

Sensors and Circuits

SENSORS, TRANSDUCERS, and SUPPORTING
CIRCUITS for ELECTRONIC INSTRUMENTATION,
MEASUREMENT and CONTROL

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PTR Prentice Hall, Englewood Cliffs, New Jersey 07632

WiTricity Corp.

Exhibit 2011

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Library of Congress Cataloging-in-Publication Data

Carr, Joseph J.

Sensors and circuits : sensors, transducers, and supporting
circuits for electronic instrumentation, measurement, and control /
Joseph Carr.

p. cm.

Includes bibliographical references and index

ISBN 0-13-805631-5

1. Transducers. 2. Detectors. 3. Biosensors. I. Title.

TK7872.T6C375 1993

681'.2—dc20

92-14958

CIP

Editorial Assistant: Diane Spina

Prepress and manufacturing buyer: Mary McCartney

Cover design: Wanda Lubelska

Copyeditor: Barbara Liguori

Proofreader: Kristen Cassereau, Carol A. Flynn, and Steven Fine



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A Simon & Schuster Company

Englewood Cliffs, New Jersey 07632

The publisher offers discounts on this book when ordered in
bulk quantities. For more information, contact:

Corporate Sales Department

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Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-805631-5

Prentice-Hall International (UK) Limited, *London*

Prentice-Hall of Australia Pty. Limited, *Sydney*

Prentice-Hall Canada Inc., *Toronto*

Prentice-Hall Hispanoamericana, S.A., *Mexico*

Prentice-Hall of India Private Limited, *New Delhi*

Prentice-Hall of Japan, Inc., *Tokyo*

Simon & Schuster Asia Pte. Ltd., *Singapore*

Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

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Exhibit 2011

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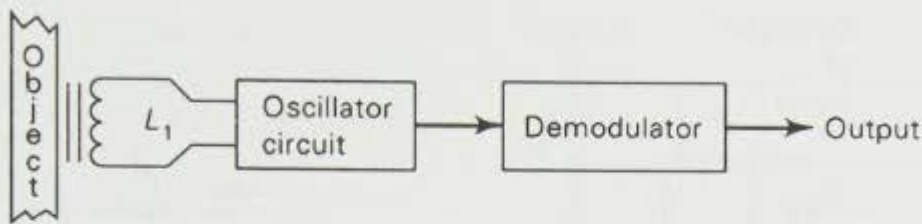


Figure 9-10 Oscillator circuit implementation.

INDUCTIVE PROXIMITY SENSORS

Inductive proximity sensors depend on changing a magnetic field surrounding a sensor element by inducing eddy currents in a ferrous or nonferrous target brought into close proximity with the sensor element. This type of sensor is also sometimes called a *proximity switch*. It offers fast, accurate, and highly repeatable (3 percent of target distance, typically ± 0.0005 in.) operation at relatively low cost. Eddy current proximity sensors will operate at temperatures up to about 250°F and at frequencies to 10 kHz for some designs, and 2 MHz for others. They can differentiate metallic object thickness variations on the order of 0.03 in.

The eddy current inductive sensor circuit (Fig. 9-10) consists of an ac oscillator circuit, an inductor coil L_1 , and an output voltage detector (or demodulator circuit) that senses the amplitude of the output waveform produced by the oscillator. When nothing is near the inductor sensor head, the oscillator amplitude will stabilize to some nominal value. But when a metallic target is in the field of the coil, the magnetic field of the coil will induce eddy currents in the target. These eddy currents create a magnetic field around the target, and this field will change the resistance component of the impedance of the sensor coil. This interaction will cause a sudden drop in the output amplitude of the oscillator, and this drop can be used to indicate the presence of the object.

The reduction of amplitude is usually quite sharp with respect to position. At some minimum *deadband* gap (usually 5 to 20 mils) the amplitude will drop to zero.¹ Below this distance, sensing will not occur.

Other inductive proximity sensors operate by allowing the metallic target to create a change in the oscillator frequency. If a frequency-selective circuit is monitoring the output, then its output level is a function of target position.

In both amplitude and frequency versions, the inductor sensor coil is calibrated using a standard target. In many cases a 30 mm × 30 mm × 1 mm mild steel disk at a specified sensing range is used as the standard.

MAGNETIC PROXIMITY SWITCHES

Reed switches are a class of switches used in certain areas of electronics. These devices consist of a set of magnetized switch contacts inside an evacuated glass envelope (Fig. 9-11). When a magnet is brought near the glass

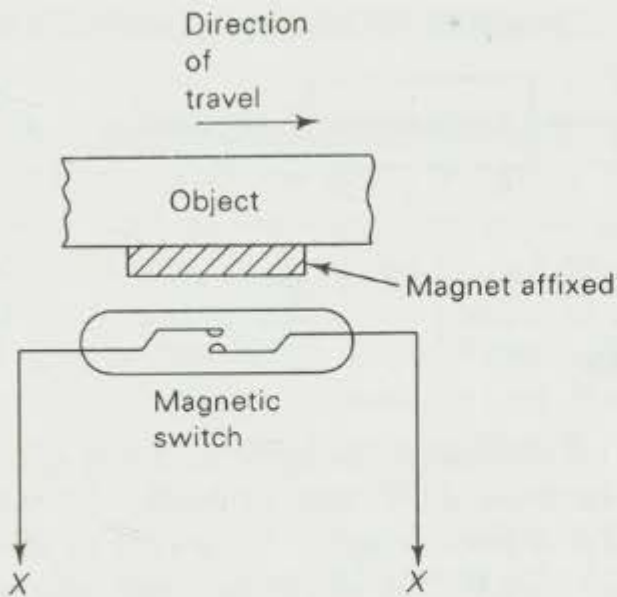


Figure 9–11 Magnetic reed switch proximity sensor.

envelope, the switch contacts either move apart or come together, depending on which pole of the magnet is nearest. Some reed switches are *normally closed* (N.C.), so they open when the magnet is present. Others are *normally open* (N.O.), so they close when the magnet is close. Still others are single-pole, double-throw (SPDT) types, so they provide both N.C. and N.O. functions.

