POWER MANAGEMENT FOR ENERGY DISTRIBUTION AUTOMATION

Design Guide

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Table of Contents

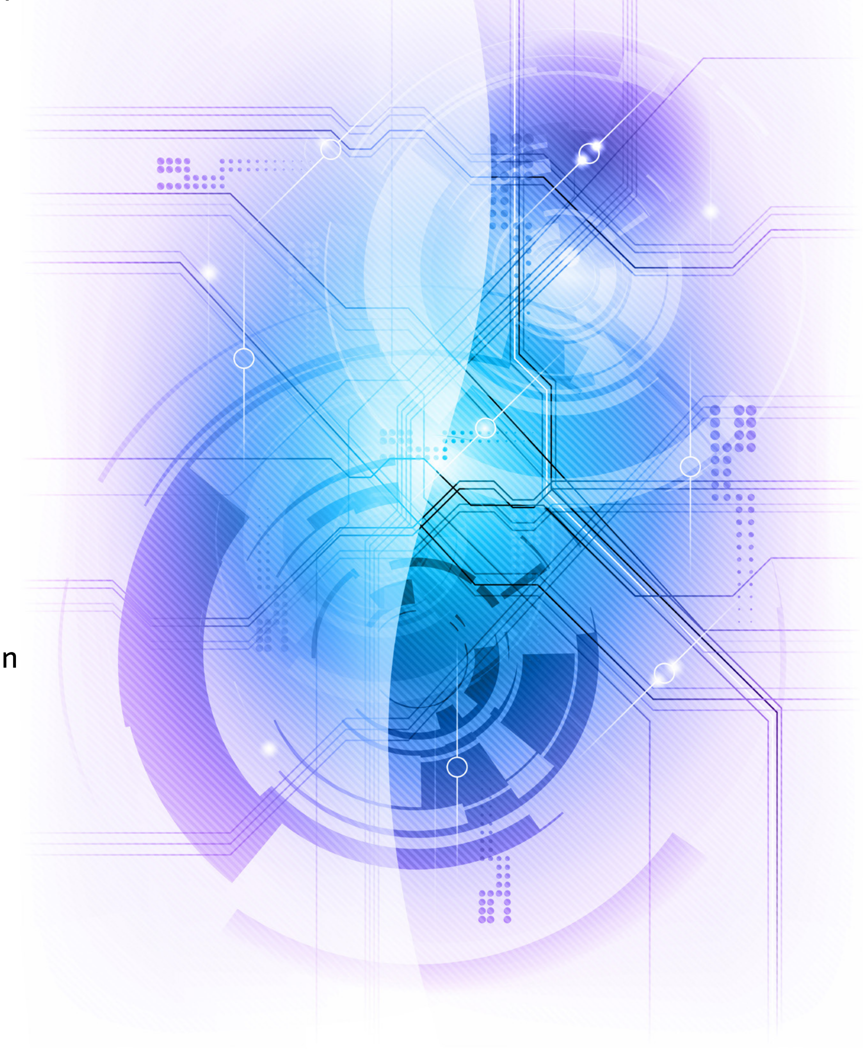

Figure 1. Power Substation Electrical Switchgear

Introduction

Power grid modernization is progressing at a steady pace. Modern control and automation techniques can have significant energy savings, protect the environment, and enhance quality of life by improving the health and safety of citizens. Energy distribution automation uses digital sensors and switches with advanced control and communication technologies to automate functions including electric power generation, switching, real-time adjustments to load changes, monitoring, and management of outages, overvoltages and undervoltages, and power factor correction. Automation can improve the speed, cost, and accuracy of these key distribution functions to deliver reliability improvements and cost savings to customers. This requires control of field devices, to enable automated decision making in the field and relaying critical information to the utility control center.

Designing for energy automation ***(Figure 1)*** introduces issues of energy efficiency, solution size, system safety, and reliability of the electronics used. This design guide will review the megatrends underlying the energy distribution automation revolution and its associated system challenges, from networking protocols all the way to the hardware. It then examines new solutions for the power management of field devices through several case studies.

[1] Architecture 2030
[2] Actual green building performance

Megatrends in Energy Distribution Automation

Energy operators are increasingly managing energy distribution remotely using the cloud. Their software platforms provide performance monitoring, data analytics, visualization, fault detection and diagnostics, and portfolio energy management. These automation systems can monitor several variables in real-time and analyze historical data to adjust the devices to provide energy management while complying with government regulations and tariff policies. By networking the equipment data to the cloud, analytics can be run in real time using advances in artificial intelligence (AI) to determine action to be taken. Advanced Distribution Automation (ADA) extends intelligent control over electrical power grid functions at the distribution level and beyond. Electric utilities with supervisory control and data acquisition (SCADA) systems have extensive control over transmission-level equipment, and have increasing control over distribution-level equipment via distribution automation. Energy distribution automation results in higher availability, serviceability, predictive maintenance, as well as fault detection, isolation and mitigation.

The Energy Automation System

Energy automation system architecture ***(Figure 2)*** includes different layers for management, control, and the field. The management layer operates and controls the energy distribution from one central location, recording and optimizing data as necessary. Problems are spotted in real time and action can be taken immediately. The control layer deals specifically with the equipment control at the hardware level. At the field layer, intelligent sensors and actuators collect data and perform tasks. Sensor and control systems embedded in the distribution system signal the reduction or elimination of outage time, hot-running equipment, circuit-breaker trips, flickering and blinking lights.

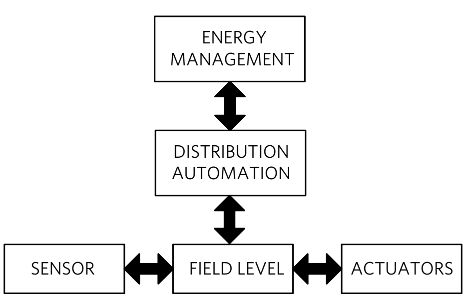

Figure 2. Energy Distribution Automation System

The Technology Enablers

Distribution automation (DA) systems use a variety of wired and wireless communication media, depending on the particular segment of the communication network. All this intelligence, networking, and control is enabled by phenomenal advances in hardware and software. At the field level, it is manifested through controllers, sensors, I/Os, and actuators. A controller can be a programmable logic controller (PLC), motor/motion controller, or a distributed control system (DCS) using advanced processors and microcontrollers. Sensors can be either digital or analog and used to measure temperature, humidity, vibrations, opens and shorts. Actuators can be used to control energy flow, temperature, humidity and other parameters. Sensors and actuators communicate on wire or wireless gateways to the control center. They are powered by batteries or wired DC voltages, typically in the 5V to 24V+ range. ***Figure 3*** shows a transformer substation's control panels with its switches, signaling lamps, sensors and scales.

Figure 3. Transformer Substation with Switches and Sensors

The controller receives inputs from sensors on the field, processes them, and drives the proper actuators. Today's sensors and actuators are equipped with internal processors that make simple decisions locally without the need to escalate to the controller, thereby improving throughput.

The Challenges

The proliferation of intelligent, internet-connected equipment places new requirements on system hardware: reduced component size to fit additional electronics in the same chassis, improved energy efficiency to perform within the same or lower thermal budget and increased electrical/mechanical safety and reliability to reduce downtime. In summary, the challenges for the electronic components are:

1. Higher Energy Efficiency
2. Reduced Solution Size
3. Increased Safety and Reliability

In the following sections, we will present a few examples of how power management electronics can come to the rescue in each case.

Challenge 1 - Higher Energy Efficiency

Case Study: Design 20W to 30W power supplies with over 90% efficiency for +24V building automation systems

The smaller PCB size that results from miniaturization presents a challenge for thermal dissipation. Thermal management options, such as heatsinks, are ruled out since board space is at a premium. Fans for forced airflow cannot be used due to sealed enclosures that prevent ingress of dust and pollutants. Therefore, it is crucial that the power-supply solution is extremely efficient, while delivering higher power and occupying a smaller area than ever before.

Solving the Power Dissipation Problem

Wired energy distribution field applications are characterized by a 24V nominal DC voltage bus that has its history in old analog relays and remains the de-facto industry standard. However, the maximum operating voltage for these applications is expected to be 36V to 40V for non-critical equipment, while critical equipment, such as controllers, actuators, and safety modules, must support 60V (IEC 61131-2, 60664-1, and 61508 SIL standards). Popular output voltages are 3.3V and 5V with currents that vary from 10mA in small sensors to tens of amps in motion control, CNC, and PLC applications. Thus, the obvious choice for control applications is a step-down (buck) voltage regulator.

The most common step-down architecture available is the nonsynchronous buck converter because it is easy for semiconductor manufacturers to design nonsynchronous buck regulators for high voltages. In this architecture, the low-side rectifier diode is external to the IC.

For a 24V input and 5V output, the buck converter works with a duty cycle of about 20%. This means that the internal high-side transistor (T in ***Figure 4***) conducts only 20% of the time. The external rectifier diode (D) conducts the remaining 80% of the time, which accounts for most of the power dissipation.

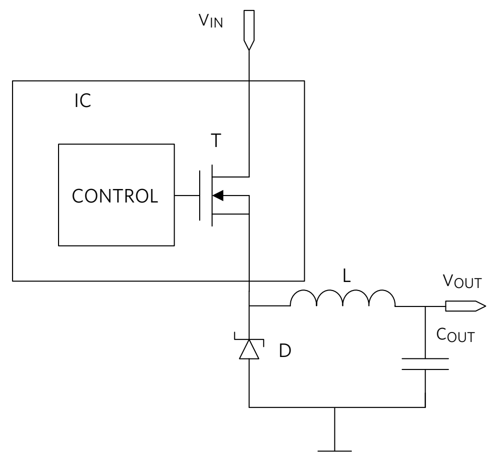

Figure 4. Nonsynchronous Buck Converter

As an example, with a 4A load, a Schottky rectifying diode such as the B560C, exhibits a voltage drop of about 0.64V. Consequently, at 80% duty cycle, the conduction loss (the dominant loss at full load) is approximately equal to (0.64V) x (4A) x (0.80) = 2W.

On the other hand, if we utilize a synchronous architecture ***(Figure 5)***, the diode is replaced with a low-side MOSFET that acts as a synchronous rectifier. We can trade off the 0.64V drop across the diode with the drop across the MOSFET transistor's T2 on-resistance, $R_{DS(ON)}$.

In our example, the MOSFET (RJK0651DPB) has an $R_{DS(ON)}$ of only 11mΩ. This leads to a corresponding voltage drop of only (11mΩ) x (4A) = 44mV and a power loss of only (0.044V) x (4A) x (0.80) = 141mW. The MOSFET power loss is about 14 times smaller than the Schottky power loss at full load! Clearly, the logical way to minimize power dissipation is to use synchronous rectification.

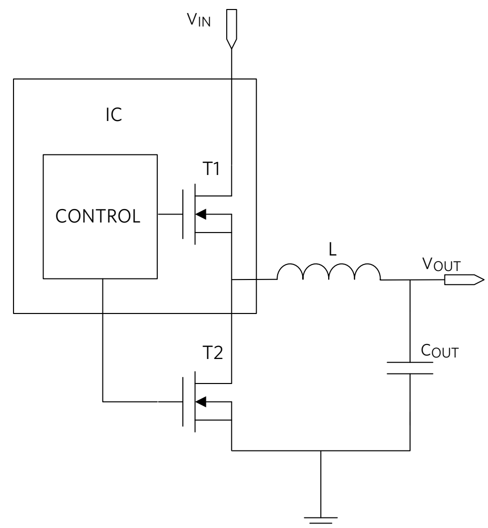

Figure 5. Synchronous Buck Converter

To minimize the overall size of the power-supply circuit, the synchronous rectifier IC should include internal compensation. Newer synchronous rectifiers provide internal compensation for any frequency and output voltage without requiring an oversized output capacitor that hurts bandwidth. The rectifier should also operate at high frequencies to allow the use of small inductors and capacitors.

Naturally, the goal is to fully integrate the entire synchronous rectification half-bridge (T1 and T2) into the IC, as illustrated in *Figure 6*.

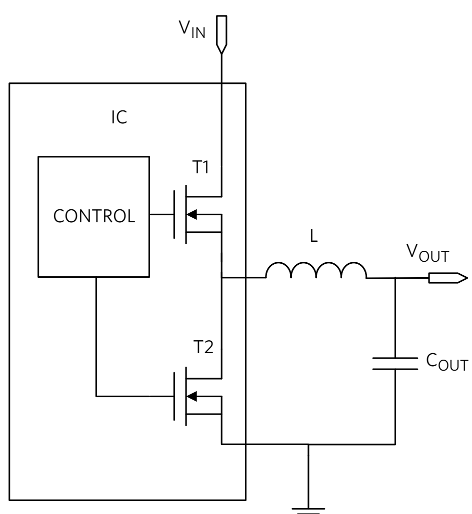

Figure 6. Fully Integrated Synchronous Buck Converter

A Word of Caution on Maximum Input Voltage

While 24V is the nominal rail for many applications, carefully consider the maximum operating voltage. Select from 28V, 36V, 42V, or 60V input power management solutions available on the market today. With a margin of only 4V, a soution with 28V input is too close to 24V to provide a reliable margin. Many standards require 60V tolerance, removing the need to make a choice. It is tempting for many designers to choose a device with a 36V maximum input. However, using a 36V input is a high-risk approach for sensors and encoders working on a 24V rail. Even if TVS diodes are used for surge protection, they have a wide tolerance and could still expose equipment to excessive voltages. Unless you know and have modeled every possible surge scenario resulting from long cables and PCB traces, use devices with a 42V or 60V maximum operating voltage even if the standard does not require it.

