AN2383
Application note

A single plate induction cooker with the ST7FLITE09Y0

Introduction

This application note describes an induction cooking design which can be used to evaluate ST components or to get started quickly with your own induction cooking development project.

Induction cooking is not a radically new invention; it has been widely used all around the world. With recent improvements in technology and the consequent reduction of component costs, Induction cooking equipment is now more affordable than ever.

The design provides an opportunity to understand how an induction cooker works and to make an in-depth examination of the various blocks and parts of this type of cooking application such as the driving topology, how the resonant tank works, how the pot gets hot and how to remove it safely from the cooking element.

The design is entirely controlled by a simple ST7FLITE09Y0 8-bit microcontroller, which provides the PWM driving signals, communicates information to the user interface, and drives the fan and relay control to the plate feedback.

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1 Induction heating basics

Put simply, an induction cooking element (what on a gas stove would be called a "burner") is a special kind of transformer. When a good-sized piece of magnetically conducting material such as, for example, a cast-iron frying pan, is placed in the magnetic field created by the cooking element, the field transfers ("induces") energy into the metal. That transferred energy causes the metal - the cooking vessel - to become hot.

By controlling the intensity of the magnetic field, we can control the amount of heat being generated in the cooking vessel and we can change that amount instantaneously.

Induction cooking has several advantages over traditional methods of cooking:

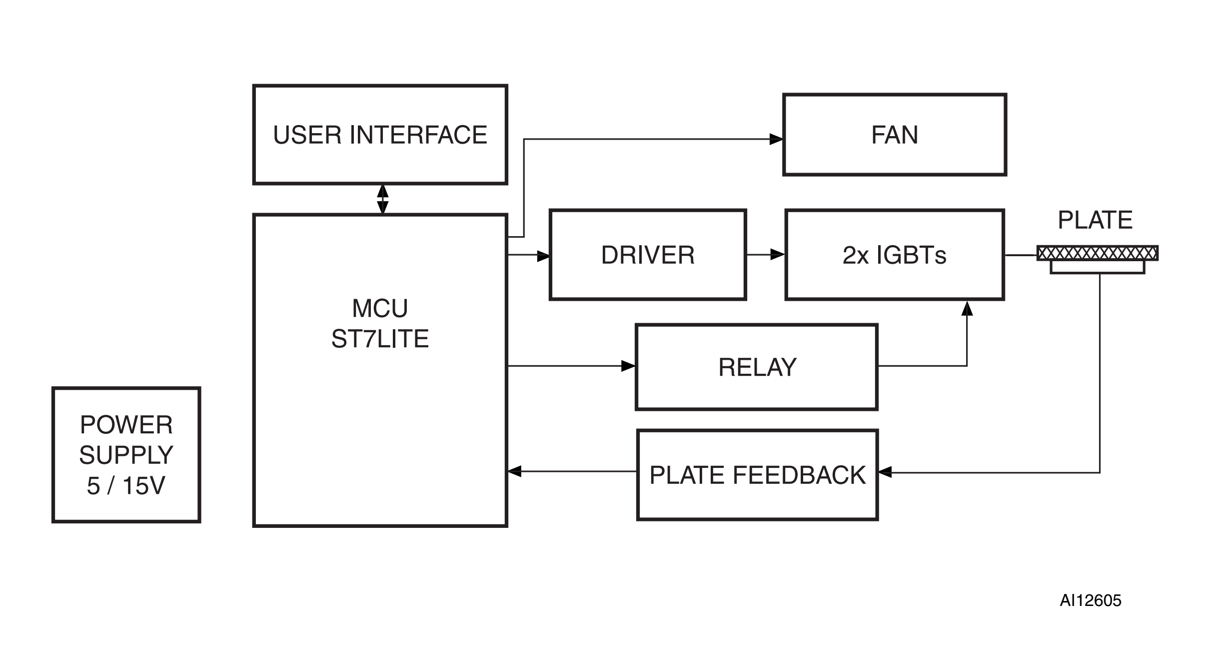
- Speed: conductive heat transfer to the food is very direct because the cookware is heated uniformly and from within. Induction cooking is even faster than gas cooking
- Safety: there are no open flames. This reduces the chances of fire and the cold stove top is also more child safe
- Efficiency: around 90%. Heat is generated directly in the pot, while for electric and gas the efficiency is around 65% and 55% respectively due to heat transfer loss.

Induction cooking functions based on the principle of the series L-C resonant circuit, where the inductance L is the cooking element itself.

