Smallest Thinnest Power Modules for Data Center Optical Modules

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Abstract

Data transmission rates in optical communication field are on a constant rise. This paper describes the ever-increasing demand for highly integrated, small form factor, low profile yet thermally superior and electrically efficient power supply solution to support these high data rates and large amount of data transfer. It then follows to highlight Renesas's best in class mini power modules ideal for space-constrained applications such as optical modules, wearables, Home IoT, Medical equipment etc

What is an Optical Module?

An optical module is one of the core components of fiber-optic communication where its transmitting end converts the electrical signal to an optical signal and the receiving end converts the optical signal back to an electrical signal. It mainly consists of light-emitting components (such as lasers), light-receiving components (such as detectors), driving circuits, and photoelectric interfaces.

The optical module is majorly employed in the field of data communication. Data traffic has increased manifold with the emergence and rise of big data, blockchain, cloud computing, the IoT, artificial intelligence, and 5G, and optical interconnection of data centers and mobile communications has become a research hotspot in the optical communications industry.

The interconnections internal to the data centers account largely for the overall traffic distribution of the data center. Since in high-capacity data centers, multiple copper-fiber connections are required, multiple numbers of optical modules are used. Each optical module is exposed to a high volume of data packets and therefore, design engineers for high-capacity data centers often face challenges for optical modules. Due to this the development trends are increasingly towards high speed, low power consumption, low cost, demand for performance efficiency, higher integration, and higher power density.

Trend towards High Speed:

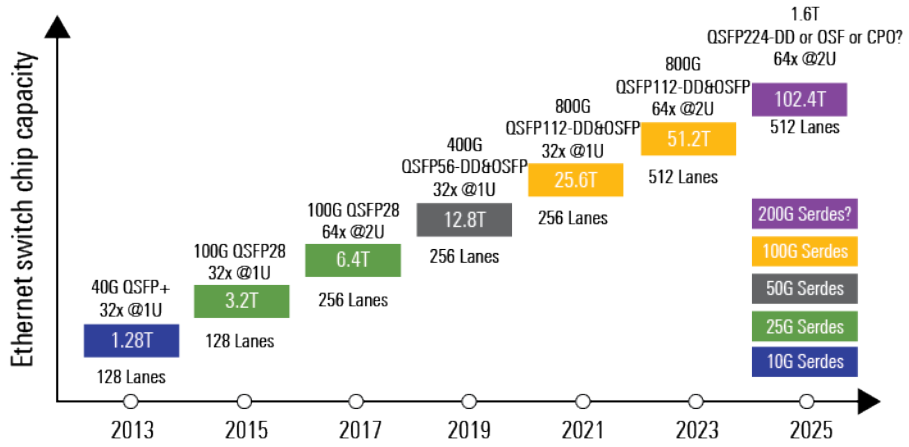


Figure 1: High Speed Trends in Optical Modules (reference 1)

While the data rates are transitioning from 400Gbps to 800Gbps with large scale deployment to be realized towards 2023-2024 (per the above graph), the power supply solution must still meet the form factor and thermal requirements of the previous generation of optical module. Higher data rate means higher currents for high performance Digital Signal Processor (DSP) or Clock and Data Recovery (CDR) Chips and MCUs that often push the power supplies at the back of the PCB where the height is limited to <1.2mm.

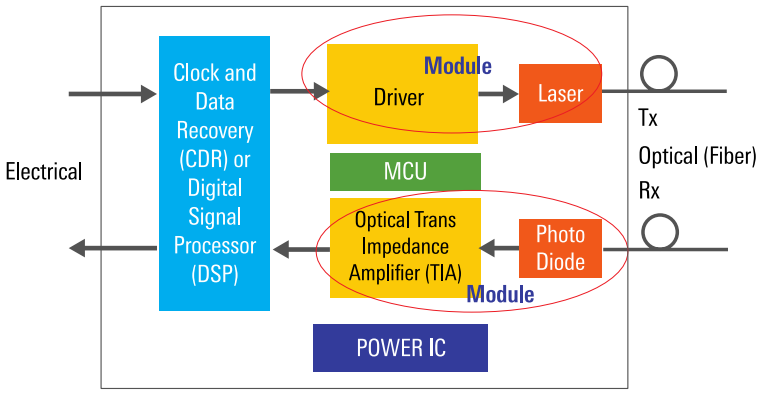
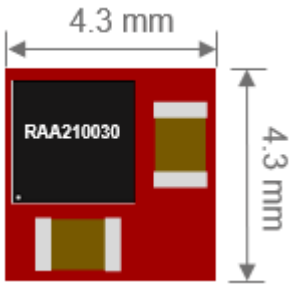


Figure 2: Optical Module Power Architecture showing where Renesas mini modules fit in

Renesas's Smallest Thinnest Modules for Optical modules

Renesas proudly offers RAA210040 and RAA210030 power modules that are compact, synchronous step-down, non-isolated complete power supply, capable of delivering up to 4A and 3A of continuous current respectively. By operating from a single 2.7V to 5.5V input power rail and integrating the controller, gate driver, power inductor, and MOSFETs, these mini modules are optimized for space-constrained applications like optical modules, wearables, IoT, networking. RAA210030 is the industry's smallest and thinnest over-molded package that provides 3A of continuous output current. The total solution size is just about 18.5mm^2.