No Need for Trade-Offs

Maxim's Himalaya family of high-voltage buck converters implements synchronous rectification for higher efficiency. Himalaya regulators also feature input voltages up to 60V and output currents from 25mA to 50A, with fully integrated dual MOSFETs for devices that support loads up to 5A. Tagged with the slogan "Bye-Bye Schottky," Himalaya buck converters include internal compensation that does not require settling for the trade-offs discussed earlier.

Figure 7 shows the **MAX17503**, a 60V, 2.5A fully integrated buck converter configured for 5V output.

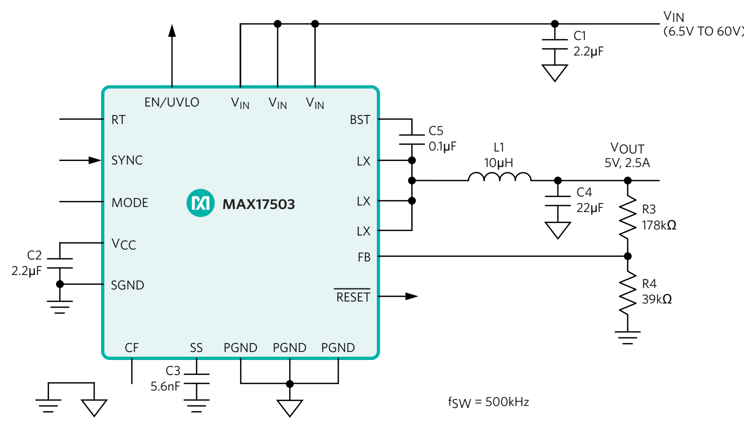

Figure 7. Typical Application Circuit for MAX17503 $24_{VIN}/5V_{OUT}$, 2.5A Synchronous Rectification Buck Converter

An efficiency comparison of the MAX17503 vs. another synchronous solution, based on published specifications, is shown in Figure 8. The MAX17503 shows an efficiency advantage of up to 5%.

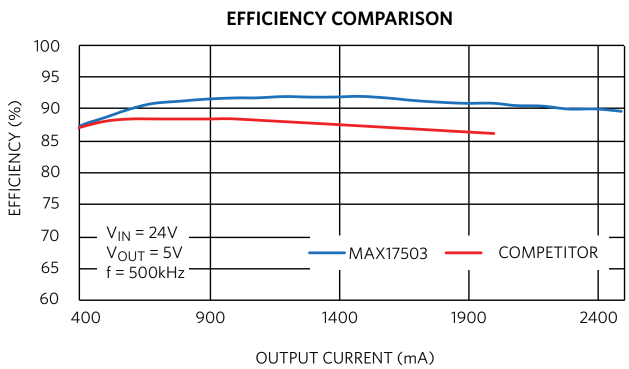

Figure 8. Efficiency Comparison Between the MAX17503 and Another Synchronous Buck Converter

For higher levels of current, the MAX17506 synchronous rectification buck converter can be used. *Figure 9* shows the **MAX17506** application diagram for a 5V, 4A, 20W solution.

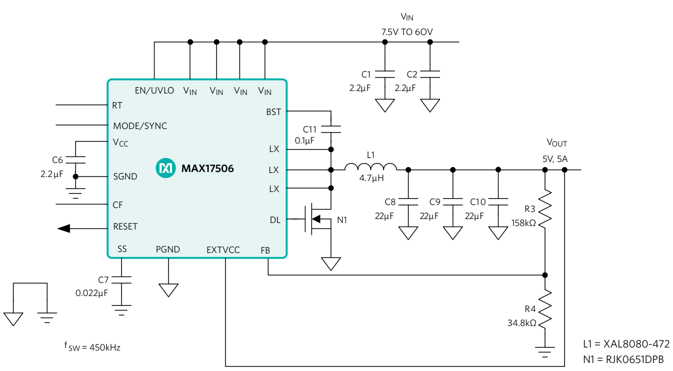

Figure 9. Typical Application Circuit for MAX17506 24V$_{IN}$/5V$_{OUT}$, 4A Synchronous Rectification Buck Converter

An efficiency comparison of the MAX17506 vs. a nonsynchronous solution, based on published specifications, is shown in *Figure 10*. For both devices, the test conditions are 24V input and 5V, with a 4A output. As expected, the synchronous solution exhibits higher efficiency across the entire load current range. At full load (4A), the efficiency of the synchronous solution is above 92% while that of the nonsynchronous device is only about 86%, a difference in efficiency of more than 6%.

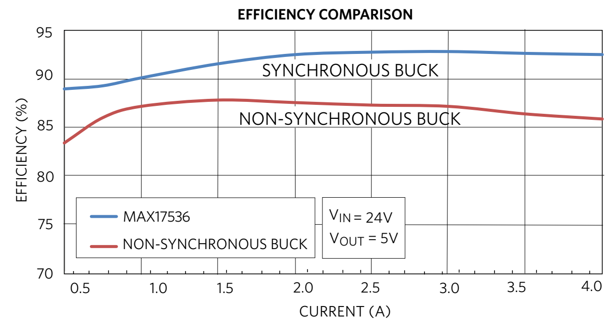

Figure 10. Efficiency Comparison Between MAX17506 and a Nonsynchronous Buck Converter

The MAX17506 synchronous solution demonstrates a clear efficiency advantage that eases thermal management challenges in field applications.

With the industry's first 60V synchronous buck regulators, Maxim's Himalaya family combines high efficiency and small size to cover a wide range of design requirements.

Case Study: Leverage a power module for faster time-to-market

Built using Himalaya voltage regulator ICs, the Himalaya power modules enable cooler, smaller, and even simpler power supply solutions. The **MAXM17504** ***(Figure 11)*** is an easy-to-use, step-down power module that combines a switching power-supply controller, dual n-channel MOSFET power switches, a fully shielded inductor, and compensation components in a low-profile, thermally efficient, system-in-package (SiP) framework.

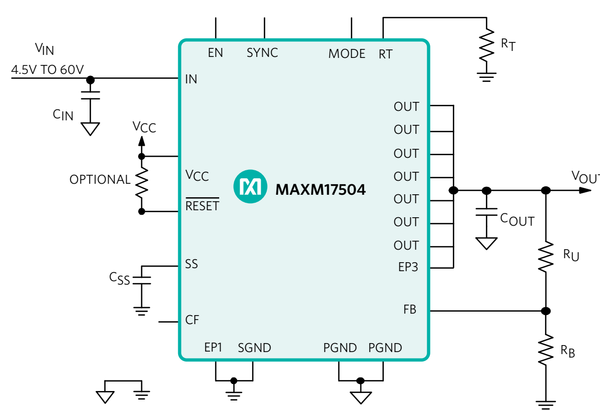

Figure 11. MAXM17504 Power Module

The MAXM17504 operates over a 4.5V to 60V wide input voltage range and delivers up to 3.5A continuous output current with excellent line and load regulation over a 0.9V to 12V output voltage range. The device only requires five external components to complete the total power solution. The device's high level of integration significantly increases reliability, reduces design complexity, reduces manufacturing risks, and offers a true plug-and-play power supply solution that accelerates time-to-market. It can be operated in the pulse-width modulation (PWM), pulse-frequency modulation (PFM), or discontinuous conduction mode (DCM) control schemes. The MAXM17504 is available in a 29-pin, highly thermal-emissive, low-profile 9mm x 15mm x 2.8mm SiP package that reduces power dissipation in the package and enhances efficiency. The package is easily soldered onto a PCB and is suitable for automated circuit board assembly. The device operates over the temperature range from -40°C to +125°C.

Productive Power Design for Every User with EE-Sim

Interested in quickly trying any of the switching power supply ICs in this design guide? They are all available in the EE-Sim® Simulation Tool Suite, where designing and simulating a personalized circuit takes just minutes.

Enter your own design requirements in the EE-Sim DC-DC Design Tool, and it delivers a circuit schematic and complete bill of materials. Then easily set up and run both time- and frequency-domain simulations in just minutes. Or download the schematic for analysis in the offline EE-Sim OASIS Simulator featuring Simplis as well as SIMetrix/SPICE simulation engines.

Visit the **EE-Sim Switching Regulator Reference Designs** table at the end of this guide to select and open one of these ICs directly in the EE-Sim tools, or **view the EE-Sim DC-DC Tool Overview** video to learn more.

Challenge 2 - Reduced Solution Size

Case Study: Pack more punch in your small sensor while keeping it cool

Sensors have become ubiquitous in the control environment. As they increase in sophistication and shrink in size, sensors enable Industry 4.0 applications. In turn, sensor electronics are becoming more complex, requiring on-board voltage regulators to deliver power more efficiently with minimal heat generation. How do you safely deliver low-voltage power to tiny sensors in high-voltage environments, while minimizing solution size and maximizing efficiency? In this section, we will review a typical sensor architecture and provide a simple solution to this challenge.

Field Sensor Applications

Strategically placed throughout the distribution network, current, voltage, power and temperature sensors provide multiple benefits including identification of fault locations and causes to support quicker restoration efforts and proactive actions to avoid future unplanned outages. An intelligent sensor provides fault detection, captures key power quality data for day-to-day grid management and supports renewable energy integration with the ability to detect and report on reverse power flows. As an example, once a fault is detected, an actuator like the 3-phase relay shown in ***Figure 12***, can automatically break the power line.

Figure 12. 2.5MW 3-Phase Relay

The Sensor System

Sensors may be located anywhere on the field. The sensor "box" includes a front-end transceiver that handles data and routes power to a step-down voltage regulator. This delivers the appropriate voltage to the ASIC/microcontroller/FPGA and the sensing element as well as communication devices. A smart-grid sensor or overhead powerline sensor uses wireless or powerline communication. ***Figure 13*** shows an overhead sensor in a 3-phase power line.

Figure 13. Overhead Line Sensors (Photo licensed under CC BY-SA)

Safe Low-Voltage Operation

The sensor is typically powered by a 24V DC power source. However, the field can be a very challenging environment, with long cables and strong electromagnetic interference resulting in high-voltage transients. Accordingly, the step-down converter inside the sensor must withstand voltage transients of 42V or 60V, which are much higher than the sensor operating voltage. As discussed before, for 24V rails, it is best to rely on devices that have an operating maximum of 42V. According to SELV/PELV/FELV (Safety/Protection/Functional Extra Low Voltage) regulations, an isolated device that handles up to 60V is considered safe to touch. Protection above 60V is provided with the addition of dedicated TVS (transient voltage suppressor) devices.

Powering the Sensing Elements

Most sensing elements need an input voltage significantly lower than that supplied by the system to power digital and analog ICs. With increasing currents, as illustrated earlier, traditional LDO regulators are not viable solutions due to excessive heat dissipation. ***Figure 14*** shows the case in which an LDO is used to step-down a 24V system voltage to 5V to power the microcontroller and the sensing elements. This is a lossy process (η = 21%) that ends up costing 1.3W of input power.

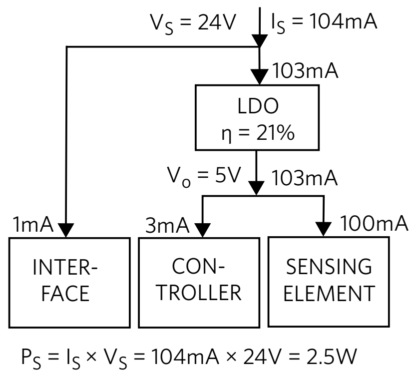

Figure 14. LDO-Powered Sensor

In ***Figure 15***, the voltage step-down is performed by a simple switching regulator with 85% efficiency at 50mA.

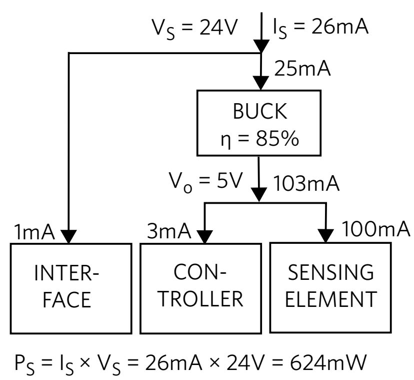

Figure 15. Buck-Powered Sensor

Here, the buck converter transfers power with efficiency higher than an LDO, resulting in an input power of only 336mW.

