**The TouchSensor™ Technologies Field Effect™ approach uses one ASIC per switch or sensor. Is that required? Could you use one ASIC to serve multiple switches?**

■ Having one ASIC located at each switch or sensor is required for TouchSensor™ Technologies' Field Effect™ approach, and is much to your advantage. Combined with our proprietary electrode structure, having an ASIC at each switch ensures robust performance. It eliminates several major problems associated with capacitive sensing approaches that use a shared ASIC, including noise pick up and cross talk on the analog traces between the point of touch and their ASIC.

**Isn't one ASIC per switch more expensive than using a shared ASIC?**

■ Using one of our ASICs per switch is not necessarily more expensive than using a shared capacitive sensing ASIC, unless your application requires perhaps 30 or more switches. And, even then, many factors other than just ASIC cost need to be considered in order to compare total system cost for each approach. For some applications requiring only a few switches, our approach can even be less expensive than using a shared capacitive sensing ASIC. In addition, we can often deliver improved performance at lower overall cost, compared to shared ASIC approaches, because we eliminate or reduce your need for product design and software resources.

**Was your ASIC designed by TouchSensor™ Technologies, or is it something available from other sources?**

■ We designed our ASIC from the ground up to enable the creation of a software free, digital, touch activated switch with robust performance. We are a fabless semiconductor manufacturer of our ASIC. It is not available from any other source.

**What are the typical output signals from the TouchSensor™ ASIC?**

■ Typical output signals from our ASIC include a digital "active high" output and a digital "active low" output. The active high output signal is at ground potential through a pull down resistor when the sensor is not activated, and goes to approximately 5VDC when the sensor is activated. The active low output signal is at 5VDC through a pull up resistor when the sensor is not activated, and goes to ground potential when the sensor is activated. The ASIC is available with three different output configurations; PD, PE, and ND. The PD version is essentially a P channel open drain configuration (active high). The ND version is essentially an N channel open drain configuration (active low). The PE version is essentially a P channel (NPN) emitter follower configuration (active high) with an internal diode.

**Is 5VDC required for the power source and what current does the TouchCell™ draw from the power supply?**

■ 5VDC +/- 10% is the recommended power source. If only battery voltage of say 12VDC is available, a voltage regulator circuit is supplied with the TouchCell™ electronics to regulate the 12VDC down to 5VDC. Average current draw in the unactivated state is 16 microamps typically. This "quiescent" current draw is much less than traditional capacitive sensing approaches. Current draw in the activated state depends on the output load and is usually 1 milliamp or less, but may approach 10 milliamps. Therefore, the power source should be capable of supplying approximately 10 milliamps.

**What are the economics of TouchSensor's™ approach compared to using a tact switch?**

■ A TouchSensor™ Technologies touch activated switch will be more expensive than a simple 25 cent tact switch. However, the economics are almost always still in TouchSensor's™ favor when all system costs are taken into consideration. And, TouchSensor's™ Field Effect™ technology allows you to offer your customers unique features that are not possible with tact switches. TouchSensor™ eliminates the need for multiple plastic switch buttons, eliminates the tooling cost for the buttons and other associated hardware, eliminates many parts in the overall instrument panel or center stack assembly, eliminates form, fit, and BSR concerns, eliminates concerns about liquids or dirt getting into the switches, and reduces or eliminates warranty costs due to switch failure. So, in addition to the styling flexibility and "wow factor" TouchSensor's™ Field Effect™ technology provides, it can often result in an overall system cost that is equal to, or lower than, the cost of using tact switches.

**I see that your standard application uses a 3 wire approach (power, ground, and output). Is a 2 wire approach possible?**

■ Yes, a 2 wire approach is possible (power and ground). We offer several products today that use our patented 2 wire approach.

**What are the limits to how thin or how thick the plastic substrate can be?**

■ In theory, the plastic substrate can be as thin as .025 mm or as thick as about 12 mm. Practically, most plastic substrates on our production products range from 1 mm to 3 mm thick. One product, our SensaTank™ system, senses liquids through a 9 mm thick plastic tank wall. Thicker substrates tend to require larger TouchCells™, so the substrate thickness used for your application may depend on how much room you have to place all the required TouchCells™.

**What are the limits to how small or how large the TouchCell™ electrode structure, can be?**

■ The size of the TouchCell™ electrode structure is dependent on the application, the substrate thickness, the object to be sensed, and so on. Theoretically, the TouchCell™ electrode structure could be as small as the head of a pin, or as large as about 16 square centimeters. Typically, smaller electrode structures are used with thinner substrates and larger electrode structures are used with thicker substrates. Most of our products in production use TouchCells™ that range in size from 12mm X 12mm up to 25mm X 25mm.

