Heat Removal from Matrix Transformers

Heat removal from matrix transformers is very good, allowing them to be operated at very high flux densities and high currents. The thermal loading is distributed, and the thermal paths are very short. When it is practical to use a "live heat sink", heat can be conducted directly from the secondary windings to the heat sink.

In many matrix transformers, the transformer cores are considered to be part of the secondary circuit. This means that the thermal impedance between the core and the secondary winding can be greatly improved by not having to have thick dielectric isolation between the secondary winding and the core. This concept has been accepted by the safety agencies, and many production matrix transformer modules have agency approval.

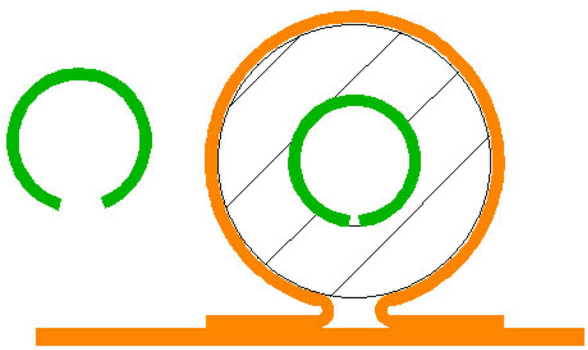

Figure 1: In this cross section of a matrix transformer core the single secondary winding has a slight springiness to maintain good contact with the inside of the core. A metal wrap can be used to conduct heat to a heat sink.

A matrix transformer used in a forward converter, a double forward converter or a current doubler configuration has a single secondary winding. The secondary winding may be made of slightly springy strip, formed to press tightly against the inside of the core when installed. This gives a good thermal contact which can be improved further with a thermal compound or adhesive. The core may need a thin insulating coating, but for low voltage applications the resistivity of the core may be sufficiently high that no coating is necessary.

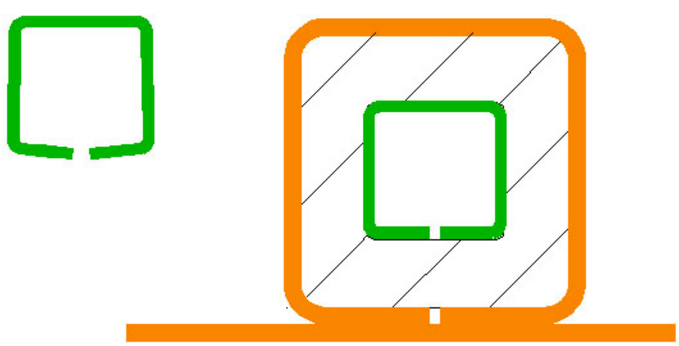

Figure 2: This matrix transformer uses square cores. Heat from the losses in the windings is distributed over the length of the core, and the thermal path through the core is very short.

Figure 3 shows a cross section of a matrix transformer having a push pull secondary winding. As before, the core is considered to be part of the secondary circuit for safety considerations, but the potential difference between the two sides of the winding place a greater stress on the insulation than the voltage gradient with a single secondary winding. The core and/or the winding should be insulated, and a hi-pot test from winding half to winding half is suggested.

The arrangement of the secondary winding in figure 3 provides four conduits for the primary winding, each surrounded by metal. Not only does this make the transformer easier to wind, it also improves the heat sinking of the primary winding and decreases the leakage inductance.

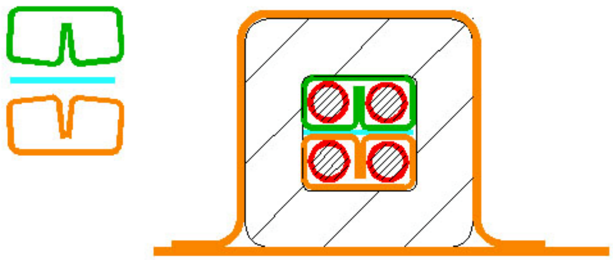

Figure 3: This matrix transformer has one turn push-pull (two turn split) secondary windings separated by an insulator. A two turn (four turn, center-tapped) primary winding is show.

