

Selecting a Power Module for Your Application

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Many of today's telecommunication, data communication, electronic data processing and wireless network systems are powered with distributed power architectures. These complex systems require power management solutions that are capable of monitoring and controlling the power supply to very precise parameters. To achieve this level of performance, most designs use an FPGA, microprocessor, microcontroller or memory block.

This level of design sophistication has placed a heavy burden on application designers serving these communication infrastructure companies. Their choice is simple: either invest significantly to improve their in-house power management proficiency or rely on the expertise of outside design companies. Neither option is particularly desirable.

Recently, a new option has emerged: the point-of-load dc-dc power module. These modules combine most or all of the components necessary to deliver a plug-and-play solution that can replace up to 40 different components. This integration simplifies and speeds designs while reducing the power management footprint.

The key to getting the performance you need from these modules – while staying within budget and space restraints – requires a firm grasp of the different technologies available.

The most traditional and common of the non-isolated dc-dc power modules is still the single in-line package (SIP, see Fig. 1). This open frame solution certainly made progress in minimizing design complexity. However, most simply employ standard packaged parts on a printed circuit board (PCB). They are typically lower-frequency designs (around 300 kHz) and their power density is not stellar, so their size makes them a poor choice for many space-constrained applications. The next generation of power modules needed to make significant progress in reducing the form factor to improve design flexibility.

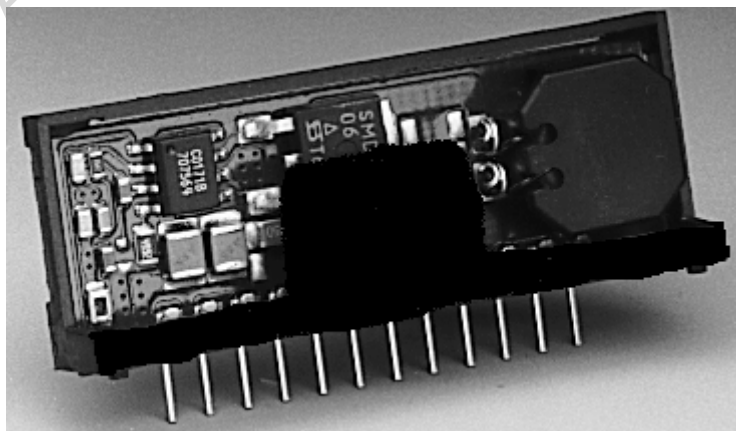


Fig. 1: Traditional SIP Open Frame Module

To achieve the higher power density designers need, power management providers must push up the switching frequency to reduce the size of the energy storage elements. But increasing the switching frequency with standard components yields lower efficiency, predominantly due to MOSFET switching losses. This has driven the industry to find ways to cost-effectively reduce parasitic impedances in the driving and power path of the MOSFETs in a dc-dc module, producing molded modules about the size of a single integrated circuit.

ISL8201M Dc-Dc Module

This module integrates most of the components required for a complete dc-dc converter, including the PWM controller, MOSFETs, and switching inductor. Its input voltage range is 3 - 20 V, and it has 10 A current capability. It achieves much higher switching frequencies than the traditional SIP dc-dc modules, with good efficiency and thermal performance, by eliminating the MOSFET packages and co-packing the parts in a compact 15 x 15 x 3.5mm QFN package (see Fig. 2). This is the first in a family of modules: further size and performance improvements are in development.

