WILSON HURD
Our Innovation, Your Solution

Capacitive Switch Design Guidelines

Capacitive switches are electronic devices that detect the presence or absence of a conductive object, such as a finger, by measuring changes in **capacitance**. This means that there are no mechanical components within the switch, eliminating any potential mechanical failure. They can be used in a variety of applications including automobiles, industrial applications, computers, cell phones, home appliance, and medical equipment.

Because every capacitive switch we create is designed custom for your unique application, certain specifications are required for each design. This set of design guidelines was created to assist you with the design and creation of your custom capacitive switch. Our highly skilled engineering team will carefully review your requirements to assist in designing the optimum switch for your application.

Things to Consider when Designing your Capacitive Switch:

1. **Environmental conditions** *(indoor/outdoor, harsh environments, sunlight, etc.)*
2. **Mechanical requirements** *(tactile feedback, actuations, etc.)*
3. **Electrical requirements** *(layout, resistance, shielding, etc.)*
4. **Appearance** *(embossing, color matching, selective texture, etc.)*
5. **Certifications** *(ISO, U.L., etc.)*

Capacitive Switch Construction:

A capacitive switch consists of three main sections: the **graphic overlay**, **circuit**, and **backer**. The overlay displays your graphics and can also include **windows**, **embossing**, **coatings**, **adhesives**, and **selective texturing**. The switch will either be a **Flexible Printed Circuit (FPC)** or a **Printed Circuit Board (PCB)**. The backer is the final part of your capacitive switch, and may or may not include an adhesive that must bond to your specific **substrate**.

Overlay Materials: The overlay is the outermost layer, and will establish the design and feel of your capacitive switch. All overlays for a capacitive switch must be constructed out of a non-conductive material, like plastic or glass. This can be determined by referring to a material's **dielectric constant**. A dielectric constant, also known as relative permittivity, is the factor by which the electrical field between the charges is decreased or increased. It is depicted by the symbol ε_r. The higher the dielectric constant, the better sensitivity your overlay will have, and the thicker the material can be. Please refer to **Table 1** below for a selection of materials and their dielectric constants.

Table 1

Material	ε_r
Air	1.0
Formica	4.6 - 4.9
Glass (Standard)	7.6 – 8.0
Glass (Ceramic)	6.0
PET Film (Mylar ®)	3.2
Polycarbonate (Lexan®)	2.9 – 3.0
Acrylic (Plexiglass®)	2.8
ABS	2.4 – 4.1
Wood	1.2 – 2.5
Gypsum (Drywall)	2.5 – 6.0

The most common materials used for overlays are plastic, acrylic, and glass due to their durability and versatility. Any adhesives that are used on the overlay must make good mechanical contact, as air gaps reduce the dielectric constant and sensing uniformity. The adhesive must also be non-conductive. A commonly used acceptable adhesive is the 3M 200MP series acrylic adhesive (3M467, 3M468).

Capacitive Switch Design Guidelines

Color Matching: Wilson-Hurd most commonly uses the **Pantone Matching System** or **CMYK color model** to match custom colors. We can match to a specified or provided color. If you wish to submit a sample, we prefer that it be 2 x 2" in size.

Artwork: Please visit the Resources section on Wilson-Hurd's website to submit artwork, or simply visit the link below.

www.wilsonhurd.com/submit-artwork

We accept the following types of artwork (listed in order of preference):

- AutoCAD (2D)*
- Solidworks (3D)*
- IGES (3D)
- STEP (3D)
- DXF (2D)
- Gerber (PCB) – include dimensional of your part in one of the other formats
- Adobe Illustrator (Graphics) – include dimensions of your part
- PDF (Graphics or Dimensional Support) – with embedded fonts (Graphics)
- Postscript (Graphics) – with embedded fonts

**Most preferred forms of artwork*

Ultraviolet Hard-coats: Should you decide that you would like your capacitive switch to have a plastic overlay, you may want to consider an ultraviolet hard-coat. Plastic materials themselves may not hold up well to weather and ultraviolet light without enhancements. Using an ultraviolet hard-coat on these materials increases their durability, enhances their appearance, and protects them from the environment. Some coatings are available from the manufacturer themselves, or from Wilson-Hurd.

