TOSHIBA

APPLICATION NOTE
M-3

Magnetic Amplifier Regulation of Switch Mode Power Supplies

Temperature Rise in Saturable Reactors

As a Magnetic Amplifier operates, the magnetic flux in the saturable reactor changes as the magnetic hysteresis loop is traversed. There is some loss associated with this flux change. In an actual device this Core Loss, or Iron Loss, leads to an increase in temperature of the saturable reactor.

To calculate the temperature rise, the flux change, $\Delta\Phi$, must be known. From the flux change, the change in flux density, ΔB, of the core of the Magnetic Amplifier can be determined:

$$\Delta B = \Delta\Phi / (N \cdot A) \text{ [MT]} \quad (1)$$

where:

$\Delta\Phi$ = Flux change [Wb]
N = Number of turns of wire around core
A = Cross-Sectional Area of Core [mm²]

Figure 1 is used to determine the Core Loss/Volume. Multiplying by the volume of the core, yields the Core Loss. The temperature rise is determined from Figure 2.

If the temperature rise is too large, increasing the number of turns can decrease the flux change.

EXAMPLE

Calculate the temperature rise in an MS 12x8x4.5W core with 12 turns and a 15 μWb Flux change at 200 kHz.

From Equation (1), ΔB can be calculated, after the Cross-Sectional Area of the MS 12x8x4.5W core has been determined from Table 1 (Area = 6.75 mm² in this case):

$$\Delta B = (15 \times 10^{-6}) / (12 \times 6.75)$$
$$= 1.9 \times 10^{-7} \text{ MT}$$
$$= 0.19 \text{ T}$$

From Figure 1, the Core Loss/Volume for 0.19T at 200 kHz is determined to be about 0.5 mW/mm³.

The Volume of an MS 12x8x4.5W is found to be 212 mm³ from Table 1. Therefore, the Core Loss is about 100 mW.

Using Figure 2, for a Core Loss of 100 mW in an MS 12x8x4.5W core, leads to a **predicted temperature rise of about 8°C**. [Please note that there is a possibility of an additional temperature rise due to the wound wire itself.]

Table 1
Toshiba Amorphous Saturable Cores - MS Series

Part Number	Core Size O.D. [mm]	I.D. [mm]	Height [mm]	Cross-Sectional Area [mm²]	Magnetic Path Length [mm]	Total Flux [μWb]	Core Volume [mm³]
MS 7x4x3W	7.5	4.5	3	3.38	18.8	3.16	64
MS 8x7x4.5W	8	7	4.5	1.69	23.6	1.58	40
MS 9x7x4.5W	9	7	4.5	3.38	25.1	3.16	85
MS 10x7x4.5W	10	7	4.5	5.06	26.7	4.73	135
MS 10x6x4.5W	10	6	4.5	6.75	25.1	6.31	169
MS 12x8x3W	12	8	3	4.50	31.4	4.20	141
MS 12x8x4.5W	12	8	4.5	6.75	31.4	6.31	212
MS 14x8x4.5W	14	8	4.5	10.13	34.6	9.47	350
MS 15x10x3W	15	10	3	5.63	39.3	5.26	221
MS 15x10x4.5W	15	10	4.5	8.44	39.3	7.89	332
MS 18x12x4.5W	18	12	4.5	10.13	47.1	9.47	477
MS 21x14x4.5W	21	14	4.5	11.81	55.0	11.04	650