By changing the switching frequency of the high voltage half-bridge driver, the alternating current flowing through the cooking element changes its value. The intensity of the magnetic field and therefore the heating energy can be controlled this way.

2 Block diagram

Figure 1. Induction cooking design block diagram



The induction cooking design consists of a small number of simple blocks.

The isolated power supply is obtained directly from the mains, 220 V AC 50 Hz. 15 volts are used to supply the IGBT driver, fan, relay and feedback circuitry, while 5 volts are needed to supply the rest of the ICs, including the MCU.

The ST7FLITE09Y0 microcontroller controls the whole process and communicates with the user interface (buttons and display), drives the fan and the relay, receives feedback from the cooking element (referred to in this document as “plate” for simplicity) and generates the PWM signal to drive the IGBTs.

3 Schematic

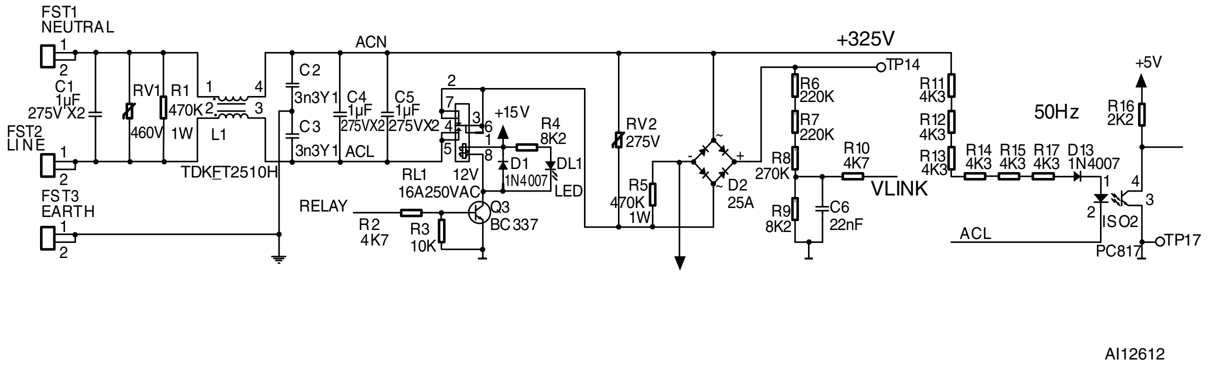
Although the schematic is not very complex, this section presents the different parts as separate topics:

- Mains, DC link and zero voltage switching
- Isolated power supply
- Power stage
- Feedbacks
- MCU pin configuration

The user interface schematic is not presented in this section. It is discussed and analyzed in *Section 8*.

3.1 Mains, DC link voltage and zero voltage switching

Figure 2. Mains and +325 volt DC link



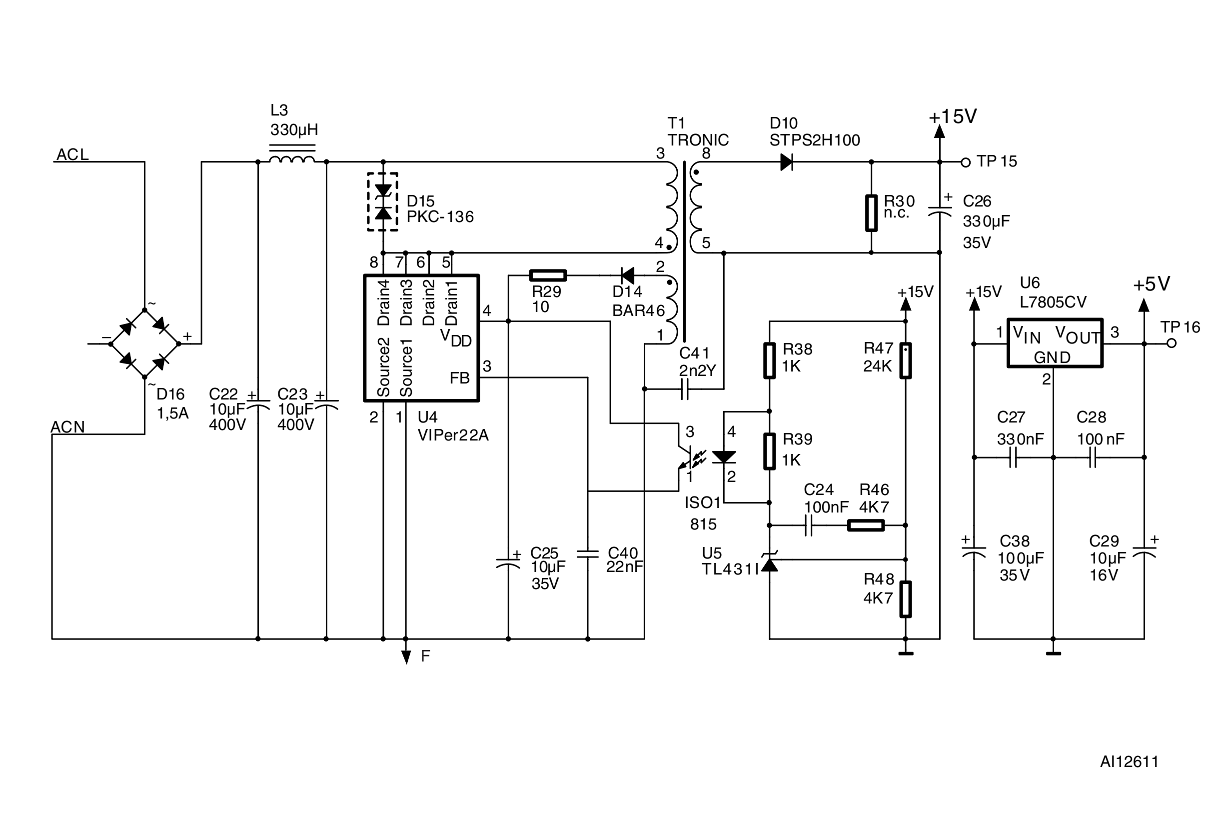
The mains is filtered and is not applied directly to the power diode bridge: for safety reasons, it goes through a relay. This means that the DC link voltage is not applied to the IGBT while the system is off.

