International Rectifier

APPLICATION NOTE

Application Note AN-1046

Dual Synchronous PWM Controller and LDO Controller in TSSOP Package Eases Multi-Output and Two-Phase Power Supply Solutions

By Parviz Parto, International Rectifier

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Many applications like DDR memory, and set top boxes require at least two output voltages. And then there are some others such as graphics cards where the output power exceeds any single input power budget. Or, application when the current required is too large that two-phase solution should be used. International Rectifier's IRU3046, a monolithic dual synchronous PWM controller with a built-in linear regulator controller, offers unprecedented flexibility to configure these multiple types of power supplies.

Until now, the traditional way to address these requirements has been to use separate controllers for each output with associated passive and discrete components. Now, with the introduction of IRU3046, that task is tremendously simplified. Housed in a low-cost 24-pin plastic TSSOP package, this single versatile bipolar device allows the user to configure two independent voltage outputs with either common or different inputs. Or, create a dual-phase design for single output with programmable current sharing when

using two different input supplies. Or, two-phase application when high output current and high efficiency are required. In addition, it offers a separate linear controller for an additional independent adjustable voltage output. In short, the IRU3046 brings flexibility to the power supply designer that is unmatched.

DDR Memory Application

One such solution with two outputs for DDR memory is shown in figure 1. The channel 1 generates the Vcore (V_{DDQ}) and the channel 2 generates the termination voltage (V_{TT}=1/2 V_{DDQ}) by tracking the Vcore, this is achieved by sensing the V_{DDQ} and using the integrated uncommitted error amplifier (Vp2). The two external resistors (R5, R9) generate the reference voltage for channel 2 to track the V_{DDQ}. The V_{TT} tracking accuracy is about 1.5% for optimized data rate transfer accuracy. Figures 2 and 3 show how the VTT tracks the VDDQ both statically when the VDDQ changes from 2.5V to 2.87V and dynamically when the output current for VDDQ steps from 0-to 2A.

