

Inductive Sensing: Setting the Sensor Current-drive without a Fancy Impedance Analyzer



Ben Kasemsadeh

TI's multichannel inductance-to-digital converters (LDCs) feature an adjustable sensor current-drive to set the optimal sensor amplitude. The optimal current-drive level is sensor-dependent and based on the parallel resistance at resonant frequency, R_p . A sensor with a lower R_p needs a higher current-drive than one with a higher R_p .

The LDC1612, LDC1614, LDC1312 and LDC1314 have a dedicated current-drive control called the IDRIVE. The control is available on each channel individually, and settings go from $16\mu\text{A}$ (IDRIVE = 0) to 1.56mA (IDRIVE = 31). A higher current increases a sensor's oscillation amplitude. The preferred IDRIVE setting is the highest value for which $V_{\text{OSC}} < 1.8V_p$.

Why Is the Correct Sensor Amplitude Important?

A sensor oscillation amplitude (V_{OSC}) of $1.2V_p$ to $1.8V_p$ results in the best measurement accuracy. The following conditions could have a negative impact on performance:

- If $V_{\text{OSC}} > 1.8V_p$, due to the internal architecture of the LDC, the measurement accuracy is reduced over temperature.
- If $V_{\text{OSC}} < 1.2V_p$, then the Signal-to-noise ratio (SNR) degrades.
- If $V_{\text{OSC}} < \sim 0.5V_p$, then the sensor may not have a stable oscillation and the LDC cannot measure the inductance.

It is more important to stay below $1.8V_p$ than it is to stay above $1.2V_p$. The amplitude decreases as the target moves close to the sensor. To avoid exceeding the upper limit, take the measurement at the maximum target distance of the system. This can be free air if a target is not necessarily present in the system.

Why Not Use the Automatic Amplitude Setting?

I only recommend the automatic amplitude features for quick prototyping purposes. By enabling R_p override (RP_OVERRIDE_EN=1) and disabling auto amplitude correction (AUTO_AMP_DIS=1), the LDC uses the current-drive setting in the IDRIVE register. Manual control ensures that the same IDRIVE setting is used on each channel every time the system powers up, and that the same current-drive is used regardless of target distance.

There are several ways to determine a suitable current-drive level. Using an oscilloscope is usually the most straightforward method, so I will explain that method here.

How to Set IDRIVE

You can set the IDRIVE either directly in the DRIVE_CURRENT_CHx registers, or [program it in the GUI](#), as shown in [Figure 1](#).

Current Drive and Power

Power Mode

Enable Low Power Sensor Activation Mode (Recommended)
 Enable High Current Sensor Drive (ch0 only)

Sensor Initialization Current

Channel	I _{drive}		Detect I _{drive} Init	
	Code	Current (uA)	Code	Current (uA)
0	19	264	17	196
1	1	18	17	196
2	1	18	0	16
3	1	18	0	16

● Connected | Register loading complete

Figure 1. Programming Sensor IDRIVE in the Sensing Solution’s Evaluation Module GUI

How Do I Use an Oscilloscope to Determine the Best Current-drive?

As an example, I connected a suitable sensor to the EVM and moved the target as far away from the sensor as it will be in the final system. Then, I set the probe to the INAx pin and measured the oscillation voltage with respect to ground.

I started by selecting a very high IDRIVE setting of 25 and measuring the output at the IN0A pin. You can see in [Figure 2](#) that the peak amplitude is 3.3V, which is higher than the 1.8V_P recommended limit.