A Tailor-Made Buck Converter Family

The **MAX15062** and **MAX15462** high-efficiency, high-voltage, synchronous step-down DC-DC converters are part of the Himalaya family. They save space with integrated MOSFETs and operate over a 4.5V to 60V and 4.5 to 42V input voltage range, respectively. Delivering output current up to 300mA, the devices are ideal for sensor applications. Their low-resistance, on-chip MOSFETs ensure high efficiency at full load and simplify PCB layout. The devices offer programmable switching frequency to optimize solution size and efficiency and are available in compact 8-pin (2mm x 2mm) TDFN packages. Simulation models are available. We will further examine the MAX15462 in our discussion. Because the MAX15462 and MAX15062 are pin-compatible, they have the same performance – the only difference is the maximum input voltage they support.

Figure 16 shows the typical application circuit for the 5V fixed configuration—optimized for small PCB size—delivering 5V to a load up to 300mA.

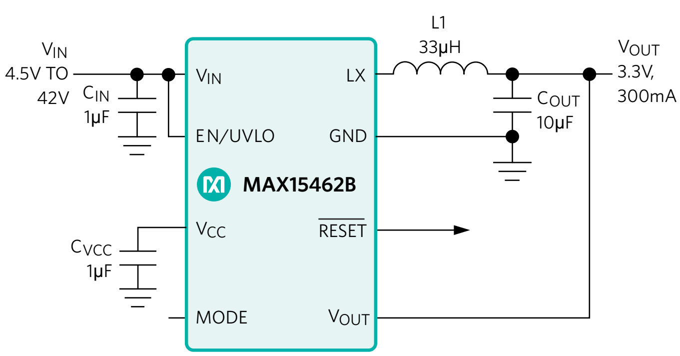

Figure 16. MAX15462B Typical Application Circuit of a High-Efficiency, High-Voltage Synchronous Step-Down Converter

The MAX15462 A version has a 3.3V fixed output voltage and the MAX15462 C version supports adjustable output voltages.

Figure 17 shows the typical efficiency curves at various input voltages with a 5V output. With a 24V input, the peak efficiency is 90%. As shown earlier, these devices decisively outperform any LDO-based solution in terms of power savings.

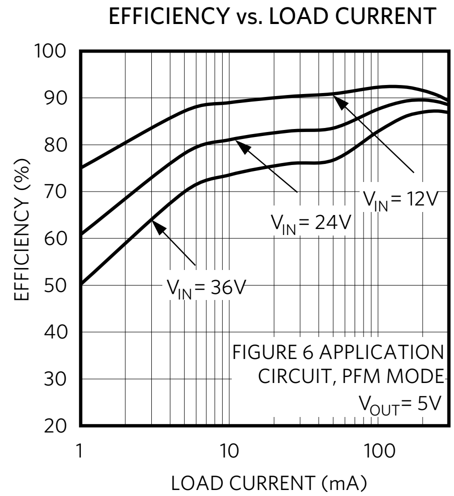

Figure 17. MAX15462B Typical Efficiency Curves of Input Voltages with a 5V Output

A PCB layout for the MAX15462 operating at $24V_{IN}$ with a 300mA output is shown in *Figure 18.* While Himalaya ICs have transformed the industry with their small size, the constraints of the one-dimensional layout and size of the passives still stresses utilization (net component area of 28.12mm^2). Compared to a traditional synchronous buck regulator solution that only delivers 150mA, this solution is 12.5% smaller.

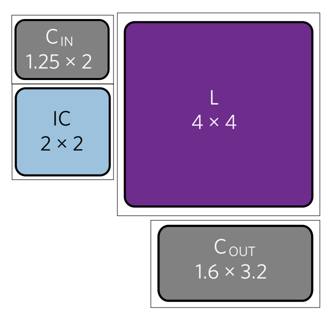

Figure 18. MAX15462 Buck Converter Layout (Net Component Area 28.12mm^2)

Note that manufacturing guidelines on the clearance between components will add additional area. This approach requires some knowledge of switching regulator design or testing to optimize component value/size.

Traditional Module Solutions Fall Short

To specifically address ease-of-use issues and to reduce design time and testing, many vendors have developed switching regulator modules. A typical switching regulator module that houses a buck converter IC and an inductor in a single package is shown in ***Figure 19***. This solution attempts to address ease-of-design and efficiency requirements, but clearly falls short in the utilization of the PCB area. In this example, with a net component area of 47.2mm2, the module solution takes up 68% more area than the discrete DC-DC regulator solution shown in ***Figure 20***.

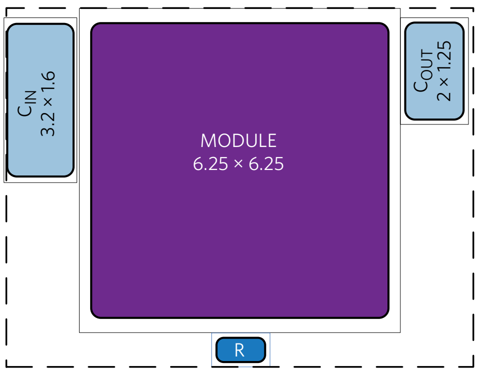

Figure 19. Traditional Buck Converter Module Layout (Net Component Area 47.2mm²)

Case Study: Add more power density than ever to your small sensor

The electronics industry continues to find ways to pack more data in the same space, first with Moore's Law for silicon, and then beyond ("More than Moore") with sophisticated multidimensional IC packaging techniques. These techniques help push the power density envelope by packing more Watts within the same square millimeters. In this section, we will introduce a disruptive approach for sensors that pushes the power density envelope even further with a novel, miniaturized, easy-to-design, high-performance solution.

Himalaya uSLIC™ Packaging Technology

Can more power be delivered in a solution size even smaller than Himalaya-based power supply solutions without sacrificing the efficiency and reliability benefits? Effectively, the quest is for LDO-like size with all the benefits of a switching regulator! A revolutionary technology has been developed which co-packages a state-of-the-art Himalaya buck converter with passive components in a micro-sized system-level IC (uSLIC). The Himalaya uSLIC power module delivers more power in a smaller space than ever before, with high efficiency, ease of use, and faster time to market.

uSLIC Power Module Specifications

The uSLIC power module vertically integrates the inductor and the buck converter IC, dramatically reducing the PCB space occupied by the standard buck converter solution. This still meets expectations of high-voltage tolerance and high-temperature operation. The **MAXM17532** module ***(Figure 22)*** is available in a low-profile, compact 10-pin, 2.6mm x 3mm x 1.5mm uSLIC package. The device operates over a wide temperature range from -40°C to +125°C. ***Figure 20*** shows the dramatic size reduction achieved with the MAXM17532, 100mA, 42V buck converter uSLIC module. This product meets a 42V maximum operating voltage (not just the absolute maximum voltage) and supports output voltages below 1.8V to support the latest digital ICs. For higher loads, the **MAXM15462** provides up to the 300mA output in the same form factor.

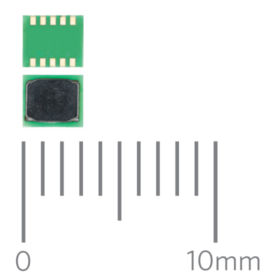

Figure 20. Less Than 8mm² Footprint of the MAXM15462 uSLIC Buck Converter

Miniaturized Size

Figure 21 shows the PCB of a complete power supply solution using the MAXM17532 switching regulator module. Thanks to the vertical integration of the inductor, the net component area is a mere 14.3mm².

Compared to the IC solution of Figure 20, the uSLIC module solution's net component area is 2x smaller. Compared to the traditional module of *Figure 21,* the uSLIC module solution is 3.3x smaller.

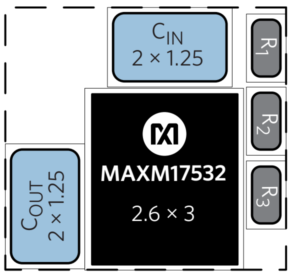

Figure 21. MAXM17532 uSLIC 5V$_{OUT}$, 100mA Buck Solution (Net Component Area 14.3mm²)

High Efficiency

Figure 22 shows the efficiency of the MAXM17532 with 5V output and various input voltages. Despite the small size, the buck converter delivers high efficiency with peaks up to 90%.

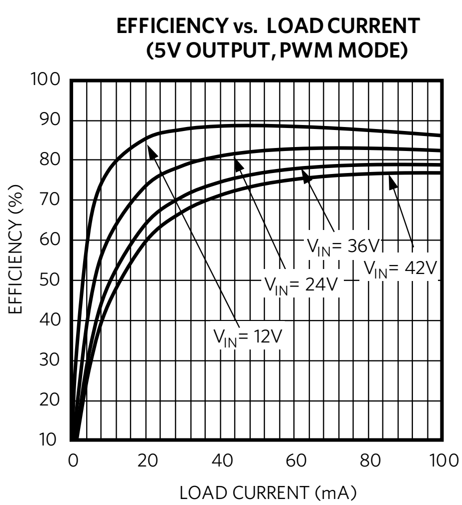

Figure 22. MAXM17532 uSLIC Power Module Efficiency

Low Emissions

The module's PCB layout is designed to minimize trace lengths and eliminate ground loops for minimum radiated emissions. The use of high-frequency ceramic capacitors minimizes conducted emissions. *Figure 23* shows that the MAXM17532 radiated emission comfortably meets the CISPR22 CLASS B specification.

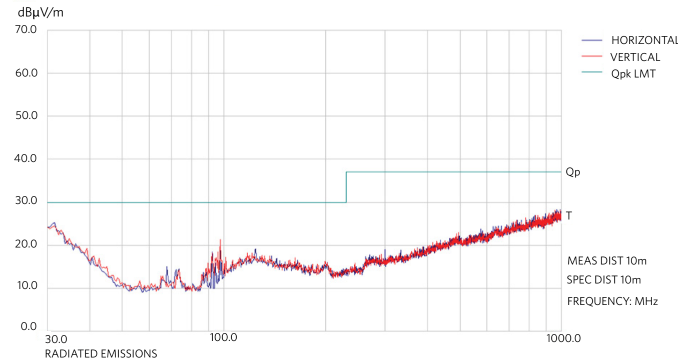

Figure 23. MAXM17532 Radiated Emission

Figure 24 shows that the MAXM17532's conducted emission also comfortably meets the CISPR22 CLASS B specification.

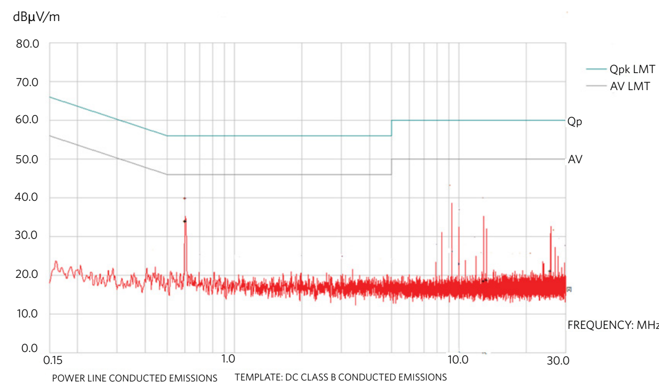

Figure 24. MAXM17532 Conducted Emission

Drop, Shock, and Vibration Tolerance

Beyond thermal, electrical, and electromagnetic performance, it is important that power supplies are tolerant of mechanical stresses. Himalaya uSLIC modules meet JESD22-B103/B104/B111 standards for drop, shock, and vibration guaranteeing fool-proof operation in sensors deployed in harsh energy, industrial, medical, defense, and consumer applications.

For Higher Current

For higher loads, the MAXM15462 Himalaya uSLIC module outputs up to 300mA with the same package footprint and provides similar benefits for solution size, efficiency, CISPR 22-compliance and shock, drop, and vibration tolerance.

Case Study: Protect your small sensor from harsh environments

Sensors are ubiquitous in the electrically harsh energy environment ***(Figure 25)***. As they increase in sophistication and shrink in size, they become more complex, requiring on-board switching regulators to deliver power more efficiently with minimal heat generation. How do you safely deliver low-voltage power to tiny sensors in high-voltage environments while also minimizing solution size and maximizing efficiency? In this design solution, we will review a typical sensor architecture and provide an innovative solution to this challenge.

Figure 25. Medium Voltage Switchgear and Bay Control Unit

Safe Power Challenge

The sensor "box" includes a front-end transceiver that handles data and routes the power to a step-down buck converter, which delivers the appropriate voltage to the ASIC/microcontroller/FPGA and sensing element. The sensor is typically powered by a 24V DC power source (V_{BUS}). The power path is shown in ***Figure 26***.

