Using DC/DC Controllers to Improve Bitcoin Miner Designs

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Bitcoin and other cryptocurrency mining have vastly taken off over the past couple of years. In the early stages of Bitcoin mining, CPUs and then GPUs were used to solve complex mathematical equations, which in turn gave users bitcoins. Today, the most efficient Bitcoin miners use specially designed application-specific integrated circuits (ASICs) to solve these increasingly difficult equations. The more ASIC processing power a Bitcoin miner has, typically defined by a hash rate, the more Bitcoins per unit of time one is able to mine. The problem with using ASICs, however, is that they consume much more electricity than typical CPU/GPU setups. Electricity consumption in relation to Bitcoin mining has become a topic of conversation around the world with more and more mining farms building up shop. There are many statistics showing how the electricity consumption of Bitcoin mining may exceed the overall consumption of many first world countries. For Bitcoin miners specifically, depending on how expensive electricity is in their region, mining bitcoins could actually lose them money. And even if electricity in their area is not expensive now, prices will most likely increase over time due to inflation and increasing environment regulations on electricity production and usage. It is because of this that the power efficiency of a Bitcoin miner is becoming ever so important.

1 Thermal Considerations

Since mining bitcoin now requires power hungry ASICs that collectively pull large amounts of electricity, another thing to keep in mind is all of the heat that is created. This heat, if undealt with, can either slow down the performance of the ASICs or even destroy the Bitcoin miner hardware. Heat from Bitcoin miners is typically mitigated by heavy-duty cooling fans, HVAC systems, water chillers, or evaporative cooling, but these solutions can be expensive and must be implemented by Bitcoin-miner users. As a Bitcoin miner designer, there are design choices you can make to better dissipate the heat on the boards. One technique is using heat sinks, but this is only so effective and also adds more components to the board. Another approach is to look at using a highly efficient buck controller with external FETs. It is generally thought that the fewer components there are on the bill of materials (BOM), the more reliable a system will be. This may not be the case all the time. Bitcoin miner designers thinking of using converters will need to take into account how the heat of the integrated MOSFETs affects the performance and reliability of the controller since their proximity is now closer inside one integrated package. In both Figure 1 and Figure 2, thermal performance was measured for buck controller LM27402 and buck converter TPS548B22. Conditions for LM27402 were 12-V input, 0.9-V output, at 15 A. Conditions for TPS548B22 were 12-V input, 0.9-V output, at 16 A. Results from LM27402 were a maximum temperature of 43°C, while results from TPS548B22 were a maximum temperature of 55.6°C. From comparing the thermal performance in these images, it can be argued that because a controller with external MOSFETs is spaced further from the controller then it may have better reliability. Reliability is very important to Bitcoin miner users because any time the miner spends offline is lost potential profit. Designing for superior thermal performance separates the top Bitcoin miners from lower tier designs.

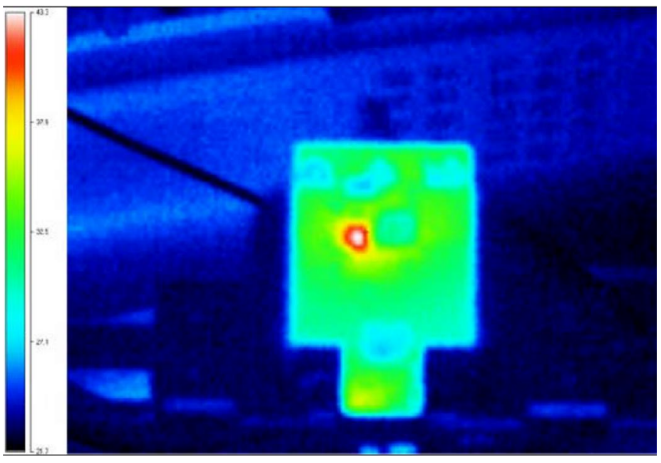

Figure 1. LM27402 Thermal Performance

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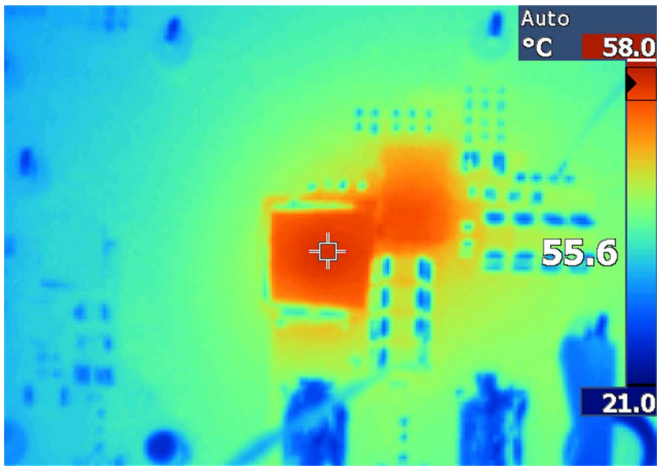

