Application Brief

Achieve Low Loss Rectification Using TI's Diode Bridge Controllers

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End equipments such as home security sensors, video doorbells, landscape lightning, thermostats, Power over Ethernet (PoE) powered security cameras use low-voltage AC sources (typically 24Vac) as input but downstream loads require a DC source. For these kinds of applications, full wave rectifiers are used to convert AC to DC. Conventionally, this is achieved by Schottky diodes which have poor performance in terms of power dissipation and thermals. This article highlights how LM74680/1 Ideal Diode Bridge Controller enables lower power dissipation for better thermal management in a space constraint end equipments.

Low Voltage AC Rectification

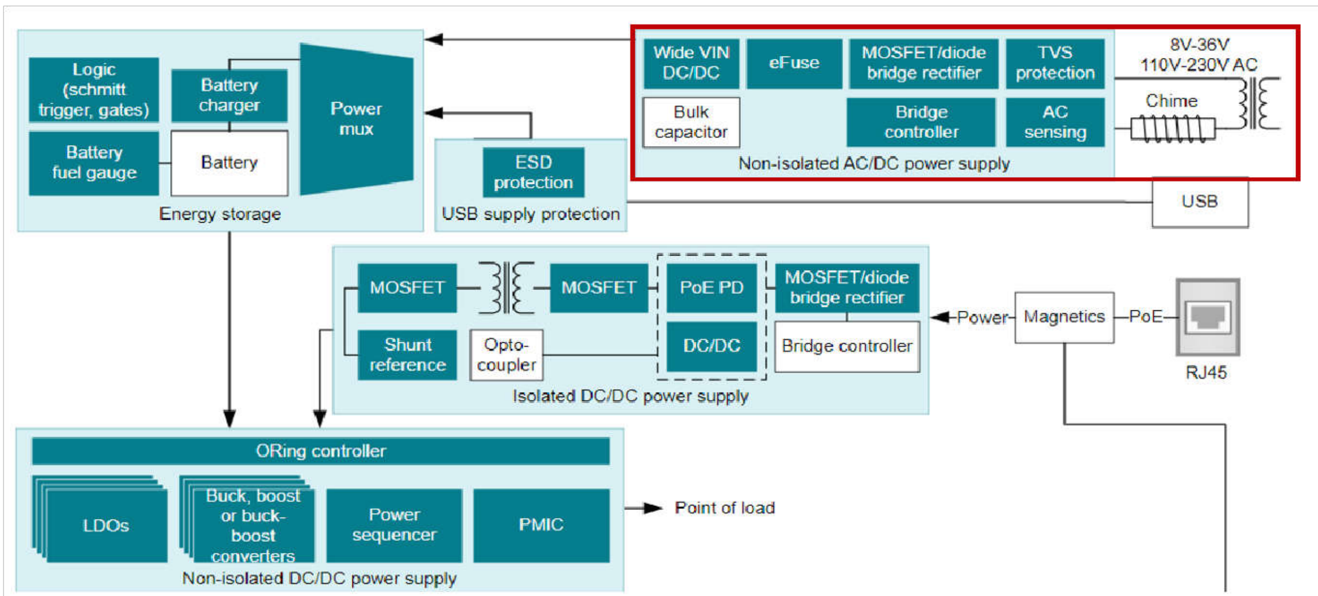

Figure 1. Typical Block Diagram of a Video Doorbell

Many modern-day doorbells even including low-voltage AC powered doorbells, contain circuits that require a DC power supply such as microcontrollers, sensors, or communication modules. Conventionally, a diode bridge is used to convert low-voltage AC to a steady DC voltage for powering these components. These components are particularly sensitive to noise sources such as fluctuations in the power supply, electromagnetic interference, and temperature variations. The most important feature is wide input range to support operating voltage due to different transformer rating ranging from 8V to 36V AC. Video doorbell front end designs must include power-management products that support high efficiency across a wide input range and operating load current.

To design a video doorbell that can be mounted on any door frame and perform best in any temperature, the designer must consider the thermals of the power-management components. Traditionally, diode bridge rectifiers are used at the input to power the downstream loads in the design which offer poor performance due to high drop across each diode in each AC cycle.

