Spread-Spectrum DC-DC Converter Combats EMI

Ken Yang

Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, CA 94086

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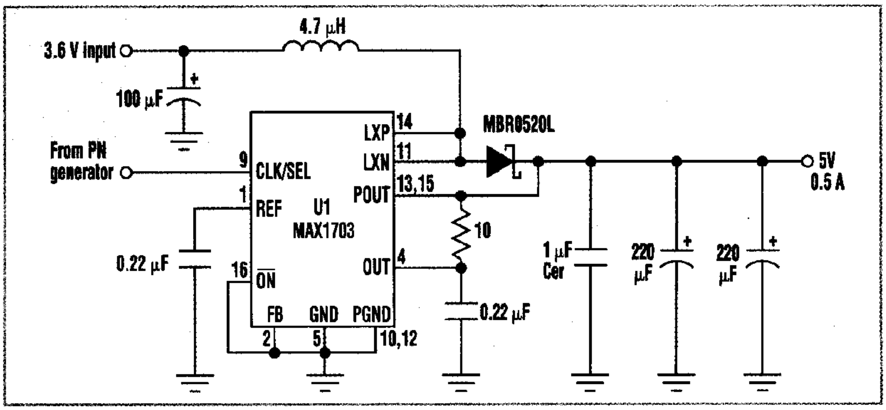
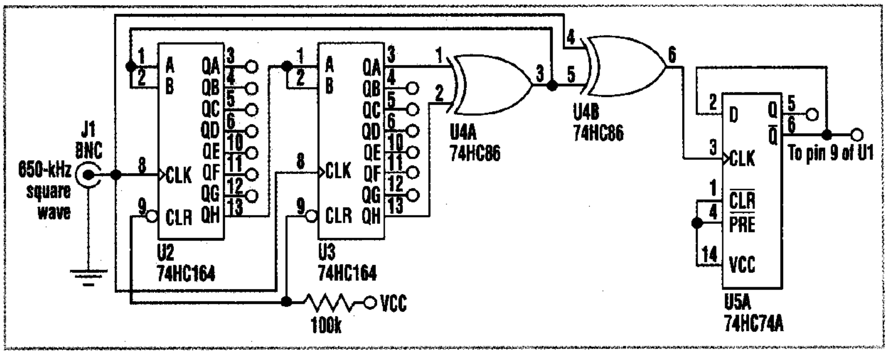
Electromagnetic radiation (called electromagnetic interference or EMI when unwanted) is emitted by almost all electronic systems, including switching regulators. The conventional approach to suppressing EMI is to block the radiation at its source with a metallic or magnetic shield, or both. For switching regulators, you can further enhance suppression by adopting a spread-spectrum pulse-width-modulation (SSPWM) control scheme.

In Fig. 1, the switching regulator IC (U1) has an external clock input. Driving this input with a digital signal of pseudorandom noise (PN) provides the regulator with a spread-spectrum clock that reduces EMI. By spreading interference frequencies over a wide range, this technique lowers the EMI power density that is otherwise concentrated at a single clock frequency.

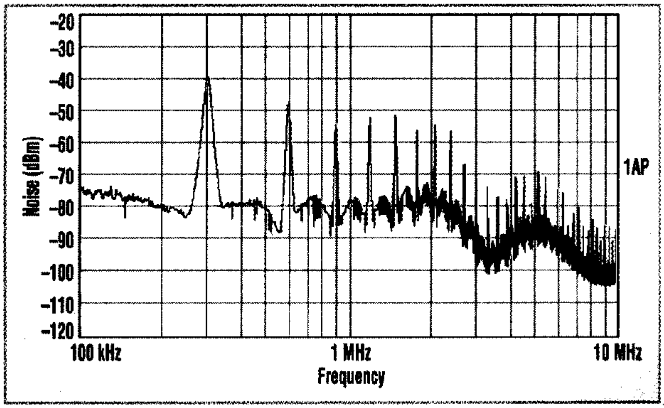
The PN generator spreads interference over a wide spectrum. Its key element is a 16-bit shift register formed by the series connection of two 8-bit shift registers (U2 and U3), with feedback from the XOR gate U4A *(Fig. 2)*. The result is an almost random (pseudorandom) output, consisting of a repeat-



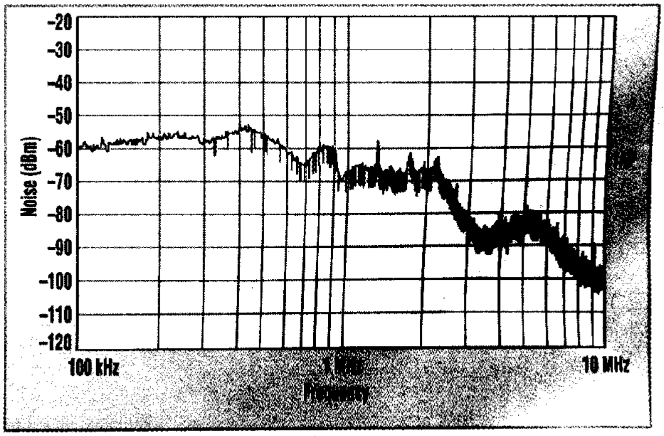
1. To reduce EMI, this conventional step-up dc-dc converter employs spread-spectrum pulse-width modulation (SSPWM) produced by the pseudorandom noise at the clock input.



2. This generator of pseudorandom noise (PN) produces a nominal 325-kHz clock signal for the step-up dc-dc converter circuit in Figure 1.



3. The output-noise spectrum produced by the Fig. 1 circuit operating with a fixed-frequency control scheme contains strong peaks at the clock harmonics.



4. An SSPWM control scheme produces less output noise in the Fig. 1 circuit than the conventional fixed-frequency approach.

ing sequence of ones and zeroes at a nominal frequency of 650 kHz. The D-type flip-flop (U5) divides this frequency by two, producing a nominal 325-kHz spread-spectrum clock signal to the switching regulator.

Bench measurements show a 15-dB reduction in peak power density at about 300 kHz. Except for 9 mA of extra current drawn by the PN generator, the regulator's efficiency remains unchanged. (The efficiency is 94% while delivering 0.5 A with a 3.6-V input and a 5-V output.) Ripple amplitude in the time domain also remains unchanged. Output spectra demonstrate that a conventional fixed-frequency clock *(Fig. 3)* produces considerably more noise than does the spread-spectrum technique *(Fig. 4)*.