**If I want to have a large surface area touch sensitive, can I use one TouchCell™, or will I have to use multiple TouchCells™?**

■ If you want an area larger than approximately 16 square centimeters to be touch sensitive, you will need to use multiple TouchCells™.

**What is the minimum center-to-center spacing for TouchCells™ and how many TouchCells™ can I have in a given area?**

■ The minimum center-to-center spacing for TouchCells™ and TouchCell™ size, is dependent on the application, the substrate thickness, the object to be sensed, and so on. Center-to-center spacing also depends on the shape used for the TouchCell™ electrode pattern (e.g. square, rectangular, round). As an example, a guideline would be to allow a 21 mm center-to-center spacing for square electrode patterns used on a 3 mm thick polycarbonate substrate. Thus, if you had a 200 mm by 200 mm panel, you could place up to 100 TouchCells™, but would have to reduce that number depending on space required for other features, circuit traces, and external electronic components.

**Are there any direct competitors that use two electrodes that work like they do in your TouchCells™?**

■ To our knowledge, there are no direct competitors that use two active electrodes like we do. And, if such a competitor exists, they are almost certainly violating our patents. Some capacitive sensing approaches use two electrodes, but one of the electrodes is a ground electrode. Only one electrode is active. This results in a sensor that is less robust, less precise, and more sensitive to electrical noise and surface contaminants.

**Can I use chrome plated "buttons" in my switch, instrument panel, or center stack applications?**

■ A solid surface of chrome or other conductive material will activate all of the sensors behind the conductive surface. A substrate that is totally conductive over it's whole surface area, like chrome plated plastic, can't be used with Field Effect™ sensing, or any capacitive sensing approach either. A chrome plated area over a TouchCell™ can be used, as long as it is isolated from surrounding metal by some non-conductive dielectric material. Likewise, a chrome plated area surrounding a TouchCell™ can be used, as long as the area directly over the TouchCell™ is non-conductive dielectric material. Chrome-like materials are also available that look like chrome, but are nonconductive. These materials can be used anywhere on in-mold decorated panels with TouchCells™ behind them to create a chrome-look user interface.

**Can I change the sensitivity of the TouchCells™ later?**

■ TouchCell™ sensitivity is set at the design stage, taking into account all factors that can affect performance now, and over time. Once a product is in production, the sensitivity does not ever have to be changed. No sensitivity changes are ever required to accommodate drift or temperature extremes, for example. If, for some reason, you do desire to change the sensitivity level in the future, a simple resistor value change is all that is required, along with testing to ensure product performance is still within your desired range.

**Can light shine through the TouchCell™ electrode structure?**

■ Yes, light can shine through the TouchCell™ electrode structure. Usually when light transmission is required, a cross hatched, lined, or Indium Tin Oxide inner electrode pattern is used on clear flexible printed circuit carrier or translucent FR4 PCB material.

**What methods of lighting can be used?**

■ A wide variety of lighting methods can be used, including several pioneered by, and patented by, TouchSensor™ Technologies that integrate lighting with touch sensitive controls. Lighting methods commonly used with TouchSensor™ Technologies Field Effect™ switches and sensors include jewel lighting with discrete LEDs, ring lighting with an LED in the center of the TouchCell™ along with an associated reflector, icon lighting using light guides or with LED light projected from a second lighting PCB, and side lighting using light guides or reflectors.

**Can an LED be placed right in the center of the TouchCell™?**

■ Yes, an LED can be placed in the center of the TouchCell™, and is placed there on our production products that offer ring lighting of switch "buttons".

**Can metal objects or other materials be located behind the TouchCell™ without affecting its performance?**

■ Yes, metal objects and other materials can be located behind the TouchCell™. Our guideline is that they be placed at least 10 mm behind the TouchCell™ to eliminate any effect on performance. Metal objects and other materials can be located closer than 10 mm behind the TouchCell™ if we know about it at the design stage so we can make allowances for the presence of these materials.

**Must the recommended adhesive be used to adhere the TouchCell™ electronics to the substrate?**

■ Yes, currently the recommended adhesive must be used to adhere the TouchCell™ electronics to the substrate to avoid delamination and minimize air bubbles or air gaps. These adhesives have been proven over years of field experience and exhaustive environmental testing to be the best adhesives for the purpose.