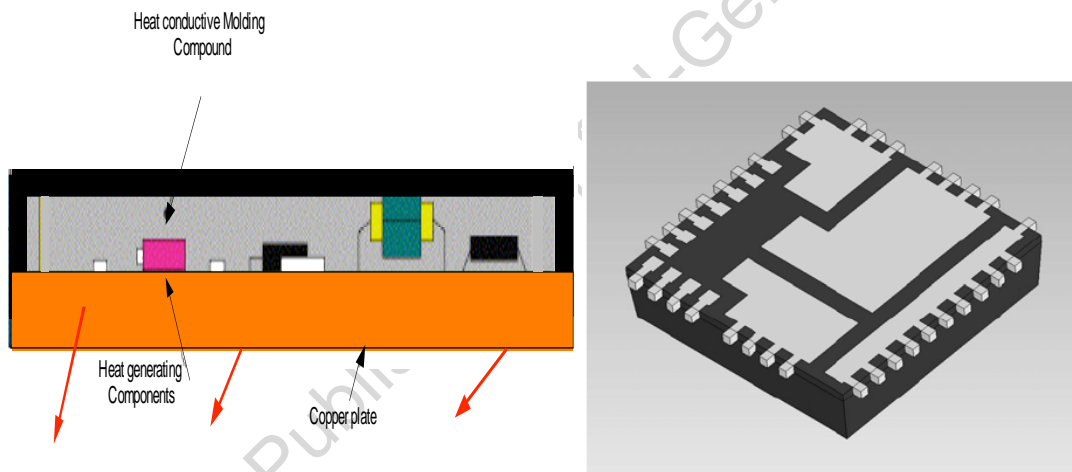


Fig. 2: ISL8201M Conceptual Package Drawings

The module achieves very good performance from an efficiency perspective and the excellent thermal performance of the QFN package allows for very compact designs that do not require a heatsink. This allows the ISL8201M to achieve a power density of approximately 200 W/in^3 , roughly 4 times that of conventional open-frame modules.

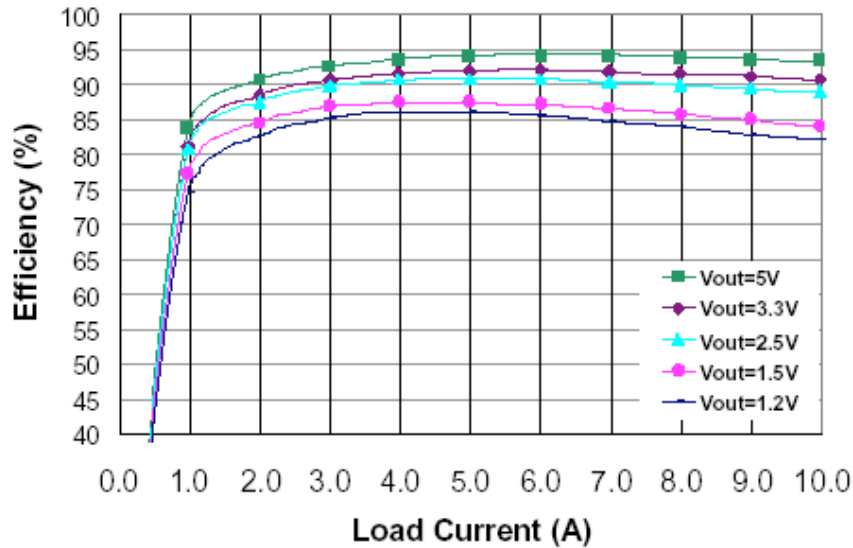


Fig. 3: ISL8201M Efficiency Curves (Vin = 12 V)

When evaluating solutions for a specific application, size and cost are two major considerations. But other factors can be equally or more important in the end application. Some of these additional considerations are now examined.

Reliability

One major issue that all system designers have to deal with is reliability. Many distributed power architecture applications need to be fully operational for many years with little downtime. Reliability plays an important role in total-system ownership costs. Reliability issues are important when dealing with power modules due to the number of co-packaged parts, heat-fatigue phenomenon due to high power density and, finally, the attachment mechanism failure.

Failure of electrical systems and parts follows the bathtub curve shape (see Fig. 4). The steepness and sharpness of transition from one state to the other in this curve depends upon the choice of the components used, the rating of those components, and their compatibility with the rest of the components in the module. For example, using a 30 V MOSFET in a 20 V input capable dc-dc module would be acceptable as long as care was taken in the choice of the driver, the Schottky diode and the snubber circuit.

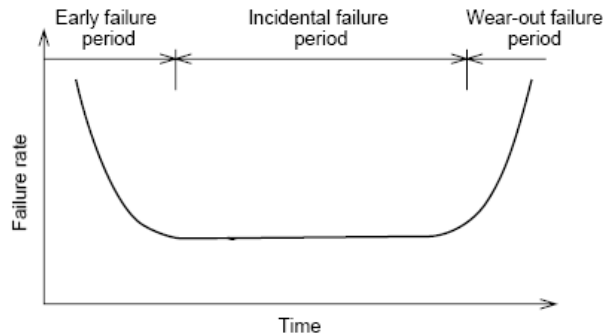


Fig. 4: Life Cycle Failure Rate

Heat-fatigue phenomenon in power modules is caused by inefficiencies in the power conversion and the limited available space to dissipate it. This can ultimately increase the rate of temperature rise and consequently reduce the life of the product. In order to minimize the effect of temperature on the mean-time before failure (MTBF), the system designer should take into consideration heat sinking, available airflow, and de-rating curves based upon the power losses of the module.

