Tim Williams

Seven Transistor Labs

November 10, 2013

Proposal:

High Frequency Induction Heater

Prepared for: General Interest

1 Summary

A high frequency induction heater, suitable for general purpose heating, soldering, brazing, staking, heat treating, powder metallurgy, metal melting and more. The pilot model is low power, up to 1 kW, powered by a household outlet (120 V or 240 V), enough to perform small jobs comparable to a handheld torch. With a smaller profile than any unit available today, induction heating can be brought to industries never before served. If well received, the design can be scaled up to 10 kW and beyond with relative ease.

Contents

2 Introduction

Small induction heaters are commercially available, but few operate at really high frequencies. This is a shame, because high frequencies use smaller components. Because this machine can be made smaller than ever, induction heating can be brought to previously inaccessible applications—for example, plumbing often involves using a torch in a tight area, surrounded by flammable construction materials. Induction heats only the pipe, eliminating the fire hazard. What's more, it's powered electrically, eliminating the cost and hassle of fuel gasses.

The technical design goals of this induction heater are:

1. High operating frequency: over 500 kHz—previously only used by radio transmitters
2. Low power model: 1 kW, comparable to a handheld propane torch or a microwave oven; future designs will develop 10 kW or more, enough to melt right through a bolt in seconds
3. Industry's smallest in-class packaging, yielding the most flexible and handy induction heater ever

2.1 What is Induction?

I push the button and it makes stuff glow! Induction heating is the process of using magnetic fields to push energy into metals (or other conductive materials) without requiring direct contact.

Although induction heating and conventional methods (flame or electric) share many uses in common (they can all *make stuff glow*), induction heating has a few unique features which set it apart: 1. Whereas conventional heating methods only apply heat to the surface (heat has to soak into the work to heat it fully), induction can actually deposit more heat inside the material than at the surface! 2. A torch is limited by how hot the gasses burn, but induction is almost unlimited: 10 kW is enough

to melt a U.S. Quarter within seconds, and as long as the power supply is compatible with that coil, it will deliver full power into the load, no matter what size. (Very small coils are difficult to build and use, so the heat may not be as intense as an oxyfuel torch, let alone something like a plasma torch. But heat can also be applied evenly over very large areas, something a simple torch cannot do.)

Where is it used? Induction heating and conventional (flame or electric) heating methods overlap widely, and each has their own advantages. Induction is most important for its consistency, reliability, speed, and in critical applications, its operation under inert atmosphere or total vacuum (necessary for extreme reliability parts). Outside of special purposes, however, the choice of induction heating traditionally comes down to heating millions of identical parts, since a production line environment is required to justify the cost of very expensive industrial machines and their single-purpose heating coils.

2.2 What is Frequency?

Frequency is how fast the magnetic field changes over time, and this controls the penetration depth—how far below the surface the heat will go. At very high frequencies, induction heating resembles traditional heating methods: heat is deposited in the surface, and soaks into the part over time. At frequencies tailored to a part's shape, the entire part can be heated almost simultaneously, minimizing soak time. Frequency selection is an important consideration in traditional induction heating applications.

Applications in the low-power range (under 10 kW) rarely operate at frequencies below 10 kHz. There are two reasons for this: 1. the material being heated normally isn't very big, so full heating is achieved at moderate frequencies, and 2. low frequency power supplies get bulky and expensive, as the power-handling components have to be made larger to operate to low frequencies.

Frequencies up to 400 kHz are common for case hardening applica-

tions, where only the outer surface of a much thicker workpiece is heated. Higher frequencies are not demanded by heat treaters because extremely thin case hardening is not desired (or is more easily achieved chemically), and because manufacturers are hesitant to supply products operating at such high frequencies due to technical issues. (By leaving those technical issues unsolved, manufacturers are missing out on the opportunities this proposal is aimed for.)

Now, most power supplies in this size range operate at frequencies just over the audible range, where electrical design is easy, if a bit chunky in size. By pushing frequency into previously unused territory, this proposal also benefits from the ability to heat very small parts, and the use of very small coils (which are difficult to use otherwise). Some applications include: fine wire, foil, powder metallurgy, precious metals, and more. With a truly "hand-held" torch accessory now possible, induction heating can be brought into markets traditionally dominated by gas torches, like soldering, plumbing and HVAC pipe sweating, brazing and jewelry manufacture.

3 Specifications

With all that said, here's a nuts-and-bolts listing of the proposed features for this power supply. These are preliminary and subject to change. If you have any questions or ideas, something you'd like to see, please contact us!

- Power Input: 120/240 V (selectable or universal input)
- Frequency Range: 500 kHz to 2 MHz
- Tuning: Q selector only (no frequency band control on the basic model)
- Load Inductance Range: 0.03 μH to 0.5 μH
- Load Q Range: 5 to 30
- Maximum Capacity: 1 kW (real power), 30 kVA (apparent power)

- Maximum Coil Output: 107 V, 280 A (lowest inductance) to 216 V, 139 A (highest inductance)
- Cooling water: 0.5 GPM (1.9 LPM). Can be supplied by attached 'chiller' unit.

Controls:

- Adjustable power output; voltage and current control available
- Momentary start/stop buttons
- Indicator lights showing status (including which type of fault occured, if any)
- Analog or digital meters, or a display, indicating operating conditions (output power, voltage, current, load Q, etc.)
- Selectable between front panel controls, work head controls and external 0-5 V control voltage inputs
- Programmable digital timer for semi-automated operation
- Basic accuracy: worst case 5% error

Automatic protection features: current overload detection, short circuit detection, thermal protection, etc.

4 Terms and Conditions