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Lossless Method Boosts Current-Sense Signal

by Patrice Lethellier, It Can Be Done, Salt Lake City, Utah

Inductive sensing is sensing an inductor current without incurring the losses of a sense resistor. While the technique is quite universal it will be discussed here in the context of the familiar buck regulator as illustrated in the top schematic in Fig. 1. Here inductive sensing is providing a virtual signal equal to the actual current signal in the inductor, which would be obtained across the parasitic resistance of the inductance L (brown arrow).

The sensed voltage is produced by an RC filter across the inductance. In the Fig. 1 top schematic, these elements are labelled R_{SENSE} and C_{SENSE}, respectively. The values for these sense components should be chosen so that the filter RC equals L/R where R is the DCR of the inductor as shown in the schematic. This is a lossless sense because it does not add any loss to the regulator. However, the sensed voltage signal has a small amplitude which could pick up noise that will be amplified.

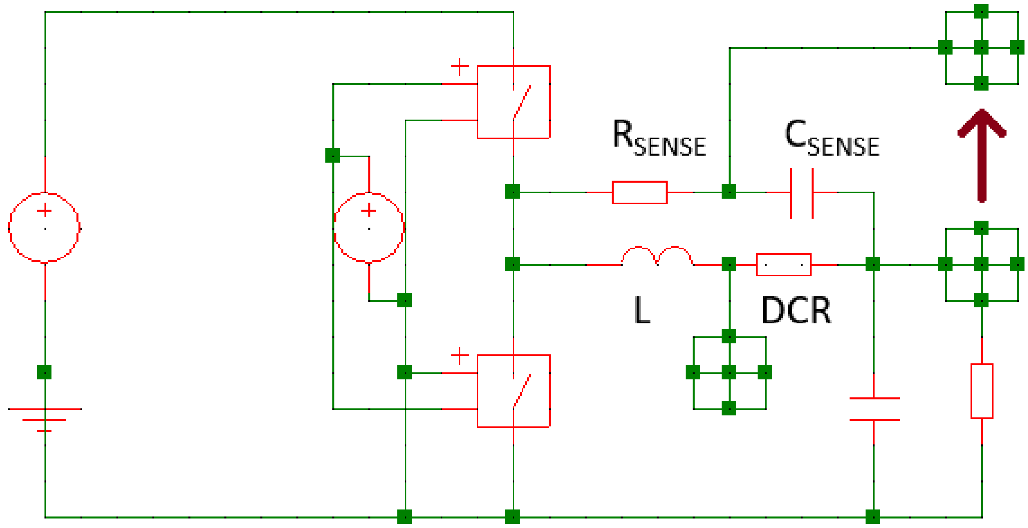
The Combi-Sense method depicted in the Fig. 1 bottom schematic provides a similar sense signal but larger and less noise sensitive (blue arrow). A small internal totem-pole made with small-signal MOSFETs is added inside the driver chip. The small-signal MOSFETs have the same gate drive as the power MOSFETs and provide a “signal switch node”.

The RC filter does not go to the power switch node anymore but to the signal switch node. The sense is not made across the inductance DCR alone but across the inductance plus the MOSFETs’ $R_{DS(ON)}$. We sense the inductance + the top MOSFET, then the inductance + the bottom MOSFET in the totem pole.

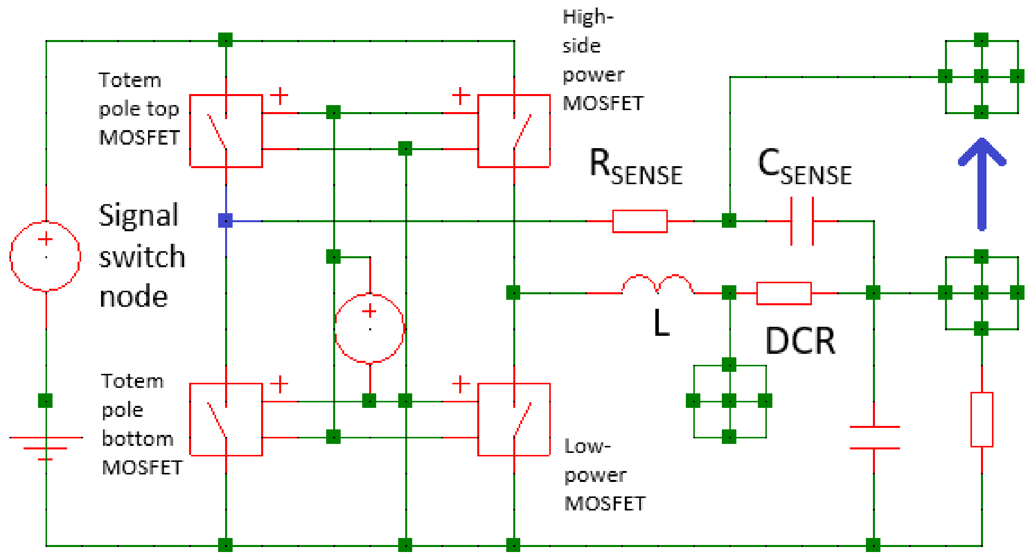
The filter RC has to be modified to match the new L/R because the R is now larger. The added resistance is the average of the $R_{DS(ON)}$ of the two power MOSFETs. The penalty for the larger signal is not the added MOSFETs since they are very small. It is the extra pin added to the driver chip for the signal switch node. This extra pin adds a negligible amount to the cost of the driver.

