Application Brief

Design Considerations for Inductive Touch Buttons for the Human-to-Machine Interface

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Sensor Products

Consumer electronic device designs need to be attractive and reliable to be successful. However, most devices still rely on mechanical buttons which often employ moving parts, gaskets, and cutouts leading to long term reliability issues, increased costs, and inferior immunity to environmental factors. Inductive touch buttons on the other hand enable aesthetically attractive, gasket less, and waterproof mechanical designs. These buttons are physically robust, can be used with gloves, and respond directly to the amount of force being applied on the conductive surface.

The three main components of the inductive touch button technology are the inductive sensor, target surface and an inductance to digital converter.

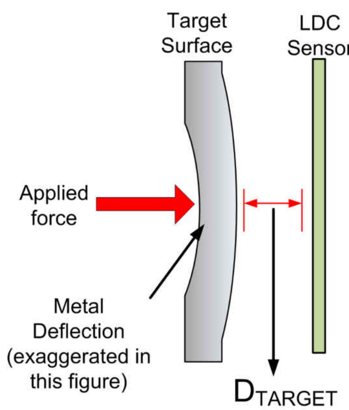

Figure 1. Inductive Touch Components

When a force is applied on the target surface, the material deflects slightly, reducing the distance between the inductive sensor and the target surface (D_{TARGET}). This change in D_{TARGET} changes the inductance of the sensor ($D_{TARGET} \propto$ Sensor Inductance) which is measured by the inductance to digital converter. When the force is removed the surface returns to its original shape.

The primary factors that contribute to the sensitivity of an inductive touch button are Target Material, Target Thickness and Target Distance (D_{TARGET}) and Sensor Size. Button sensitivity is defined in terms of force that needs to be applied on the target conductive surface to trigger a response.

Target Material

A material with higher electrical conductivity (σ) is a better target for inductive sensing technologies.

The amount of eddy currents being generated on the target surface are directly related to σ of the target material making higher conductivity materials (such as copper, aluminum, or silver) optimum targets for inductive touch buttons. A thin layer of conductive material can be added on to non-conductive materials like wood or plastic to enable inductive sensing. Refer to the *LDC Target Design* and *Sensor Design for Inductive Sensing Applications Using LDC* application reports for more information about Eddy Currents and LDC sensor design.

Target Thickness

Deflection produced in the target surface with a given amount of force is inversely proportional to the material's tensile strength and thickness. A given amount of force produces a larger deflection in a thinner or less rigid material than a thicker or more rigid one. See the *Inductive Sensing Design Calculator Tool* for more information regarding deflection in different materials.

Target Distance (D_{TARGET}) and Sensor Size

Inductive sensing relies on the interaction of EM fields generated by the inductive sensor and the eddy currents being induced on the conductive surface. The amount of eddy currents induced on the target surface decrease with an increase in D_{TARGET} as the target conductive surface now captures a smaller portion of the electromagnetic field being generated by the inductive sensor. In turn, the size of electromagnetic field lines generated by an inductive sensing coil is directly proportional to the diameter of the sensor. Figure 2 shows how to set D_{TARGET} as a percentage of the coil diameter for inductive touch.

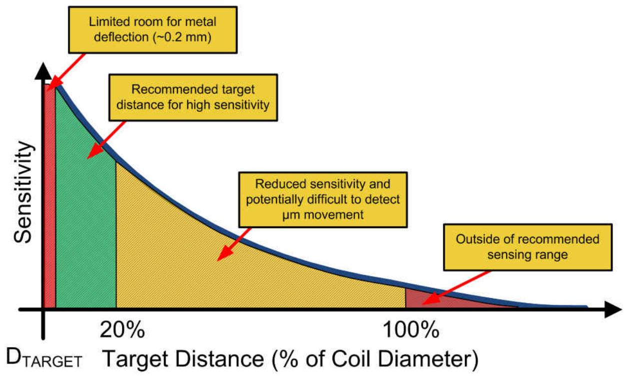

Figure 2. Shows Button Sensitivity as a Function of D_{TARGET}

Even with ideal target conductivity and target surface thickness, the amount of deflection produced in the target surface with nominal amounts of force is only at the micron level. For example, a 1.5 N (150 g) force applied on a 10 mm × 3 mm rectangular surface made out of 0.2 mm thick aluminum produces a meager 1.9 µm deflection in the surface. With D_{TARGET} = 0.2 mm and a 10 mm × 3 mm rectangular sensor, the 1.9 µm deflection changes the sensor's inductance by 5700 PPM. However, the LDC3114 is a high resolution inductance to digital converter designed specifically to sense minute changes in inductances as low as 200 PPM.