Embossing: Embossing is a physical change to the shape of a normally flat overlay film. Types of embossing include:

- **Pad** (pillow, plateau)
- **Dome** (spherical, machined)
- **Rim** (rail, ridge, ring, perimeter)

Polycarbonate material produces very crisp embossing; however it is not preferred for switches due to its limited flexing properties. Polyester material has increased flexibility which makes it a good choice for embossing with switches. Heat stamping or forming is required to emboss polyester overlays. Embossing is not available on glass overlays.

Laser Cutting: Laser cutting is a form of cutting that utilizes a CO2 laser as a cost-effective alternative to steel rule die cutting. Cutting with a laser can also provide improved precision, since the laser beam is narrow and cuts all the way through the material, dropping out all internal cuts.

Tooling: Two tooling techniques are generally used when producing a custom capacitive switch, steel rule die and hard tools. **Steel rule die** tooling consists of cutting blades (rules) embedded in a wooden base and surrounded by rubber cushions. Outside shapes and interior holes can then be die cut in a single stroke. Steel rule die tooling has a tolerance of ±0.10", and lasts approximately 25,000 strikes before needing to be replaced. **Hard tools** (Class A Tools) perform the same process; however they are made out of harder steel and consist of both male and female tools, which results in a tighter tolerance of ±0.005" and an extended tool life that lasts millions of strikes before replacement.

Connectors: When selecting a connector for your capacitive switch, a number of factors should be considered including cost, reliability, performance, design, environment, as well as any anticipated insertions and extractions. Mechanical specifications for most interface

terminations are standard. Consequently, circuit construction techniques can be designed for compatibility with specific types of interface termination methods. The typical switch, for instance, consists of one or two **flex tails**. As a result, only certain types of interface terminations are possible. There are two main types of connectors, single row/crimp and ZIF (Zero Insertion Force).

Single Row/Crimp Type connectors provide a gas-tight termination interface between a flex tail and connector. In this method the switch is supplied with a flex tail of a specific length. Crimped to the flex tail(s) are male or female pins with or without housing. The cost of this interface depends on its contact plating material (tin/lead or gold) and the number of pins required. The Berg Clincher 65801 is a commonly used connector of this type and is available in either receptacle or pin type construction. Other common manufacturers are Nicomatic, Tyco, Molex, and Taiwan.

Zero Insertion Force (ZIF) connectors require very little force for insertion. Common manufacturers include Molex, Hirose, and Tyco.

Circuit Types: There are two main types of circuits that can be included in your capacitive switch:

- **Printed Circuit Board (PCB):** An electrical circuit manufactured using standard printing or screen-printing methods along with conductive inks.
- **Flexible Printed Circuit (FPC):** An etched circuit using Kapton polyimide film as a substrate. The end result is a thinner, higher density, and more flexible printed circuit.

Windows: The type of window you choose for your capacitive switch depends on the type of display you plan on using. **LCD displays** need clear windows. Anti-glare is okay for LCD displays within .125”, however gloss is required for distances greater than .125”. **VFDs** are a bit more forgiving and may accept a matte finish if the user will be close to the window. **Segment LED displays** require even less clarity. A velvet texture can be acceptable if the display is close (<.040”). Matte or fine textures should work okay at an increased distance (.040”-.062”), but gloss or antiglare should be used for greater distances (>.062”). **Discrete LED displays** work well under velvet textures.

Backlighting Options: We offer **LEDs**, **electro-luminescence**, **fiber optics**, and **light guide film** for backlighting options.

