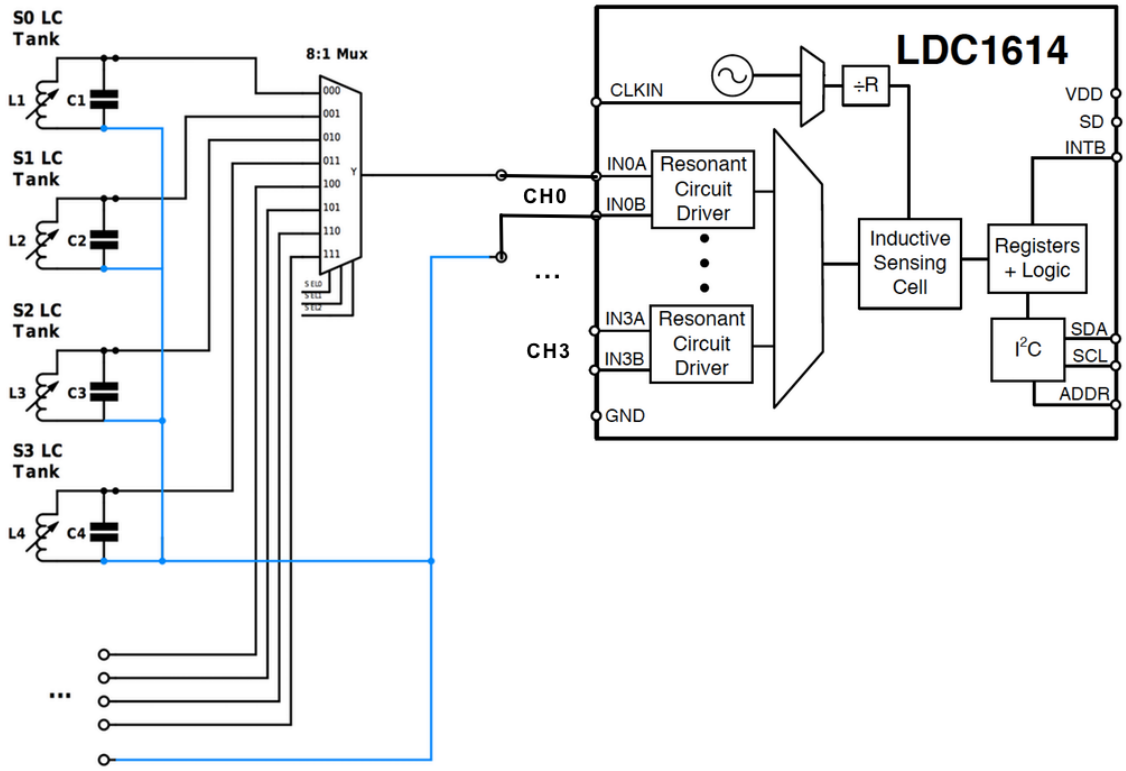
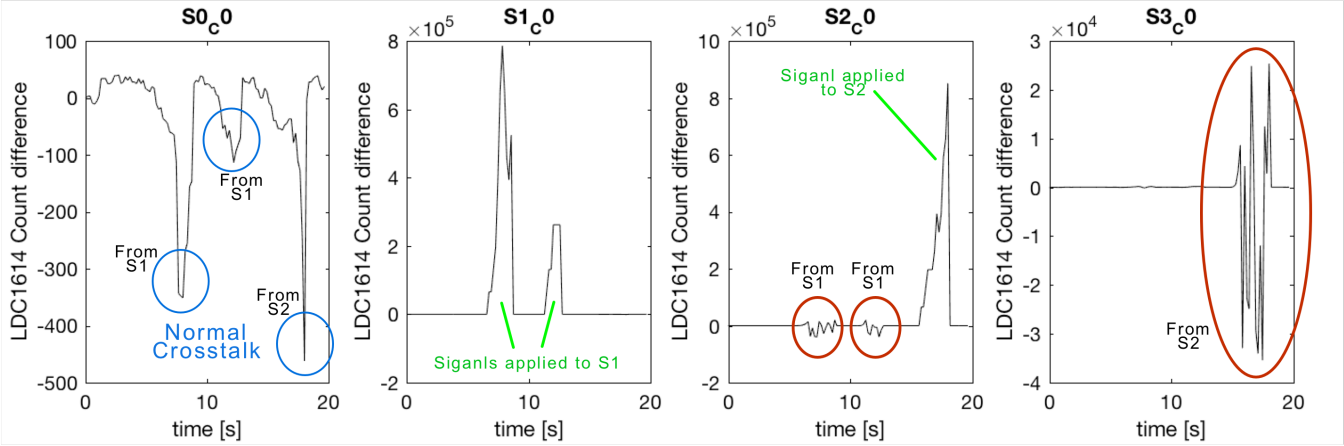
Special crosstalk with Ti LDC1614 and multiplexed coils