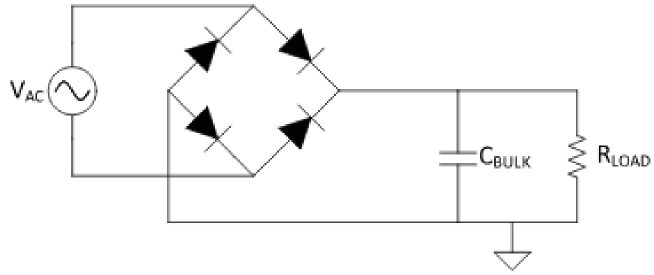

Figure 2. Conventional Diode Bridge Rectifier

Considering 0.5V Schottky in a conventional diode bridge, the drop in each cycle is around 1V (0.5V × 2). This dissipates around 1.5W power each cycle for 1.5A load.

Power over Ethernet (PoE)

Power over Ethernet allows electrical power and data to be transmitted simultaneously over a single Ethernet cable. This eliminates extra wiring for electrical power and simplifies the installation process. PoE mainly consists of three components.

- Power Source Equipment (PSE)
- Powered Device (PD)
- Ethernet Cable

With addition of IEEE 802.3bt in 2018, the power capability of POE has increased which enables a wider range of applications, such as powering devices like high-performance IP cameras, wireless access points, and LED lightning systems. The new standard introduced type 3 (up to 60W) and type 4 (up to 100W) power delivery by using of all four pairs of wires.

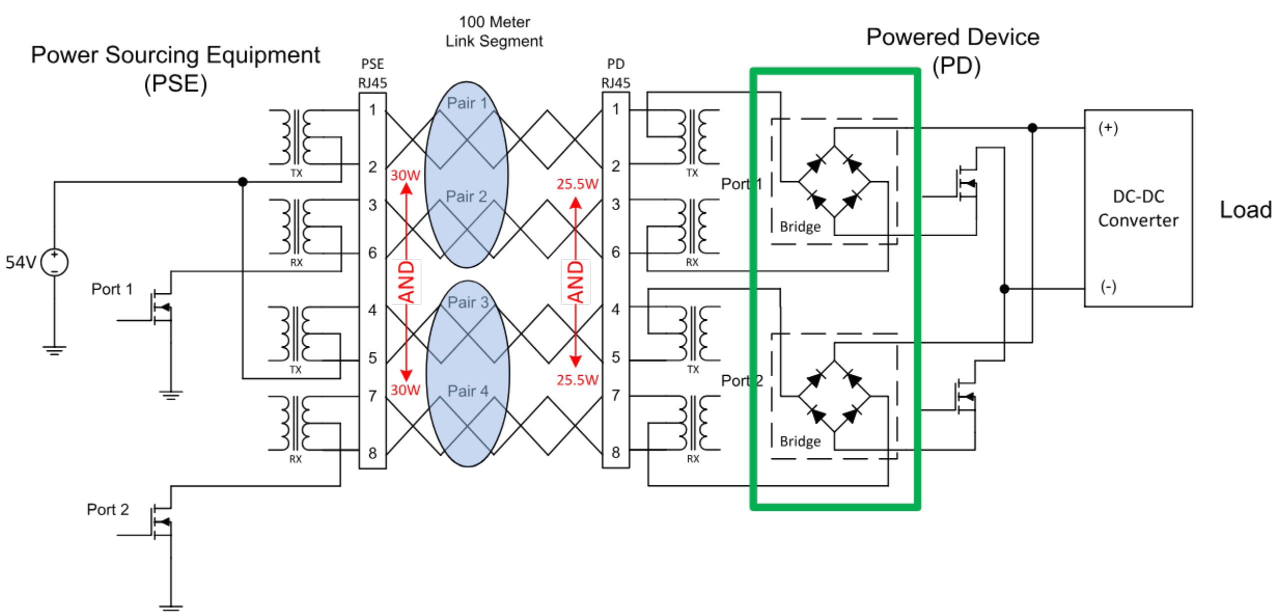

Figure 3. Power Over Ethernet Input Architecture

Conventionally, the design uses two diode bridges which results in total voltage drop of 0.5V × 4 = 2V (considering a 500mV Schottky). To deliver 90W power to downstream load with 48V rail, the required current is about 1.9A if equal current sharing is considered. This dissipates a total of 1.9W power.

