Infineon Smart Building Solution

With intelligence comes power: How Power over Ethernet is enabling smarter buildings?

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Contents

1. With intelligence comes power: How Power over Ethernet is enabling smarter buildings 3

2. Selecting the optimum approach for the PSE SMPS 7

3. Options for a standard PD-side SMPS 8

4. Application specific PoE needs: Powering LED lighting 9

5. Summary 10

1. With intelligence comes power: How Power over Ethernet is enabling smarter buildings

For years, the various domains of building management were handled as disparate systems, with suppliers attaining recognition for their skill in areas such as fire and life safety, security and alarms, energy management, and HVAC and sanitation. However, like in many other industry segments, the room to achieve further efficiencies reaches its limits when each segment is handled separately.

As an example, a networked, intelligent luminaire makes little economic sense in isolation unless that intelligence can be leveraged for other purposes. Functionalities such as temperature measurement, humidity and room occupancy could be determined through suitably designed intelligent luminaires. With the forthcoming roll-out of 5G, the integration of a pico-cell for wireless connectivity could also be considered in many building management application nodes. If cross-domain integration at software-level is also achieved, both installation and long-term building operating costs can be reduced. The ubiquity of Ethernet as a technology for data exchange is highly attractive. It is well understood, easy to install and integrates well with existing platforms. However, like many data-transfer technologies, power has to be provided separately. In an area like building management this requires both a data-system expert as well as an electrician to install the system. Should the building be reconfigured at some point, again both roles will be required to complete the work. With the introduction of Power over Ethernet (PoE), suddenly the challenges for both installation, reconfiguration, and operation of the complete building management system become much simpler. A PoE switch can be installed capable of powering multiple devices simultaneously, while those devices, whether IP phones, 5G pico-cells, Wi-Fi access points, or luminaires, can simply be attached via conventional Ethernet cables to the switch, both at initial installation, or later reconfiguration of the office space.

The advantages have been recognized in projects such as The Edge, a multi-tenant office building in Amsterdam featuring 650 PoE switches. Lighting and temperature are under the control of employees via a smartphone app while facility managers retain a clear overview, allowing them to maximize operational efficiency and minimize the CO_2 footprint. Over a period of 20 months, cost per employee has been lowered by over €1,800.

PoE itself is not new, having been used for typical office applications for some time. Desk phones are one example, drawing their power from Ethernet cables as well as being digitally connected to the network. With the recent release of the amendment to IEEE 802.3bt-2018, new technical opportunities for designers of Smart Buildings open up, regardless of whether they are existing or new constructions. The changes make use of all four twisted pairs of the installed network cable infrastructure for PoE, allowing more power to be delivered to many more end devices (figure 1). The amendment additionally addresses overall energy efficiency with lower standby power consumption in end devices, and mechanisms to better manage the available power budget, thus increasing the benefits of PoE even further.

