Two-Wire Sensor Interfaces

Two-wire sensors are common in industrial control to simplify wiring. But for many sensors, competing constraints make designing two-wire interface circuitry tricky.

Two wire interfaces need to operate over a wide power supply range. With the sensor off, the circuit should draw a minimal residual current, typically less than 1.5 milliamps. With the sensor on, the circuit must provide enough current to drive a significant load such as a motor or solenoid.

NVE's ADL-Series sensors are perfect for two-wire applications, because their low supply voltage and low quiescent current provide plenty of design margin. Also, the ADL-Series' small package (1.1 x 1.1 x 0.45 mm) allows the parts to fit in the smallest assemblies, such as those for 3 mm-wide cylinder grooves.

A Simple Reference Circuit

Here's a simple, inexpensive reference circuit:

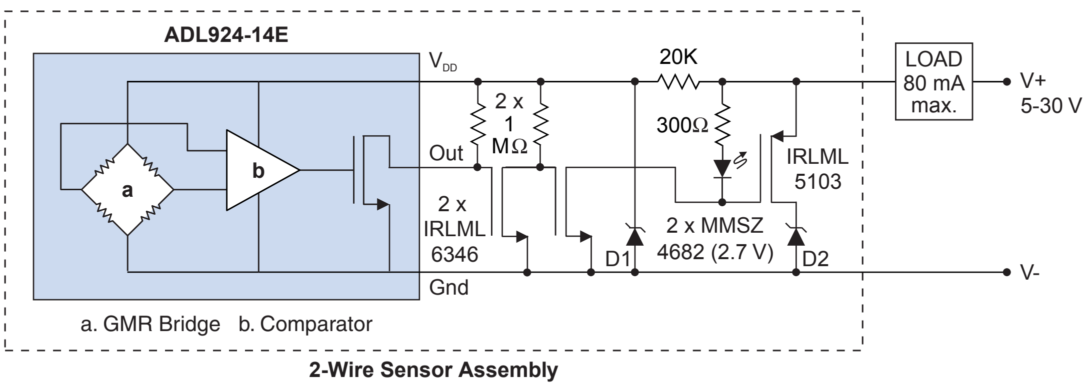

Figure 1. An inexpensive 2-wire interface reference circuit.

In this circuit, when a magnetic field is applied to the sensor, the MOSFETs turn on, turning on the LED and powering the load.

With no magnetic field and the sensor off, the residual current of the circuit is the D1 Zener diode bias current plus the sensor quiescent current. The ADL924 quiescent current is negligible, so the residual current is dominated by the Zener current, which is less than 1.5 milliamps. D1 should be a low-current Zener to allow a higher series resistor for minimal residual current.

Zener diode D1 limits the ADL925 supply voltage with the load unpowered; Zener diode D2 provides enough voltage to power the circuitry when the load is powered.

Better Voltage Regulation

A voltage regulator instead of the D1 Zener diode provides better regulation and better operating latitude over the input voltage range. This reference circuit is shown in Figure 2:

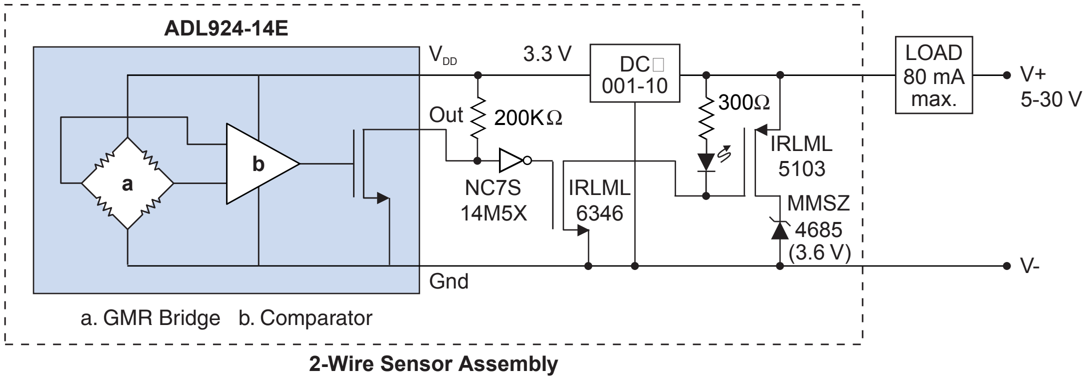

Figure 2. A simple 2-wire interface using a voltage regulator and a TinyLogic invertor.

The residual current is dominated by the regulator's quiescent current, which is less than one milliamp and relatively constant over input voltage.

The Figure 2 circuit also uses an invertor in place of one of the MOSFETs, which eliminates a resistor.

Circuit Characterization

Measured characteristics of the Figure 1 and Figure 2 reference circuits are summarized as follows:

Parameter	Symbol	Circuit Figure 1	Circuit Figure 2
Min. Input Voltage (sensor on; $R_L = 100\Omega$)	V_{MIN}	5 V	3.1 V
Max. Input Voltage (sensor on; $R_L = 100\Omega$)	V_{MAX}	30 V	30 V
Residual Current (V+ = V_{MAX} = 30 V)	I_Q	1.3 mA	0.6 mA
Holding Current	I_H	11 mA	11 mA

Where:

V_{MIN} is the minimum input voltage for the assembly to operate, which means there is at least 2.4 volts for to the ADL924 sensor, which is its minimum supply voltage. V_{MIN} must typically be 5 volts or less.

