Technical Bulletin

L3751: Wide 6 V to 75 V Input Voltage Synchronous Buck Controller

Overview

5G networks, wide-band internet connections, industrial automation, smart mobility (e-bikes, and e-scooters) are only some of the disruptive innovations that the semiconductor industrial arena is now facing. As the demand for greater energy efficiency, reliability, and performance continues to grow with a focus on achieving a smarter future, DC-DC switching regulators play an important role, meeting every market requirement and power management needs.

This article reports on a possible application for the telecom domain while also being considered as a guideline and applicable to other sectors.

The solution described here implements the L3751 Synchronous Buck Controller from STMicroelectronics coupled with the ZC1818 Shielded Power Inductor from Coilcraft for a 60 V to 12 V conversion with an output current of 10 A to 15 A, delivering up to 180 W.

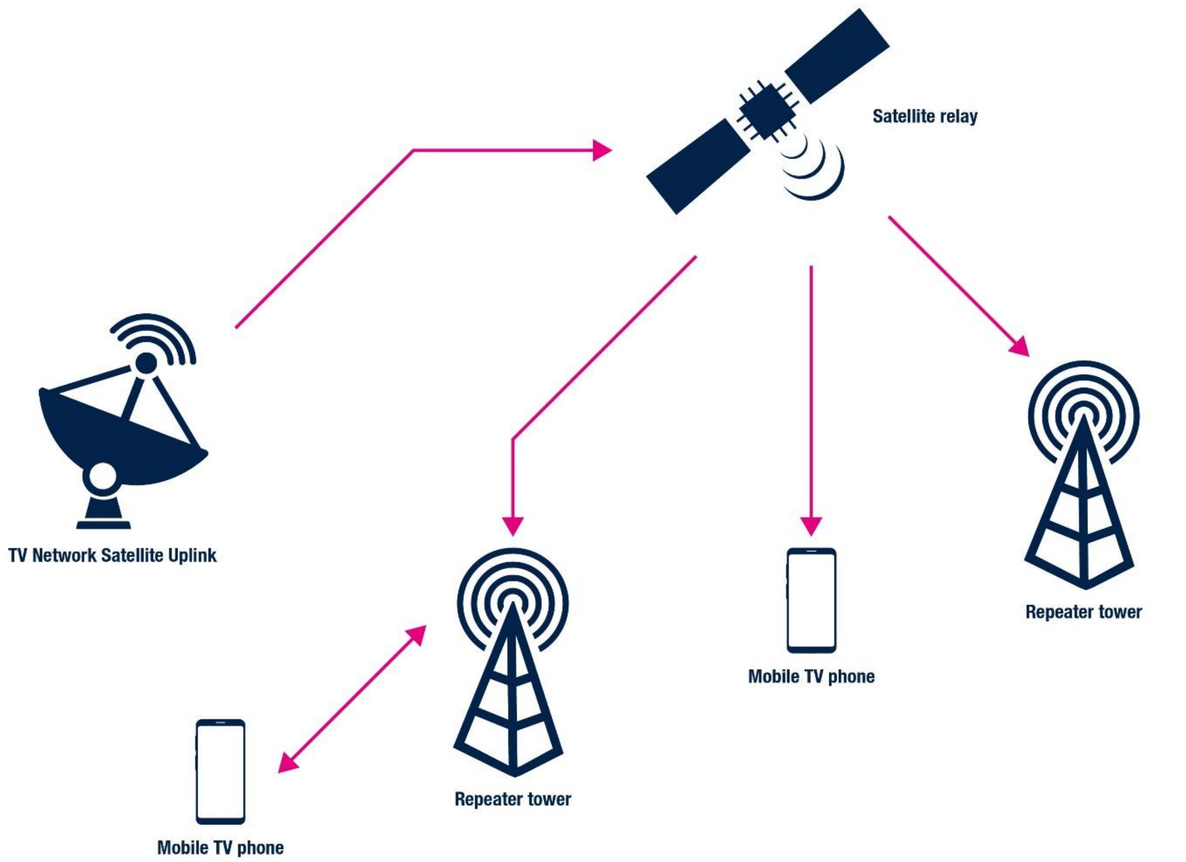

Figure 1. Generic telecom applications where L3751 can be used

Application results

With a compact dimension and an input-voltage range from 6 V to 75 V, the L3751 features an extreme conversion ratio over switching frequency. This new product introduced by ST controls external power MOSFETs and can reach an output current over 20 A.
Depending on the targeted application, it is possible to use very fast switches to reduce the output voltage ripple or ultra-low $R_{DS(on)}$ transistors to increase the overall efficiency. This unique feature provides greater flexibility in the design process.
Furthermore, the switching frequency of the system can be selected in the range of 100 kHz to 1 MHz, which covers most typical applications.
The QFN20 package is also available with wettable flanks and provides high reliability despite the significant amount of power that the device can transfer.

The application depicted in this article is the STEVAL-L3751V12, an application board designed by STMicroelectronics for evaluation purposes and fast prototyping – it is used to perform some measurements. The board is equipped with an optimized power inductor, the ZC1818 from Coilcraft: this component has a higher voltage rating matching the L3751's input voltage specifications. It also offers low DCR and soft saturation characteristics for high-current applications. The switching frequency selected for this application is 240 kHz, resulting in a good compromise between power efficiency and output current.

The efficiency curves in **Figure *2*** show a comparison between the targeted application of Vin = 60 V and other input voltages. Measurements are performed over a full range of current from 0 to 20 A. **Figure *3*** focuses more closely on ratings from 10 A to 15 A, which are more typical for telecom applications. The average efficiency for the solid line is above 95%.