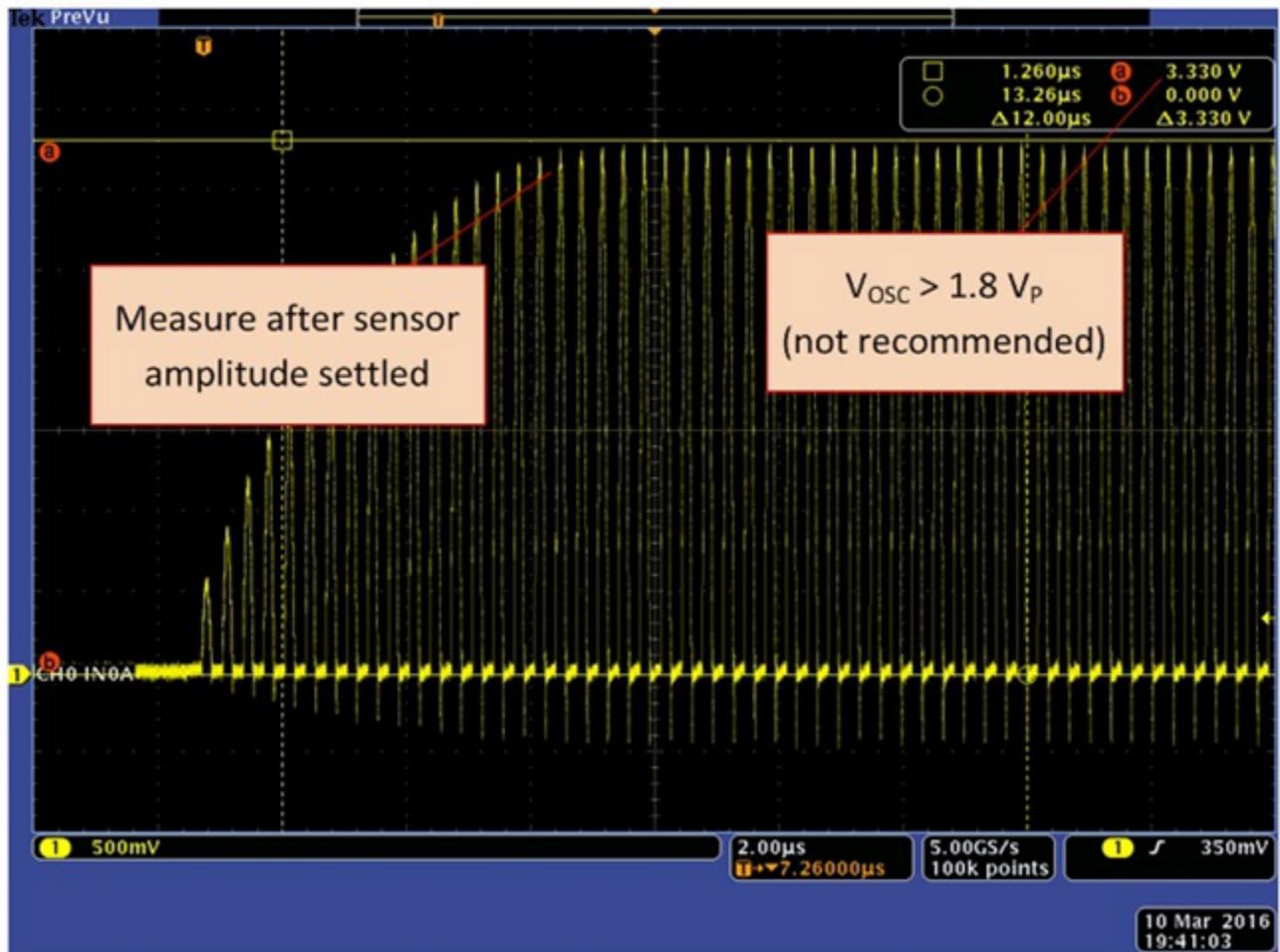


Figure 2. IDRIVE = 25 causes $V_{OSC} > 1.8V$ (not recommended)

I then decreased the current setting until $V_{OSC} < 1.8V$. With the chosen sensor and target distance, this happened at an IDRIVE setting = 19 (see [Figure 3](#)). Note that reducing my target distance caused the amplitude to decrease, but that is not a concern as long as I still meet my system-accuracy specifications.

