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Simple Mounting Error Detection Technique for Pressure Conductive Rubber Based Slip Sensor

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Abstract

Pressure conductive rubber has become a subject of interest in the field of slip or pressure sensor development because of it's high sensitivity, flexibility and light weightiness. It is also been used where soft and flexible solder less connector is required. But this flexibility also creates some difficulties for making contacts with electrodes. Generally conducting glue or lamination or electrical wire stitch technique is used to attach electrodes with pressure conductive rubber. But it can't be said whether rubber is properly attached with electrodes or not. This may cause erroneous result while measuring resistance of pressure conductive rubber. In this paper a simple mounting error detection technique has been explored.

1. Introduction

Advancement in robotics has opened opportunities to face new challenges, to develop light weight flexible sensors for intelligent dexterous manipulators. Pressure conductive rubber is one of the most interesting smart materials in this field. With the development of electronic, information and other high technology, the conducting polymer is used tremendously. Generally the rubber acts as an insulator. But doping of conductive fillers or polymers in an insulating rubber matrix creates of new polymeric material which is electrically conductive [1]. It is light weight, it has excellent flexible mechanical properties and it is highly sensitive such as temperature, pressure sensitive device and over current protective switches. These special features make it special. It can be used as thermistors, chemical sensors, slip or pressure sensor. It can also be used for solder less connectivity [1]. But main drawback of this rubber is that nonlinear relationship with applied pressure. Again it has also resistance relaxation phenomenon

[2] for which it takes some time for elastic deformation after certain pressure is applied on it. As a result resistance of the rubber also changes with time with constant pressure. However, if this rubber is used as a slip sensor and an object starts to slip, a complicated voltage change occurs immediately before object slips [3] and by distinguishing the high frequency components of output signal we can detect when slip is occurring. But as this high frequency components of output signal is dependent on the voltage magnitude and this also depends on how well the rubber is in contact with electrodes, it is important to determine whether electrodes are properly attached with the rubber or not. Otherwise we may have erroneous resistance hence voltage output. Normally conducting glue, lamination of rubber with conne ctors or electrical wire stitch technique [4] is used for mounting the sensor with electrodes. Now there may be two types of mounting errors. Firstly, there may be loose ends of the rubber because of improper attachment with manipulator body. This may cause unexpected external vibration noise. Secondly, error may occur due to improper attachment of the rubber with electrodes. In this paper some techniques are discussed that are used to detect those said errors.

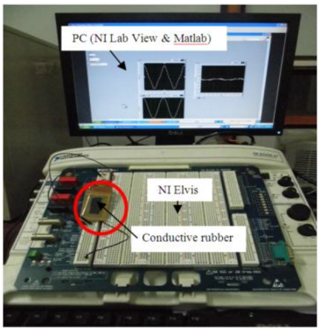

Fig. 1: Basic setup for detection of mounting error. Here sensor (red circled).

Data are fed to the computer through commercial data acquisition system (NI ELVISE) and data is analyzed using NI labview and mat lab

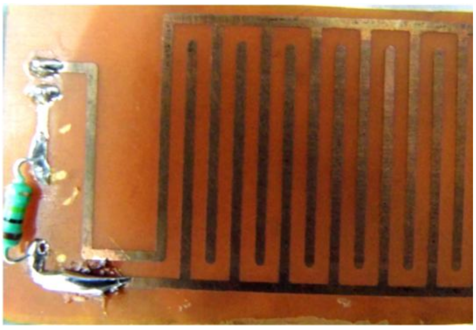

Fig. 2: comb like electrodes for pressure conductive rubber. Upper comb acts as positive electrode and lower part as negative when DC voltage is applied.

Basic setup for detection of mounting error. Here sensor (red circled) .Data are fed to the computer through commercial data acquisition system (NI ELVISE) and data is analyzed using NI labview and mat lab .