The 14 V DC relay is driven by the MCU through a classic NPN transistor. An LED is also present.

When the system is on - and the AC line is applied to the power diode bridge - the IGBTs are supplied with +325 V. The resistive divider sends an image of the DC link voltage to the MCU (label VLINK). The last part of the schematic is an isolated zero voltage switching (ZVS): a square waveform at 50 Hz synchronized with the mains (label 50 Hz).

3.2 Isolated power supply

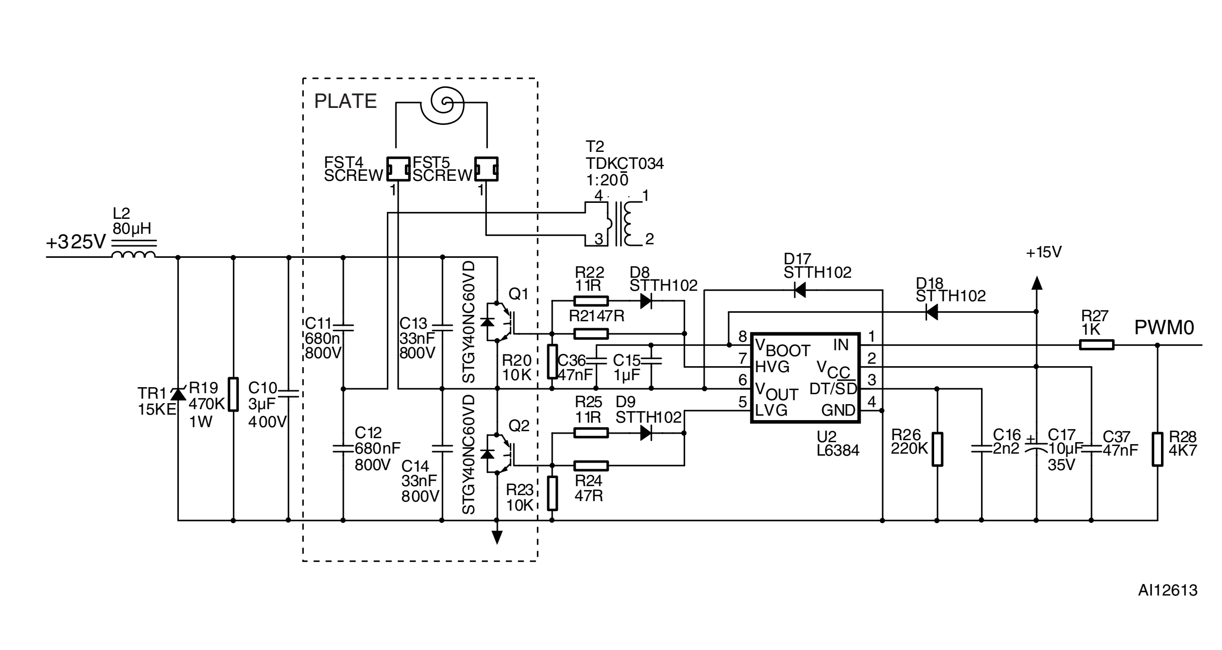
Figure 3. Isolated power supply, 5 and 15 volt



An isolated power supply is connected immediately after the mains filtering, without passing through the safety relay. A VIPer22A and a simple voltage regulator provide 15 and 5 volts respectively. The power supply ground is isolated from the system ground.

