

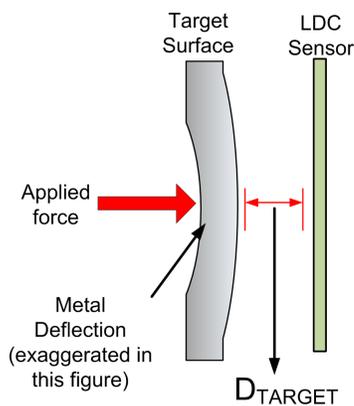
# Inductive Touch Buttons for HMIs

Varn Khanna, 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 ( $D_{TARGET} \propto \text{Sensor Inductance}$ ) 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 an inductive touch button's sensitivity <sup>(1)</sup> are Target Material, Target Thickness and Target Distance ( $D_{TARGET}$ ) and Sensor Size.

## Target Material

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

<sup>(1)</sup> Button Sensitivity is defined in terms of force that needs to be applied on the target conductive surface to trigger a response.

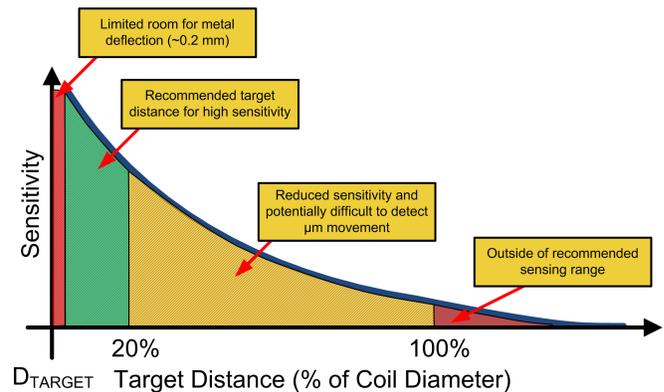
The amount of eddy currents <sup>(2)</sup> being generated on the target surface are directly related to  $\sigma$  of the target material making higher conductivity materials (such as copper, aluminum, or silver) optimum targets for inductive touch buttons. A thin layer of conductive material can be added on to non-conductive materials like wood or plastic to enable inductive sensing.

## 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 <sup>(3)</sup>.

## 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  $D_{TARGET}$**

<sup>(2)</sup> Refer to [SNOA957](#) and [SNOA930](#) for more information about Eddy Currents and LDC sensor design.

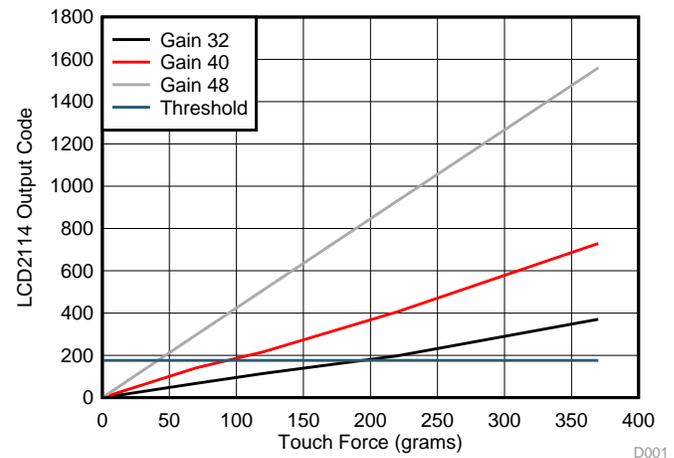
<sup>(3)</sup> Refer to [SLYC137A](#) for more information regarding deflection in different materials.

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 x 3 mm rectangular surface made out of 0.2 mm thick aluminum produces a meager 1.9  $\mu\text{m}$  deflection in the surface. With  $D_{\text{TARGET}} = 0.2$  mm and a 10 mm x 3 mm rectangular sensor, the 1.9  $\mu\text{m}$  deflection changes the sensor's inductance by 5700 PPM. However, the LDC2114 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 LDC2114 addresses.  $D_{\text{TARGET}}$  changes are not limited to deflections in the target conductive surface during a button press.  $D_{\text{TARGET}}$  can vary due to a change in mechanical tolerances over temperature or during stress events (drops, dents etc.) which lead to a permanent deformation of the target surface. The LDC2114 addresses these situations by using an integrated base-line tracking algorithm that tracks slow changes in  $D_{\text{TARGET}}$  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 LDC2114 that make it the optimal inductance to digital converter for inductive touch buttons. The LDC2114 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 LDC2114 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 x 3 mm,  $D_{\text{TARGET}} = 0.2$  mm) tuned to two different levels of force by simply changing the GAINn register setting of the LDC2114.



**Figure 3. Configurable Button Sensitivity**

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

#### Alternative Device Recommendations

For applications that don't 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<sup>(4)</sup>. LDC161X devices are general purpose inductance to digital converters that can operate from 3.3 V up to 5 V. LDC1101 is a single channel, low voltage, high speed general purpose device that can sample at 180Ksps.

<sup>(4)</sup> Refer to [SNOA951](#) for information regarding implementing Inductive Touch buttons using the LDC161X devices.

**Table 1. Device Recommendations**

Device	Optimized Parameter	Performance Trade-Off
LDC1614	$2.7 \text{ V} \leq \text{VDD} \leq 3.6 \text{ V}$	Higher power consumption, reduced frequency range and needs a $\mu$ controller
LDC1612	$2.7 \text{ V} \leq \text{VDD} \leq 3.6 \text{ V}$	Higher power consumption, reduced frequency range and needs a $\mu$ controller
LDC1101	High Sample Rate	Reduced frequency range and needs a $\mu$ controller

## IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2017, Texas Instruments Incorporated