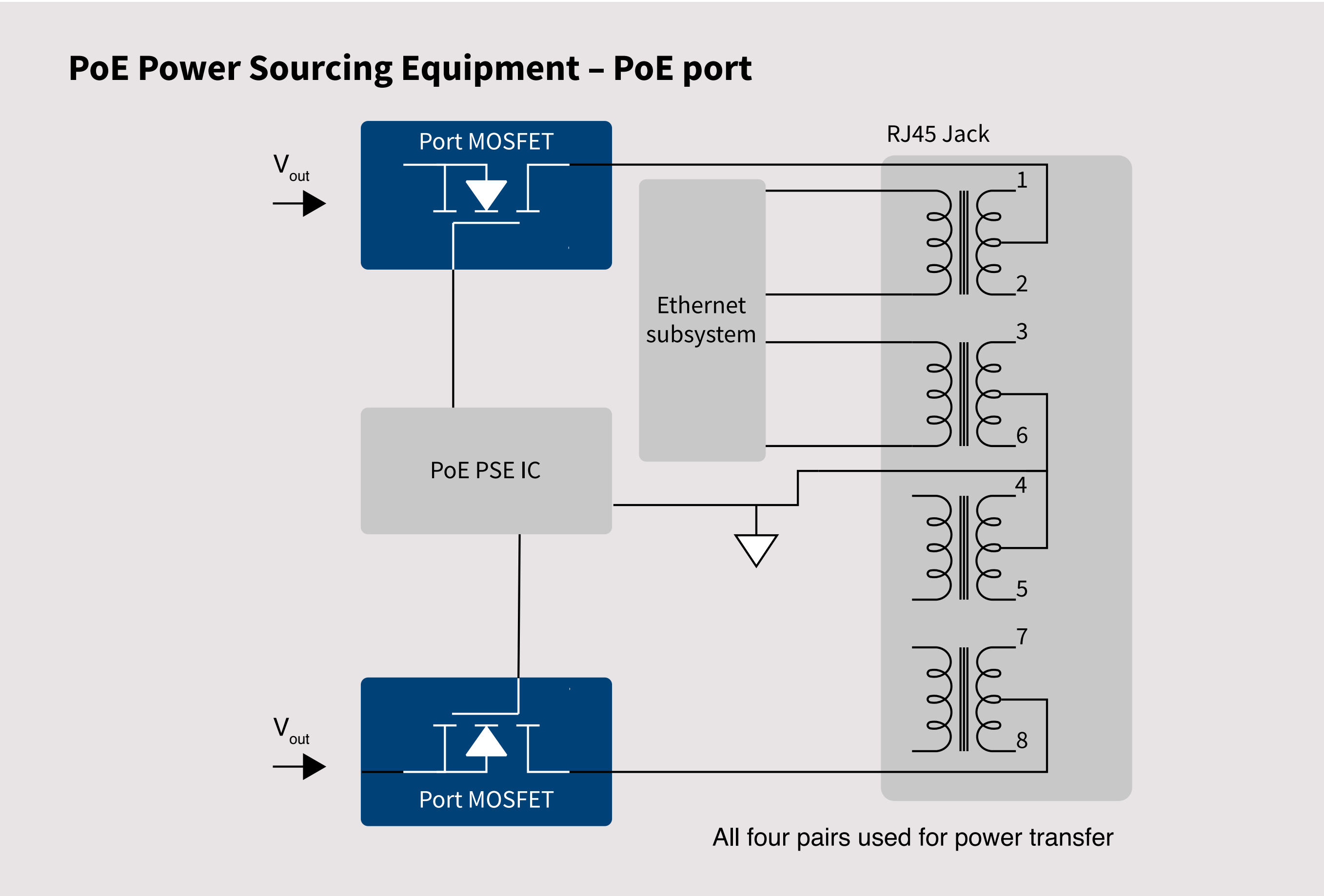

Figure 1: The latest changes to the PoE standard can make use of all four twisted-pair for both data and power delivery. Here illustrated for a single RJ45 jack of a PoE Power Sourcing Equipment.

The new nominal power levels have also been increased enabling up to 71.3 W to be delivered to the Powered Device (PD) for 100 m cable length. To support this, the Power Sourcing Equipment (PSE) must produce a minimum of 90 W per port while still reacting to the lower standby power required by PDs when in sleep mode. This enables designers to use the existing infrastructure to power devices such as security cameras with pan-tilt-zoom (PTZ) capability, LED lighting, public announcement (PA) systems, displays, signage solution, as well as future highly integrated solutions that could include luminaires featuring 5G pico-net cells and PA audio.

Another benefit of the latest amendment over the previous version is improved efficiency, since the power loss in a CAT5 cable can be cut in half thanks to using two pair-sets with just $0.5 \cdot I$ each and thus reducing power loss due to $P_{loss}=2R_{cable}(0.5 \cdot I)^2=0.5R_{cable}I^2$. This provides a further reduction in carbon footprint and energy costs, a further bonus to facility managers.

In future, we will see PoE Power Sourcing Equipment like Ethernet switches that integrate a power- and energy-efficient isolated AC/DC switched mode power supply (SMPS) that is capable of delivering up to 100 W (maximum power per port according to new standard) to multiple ports, while the PD side appliances will make use of < 100 W isolated DC/DC converters. The isolation requirements stem from the Ethernet and PoE standard and add additional requirements to the overall power supply design of PoE solutions.

Power solutions for the PSE will make use of hard- or soft-switching topologies in each of the stages featuring a low figure-of-merit (FOM), such as $R_{DS(on)}$ times gate charge Q_G, through using MOSFETs that provide low switching losses to deliver a peak output of up to 2 kW (figure 2). Use of such devices ensures high efficiency even under very light loads. An auxiliary power branch can also be implemented to power the electronics of the switch itself.

