

# UNCERTAINTY ANALYSIS OF STRAIN GAGE CIRCUITS: INTERVAL METHOD AND INTERVAL ALGORITHM

B. Vasuki, M. Umapathy, A. R. Senthilkumarr

Department of Instrumentation and Control Engineering  
National Institute of Technology, Tiruchirappalli-620 015, India  
E-mail: [bvas@nitt.edu](mailto:bvas@nitt.edu), [umapathy@nitt.edu](mailto:umapathy@nitt.edu)

*Abstract- This paper presents uncertainty analysis of a strain gage based instrumentation systems. This has been carried out by interval method and classical methods and is verified by the mean value algorithm based on interval arithmetic. The quarter, half and full bridge configuration of strain gage based circuits are considered to illustrate the analysis.*

**Index terms:** Interval analysis, Uncertainty analysis, Strain gages, Interval Optimization

I.

## II. INTRODUCTION

Historically, the development of strain gages has followed many different approaches, and gages have been developed based on mechanical, optical, electrical, acoustical and even pneumatic principles. Electrical resistance strain-gauge nearly satisfies all of the optimum requirements for a strain gage; therefore it is widely employed in stress analysis and as the sensing element in many other applications. The minute dimensional change of mechanical elements in response to a mechanical load, pressure, force, and stress causes a change in the resistance of the strain gage. Wheatstone bridge is commonly employed to convert the resistance change to an output voltage. Although the strain gage is inexpensive and relatively easy to use, care must be exercised to ensure it is properly bonded to specimen, aligned in the direction of measurement, less sensitivity to temperature, and more importantly the lead wire resistance, the excitation source and the accuracy of other components used in the signal conditioning circuit. The widely used strain gage bridge circuit topologies are Quarter bridge, Half bridge and Full bridge configurations [1]. All the strain measuring circuits have some amount of uncertainty associated with them. Understanding the uncertainty within our predictions and decisions is at the heart of understanding the problem. Uncertainty analysis using classical methods for electrical and electronic circuits can be seen in [2, 3, 4]. Uncertainty analysis using interval arithmetic is more reliable and it does not use statistical methods and it can handle simultaneously the uncertainty in more than one parameter. In interval method, the uncertain parameters are assumed to be unknown but bounded and each of them has an upper and lower limit without a probabilistic structure. As uncertainty

information required for the interval method is lesser, it happens to be an attractive prospect for engineering applications. It is an alternative and valid technique to compute how the system accuracy varies with the variation in parameters and the interval methods are able to prove (or disprove) with mathematical rigor, the existence of desired solutions. Interval methods have been used for the uncertainty analysis of passive and active electric circuits, power cables, civil and mechanical structures [5, 6, 7, 8, 9]. However the application of this technique to instrumentation systems has not been attempted. In this paper, the uncertainty analysis of strain gage circuits using interval and classical methods is carried out.

### III EXPERIMENTAL SET UP

The experimental setup to measure the strain in a cantilever beam made of aluminum is shown in Figure 1. The strain at the fixed end of the beam is measured using three different strain measuring circuits namely, quarter bridge, half bridge and full bridge and are shown in Figure 2. The measuring circuits are excited with amplitude of 5 volts using CA 100 Yokogowa universal calibrator. The resistance of strain gage is 350 ohms, the resistance of fixed resistors used in the measuring circuit is 350 ohms and the resistance of lead wire connecting the strain gage and the measurement circuit is 1.21 ohms. The tolerance of the excitation source is  $\pm 0.0025$  volts, that of fixed resistors are  $\pm 10\%$  and that of lead wire resistance is  $\pm 1\%$ .