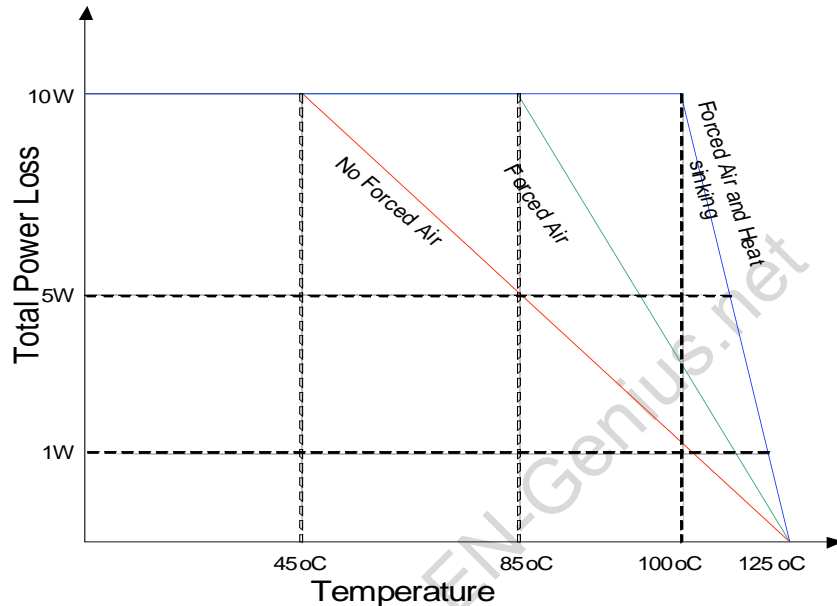


Fig. 5: Typical De-Rating Power Loss Curve

One other phenomenon that causes a major failure is temperature runaway caused by a solder joint crack. If the module is subject to mechanical vibration or several temperature cycle shocks, a crack is likely to develop in the solder joint which can eventually separate the component from the substrate. This will cause an increase in the electrical resistance, which in turn increases the temperature stress. These events may repeat until the cycle reaches wire-shear mode and results in catastrophic failures.

In the ISL8201M, system designers receive an extensively qualified and tested solution for the aforementioned reliability benchmarks.

Electrical Performance

One of the major difficulties that a system designer faces when choosing the best module is to find the delicate balance between performance, reliability and affordability. The difficulty of this task is amplified by a lack of standardized test conditions and measurement results, especially regarding some of the main parameters published in datasheets, such as power capability, efficiency and transient response.

When comparing efficiency, one has to take into consideration input voltage, output voltage and current level at the point where the efficiency is being compared. Transient

response is another parameter that needs some analysis in order to have a valid comparison. One has to make sure that the input and the output voltages are identical, the output capacitors have the same values and similar parameters (ESR, ESL, etc) and, finally, that the transient current steps applied are of the same magnitude and rate.

Thermal Performance

In many applications, power modules are required to operate in challenging environments. When comparing the power capability of a module, one should not only look at the electrical capability at 25°C but also consider the system ambient temperature, air flow and the method of heat transfer away from the module. For example the QFN package used in the modules from Intersil is designed to offer an optimum heat transfer through the PCB so the large copper plate under the module will improve the overall power performance.

Conclusion

Higher power density options are coming to market in the non-isolated point-of-load dc-dc converter space. Intersil's ISL8201M dc-dc module is one such example. It offers excellent efficiency and thermal performance in a compact 15 x 15mm QFN package. When evaluating dc-dc power modules for a specific application, care must be taken to fully examine the capabilities of the various options. The designer should go through the selection process by comparing their electrical and thermal performance, physical dimensions, and reliability specifications with the application requirements.

About The Authors

Zaki Moussaoui has 13 years of experience in power electronics and is currently a Senior Applications Manager at Intersil, where he is focused on power IC architectures including dc-dc POL converters. Prior to joining Intersil in 2002, he was Senior Principal Engineer at Unipower Corp. He earned MSEE, and PhD degrees from the University of Central Florida in 1994, and 2003, respectively. and holds many patents in the areas of power conversion.

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