An 8:1 Multiplexer is attached to channel 0, 1 and 2 of the LDC1614. Each of these multiplexers has eight LC tanks on the other side. A reference coil is attached to channel 3. In the following figures, only one multiplexer and four sensor coils are shown. The fist figure shows how the sensing coils are connected with the LDC1614 chip.

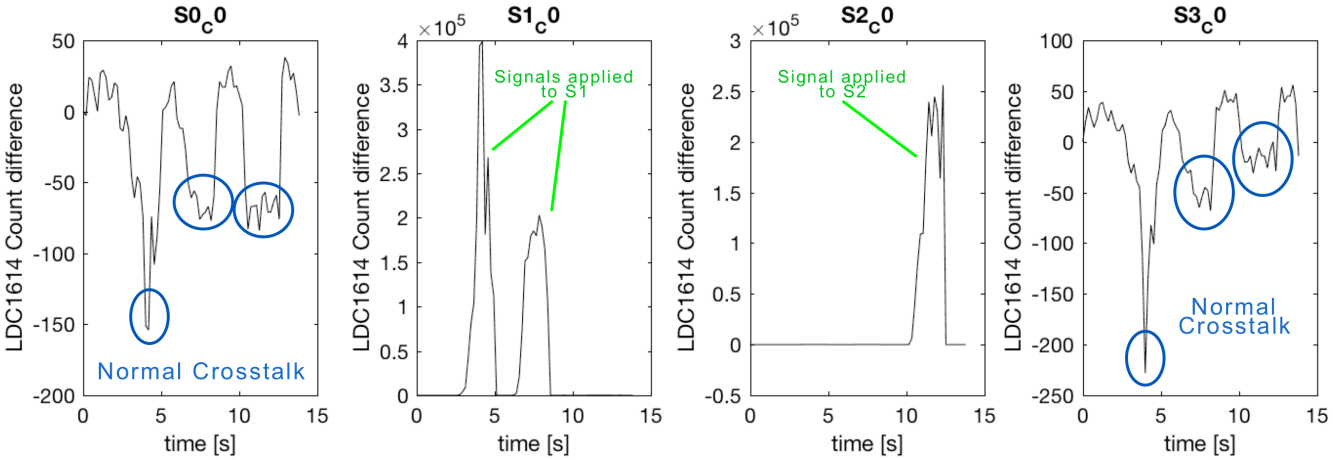


Normal crosstalk between channels and sensors does occur in the circuit as expected. The normal crosstalk influence on neighboring sensors is in the order of 0.05% of the induced signal amplitude. It is symmetric, meaning normal crosstalk from coil S0 to coil S1 is in the same order as from coil S1 to coil S0.
But an additional nonlinear kind of crosstalk was also observed, which will be addressed as „special crosstalk“. Its influence is in the order of 5% of the induced signal amplitude and it is fluctuating, it is like noise amplification. The special crosstalk occurs only in a specific situation: when a sensor coil is sampled on any channel of the LDC1614 the next coil that will be sampled by the same channel will be influenced by the previous measurement on this channel. There is no special crosstalk between different channels of the LDC1614, it occurs only within the same channel. The LDC1614 is programmed to sample channel 0 to channel 2 one after the other (or channel 0 to channel 3 one after the other). Then data from the sampled channels is read and stored. Next, the LDC1614 is put to sleep mode and all the multiplexers selection inputs are updated to connect to the next coil. Then the LDC1614 is activated again.