Based on a peak current mode control scheme, these modules provide fast transient response and excellent loop stability. The output voltage can be set as low as 0.6V, with setpoint accuracy better than 1.5% over line, load, and temperature. The operating frequency has a 2MHz default setting; however, it can also be set from 500kHz to 4MHz by an external resistor. The external synchronization is supported with an external clock signal up to 4MHz.

Modules support a 100% duty cycle operation to minimize the switching losses and allows less than 200mV dropout voltage. A dedicated enable pin and power-good flag allows for easy system power rails sequencing. By shorting the COMP pin to VIN, the module uses internal compensation to stabilize the system and optimize transient response. Other features include soft-stop output discharge, external synchronization, 100% duty cycle operation, and low quiescent current.

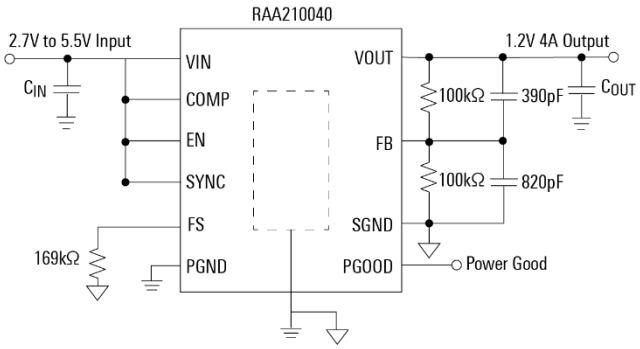


Figure 3: Typical Application Circuit of RAA210040

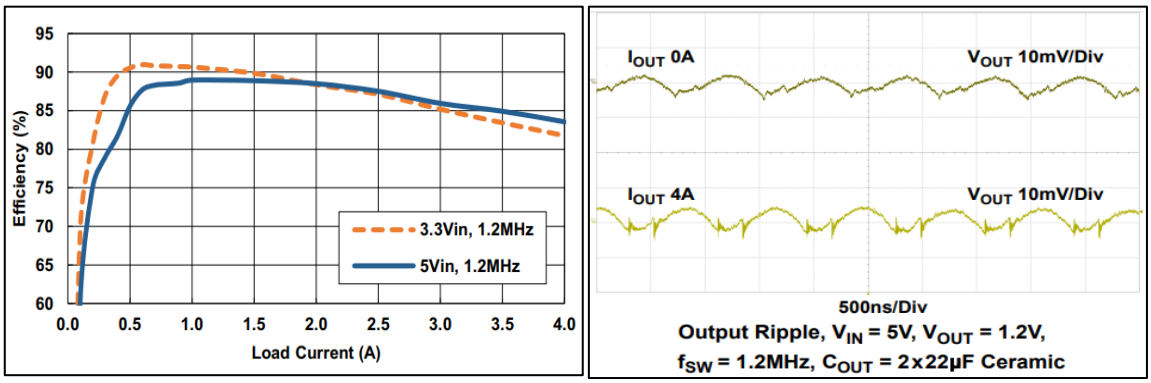


Figure 4: RAA210040 Performance: Efficiency at Vout=1.2V (Left), Output Ripple (Right)