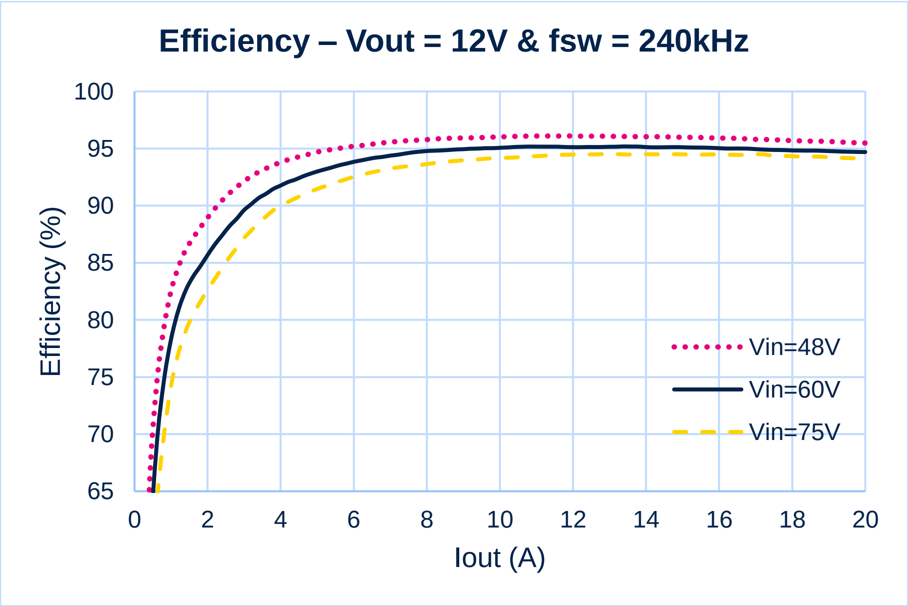

Figure 2. Efficiency measurements in FPWM

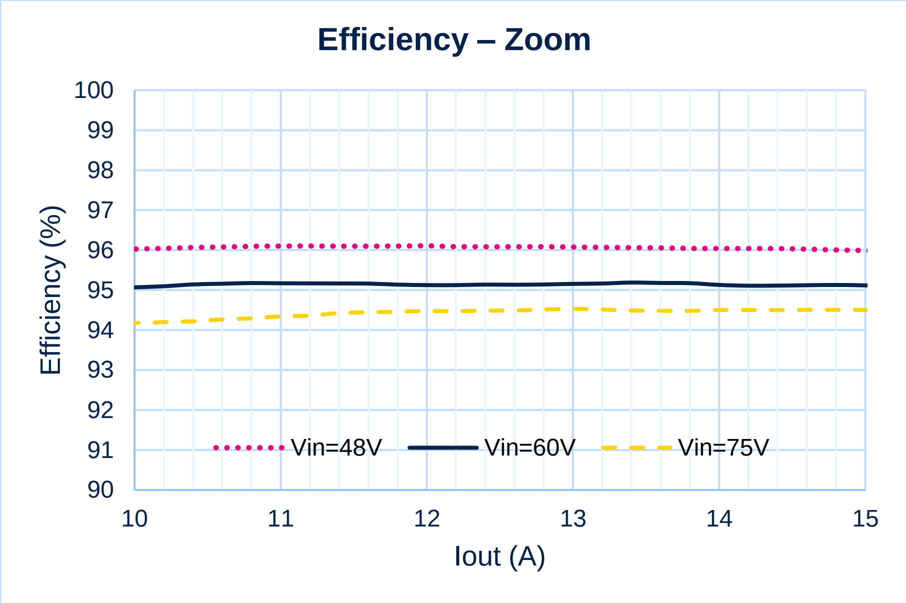

Figure 3. Zoom from 10A to 15A of output current

When analyzing power losses measured during the application, it is worth comparing the power dissipated by the inductor's DCR to the total power lost in the conversion. In *Figure 4* the effect of the low DCR of the ZC1818 can be noticed. In fact, the amount of power dissipated by the coil remains quite low even for high-frequency currents. This is due to the low 6 mΩ DCR that keeps the inductor temperature within a suitable working range.