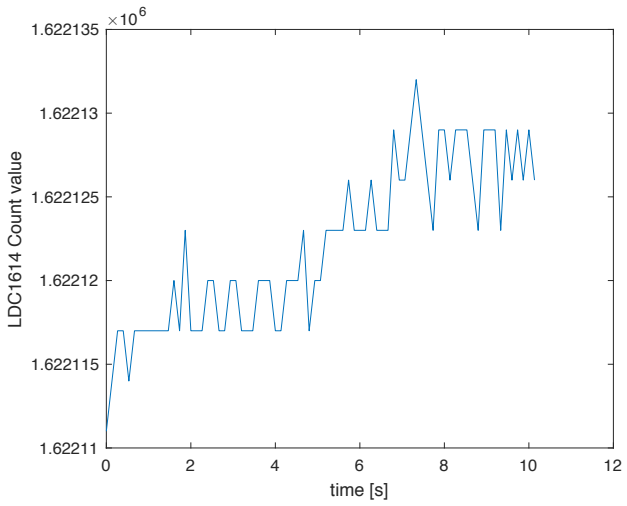
Considering only channel 0 it will start with sampling in the first round coil S0, in next round coil S1, then S2 and so on until S7. Always the previous coil value will influence the next coil that will be sampled on this cannel. The special effect is not dependent on the physical arrangement. Meaning coil S0 is influencing coil S1 only if coil S1 is sampled after coil S0. If the sequence in the multiplexer is changed for example a coil-order: S0 - S3 - S2 - S1 then S1 suffers from no special crosstalk induced by coil S0 anymore but from coil S2. This shows it has no physical relation to the structure how coils are arranged it is only a temporal dependency: what ever was sampled previously will influence the next sampling. This effect was observed in several ways.
In the next figure, some sampling data of coil S0 to coil S3 is shown, the sampling sequence is normal (S0 - S1 - S2 - S3 - S4 - …). Special crosstalk is marked red, signals on S1 will lead to special crosstalk on S2 and signals on S2 to special crosstalk on S3 (note the plots have different scales).



Many thoughts were spent on this problem and different ideas were tried out as: extreme long settling times for all channels and long delays after switching multiplexer channels before activating the LDC1614, but it did not help against special crosstalk. Only shutting down the LDC chip, start it up again and newly initialize it before every new sampling round did solve the special crosstalk problem. But a lot of sampling time is wasted this way. A very similar measurement as shown in the previous figure is shown in the next figure, with the difference that no special crosstalk occurs where it did before.



In the end, the LDC1614 is a black box, what happens on the inside is part of Texas Instruments intellectual property. Clear is that the sleep mode is different than a complete shutoff in regard of how the previous measurement on a channel will influence the next measurement on the same channel. My personal opinion is that the LDC1614 has more control mechanisms inside than the data-sheet reveals. I assume that the „Resonant Circuit Driver“ part needs some sort of self-tuning, adjustments or some frequency locking mechanism to optimal drive the LC-tank attached to it and that this regulation goes beyond the registers that can be set by the user. Normally this improves the measurements because the LDC1614 is designed to drive one coil per channel and not a lot of coils via a multiplexer. But when every sampling round another coil is attached (via the Mux) the internal adaption in the channel updates to this specific coil and the next sampled coil value on the same channel is influenced by these pre-settings / adaptions from the previous channel. The reason why I came to this idea is also the interesting behavior of the reference coil. The reference coil has its own channel without multiplexer (channel 3) and if the LDC1614 is put to sleep mode without shutting it down the measured value over several seconds or even minutes is compete stable with zero fluctuations. If the LDC1614 is turned off and on again each sampling round the reference coil measurement shows a lot of fluctuations as seen in the next figure. The fluctuation amplitude is still small (few counts) it is comparable to the LDC circuit that I have built on my own. When operating an LDC1614 chip with a multiplexer on each channel it would be preferable to have small fluctuations in the measurement signal which are insignificant instead of nonlinear special crosstalk effects. But the heavy losses with the recent solution is the time loss and therefore the decreased temporal resolution of the sensor system.



- Are there other ideas what causes this special crosstalk?
- What else could be done to solve the special crosstalk problem? Preferable with less time loss.
- How acceptable is the hypothesis about the special crosstalk described in the last paragraph?