Let there be light

A reference design for a power supply that supports more energy efficient lighting. By **Graham Pitcher**.

Energy efficiency is one of the overarching design criteria, almost independent of market sector. We all want to save power, not only making our portable devices last longer between recharges or battery changes, but also to save money. A consequence of lower power consumption is a reduced need for power generation capacity and, in the long term, reduced greenhouse gas emissions.

We face an interesting choice in our homes when it comes to lighting. For years, we've used the humble incandescent lamp; it's a device that has served us well, but which is coming to the end of its life because it is relatively inefficient. For some time, we've been using halogen – or MR16 – lighting in the home as a replacement. But while these provide better lighting that an incandescent lamp, they generate a lot of heat and, while more efficient than incandescents, have relatively short life expectancies.

Incandescent and halogen lamps are now being replaced in many applications by LEDs. But it hasn't been an easy road for the LED; it is only recently that its efficiency has reached the point where it can be considered as a suitable replacement. Now, high brightness LEDs (HB LED) can be found in applications ranging from handheld torches to architectural lighting by way of the automotive industry.

According to On Semiconductor, many applications require HB LEDs to be powered from a source with a wide input voltage range. It notes this is especially true in general illumination applications, like track lighting, in which the 12V ac or 12V dc source is loosely regulated.

On Semi says LEDs need to be driven by a current source, rather than a voltage source, since the forward voltage (3.4V nominal) can vary more than ±20% due to process tolerance and temperature.

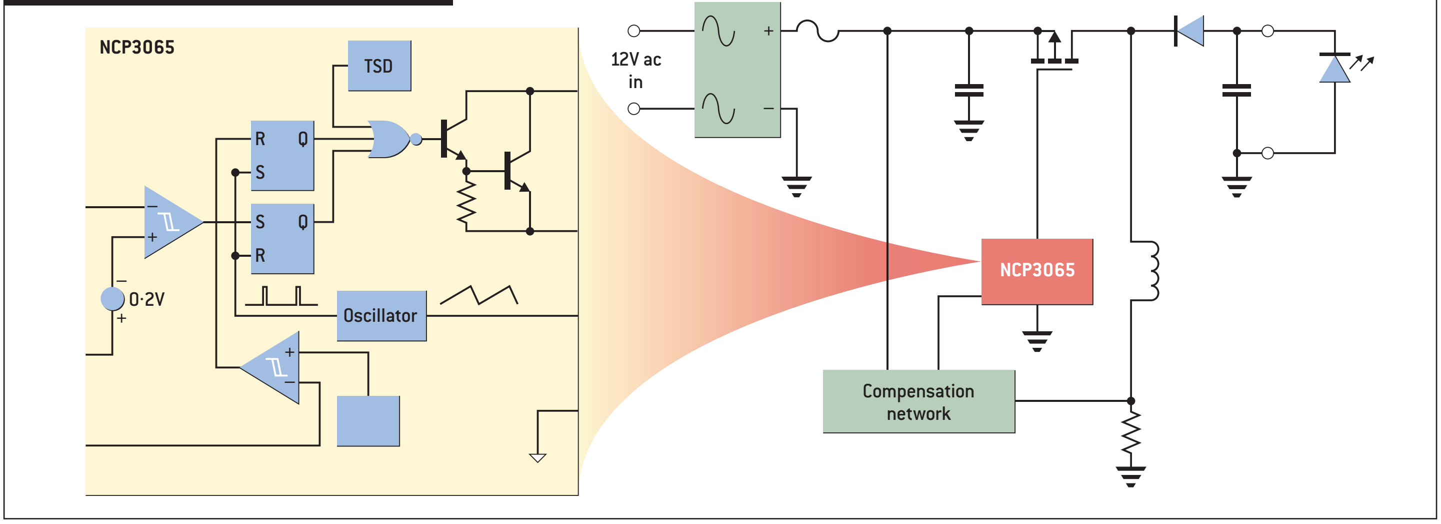
Given the flux of current 1W warm white power LEDs, it is common that three or four LEDs are required to replace the light output of a 20W incandescent. To obtain predictable and matched luminosity and chromaticity, it is also desirable to drive the LEDs with a constant current.

