# Eye on Components: DC/DC Converters with Integrated Magnetics Simplify Point-of-Load Power in Wireless Communication Equipment

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Many architectural standards for communications equipment have fixed chassis sizes and power supply budgets. A point-of-load (POL) power solution that maintains high efficiency with a reduced size allows increased card density so that space savings translate into product differentiation. At the same time, designers must quickly solve technical problems during the development phase, and a simple power solution reduces burdens and brings peace-of-mind by allowing engineers to focus on their core competency. The introduction of DC/DC converters with integrated magnetics into a single encapsulated package addresses many of these challenges. This article discusses the advantages and trade-offs of an integrated power solution and briefly explores external components, thermal implications, solution size, radiated noise, and circuit board mounting when compared to a discrete solution.

### Integrated Power Solution

Advancements in magnetics design and manufacturing allow integration of smaller, higher current inductors that can be placed in close proximity on the same substrate as a DC/DC converter integrated circuit. An integrated power solution (IPS) incorporates a power inductor that is optimized for the DC/DC converter. The entire assembly is solder reflowed to attach the IC, inductor, and passive components to a custom metal lead frame. Epoxy is molded over the entire assembly, which fully encapsulates the components. Next, the fully packaged IPS is checked by high volume automated testing equipment (ATE).

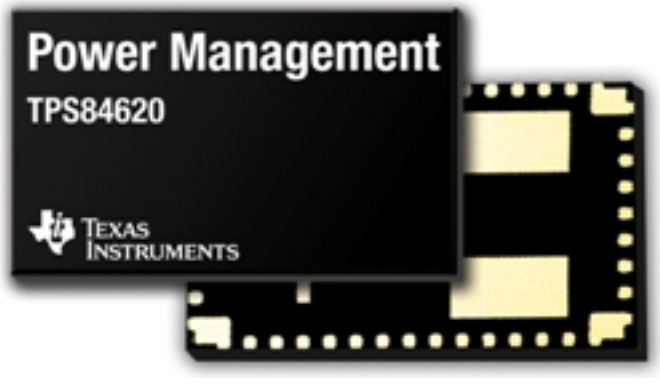

*Figure 1: TPS84620 package photo in 9x15x2.8mm QFN package.*

Figure 1 shows the back side of the TPS84620, a 4.5V to 14.5V input, 6A integrated power solution from Texas Instruments[1]. Now, a complete point-of-load power design can be mounted directly onto a circuit board, and is an alternative to traditional open frame POL DC/DC modules. Many semiconductor manufacturers are now using their packaging, ATE, lead frame, and DC/DC converter design expertise to develop POL IPS that can provide power to DSPs, FPGAs, ASICs, and other high-performance processors that are geared for wireless infrastructure applications. An IPS has the same appearance as an integrated circuit and is mounted in the same fashion on the circuit board.

**Advantages of an Integrated Power Solution**

An integrated power solution is very easy to use and requires fewer external components than a discrete solution. The task of locating a small, high-current inductor to match the DC/DC converter is eliminated. The boundaries of the input voltage, output voltage, switching frequency, and output current have already been considered when the inductor of the power solution was selected. Most integrated power solution require only input/output capacitance, and a voltage programming resistor, and these capacitance values are listed in the datasheet depending on the desired input voltage, output voltage, transient performance and ripple requirements. When the compensation components are integrated within the package, the burden of designing the compensation loop to be stable over temperature and varying load conditions is relieved. Time is also saved since the compensation loop no longer needs to be designed or mounted on the circuit board.

Integrated power solutions are available in small, thin QFN packages and can achieve a high power density. It takes considerable expertise to develop a discrete point of solution in a similar footprint. Digital designers will appreciate employing the size and performance that an experienced power designer can achieve without the required power management expertise.

**Trade Offs**

Higher switching frequencies allow smaller magnetics as shown in Equation 1. As the switching frequency (Fs) is increased, the value of the inductance (L) is decreased. However, the fast switching frequency that allows the small inductor to be packaged with the DC/DC converter may limit the achievable duty cycle (D),

which is the ratio of the output voltage divided by the input voltage.

Equation 1: L >/-Vo (1-D) / (Delta symbol i x Fs)

For powering low-voltage processors at 1.2V, for example, 5V or 12V input is a likely input voltage to consider. An integrated power solution that can operate at a higher input voltage is limited to a certain output voltage due to the minimum on-time of the DC/DC converter inside. An output voltage of 3.3V or 5V is more realistic for a 28V or higher input voltage since the switching frequency must be fast to accommodate the smaller amount of inductance. An IPS should specify a minimum on-time or indicate a minimum attainable output voltage with a given input voltage in the datasheet.

The inductor inside a power solution may have a higher DC resistance than a chosen inductor in a discrete design when a small solution area or height is not a key factor. If a small solution size is not necessary, the designer can design with a discrete inductor that has a very low DC resistance and help accommodate the efficiency target. The option depends on the application requirements and the designer’s talent

**Cost**

At first glance on the Internet, an integrated power solution may appear to be more expensive compared to a discrete DC/DC converter and inductor at a 1,000 piece suggested resale price. However, other costs such as labor, external component inventory, manufacturing, and PCB mounting costs not realized by the end customer are absorbed by the integrated power solution manufacturer. There is a good chance that the power solution is priced competitively to a discrete solution, depending on the end equipment’s production volume and time-to-market.