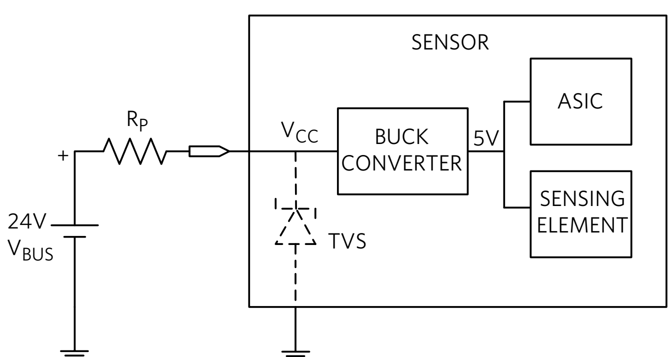

Figure 26. Sensor Power System

If the 24V bus is clean or has an electric noise level below the operating voltage of the front-end switching regulator, no protection is necessary (no TVS in ***Figure 26***) and a buck converter with a typical max input voltage of 36V or 42V is sufficient for this sensor design.

However, if strong electromagnetic interference is present, more severe measures are in order.

A typical sensor power management solution utilizes transient voltage suppressors (TVS) to limit the input voltage (V_{CC}) of the front-end buck converter. The associated input current peaks are reduced by the resistor R_P, a parasitic or physical element in the electric path between the voltage transient's source (V_{BUS}) and the sensor.

Let's see how to select a TVS out of the Littelfuse™ catalog as an example. The general characteristics of a TVS are shown in ***Figure 27***.

The TVS device is an open circuit until the voltage across it reaches V_{BR}. At this point, it starts to conduct current while its voltage rises slightly up to its maximum clamping voltage,

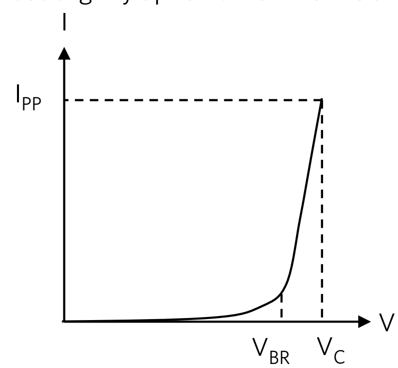

Figure 27. TVS V-I Characteristics

V_C, which corresponds to the maximum allowed peak pulse current, IPP. The product of V_C x I_{PP} is the maximum peak power that the TVS can handle (400W for this TVS family).

For effective protection, the TVS VBR must be above $V_{CC(MAX)}$ while V_C must be below the switching regulator input voltage breakdown.

Our V_{BUS} supply is 24V ±10%, with 26.4V maximum ($V_{BUS(MAX)}$). The closest possible TVS choice from the catalog is the SMAJ28A, with a minimum 28V V_{BR}, a 45.4V maximum clamp voltage, and an 8.8A maximum peak current ***(Figure 28)***. The delta between the TVS voltage and the voltage transient develops the current through the resistor, R_P, which has to be below the maximum allowed I_{PP}.

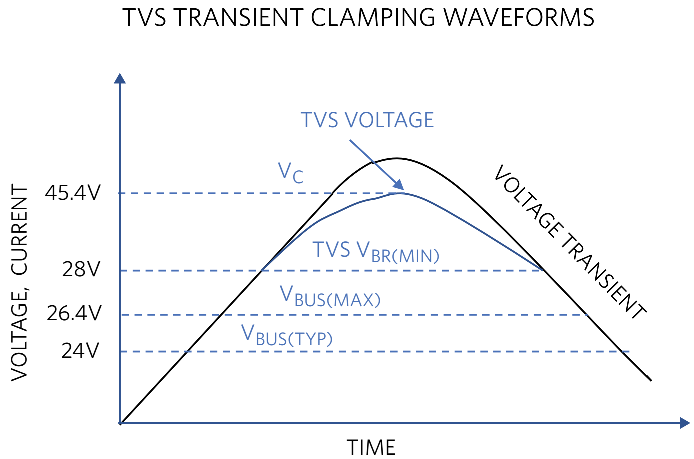

Figure 28. Minimum TVS Selection

The fact that our buck converter must withstand $24V_{DC}$ and at least a 45.4V transient removes a large group of buck converters from consideration.

Additionally, with the above selection, there is only a 1.6V margin between the maximum V_{BUS} and the minimum TVS voltage (V_{BR}). A higher margin requires a voltage rating for the buck converter (V_{CC}) well above 45.4V. Ideally, with a 60V-rated buck converter, a SMAJ33A with a minimum V_{BR} of 33V can be used (as well as a clamp voltage V_C of 53.3V, which is well below 60V). This gives an operating margin of 6.6V above $V_{BUS(MAX)}$ and 6.7V below 60V ***(Figure 29)***.

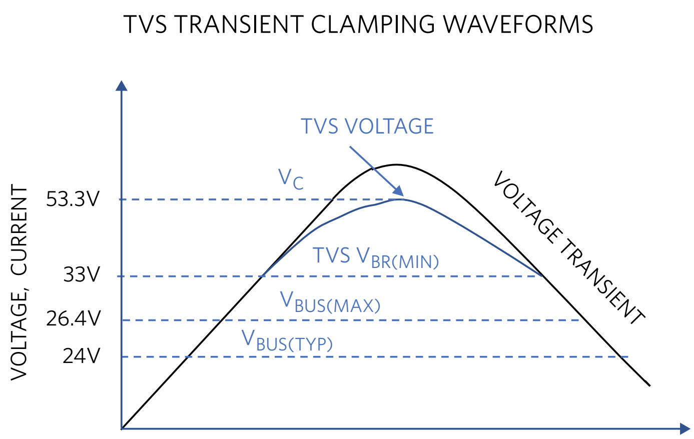

Figure 29. Ideal TVS Selection

Sensor Miniaturization Challenge

For sensor miniaturization, the typical PCB strategy of placing all the buck converter components on the same plane is not ideal. In ***Figure 30***, a 300mA buck converter IC and passives (L,R,C) require a hefty PCB area (29.3mm^2 net area).

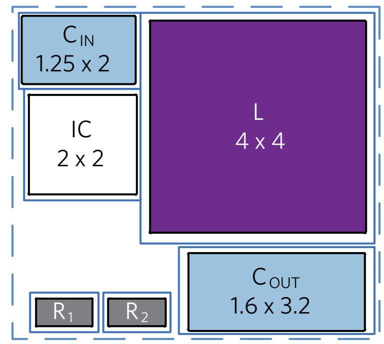

Figure 30. Typical Planar Buck Implementation (29.3mm^2 Net Area)

The Thermal Challenge

Sensors have sealed enclosures (without fans or cooling) due to the harsh environments they sit in. A small amount of heat generated inside this small enclosure can quickly raise the sensor temperature, compromising its reliability. The trend of using miniature sensors makes their thermal management even more challenging. The solution for this is a buck converter with very high efficiency.

Recalling the above challeges: an efficient buck regulator that fits inside a small PCB area and has a 60V breakdown voltage is necessary for small sensors.

The Solution: Vertical Integration

A novel way to solve space issues is to vertically integrate the inductor on top of the IC. One example of this is the Himalaya uSLIC™ power module. It delivers more power in a smaller space than ever before, with higher efficiency and ease of use. The power module vertically integrates the inductor and the buck converter IC, dramatically reducing the PCB space occupied by the standard buck converter solution. This still meets expectations of high-voltage tolerance and high-temperature operation. The **MAXM15064** module ***(Figure 31)*** is available in a low-profile, compact, 10-pin, 2.6mm x 3mm x 1.5mm package. The device operates over a wide temperature range from -40°C to +125°C.

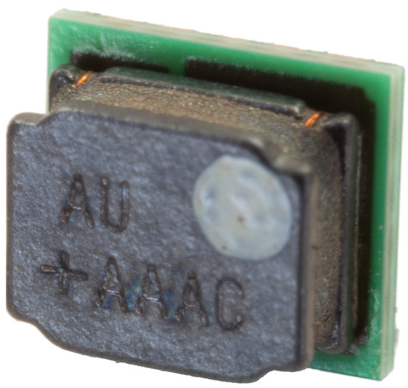

Figure 31. 60V, 300mA Module (2.6mm x 3mm x 1.5mm)

Figure 32 shows the dramatic size reduction achieved with the 300mA, 60V buck converter module. Its distinguishing features are its ability to meet a 60V maximum operating voltage (not just the absolute maximum rating) and its support of output voltages below 1.8V (for the latest digital ICs). Thanks to the vertical integration of the inductor, the net component area is a mere 21mm².

Compared to the IC solution of ***Figure 30***, the module solution's net component area is 28% smaller.

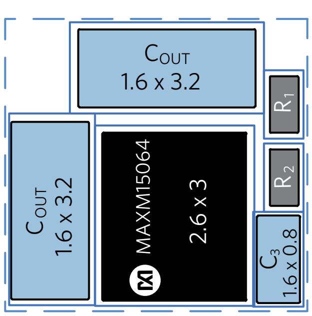

Figure 32. 60V, 300mA High-Voltage Module Implementation (21mm² Net Area)

Minimum Heat Generation

Figure 33 shows the efficiency of the module with a 5V output and input voltages from 12V to 60V. Despite the small size, the buck converter delivers high efficiency with peaks up to 90%. For a 24V-powered application, the module provides an efficiency well above 80% across most of its operating range, assuring low-power losses and low heat generation.

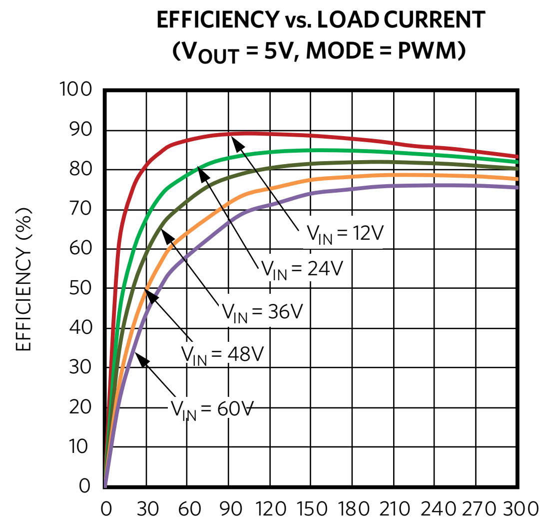

Figure 33. Minimum Heat Generation of a High-Efficiency Buck Converter

Low Emissions

The module's PCB layout is designed to minimize trace lengths and eliminate ground loops for minimum radiated emissions. The use of high-frequency ceramic capacitors minimizes conducted emissions. *Figure 34* shows radiated emissions that comfortably meet the CISPR22 CLASS B specification.

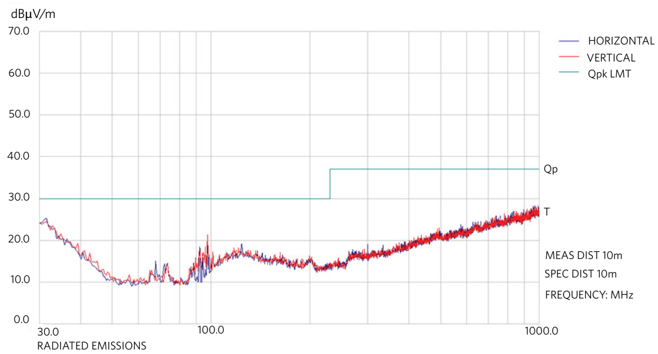

Figure 34. Radiated Emissions that Meet CISPR22 Class B Specification

Figure 35 shows that the conducted emissions also comfortably meet the CISPR22 Class B specification.

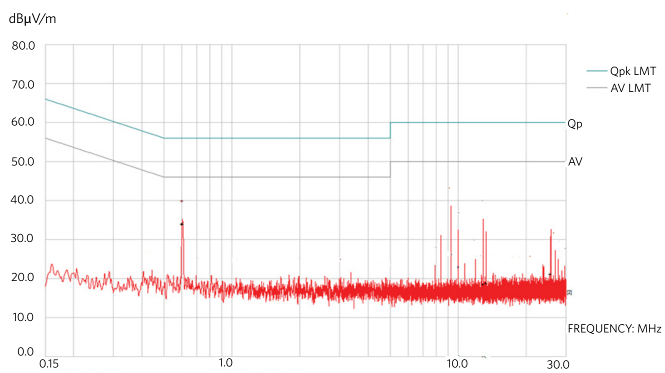

Figure 35. Conducted Emissions that Meet CISPR22 Class B Specification

Challenge 3 - Increased Safety and Reliability

Case Study: Design smaller, more reliable, more efficient isolated power supplies

Isolated DC-DC voltage regulators are found in the most diverse applications. Although an isolated solution is more complex than a non-isolated one, there is still an expectation for it to fit in a small space and be highly efficient. In this case study, we discuss the reasons for isolation in low-voltage power conversion systems.

Low-Voltage Isolated Systems

According to SELV/FELV regulations, input voltages below 60V are considered inherently safe to touch, but the need for isolation in this operating range is still pervasive for functional safety and reliability reasons. In this voltage range, the power-supply electronic load, typically a very delicate and expensive microcontroller, needs protection. It could readily self-destruct if accidentally exposed to high voltage.

Isolation also prevents ground loops, which occur when two or more circuits share a common return path. Ground loops produce parasitic currents that can disrupt the output-voltage regulation as well as introduce galvanic corrosion of the conducting traces. This is a phenomenon that degrades equipment reliability.