Using a "live heat sink" can greatly improve both the heat flow and the electrical characteristics of the matrix transformer. Consider the push-pull secondary winding shown in figure 4. The connections for the center-tap are at opposite ends of the core, and interconnection through a ground plane is preferred. If this ground plane is also a heat sink, heat is drawn directly from the secondary windings at both ends. Because the windings are designed for good electrical conduction, the thermal conduction is good as well.

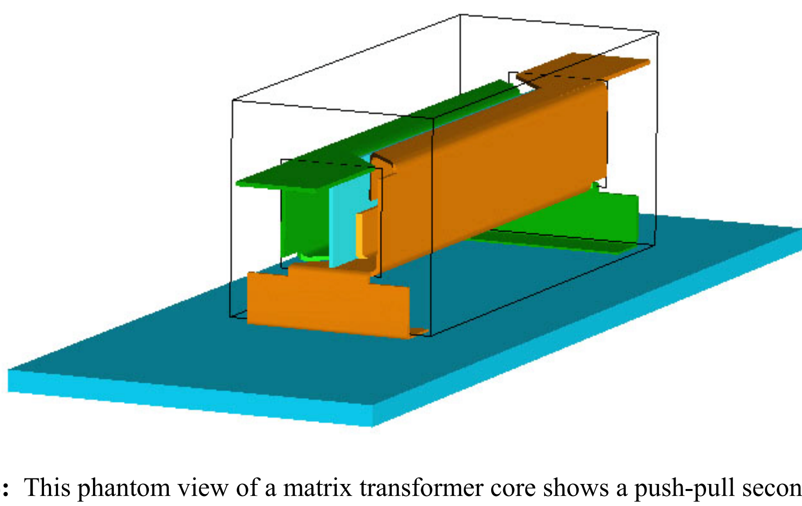

Figure 4: This phantom view of a matrix transformer core shows a push-pull secondary winding in which the center-tap connection is to a ground or power plane that also provides heat sinking (a "live heat sink").

To minimize the leakage inductance, the start and end of the secondary winding should be terminated with very short connections, preferably to immediately adjacent rectifiers. With reference to figure 4, if rectifiers are placed on a top plate with each rectifier being right at one of the secondary leads, then the top plate can be one polarity for the circuit and the bottom plate can be the other polarity. Both plates are optimal conductors of heat and current.

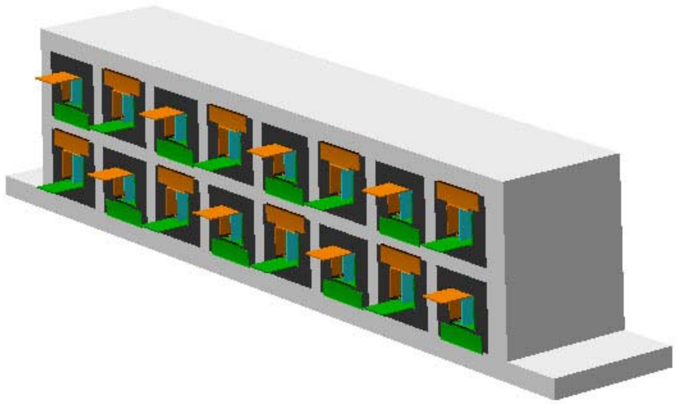

Figure 5: This block matrix transformer uses the push pull secondary winding of figure 4. The center-taps of the windings are soldered to the live heat sink, for very low electrical and thermal impedance. The cores are bonded to the heat sink with a flexible thermal adhesive.

In the block matrix transformer of figure 5, the metal housing is a live heat sink and is the center tap for the secondary windings. Contrasting colors are used to indicate the respective halves of the push pull windings, and they are oriented so that all of the "start" terminations and all of the "end" terminations are in respective rows, for easy interconnection. The common "center-taps" are soldered to the heat sink, for optimally short electrical and thermal conduction paths.