3.3 Power stage

Figure 4. L6384 IGBT driver and power stage



The +325 V DC link voltage is applied through a filter to the upper-side IGBT only when the safety relay is closed and the system is on. Components inside the dotted rectangle are the core part of the power stage: the L-C resonant tank is obtained by the plate (represented in the schematic by a spiral) and the capacitors on the left side. The resonant capacitor has been divided in two identical capacitors, so that the amount of current flowing through each capacitor is reduced by half, while the voltage to the capacitors remains the same.

A current transformer has been placed in series with the plate in order to provide plate feedback information to the MCU.

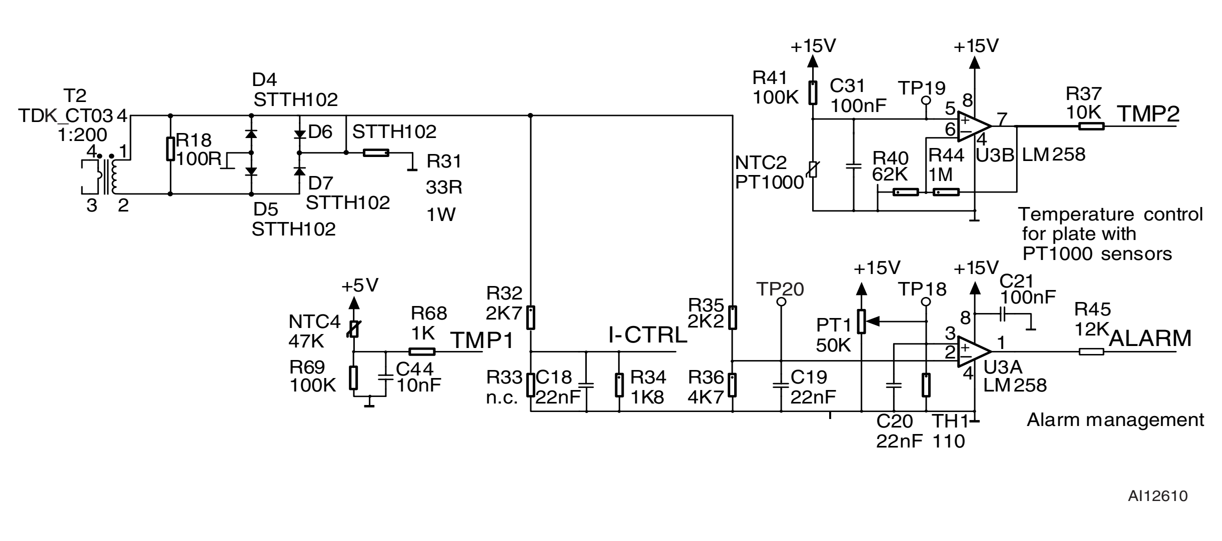
The IGBTs are driven by high frequency complementary square waves with 50% duty cycle.

The PWM0 signal applied to the driver input pin is generated directly by the MCU. The frequency varies in a range between 19 kHz and 60 kHz.

For more information regarding the dead time, charging pump capacitor and driving topology, please refer to the L6384 datasheet.

3.4 Feedbacks

Figure 5. Current peak, current phase and alarm



Feedback signals are output by the current transformer placed in series with the plate, and temperature sensors.

The most important feedback is the current signal (label I-CTRL), which sends the MCU an image of the current flowing through the plate. This signal is used to monitor the current and set it in accordance with the selected working level.