The PD side leaves more room for interpretation as it needs to be dimensioned according to the needs of the application, such as total or steady power, or stability across temperature variations. For sure an active or passive bridge rectifier will be included, coupled with a PD controller (which is mandated by the PoE standard), and DC/DC switching regulator. However, the application itself may demand a specific approach that can utilize silicon solutions that are optimized to a specific application segment, such as that of LED lighting.

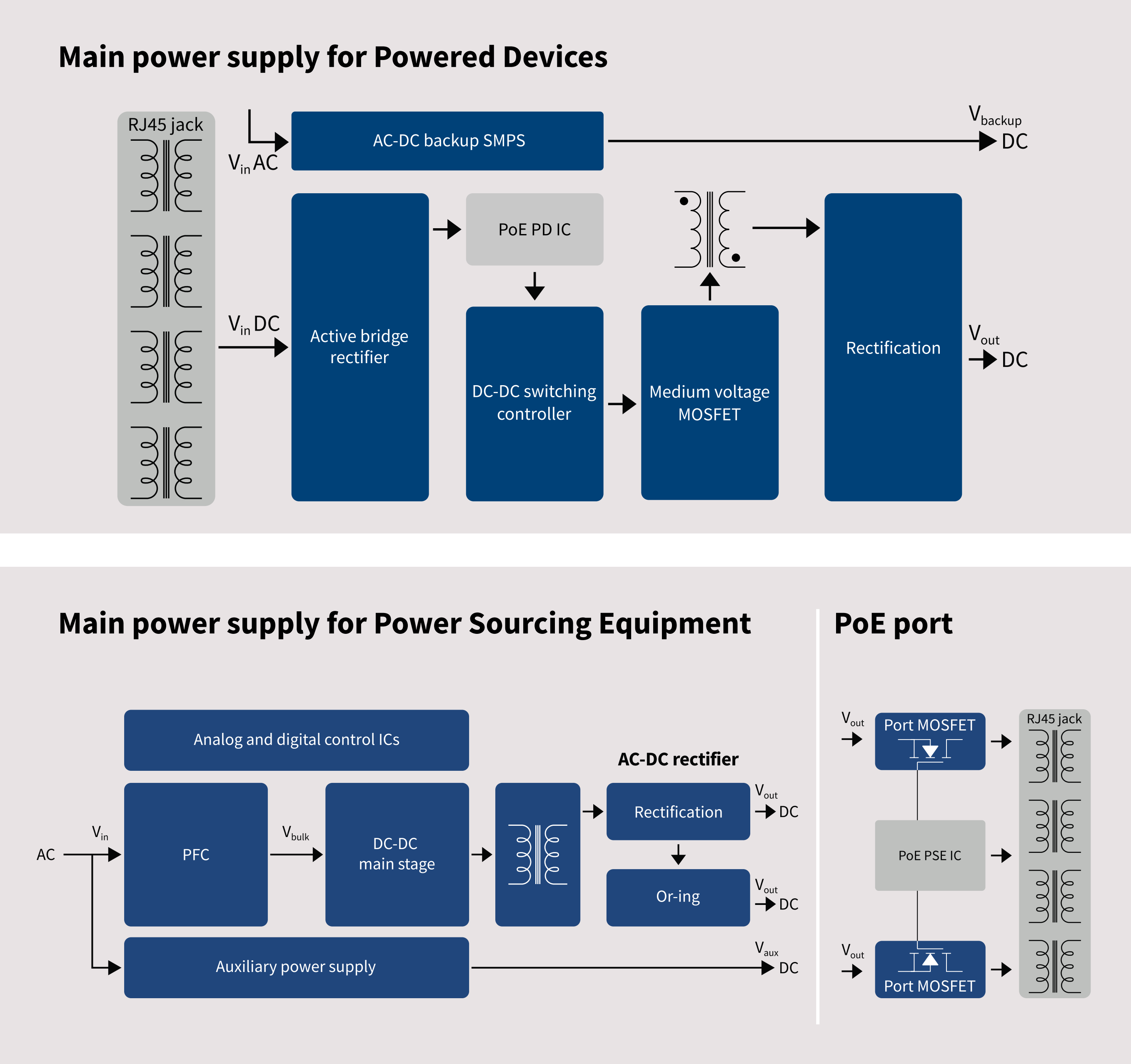

Figure 2/3: The PSE will require an efficient PFC and low-loss switches using an isolated topology (top), while PDs will make use of a generic DC/DC solution unless targeting specific applications such as LED lighting (bottom).