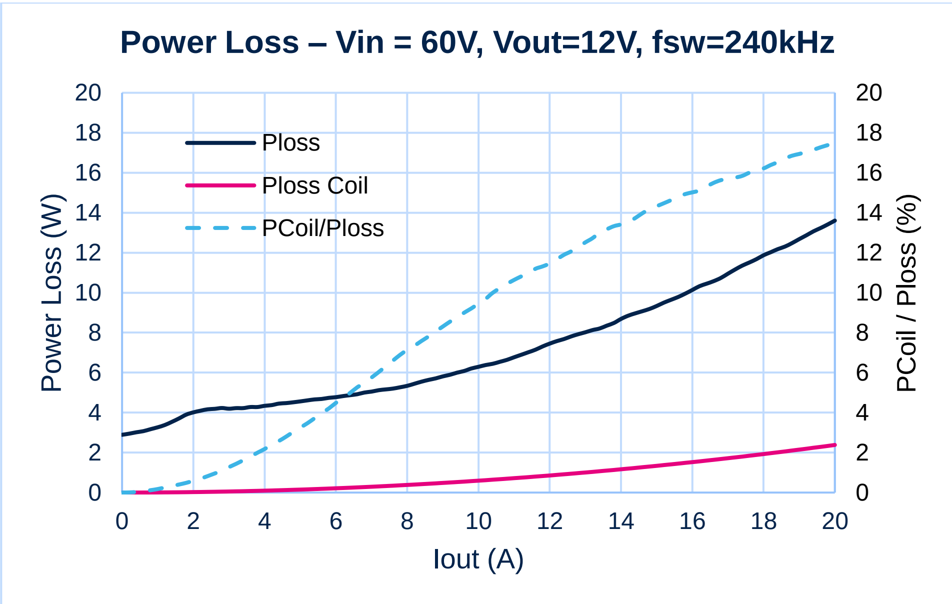

Figure 4. Power loss measurements for target application

eDesignSuite

eDSim

Design Optimization Tools

STMicroelectronics offers the possibility of streamlining the system development process with its proprietary eDesignSuite platform. This tool is ready to help in the design phase of a wide range of applications. With only a few specifications like voltage range input and output power, it provides the user with a customized Bill of Materials (BOM) optimized for the required application. Besides the BOM, the simulation tool provides circuit schematics, frequency behavior through the Bode diagram, and calculates efficiency and power losses.
The software allows designers to perform some changes in the application specifications (such as, switching frequency, current ripple, inductor, output capacitor, target bandwidth, etc.) thanks to its high flexibility in the design process while adapting all the components consistently. The software was developed entirely by ST and is based on validated models designed by the engineering teams.
Once the user has created the circuit, he can export the schematic to eDSim, a special edition of SIMPLIS/SIMetrix simulation environment. This powerful simulation tool enables 10-50x faster simulation than Spice for power supply designs. After the download, the user can create Bode simulation, load transient simulation, with a comprehensive simulation design and overcurrent simulation.