The inductive sensing method gives exactly the same signal as the virtual signal across the parasitic resistance of the inductance which unfortunately is not accessible. The Combi-Sense is giving a signal much larger with the same time constant (Fig. 2).

In this example it is three times larger: inductor DCR is 5 mΩ and MOSFETs’ $R_{DS(ON)}$ is 10 mΩ. So, the Combi-Sense is sensing voltage across 15 mΩ.



(Inductive sensing)



(Combi-Sense)

Fig. 1. Comparing two forms of lossless current sensing—inductive sensing (top schematic) versus Combi-Sense (bottom schematic). In inductive sensing we sense voltage across the parasitic resistance of the inductor, while in Combi-Sense we sense the voltage across the the parasitic resistance of the inductor plus the $R_{DS(ON)}$ of one MOSFET. Circuits shown here are block diagrams of the simulation schematics.

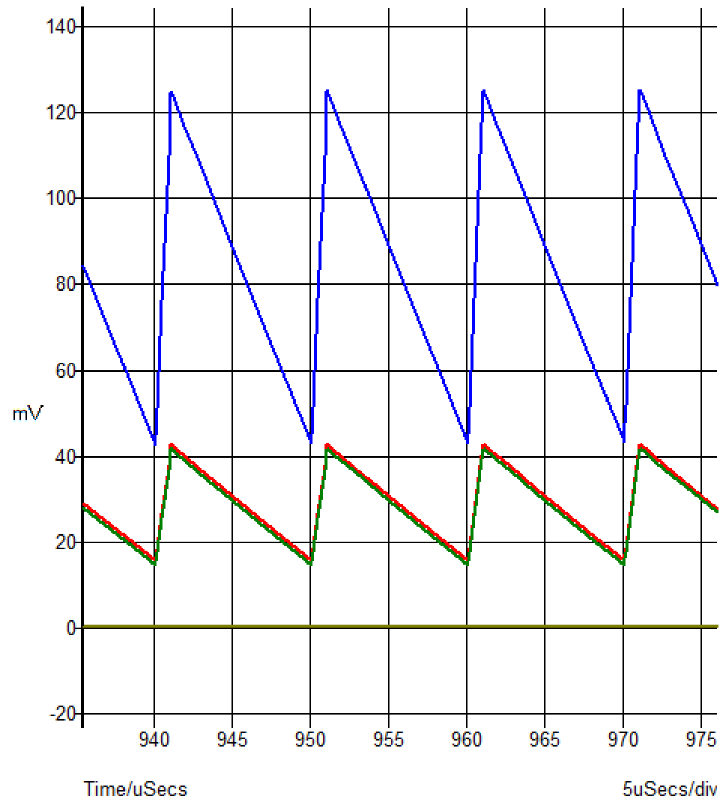


Fig. 2. Simulated waveforms for voltages measured using the Combi-Sense current sensing method (blue waveform) versus the conventional inductor DCR current sensing method. The sense signal obtained with the Combi-Sense method is three times larger and therefore less sensitive to noise than the inductive method.

About The Author

Patrice Lethellier is a consultant with "It Can Be Done" where he specializes in presenting unconventional ways of doing the designs, while also consulting on most other aspects of power conversion. Results oriented, all of his consulting work relates directly to proactive and productive design. Patrice has over 40 years of experience in industry as a power supply design engineer in OEM and merchant power supply companies and as an application engineer in power semiconductor companies. Since 2014 Patrice has been a senior engineer with Wave, where he has developed wireless battery charging solutions from 50 kW to 200 kW for electric buses.

Prior to this, he served as an application engineer with notable power semiconductor companies such as Volterra, National Semiconductor and Semtech. Before that, he worked as a design engineer at various power supply and system companies including C&D Power Technology, Pioneer Magnetics, Elgar and Unisys. Patrice holds a total of 20 patents in various fields with some currently in process. He has an Engineer Diploma from ISEN in Lilles, France.

The technique described in this article was used by the author when he was an engineer at Semtech in Camarillo, CA.

For more information on current-mode control, see How2Power's Design Guide, locate the Design Area category and select "Control Methods".