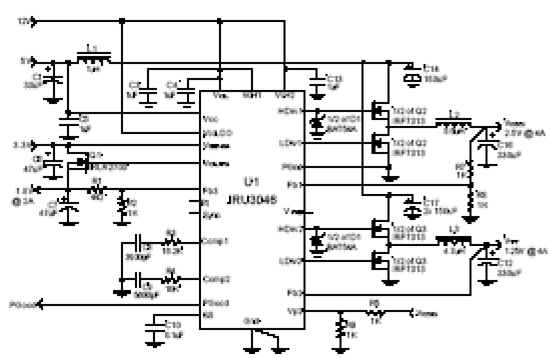

Figure 1. IRU3046 configured for DDR Memory application

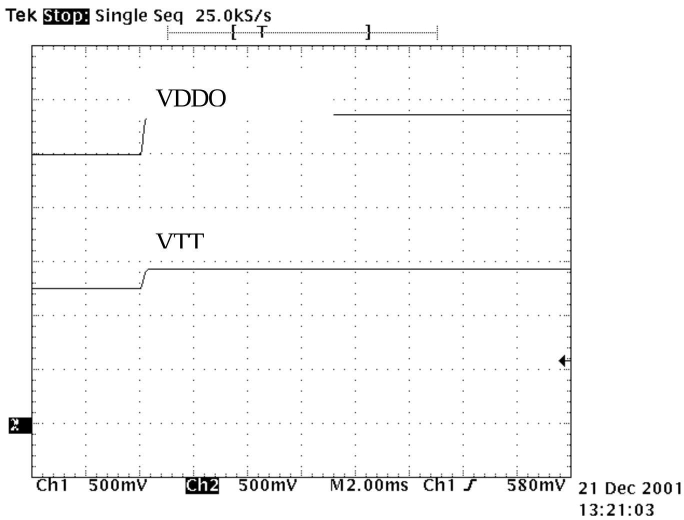

Figure 2. VDDQ changes from 2.5V to 2.87V and VTT tracks the half of VDDQ

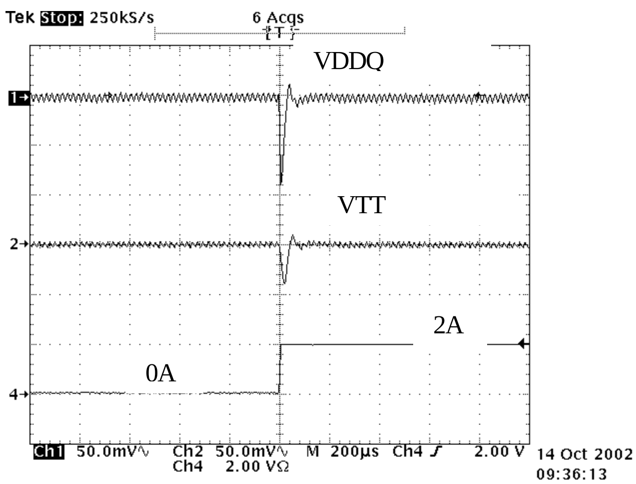

Figure 3. Transient Response for VDDQ, VTT tracks VDDQ - Ch1: VDDQ, Ch2: VTT, Ch4: IDDQ, Step load 0-2A

Independent Mode

In the independent mode, the output voltage of each independent channel is set and controlled by the output of the error amplifier. The output voltages can be set between 1.25 V and close to the input voltage. It is capable of supplying 10-15 A from single 5 V or 12 V. However, the input can be from the same supply or a separate operation for the two independent outputs. The output voltage of the each channel is set and controlled by the output of error amplifier and can be programmed by using two external resistors. This output voltage is defined by using the following equation:

$$V_{out1} = V_{REF} \text{ x } (1 + R_7/R_8)$$

Similarly, the output voltage of the linear regulator is programmed using the voltage reference and the external voltage divider (see figure 4).

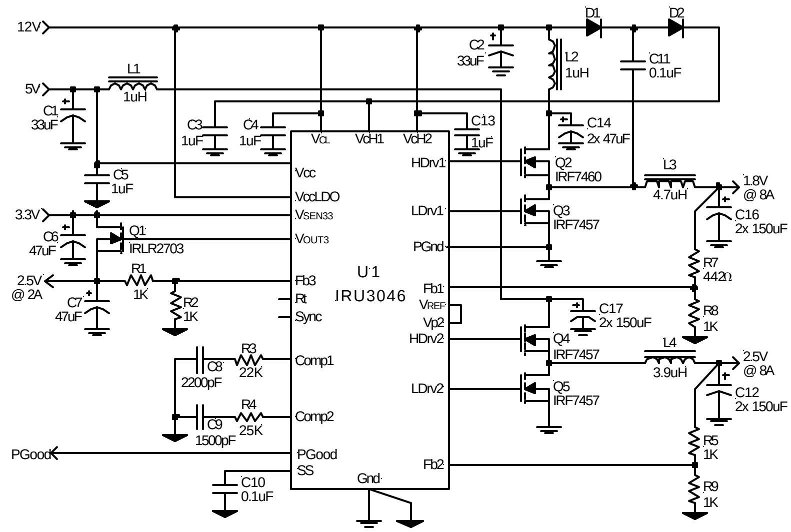

Figure 4. IRU3046 configured for two independent outputs

Dual-Phase Mode With Programmable Current Sharing

The same device can also be configured for the application when the output power exceeds any single input power budget. For example we have the following application:
Vout=1.5V @ 17A, Ptotal=25.5W. And two input supplies are Vin1=5V @ 3A, Pin1=15W and Vin2=12V @ 2A, Pin2=24W. As you see each of the inputs cannot provide the total output power. But, if we can combine the two inputs we can get the total output power (Fig.5). By appropriately selecting the two current sense resistors, the IRU3046 can combine these two input supplies and generate one single output with the total output power.

