Abstract:

Low loss MnZn ferrites which have been developed until now for transformer cores in switching power supplies were introduced with future development trends. In addition to the improvement on core loss and saturation-magnetic fux density, the temperature and frequency dependence of the core loss have been particularly improved in new materials, MBT3 and MBF4, respectively. The most suitable material for enhancing the power supply effciency of a commercial forward mode switching power supply was evaluated in comparison with the current materials, MB3 and MB4. The effciency increased in the order of MB3≤MB4<MBT3≤MBF4. Although MBT3 shows the lowest loss under the sinusoidal fux condition, the highest effciency can be obtained as using MBF4, which shows lower harmonic losses derived from the rectangular wave voltage in the actual power supply due to the excellent frequency dependence of the core loss.

but also for new materials suited to each user's design and manufacturing processes. Further development and the No. 1 core loss property among industrial products. This product is used in special power supply applications at several hundred kilohertz and higher, where compact sizes and thin designs are required.

Next, the following will introduce three products which were developed as low loss materials for use in forward mode switching power supplies as substitutes for the general-purpose materials MB3 and MB4. These are a modified MB1H material with improved core loss, MBT3, and MBF4.

2.2 Reduction of Core Loss in MB1H with High Saturation Magnetic Flux Density in High Temperature Range

The saturation magnetic flux density of conventional ternary system MnZn ferrite can be enhanced by increasing the Fe

various materials for the core of the main transformer. Because it was assumed that these were transformers in which the bobbin and winding condition were the same and only the core material was different, the substrate part in which the transformer terminal is inserted was improved, and the specimens were modif ed to receive the terminal from the transformer bobbin by way of an attachment. Power from a commercial 60 Hz, AC100 V power supply was converted to AC200 V by an autotransformer for voltage change and was supplied via an insulation transformer for noise rejection. A wattmeter was connected to the input side, and the electronic load (maximum: 144 W) was connected to the output side. Power supply ef f ciency was measured from the ratio of the input power and load power. Thermocouples were attached to the region of the outside leg of the transformer core at 4 points and the region of the back at 1 point, and the temperature change in the core were measured after operating the device at room temperature in the condition that the power supply section was exposed. The waveforms of the input current and input voltage of the primary winding of the transformer were observed using an oscilloscope in order to conf rm normal operation.

3.2 Results of Packaging of Transformer Cores Using Various Power Supply Materials

Practical shape transformers were prepared using cores of various materials and substituted for the original core (EER-35A shape, unknown material) of a commercial power supply. The power supply characteristics when these specimens were driven at a frequency of 200 kHz are shown in **Table 1**. The transformer core was the same EER-35A shape, and four materials were used, namely, MB3, MB4, MBT3, and MBF4. As the power supply drive condition, the electronic load was set so as to secure an input voltage of AC200 V and output current of DC10–8 ut ε ӟ DT –T T m

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Driving frequency: 122 kHz		MB4 EER35A	MBT3 EER35A	MBF4 EER35A
Input	V_{in} (V)	200	200	200
	I_{in} (A)	0.66	0.6	0.56
	W_{in} (W)			

power supply cover. The results when the test was performed under the same conditions, but with the driving frequency reduced to 122 kHz, are shown in **Table 2**. Power supply efficiency was unchanged from that when the driving frequency was 200 kHz, and was high in the order of MB4<MBT3 ≒ MBF4.

3.3 Correlation of Core Loss Characteristics and Power Supply Packaging Characteristics with Various Materials

As shown up to the previous section, MBF4 was the most favorable core material under the forward mode switching power supply and transformer conditions used in this research, followed by MBT3, which displayed virtually the same level of performance. Considering the fact that the working temperature of transformers is 40–50°C, the highest efficiency is expected from MBT3, which has excellent temperature dependence of core loss characteristics, as shown in Fig. 3. However, MBF4, which displayed the same temperature characteristics as MB4, demonstrated slightly higher efficiency.

In order to examine the cause of this phenomenon, the detailed magnetic properties of MBF4 and MBT3 were investigated systematically and compared. Core loss characteristics were measured at a wide range of temperature, frequency, and magnetic flux density values using a standard ring core of R31 shape (outer diameter: 31 mm, inner diameter: 19 mm, height: 7 mm). **Figure 5** shows the core loss characteristics of MBT3 and MBF4 when the frequency and magnetic flux density were changed. Temperature shows the cases of 100°C and 40°C. At 100°C, the core loss values of the two cores were reversed at approximately 80 kHz when the magnetic flux density was 50 mT and 100 mT, at approximately 100 kHz with 150 mT, and at 120 kHz with 200 mT. In general, MBF4 shows lower loss as the frequency increases. Under the conditions of 100 kHz, 200 mT, the core loss of MBT3 is the lowest, but when the frequency increases above this level, MBF4 displays lower loss. Thus, for practical use, it is necessary to consider a wide range of power supply operating frequency conditions. In the case of 40°C, the frequency at which core loss performance is reversed shifts slightly to the high frequency side and is approximately 200 kHz in the range of 50–200 mT.

Because forward mode switching power supplies are generally driven by the rectangular wave current and rectangular wave voltage of superpositioned triangular waves, the excitation waveform includes many harmonics with respect to the fundamental frequency. If the fundamental frequency is 122 kHz, 366 kHz and 610 kHz harmonics will exist, and if the fundamental frequency is 200 kHz, harmonics of 600 kHz and 1 MHz are superpositioned. If the core loss in these higher frequency ranges is taken into account, it is therefore considered that the total core loss of MBF4 is lower than that of MBT3. Accordingly, it can be estimated that the efficiency of MBF4 is slightly higher than that of MBT3, including transformer cores of forward mode switching power supplies, transformer cores of various materials were substituted and packaged using a commercial power supply, and the relationship of power supply ef f ciency