Some reed switches are used in explosive atmospheres (natural gas, gasoline vapors, etc.) where a regular electrical switch would spark and cause detonation or fire. These explosion-proof reed switches have dc electro-magnet coils surrounding them. When current is applied to the coil, a magnetic field builds up and actuates the reed switch.

Another application of magnet-operated reed switches is in intruder alarm systems for windows and doors. A close look at some such intruder alarms will reveal two pieces placed in close proximity, one on the moving part of the window and the other on the window frame, yet neither piece touching the other. The component on the moving part of the window is a permanent magnet, whereas the component on the fixed portion is a reed switch. When the window is closed, the magnet actuates a switch and closes the internal contacts. But when the window is raised, the magnet moves away, and the switch contacts open—causing the alarm to sound if everything is in good working order.

In the magnetic proximity sensor shown in Fig. 9–11, the object being detected is fitted with a permanent magnet. When the magnet comes close to the reed switch, it causes the switch to actuate and send a signal to the electronic circuits monitoring the process. Figure 9–12 shows two examples of such circuits. In Fig. 9–12(a), the reed switch is connected in series with a light-emitting diode (LED) and a current-limiting resistor R_1 . When the switch closes, the dc power supply V_1 is connected to the LED/ R_1 circuit,

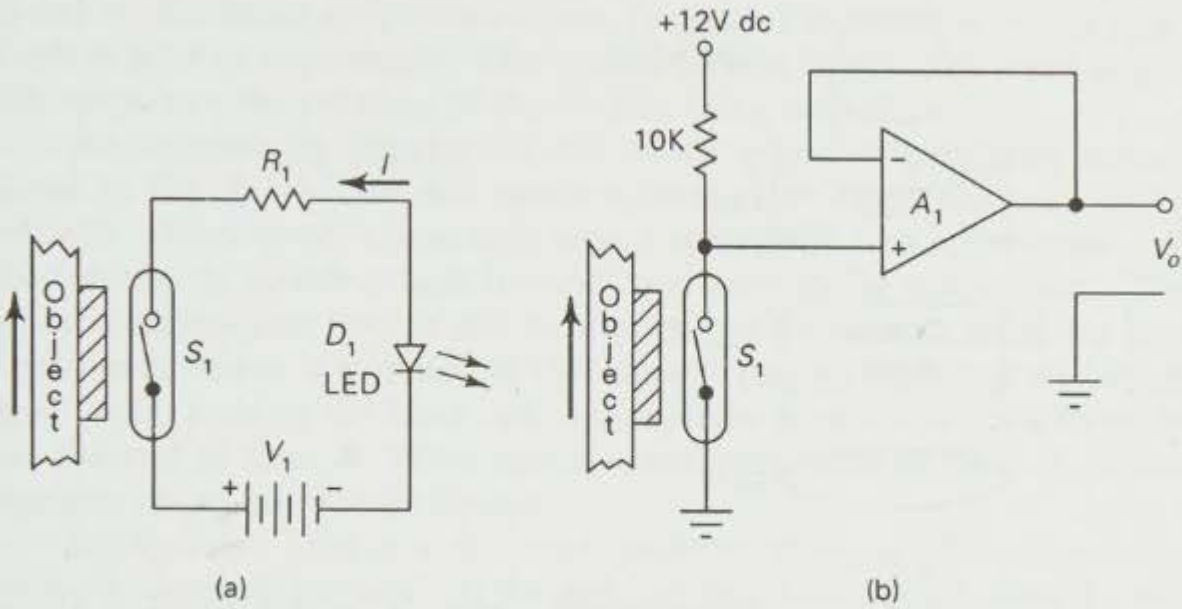


Figure 9-12 Reed switch circuits: (a) simplest form; (b) operational electronic form.

causing the LED to light up. The lighted LED indicates that the object being detected is present and in position.

A second version is shown in Fig. 9-12(b). If a N.O. reed switch is used, then the noninverting input (+) of the op-amp (see Chapters 19 and 20) will be placed at a logical HIGH level, that is, about +12 V with the configuration as shown. This voltage level is reflected as a HIGH at the output V_o . But when the reed switch closes, the noninverting input is grounded, so the op-amp sees an input voltage of zero. This LOW condition is reflected as a LOW output. Thus, the output terminal of the op-amp will switch between HIGH and LOW as the object approaches, and back to HIGH when the object passes. The polarity can be reversed by using a N.C. switch instead of a N.O., as shown.

LIGHT-OPERATED PROXIMITY/PRESENCE SENSORS

A number of different light sensors are available on the market (see Chapter 15). Devices such as photoconductive cells, photovoltaic cells, photodiodes, and phototransistors are used in various applications. Wavelength sensitivities can run from the far infrared to the far ultraviolet or near-X-ray regions of the electromagnetic spectrum. These sensors provide an output voltage, output current, or change of resistance in response to an impinging light. We will not dwell here on the nature of these electro-optical (E-O) sensors but will discuss how they are used for proximity sensing.

The simplest form of light-based sensor system is shown in Fig. 9-13. In this system the sensor (a phototransistor) is positioned opposite a light