

# DESIGN NOTES

## 4MHz Monolithic Synchronous Step-Down Regulators Bring High Efficiency to Space-Sensitive Applications – Design Note 304

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### Introduction

The LTC<sup>®</sup>3411 and LTC3412 provide compact and efficient power supply solutions for portable electronics such as cell phones, PDAs and notebook computers. These two monolithic, synchronous step-down regulators provide DC/DC conversion from either a 3.3V or 5V system voltage to outputs as low as 0.8V. They also offer switching frequencies as high as 4MHz, allowing the use of tiny inductors and capacitors. Both devices save additional space by integrating the power switches into their monolithic architecture. The LTC3412's built-in power switches have an 85mΩ on-resistance, enabling it to deliver up to 2.5A of output current with efficiencies as high as 95%. The LTC3411 is optimized for lower power applications. Its 110mΩ power switches allow output currents as high as 1.25A.

The LTC3411 and LTC3412 both utilize a constant frequency, current mode architecture that operates from an input voltage range of 2.5V to 5.5V and provide an adjustable regulated output voltage from 0.8V to 5V. The switching frequency for either part can be set from 300kHz to 4MHz by an external resistor or synchronized to an external clock. The ability to increase the switching

frequency as high as 4MHz allows for lower inductor values while still maintaining low output voltage ripple since output voltage ripple is inversely proportional to the switching frequency and the inductor value. Because smaller case sizes are usually offered for lower inductor values, the overall solution size is reduced. The LTC3411 is offered in an MSOP package to further reduce the footprint. For optimal thermal handling, the LTC3412 is offered in a 16-Lead TSSOP package with an exposed pad.

### Multiple Operating Modes Allow Optimization of Efficiency and Noise Suppression

Both the LTC3411 and LTC3412 can be configured for either Burst Mode<sup>®</sup> operation or forced continuous mode, while the LTC3411 also offers pulse skipping mode. Burst Mode operation provides high efficiency and extends battery life by reducing gate charge loss at light loads. Forced continuous mode is not as efficient at light loads but it offers advantages in noise-sensitive applications. Pulse skipping mode is a compromise between the two. With no load, the LTC3411 and LTC3412 consume only 62μA of supply current.

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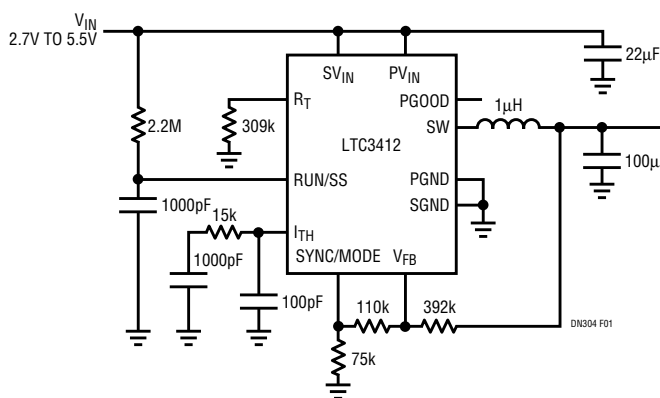


Figure 1. 2.5V/2.5A Step-Down Regulator

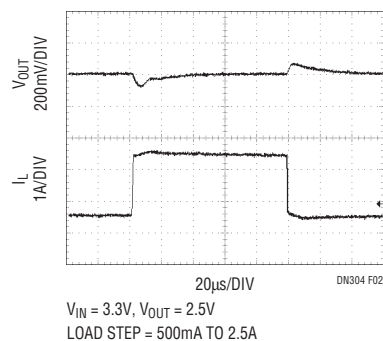


Figure 2. Load Step Transient Response

In Burst Mode operation, there is a trade off between output voltage ripple and efficiency at light loads. With the LTC3412, external control of the burst clamp level allows the burst frequency to be varied. A lower burst frequency increases efficiency at light loads due to lower gate charge losses but this also slightly increases output voltage ripple. The burst clamp level can be adjusted on the LTC3412 by varying the voltage at the Sync/Mode pin in the range of 0V to 1V.

