# Chapter 4
# Introduction and Application of Strain Gauges

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## ABSTRACT

*Strain gauge method is one of the essential and fundamental methods in experimental stress techniques that uses the resistance of the material to determine the stress at a point. The strain gauges can be used in a different combination called Rosette to obtain stress in various directions. This chapter intends to cover types of strain gauges, materials, and Rosette arrangements to provide the reader with an overview of the techniques. The chapter will discuss the basic physics behind the resistance measurement and take the reader into insights on how the developments were made to the application of strain gauges as experimental techniques.*

## INTRODUCTION

Static and dynamic loadings act on any components during the operations. In addition, other minor factors (e.g., loading of wind and vibrations) also impact on components (Karthik & Dhas, 2015a, 2015b 2016, 2018). The stresses from these various factors provide challenges to the mathematical techniques for stress evaluation (Balaji, Leblouba, Rahman, & Ho, 2016; Balaji, Moussa, Rahman, & Ho, 2016; Balaji, Moussa, Rahman, & Vuia, 2015; Balaji & Yadava, 2013; Leblouba, Altoubat, Ekhlasur Rahman, & Palani Selvaraj, 2015). Hence, experimental stress evaluation technique is required in such practical cases. The strain gauge is a reliable technique that is employed for stress evaluations. The concept of strain gauge in experimental stress analysis can be understood by understanding the resistance of the conductors, since strain measurement principles using strain gauges rely on the concept of resistance.

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This chapter covers the basics of strain measurement and its application. First, the authors discuss the resistance of a conductor. Subsequently, they illustrate strain sensitivity, gauge factors, Wheatstone bridge, and rosettes in order to detail the experimental procedure for strain measurements.

## RESISTANCE OF A CONDUCTOR

The ability of the material to resist the flow of electric current is measured as resistance (R). The unit of resistance is given in ohms (Ω), to credit the German scientist Georg Simon Ohm (1784-1854) who studied the relation between voltage, current, and resistance (Bhattacharya, 2011). The resistance of a conductor is given below:

$$R = \frac{\rho L}{A} \tag{1}$$

where $L$ is the length of the conductor, and $A$ is the cross-sectional area (Figure 1) and the specific resistance of the materials. The specific resistance is material-dependent and the values for general materials are available in the literature.

## STRAIN SENSITIVITY OF THE WIRE

The strain sensitivity of a material refers to the change in the resistance of the material for a change in the strain. The strain sensitivity of the wire can be evaluated by differentiating Equation 1 as follows:

$$\left(\frac{dR}{R}\right) = \left(\frac{d\rho}{\rho}\right) + \left(\frac{dL}{L}\right) - \left(\frac{dA}{A}\right) \tag{2}$$

In Equation 2, the last term $dA/A$ can be written in terms of $dL/L$ by considering Poisson's ratio. For a wire of diameter $D$, area $A$ is given as follows:

*Figure 1. Wire conductor*