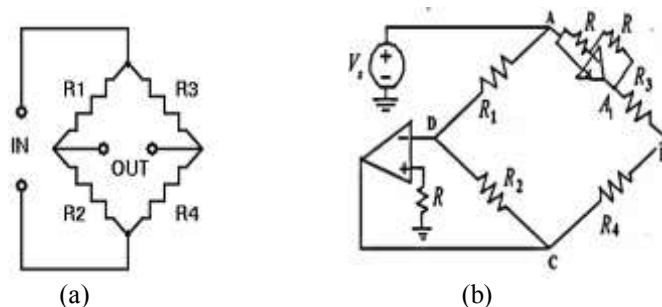


Fig. 1 (a). The conventional Wheatstone bridge; (b). Active bridge

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