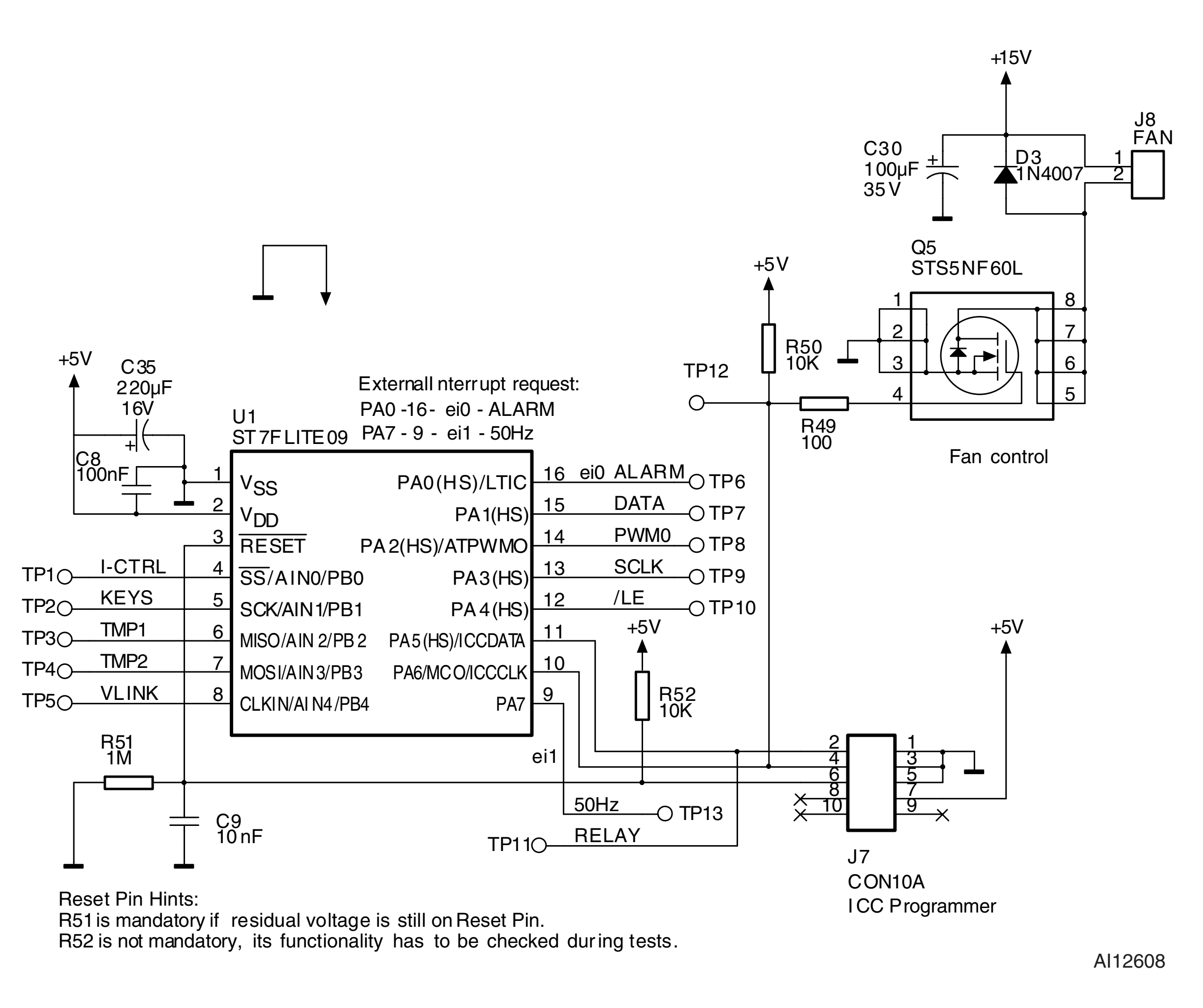
In addition, the signal coming from the current transformer is sent to an operational amplifier. If for any reason the current increases too much, exceeding the alarm threshold set by the potentiometer, the MCU immediately takes action to prevent damage to the power stage.

A NTC has been glued to the heatsink between the IGBTs. The signal is sent to the MCU to monitor the heatsink temperature and drive the fan accordingly. In the same way, a PT1000 is placed in the middle of the plate to monitor the plate temperature. The signal is amplified and sent to the MCU for processing.

Waveforms and a description of how these signals interact with the MCU are given in *Section 5: Measurements at 50 Hz*.

3.5 MCU pin configuration

Figure 6. MCU pin configuration



The ST7FLITE09Y0 microcontroller controls the whole induction cooking system. It can be in-circuit programmed (ICP) via a standard 10-pin connector.

Starting from the left, going clockwise, the first input is the VLINK. It comes from the power diode bridge and is an image of the DC link voltage applied to the upper side IGBT. Read as analog input, this signal is used by the MCU to detect when a pot is placed on the plate or when it has been removed.