Design with LM7468X Ideal Diode Bridge Controllers

The LM74680 is a diode bridge controller that provides voltage rectification by driving four N-channel MOSFETs in a full-bridge configuration. LM74680 enables lower voltage drop and reduced power dissipation as compared to conventional diode bridge rectifiers. This helps to simplify the power supply design, eliminate heat sinks, and reduce the PCB area. The integrated charge pump allows use of N-channel MOSFETs, which are smaller and more cost-effective than P-channel MOSFETs for the same power level. The charge pump also offers fast response to reverse current conditions for protection against input short events. The LM74680 has an enable pin which allows for the gate driver to be either enabled or disabled by an external signal. The LM74680 supports voltage rectification from DC to 1kHz.

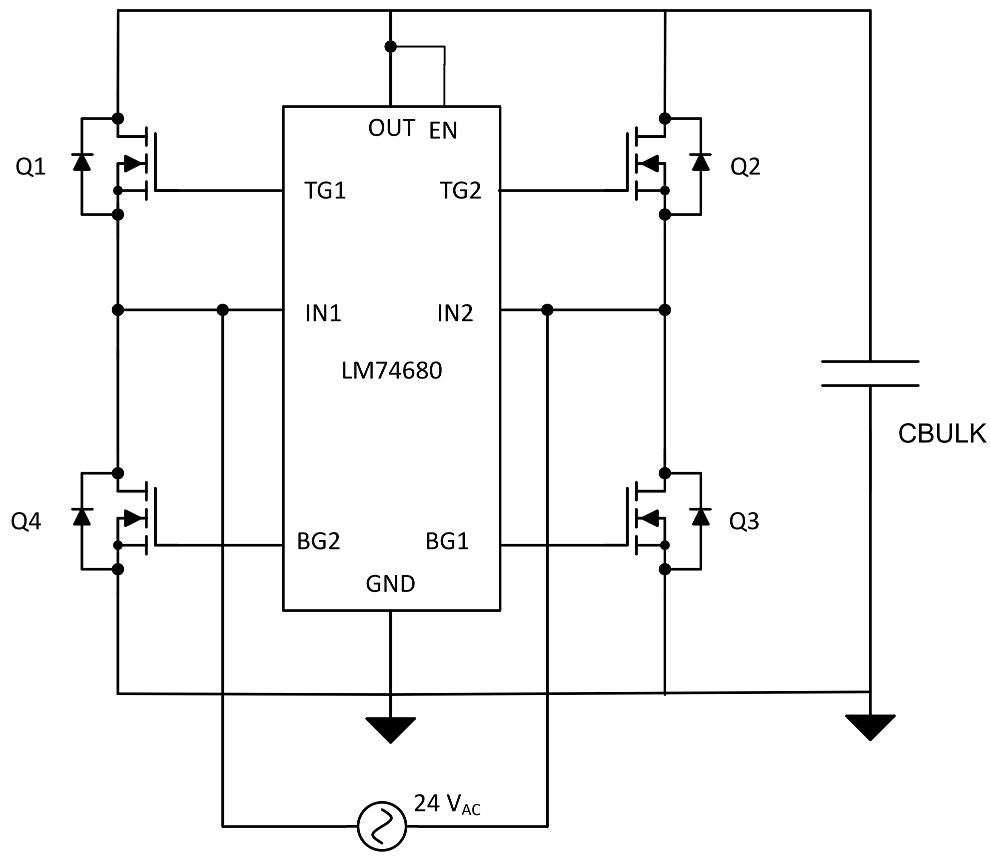

Figure 4. LM74680 Ideal Diode Bridge Controller

When compared to the performance of LM74680, the drop in each cycle is only $2(I_{LOAD} \times R_{DS\_ON})$ when operating in full conduction mode. For a 1.5A load, when using CSD88537ND FETs from our EVM, LM74680 only dissipates $2 \times (1.5A^2 \times 12m\Omega) = 54mW$ power in every cycle. A conventional bridge dissipates 27x more power than the smart controller.

