ELECTRONIC INTERFACE CIRCUIT FOR RESISTIVE SENSORS

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Abstract: A low cost, universal electronic sensor interface based on synchronous modulation and demodulation (lock-in amplifier) circuit was described. This circuit can be applied fòr many types of resistive sensor interface such as PTC, NTC thermistors, PbS, CdS photoresistor, Giant Magneto Resistor (GMR) sensors, and Hall effect sensors.

1. Introduction

There are many types of physical sensor such as themistor, photoresistor, Hall effect, GMR and Piezoelectric sensors, which have been widely developed in the material science and technology field. All of them have a weak electronic signal at output, many times smaller than the usual noise produced by some electromagnetic sources.

All the resistive sensors (themistors, photoresistors) in circuit are commonly connected in Wheastone bridges. Bridge circuits that use DC excitation are often plagued by errors caused by thermocouple effects, 1/f noise, DC drifts in the electronics, and line noise pick-up. One way to get around these problems is to excite the bridge with an AC waveform, amplify the bridge output with an AC amplifier, and synchronously demodulate the resulting signal. The AC phase and amplitude information from the bridge is recovered as a DC signal at the output of the synchronous demodulator. The low frequency system noise, DC drifts, and demodulator noise all get mixed to the carrier frequency and can be removed by means of a low-pass filter. Dynamic response of the bridge must be traded off against the amount of attenuation required to adequately suppress these residual carrier components in the selection of the filter [1, 2,].

Therefore, this paper proposes a versatile, low-cost and modular electronic board based on an AC bridge and a synchronous modulation/demodulation (lock-in amplifier) circuit. That circuit used to separate a small, narrow-band signal from interfering noise. Very small signals can be detected in the presence of large amounts of uncorrelated noise when the frequency and phase of the desired signal are known. The lock-in amplifier is basically a synchronous demodulator followed by a low-pass filter. This circuit board with an AC bridge at input is recommended for Hall effect, GMR and Piezoelectric sensors applications [3].

2. Experiment

In this experiment, the signal source is a resistor bridge which detects extremely small resistively shifts by a trimpot. Figure 1 showed the major electronic circuit having been made. Figure 2 is TDS3052B oscilloscope image demonstrating the AC signal of the circuit. The 645Hz carrier (trace A) is applied to drives the resistor AC bridge, which presents a different output to instrumentation amplifier[4] (INA - made by three operation amplifiers U1-U3 of LF353 [5]). This amplifier operates at an AC gain of 2001. A 50 Hz noise source is also deliberately injected into INA's input. The carrier's zero crossings are detected by C1. C1's output clocks the 4052 [6] multiplier integrate circuit. INA's output consist the desired 645 Hz signal buried within the 50 Hz noise source. The 4052 IC operates as synchronized switching at operation amplifier U4's positive input causes A4's gain to alternate between plus and minus one. As a result, INA's output is synchronously demodulated by U4. U4's output (trace B) consists of demodulated carrier signal and non-coherent components. The desired carrier amplitude and polarity information is discernible in U4's output and is extracted by filter-averaging at RC circuit with time constant of 100ms (trace C). To trim this circuit, adjust the phase potentiometer so that C1 switches when the carrier crosses through zero.

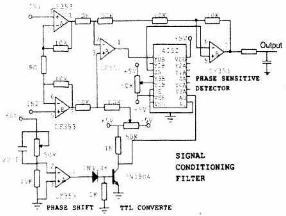

Fig.1. The sensor interface circuit

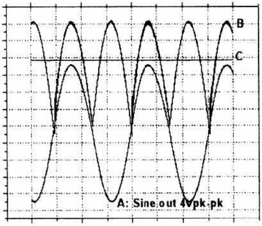

Fig.2. AC bridge synchronous demodulator signal

For Lock-in applications, we used a square wave with the same frequency of 1 Hz (trace A of Figure 3) modulated light from a bulb. The reflected light from a human is illuminated on the surface of a commercial CdS photoresistor at the input of bridge. Figure 3 shows the recovery of a signal modulated at 645 Hz from a noise signal approximately 2000 times larger (trace B). The signals produced by modulated light in CdS detectors may have similar low frequency components. This combined signal is amplified, demodulated synchronously using phase information derived from the modulator, and the result

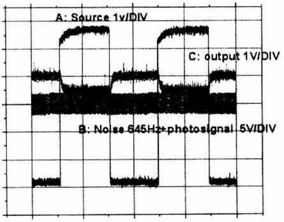

Fig.3. Lock-in amplifier signal description

is low-pass filtered using a simple filter made by RC circuit with time constant of 10 ms. This recovered signal is trace C of Figure 3.

3. Conclusions

Based on characteristic of resistive sensor and lock-in amplifier technique, we can measure the electric signal with high ratio-to-noise ratio. This interface circuit can be used wherever the signal of interest can be synchronized with or derived from a suitable reference signal. By some simple electronic components built in, this circuit is low-cost and modular, useful for many applications.

The Time Resolved Photoluminescence measurement by pulse method using digital oscilloscope was built in our lab. The resolution time of this system is about 2-3 ns and the measurement range is 10 nanoseconds to miliseconds.

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