Application Note: S1

Building a 1.5V ON, 4uA OFF 2-Wire Inductive Proximity Sensor

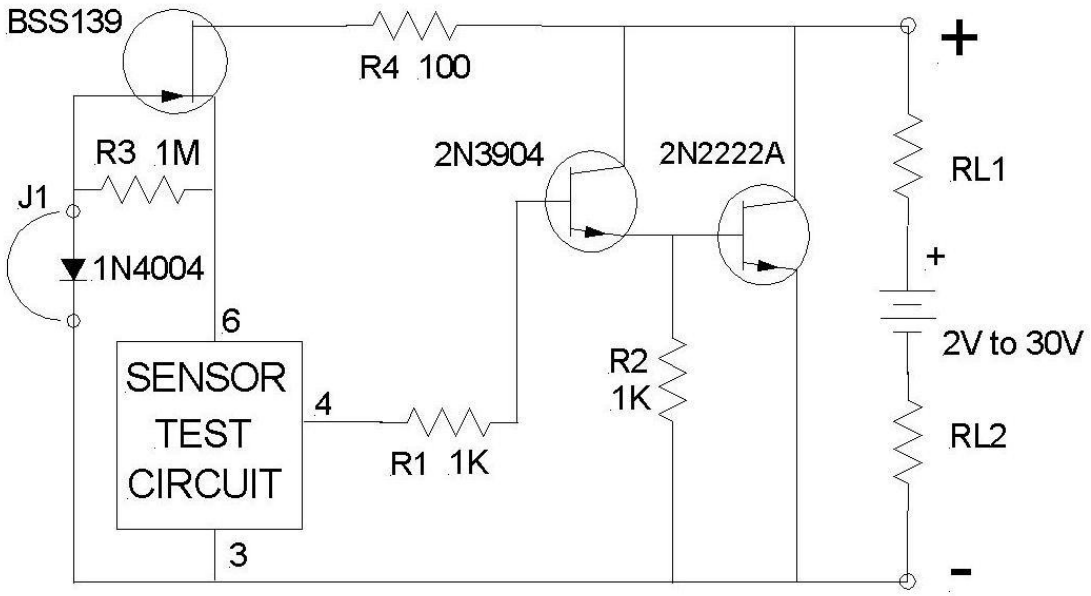

FIG. 1

1.5v ON at 150mA /Off-State (Leakage) Current ≤4 uA

Introduction;

Two wire sensors can benefit from reduced on voltage drop and off leakage current. The lower on voltage drop reduces the sensor power dissipation allowing a higher load current to be controlled. This also allows a lower supply voltage to be used and more sensors to be placed in series. The leakage current, also known as the Off-State Current, is the current that flows through the load circuit when the sensor is in the OFF-state. The lower leakage current allows more sensors to be placed in parallel before the leakage current adversely affects the load.

Operation;

2-wire DC sensors can be used to sink or source a load. The Supply voltage is connected through both external loads, represented by RL1 and RL2, to the sensor circuit. Either RL1 or RL2 can be zero ohms. The value of the combination of RL1 and RL2 must limit the sensor on current to 150mA to prevent over heating of transistor 2N222A. Transistor 2N222A has a power dissipation determined by the sensor on voltage times the load current which is about 225mW (1.5v x .150mA).

Transistors 2N3904 and 2N222A are configured to form a Darlington transistor pair. A Darlington pair behaves like a single transistor with its current gain approximately equal to the product of the gains of the two transistors. R2 is used to reduce the 2N222A leakage current and also decreases its turn off time. For a 150mA load current the 2N222A HFE is 50 min requiring I_B of 3mA max. The 2N3904 I_E is the sum of the 2N222A I_B and R2 current (3Ma + .7V/1K =3.7mA). For a 3.7mA I_E current the 2N3904 HFE is 35 min requiring a I_B of 0.1mA max. The Collector – Emitter Breakdown Voltage of the transistors, 2N3904 and 2N222A, equal 40V and the Breakdown Voltage of BSS139 is 250V. This allows safe sensor circuit operation up to 30V.

The operation of the Sensor Test Circuit is described in the "MICRO POWER IC For Inductive Proximity Sensors" LS1500 data sheet.

The Sensor Test Circuit needs an output voltage at 4 of about 1.4V to turn the Darlington transistor pair on. Since the Sensor Test Circuit output is CMOS, the output voltage swings between approximately the 0V at 3 and the voltage at 6. BSS139 is a depletion mode NMOS transistor with a $V_{GS(th)}$ of -1.4V typ. Since the IC draws only a few uA, the voltage at 6 is about the same as $V_{GS(th)}$. The circuit will not work if the voltage at 6 is not high enough to turn on the Darlington transistor pair. To increase the voltage at 6, if it is too low, jumper wire J1 is cut. This increases the voltage at 6 by about 0.3V which is the voltage drop across diode 1N4004. R3 is used to increase the supply current through the sensor when the sensor is off. This is to insure that when multiple sensors are in series they each have enough voltage drop across them to all operate correctly. R4 is used to limit the surge current through BSS139 in both the forward and reverse directions.

NOTE; The Fig. 1 circuit is only for illustration purposes. Actual use of the circuit in applications requires evaluation for suitability and reliability.