Traditional Implementation

Using galvanically isolated transformers with PWM control is the most common architecture for an isolated DC-DC power supply. The flyback converter is the classic architecture that produces an isolated output. *Figure 36* shows the traditional implementation. During the "ON" time of the transistor T1, the voltage across the primary winding is positive (equal to V_{IN}) and the voltage across the secondary winding is negative. Consequently, the Schottky diode (SD) prevents energy from passing to the output and the energy is stored in the transformer. During the "OFF" time of T1, the primary winding inverts its voltage, which allows the energy to be released to the output. The control loop is quite complex, often requiring a shunt regulator (TL431A) on the secondary to regulate the voltage at the output. An optocoupler and an error amplifier on the secondary-side of the transformer provide the isolated feedback signal needed to close the PWM control loop to the primary side.

This solution, which utilizes two ICs and many passive components, is typically expensive, inefficient, and space consuming.

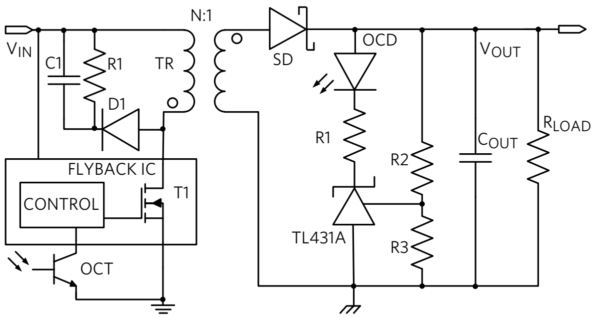

Figure 36. Flyback with Optocoupler

No-Opto Flyback Implementation

Since the transformer is magnetically coupled, the secondary winding voltage is reflected on the primary winding. The **MAX17690** samples and senses this isolated output voltage on the secondary-side directly from the primary-side flyback waveform during the off-time of the primary switch. No auxiliary winding or optocoupler is required for output voltage regulation. The patented MAX17690 is a peak-current-mode, fixed-frequency switching controller, part of our Rainier family of isolated "Bye Bye Optocoupler" solutions. It is specifically designed for an isolated flyback topology that operates in discontinuous conduction mode (DCM). Like a traditional flyback, 3% to 5% regulation accuracy is possible. However, the solution size is reduced by 30%. ***Figure 37*** shows a typical application.

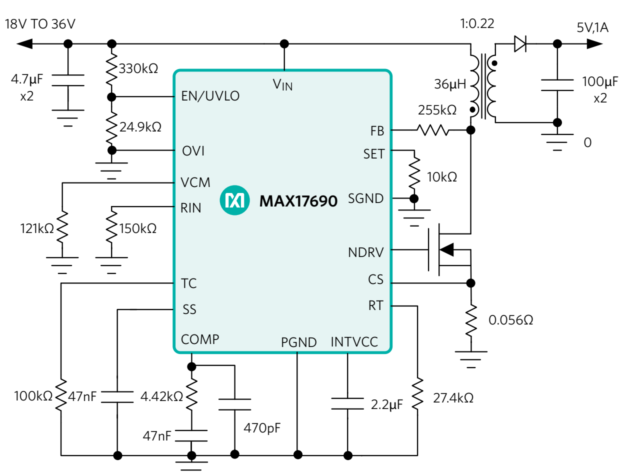

Figure 37. No-Opto Flyback Controller

The MAX17690 is designed to operate over a wide supply range from 4.5V to 60V. The switching frequency is programmable from 50kHz to 250kHz. An EN/UVLO pin allows the user to turn on/off the power supply precisely at the desired input voltage. The MAX17690 provides input overvoltage protection through the OVI pin. The 7V internal LDO output of the MAX17690 makes it suitable for switching both logic-level and standard MOSFETs used in flyback converters. With 2A/4A source/sink currents, the MAX17690 is ideal for driving low $R_{DS(ON)}$ power MOSFETs with fast gate transition times. The MAX17690 provides an adjustable soft-start feature to limit the inrush current during startup. Application Note 6394: ***How to Design a No-Opto Flyback Converter with Secondary-Side Synchronous Rectification*** is available to provide additional understanding of the topology.

The MAX17690 provides temperature compensation for the output diode forward-voltage drop. With robust hiccup protection and thermal protection schemes, it is available in a space-saving, 16-pin, 3mm x 3mm TQFN package with a temperature range from -40°C to +125°C.

Unlike above, if tight regulation accuracy is not critical and a small, compact, isolated power supply solution is still required without an optocoupler, a novel iso-buck topology is another option, as outlined in the blog, ***Iso-Buck Converters for Smaller, Simpler Isolated Power Supplies***.

Case Study: Choose the right protection for your smart load for improved system safety and reliability

Protection circuits are the unsung heroes of today's electronics. The long electrical chain, from the AC line to the digital load, no matter the application, is interspersed with fuses and transient voltage suppressors of all sizes and shapes. While common issues like ESD protection and pin-to-pin short circuits are handled within ICs, there are additional aspects to consider for safety and reliability. Along the electrical path, electrical stressors, such as inrush currents due to storage capacitors, reverse currents due to power outages, overvoltages, and undervoltages induced by inductive load switching or lightning, can damage precious electronic loads. This is true for microprocessors and memories, which are built with fragile sub-micron, low-voltage technologies. Layers of protection are necessary to handle these potentially catastrophic events ***(Figure 38)***.

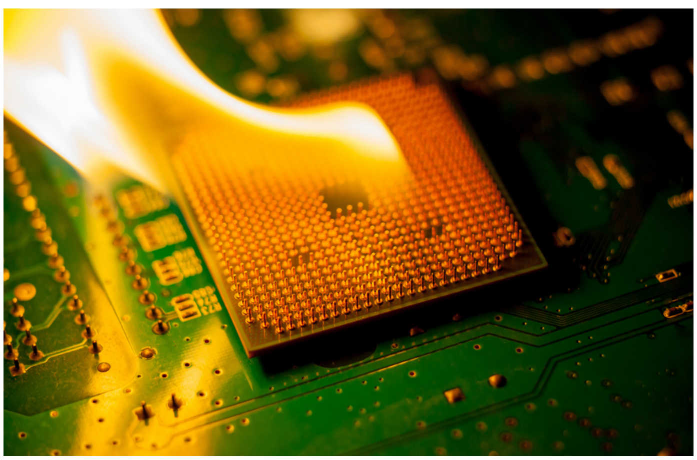

Figure 38. Unprotected CPU on fire

Typical System Protection

Figure 39 shows a typical system protection scheme around the smart load, for example, a microprocessor. A DC-DC converter—complete with control (IC_2), synchronous rectification MOSFETs (T_3, T_4), associated intrinsic diodes (D_3, D_4), and input and output filter capacitors (C_{IN}, C_{OUT})—powers the microprocessor. A voltage surge from the 48V power bus (V_{BUS}), if directly connected to V_{IN}, would have catastrophic consequences for the DC-DC converter and its load. For this reason, front-end electronic protection is necessary. Here the protection is implemented with a controller (IC_1) that drives two discrete MOSFETs, T_1 and T_2. Some control scheme designs use discrete components or a CPLD/microcontroller.

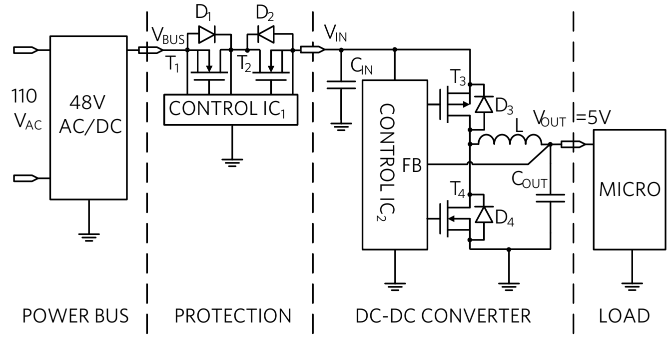

Figure 39. Typical Electronic System with Protection

Protection electronics must handle fault conditions such as overvoltage/undervoltage, overcurrent, and reverse-current flow within the limits of its voltage and current rating. If the expected voltage surge exceeds the protection electronics ratings, additional layers of protection are added in the form of filters and TVS devices. ***Figure 40*** illustrates a case of hot plug-in, which has the potential to cause voltage surges.

Figure 40. Hot Plug-in Causes Voltage Surges

Overvoltage Protection

Arc fault protectors and TVS diodes protect against lightning surges and catastrophic high-voltage events. But protection is still needed when you get down to the main input bus (48V in the example above or a typical 24V in energy applications). Hot-plugging ***(Figure 40)*** causes supply bounce while cable ringing, due to long cable inductance ***(Figure 41)***, causes voltage surges.

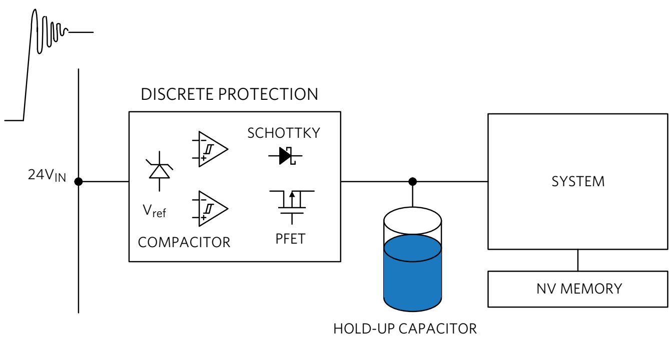

Figure 41. Cable Ringing Causes Voltage Surges

Overcurrent Protection

Even when the incoming voltage is confined within the allowed operating range, problems can persist. Upward voltage fluctuations and large storage capacitors generate high CdV/dt inrush currents that can blow a fuse or overheat the system ***(Figure 42)***, reducing its reliability. Accordingly, the protection circuit ***(Figure 43)*** must be equipped with a current-limiting mechanism. Also, in operation, it is not uncommon to face both hard and soft short-circuit faults, from which protection is needed.

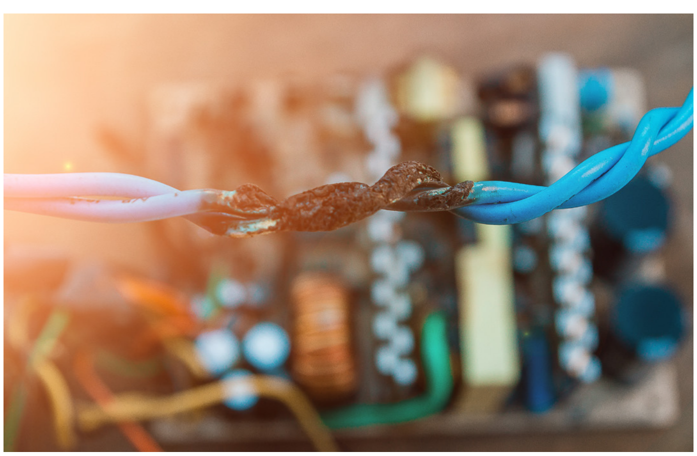

Figure 42. Heat-Damaged Electric Wires – Cable Faults Result in Short-Circuit Faults

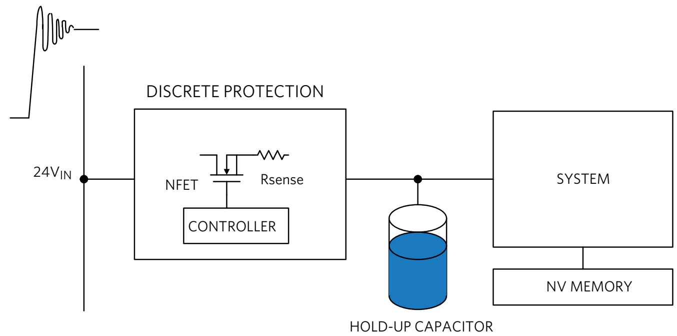

Figure 43. Current-Limit Protection illustration

Reverse-Voltage/Reverse-Current Protection

Supply reversal can also occur due to improper cabling or operator errors that require reverse-polarity protection. Reverse-current protection is also an important need. In motor drive applications, the DC motor current is PWM-controlled with a MOSFET bridge driver. During the OFF portion of the PWM control cycle, the current recirculates back to the input capacitor. Similar applications exist in other energy automation equipment, which result in sinking current that cause equipment failures.

Discrete Protection Circuits

Protection in most systems starts as a simple discrete circuit, typically designed to minimize component costs ***(Figure 44)***. However, as the final system goes through multiple phases of type testing and field deployments, more and more protection must be added. This increases costs and PCB area. A smart design practice is to first choose intelligent system protection ICs to mitigate problems late in the product development cycle.