2. Selecting the optimum approach for the PSE SMPS

The requirements for the SMPS differ quite a bit between the Power Sourcing Equipment and the Powered Devices. While the PSE side with devices such as injectors or Ethernet switches often requires a rather high power supply well above 100 W when supplying more ports. Whereas the SMPS on the PD side is typically operating below 100 W.

In terms of power supply design and management for the PSE main SMPS, CoolMOS™ from Infineon is one of the best power families in its class. The CoolMOS™ devices offer high efficiency at low line conditions and also pass brown out testing with a lower MOSFET temperature than most other devices. Its best-in-class $R_{DS(on)}$ with low switching losses provides optimized speed capability. Efficiency is high with a small footprint and, while ESD can be a problem in any design, this is where the CoolMOS™ P7 shines, with integrated ESD protection to reduce failures (figure 3). Ringing is also minimized in the CoolMOS™ design with an excellent ringing margin, and the device also has a rugged body diode for improved reliability. The aspect of quality should also be considered, with the CoolMOS™ family's broad qualification providing reliability over a wide temperature range and low failure rate, ensuring that the likelihood of power supply failure on a switch is minimized.

On the DC/DC converter stage on the PD side the requirements differ substantially with voltages staying below 60 V and current being limited. To address these requirements the Infineon OptiMOS™ or StrongIRFET™ are commonly used thanks to their capability to improve system efficiency and power density whilst keeping system costs at a minimum. For example OptiMOS™ with a 15% lower $R_{DS(on)}$ and 31% lower figure-of-merit (FOM) $R_{DS(on)}$ times gate charge QG compared to alternative devices they answer these challenges perfectly.

In addition auxiliary power supplies which often require high performance in both fixed frequency and quasi-resonant switching schemes the CoolSET™ family offers a strong portfolio with enhanced performance as well as robustness needed to reliably run in the long run.

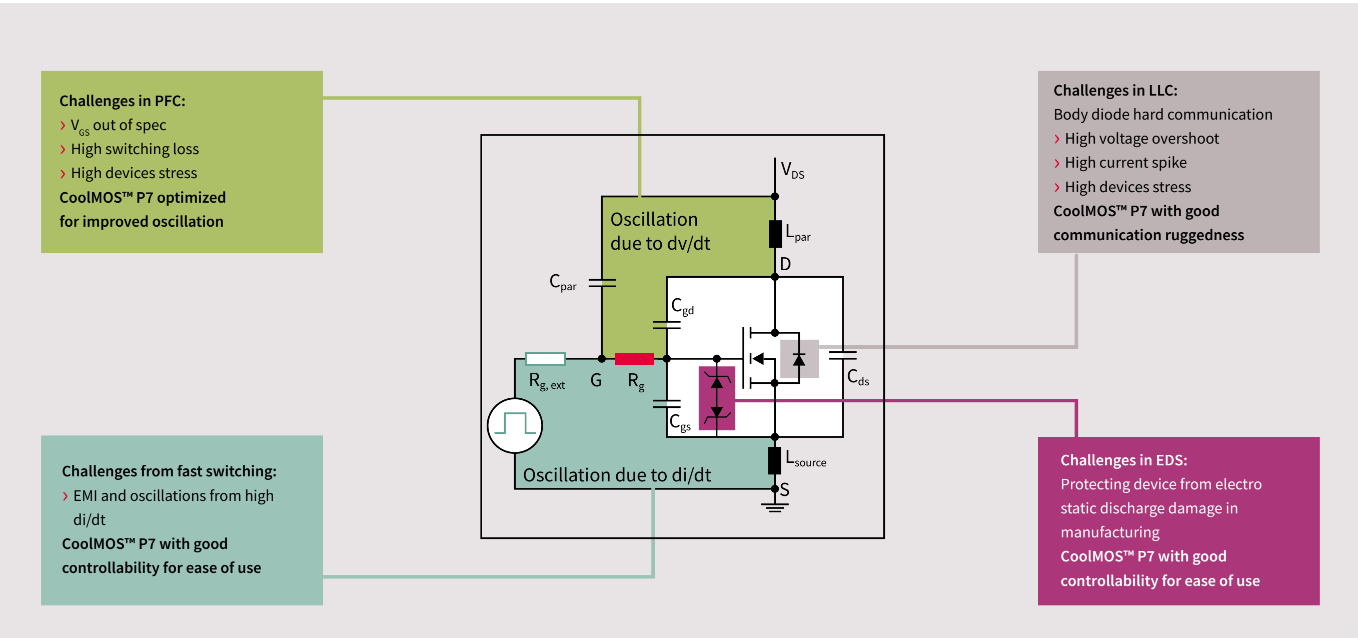

Figure 4: The 600 V CoolMOS P7 provides designers solutions for various challenges in power supply design, e.g. a robust ESD performance of >2 kV (HBM class 2)