**Can you sense a finger or hand before it touches the substrate surface?**

■ Yes, by making our TouchCells™ more sensitive, we can detect a finger or hand just before it touches the substrate surface. Our technology is optimized for "touch sensing", so if you need stable, repeatable, and robust performance, we would recommend it not be used for "proximity sensing" to sense a finger or hand from a considerable distance away.

**Can you detect a finger through a glove?**

■ Yes, we can design TouchCells™ for detecting a gloved finger. We can design to accommodate a variety of gloves, from thin driving gloves to leather gloves with a liner. TouchCells™ may have to be somewhat larger to reliably detect gloved fingers, compared to those that only have to detect non-gloved fingers. And, of course, because the sensitivity of the TouchCells™ must be set higher to detect the finger through the glove, the TouchCell™ may detect a non-gloved finger before it actually touches the substrate surface.

**Can the substrate be curved or have compound shapes?**

■ Yes, you can now think "out of the box" and can freely design user interface panels with smooth, hole-free surfaces incorporating curves or compound shapes. TouchSensor's™ technology works well on shaped panels by using flexible printed circuit carrier, thin FR4 PCB material, insert molding, or over molding.

**How long will it take you to provide a prototype for single switch application?**

■ Prototypes can be provided for simple straight forward applications without lighting in as little as two weeks. Other, more complex applications, and those with lighting, may take one to three months. Complex, multiple sensor applications with lighting may take longer.

**Are there any problems with adjacent key activation when a person has large fingers or uses a thumb to activate the switch?**

■ Our precise, localized sensing solution eliminates any problems with adjacent key activation, especially when a ground ring is used around our proprietary electrode structure. Theoretically, extremely small TouchCells™, located very close together behind a very thin substrate, could result in adjacent keys being activated by a large finger or thumb. However, in reality, adjacent key activation has never been reported as a problem with over 8 million TouchSensor™ Technologies user interface modules in use on almost 200 different products over the last ten years. Adjacent key activation is a common problem associated with traditional capacitive sensing approaches which require software or firmware to minimize this problem.

**Can there be sensitivity variations switch to switch on a panel with many switches (i.e. can some switches be more sensitive than others)?**

■ Yes, each TouchCell™ is an individual sensor, the sensitivity of which can be individually adjusted at the design stage as the application requires. Any switch, or switches, on a panel can be set to be more sensitive or less sensitive than the other switches on the panel.

**TouchSensor™ ASIC Specific Questions and Answers:**

**What is the Maximum operating voltage limit?**

■ Specified limits are 5VDC +/- 10%. Voltages outside of that range will significantly affect performance and higher voltages may damage the ASIC. Maximum Operating voltage limit is 5.5VDC. The absolute maximum voltage that can be applied to each pin of the device referenced to the ground pin is no more than one diode drop higher than the supply voltage.

**What is the Minimum operating voltage limit?**

■ Specified limits are 5VDC +/- 10%. Voltages outside of that range will significantly affect performance. Minimum operating voltage limit is 4 VDC.

**What is the Maximum operating current when idle?**

■ Maximum average idle current is 30 microamps. Typical average idle current (quiescent current) is 16 microamps.

**What is the Maximum operating current when touch is present?**

■ There are ASICs with three different output configurations. Maximum operating current when touch is present is load dependent and must not exceed 10 milliamps for the PD and ND versions and 1 milliamp for the PE version. Again, actual current will depend on the output load and is typically about 1 milliamp or less.

**What is the Minimum operating current?**

■ Minimum operating current when idle is 3 microamps. Typical average idle current (quiescent current) is 16 microamps.

**What is the Maximum operating Temperature?**

■ +120 degrees C.

**What is the Maximum Storage Temperature?**

■ +150 degrees C.

**What is the Minimum operating Temperature?**

■ -40 degrees C.

**What are the output voltage specs for the part over the operating voltage range?**

■ Output voltage changes will follow changes in operating voltage.

**What are the different types of output signals available?**

■ With additional circuitry external to the ASIC, the output signal could be handled many different ways and customized to fit your specific system needs (i.e. Logic High, Logic Low, Current Loop, Resistive Ladder, etc.)

**What is the range of recommended load resistors for the part and to what voltage source?**

■ 4.7 Kohm to 47 Kohm is the recommended range. 10 Kohm is the typical value used. The PD and PE versions source voltage as described above. The ND version provides ground to an external source, recommended to be 5VDC +/-10%.

**What are the electromagnetic radiation and susceptibility levels of the part?**

■ Electromagnetic radiation and susceptibility levels are dependent on the complete TouchCell™ design and its operating environment, and not just on the ASIC. Field Effect™ technology is inherently less susceptible to EMI than many traditional capacitive sensor approaches.

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