**Integrated LDOs: From the Ground Up!**

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**Abstract**

Supplying power is the most fundamental and intrinsic function of any electrical system, be it analog, digital, or mixed-signal in nature. Voltage regulators provide such a function, to convert unpredictable and noisy supplies to stable, constant, accurate, and load-independent voltages. The input supplies are derived, for the most part, from batteries, generators, and other off-line ac or dc sources, which usually exhibit significant voltage variations. Most integrated circuits (ICs), in particular, draw power from already available dc supplies like batteries, ac-dc converters, and dc-dc converters. The choice between using a **linear regulator** and its switching counterpart, a **dc-dc converter**, is predominantly dictated by the specifications demanded by the system. General metrics for performance, used to classify these regulators, include power efficiency, noise content, accuracy performance, and load requirements. Accuracy is described by its dependence to the operating environment, which includes load current, input supplies, temperature, and transient excursions. More basic, however, is the stability robustness of the system. The characteristics of the load are essential in this regard, for proper frequency compensation. The inherent variability of the load makes the task of guaranteeing a stable system difficult and constricting. Parasitic resistors, stray inductors, output capacitors, and other parasitic components, which make up the load, vary considerably from board to board and chip to chip. Consequently, the ac characteristics of the load are diverse and complex. Designing a regulator, as a result, must cater to the unpredictable nature of the loading environment as well as the specific needs of the application.

This tutorial will not only introduce and discuss the emergence of linear regulators, and low dropout (LDO) regulators, into the marketplace but also deal with the practical issues behind their design. First, a brief overview of the market is presented and gauged against the characteristics of both linear and switching regulators, while addressing their relevant tradeoffs. The operation and classification of linear regulators are then discussed, from an intuitive perspective to formalized steady-state and transient-response analyses. Ultimately, the concepts presented are used in a practical circuit to highlight important integrated circuit design tradeoffs and system issues.