Principle and mounting techniques: This section describes basic working principle of pressure conductive rubber and different mounting techniques of this rubber with electrodes to make pressure or slip sensors

Pressure conductive rubber: The pressure conductive rubber is an insulating silicon rubber matrix with uniformly distributed carbon particles [1]. Initially most of the carbon particles are separated from each other. So the rubber provides a very high degree of electrical resistance. But with the increment of pressure, the carbon particles are going to contact with each other forming a conduction route. This phenomenon is used for tactile pressure sensor or slip sensor development [5]. However resistance pressure relationship is nonlinear and when slip occurs over the rubber, a complex voltage changes occur. Hence high frequency components come as the output signal [3]. We can identify slip occurrence phenomenon by distinguishing these high frequency components by DWT (Discrete Wave let Transform) or STFT (Short Time Fourier Transform).

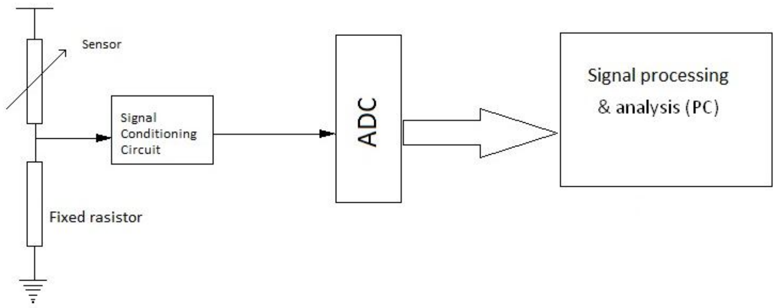

Fig. 3: Blok diagram of total error detection system. Conductive rubber is in series with fixed resistance. And data are taken across fixed resistance and then conditioned and digitized by ni elvis.

Different mounting techniques: There is no such standard technique for mounting conductive rubber. Conductive glue can be used but it is costly and the mechanical strength is not too good to use. Another popular mounting technique is laminating the rubber with electrodes by insulating polymer material. Another cost effective solution is electrical wires stitching method [4] can also be used as cost effective mounting techniques. In this technique conductive wires are stitched through the conductive rubber, where the mechanical strength of mounting is increased.

2. Types of Mounting Error And Detection

If rubber is not properly mounted then different types of error noise will be occurred. If rubber is not properly attached with body of the manipulator i.e. if there is any loose end exists or any other external vibration occurs then high frequency noise will occur at the output signal. Again, if rubber is not in contact with electrodes properly that may also distort the input signal especially when signal has both positive and negative magnitude. Fig. 1 shows the basic setup for error detection. Here pressure conductive rubber is connected with a resistance in series and output is taken across a fixed resistance. Output signal is fed to the computer through a commercial signal conditioning and data acquisition system (NI-Elvis) and software (NI LAB VIEW and Matlab). For this experiment, traditional comb like printed cupper electrodes are used as shown in figure2. Upper comb acts as positive electrode and lower part as negative when DC voltage is applied.

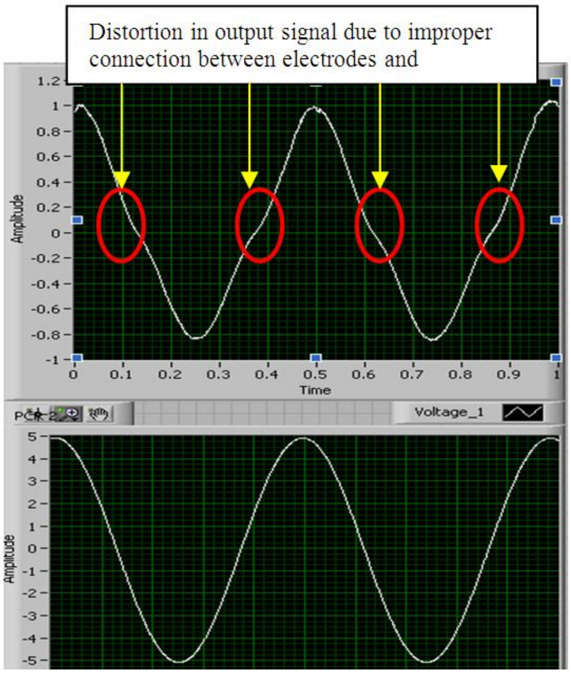

Fig. 4: Lower screen shows the actual input signal and upper screen shows deformation due to improper mounting of rubber with electrodes.

