AN2384
Application note

How to size the resonant tank of the Induction Cooking Evaluation Board

1 Introduction

Generally speaking, the resonant circuit of a resonant converter consists of a capacitor, an inductor, and resistance. Two types of resonant converters are generally used: a series resonant circuit and a parallel resonant circuit.

The Induction Cooking evaluation board has been provided with a series resonant circuit. The component L is the cooking element itself.

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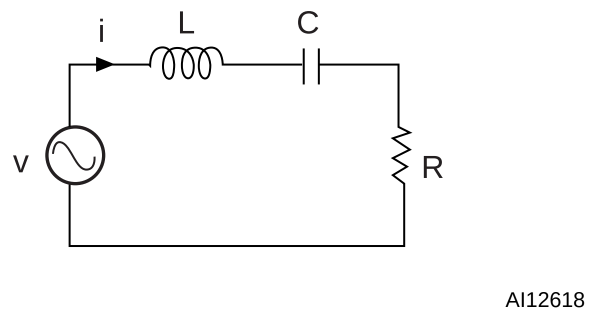
2 The resonant converter

Figure 1. The series resonant circuit



Formula 1

$$X_L = j\omega L = j2\pi fL\ [\Omega]$$

Formula 2

$$X_c = \frac{1}{j\omega C} = \frac{1}{j2\pi fC}[\Omega]$$

Formula 3

$$|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}[\Omega]$$

At the resonance frequency, the inductive reactance X_L of *Formula 1* and the capacitive reactance X_C of *Formula 2* become the same. The current in the circuit reaches its peak when the switching frequency becomes identical to the resonance frequency. In the case of the Induction Cooking evaluation board, the switching frequency is set by MCU, and the signal sent directly to the IGBT driver.

The resonance frequency can be calculated as shown in the following formula:

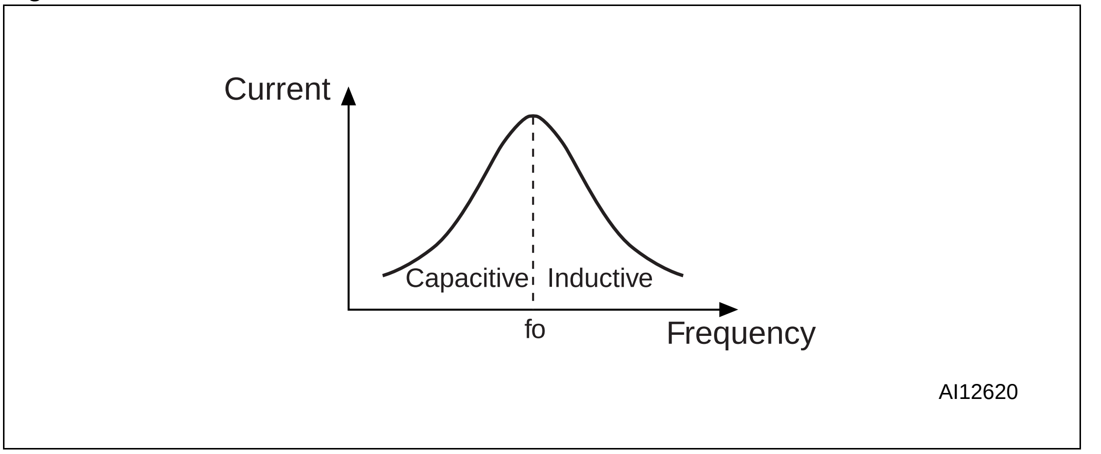
Formula 4

$$2\pi fL = \frac{1}{2\pi fC} \Rightarrow f_0 = \frac{1}{2\pi\sqrt{LC}}[Hz]$$

There are two areas around the resonant frequency: the area where the switching frequency is lower than the resonant frequency and the area where the switching frequency is higher than the resonant frequency. In an Induction Cooking application, the system works always on the right side of the curve, therefore in the inductive area (*Figure 2*).