V_{MAX} = is the maximum input supply voltage, which is typically at least 24 volts. V_{MAX} is limited by the maximum voltage of the MOSFETs and component power dissipation, especially the D2 Zener diode power dissipation.

I_Q is the worst-case residual, or quiescent, current with the sensor off and the V+ supply at maximum. This is typically in the one milliamp range.

I_H is the holding current, which is the minimum current that must be sourced through the load with the sensor ON to ensure the sensor will operate (i.e., 2.4 volts to the sensor). Holding current for industrial control two-wire interfaces typically ranges from 3 mA to 20 mA.

Note that these are measured parameters, not worst-case specifications.

As shown in the table above, the Figure 1 reference circuit has a higher residual current than the Figure 2 circuit because of the Zener diode bias. The Figure 2 circuit has a lower minimum voltage with the better

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 www.nve.com sensor-info@nve.com

line regulation provided by the regulator. Lower dropout regulators can be used in place of the DC001-10 for even lower minimum input voltages.

For these circuits, the holding current is dominated by the LED current, and can be reduced by reducing the LED drive.

The output current versus input voltage for the Figure 1 reference circuit is shown below:

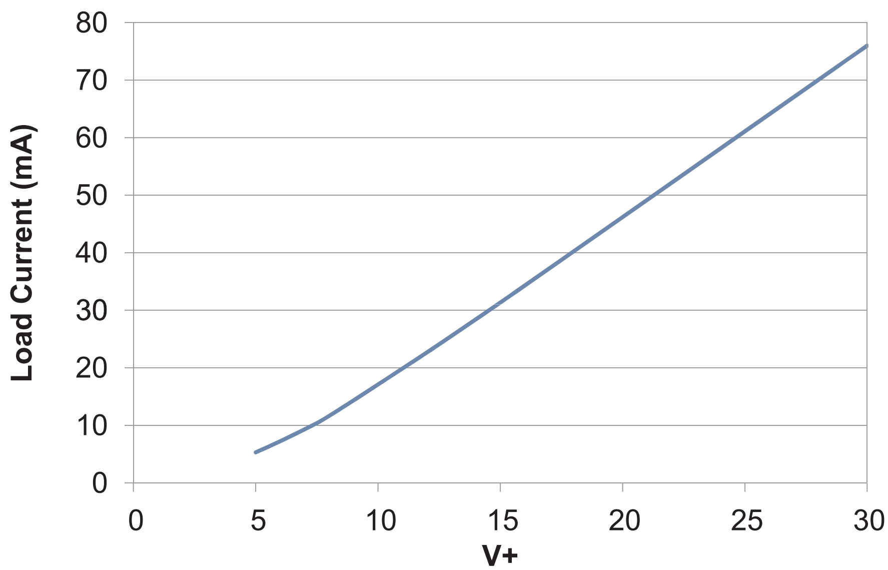

Figure 3. 2-wire interface reference circuit (Figure 1) output current versus input voltage; R_L = 333Ω.

Conclusion—ADL924 Sensor Are Ideal for 2-Wire Interfaces

ADL-Series sensors are ideal for two-wire proximity sensors because of their small size, low supply voltage, and low quiescent current.

In addition to their impressive electrical specifications, ADL-Series sensors feature precise magnetic operate points. Standard ADL-Series magnetic operate points are 20±5, and 28±7 oersteds, with other ranges available by special order.

Buy Online

NVE Corporation 11409 Valley View Road, Eden Prairie, MN 55344-3617 Phone: (952) 829-9217 www.nve.com sensor-info@nve.com

Limited Warranty and Liability
Information in this document is believed to be accurate and reliable. However, NVE does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

In no event shall NVE be liable for any indirect, incidental, punitive, special or consequential damages (including, without limitation, lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Right to Make Changes
NVE reserves the right to make changes to information published in this document including, without limitation, specifications and product descriptions at any time and without notice. This document supersedes and replaces all information supplied prior to its publication.

Use in Life-Critical or Safety-Critical Applications
Unless NVE and a customer explicitly agree otherwise in writing, NVE products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical devices or equipment. NVE accepts no liability for inclusion or use of NVE products in such applications and such inclusion or use is at the customer's own risk. Should the customer use NVE products for such application whether authorized by NVE or not, the customer shall indemnify and hold NVE harmless against all claims and damages.

Applications
Applications described in this datasheet are illustrative only. NVE makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NVE products, and NVE accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NVE product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customers. Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NVE does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customers. The customer is responsible for all necessary testing for the customer's applications and products using NVE products in order to avoid a default of the applications and the products or of the application or use by customer's third party customers. NVE accepts no liability in this respect.

Limiting Values
Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and operation of the device at these or any other conditions above those given in the recommended operating conditions of the datasheet is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and Conditions of Sale
In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NVE hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NVE products by customer.

No Offer to Sell or License
Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export Control
This document as well as the items described herein may be subject to export control regulations. Export might require a prior authorization from national authorities.

Automotive Qualified Products
Unless the datasheet expressly states that a specific NVE product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NVE accepts no liability for inclusion or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NVE's warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NVE's specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NVE for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NVE's standard warranty and NVE's product specifications.

An ISO 9001 Certified Company

NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
Fax: (952) 829-9189
www.nve.com
e-mail: sensor-info@nve.com

SB-AP-26

October 2015