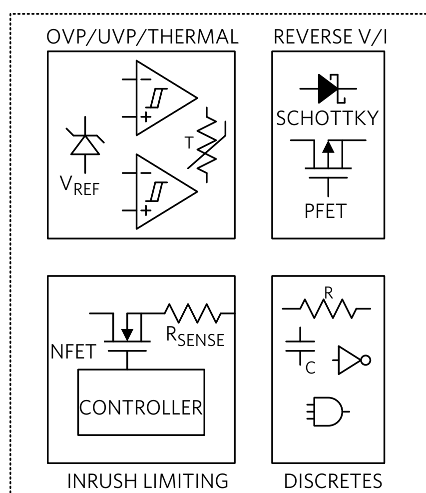

Figure 44. Discrete Protection Circuits Found in Most Systems

Integrated Solution

Figure 45 shows an integrated protection circuit that addresses overvoltage, reverse polarity, current limiting, reverse current, and short-circuit protection with all the benefits of an e-fuse and surge stopper. Designers can easily implement robust protection in their smart grid equipment and pass compliance with configurable pins to set UVLO/OVLO, current limit, real-time voltage, and current monitoring, current thermal foldback, thermal shutdown, and other features.

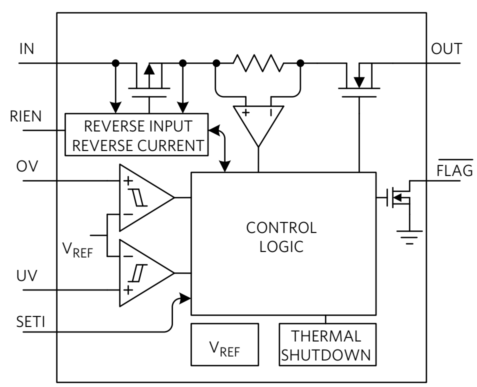

Figure 45. Integrated Protection in a Single IC

Integrated Protection Family

The Olympus family of protection ICs provides adjustable overvoltage and overcurrent protection. As an example, the **MAX17523** adjustable overvoltage and overcurrent protection device is ideal for protecting systems against positive and negative input voltage faults up to ±40V, and features low 190mΩ (typ) R_{ON} integrated FETs. The adjustable overvoltage range is between 6V and 36V, while the adjustable undervoltage range is between 4.5V and 24V.

Overvoltage lockout (OVLO) and undervoltage lockout (UVLO) thresholds are set using optional external resistors. The factory preset internal OVLO threshold is 33V (typ), and the preset internal UVLO threshold is 19V (typ). The MAX17523 also features programmable current-limit protection up to 1A. The device can be set for autoretry, latch-off, or continuous fault response when an overcurrent event occurs. Once current reaches the threshold, the MAX17523 turns off after 21ms (typ) blanking time and stays off during the retry period when set to autoretry mode. The device latches off after the blanking time when it is set to latch-off mode. The device limits the current continuously when set to continuous mode.

The MAX17523 also features reverse-current and thermal shutdown protection. The MAX17523 is available in a small, 16-pin (3mm x 3mm) TQFN package. The MAX17523 operates over the -40°C to +125°C extended temperature range.

Electronic loads require protection from the effects of power outages and fluctuations, inductive load switching, and lightning. A typical protection solution with a low level of integration leads to inefficiencies in PCB space and requires a large bill of materials. The MAX17523 integrated, highly flexible, low R_{DSON} protection IC provides direct and reverse-voltage/reverse-current protection with minimal BOM costs and smaller PCB space.

Conclusion

We discussed the challenges of safely delivering higher power more efficiently with minimum heat generation for small sensor applications used in energy distribution systems. We showed how proper protection of a 24V input power is best served by a buck converter that can withstand a 60V input. Finally, we introduced a disruptive approach that stretches the input voltage rating and the power density envelope with a novel, miniaturized, easy-to-design, high-performance buck converter module based on uSLIC technology. The power module is a high-efficiency, small-size, low-EMI buck converter ideal for powering tiny sensors in energy applications.

Summary

Table 1 is a summary of the power management approach for energy distribution automation.

Table 1. Power Management for Energy Distribution Automation

Challenge	Application	Products	Product Type
Energy Efficiency	Actuators, PLC, I/O, Motion Control	**MAX17503** 60V, 2.5A **MAX17506** 60V, 5A	IC
		MAXM17504 60V, 3.5A	SIP Module
Small Size	Sensors, Encoders, I/Os	**MAX15062** 60V, 300mA **MAX15462** 42V, 300mA	IC
		MAXM17532 100mA **MAXM15462** 300mA	uSLIC Module
Safety and Reliability	Safety	**MAXM15064**, 60V, 300mA	uSLIC Module
	Isolation	**MAX17690** 60V, 5Vout, 1A No-Opto	IC
	Protection	**MAX17523** 4.5V to 36V, 1A	IC

Conclusion

As the current trend of automation and data exchange continues, it will rely on new technologies and approaches to achieve higher energy availability, serviceability, predictive maintenance, as well as fault detection, isolation and mitigation. The adoption of these technologies introduces challenges in terms of energy efficiency, miniaturization, and system reliability. For each challenge we presented, we showed how more efficient power management can improve the design of energy distribution automation systems. For energy efficiency, we proposed two highly integrated, high-power buck converter ICs for high-performance systems from the Himalaya IC family and a power module from the Himalaya SiP module family. Similarly, for sensors, we proposed two low-power, highly integrated ICs from the Himalaya IC family and two fully integrated power modules for highly space-constrained applications from the Himalaya uSLIC power module family. Finally, for safety and reliability, we presented a no-opto isolated flyback converter IC from the Rainier isolated family and a highly integrated protection IC from the Olympus protection family. These power management solutions overcome the critical challenges faced by today's energy distribution automation systems.

Glossary

CNC: Computer numerical control

PLC: Programming logic controller

SCADA: Supervisory control and data acquisition

Product Selector Tables

Himalaya Wide Input Synchronous Voltage Regulators

Part	I_{OUT} (A)	V_{IN} (V)		V_{OUT} (V)		Frequency Range (MHz)	PFM Option	Package Type	Package Size (mm)
	Max	Min	Max	Min	Max				
60V/76V Input, Step-Down Regulators									
MAX17761	1.0	4.5	76.0	0.8	68.4	0.2 to 0.6	Yes	TDFN	3.0 x 3.0
MAX17550	0.025	4.0	60.0	0.8	54.0	0.1 to 2.2	Yes	TDFN/µMAX	2.0 x 3.0/3.0 x 5.0 pin-compatible
MAX17551	0.050								
MAX17552	0.1								
MAX15062(1)	0.3	4.5	60.0	0.9	53.0	0.5	Yes	TDFN	2.0 x 2.0
MAX17501(1)	0.5				55.0	0.3/0.6	Yes[3]	TDFN (TSSOP[3])	2.0 x 3.0 (3.0 x 3.0)
MAX17502(1)	1.0					0.3/0.6	No	TDFN/TSSOP	2.0 x 3.0 / 4.4 x 5.0
MAX17572	1.0				54.0	0.4 to 2.2		TDFN	3.0 x 3.0
MAX17575	1.5								
MAX17505	1.7					0.2 to 2.2	Yes	TQFN	4.0 x 4.0 pin-compatible
MAX17503	2.5					0.1 to 2.2			
MAX17574	3.0								4.0 x 5.0
MAX17504	3.5					0.2 to 2.2			5.0 x 5.0
MAX17536	4.0					0.1 to 2.2			5.0 x 5.0 pin-compatible
MAX17506	5.0								
42V/60V Input, Step-Down Regulators									
MAX17521	1.0 per output	4.5	60.0	0.9	55.0	0.3/0.56	Yes	TQFN	4.0 x 5.0
MAX17558(2)	10.0 per output			0.8	24.0	0.1 to 2.2	No		5.0 x 5.0
MAX17559(2)								TQFP	7.0 x 7.0
MAX17548(2)			42.0					TQFN	5.0 x 5.0
42V Input, Step-Down Regulators									
MAX17530	0.025	4.0	42.0	0.8	37.0	0.1 to 2.2	Yes	TDFN/µMAX	2.0 x 3.0/3.0 x 5.0 pin-compatible
MAX17531	0.050								
MAX17532	0.1								
MAX15462(1)	0.3	4.5	42.0	0.9	37.0	0.5	Yes	TDFN	2.0 x 2.0
MAX17541G	0.5					0.6	Yes[3]	TDFN (TSSOP[3])	2.0 x 3.0 pin-compatible
MAX17542G	1.0								
MAX17545	1.7					0.1 to 2.2	Yes	TQFN	4.0 x 4.0 pin-compatible
MAX17543	2.5								
MAX17544	3.5								5.0 x 5.0
MAX17546	5.0								

Notes:
1. Fixed 3.3V and 5.0V pin-compatible options available for even more compact designs.
2. Controller ICs for use with external MOSFETs to support high current applications.
3. Contact factory Maxim Technical Support.

Himalaya Wide Input Synchronous Voltage Regulators (Continued)

Part	I_{OUT} (A)	V_{IN} (V)		V_{OUT} (V)		Frequency Range (MHz)	PFM Option	Package Type	Package Size (mm)
	Max	Min	Max	Min	Max				
36V Input, Step-Down Regulators									
MAX17630	1	4.5	36	0.9	90% V_{IN}	0.4 to 2.2	Yes	TQFN 16	3.0 x 3.0
MAX17631	1.5	4.5	36	0.9	90% V_{IN}	0.4 to 2.2	Yes	TQFN 16	3.0 x 3.0
MAX17632	2	4.5	36	0.9	90% V_{IN}	0.4 to 2.2	Yes	TDFN 16	3.0 x 3.0
MAX17633	3.5	4.5	36	0.9	90% V_{IN}	0.4 to 2.2	Yes	TDFN 20	4.0 x 4.0
MAX17634	4.25	4.5	36	0.9	90% V_{IN}	0.4 to 2.2	Yes	TDFN 20	4.0 x 4.0

Himalaya Power Modules

Part Number	V_{IN} (V)		V_{OUT} (V)		I_{OUT} (A)	Frequency (MHz)		Package Type	Size (mm)
	Min	Max	Min	Max	Max	Min	Max		
5.5V Input Step-Down Power Modules									
MAXM17623	2.9	5.5	0.8	1.5	1.0	2	2	µSLIC 10	2.6 x 2.1 x 1.3
MAXM17624	2.9	5.5	1.5	3.3	1.0	4	4	µSLIC 10	2.6 x 2.1 x 1.3
MAXM17514	2.4	5.5	0.75	5.5	4.0	1.0	1.0	SiP 28	6.5 x 10 x 2.8
MAXM17515					5.0				
MAXM17516					6.0				
24V Input Step-Down Power Modules									
MAXM17900	4.0	24.0	0.9	5.5	0.1	0.1	0.9	µSLIC 10	2.6 x 3 x 1.5
MAXM17903	4.5	24.0	0.9	3.3	0.3	0.465	0.535	µSLIC 10	2.6 x 3 x 1.5
36V Input Step-Down Power Modules									
MAXM17630/31/32	4.5	36.0	0.9	12	1.0	0.4	2.2	µSLIC 16	3 x 3 x 1.75
MAXM17633/34/35	4.5	36.0	0.9	12	2.0	0.4	2.2	µSLIC 24	4 x 4 x 1.75
42V Input Step-Down Power Modules									
MAXM17532	4.2	42.0	0.9	5.5	0.1	0.1	0.9	µSLIC 10	2.6 x 3 x 1.5
MAXM15462	4.5	42.0	0.9	5.0	03	0.465	0.535	µSLIC 10	2.6 x 3 x 1.5
MAXM17545	4.5	42.0	0.9	12.0	1.7	0.1	1.8	SiP 29	9 x 15 x 2.8
MAXM17543					2.5				
MAXM17544					3.5				
MAXM17546	4.5	42.0	0.9	12	5.0	0.1	2.2	SiP 29	9 x 15 x 4.32

Himalaya Power Modules (Continued)

