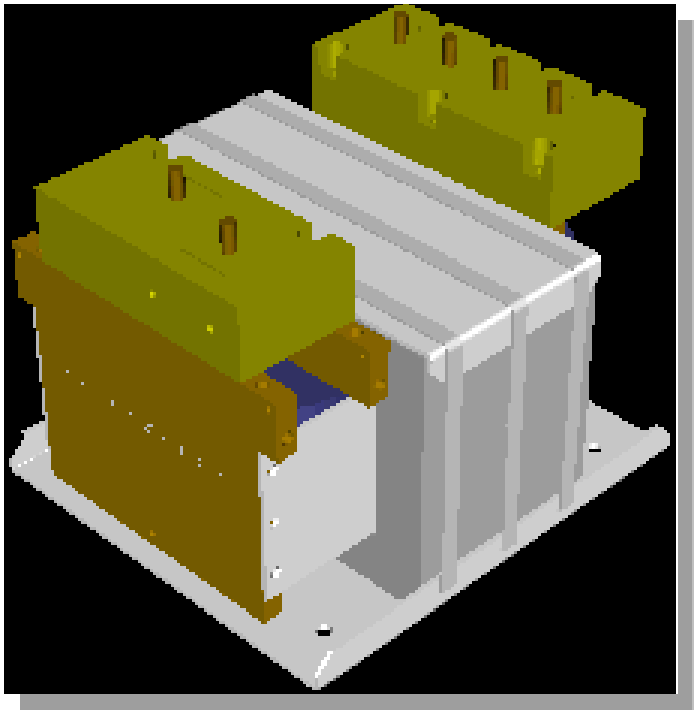
RAF TABTRONICS
Technology to the global power

CASE STUDY

Unique 75kW Water-Cooled Custom Auto Transformer, Delivered in 27 Days

Abstract:

RAF Tabtronics was challenged to deliver a unique custom transformer in less than 6 weeks for a specialized power application.



Challenge – Deliver a unique custom transformer requiring design engineering, water-cooling, custom core and bracket fabrication, and vacuum-pressure encapsulation.

Results – The transformer was delivered 27 business days after receipt of the order and all parameters were acceptable.

The Challenge

Deliver a unique high power, high voltage, high current, high frequency custom transformer requiring design engineering, water-cooling, custom core and bracket fabrication, and vacuum-pressure encapsulation in less than 6 weeks for a specialized power application.

Technical Objectives

Design and produce a 75 kW (kilowatt) transformer to achieve 11 to 1 step up. The transformer must generate 9000 Volts (RMS) @ 8.33 Amps (RMS) from an input of 830 VRMS with a frequency range of 20 kHz to 40 kHz. Additional taps must be provided at 5400 VRMS and 3000 VRMS for other load values.

Specific Hurdles

High Current and High Frequency

- The step up ratio will generate about 90 ARMS conducted through the primary winding. At other tap configurations, primary current will exceed 100 ARMS. Although the referenced frequencies are not high in comparison to the harmonic frequencies of certain filtering or switch mode power applications, the high power rating of 75 kW necessitates careful consideration of eddy current loss effects in the selection of winding conductors.

Low Magnetic Field Leakage versus Low Electric Field Intensity

- The transformer must generate minimal phase shift for satisfactory circuit function. Additionally, leakage magnetic field intensities in multiple layers also contribute to eddy current losses as a result of proximity effects. Low profile interleaved construction can be used to mitigate these leakage field effects.
- However, high intra-winding voltage gradients can result in excessive distributed capacitive energy and insulation degradation from corona effects in poorly designed low profile constructions. For high voltage considerations, high profile, multiple layer constructions are preferred to minimize these electric field effects.

Electric Isolation Versus Thermal Intimacy

- The most efficient means of cooling a conductor is to utilize a pipe that functions as both conductor and heat exchanger. However, this method results in a significant voltage gradient across the terminals of the heat exchanger with potentially large pressure drops at the required coolant flow rates. Furthermore, this approach does not facilitate high degrees of magnetic coupling and thermal intimacy to the high voltage secondary.
- In the multiple layer, high voltage secondary, the section of highest dissipation is expected to be the outer most layers where proximity effects are greatest. At these outer most layers of the high voltage secondary, consideration of electric field intensities will force large insulation barriers to the primary or any other conductor at near ground potential. Therefore, cooling the high voltage multiple layer secondary will not be trivial.

<u>The Solution</u>

- A grounded autotransformer was selected to mitigate inter-winding voltage concerns and maximize performance.
- Sufficient primary inductance was provided to limit exciting current to less than 10% of the reflected load current.
- An interleaved foil primary was used to reduce leakage magnetic field effects. Each separate primary section was cooled by an adjacent machined heat sink positioned at the regions of lowest voltage to minimize insulation barriers. These heat sinks were electrically isolated from the transformer windings and no differential voltage was generated across the heat sink terminals. The interleaved primary sections, in turn, provide adequate cooling for the multiple layer high voltage secondary.
- Machined epoxy glass blocks were used to mount the terminals, which were configured in the form of conductive surfaces with embedded threaded studs. These threaded studs will not carry appreciable current; they function only as fasteners, holding the mating terminals of the external wiring to the appropriate terminal surfaces of the transformer.

- The coil assembly was vacuum - pressure encapsulated to enhance the insulation system and improve heat transfer within the coil to the embedded heat sinks.
- The core assembly was fashioned from multiple machined ferrite blocks and was placed directly on a folded steel bracket to enhance heat transfer from the core to the chassis.
- High precision impedance analyzers combined with resonant test methods were used to verify acceptable power dissipation and insulation integrity prior to delivery of the transformer to the customer.

Customer Success

- The transformer was delivered 27 business days after receipt of the order.
- The customer conducted multiple tests at various input levels and frequency levels for a variety of load configurations. During these tests, the transformer temperature rise was verified using resistance change calculations.
- All parameters were acceptable and the customer validated the RAF Tabtronics First Article Report with the note: "Thanks very much for the excellent design and steadfast support."

Customer Rave

"I want to express our pleasure regarding your efforts in communicating status, and the design aspects of the program which ultimately resulted in a product that met our goals in spite of the compressed time frame."

About RAF Tabtronics LLC

RAF Tabtronics creates advanced electromagnetic technologies and cost-effective customized solutions for the world's leading power technology companies. We produce innovative ultra-high power density and high-efficiency components which provide significant competitive advantage to our customers in defense electronics, homeland security, medical electronics, aerospace, data management, and several diverse high technology sectors.

RAF Tabtronics facilities are certified to AS9100 and ISO9001 quality management systems.

RAF Tabtronics - ***Technology to the global power***.

LEARN MORE
ABOUT US
BY VISITING
OUR WEBSITE
AT
WWW.RAFTABTRONICS.COM

TO CONTACT US
BY PHONE
CALL
888 876 6424

RAF TABTRONICS
Technology to the global power

200 Lexington Avenue
Deland, Florida
32724-2118