Being able to sense minute deflections in surfaces is not the only challenge that the LDC3114 addresses. D_{TARGET} changes are not limited to deflections in the target conductive surface during a button press. D_{TARGET} can vary due to a change in mechanical tolerances over temperature or during stress events (drops, dents, and so forth) which lead to a permanent deformation of the target surface. The LDC3114 addresses these situations by using an integrated base-line tracking algorithm that tracks slow changes in D_{TARGET} maintaining button functionality over a wide temperature range and varying degree of stress events.

High Resolution and Baseline Tracking are only a few of the features of the LDC3114 that make it the optimal inductance to digital converter for inductive touch buttons. The LDC3114 provides an easy to use 12-bit output that can be scaled to the amount of force being applied to the inductive touch button.

The scaled 12-bit signed output enables a direct force response that does not require any post processing, reducing system lag. In addition, the device has a push-pull output with configurable polarity that triggers when the output value reaches a pre-set threshold, emulating a mechanical button and eliminating the need for processor intervention.

The LDC3114 can be used to implement inductive touch buttons that can be tailored to trigger at specific force levels without requiring a change in the mechanical design of the encompassing enclosure. Figure 3 shows output response of the same button (Sensor Size = Button Size = 10 mm × 3 mm, D_{TARGET} = 0.2 mm) tuned to two different levels of force by simply changing the GAINn register setting of the LDC3114.

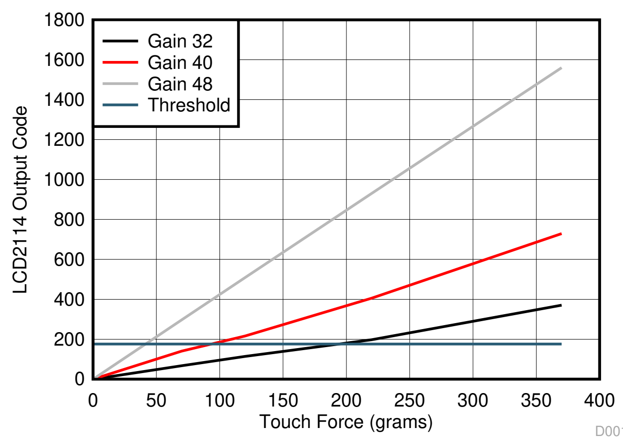

Figure 3. Configurable Button Sensitivity

The GAIN Factors (Figure 3) can be configured to values between 1 and 232.

Alternative Device Recommendations

LDC2112 and LDC2114 are an alternative inductive touch solution for low-power HMIs. For applications that do not require high resolution and need to operate above 1.8 V, the previous generation of LDC devices (LDC161X) can be used to implement inductive touch buttons. Refer to the *Inductive Sensing Touch-On-Metal Buttons Design Guide* application report for information regarding implementing Inductive Touch buttons using the LDC161X devices. LDC161X devices are general purpose inductance to digital converters that can operate from 3.3 V up to 5 V.

Table 1. Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
LDC3114	1.71 V ≤ VDD ≤ 1.89	Raw data mode available, reduced maximum scan rate
	V > 50-s button timeout	
LDC211X	1.71 V ≤ VDD ≤ 1.89	No raw data mode available, reduced maximum scan rate
	V > 50-s button timeout	
LDC1614	2.7 V ≤ VDD ≤ 3.6 V	Higher power consumption, reduced frequency range and needs a µcontroller
LDC1612	2.7 V ≤ VDD ≤ 3.6 V	Higher power consumption, reduced frequency range and needs a µcontroller