

Solid State Sensors

Current Sink and Current Source Interfacing

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NPN AND PNP TYPES

Linear and digital Hall effect are offered in two basic types — NPN (sinking) or PNP (sourcing). A current sinking device (open collector, normally high) “sinks current from a load”. Consequently, current flows from the load into the transducer **Figure 1**. A current sourcing device (open emitter, normally low) “sources current into a load” causing current to flow from the transducer into the load **Figure 2**.

The digital Hall effect sensor can be envisioned as a mechanical switch which allows current to flow when turned on and blocks current flow when turned off. The transducer will only switch low level DC voltages (30 VDC maximum) at currents of 40mA or less. The linear Hall effect transducer puts out a continuous signal proportional to the sensed magnetic field.

INTERFACES

Conditions that must be met when interfacing with digital Hall effect sensors are: (1) the interface must appear as a load that is compatible with the output, and (2) the interface must provide the combination of current and voltage required in the application.

PULL-UP AND PULL-DOWN RESISTORS

A pull-up resistor must be used with a current sinking device and a pull-down resistor for current sourcing devices. The outputs are floating, therefore the pull-up or pull-down resistor helps establish a solid quiescent voltage level. These resistors also minimize the effect of small leakage currents from the output of the device or from the electronics with which the transducer is interfaced. Additionally, they provide better noise immunity and faster rise and fall times.

A pull-up resistor is connected directly across the positive terminal (+ supply) and output (O). When the device is deactuated, the input to the load is “pulled-up” to near V_{Supply} . In other words, a current sinking device will output a voltage equal to the supply voltage when it is in a non-operated state. In addition, it will output approximately 0.4 volts in an operated state (output transistor’s saturation voltage plus a diode drop).

A pull-down resistor is connected directly across the output of the device and the negative terminal (ground). When the transducer is actuated, the input to the load rises to near V_{Supply} independent of the pull-down resistor. Conversely, when the device is deactuated, the input to the load is “pulled-down” to near ground potential. When selecting a pull-up or pull-down resistor, it must be determined if the interface will tolerate a resistance in parallel. If there is a parallel resistance, the total resistance and load current should be calculated to make sure the Hall effect transducer’s output current will not be exceeded.

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Current Sink and Current Source Interfacing

Figure 1
Current Sinking Outputs

The schematics shown are typical of the outputs with which MICRO SWITCH Hall effect sensors can be interfaced. Values shown are representative only.