The CoolMOS™ P7 finds a home in both the PFC and the DC/DC converter, ably supported by the rugged EiceDRIVER™ family of low-side gate drivers. High efficiency is also a focus here, with 5 ns slew rates and propagation delays of just ±5 ns. With -10 V robustness at its inputs, these devices also protected against GND-bounce, providing a crucial safety margin when driving pulse transformers. They also provide under voltage lock out (UVLO) options for protection of the switches during start-up and abnormal conditions, contributing to the overall reliability of the PoE solution.

3. Options for a standard PD-side SMPS

For the DC/DC isolated SMPS reliable and robust MOSFETs such as Infineon's 100 V MOSFETs are ideal in combination with the CoolSET™ auxiliary power supplies for standards below 50 W.

On the PD side, a transformer isolates the cable and is followed by a bridge rectifier. Bearing in mind the voltages involved, low-voltage switches are more than adequate as part of a flyback, LLC or further converter topologies with galvanic isolation. Here the core requirements are low $R_{DS(on)}$ and gate charge Q_g enabling an efficient implementation, along with innovative packaging that is both compact and allows for noise-free thermal dissipation. Here the OptiMOS™ family is ideally suited for the switches. Devices such as the BSC440N10NS3 G, a 100 V power MOSFET, offer the world's lowest $R_{DS(on)}$ in low package-resistance SuperSO8 packages, in a footprint of just 31.7 mm2. Designers also benefit from the very low Q_g and Q_{gd} that contribute to an improved figure-of-merit (FOM).

Of course, some applications may require an alternative auxiliary power source for when PoE is unavailable. Here high efficiency, fixed frequency (FF) or quasi-resonant (QR) AC/DC topologies can be used, either integrated into the application or as an external solution. The CoolSET™ range of switching converters provide a high efficiency when in operation, and the robustness required for long-term reliable operation. The change to low or medium load conditions is made more efficient thanks to frequency optimization that reduces switching losses and increases efficiency, while selectable burst mode entry/exit profiles optimize light-load efficiency. Devices such as the ICE5AR0680AG deliver up to 40 W with a universal wide input range of 85 – 300 V_{AC} offer robust brown in protection, auto-restart for its protection features, and all in conjunction with a low bill-of-materials (BOM) count.

4. Application specific PoE needs: Powering LED lighting

Certain applications already have dedicated power solutions optimized to meet their unique needs. Smart lighting, one such application space, is considered crucial in maximizing employee performance and health. Here, an efficient, LED-optimized power solution with protection functions will lead to less maintenance, reducing the need to replace luminaires in ceilings over their lifetime. In smart building lighting, there are always last minute changes, so a configurable solution that can help reduce hardware variation and speed up the product development time will also contribute to completing a project on time, in budget, with a solid and reliable design architecture.