On Semi has recently announced a reference design for a 1 to 5W LED driver for MR16 replacement applications. The circuit is designed to drive HB LEDs in a range of lighting applications, such as track lighting, automotive and low voltage AC landscaping. Other potential applications include task lighting.

"The market for solid state lighting continues to grow as new and traditional manufacturers look to capitalise on the performance, cost, reliability and efficiency benefits that LEDs offer over conventional alternatives," said Laurent Jenck, ON Semiconductor's marketing director for power supply applications. "These reference designs allow designers of new and emerging lighting applications to reduce development times by providing a proven and tested solution to driving high brightness LEDs as efficiently as possible."

The MR16 reference design is based on a buck-boost topology using ON Semiconductor's NCP3065 switching regulator operating at around 150kHz in a non isolated constant current configuration. A key consideration in this design, says On Semi, was achieving flat current regulation across input line variation and output voltage variation with a 12V ac input.

Fig 1: Simplified reference design block diagram



Suitable for use with 12V ac or 12V dc applications, such as track lighting, automotive lighting and landscape lighting, the circuit delivers flat current regulation irrespective of input line and output LED voltage variation.

The design also features an autodetect circuit which, in combination with the NCP3065, allows input from a 12V dc or 12V ac supply while maintaining the targeted output current regulation.

The reference design has been optimised to drive up to eight high power LEDs in a range of applications. It uses a novel circuit configuration to achieve a power factor of in excess of 0.85 at 115V ac without the addition of a passive power factor correction network. This, says the company, reduces the component count and meets residential power factor requirements.

The design operates from a 90V ac to 265V ac universal input and is built around the ON Semiconductor NCP1014 switcher, which integrates a fixed frequency current mode controller with a 700V mosfet.

The reference design's basic control loop consists of a 235mV internal reference, a feedback comparator and two set dominant RS latches. Basically, says On Semi, the NCP3065 allows the power fet for the buck-boost stage to switch on as the feedback voltage falls below the reference voltage. The power fet will be then be forced off unconditionally during C_t ramp down. A resistor senses the inductor current and is fed to the NCP3065's feedback pin.

This application produces off time instantaneous (I_{valley}) inductor current control. A cycle of switch on time is only allowed to start once the off time inductor current crosses the V_{ref} threshold.

Since the controller does not provide integral PWM control and uses only a comparator trip point for feedback, the peak to average load current is not in direct proportion as it would be in a buck converter. Therefore an input voltage feed forward compensation network is used to reduce the error due to the nonlinear response of the I_{out} vs V_{in} curve.

A resistive divider network consisting of three resistors is used to add V_{in} proportional voltage to the FB pin in order to reduce the load current as V_{in} is increased. This has the effect of flattening the curve and reducing the overall current error.

Since there is a half sine wave input to the buck-boost stage, there is a different operating point as compared with pure dc input. Since one of the goals for the reference design is small size, very little input capacitance is used past the full bridge rectifier.

As a result, the line voltage can drop as low as 3V, depending on the input capacitance selection. Therefore, the input to the converter is a full wave rectified sine wave.

Since the regulator is non functional at less than approximately 4V, there are dead spots in the regulation. So the end result is regulation for approximately 80% of the 120Hz line cycle and then no output for the remainder. This has the effect of reducing the average current by about 20% when operating with ac input.

Thermal consideration should be taken when running with supplies in excess of 12V ac and, in most applications, the module is potted to increase thermal dissipation. An additional ac compensation network is added to the V_{in} compensation to account for the different operating point.

The reference design comes with a full bill of materials, as well as a schematic and pcb layout information.

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