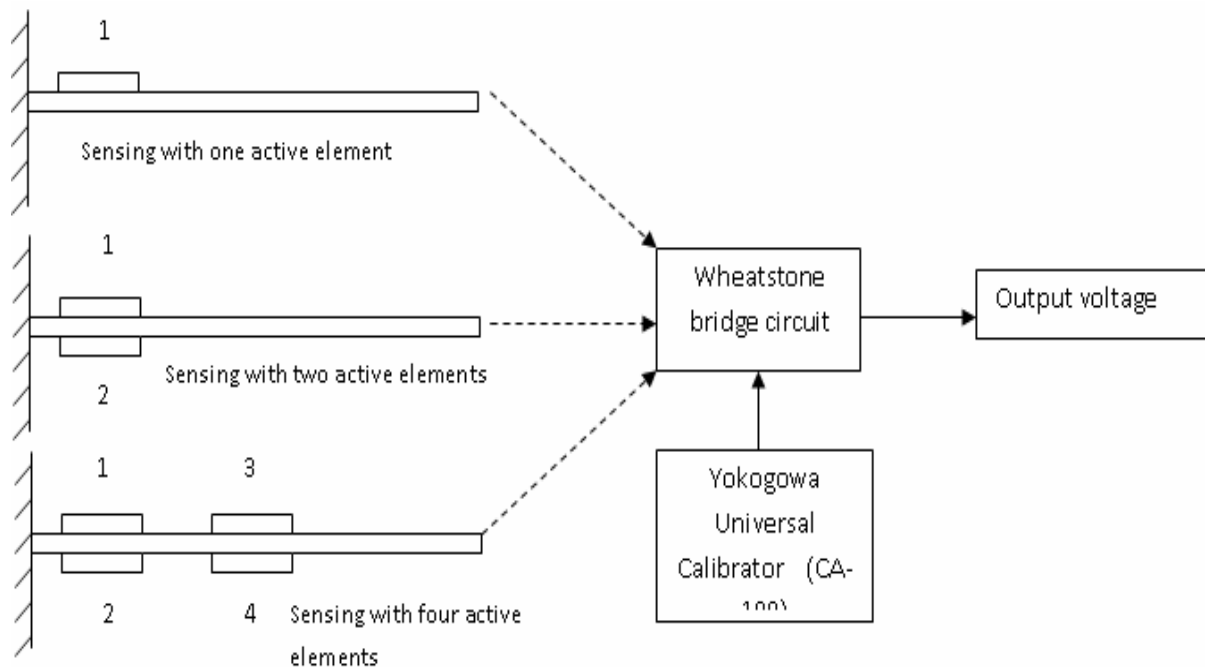
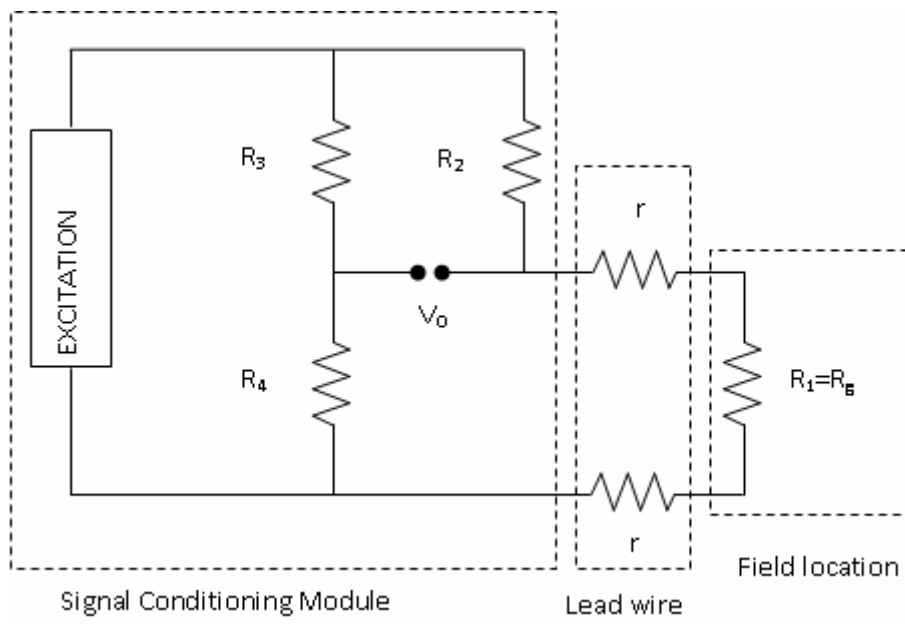
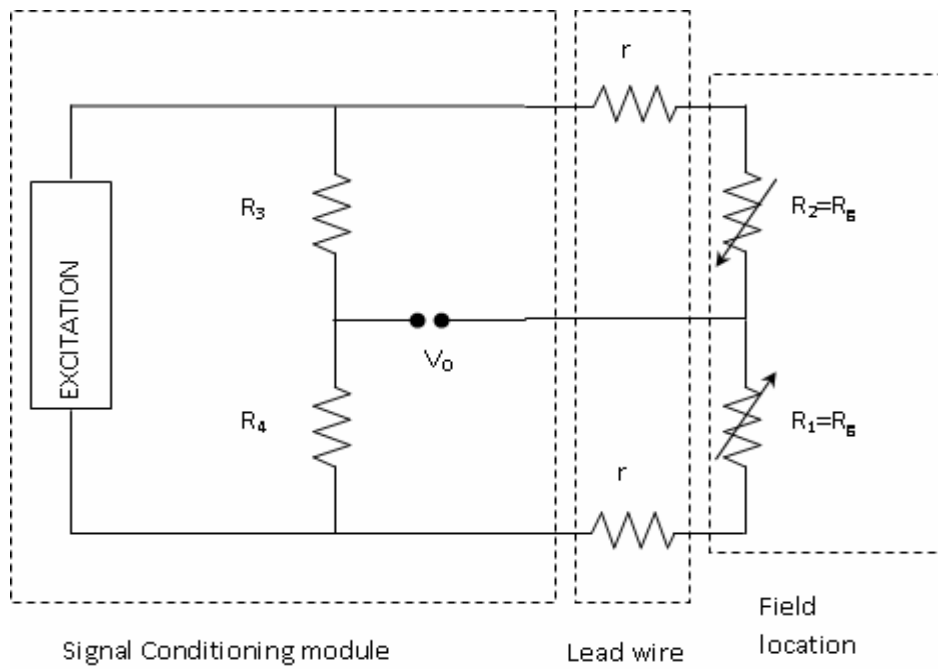


Figure 1 Schematic of experimental setup for strain measurement



(a)



(b)





