TMP1 and TMP2 provide the MCU with the temperature information coming from the heatsink and plate, respectively.

KEYS is an analog input read by the internal A/D converter of the MCU, and is connected to the keyboard in the user interface. The keyboard features 3 buttons. In order to save MCU pins, a smart schematic has been adopted, so that just one input pin is needed to read all the keys.

The I-CTRL feedback is processed as analog input. It is an image of the current flowing through the plate.

ALARM has to be sent to the MCU as fast as possible, therefore this input has been configured as an external interrupt. As soon as an alarm occurs, the MCU immediately starts the alarm management routine so it can rapidly take the necessary actions.

DATA, SCLK and /LE are used to drive the 8-bit constant current LED sink driver present in the user interface board. In this way, the MCU can address a 7-segment display using only 3 pins.

PWM0 generates a PWM signal with a 50% duty cycle. It is sent directly to the IGBT driver. Depending on the working level (and therefore on the power required), the frequency of the square waveform varies in a range between 19 and 60 kHz.

RELAY and FAN drive the safety relay in the mains circuitry and the fan, respectively. The fan is used to cool the heatsink next to the IGBTs and the power diode bridge.

The last pin, 50 Hz, is configured as an external interrupt. It is synchronized with the voltage mains and, every 10 ms, it captures the moment when the AC voltage crosses zero.

4 How the system works

4.1 Standby (system off)

As soon as the induction cooking system is plugged into the mains, the system is running and the MCU goes into standby mode, or put simply, “system off”.

No controls or actions are taken, only the keyboard is scanned to capture a “button pressed” event. The display shows "-".

In this status, putting or removing a pot from the plate has no impact on the system functionality. The safety relay contacts are open, so no DC link voltage is applied to the resonant tank.

4.2 System on

The system is turned on by pressing the on-off button (the first on the left in the user interface).

Each time it is switched on the induction cooking system performs a sequence: safety relay first, then plate power-on. The safety relay contacts close, which applies the DC link voltage to the resonant tank.

At this point, the system temporarily powers-on the plate: a 60 kHz PWM signal is applied to the half-bridge driver for half a second. During this time, if a pot is placed on the plate, or it is there already, the system moves to the lowest operating power level, shown as "1" in the user interface display. If however, no pot is detected on the plate, the system stops the PWM signal. Another power-on sequence is performed after 10 seconds. After 5 unsuccessful power-on sequences, the system goes back to standby mode.

When the PWM signal is applied to the half-bridge driver, the decimal point in the user interface display turns on.

Once a pot is detected, the user can move through 9 working power levels by pressing the buttons on the user interface. 1 is the lowest level, and 9 is the maximum.

4.3 Safety relay and fan management

The safety relay prevents the DC link voltage from being applied to the resonant tank when the system is off. The relay contacts are connected in series with the plate, and they close when the system is turned on. To prevent oscillation or undesired relay commutations, an anti-bounce software routine is implemented. The relay turns off when the system turns off.

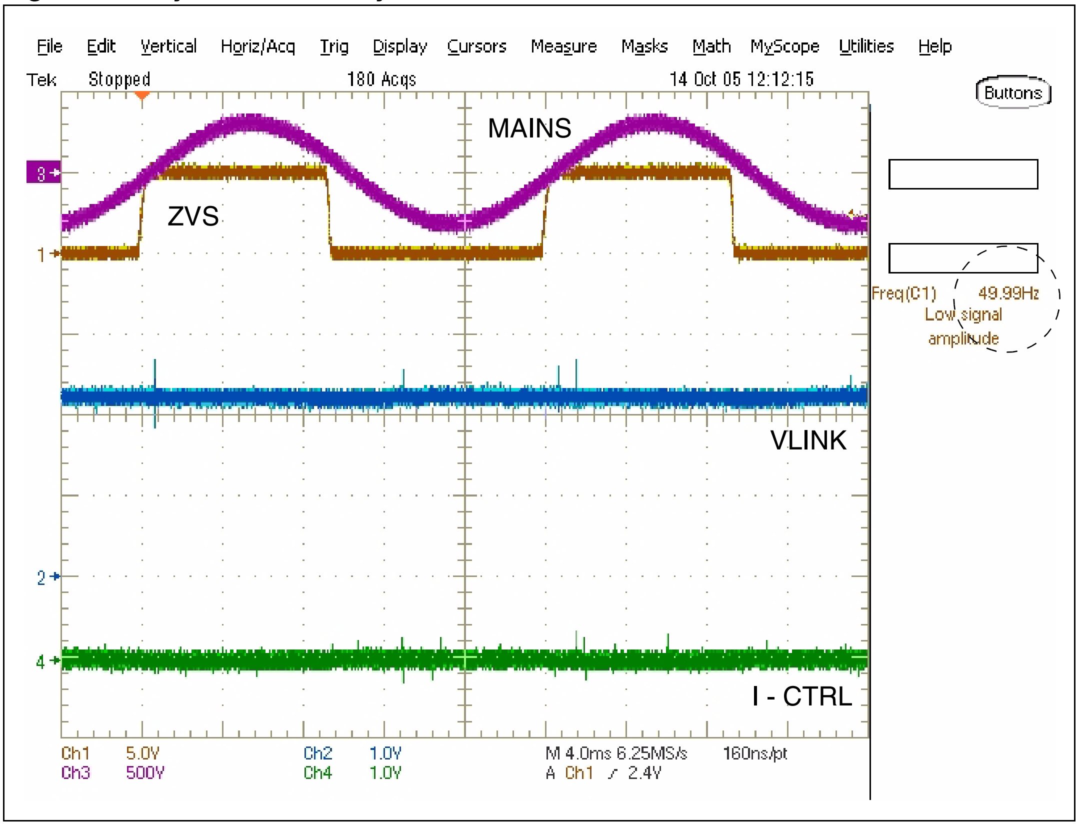
The fan helps the heatsink dissipate the heat while the system is working. It is turned on as soon as the heatsink temperature reaches 55 °C. The fan stays on for at least one minute, whether the system is on or in standby mode.