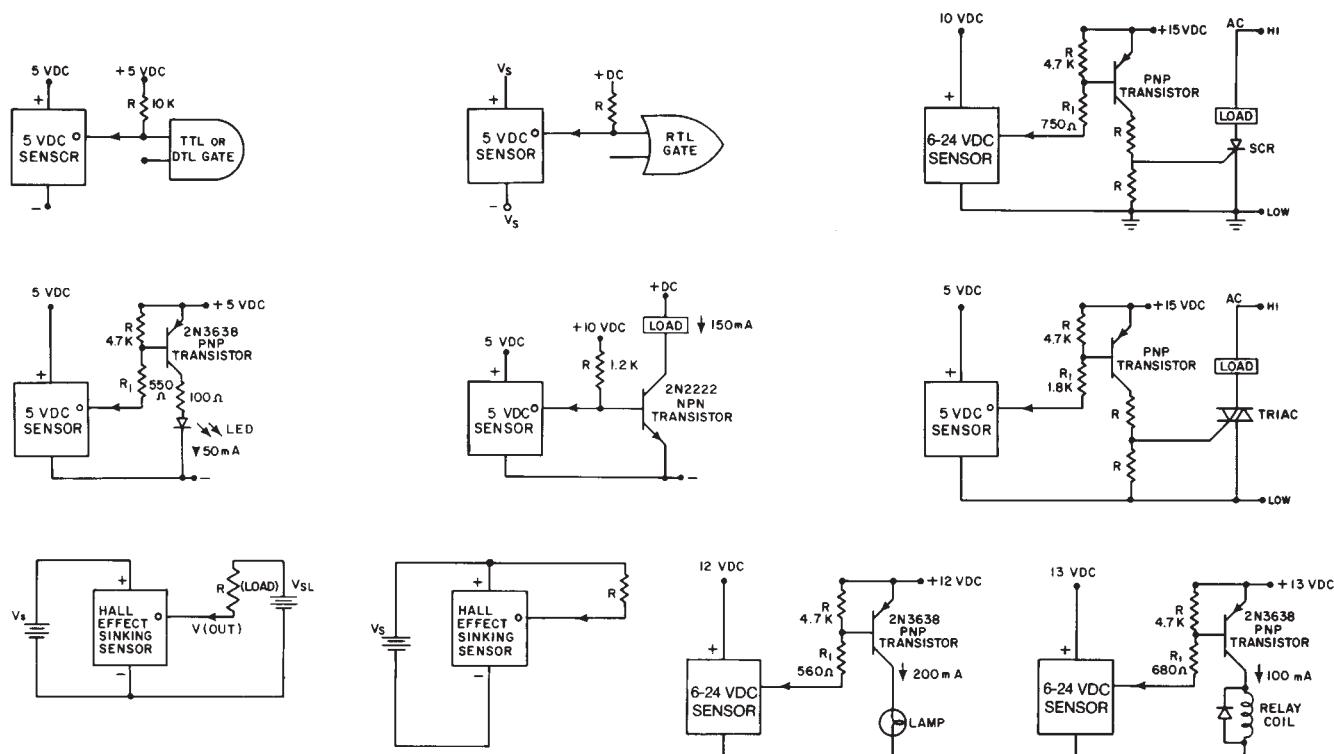
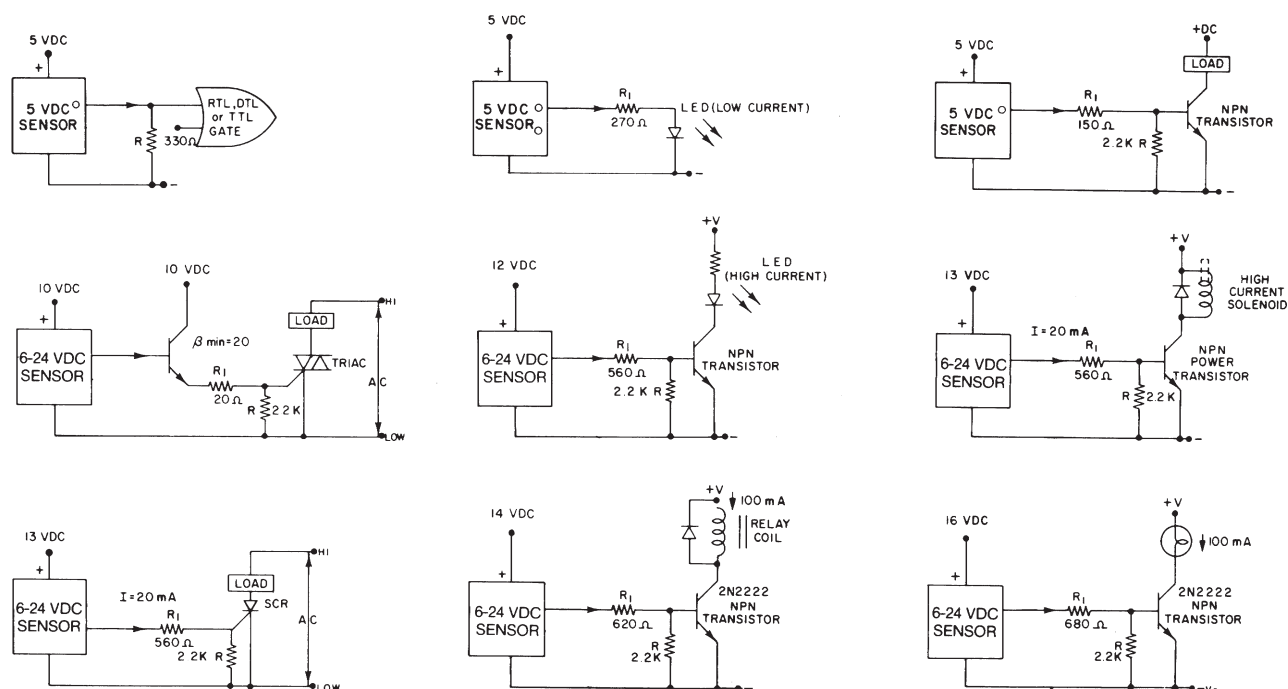


Figure 2
Current Sourcing Outputs

The schematics shown are typical of the outputs with which MICRO SWITCH Hall effect sensors can be interfaced. Values shown are representative only.