Figure 1

Core Loss/Volume vs Flux Density Change

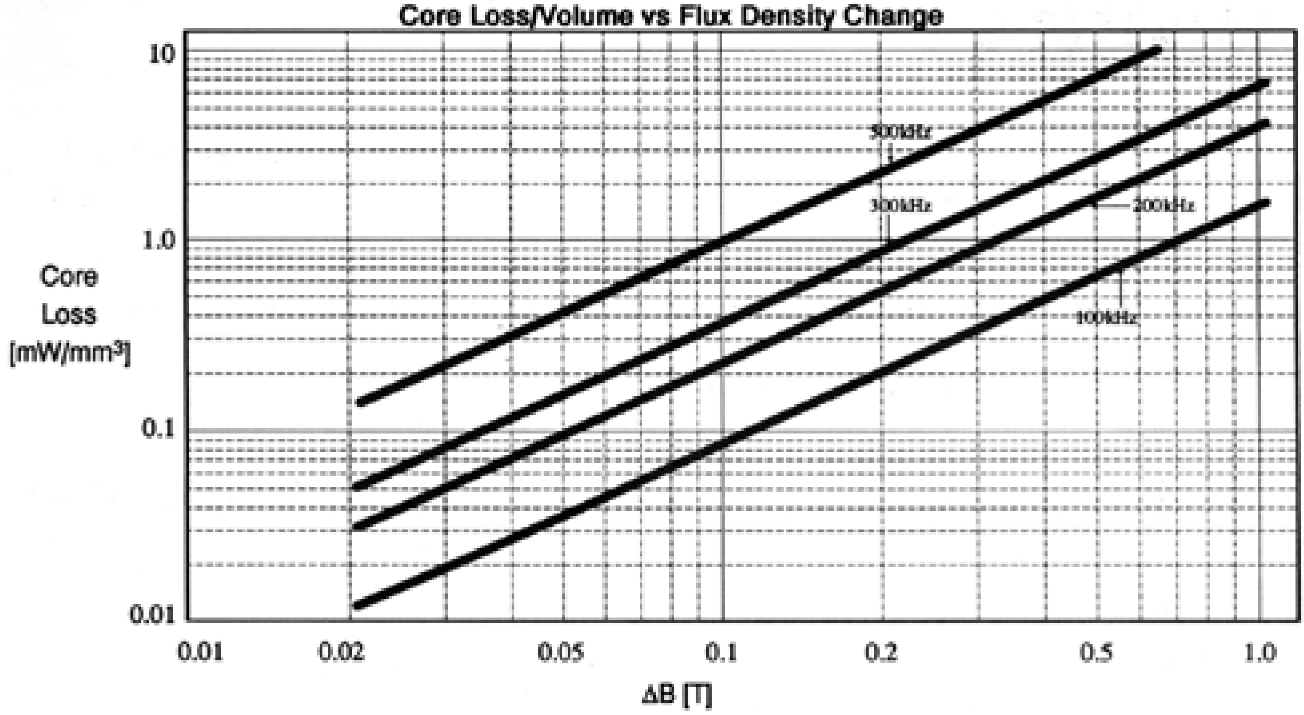
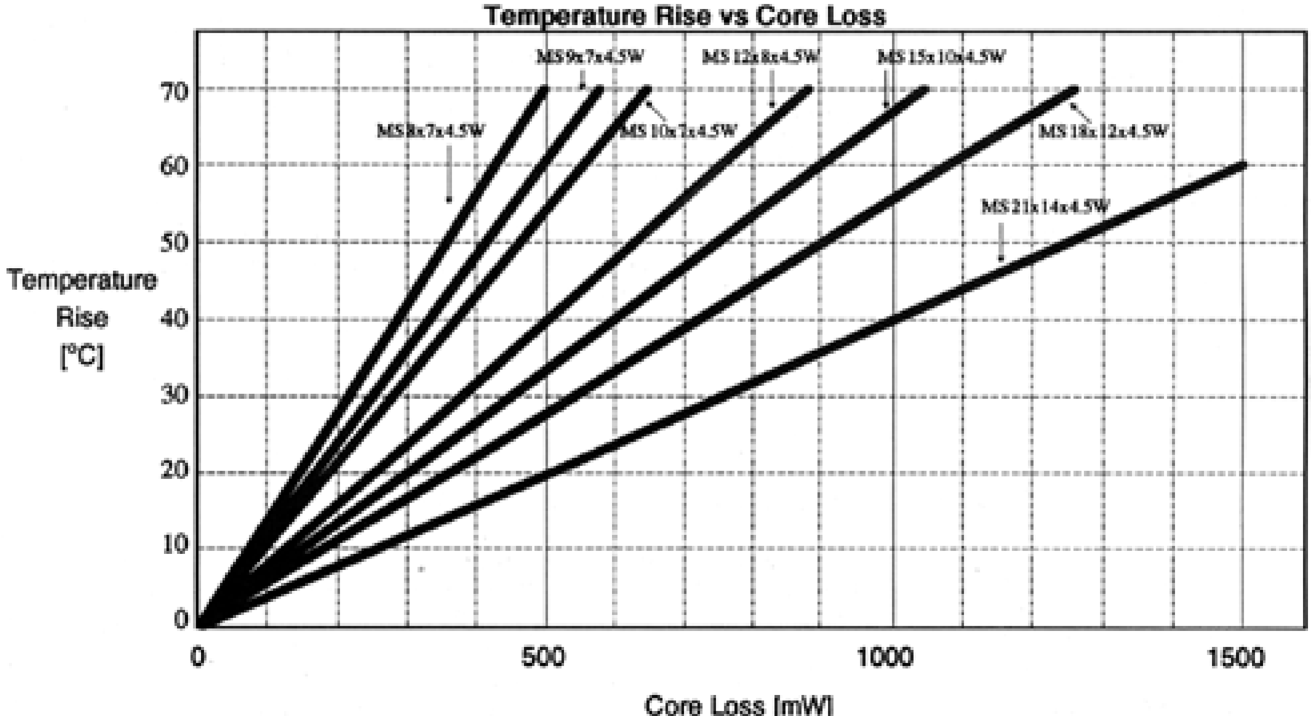


Figure 2

Temperature Rise vs Core Loss



In Touch with Tomorrow

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