In combining both tools, the user can optimize the circuit for the target application with minimum effort. The tools can also be used as a support for fast prototyping or preliminary evaluation of a device.

Coilcraft offers the same advantage with its MAGPro™ online DC-DC optimizer tool for inductor selection and analysis. As shown in Figure 5, starting with the user's Vin/Vout power converter parameters, the tool calculates the needed inductor specifications, identifies off-the-shelf part numbers, and provides complete side-by-side performance analysis with losses and saturation analysis, all based on verified inductor data.

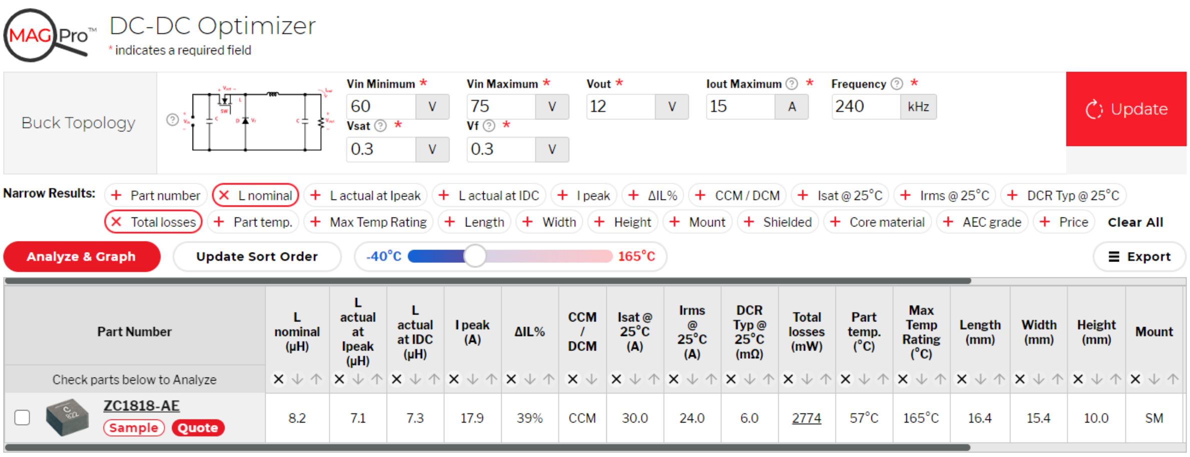

Figure 5. MAGPro DC-DC Optimizer

Coilcraft worked in partnership with ST to design a specific high-performance coil to match the high voltage and high current specifications. The ZC1818-AE coil belongs to the Coilcraft XAL molded power inductors family. It is mechanically rugged and magnetically shielded, which is useful in high-density power converter circuits. It offers high current ratings and is ideal for high switching frequencies with low AC losses.