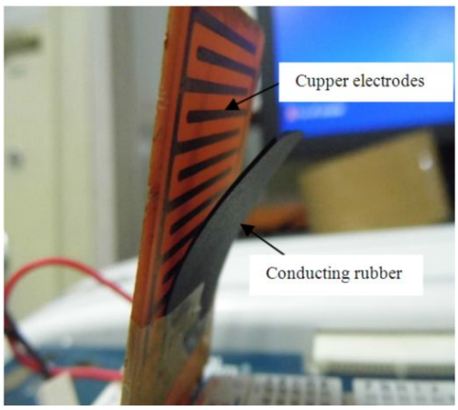

Fig. 5: One side of the conductive rubber is kept unattached with the electrodes intentionally.

Error due to unattached rubber ends and detection: Pressure conductive rubber is purely resistive in nature. So ideally output signal should be exact copy (same phase, same frequency) of input with decreased peak value. Now a periodic Sinusoidal signal with both positive and negative peak ,is used for the test of mounting error .At output stage a high frequency noise will occure with the applied periodic signal, if there is any unwanted vibration exsists in the mounting stage . With frequency domain analysis or power spectrum analysis it can be detected. If the power of high frequency components are more than tolerance level then there must be some problem regarding to the attachment of the sensor with body contact.

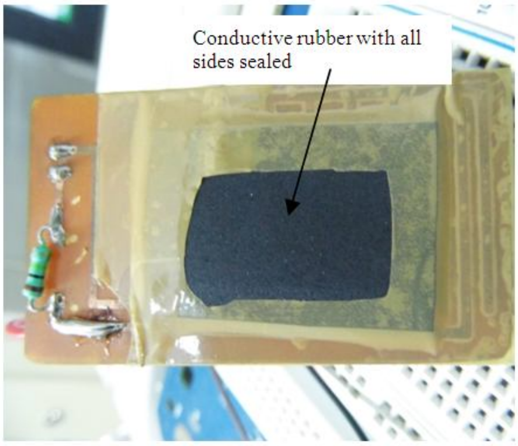

Fig. 6: Pressure conductive rubbers with all sides are sealed.

Error due to improper attachment with electrodes: If electrodes are not properly attached with the rubber as input signal, that will deform not only by peak magnitude but also by it’s original shape. So at no load condition if we apply a sinusoidal signal with both negative and positive magnitude and amplitude we will get a deformation signal like figure 4. Due to resistive nature of the rubber, the magnitude of the output signal will decrease. As the amplitude of the input signal is high so it cannot be compared with the distorted signal that is generated due to the mounting error whose amplitude is less than the input signal. For this particular problem another signal have to be generated which can be used for comparison with the distorted output signal, better the connection between electrode and conducting rubber, lesser the deviation between generated signal and output signal.

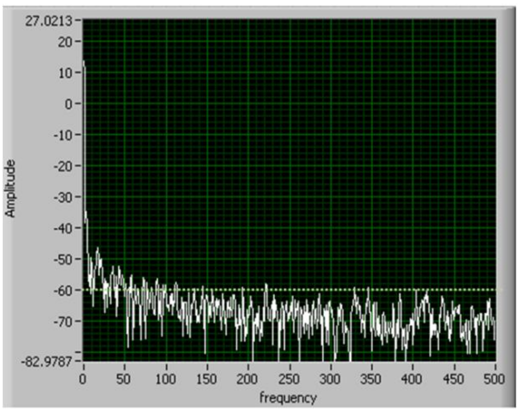

Fig. 7: Power spectrum of noise when one side of pressure conductive rubber was kept unattached intentionally (average value is near -60 db marked by yellow line)

3. Experimental Setup

An experimental setup, shown in figure 3, has been made and detection of these two types of error has been done. Here pressure conductive rubber is in series with a 100k ohm fixed resistance. Output of the sensor has been taken across the fixed resistance when there is no load on pressure conductive rubber. Output signal is fed to computer through the signal conditioning and analog to digital converter circuit. Here signal conditioning, ADC conversion and data acquisition has been done by NI Elvis platform. Comb like electrode for the pressure conductive rubber has been made.