**Important Considerations**

Since the inductor and DC/DC converter are located in close proximity inside the package and dissipate considerable power, it is important to consider the power dissipation characteristics of the integrated power solution. Recent advancements in packaging and lead frame technology allow very small packages with excellent thermal dissipation performance. The datasheet shows the junction to ambient thermal resistance under natural convection (no airflow) to indicate how well the package removes heat from inside. If the junction to ambient thermal resistance (?ja) is 13 degree C/W, an integrated power solution delivering 20W at 90 percent efficiency dissipates about 2W (neglecting power loss in the capacitors) and increases the junction temperature by 26 degree C. A lower package thermal resistance increases the long term reliability of the power device. Thermal pads on the bottom side of the power solution and a metal lead frame help direct heat to the circuit board. Allowing for adequate copper on the circuit board with vias connecting the power planes to internal PCB layers is important to achieve good thermal results.

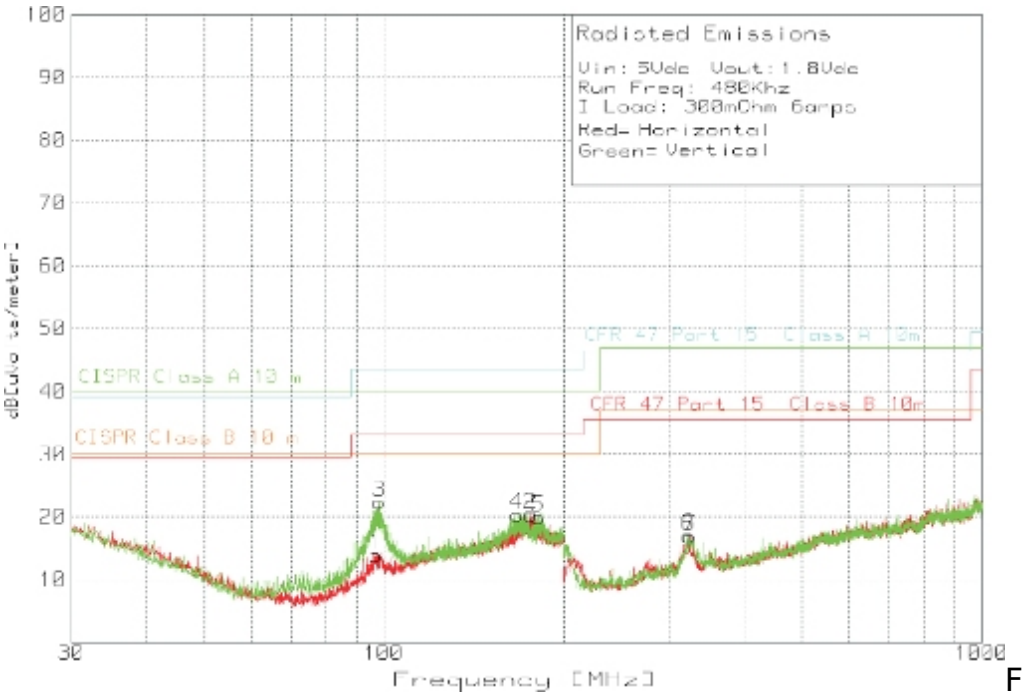


Figure 2: Radiated emissions 5-V input, 1.8-V output, 6-A load (EN55022 Class B).

Designers of wireless communication equipment are concerned about radiated noise. Since an integrated power solution houses the inductor, which is switching at a fairly fast frequency, it is important to verify whether the inductor used is shielded. Several power solution manufacturers indicate compliancy to EN55022 Class B radiated emissions on the datasheet. Figure 2 shows an example of radiated emissions plots for the TPS84620 operating from 5V and includes the plots of the antenna in the horizontal and vertical positions. If the data is not provided, request the radiated emissions data from the manufacturer, or inquire about the specifics of the inductor. After all, the inductor is being purchased and the user has every right to know what’s inside. If the power solution has a synchronization pin, the switching frequency can be synchronized to a master clock to eliminate the annoying beat noise of multiple switching regulators operating at different frequencies.

Since this integration technology is relatively new, manufacturers are posting quality and environmental data in product folders or in documentation on the websites to provide peace of mind. At Texas Instruments, an integrated power solution uses the same rigorous qualification procedures and reliability tests used in our power semiconductor manufacturing process.

**Summary**

The typical wireless communications application implementing a 5V or 12V bus for POL power values a very simple and reliable solution. Communications equipment is highly differentiated and the designer usually has another area of expertise other than power management. A design that removes the magnetics selection process, eliminates compensation components, and reduces the count of small external components is advantageous. An integrated power solution, such as the TPS84620, addresses these issues without sacrificing efficiency, performance or feature set, yet allowing an inexperienced power designer to construct very small and dense form factor directly on the circuit board.

www.ti.com [1]

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**Links:**
[1] http://www.ti.com