Figure 6 shows an example of the calculation of the contribution of total power losses due to the above-mentioned application.

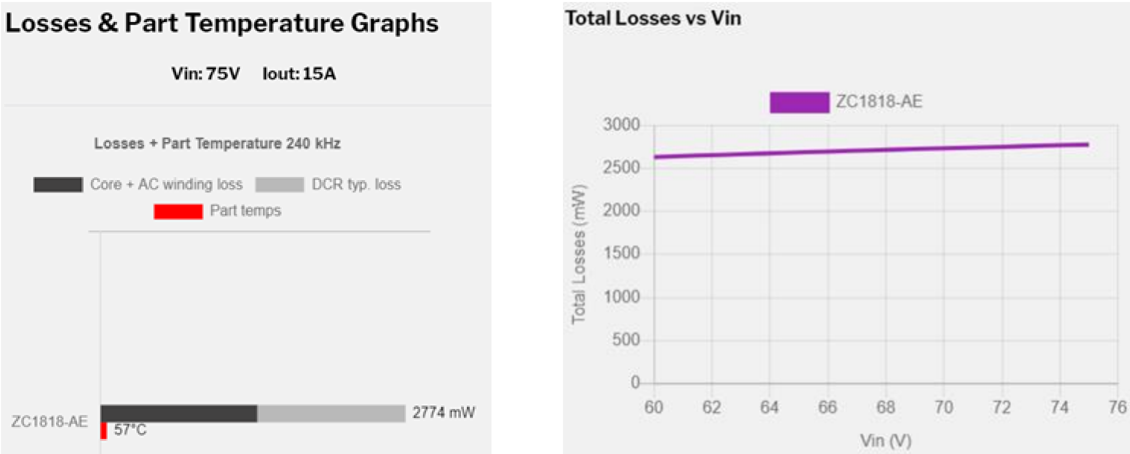

Figure 6. Contributions of total power losses – ZC1818-AE

The ZC1818-AE also has an improved operating voltage rating compared to the standard XAL family, achieving a maximum value of 75 V.
Voltage ratings are usually specified for many electronic components, including capacitors, resistors, and integrated circuits, but traditionally this is not significant for inductors.

Recent trends, in particular the introduction of high voltage semiconductor devices, have given a new emphasis on operating voltage as part of the inductor selection process.
Inductors are facing an increasing demand in new designs that apply higher voltage stress to the inductor, such as the L3751 device.
The operating voltage for an inductor is the voltage between the two terminals and represents the highest voltage the coil can withstand when the circuit is being operated. Within this range, the inductor insulation cannot be damaged.
When an application requires high current loads, the voltage rating is generally lower than 75 V because of the low inductance, the coil core material, and the large size. However, the ZC1818-AE is the single exception on the market with such a high voltage rating.
For more information about operating voltage ratings for inductors, please refer to the Coilcraft website. (Application Note: Operating Voltage Ratings For Inductors)

If a lower output current is needed, Coilcraft's latest XGL family should be considered. When operating voltage ratings are up to 80 V, XGL inductors can support the wide input voltage range of the L3751 device without any limitations.

For example, the XGL60xx Series would be ideal for an application that converts 36 V to 12 V, with a 4 A load and 400 kHz of switching frequency, like those typically used in e-bikes batteries or in industrial applications. For this application, the DC-DC Optimizer tool demonstrates that it is a useful tool to evaluate and compare composite material inductors, like the XGL60xx Series, with traditional ferrite parts like Coilcraft's MSS12xx Series.