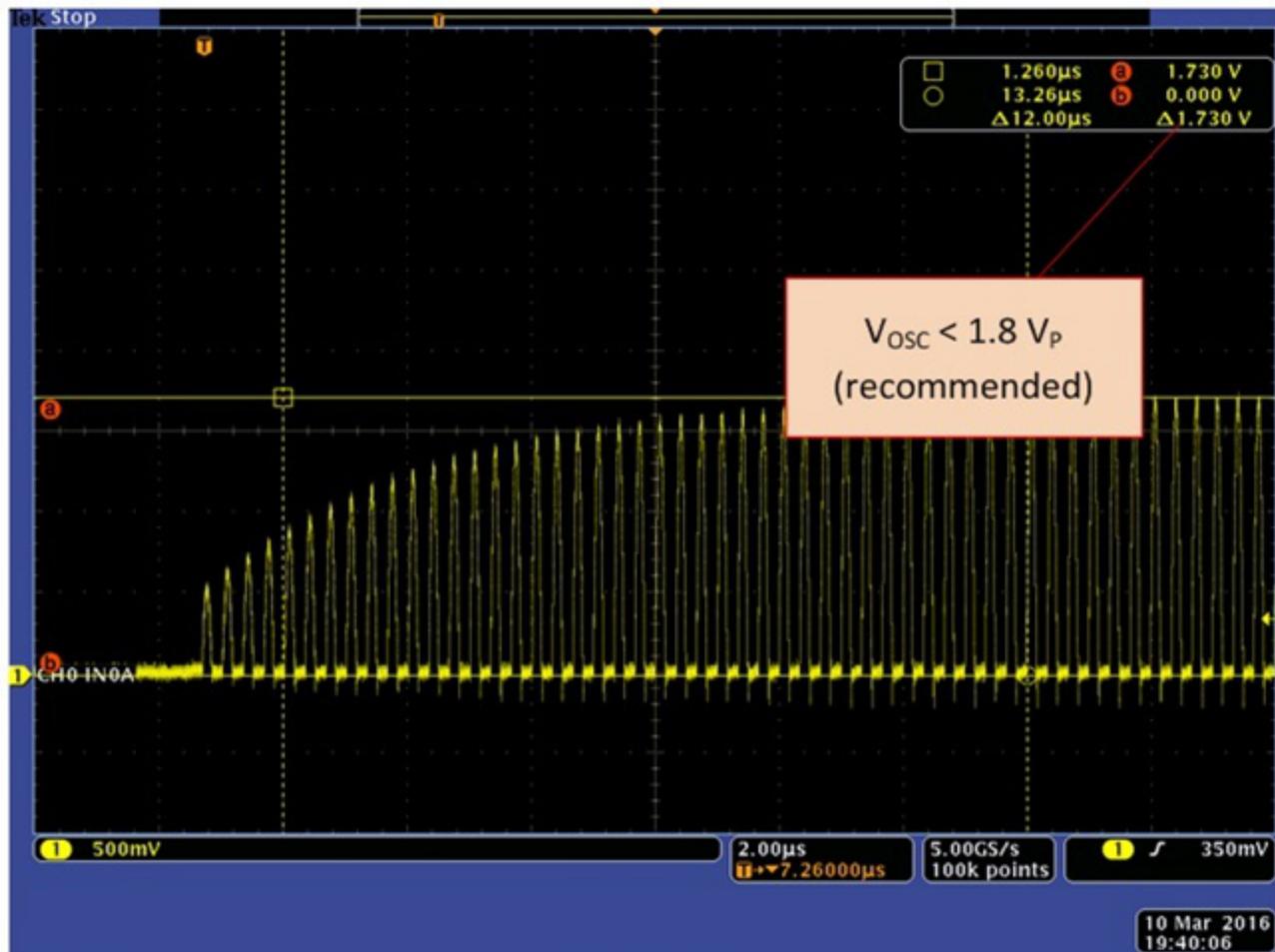


Figure 3. IDRIVE = 19, Which Is the Highest Setting That Meets the $v_{osc} < 1.8V_p$ Criterion (Recommended)

If R_p is so low that an IDRIVE setting as high as 31 shows an amplitude of less than $1.2V_p$, and if you only need channel 0, then you can use the high current sensor drive to boost the current(HIGH_CURRENT_DRV=1).

How to Use Multiple Sensors

Many systems use multiple sensors with the same sensor characteristics in order to perform measurements of multiple targets, to perform differential measurements, or to use one sensor as a reference sensor. In this case, it is possible to use the same IDRIVE setting for all channels to ensure consistent measurement results. I recommend checking all sensors using the process described above.

If different channels use different sensor components, then evaluate each channel individually. It is not necessary to use the same IDRIVE setting across all channels.

Summary

To achieve the highest performance from your multichannel LDC, set the IDRIVE current to the highest setting below $1.8V_p$. Knowing the R_p value is not necessary for this; you can determine the optimal setting by using an oscilloscope with the procedure I described in this post.

Additional Resources

- Read my other blogs on [inductive sensing](#).
- Learn more about TI's [inductive-sensing portfolio](#).
- Design your sensor coil and start your system design in seconds with [WEBENCH® Inductive Sensing Designer](#).

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated