Increasing Switching Frequency in DC-DC Regulators

There has been a trend to develop DC-DC regulators that run at higher and higher switching frequencies. Most manufacturers have made advances into the multi-MHz switching territory regardless of their applications or the delivered power levels. Regulators switching at 2, 3, 4 and even 8 MHz exist now and their vendors all claim to offer the best and smallest solution size and highest possible power density per volume. Recent advancements in passive technology have also enabled system designers to shrink both footprint and profile of power systems by using smaller inductors and capacitors. Perhaps the real questions to ask here are: How effective is increasing switching frequency in reducing the overall size of a DC-DC solution? Is there an optimum frequency? Is there a limit, and if so where is it? What are the drawbacks?

The main goal of increasing the operating speed of a DC-DC regulator is to reduce the overall solution size by decreasing passive values; but it seems that in the rush to use higher frequencies at any cost, there are rarely any discussions about the limits and potential drawbacks involved in using such an approach. Most will point out the obvious rule, that the switching frequency has an inverse relationship to the square root of LC or ($f_{osc} \propto 1/[LC]^{1/2}$), and as a result, the switching speed must be increased in order to have a smaller solution. Few will recall however that there are limits to such a solution.

Eighteen step-down regulators from various IC suppliers were surveyed in order to explore the validity of increasing the switching speeds to reduce the solution size. Figure 1 shows a plot

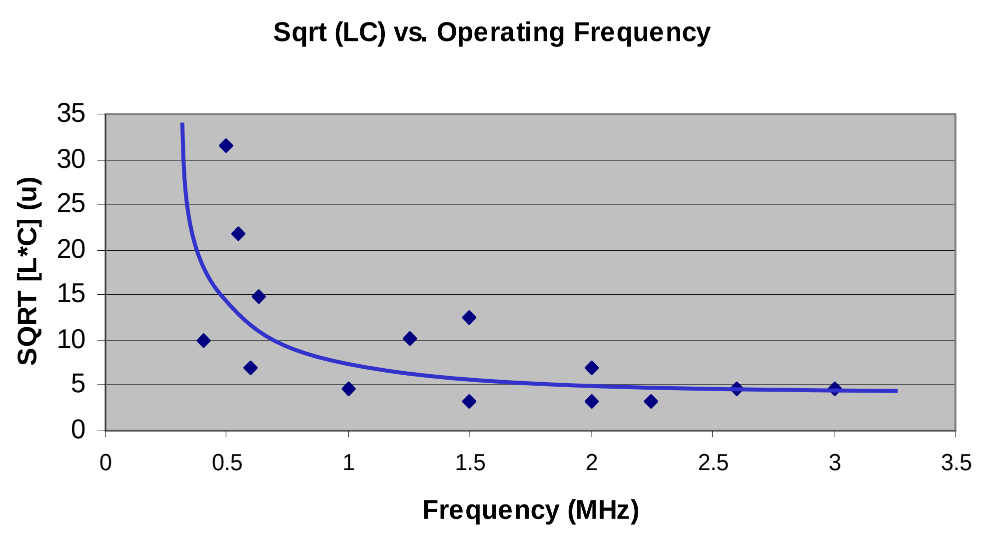

Figure 1. Size of L & C vs. Switching Frequency

of the data taken from publicly available data-sheets for these 18 parts. All of these parts were designed for portable devices with 600mA to 800mA output current. The vertical axis is the value of the square root of LC ($[LC]^{1/2}$) as was recommended in the data-sheets for each part. This has been plotted against the switching frequency on the horizontal axis for each part.

The plotted data in Figure 1 shows the value of $[LC]^{1/2}$ drops sharply as the switching frequency increases from 400 kHz to 1 MHz. At switching frequencies higher than 1MHz the reduction in size levels off. There is no net reduction in the value of $[LC]^{1/2}$ above a 1 MHz switching frequency. One unwanted consequence of the rising switching frequency is a reduction in efficiency. Figure 2 shows the stated peak efficiency of the same 18 parts used in Figure 1. As expected, the efficiency of the parts drops as the switching speed is increased. Another unwanted result of higher frequency is the increase in the switching noise which is not discussed.

As illustrated by the data increasing the switching may not always be the most effective method since it lowers efficiency and increases noise. The selection of a regulator to meet all of a design’s requirements for size and efficiency is a critical task. The system designer must evaluate all of the requirements and not just jump on the latest “One Size Fits All” solution.

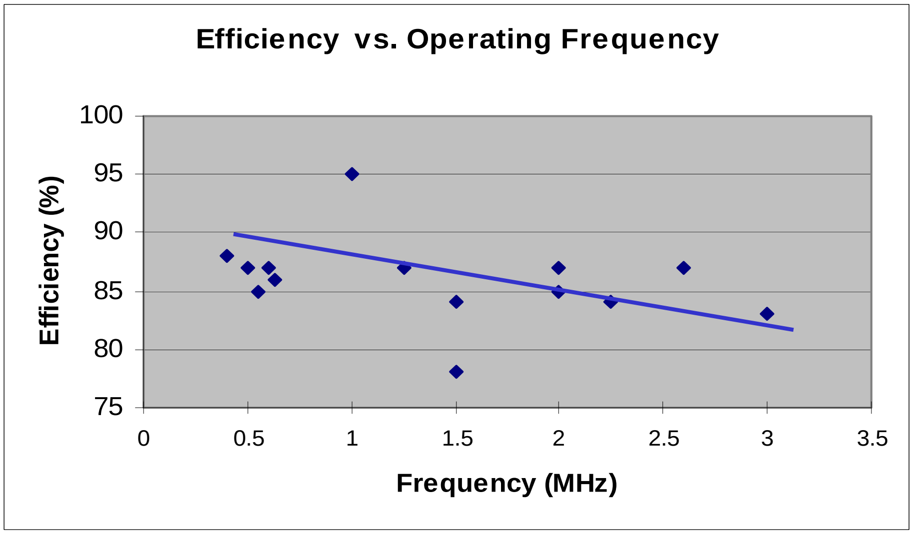

Figure 2. Efficiency vs. Switching Frequency