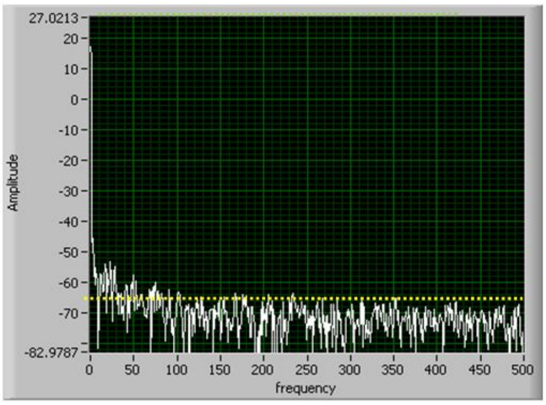

Fig. 8: Power spectrum of noise when all sides of pressure conductive rubber are attached with electrodes (average value is near -65 db)

4. Experimental Result

For detection of high frequency noise error one end of the pressure conductive rubber has been kept unattached intentionally (figure 5) power spectrum has been analyzed. Then same condition has been created except there were no loose ends of the rubber (fig. 6). In first case average noise frequency power was near -60 db (figure 7) but in second case that amount was near -65 db as shown in figure 8. Now for detection of error due to improper attachment of rubber with electrodes, a 10vpp (+5v to -5v), 2 Hz. Sinusoidal signal with zero phase shifts has been applied to the sensor and output value has been taken for an instant. Then the deformed signal is compared with another sinusoidal signal with same frequency and phase that of input signal except peak to peak voltage was same as output signal. By taking least square error deviation between these two signals, the error can be detected .With the decrement of imperfection, this error also decreases. With perfect attachment of electrodes, output signal will be exactly same as input except the amplitude. In figure 9 red colored curve represents the simulated signal taken as a reference signal. Blue line represents original output signal received from the sensor. And green curve represents least square deviation of original and simulated signal. With the decrement of imperfection, this error also decreases. With perfect attachment of electrodes, output signal will exactly same as input except the amplitude.

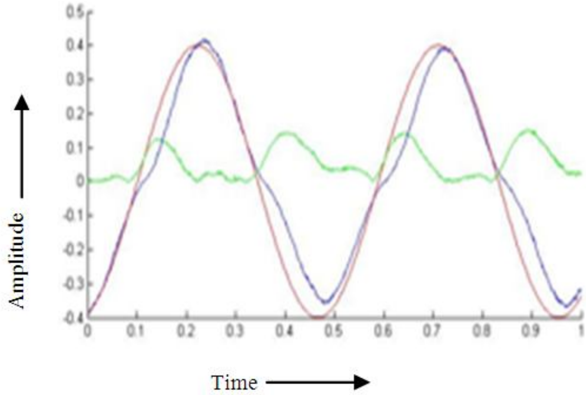

Fig. 9: original distorted output (blue) is compared with ideal sinusoidal signal (red) with same Vpp. And their least square deviation is plotted (green).

5. Conclusion and Future Work

This experiment shows simple techniques for detection of error due to improper mounting of pressure conductive rubber. However there may be some other kinds of unknown source of errors which are yet to be explored**.** Again for which phenomenon of the rubber, output signal is deforming is not clear. In future detailed study may be carried out on this purpose. Regarding the second technique, perfect sinusoidal curve can also be achieved by applying high amount of pressure upon the conductive rubber. So experiment should be done under no load condition and if lamination technique is used to attach the sensor, minimum or optimum level of pressure should be maintained. Again although second technique shows the amount of error due to improper attachment of the electrodes with the rubber, it does not point out exactly where the error is taken place. In future work this point will be focused how to detect the exact location of error. This experiment has been tested only on laminated rubber and electrodes. In future it will be tested on other systems also.

6. Acknowledgment

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