MICROMETALS POWDER CORE SOLUTIONS

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SWITCHMODE DC-AC INVERTER CORE LOSS CALCULATIONS

Bruce Carsten
Bruce Carsten Associates, Inc. USA

Non-isolated switchmode inverters are usually realized as half bridge or full bridge circuits, as shown in basic form Fig. 1 and Fig. 2 respectively, with generic switches in place of transistors. The switches are operated with complementary duty cycles "D" and "1-D" as shown to produce an instantaneous output voltage Vo that is between the input voltage (Vi) supply rails. The output voltage is considered to be "zero" when it is midway between the supply rails.

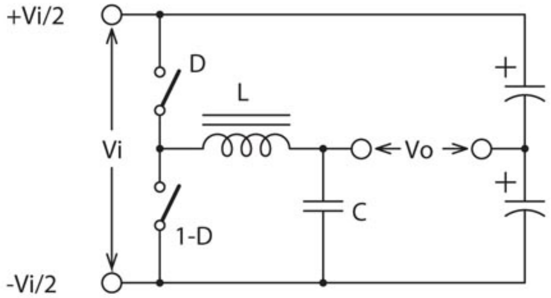

Fig. 1

Half Bridge dc-ac Inverter

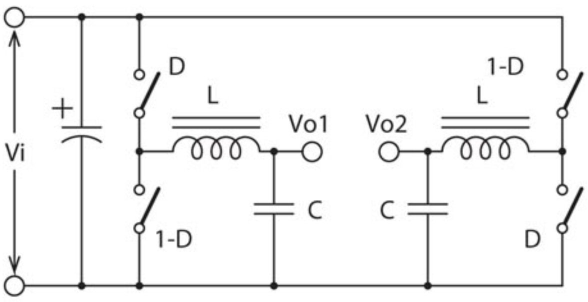

Fig. 2

A Full Bridge dc-ac Inverter

The ripple current in inductor L, and switching frequency flux "B" in the core, is a maximum when D=0.5 and Vo=0. For a constant switching frequency "f", the maximum peak-peak ripple current "Ipp" in L (as well as filter capacitor C) is given by:

$I_{pp} = V_i / (4fL)$ (1)

The corresponding peak flux in the inductor core is given (in CGS units) by:

$B_{pk} = (10^8 V_i) / (8 f A N)$ (2)

Where "A" is the core area and "N" is the number of turns on the core. The switching frequency ac flux may also be calculated from the ripple current as:

$B_{pk} = (10^8 I_{pp} L) / (2 A N)$ (2)

The output voltage varies linearly with switch duty cycle, but the inductor ripple current and peak flux decrease parabolically as Vo deviates from Vo=0, reaching zero at the supply rails, as shown in Fig. 3.

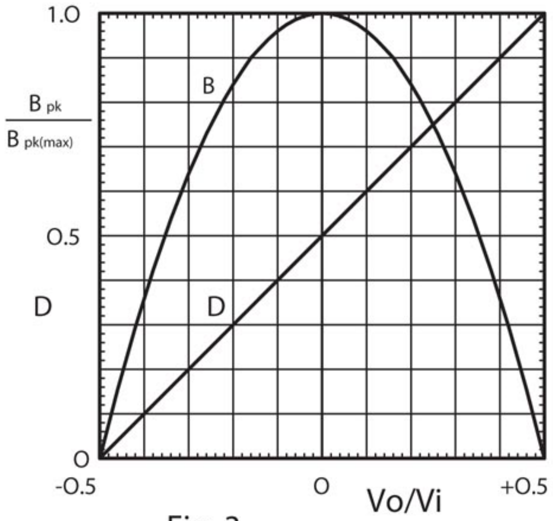

Fig. 3

Variation of Duty Cycle "D" and Relative Core Flux with Vo/Vi

Generation of a low frequency (such as 50 or 60 Hz) output voltage causes the peak flux to sweep across the Fig. 3