For applications in which noise suppression is a priority, both devices offer forced continuous (frequency) mode, in which constant frequency is maintained regardless of output load. The LTC3411 also offers pulse skipping mode. In pulse skipping mode, the LTC3411 continues to switch at a constant frequency down to very low output currents, minimizing the ripple voltage and ripple current at the output.

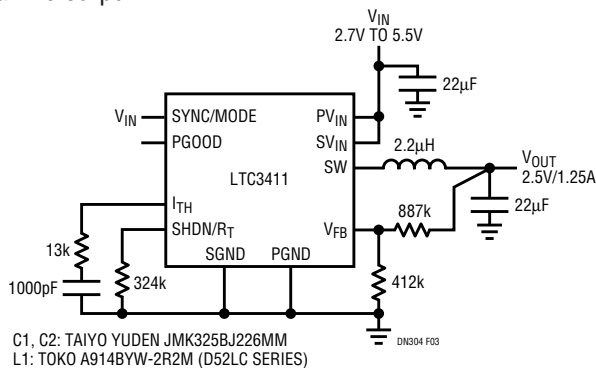


Figure 3. 2.5V/1.25A Step-Down Regulator

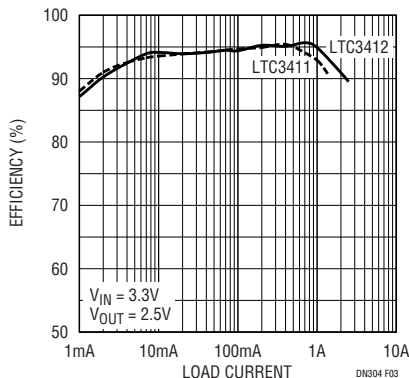


Figure 4. Efficiencies for the Circuits Shown in Figure 1 and Figure 3

## Two 2.5V Step-Down Converters

Figure 1 shows a design using the LTC3412 for a 2.5V step-down DC/DC converter that is capable of sourcing up to 2.5A of output current. Figure 3 shows a design using the LTC3411 for a 2.5V step-down converter that is capable of sourcing up to 1.25A of output current. Efficiencies for these circuits are as high as 95% for a 3.3V input as shown in Figure 4. The input and output capacitors are ceramic, which are desirable because of their low cost and low ESR. Many switching regulators have difficulty operating with ceramic capacitors because they rely on the feedback response zero that is generated by the larger ESR of tantalum capacitors. The LTC3412 and LTC3411, however, feature loop compensation, which allows them to operate successfully with ceramic capacitors. The frequencies for these particular demonstration circuits are set at 1MHz by a single external resistor, allowing for small inductors and capacitors, as illustrated in Figure 1 and Figure 3.

## Conclusion

The LTC3411 and LTC3412 are high performance monolithic, synchronous step-down DC/DC converters that are well suited for applications requiring up to 1.25A and 2.5A of output current, respectively. Their high switching frequency and internal low  $R_{DS(ON)}$  power switches allow the LTC3411 and LTC3412 to offer compact, high efficiency power supply solutions for any application, as can be seen in Figure 5.

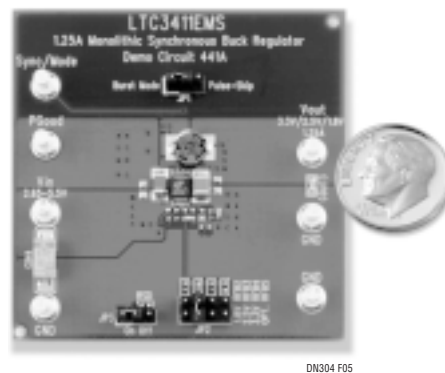


Figure 5. The LTC3411 is a Space Saving Step-Down Regulator

### Data Sheet Download

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