A 3-TO-2 WIRE CONVERSION CIRCUIT FOR A REDROCK® TMR MAGNETIC SENSOR

Background

Two-wire interfaces are found commonly in proximity sensing functions. For example, in any application with a door, lid, or cover, a proximity sensing function indicates to the system whether the door, lid, or cover is open or closed. In many legacy designs the proximity sensing function is implemented with a reed switch and magnet or an electromechanical switch that depresses when the door, lid, or cover is closed. However, in recent years, solid state magnetic sensors, such as Coto's RedRock® Tunneling Magnetoresistance (TMR) sensors, have become an attractive alternative. These RedRock® TMR magnetic sensors offer extremely low power consumption, very small package size, and exceptionally high reliability; they are also cost competitive with reed switches and mechanical switches. Nevertheless, despite the more desirable features and benefits of the TMR magnetic sensors, designers often want to keep the two-wire interface either because it's less expensive or because they don't want (or have the freedom) to change the interface to the system from 2-wire to 3-wire. This application note explains how the benefits of a solid state magnetic sensor such as a very low power RedRock® TMR sensor – consisting of a signal, ground and power connection – can be achieved without sacrificing the 2-wire interface.

A two-wire interface has only power and signal-out lines since it does not, itself, require any power to perform its function (switching). Therefore, it relies on current change to deliver signal information. Two-wire control has advantages such as low cost, easy expansion, and installation. A typical device used in two-wire circuitry is a reed switch because it has a simple structure containing two ferromagnetic contact blades, hermetically sealed in a glass envelope.

By serially connecting a resistor to a reed switch, the voltage drop across the resistor can be used as an input signal for the micro-processor (µP) to obtain information about whether the magnet is close or distant.

Application Circuit

We use the RedRock® RR122-1B13-511 as the solid-state magnetic sensor in the diagram below to illustrate how it can mimic the two-wire mechanism of a reed switch. The RR122-1B13-511 is an ultra-low current consumption magnetic sensor based on Tunneling Magnetoresistance (TMR) technology. Its output state will change between HIGH and LOW to indicate the absence or presence of a magnetic field. Since the average current consumption of the RedRock® series TMR magnetic sensor can be substantially less than 200nA, it's the ideal magnetic sensor to replace a reed switch in a two-wire application.

There are various methods to convert a typical three-wire device into a two-wire output. One of the simplest ways is to use a pull-up resistor (R_{LOAD}) tied between the output pin of the RR122-1B13-511 and its V_{DD} pin. With a proper value resistor (R_{SENSE}), implemented at the interface of a microprocessor, the voltage change at the sensor's GND pin could be used to define the ON/OFF state, based on the level of magnetic stimulation from a nearby magnet.

Without Magnetic Field - When there is no magnetic field present, the current consumption of the RR122-1B13-511 is only 300nA at 5V. Therefore, the microprocessor will read only

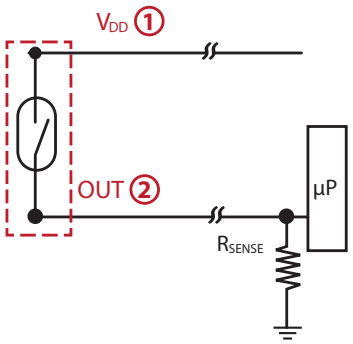

Figure 1: Typical 2-wire sensor circuit

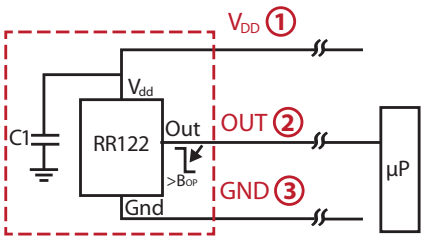

Figure 2: Typical 3-wire sensor circuit

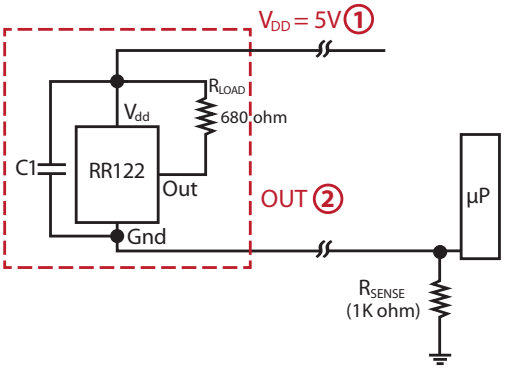

Figure 3: A simple 3-to-2 wire conversion circuit

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about 0.3mV across R_{SENSE}.

With Magnetic Field – When the magnetic field applied to the sensor exceeds its operating point (BOP), the sensor's output will turn ON and sink current through resistors R_{LOAD} and R_{SENSE} to ground. Based on the voltage divider rule, the voltage read across R_{SENSE} will be 5*(1000/1000+680) = 2.97V. This voltage change level is sufficient for most interfaces of a microprocessor to read.

Because the RR122 series low power RedRock® TMR magnetic sensor requires a supply voltage between 1.7V to 5.5V, it can operate normally – even when the R_{SENSE} voltage level is almost 3V while V_{DD} is 5V. Therefore, it is important to choose the appropriate R_{SENSE} resistor value in accordance to the R_{LOAD} resistor value, to ensure the sensor has sufficient supply voltage to keep it active and still supply a voltage change that is compatible with the microprocessor.

Note: in addition, the RR122 series RedRock® TMR magnetic sensor requires a few mA for a short amount of time during power-on stage. Therefore R_{SENSE} value should not be greater than 2K Ohm, otherwise the sensor might not be able to start-up successfully.

Conclusion

A two-wire interface has several advantages leading to its popularity in many industrial and consumer applications due to its robustness for long distance signal transmission. The RR122 series low power RedRock® TMR magnetic sensor is a three-terminal magnetic sensor, but with the simple resistor arrangement between R_{LOAD} pull-up resistor and R_{SENSE} resistor at the interface of the microprocessor, a 3-to-2 wire conversion circuitry is achieved, allowing the designer to gain the benefits of robust, solid state, contactless proximity sensing while retaining the existing two-wire system interface.

For further application assistance, please contact Coto Technology's Sales and Applications Engineering team. (appsupport@cotorelay.com).