Backer Adhesive Selection:

100 MP Acrylic: Highest performing 3M **PSA** with resistance to solvents and up to 500°F.

200MP High Performance Acrylic: Excellent resistance to solvents and up to 400°F.

220 Industrial Acrylic: Good chemical resistance and shear strength. Resists up to 350°F.

300MP High Strength Acrylic: Bonds low surface energy (LSE) plastics and resists heat up to 250°F.

Moisture Resistant Designs: Water droplets and constant water streams adversely affect capacitance sensing causing false triggering. Combating this begins with the physical construction to protect and route water away from the switch areas. The use of Guard and Shield sensors with higher order processing further combats water effects.

Input Devices: A capacitive design can be configured to act as a variety of input devices such as buttons, sliders (switches or potentiometer), touch-pads, touchscreens, and proximity sensing. Please refer to **Table 2** on the following page for a detailed overview on each interface and what applications they work best in.

Capacitive Switch Design Guidelines

Technical Data:

- Utilize Cypress and Atmel in-system serial programmable flash memory micro-controllers
- Wide range of micro-controller packages available
- 4MIPS 8bit Harvard architecture
- Configurable analog/digital GPIO
- Internal oscillator
- Counters, timers, PWM, ADC, Vref
- Supports serial communication 12C, SPI, UART, USB

Specifications:

Type	Specification
RAM	512 to 1k
Flash Memory	8k to 16k
Supply Range	2.4V – 5.25V
Possible Battery Supply	1.2V
Industrial Temperature Range	-40°C *(-40°F)* to 85°C *(185°F)*

Table 2

Interface Type	Overview	Applications
Buttons	Low-cost, simple solution for integrating up to 46 buttons. Flexible technology enables sensing through a wide range of protective overlay materials. Buttons can be calibrated individually with firmware parameters.	Wireless handsets, PC peripherals, appliances, LCD monitors, TVs, PC mice, laptops, automotive, toys
Sliders	Useful in applications requiring precise multi-level sensing: - Volume control - Brightness control - Temperature control Achieve greater resolution than is inherent to IC pin count.	Wireless handsets, PC peripherals, appliances, LCD monitors, TVs, laptops, digital cameras, automotive, exercise equipment
Touch-Pads	Touch-pads can be integrated into non-traditional touch-pad applications, and automated design makes touch-pad implementation easy. Capacitive sensing can offer a cost-reduction to expensive modules and resistive overlay technologies.	Wireless handsets, laptops, keyboards
Touchscreens	Touchscreens can be integrated into non-traditional touchscreen applications. Configurable I/O allows for the support of a wide range of panel sizes. Touchscreens are multi-touch capable.	Wireless handsets, appliances, hand-held devices, kiosks, PQS terminals
Proximity Sensing	Proximity sensing allows you to wake your system before the user's hand reaches the touch surface. Proximity sensing can be applied to any application that senses a conductive object, such as fluid-level sensors and pulse-rate monitors. It is implemented by adjusting the sensor design and sensitivity of the capacitance measurement.	Appliances, keyboards, PC mice, laptops, automotive, lighting sensors, industrial sensors, controls

GLOSSARY

Adhesives: Substances applied to the surfaces of materials within the different layers of a capacitive switch that binds them together and resists separation.

Backer: A rigid substrate or subpanel to which the back surface of a capacitive switch is attached.

Backlighting: Illumination originating from within or behind the switch panel which outlines or accents specific areas. Typical lights are LEDs, fiber optics, electro-luminescence, and light guide film.

Capacitance: The property exhibited by two conductors separated by a dielectric, whereby an electric charge becomes stored between the conductors.

Capacitive Switches: Detects the presence or absence of a conductive object, such as a finger, by measuring changes in capacitance.

Carbon: A non-metallic element that conducts electricity.

Circuit: The main functioning component of a switch.

CMYK Color Model: Also known as process color and four color, it is a color model used in color printing utilizing the four inks cyan, magenta, yellow, and key (black).