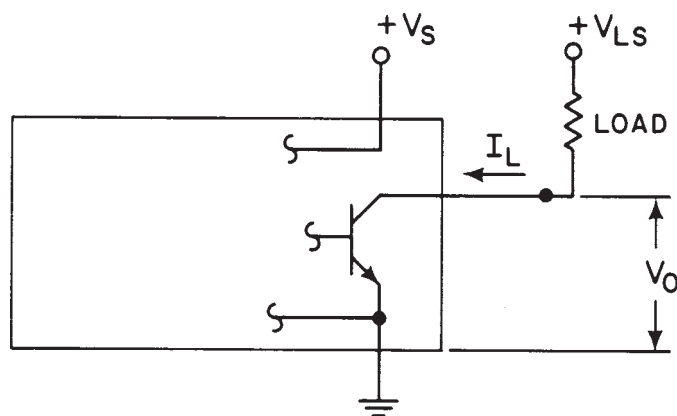
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Current Sink and Current Source Interfacing

CURRENT SINKING OUTPUT

Figure 3 represents the output stage of a typical current sinking sensor. In this circuit configuration, the load is generally connected between the supply voltage and output terminal (collector) of the sensor. When the sensor is actuated (turned ON), current flows thru the load, into the output transistor to ground. The supply voltage of the sensor (V_S) need not be the same value as the load supply (V_{LS}); however, it is usually convenient to use a single supply. The output voltage is measured between the output terminal (collector) and ground (-). When the sensor is not actuated, current will not flow thru the output transistor (except for a small leakage current). The output voltage, in this condition, will be equal to V_{LS} (neglecting the leakage current). When actuated, the output voltage will drop to ground potential (except for the saturation voltage of the output transistor).

Figure 3
Typical Current Sinking Output Circuit

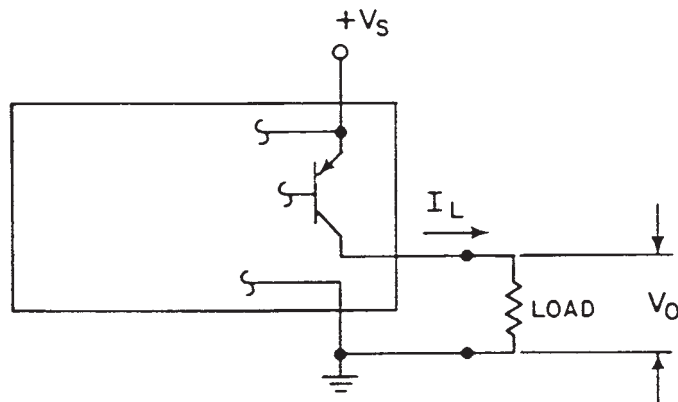


Current sinking derives its name from the fact that it “sinks current from a load.” The current flows from the load into the sensor. Like a mechanical switch, the sensor allows current to flow when turned-ON and blocks current flow when turned-OFF. Unlike an ideal switch, the sensor has a voltage drop when turned-ON and a small current (leakage) when turned-OFF.

CURRENT SOURCING OUTPUT

Figure 4 represents the output stage of a typical current sourcing sensor. In this circuit, the load is generally connected between the output terminal (collector) of the sensor and ground. When the sensor is actuated, current flows from the output transistor into the load to ground. The sensor output voltage is measured between the output terminal and ground (-), and is equal to the voltage across the load. When the sensor is not actuated, current will not flow thru the output transistor (except for the leakage current). The output voltage will equal zero (neglecting the leakage current). When the sensor is actuated, the output voltage will rise to V_S less the collector-to-emitter voltage drop of the output transistor.