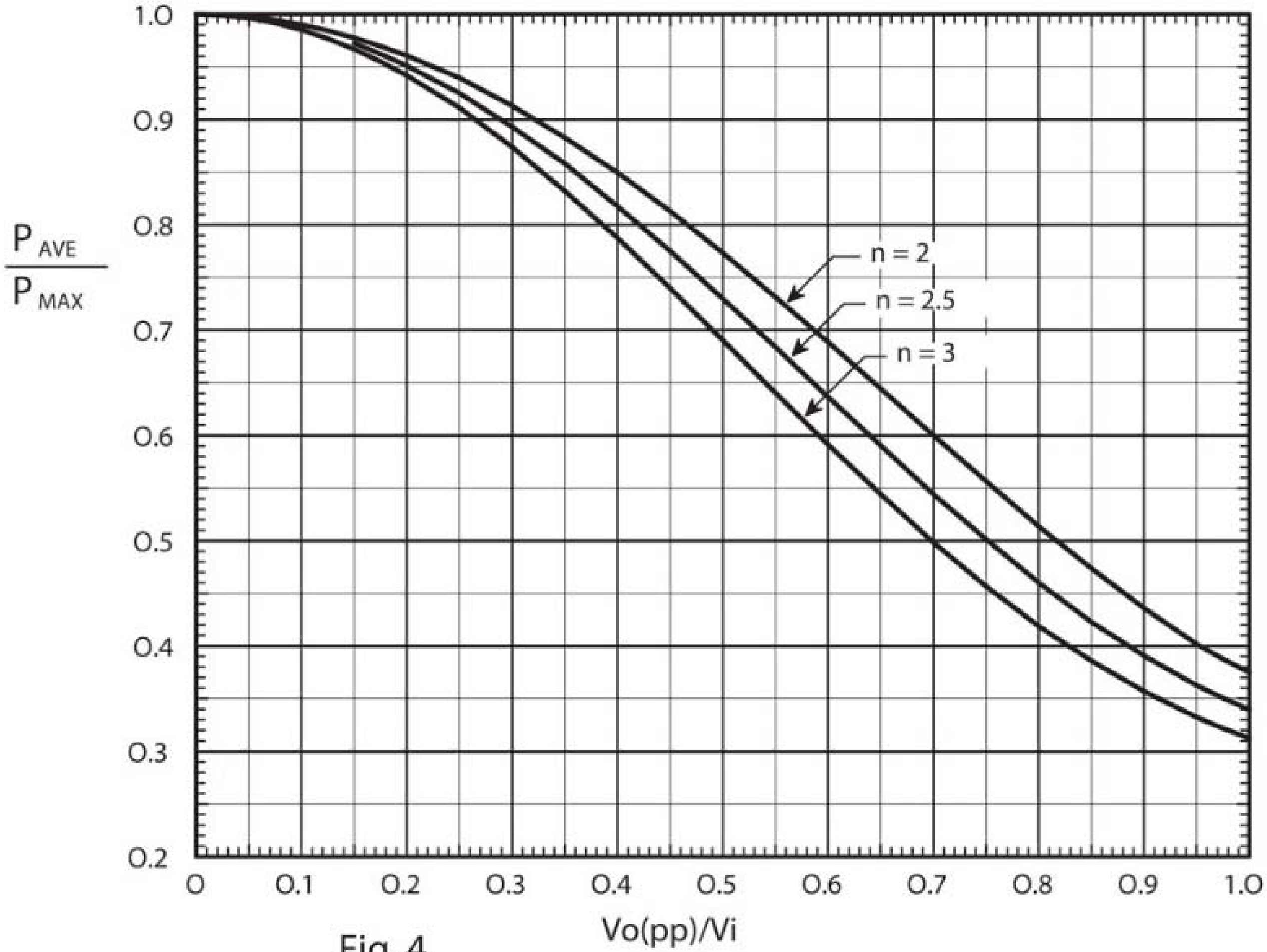

Fig. 4

Ratio of Average to Maximum Core Loss vs. Vo(pp)/Vi and Steinmetz Loss Exponent "n"

parabola sinusoidally, reducing the average hysteresis loss in the core due to the lower flux swing at the output voltage peaks. This effect is quantified in Fig. 4, which shows the ratio of average power loss in the core (Pave) to the maximum loss (Pmax) for various Steinmetz core loss exponents “n” and ratio of peak-peak (low frequency) output voltage “Vo(pp)” to dc input voltage (Vi).

The maximum core loss occurs when Vo=0 as noted, and can be determined from the peak flux calculated by equation (2) or (3) and the loss curves or equations provided in the Micrometals catalog. Average core loss is then determined from the curves of Fig. 4.

Note that Pave decreases significantly as the peak output voltage approaches the supply rails, and the effect is greater as the loss exponent increases.

The effective loss exponent of Micrometals materials changes with flux density and frequency, but can be readily determined from the slope of the loss curves provided. If the loss is noted at two flux densities B_1 and B_2 (with losses P_1 and P_2 respectively), the loss exponent between those points is calculates as:

$$n = \log(P_1/P_2) / \log(B_1/B_2) \qquad (4)$$

The effective loss exponent for Micrometals materials at 100 KHz and 100 to 200 mW/cc are given in Table 1 below.

Effective Core Flux Loss Exponents "n" for Micrometals Materials at 100 KHz and 100 to 200 mW/cc:

Mat’l:	u	n	Mat’l:	u	n
-2	10	2.27	-34	33	2.08
-8	35	2.29	-35	33	2.00
-14	14	2.20	-38	85	2.13
-18	55	2.26	-40	60	2.12
-26	75	2.14	-45	100	2.11
-30	22	2.05	-52	75	2.13

Table 1