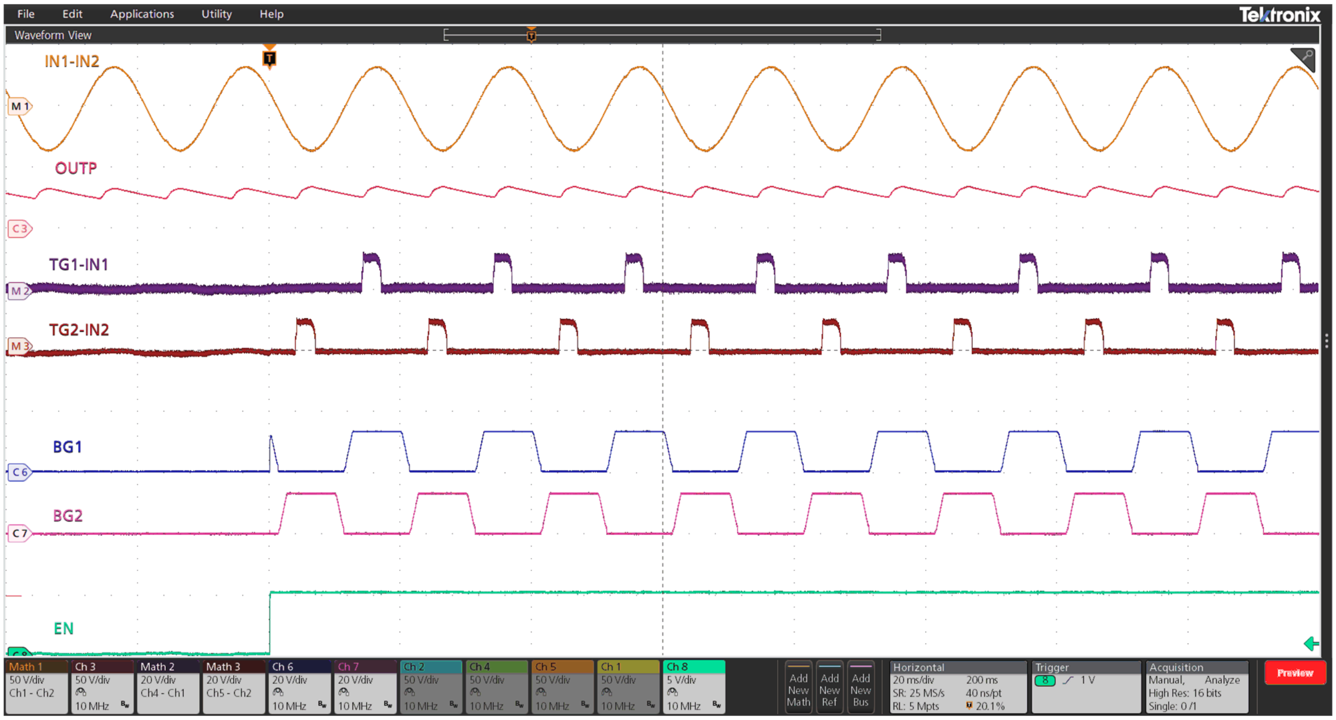

Figure 5. LM74680 Active Rectification of 24VAC 50Hz Source

Note

Component selection to achieve AC rectification as shown in Figure 5 can be found in the LM74680 data sheet referenced below.

The size, power consumption and thermal management play significant role in designing smaller end equipment such as video doorbell. The LM74680 diode bridge controller is a good fit to address those challenges and design systems which can reliably work across the desired temperature range.

Figure 6 shows the theoretical power dissipation comparison between B360A schottky diode and CSD88537ND MOSFET when paired with LM7468x.