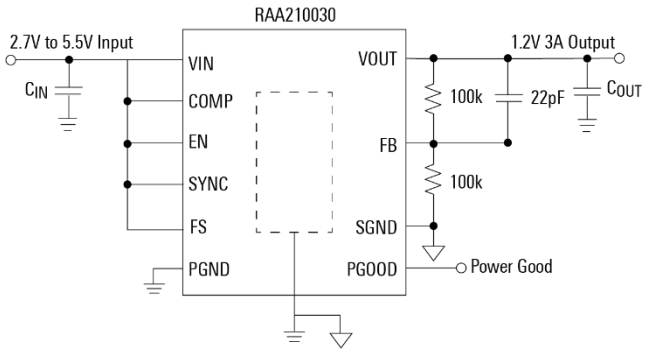


Figure 5 Typical Application Circuit of RAA210030

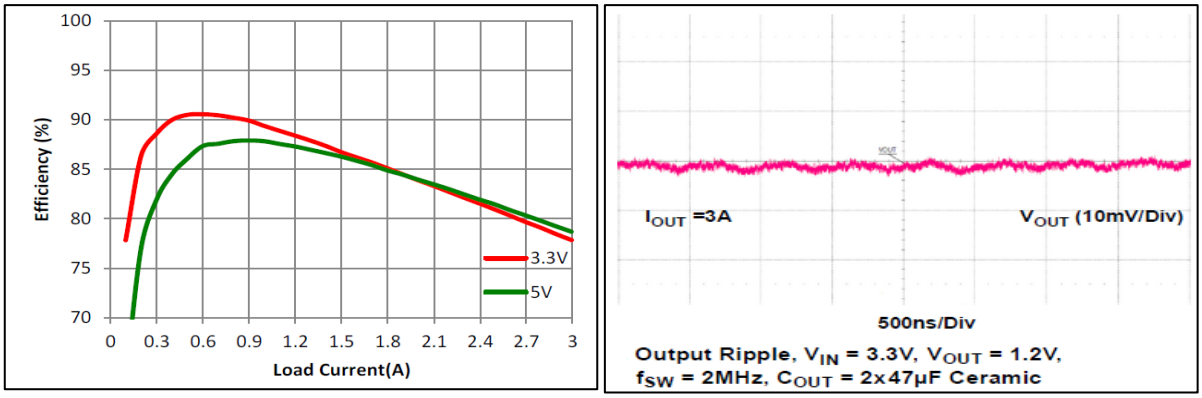


Figure 6: RAA210030 Performance: Efficiency at Vout=1.2V (Left), Output Ripple (Right)

Typical input voltage for the Trans-Impedance Amplifier and Laser Driver is 3.3V+/-5% with a current requirement of <2A. Maximum ambient temperature inside the optical module housing is ~70 degrees C. Both Renesas modules RAA210040 and RAA210030 can support continuous 4A and 3A of current at these ambient conditions as shown in the current derating graphs in Figure 7.

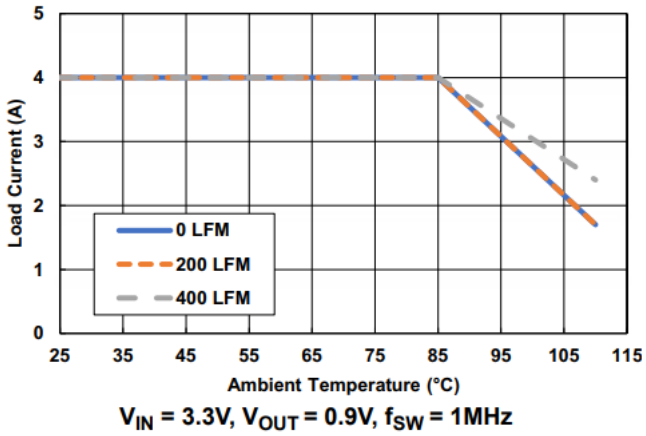


Figure 7: RAA210040: Output Current Derating

Integrated Inductor Solution with IC-in-substrate technology

Both RAA210040 and RAA210030 modules are integrated into a Dual Flat No-Lead (DFN) package with exposed copper thermal pads. This package has advantages such as good thermal and electrical conductivity, low weight, and small size. The DFN package is suitable for surface mounting technology and is widely used in industry. The embedded laminate substrate and inductor are over-molded with a polymer mold compound to protect these devices. The bottom of both RAA210040 and RAA210030 is an embedded laminate substrate, which is attached to the PCB by surface mounting.

Low profile DFN package allows placement on the backside of the PCB or under a common heat sink with digital devices such as FPGAs, ASICs and processors.

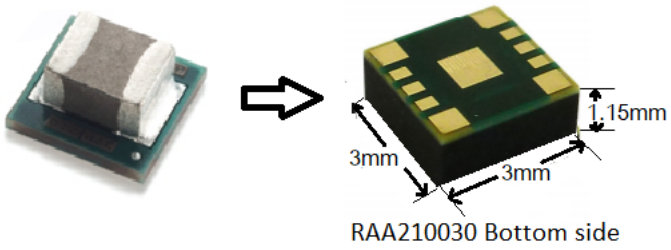


Figure 8: IC in substrate, Inductor on top

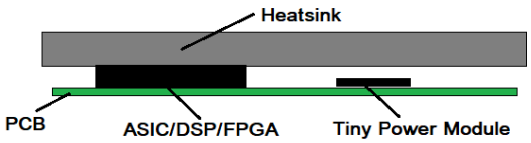


Figure 9: Power module placed under the heatsink with high performance ICs

Conclusion

This paper explored two mini module solutions from Renesas including the RAA210040 and the RAA210030. Both modules are a complete power supply solution with integrated inductor. RAA210030 is the thinnest over-molded module available with a height of just 1.15mm highly suitable for the optical module application. The modules are suited for 3.3V and 5V power supply rails in any space constrained applications.

References

- Optical Transceiver Technology Trends of Data Center in 2022: Blog post, Fibermall.com

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