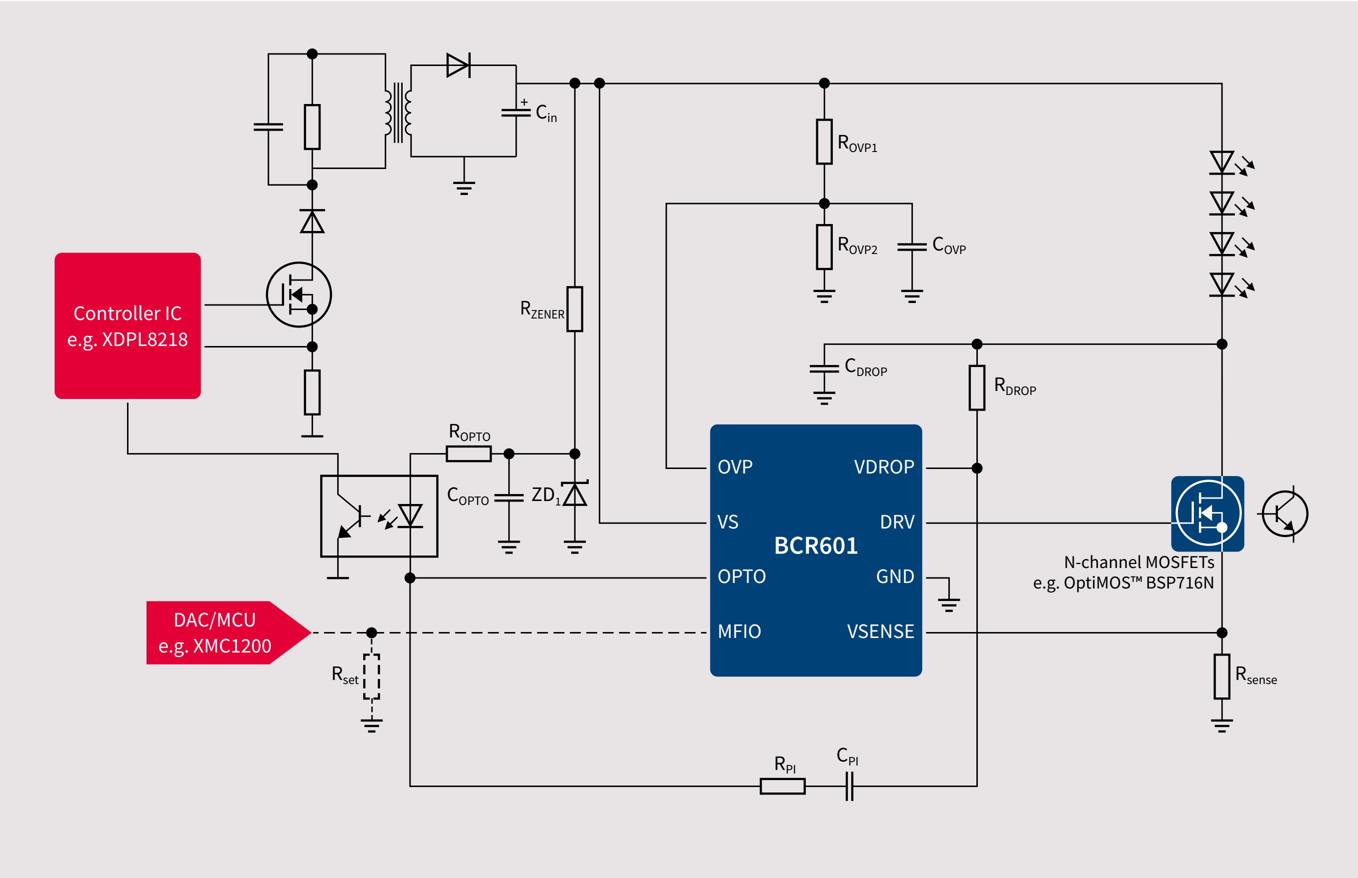

Figure 5: The BCR601 series offers linear control with voltage feedback to the primary side in an SO8 package.

The LED controller itself needs to ensure a flicker-free light output, while options for dimming are an essential element of the smart building approach. The addition of thermal protection contributes to the long-term reliability of the resulting luminaire. A good choice for a digital power, constant current LED controller is the BCR601 series, a 60 V constant current controller that can use either NPN bipolar transistors or an N-channel MOSFET as the power element to drive the LED diode strings. The OptiMOS™ family is also a good match here too. The BCR601 has supply voltage ripple suppression, hot-plug protection, overvoltage and overtemperature protection. It also offers analog dimming and an R-set function to set the LED current with multiple LED strings in the design.

Demonstration or evaluation boards are also available that can help developers get started and review the capabilities of such silicon solutions. Because they are well designed by the manufacturer and Gerber files are provided, designers can easily integrate useful circuit and PCB elements into their final PC board artwork, enabling faster time-to-market.

5. Summary

Since the ratification of IEEE 802.3bt-2018, foundations are in place for rapid changes as well as disruptions in Building Management Systems (BMS). The building installations and the way smart buildings will be developed and used will necessitate new and more efficient solutions not just for power conversion architectures, but the applications they power, such as LED lighting, as well. Engineers looking to tackle these challenges can draw upon the fast time-to-market component solutions and tools, application experience, as well as the high-reliability product portfolio, that suppliers such as Infineon can provide.

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