Figure 4
Typical Current Sourcing Output Circuit



Current sourcing gets its name from the fact that it “sources current to a load.” The current flows from the sensor into the load.

Application Note

Two additional combinations of transistor interfaces can be realized with current sourcing and current sinking sensors. These are:

- Current sinking sensor with a current sourcing drive
- Current sinking sensor with a current sinking drive

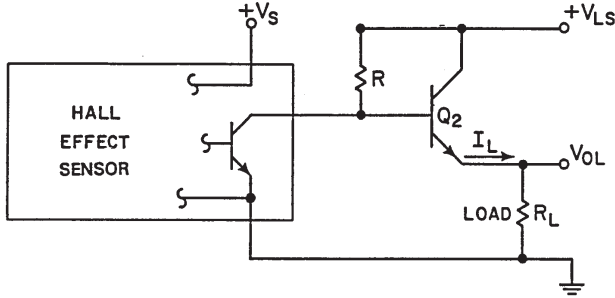


Figure 5 Sinking sensor – sourcing output

R for a given sensor:

$$R_{\min} = \frac{V_{LS} - V_{CE(Q1)}}{I_{ON}}$$

R for adequate load current:

$$R_{\max} = \frac{(\beta_{\min} + 1)(V_{LS} - R_L I_{L(\max)}) - B_{BE(ON)}}{I_{L(\max)}}$$

If $R_{\max} \leq R_{\min}$ then use either a transistor with a higher β or a second amplifier stage.

$\beta_{\min}$ for given R:

$$\beta_{\min} = \frac{R I_{L(\max)}}{V_{LS} - R_L I_{L(\max)} - V_{BE(ON)}}$$

Output voltage:

$$V_{OL} = \frac{\frac{V_{LS} - V_{BE(ON)}}{R}}{1 + \frac{R_L \beta + R_L}{R}}$$

Transistor output requirements:

$$\begin{aligned} I_{L(\max)} &< I_{C(\max)} \\ V_{LS} &< BV_{CER} \end{aligned}$$

Transistor power dissipation:

$$P_D = I_L(V_{LS} - V_{OL}) = \frac{\frac{R_{VLS}}{R_L \beta + R_L + V_{BE(ON)}}}{1 + \frac{R}{R_L \beta + R_L}}$$

The design equations necessary to choose the correct bias resistors and drive transistors for the first two are shown in Figures 5 and 6.

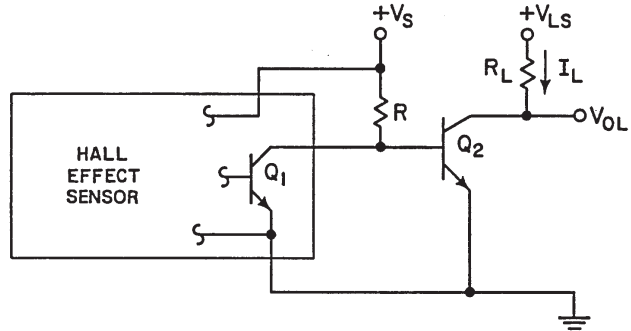


Figure 6 Sinking sensor – sinking output

R for given sensor:

$$R_{\min} = \frac{V_S - V_{CE(Q1)}}{I_{(ON)}}$$

R for adequate load current:

$$R_{\max} = \frac{\beta_{\min} (V_S - V_{BE(ON)})}{V_S - V_{BE(ON)}}$$

If $R_{\max} \leq R_{\min}$ then use either a transistor with a high β or a second amplifier stage.

$\beta_{\min}$ for given R:

$$\beta_{\min} = \frac{R I_{L(\max)}}{V_S - V_{BE(ON)}}$$

Output voltage:

$$V_{OL} = V_{CE(SAT)Q2} \text{ for } I_L$$

A minimum β of 10 is recommended for good saturation voltage.

Transistor output requirement:

$$\begin{aligned} I_{L(\max)} &< I_{C(\max)} \\ V_{LS} &< BV_{CER} \end{aligned}$$

Transistor power dissipation:

$$P_D = V_{OL} \bullet I_L$$