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Capacitive Sensors

Design and Applications

Larry K. Baxter

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Preface

Capacitive sensors can solve many different types of sensing and measurement problems. They can be integrated into a printed circuit board or a microchip and offer non-contact sensing with nearly infinite resolution. They are used for rotary and linear position encoding, liquid level sensing, touch sensing, sensitive micrometers, digital carpenter's levels, keyswitches, light switches and proximity detection. Your telephone and tape recorder probably use electret microphones with capacitive sensing, and your car's airbag may be deployed by a silicon accelerometer which uses capacitive sensing. The use of capacitive sensors is increasing rapidly as designers discover their virtues.

Capacitive sensors can be unaffected by temperature, humidity, or mechanical misalignment, and shielding against stray electric fields is simple compared to shielding an inductive sensor against magnetic disturbances. Capacitive transducer accuracy is excellent, as the plate patterns which determine accuracy can be reproduced photographically with micron precision. The technology is easily integrated, and is displacing traditional silicon-based transducers using piezoresistive and piezoelectric effects, as the sensitivity and stability with temperature are ten times better. Capacitive sensors consume very little power; battery life for small portable products may be several years.

Several factors inhibit the use of capacitive sensors, including the specialized circuits needed and the lack of understanding of the technology, including a widely held superstition that capacitive sensors are nonlinear and cannot operate at extremes of humidity. But many products which embed capacitive encoders have been successful in the market. This book surveys different types of sensors and shows how to build rugged, reliable capacitive sensors with high accuracy and low parts cost. Several product designs which use capacitive sensors are analyzed in detail.

The book is organized as follows.

- **Basics** This section covers theoretical background, different electrode geometries, and basic circuit designs.

- **Applications** Four different uses of capacitive sensors are presented: micrometers, proximity detectors, motion encoders, and some miscellaneous sensors. The theory behind these different uses is discussed.
- **Design** The electrode configurations and the basic circuit designs which were briefly discussed in the Basics section are more fully explored here.
- **Products** This section presents design details of several different products which use capacitive sensors.

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Capacitive Sensors