

## Temperature Specmanship and Selecting Power Inductors

By Jamie Hopper  
Senior Applications Engineer  
Datatronic Distribution, Inc.

How many datasheets have we, as engineers, reviewed and all of the data we need is there? Well, if your experiences are like mine, very few times if at all. And to compound the problem the data listed that pertains to your project was measured at a temperature not where you are planning to run your board.

Choosing the correct power inductor may seem like an easy task. Choose the inductance needed for your SMPS, verify temp rise on the data sheet and your off. But wait. That part is specified for a temperature rise at 25°C. Your board is going to see an ambient temperature of 75°C. Will the inductor you chose work?

Inductors are fairly simply constructed devices. You have core material and wire. Each material is affected by temperature and each of their properties change as temperature increases. So how will knowing temperature effects on core materials and wire affect how you choose an inductor? Simple, you will know what questions to ask your supplier before sampling and releasing the magic smoke in your breadboards!

Power inductor core materials can have varying stabilities over temperature. Curie temperature,  $T_c$  (above  $T_c$ , ferrite materials lose their ferromagnetic properties, thus their ability to function as an inductor), should be one of your main considerations in determining if an inductor will work in your circuit.  $T_c$  can range from as low as 105°C to above 200°C. This means if your circuit is going to run in an ambient temperature of 100°C and the inductor you chose has a  $T_c$  of 105°C there is a good chance of your inductor turning into an expensive piece of wire. Knowing the material used in the magnetic component will aid you in choosing the proper inductor that will maintain its functionality while running at temperature in your circuit.

Wire is the most basic of electronic components. Current goes in, current goes out. How much current comes out is a topic that has been exhausted numerous times, and I'll leave the equations to the search engines if you're so inclined. But the point I want to make is that all wires are not created equal. Take a quick glance at any wire catalog and you'll see that wire has temperature ratings anywhere from 130°C up to 240°C and above.

So why not make all magnetic parts from the high temperature wire? Well it's the same reason we as engineers aren't millionaires...cost savings. In general, the lower the temperature rating of the wire, the cheaper the cost of the material. So, when you choose a 5-cent inductor over a 7-cent inductor your purchasing manager may love you, but your circuit designer is going bald trying to figure out why his boards are burning up.

Ok, so you're now a professional inductor selector. What now? For the sake of argument I selected one inductor sitting on my desk. I then crossed that particular manufacturer's part with as many competitors as I could find. I got 10 different sets of datasheets each describing the same type of inductor 10 different ways. Sure, the inductance, current and dimensions were the same, but the operating temperatures, temperature rise and material ratings were all different (if listed at all).

The first datasheet I picked states an operating temp of +85°C with a max temp rise of 45°C in free air and that all materials are rated for 155°C or higher. Another sheet only states that the operating temperature is -45 to +85°C with a "typical temp rise" of 40°C. This statement is actually found on the majority of my datasheets. I saw several with just operating temperature listed and a couple with no specifications listed at all. My point to all of this is that most datasheets are vague, at best, and this can lead to a lot of confusion in the selection process. Knowing some basic questions to ask your magnetic supplier will aid you greatly in picking the correct inductor the first time.

It's becoming an even more rare condition when power supplies are expected to see ambient temps of 25°C all of the time. As boards are becoming smaller, surrounding air temperatures are ever increasing. Personally, I've seen an increase in customer inquiries about inductor performance at temps other than 25°C. Today, 75-85°C ambient temperatures are becoming much more common. With performance specifications being listed on datasheets as 40°C temp rise at room temp, is the final temperature of the inductor simply *ambient temp + temp rise*? No. Obviously, the current carrying ability of the inductor will go down as temperatures increase. The wire alone will increase in resistance as temperatures increase, and thus the temp rise of the inductor with 10 amps will be higher at 75°C than at 25°C.

In many cases this one point alone will cause failures in power inductors. The typical 40°C temp rise may now be 55°C or higher (depending on higher ambient temps and conditions) and in turn this will push the operating temperature of the inductor to 130°C (ambient 75°C + temp rise 55°C). And as stated earlier, some wire is only rated at 130°C and some core materials are rated even lower than that. So there are some inductors that would not meet this particular application's needs, even though all of the values seemed good on the datasheet.

Some other commonly listed values on datasheets for power inductors are currents and DCR. MAX rated current typically refers to the current at which the specified temp rise occurs. Again, this value is most likely based on room temperature and the MAX current would be expected to be lower as ambient temperatures increase. On the flip side, DCR will, of course, go up as temperature increases. Always allow enough room for DCR fluctuations in your designs where exact operating temperatures are not known.

On a more positive note most power inductors can be run well above the listed MAX current. If the standard 40-45°C temp rise is not as important to you as other requirements (size, cost etc.) be sure to include the possibility of a smaller inductor and

pushing it harder than is listed on the datasheet. Any manufacturer should be able to run a simple test to measure temp rise at any potential current level you may wish to run.

So keep in mind when reading datasheets for power inductors that the listed values may not be valid for your particular application. If you know the final operating temperature of your board then you can make sure the inductor that you choose will be made with a core and wire that can handle the heat as well as the current applied. If these few points can be addressed with no problems, then your selected power inductor should serve you well (or at least it won't be the cause of your board's meltdown).