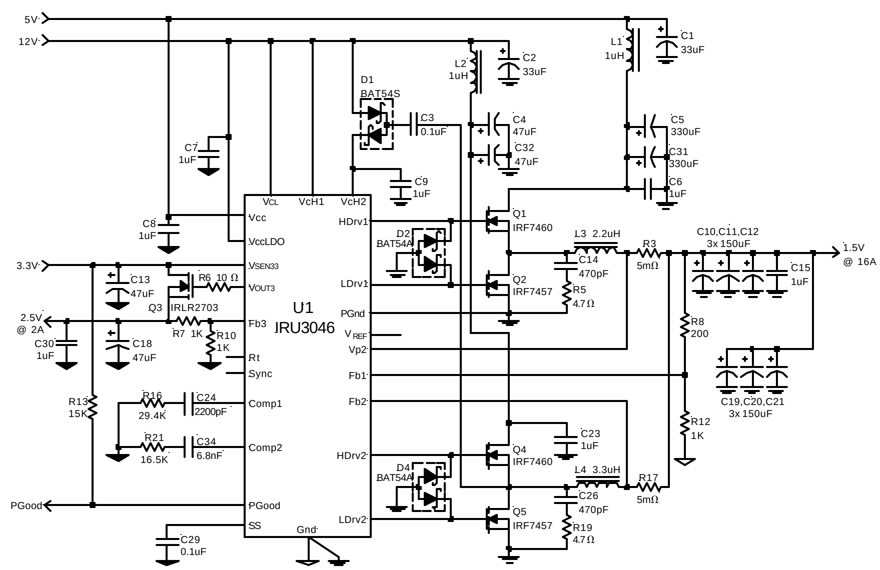

Figure 5. IRU3046 configured as 2-phase converter with current sharing.
5V input is the Master channel and set the output and 12V input is the slave channel that monitors the currents for achieving an accurate current sharing

In this Mode, the first error amplifier (E/A) acts as a master and sets the output voltage, while the second E/A acts as a slave and monitors the currents for current sharing. The slave's error amplifier measures the voltage drop across the current sense resistors, and the differential of these signals is amplified and compared with the ramp signal to generate the fixed-frequency pulses of variable duty cycle to match the output currents.
Two sense resistors (R3, R17 in figure 5) are used for current sharing. The relationship between the master and slave output current is expressed by:

Rsen1*Imaster = Rsens2*Islave

For equal current sharing Rsens1=Rsen2.
To ensure accurate current sharing, proper attention must be paid to layout to create a symmetrical path.

Because the two output stages are 180 degrees out of phase, the two inductor ripple currents cancel each other to result in a substantial reduction of output ripple current, thereby permitting a smaller output capacitor for the same ripple voltage requirement, Figure 6 shows the inductors ripple current and current matching.

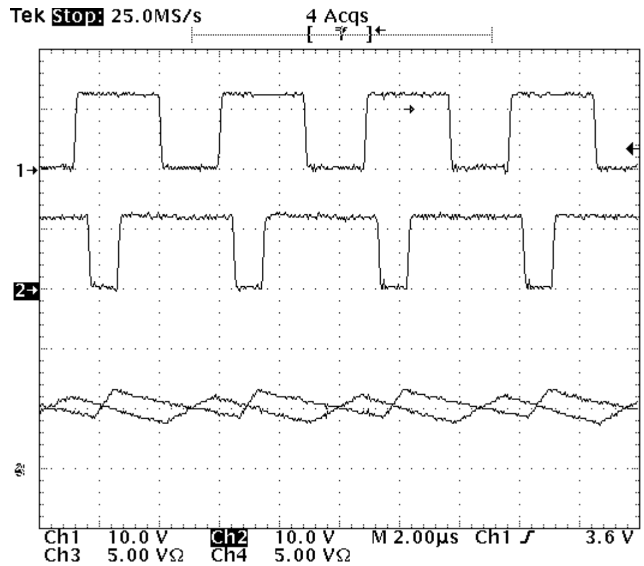

Figure 6. Inductors current matching.
Ch1: Gate signal for sync FET(master) (10V/div).
Ch2: Gate signal for sync FET(slave) (10V/div).
Ch3: Inductor current for master channel (5A/div).
Ch4: Inductor current for slave channel (5A/div).
VMASTER=5V, VSLAVE=12V, IOUT=10A

