

Dither a power converter's operating frequency to reduce peak emissions

Bob Bell and Grant Smith, National Semiconductor, Phoenix, AZ

Designers of dc/dc switching power converters face the challenge of controlling EMI (electromagnetic-interference) emissions produced during normal operation. If large enough, these emissions conduct through power lines or radiate to other assemblies within a system and can compromise a system's performance. Emission peaks typically occur at the converter's fundamental switching frequency and gradually reduce in amplitude at each higher order harmonic, with most of the emitted energy confining itself to the fundamental and lower order harmonics. Modulating, or dithering, the power converter's operating frequency can reduce the peak emissions by spreading EMI over a band of frequencies.

Most modern PWM controllers use an external resistor to set the operating frequency, which typically increases with decreasing resistor values. For

example, the LM5020's internal oscillator delivers a regulated 2V at its programming pin (RT), and a programming resistor connected to RT sets the current that RT delivers. The oscillator also delivers a proportional current into an internal timing capacitor (Reference 1). The period of the timing capacitor's ramping voltage determines the oscillator's frequency.

The external dithering circuit in Figure 1 comprises a simple stand-alone comparator-based oscillator configured to operate at approximately 800 Hz. The output state of comparator IC₂ goes high upon power-up. R₁, R₂, and R₃ set the comparator's positive input, which initially rests at 2.9V. The voltage at capacitor C₃ ramps up toward the positive threshold.

When the voltage at the comparator's negative input reaches the positive-threshold voltage, the comparator's output switches low, which also

DIs Inside

100 Single-port pin drives dual LED

102 Network linearizes dc/dc converter's current-limit characteristics

104 Add a Schmitt-trigger function to CPLDs, FPGAs, and applications

► What are your design problems and solutions? Publish them here and receive \$150! Send your Design Ideas to edndesignideas@reedbusiness.com.

lowers the threshold at the comparator's positive input to 2.1V. The voltage at capacitor C₃ then ramps down toward the new threshold, and, when it reaches the lower threshold voltage, the cycle repeats. The voltage across C₃ approximates a triangular wave with a minimum voltage of 2.1V and a maximum of 2.9V.

To dither the LM5020 controller's PWM-oscillator base frequency, the triangular wave generated by IC₂ modulates the current from the controller's RT pin. Resistor R₅ sets the percentage of modulation dither. The right side of R₅ is fixed at the RT pin's regulated potential of 2V, and the low-frequency triangle wave coupled from IC₂ through capacitor C₂ drives R₅'s left side. For R₅ with a value of 64.9 kΩ, the peak-to-peak current through resistor R₅ is approximately 12 μA. With the dither circuit disconnected, the steady-state current that RT sources is approximately 121 μA, and the 12-μA p-p dither current thus represents 10% total modulation.

An LM5020-controlled PWM fly-back dc/dc converter, IC₁, evaluates the dither circuit's effectiveness. The circuit's fundamental operating frequency is 250 kHz, which the controller's R_T

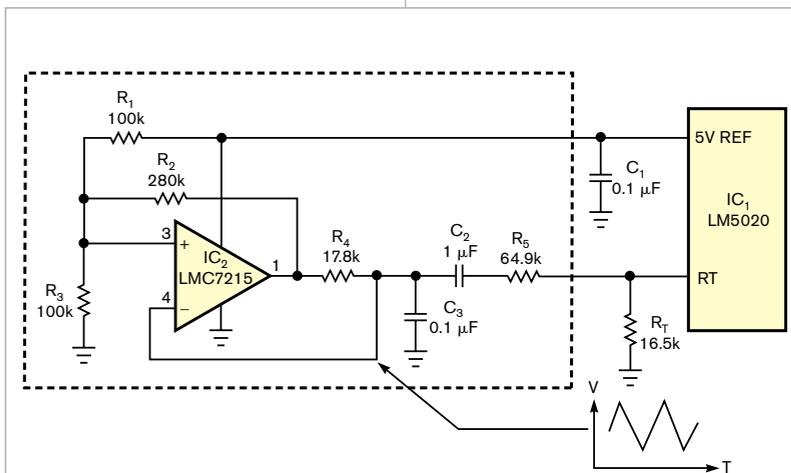


Figure 1 A low-frequency triangular-wave oscillator modulates a PWM controller's oscillator frequency.

resistor sets. The red trace of **Figure 2** shows the conducted emissions on the circuit's positive input-power line without the dither circuit in operation. The peak emissions are narrowly confined around the fundamental oscillator frequency of 250 kHz with a measured amplitude at the fundamental frequency of -24 dB.

Connecting the dither circuit to the controller's RT input produces the blue trace of **Figure 2**. Conducted emissions around the fundamental frequency now disperse around the fundamental frequency with maximum amplitude reduced by -34 to $+10$ dB. **EDN**

REFERENCE

1 LM5020 data sheet, National Semiconductor, www.national.com/pf/LM/LM5020.html#Datasheet.

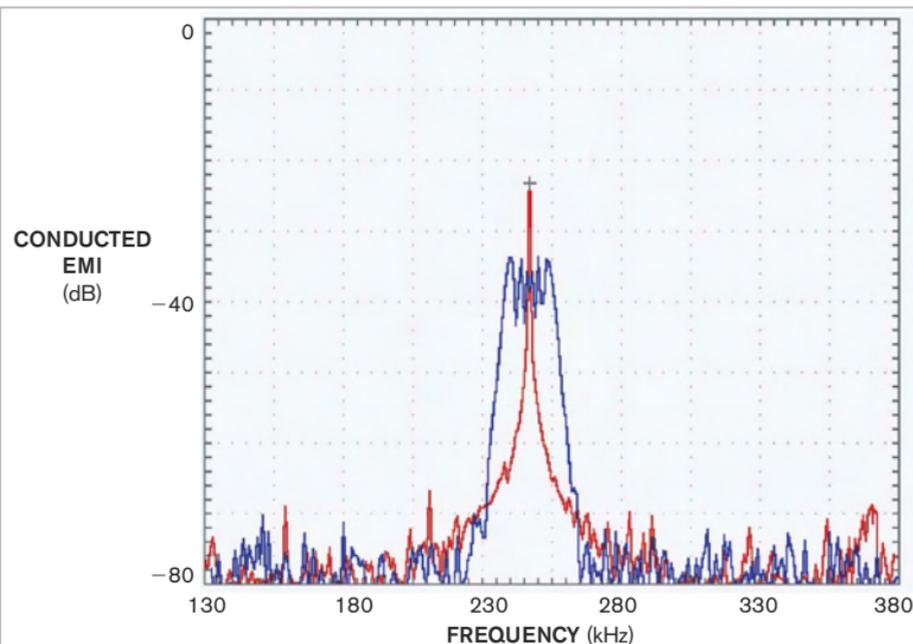


Figure 2 Measured at the dc/dc converter's input, peak conducted emissions without dither (red trace) decrease by 10 dB with dithering applied (blue trace).