Linear controller attenuates switching-supply ripple

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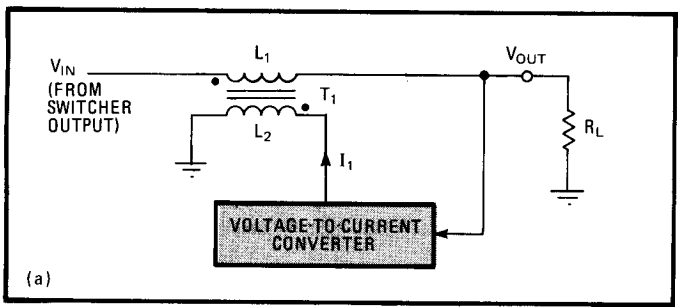
One of the big disadvantages of a switching power supply is ripple. However, at the cost of a slight efficiency loss and a few parts, this linear controller (a) rejects any ac variations in its dc output when placed at the output of the switcher.

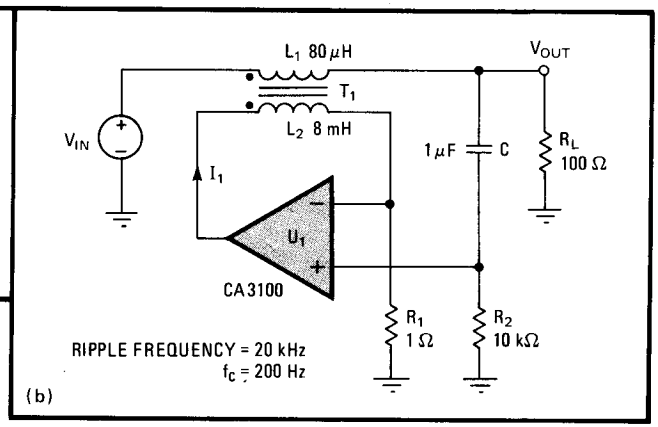
A Laplace voltage-transfer function for the general scheme can be written as:

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{1}{s([L_1 + k_1k_2(L_1L_2)^{1/2}R_L]/R_L)+1}$$

where k_1 = the coefficient of coupling, k_2 = the transconductance of the voltage to the current converter, R_L = the load resistance, and L_2 and L_1 are the respective primary and secondary inductances of transformer T_1. When $k_1 = 1$ and $L_2 = n^2L_1$, where n is T_1's turns ratio, $V_{out}(s)/V_{in}(s)$ may be expressed as:

$$\frac{1}{(sL_1/R_L)(k_2nR_L+1)+1}$$





Power-supply ripple. This design uses a linear controller (a) at the output of a switching power supply to attenuate ripple at its dc output. The practical implementation (b) uses op amp U_1 and transformer T_1 to attenuate 20-kHz ripple by more than 30 dB.

This equation is for a first-order, low-pass filter having cutoff frequency $f_c = R_L/2\pi L_1(k_2nR_L+1)$ hertz. To reduce ripple by more than 20 decibels, f_c must be at least a decade below the switching frequency.

A possible implementation of the idea is shown in (b). As an example, the design uses a ripple frequency of 20 kilohertz and a load impedance of 100 ohms. With n = 10, $k_2 = 1$, and $f_c = 200$ Hz, $L_1 = 80$ microhenrys and $L_2 = 8$ millihenrys. Also, when $1/2\pi R_2C << 200$ Hz, $R_2 = 10$ kilohms and $C = 1$ microfarad, where R_2 and C may be arbitrarily chosen. The ripple contents measured at the output were found to be below 30 dB. If the ripple frequency is much higher, other parts should be substituted as needed. □