For fast load response and steady state output, the designer must pay careful attention to the feedback control loops. It must provide a loop gain function with a high bandwidth (high zero-crossover frequency) and adequate phase margin (for details see AN-1043).

Figure 7 shows load transient response when the output current steps from 0 to 10A.

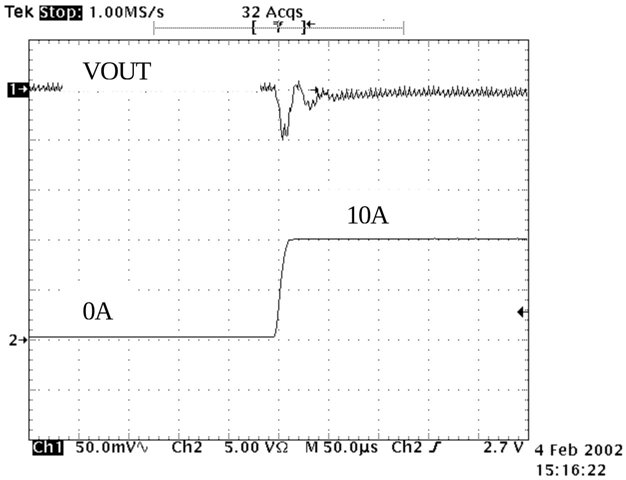

Figure 7. Load Transient Response, 0-10A
Ch1:Vout, Ch4:Iout

However, if single supply powers both the phases, the 2-phase configuration reduces the input ripple current. This results in much smaller RMS current in the input capacitor and reduction of input capacitor. Figure 8 shows the estimate RMS current for 2-phase versus single-phase converters.

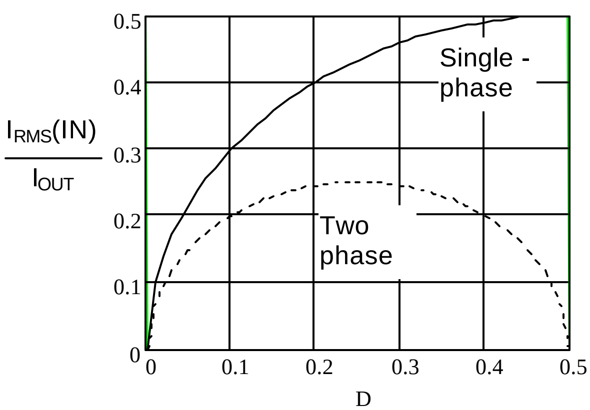

Figure 8. Normalized input RMS current vs. duty cycle

Salient Features

Other key features offered by this device include programmable soft-start, programmable switching frequency up to 400 kHz, under-voltage lockout (UVLO) function, power good signal, shutdown mode, short-circuit protection and frequency synchronization. While soft-start controls the output voltage and limits the current surge at the start-up, the UVLO circuit assures that the MOSFET driver outputs and LDO controller remain in the off-state whenever the supply voltages drop below set parameters. Normal operation will resume once the supply voltages rise above the set values. Likewise, the IRU3046 provides a power good pin, which is an open collector output that switches low when any of the outputs are outside the specified under voltage trip point. By sensing the output voltage constantly, the unit shuts down the PWM signal and LDO controller when the output drops below the threshold, guaranteeing protection against short-circuit. The IRU3046 also allows frequency synchronization with an external clock signal using the Sync pin.
More information for selecting of components and layout tips can be found on IRU3046 data sheet.