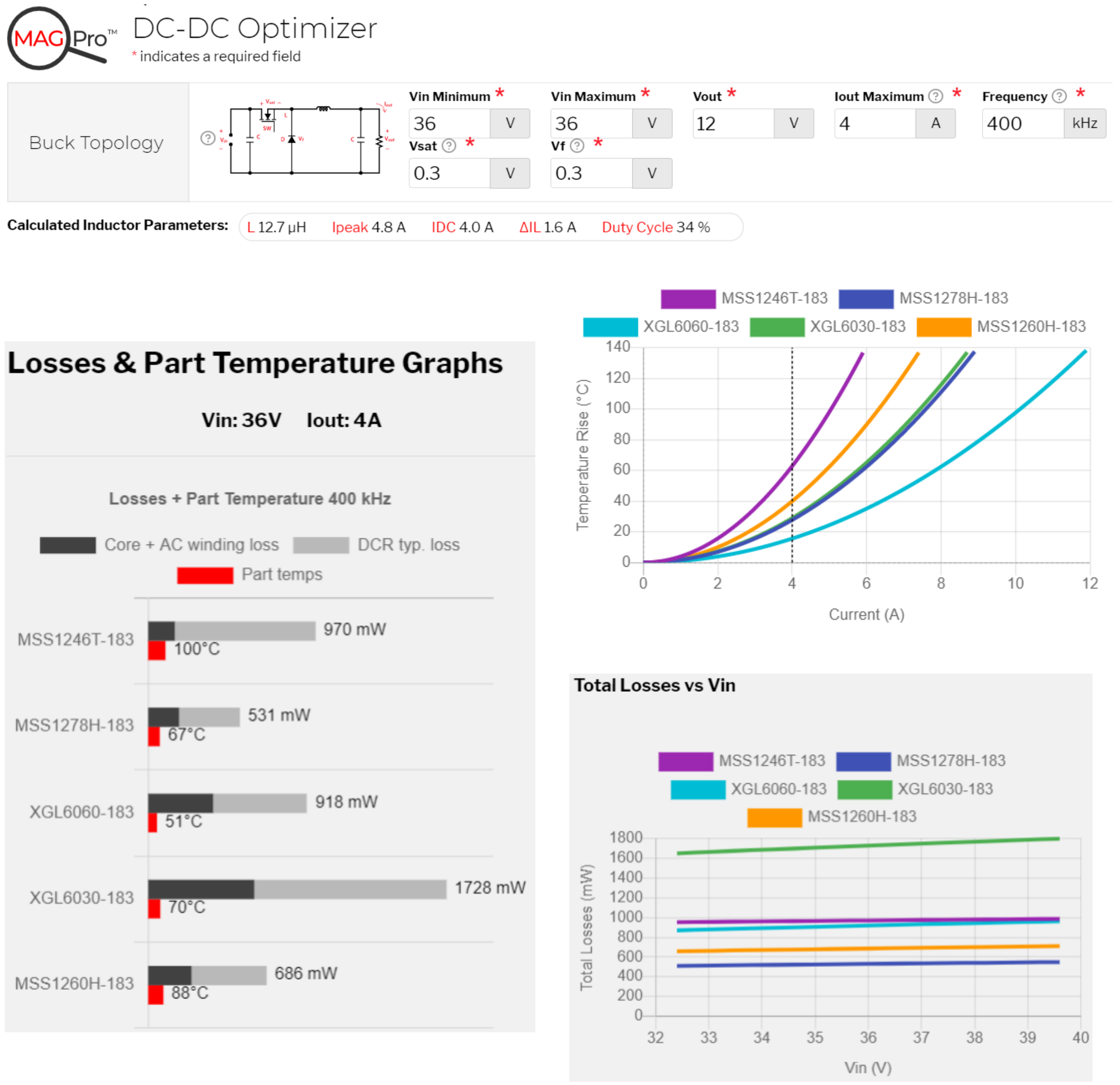

Figure 7. Comparison between MSS12xx and XGL60xx families

When comparing the tool results shown in Figure 7, the XGL6060 seems to be the best solution for this example. In fact, it shows a lower operating temperature rise and has a similar total loss as the MSS family. In addition, the XGL6060's half footprint size makes it a perfect solution when compact size is required.