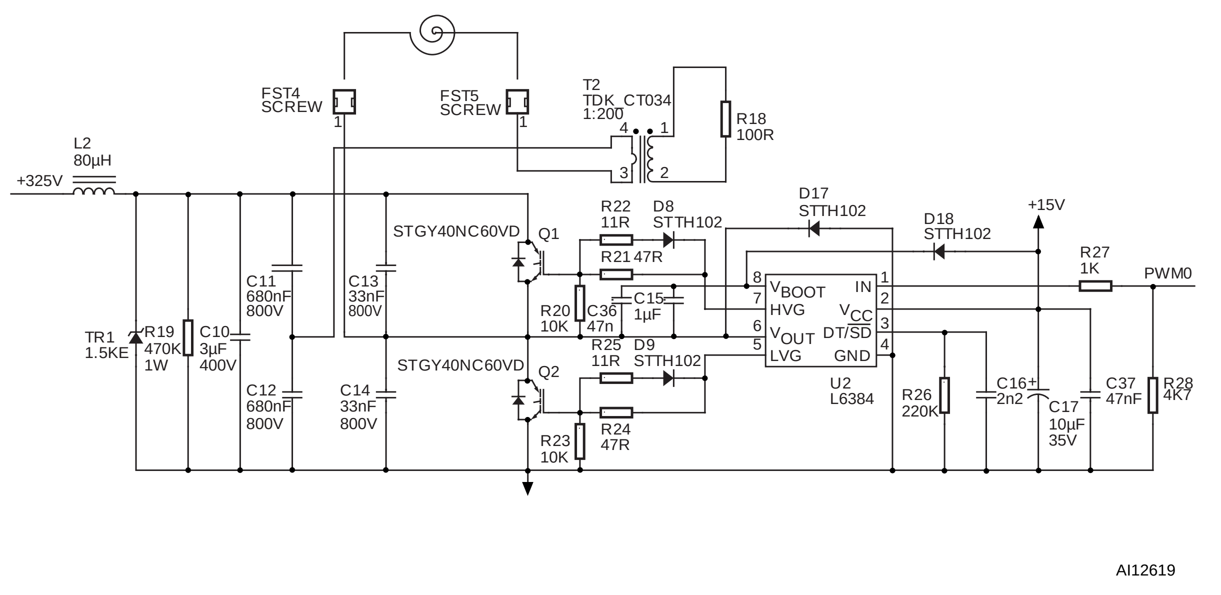
The value of the capacitive reactance becomes smaller according to *Formula 2*. In this situation, a higher switching frequency is followed by an increase in impedance (*Formula 3*), causing the output energy to be lower (as shown in *Figure 2*).

Figure 2. The resonant curve



3 The half bridge driver configuration

Figure 3. The power stage



Note: *D17 and D18 are not installed.*
C16, R26 must be as close as possible to the driver.

The DC link voltage is applied directly to the IGBTs. 220 VAC coming from MAINS are rectified by a diode bridge (not present in the *Figure 3*) and leveled by capacitor C10.

Note that this capacitor is too small in capacity to level the voltage properly. In any case, the Induction Cooking board does not require a bigger capacitor to get the voltage more level. In fact, the primary purpose of the system is to generate heat. Moreover, the rugged shape of the DC link voltage improves the system power factor, which is around 0,98. Capacitor C10 is used as a filter, preventing the high frequency current from flowing toward and entering the input circuitry.

The DC link voltage is applied to the load through the IGBT half bridge at high switching frequency. The high frequency harmonics contained in the signal are eliminated by the resonant tank. The circuitry creates a magnetic field around the resonant inductor, affecting the load (pot on the plate).

Capacitors C13 and C14 are placed in parallel to the IGBTs. They act as lossless turn off snubbers keeping the switching losses to a minimum.

The resonant capacitor has been divided in two identical capacitors, C11 and C12 (C11 = C12). In this way, the amount of current flowing through each capacitor is reduced by half, while the voltage across the capacitor remains the same.

A current transformer T2 has been placed in series with the cooking element (shown in *Figure 3* as FST4 and FST5). This does not affect the resonant tank, and provides the MCU with the feedback information needed to control the system.

The gate pulses necessary for the IGBTs are sent and controlled by the half bridge driver U2. The MCU provides the driver with the proper PWM signal, with 50% constant duty-cycle. The operating frequency is in a range between 19 and 60 kHz.

4 References and related materials

For further information strictly related to the basic functionality of each integrated circuit, please refer to the following documentations:

1. ST7LITE datasheet
2. L6384 datasheet
3. STGY40NC60VD datasheet.

5 Revision history

Table 1. Document revision history

Date	Revision	Changes
05-Sep-2006	1	Initial release.