5 Measurements at 50 Hz

The following oscilloscope waveform readings have been taken during the different operating phases. These signals are synchronized with the voltage mains, therefore running at 50 Hz frequency.

5.1 Standby (system off)

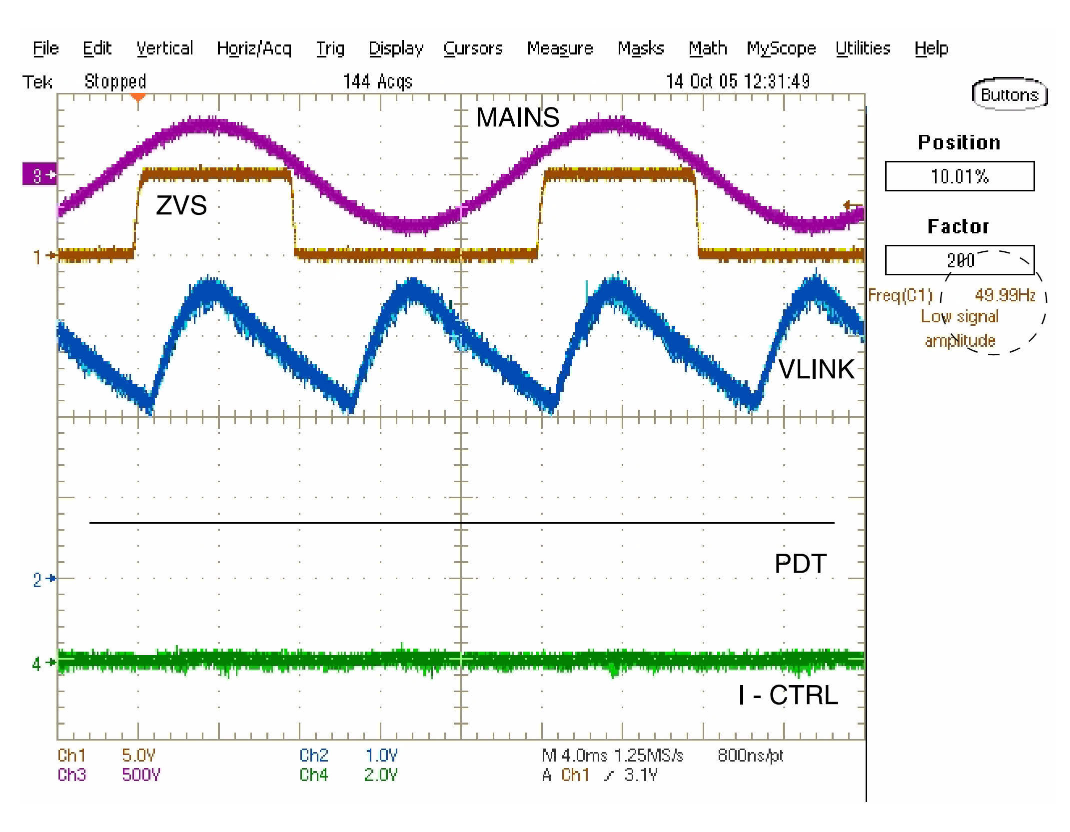
Figure 7. System in standby mode



In standby mode, the zero voltage crossing signal is the only active one. The square wave is sent to the MCU and used to synchronize all the events. VLINK, an image of the DC link voltage (not yet applied to the plate), is constant. No current flows through the plate.