<table>
<tr><th rowspan="2">Part Number</th><th colspan="2">V_{IN} (V)</th><th colspan="2">V_{OUT} (V)</th><th>I_{OUT} (A)</th><th colspan="2">Frequency (MHz)</th><th rowspan="2">Package Type</th><th rowspan="2">Size (mm)</th></tr>
<tr><th>Min</th><th>Max</th><th>Min</th><th>Max</th><th>Max</th><th>Min</th><th>Max</th></tr>
<tr><td colspan="10">60V Input Step-Down Power Modules</td></tr>
<tr><td>MAXM17552</td><td>4.0</td><td>60.0</td><td>0.9</td><td>5.5</td><td>0.1</td><td>0.1</td><td>0.9</td><td>µSLIC 10</td><td>2.6 x 3 x 1.5</td></tr>
<tr><td>MAXM15064</td><td>4.5</td><td>60.0</td><td>0.9</td><td>5.0</td><td>0.3</td><td>0.465</td><td>0.535</td><td>µSLIC 10</td><td>2.6 x 3 x 1.5</td></tr>
<tr><td>MAXM17502</td><td rowspan="6">4.5</td><td rowspan="6">60.0</td><td rowspan="6">0.9</td><td>5.0</td><td>1.0</td><td>0.3</td><td>0.6</td><td>SiP 28</td><td>6.5 x 10 x 2.8</td></tr>
<tr><td>MAXM17575</td><td>12.0</td><td>1.5</td><td>0.4</td><td>2.2</td><td>SiP 28</td><td>6.5 x 10 x 2.92</td></tr>
<tr><td>MAXM17505</td><td rowspan="2">12.0</td><td>1.7</td><td rowspan="4">0.1</td><td rowspan="2">1.8</td><td rowspan="2">SiP 29</td><td rowspan="4">9 x 15 x 2.8</td></tr>
<tr><td>MAXM17503</td><td>2.5</td></tr>
<tr><td>MAXM17574</td><td rowspan="2">15.0
12.0</td><td>3.0</td><td>2.2</td><td>SiP 33</td></tr>
<tr><td>MAXM17504</td><td>3.5</td><td>1.8</td><td>SiP 29</td></tr>
<tr><td>MAXM17536</td><td></td><td></td><td>0.9</td><td>12</td><td>4.0</td><td rowspan="2">0.1</td><td rowspan="2">2.2</td><td rowspan="2">SiP 29</td><td rowspan="2">9 x 15 x 4.32</td></tr>
<tr><td>MAXM17537</td><td></td><td></td><td>12</td><td>24</td><td>3.0</td></tr>
<tr><td colspan="10">76V Input Step-Down Power Modules</td></tr>
<tr><td>MAXM17761</td><td>4.5</td><td>76.0</td><td>0.8</td><td>5.0</td><td>1.0</td><td>0.18</td><td>0.537</td><td>SiP 28</td><td>6.5 x 10 x 2.92</td></tr>
<tr><td colspan="10">60V Input Step-Down Buck + LDO Power Modules</td></tr>
<tr><td>MAXM17712</td><td>4.0</td><td>60.0</td><td>3.3</td><td>3.3</td><td>0.15 +
0.5 LDO</td><td>0.35</td><td>2.2</td><td>µSLIC 10</td><td>2.6 x 3 x 1.5</td></tr>
<tr><td>MAXM17720</td><td>4.0</td><td>60.0</td><td>0.9</td><td>5</td><td>0.15 +
0.5 LDO</td><td>0.35</td><td>2.2</td><td>µSLIC 10</td><td>2.6 x 3 x 1.5</td></tr>
<tr><td>MAXM17724</td><td>4.0</td><td>60.0</td><td>2.5</td><td>5</td><td>0.15 +
0.5 LDO</td><td>0.35</td><td>2.2</td><td>µSLIC 10</td><td>2.6 x 3 x 1.5</td></tr>
</table>

Rainier Isolated DC-DC Power Solutions

<table>
<tr><th rowspan="2">Part Number</th><th colspan="2">Supply Voltage (V)</th><th rowspan="2">Feedback</th><th rowspan="2">FET</th><th rowspan="2">Frequency Range (MHz)</th><th rowspan="2">Package Type</th><th rowspan="2">Package Size L (mm) x W (mm)</th></tr>
<tr><th>Min</th><th>Max</th></tr>
<tr><td colspan="8">DC-DC Peak Current-Mode Flyback Converters</td></tr>
<tr><td>MAX17498B</td><td rowspan="2">4.5</td><td rowspan="2">36</td><td rowspan="2">Opto</td><td rowspan="2">Integrated</td><td>500</td><td rowspan="2">TQFN</td><td rowspan="2">3 x 3</td></tr>
<tr><td>MAX17498A/C</td><td>250</td></tr>
<tr><td colspan="8">High-Efficiency, Iso-Buck DC-DC Converter</td></tr>
<tr><td>MAX17681/A</td><td rowspan="2">4.5</td><td rowspan="2">42</td><td rowspan="2">Primary Side</td><td rowspan="2">Integrated</td><td>200</td><td>TDFN</td><td>2 x 3</td></tr>
<tr><td>MAX17682</td><td>100 to 500</td><td>TQFN</td><td>4 x 4</td></tr>
<tr><td>MAX17686</td><td rowspan="2">4.5</td><td rowspan="2">60</td><td rowspan="2">Primary Side</td><td rowspan="2">Integrated</td><td>200</td><td>TDFN</td><td>3 x 2</td></tr>
<tr><td>MAX17687</td><td>250 to 500</td><td>TDFN</td><td>4 x 4</td></tr>
<tr><td colspan="8">No-Opto Flyback Controller</td></tr>
<tr><td>MAX17690</td><td>4.5</td><td>60</td><td>Primary Winding*</td><td>External</td><td>50 to 250</td><td>TQFN</td><td>3 x 3</td></tr>
<tr><td colspan="8">Peak-Current-Mode Controllers for Flyback Applications</td></tr>
<tr><td>MAX17596</td><td rowspan="2">4.5</td><td rowspan="2">36</td><td rowspan="2">Opto</td><td rowspan="2">External</td><td rowspan="2">100 to 1000</td><td rowspan="2">TQFN</td><td rowspan="2">3 x 3</td></tr>
<tr><td>MAX17597</td></tr>
<tr><td colspan="8">Peak-Current-Mode Controllers for Active-Clamp Forward Applications</td></tr>
<tr><td>MAX17598</td><td>8.0</td><td>29</td><td rowspan="2">Opto</td><td rowspan="2">External</td><td rowspan="2">100 to 1000</td><td rowspan="2">TQFN</td><td rowspan="2">3 x 3</td></tr>
<tr><td>MAX17599</td><td>4.5</td><td>36</td></tr>
</table>

**Output voltage regulated using the primary winding of transformers.*

<table>
<tr><th rowspan="2">Part Number</th><th colspan="2">V_{IN} (V)</th><th rowspan="2">Drive Source/Sink Current (A)</th><th rowspan="2">Turn-On Prop. Delay (nS)</th><th rowspan="2">Turn-Off Prop. Delay (nS)</th><th rowspan="2">Package Type</th><th rowspan="2">Package Size L x W</th></tr>
<tr><th>Min</th><th>Max</th></tr>
<tr><td colspan="8">Secondary-Side Synchronous MOSFET Driver for Flyback Converters</td></tr>
<tr><td>MAX17606</td><td>4.5</td><td>36</td><td>2/4</td><td>26</td><td>32</td><td>TSOT</td><td>2 x 3</td></tr>
</table>

<table>
<tr><th rowspan="2">Part Number</th><th colspan="2">V_{IN} (V)</th><th rowspan="2">Drive Source/Sink Current (A)</th><th rowspan="2">Turn-On Prop. Delay (nS)</th><th rowspan="2">Turn-Off Prop. Delay (nS)</th><th rowspan="2">Package Type</th><th rowspan="2">Package Size L x W</th></tr>
<tr><th>Min</th><th>Max</th></tr>
<tr><td colspan="8">Dual MOSFET Driver (Inverting/Non-Inverting, TTL/HNM)</td></tr>
<tr><td>MAX17600/1/
2/3/4/5</td><td>4</td><td>14</td><td>4</td><td>12</td><td>12</td><td>TDFN
µMAX
SO-8</td><td>3 x 3
3 x 5</td></tr>
</table>

Rainier Isolated DC-DC Power Solutions (Continued)

<table>
<tr><th>EV Kit</th><th>Configuration</th><th>Input</th><th colspan="2">Output</th></tr>
<tr><td>MAX17681EVKITA</td><td rowspan="8">Iso-Buck</td><td>17V to 32V</td><td>±15V</td><td>100mA</td></tr>
<tr><td>MAX17681EVKITB</td><td rowspan="6">17V to 36V</td><td>±7V</td><td>100mA</td></tr>
<tr><td>MAX17681EVKITC</td><td>+15V</td><td>200mA</td></tr>
<tr><td>MAX17681EVKITD</td><td>+7V</td><td>200mA</td></tr>
<tr><td rowspan="2">MAX17681EVKITE</td><td>±15V</td><td>75mA</td></tr>
<tr><td>±7V</td><td>75mA</td></tr>
<tr><td>MAX17681EVKITF</td><td>+24V</td><td>100mA</td></tr>
<tr><td>MAX17682EVKIT</td><td>16V to 42V</td><td>+12V</td><td>750mA</td></tr>
</table>

<table>
<tr><th>EV Kit</th><th>Configuration</th><th>Input</th><th colspan="2">Output</th></tr>
<tr><td>MAX17598EVKIT</td><td>Active-Clamp</td><td>36V to 72V</td><td>3.3V</td><td>8A</td></tr>
<tr><td>MAX17498BEVKIT</td><td>Flyback</td><td rowspan="7">18V to 36V</td><td>+5V</td><td>1.5A</td></tr>
<tr><td>MAX17596EVKIT</td><td>Flyback</td><td>+24V</td><td>833mA</td></tr>
<tr><td>MAX17597FBEVKIT</td><td>Flyback</td><td>+24V</td><td>833mA</td></tr>
<tr><td>MAX17690EVKITB</td><td>Flyback</td><td>+5V</td><td>1A</td></tr>
<tr><td>MAX17690EVKITC</td><td>Flyback</td><td>±15V</td><td>200mA</td></tr>
<tr><td>MAX17606SFBEVKIT</td><td>Sync. Flyback</td><td>+5V</td><td>3A</td></tr>
<tr><td>MAX17690EVKITA</td><td>Sync. Flyback</td><td>+5V</td><td>1A</td></tr>
</table>

Olympus Overvoltage and Overcurrent Protectors

Part Number	V_{IN} (V)		Current Limit (A)		Fault Response	Dual-Stage Current Limiting[1]	Features	Package-Pin
	Min	Max	Min	Max				
MAX17612A	4.5	60	0.01	0.25	Pin-selectable (latch-off, autoretry, continuous)		OV, UV, OC, OT, reverse-current protection (internal FET), FLAG and UVOV signals	TDFN-EP/10 3 x 3
MAX17612B	4.5	60	0.01	0.25	Pin-selectable (latch-off, autoretry, continuous)		OV, UV, OC, OT, FLAG and UVOV signals	TDFN-EP/10 3 x 3
MAX17612C	4.5	60	0.01	0.25	Pin-selectable (latch-off, autoretry, continuous)		OC, OT, reverse-current protection (internal FET), FWD and REV signals	TDFN-EP/10 3 x 3
MAX17608	4.5	60	0.1	1	Pin-selectable (latch-off, autoretry, continuous)		OV, UV, OC, OT, reverse-current protection (internal FET), FLAG and UVOV signals	TDFN-EP/12 3 x 3
MAX17609	4.5	60	0.1	1	Pin-selectable (latch-off, autoretry, continuous)		OV, UV, OC, OT, FLAG and UVOV signals	TDFN-EP/12 3 x 3
MAX17610	4.5	60	0.1	1	Pin-selectable (latch-off, autoretry, continuous)		OC, OT, reverse-current protection (internal FET), FWD and REV signals	TDFN-EP/12 3 x 3
MAX14721	5.5	60	0.2	2	Pin-selectable (latch-off, autoretry, continuous)	1.0x	OV, UV, OC, OT, reverse-current (with external FET)	TQFN/20 5 x 5
MAX14722	5.5	60	0.2	2	Pin-selectable (latch-off, autoretry, continuous)	1.5x	OV, UV, OC, OT, reverse-current (with external FET)	TQFN/20 5 x 5
MAX14723	5.5	60	0.2	2	Pin-selectable (latch-off, autoretry, continuous)	2.0x	OV, UV, OC, OT, reverse-current (with external FET)	TQFN/20 5 x 5
MAX17613A	4.5	60	0.15	3	Pin-selectable (latch-off, autoretry, continuous)		OV, UV, OC, OT, reverse-current protection (internal FET), FLAG and UVOV signals	TQFN-EP/20 4 x 4
MAX17613B	4.5	60	0.15	3	Pin-selectable (latch-off, autoretry, continuous)		OV, UV, OC, OT, FLAG and UVOV signals	TQFN-EP/20 4 x 4
MAX17613C	4.5	60	0.15	3	Pin-selectable (latch-off, autoretry, continuous)		OC, OT, reverse-current protection (internal FET), FWD and REV signals	TQFN-EP/20 4 x 4

Olympus Overvoltage and Overcurrent Protectors (Continued)

Part Number	V_{IN} (V)		Current Limit (A)		Fault Response	Dual-Stage Current Limiting[1]	Features	Package-Pin
	Min	Max	Min	Max				
MAX17525A	5.5	60	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	1.0x Option 1.5x Option 2.0x	OV, UV, OC, OT, reverse-current protection (external P-FET), FLAG signal	TQFN-EP/20 5 x 5
MAX17526A	5.5	60	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	1.0x	OV, UV, OC, OT, reverse-current protection (external N-FET), FLAG signal, power limit	TQFN-EP/20 5 x 5
MAX17526B	5.5	60	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	1.5x	OV, UV, OC, OT, reverse-current protection (external N-FET), FLAG signal, power limit	TQFN/20 5 x 5
MAX17526C	5.5	60	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	2.0x	OV, UV, OC, OT, reverse-current protection (external N-FET), FLAG signal, power limit	TQFN-EP/20 5 x 54
MAX14691	5.5	58	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	1.0x	OV, UV, OC, OT, reverse-current (external FET)	TQFN-EP/20 5 x 5
MAX14692	5.5	58	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	1.5x	OV, UV, OC, OT, reverse-current (external FET)	TQFN-EP/20 5 x 5
MAX14693	5.5	58	0.6	6	Pin-selectable (latch-off, autoretry, continuous)	2.0x	OV, UV, OC, OT, reverse-current (external FET)	TQFN-EP/20 5 x 5
MAX17523	4.5	36	0.15	1	Pin-selectable (latch-off, autoretry, continuous)	1.0x	OV, UV, OC, OT, reverse-current (with external FET)	TQFN-EP/16 3 x 3
MAX17561	4.5	36	0.7	4.2	Autoretry		OV, UV, OC, OT, reverse-current protection (internal FET), FLAG signal	TSSOP-EP/14 5 x 6.5
MAX17562	4.5	36	0.7	4.2	Latch-off		OV, UV, OC, OT, reverse-current protection (internal FET), FLAG signal	TSSOP-EP/14 5 x 6.5
MAX17563	4.5	36	0.7	4.2	Continuous		OV, UV, OC, OT, reverse-current protection (internal FET), FLAG signal	TSSOP-EP/14 5 x 6.5

1. During initial startup period, the current limit is increased by the indicated ratios.

EE-Sim Switching Regulator Reference Design

Please note: You must be logged in to MyMaxim to access the EE-Sim Design tools in the table below.