Figure 2. TPS548B22 Thermal Performance

2 Output Power Considerations

As we discussed previously, Bitcoin miners are using the higher hash rates of specially designed ASICs to achieve better mining efficiency. Top-tier Bitcoin miners use the processing power of numerous ASICs per board to increase their total hash rate and to be more competitive than other Bitcoin miners. From a hardware design standpoint, this translates to an ever-increasing output voltage and current requirements in order to supply sufficient power to the ASICs. As the output voltage and current requirements rise, the need for buck controllers with external FETs becomes clear. Over the years, buck converters with integrated FETs have increased the amount of output current they can supply using multi-chip module (MCM) technology, but the output voltage capabilities of converters is a limitation for most Bitcoin miner designs. Because most designs power these ASICs in series, as shown by the block diagram in Figure 3, the more ASICs a designer uses in their Bitcoin miner, the higher the output voltage requirement is. The output voltage requirement has become so high that using a converter cannot meet these demands. Selecting a controller with a high output voltage limit and a high duty cycle, such as the LM27402 device, shown in Figure 4, ensures that every ASIC is fully powered. LM27402 can support up to 18.6 V on the output with a maximum duty cycle of 95%. This means that with a standard input voltage of 12 V, it is possible to supply up to 11.4 V on the output.

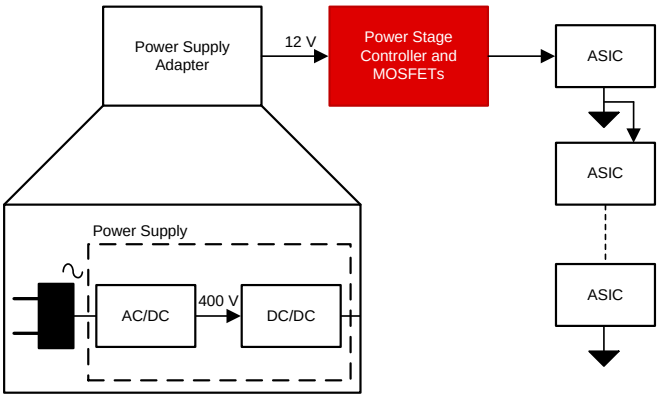

Figure 3. Bitcoin-Miner Power Tree

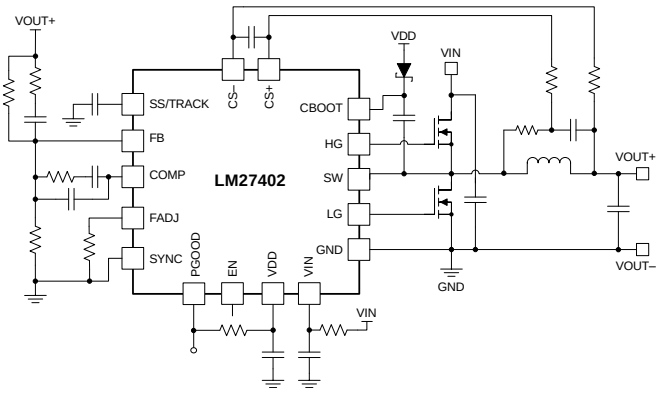

Figure 4. LM27402 Synchronous Buck Controller

3 Final Remarks

In a rapidly growing market like Bitcoin mining, it is even more critical that Bitcoin mining hardware be as competitive as possible. To keep up with increasing hash rate needs, Bitcoin mining machines require more ASICs per board than ever before. For Bitcoin miner power designers this translates to higher efficiency and better thermal performance requirements. To meet these requirements, buck controllers with external MOSFETs are great options to consider due to their high efficiency, thermal performance, and high output voltage and current capabilities.

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