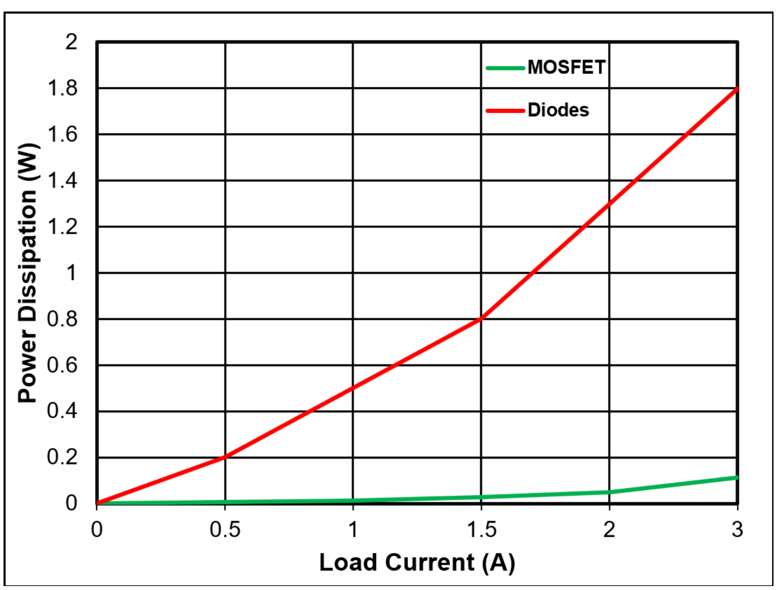

Figure 6. Power Loss Comparison Between Schottky Diode and LM7468x Design

Figure 7 and Figure 8 show the difference in temperature rise when each of the design scheme is subjected to 3A DC load at room temperature.

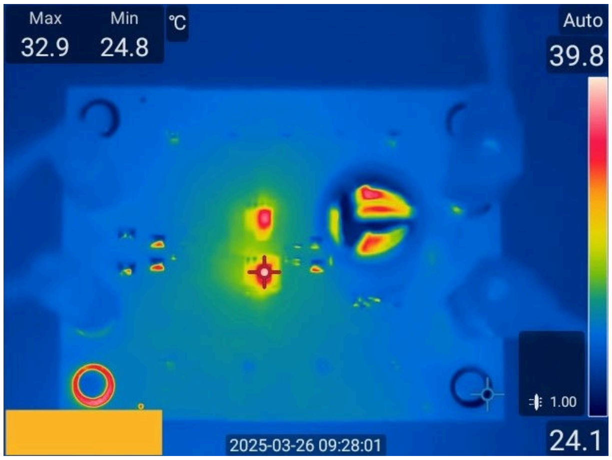

Figure 7. CSD88537ND FETs Thermal Performance with 3A DC Load

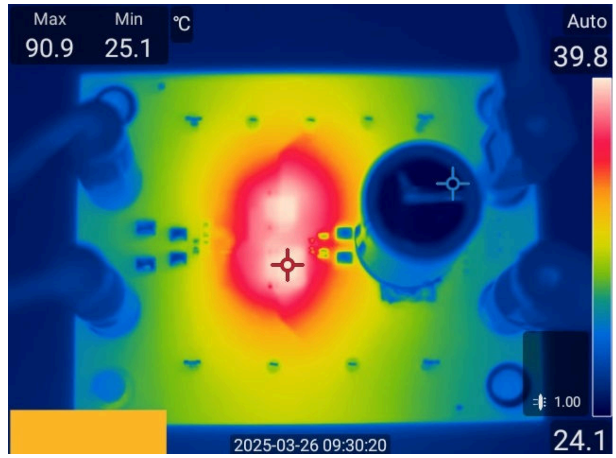

Figure 8. B360A Diodes Thermal Performance with 3A DC Load

Conclusion

Passive diodes are an easy way to design a circuit but are very inefficient to use because of bigger size, high voltage drop, and poor thermals. With miniaturization of new age designs, replacing the passive diodes is critical to increase the performance. Active bridge rectifier controllers like LM74680 and LM74681 offer best in class performance from thermals and efficiency aspect. With help of the controllers, reliability and lifespan of designs can be increased.

References

- PoE Lighting Is Coming
- Enabling the next generation of video doorbells
- LM74681 100V Ideal Diode Bridge Controller for PoE Powered Applications
- LM74680 Ideal Diode Bridge Controller for Low Loss Rectification