Reference Design	Description	V_{IN} (min)	V_{IN} (max)	V_{OUT} (V)	I_{OUT} (V)
MAX15062AEVKIT PFM	60V, 300mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converters EVKIT Design	4.5	60	3.3	0.3
MAX15062AEVKIT PWM	60V, 300mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converters EVIT Design	4.5	60	3.3	0.3
MAX15062BEVKIT PFM	60V, 300mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converters EVKIT Design	6.5	60	5	0.3
MAX15062BEVKIT PWM	60V, 300mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converters EVKIT Design	6.5	60	5	0.3
MAX15062C12EVKIT PFM	60V, 300mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converters EVKIT Design	14	60	12	0.3
MAX15062C12EVKIT PWM	60V, 300mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converters EVKIT Design	14	60	12	0.3
MAX15462AEVKIT PFM	Fixed 3.3V Output	4.5	42	3.3	0.3
MAX15462AEVKIT PWM	Fixed 3.3V Output	4.5	42	3.3	0.3
MAX15462BEVKIT PFM	Fixed 5V Output	6.5	42	5	0.3
MAX15462BEVKIT PWM	Fixed 5V Output	6.5	42	5	0.3
MAX15462C12EVKIT PFM	Adjustable 12V Output	14	42	12	0.3
MAX15462C12EVKIT PWM	Adjustable 12V Output	14	42	12	0.3
MAX17501AEVKIT PFM	60V, 500mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	6.5	40	5	0.5
MAX17501BEVKIT PFM	60V, 500mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	6	60	5	0.5
MAX17501EEVKIT PWM	60V, 500mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	4.5	60	3.3	0.5
MAX17501FEVKIT PWM	60V, 500mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	6.5	40	5	0.5
MAX17501GEVKIT PWM	60V, 500mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	14	60	12	0.5
MAX17501HEVKIT PWM	60V, 500mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	4.5	60	2.5	0.5
MAX17502EEVKIT PWM	60V, 1A, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Con-verter	5	60	3.3	1
MAX17502FEVKIT PWM	60V, 1A, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Con-verter	7	60	5	1

EE-Sim Switching Regulator Reference Designs (Continued)

Reference Design	Description	V_{IN} (min)	V_{IN} (max)	V_{OUT} (V)	I_{OUT} (V)
MAX17502GEVKIT PWM	60V, 1A, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	15	60	12	1
MAX17502HEVKIT PWM	60V, 1A, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter	4.5	60	2.5	1
MAX17503 EVKit	MAX17503 5V Application	6.5	60	5	2.5
MAX17504 EVKit	MAX17504 5V Application	7.5	60	5	3.5
MAX17505 EVKit	MAX17505 5V Application	6.5	60	5	1.7
MAX17506EVKITA DCM	Adjustable 3.3V Output	5	60	3.3	5
MAX17506EVKITA PFM	Adjustable 3.3V Output	5	60	3.3	5
MAX17506EVKITA PWM	Adjustable 3.3V Output	5	60	3.3	5
MAX17506EVKITB DCM	Adjustable 5V Output	6.5	60	5	5
MAX17506EVKITB PFM	Adjustable 5V Output	6.5	60	5	5
MAX17506EVKITB PWM	Adjustable 5V Output	6.5	60	5	5
MAX17521 EVKIT PFM	Dual Output, PFM Mode	7	60	5, 3.3	1, 1
MAX17521 EVKIT PWM	Dual Output, PWM Mode	7	60	5, 3.3	1, 1
MAX17524EVKIT DCM	MAX17524 Dual-Output Voltage 3.3V and 5V Application	6.5	48	5, 3.3	3
MAX17524EVKIT PFM	MAX17524 Dual-Output Voltage 3.3V and 5V Application	6.5	48	5, 3.3	3
MAX17524EVKIT PWM	MAX17524 Dual-Output Voltage 3.3V and 5V Application	6.5	48	5, 3.3	3
MAX17536EVKITA DCM	3.3V Adjustable Output	5	60	3.3	4
MAX17536EVKITA PFM	3.3V Adjustable Output	5	60	3.3	4
MAX17536EVKITA PWM	3.3V Adjustable Output	5	60	3.3	4
MAX17536EVKITB DCM	5V Adjustable Output	6.5	60	5	4
MAX17536EVKITB PFM	5V Adjustable Output	6.5	60	5	4
MAX17536EVKITB PWM	5V Adjustable Output	6.5	60	5	4
MAX17543EVKITB PWM	MAX17543 in 5V Output-Voltage Application	6.5	42	5	2.5

EE-Sim Switching Regulator Reference Designs (Continued)

Reference Design	Description	V_{IN} (min)	V_{IN} (max)	V_{OUT} (V)	I_{OUT} (V)
MAX17544EVKITA PWM	MAX17544 in 3.3V Output-Voltage Application	5	42	3.3	3.5
MAX17544EVKITB PWM	MAX17544 in 5V Output-Voltage Application	7.5	42	5	3.5
MAX17545EVKITA PWM	MAX17545 in 3.3V Output-Voltage Application	4.5	42	3.3	1.7
MAX17545EVKITB PWM	MAX17545 in 5V Output-Voltage Application	6.5	42	5	1.7
MAX17546EVKITA DCM	3.3V Adjustable Output	5	42	3.3	5
MAX17546EVKITA PFM	3.3V Adjustable Output	5	42	3.3	5
MAX17546EVKITA PWM	3.3V Adjustable Output	5	42	3.3	5
MAX17546EVKITB DCM	5V Adjustable Output	6.5	42	5	5
MAX17546EVKITB PFM	5V Adjustable Output	6.5	42	5	5
MAX17546EVKITB PWM	5V Adjustable Output	6.5	42	5	5
MAX17550 EVkit	MAX17550 5V Output Evaluation Kit	6.5	60	5	0.025
MAX17551 EVkit	MAX17551 5V Output Evaluation Kit	6.5	60	5	0.05
MAX17552 EVkit	MAX17552 5V Output Evaluation Kit	6.5	60	5	0.1
MAX17558DPEVKIT PWM	MAX17558 Dual-Phase Evaluation Kit	6	54		
MAX17558EVKIT PWM	MAX17558 Evaluation Kit	6	60		
MAX17572EVKITA	MAX17572 3.3V Output Evaluation Kit	4.5	60	3.3	1
MAX17572EVKITB	MAX17572 5V Output Evaluation Kit	6	60	5	1
MAX17574 EVKITA DCM	Fixed 3.3V Output DCM Mode	5	60	3.3	3
MAX17574 EVKITA PFM	Fixed 3.3V Output PFM Mode	5	60	3.3	3
MAX17574 EVKITA PWM	Fixed 3.3V Output PWM Mode	5	60	3.3	3

EE-Sim Switching Regulator Reference Designs (Continued)

Reference Design	Description	V_{IN} (min)	V_{IN} (max)	V_{OUT} (V)	I_{OUT} (V)
MAX17574EVKITB DCM	Fixed 5V Output DCM Mode	7	60	5	3
MAX17574EVKITB PFM	Fixed 5V Output PFM Mode	7	60	5	3
MAX17574EVKITB PWM	Fixed 5V Output PWM Mode	7	60	5	3
MAX17575EVKITA	MAX17575 3.3V Output Evaluation Kit	5	60	3.3	1.5
MAX17575EVKITB	MAX17575 5V Output Evaluation Kit	6.5	60	5	1.5
MAX17632AEVKIT DCM	Fixed 3.3V Output DCM Mode	4.5	36	3.3	2
MAX17632AEVKIT PFM	Fixed 3.3V Output PFM Mode	4.5	36	3.3	2
MAX17632AEVKIT PWM	Fixed 3.3V Output PWM Mode	4.5	36	3.3	2
MAX17632BEVKIT DCM	Fixed 5V Output DCM Mode	6.5	36	5	2
MAX17632BEVKIT PFM	Fixed 5V Output PFM Mode	6.5	36	5	2
MAX17632BEVKIT PWM	Fixed 5V Output PWM Mode	6.5	36	5	2
MAX17632C5EVKIT DCM	Adjustable 5V Output DCM Mode	6.5	36	5	2
MAX17632C5EVKIT PFM	Adjustable 5V Output PFM Mode	6.5	36	5	2
MAX17632C5EVKIT PWM	Adjustable 5V Output PWM Mode	6.5	36	5	2
MAX17671FEVKIT PFM	MAX17671 5V Switcher and 3.3V LDO	6.5	60	5	0.1
MAX17671FEVKIT PWM	MAX17671 5V Switcher and 3.3V LDO	6.5	60	5	0.1
MAX17690EVKITB	No Opto Flyback	18	36	5	1
MAX17761 EVKITA	3.3V, 1A Output, PFM Mode, 400kHz Switching Frequency	4.5	76	3.3	1
MAX17761 EVKITB	5V, 1A Output, PWM Mode, 400kHz Switching Frequency	4.5	76	5	1
MAXM15062 EVKit	MAXM15062 EV Kit	5.5	48	3.3	0.3
MAXM15063 EVKit	MAXM15063 EV Kit	12	60	5	0.3
MAXM15064 EVKit	MAXM15064 EV Kit	12	60	5	0.3
MAXM15462 EVKit	MAXM15462 EV Kit	5.5	42	3.3	0.3
MAXM15463 EVKit	MAXM15463 EV Kit	5.5	42	3.3	0.3
MAXM15464 EVKit	MAXM15464 EV Kit	12	42	5	0.3
MAXM17502EVKIT	1A, 60V High-Efficiency, DC-DC Step-Down Power Module with Integrated Inductor	7	42	5	1

EE-Sim Switching Regulator Reference Designs (Continued)

Reference Design	Description	V_{IN} (min)	V_{IN} (max)	V_{OUT} (V)	I_{OUT} (V)
MAXM17503EVKIT PWM	MAXM17503 in 5V 2.5A Output Application	11	60	5	2.5
MAXM17504EVKIT PWM	MAXM17504 in 5V 3.5A Output Application	11	60	5	3.5
MAXM17505EVKIT PWM	MAXM17505 in 5V 1.7A Output Application	11	60	5	1.7
MAXM17514EVKIT	4A 1.5V Integrated Power Module	2.4	5.5	1.53	4
MAXM17515EVKIT	5A 1.5V Integrated Power Module	2.4	5.5	1.53	5
MAXM17516EVKIT	6A 1.5V Integrated Power Module	2.4	5.5	1.53	6
MAXM17532EVKITA	4V to 42V, 100mA Compact Step-Down Power Module	10	42	5	0.1
MAXM17543EVKIT PWM	MAXM17543 in 3.3V 2.5V Output Application	4.5	42	3.3	2.5
MAXM17544EVKIT PWM	MAXM17544 in 3.3V 3.5A Output Application	6.5	42	3.3	3.5
MAXM17545EVKIT PWM	MAXM17545 in 3.3V 1.7A Output Application	11	42	3.3	1.7
MAXM17552EVKITA	4V to 60V, 100mA Compact Step-Down Power Module	14	60	5	0.1
MAXM17574 EVKIT PWM	MAXM17574 EVKIT	10	60	5	3
MAXM17575EVKIT	4.5V to 60V, 1.5A Step-Down Power Module	7.5	60	5	1.5
MAXM17761 EVKIT PWM	MAXM17761 EVKIT	10	76	5	1
MAXM17901 EV Kit	MAXM17901 EV Kit	5.5	24	3.3	0.3
MAXM17900EVKITA	4V to 21V, 100mA Compact Step-Down Power Module	10	21	5	0.1
MAXM17903 EV Kit	MAXM17903 EV Kit	4.5	21.5	1.5	0.3

Related Resources

Himalaya Power Modules

Himalaya Step-Down Switching Regulators

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