Color Matching: The physical creation of a color in the range of one-dimensional hues.

Connector: A device that provides electrical connection.

Current (A or I) Unit, Amp: The flow of electricity, i.e., the characteristic drift movement of carriers such as ions, electrons, or holes. I=E/R

Die Cut: To make an opening by means of a sharp edged steel knife set in a holding tool.

Dielectric: A material which is a nonconductor of electricity (insulator).

Dielectric Constant: The factor by which the electrical field between the charges is decreased or increased.

Discrete LED Display: An electronic flat panel display that utilizes discrete light-emitting diodes.

Electro-luminescent Lighting (EL): Light produced by charged phosphorous.

Embossing: A shallow profile extending above the surface of an overlay selectively formed under heat and/or pressure with a die, i.e., rim (raised border), pad (raised keys), and raised lettering. Achieved by using a steel rule die. Material is forced upward a max. of .006” to .010” from the substrate, thus creating a raised image.

Feedback: The mechanism by which the operator senses that a switch has been activated; audio, visual, or tactile.

Fiber Optic: Extruded materials, such as certain plastic filaments, which provide paths for light.

Flexible Printed Circuit (FPC): A printed circuit using Kapton polyimide film as a substrate.

Flexible Tail: The termination exit which is an integral part of a flexible circuit in all flexible switches.

Graphic Overlay: The outer visible layer of the capacitive switch and the layer on which the graphics are printed.

Hard-Coating: A coating applied to the surface making it impervious to particular chemicals and at the same time adding scratch resistance.

Hard Tools (Class A Tools): Tooling made out of steel which results in a tighter tolerance and extended tooling life compared to steel rule die tooling.

Interface: A device used so that two or more independent systems can meet and act on or communicate with one another.

Laser Cutting: A form of cutting that utilizes a CO2 laser.

LCD: Liquid Crystal Display

LED: Light-Emitting Diode

LED Display: A flat panel lighting or video display which utilizes light-emitting diodes.

Light Guide Film: A more recently developed backlighting technology that uses LEDs to create a solid film of light.

Pantone Matching System (PMS): An ink color designation system commonly used in a variety of industries, including printing as well as the manufacturing of paint, fabric, and plastics.

Polycarbonate: A plastic material often used for overlays due to its excellent clarity, stability, printing, and die cutting characteristics.

Polyester: A plastic material often used for overlays, also known as polyethylene terephthalate (PET).

Pressure Sensitive Adhesive (PSA): An adhesive that is activated by pressure.

Printed Circuit Board (PCB): A circuit board comprised of conductive tracks, pads, and other features that have been etched and laminated onto a non-conductive substrate.

Segment LED Display: A type of electronic display using LEDs to light segments that make up decimal numerals.

Selective Texture: A surface coating to texture selective areas on a graphic overlay.

Single Row/Crimp Type Connector: Provides a gas-tight termination interface between a flex tail and a connector.

Steel Rule Die: Used to fabricate plastics and adhesives to their final configuration. Outside shapes and interior holes are die cut in a single stroke. The die consists of cutting blades (rules) embedded in a wooden base and surrounded by rubber cushions.

Substrate: A layer of film in a laminate. In flexible circuitry, the plastic film to which the electrically conductive materials is laminated or screen-printed.

Switch: The electronic layer of a capacitive switch.

Termination: The means to electrically connect the contact switches of a capacitive switch.

Ultraviolet Curing: A system which employs ultraviolet radiation to complete the curing process of hard-coats.

Vacuum Fluorescent Display (VFD): A display that emits a very bright light with high contrast.

Voltage (V or E): Electromotive force, or difference of potential; E=IR, where I is current and R is resistance.

Windows: Portions of the graphic overlay material that do not have color printed on them. Hard-coats and textures can be applied to these areas as well.

ZIF Connector: Zero Insertion Force connector.