5.2 Powering the plate (without pot)

Figure 8. Plate power-on (without pot on the plate)



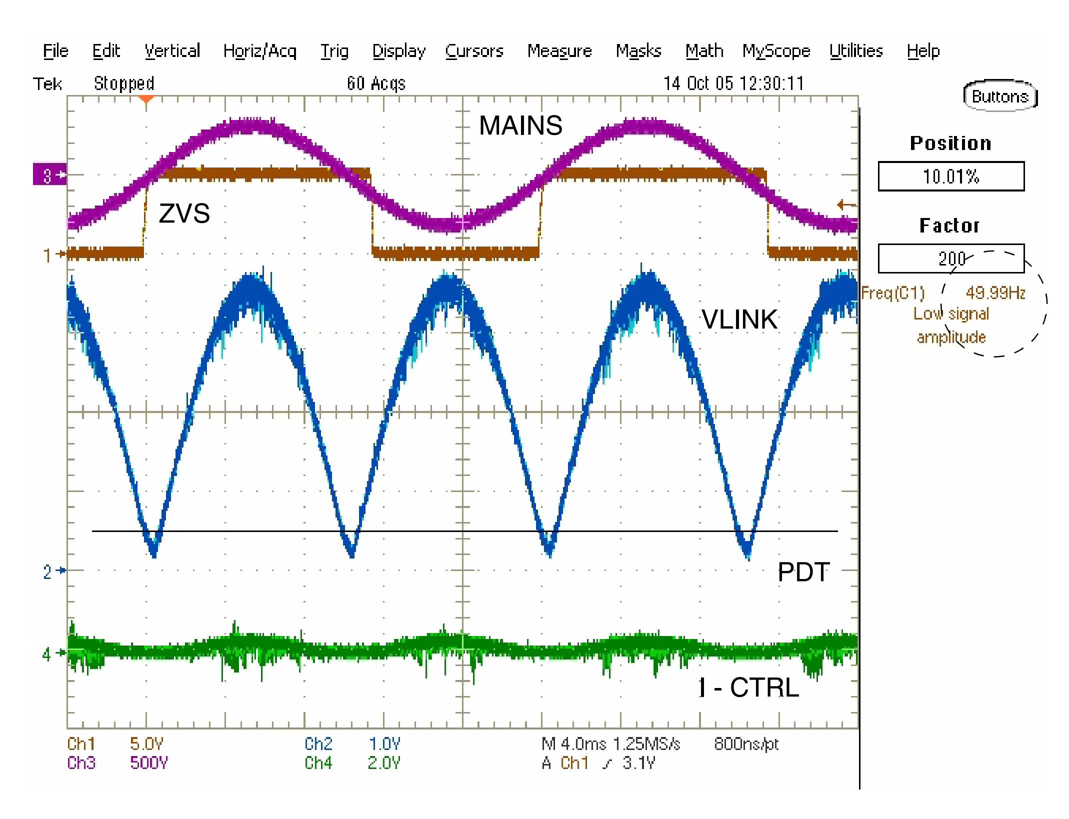
The DC link voltage is applied to the plate and the PWM signal is applied to the half-bridge driver for half a second. Due to the resonant tank consumption, a voltage drop appears on the VLINK signal. The voltage drop is read by the MCU to detect if a pot is present on the plate.

No pot is on the plate, so the voltage drop is not big enough to exceed the pot detection threshold (PDT), set by software at 500 mV. The PWM signal is stopped, and the powering sequence is repeated after a break of 10 seconds.

Powering the plate continuously in order to detect a pot would result in an increase in power consumption. However, no parts would burn or be damaged. The break of 10 seconds between one powering sequence and another reduces power consumption while keeping full functionality and pot control.

5.3 Powering the plate (with pot)

Figure 9. Plate power-on (with pot on the plate)



The DC link voltage is applied to the plate and the PWM signal is applied to the half-bridge driver for half a second. Due to the resonant tank consumption, a voltage drop appears on the VLINK signal. The voltage drop is read by the MCU to detect if a pot is present on the plate.

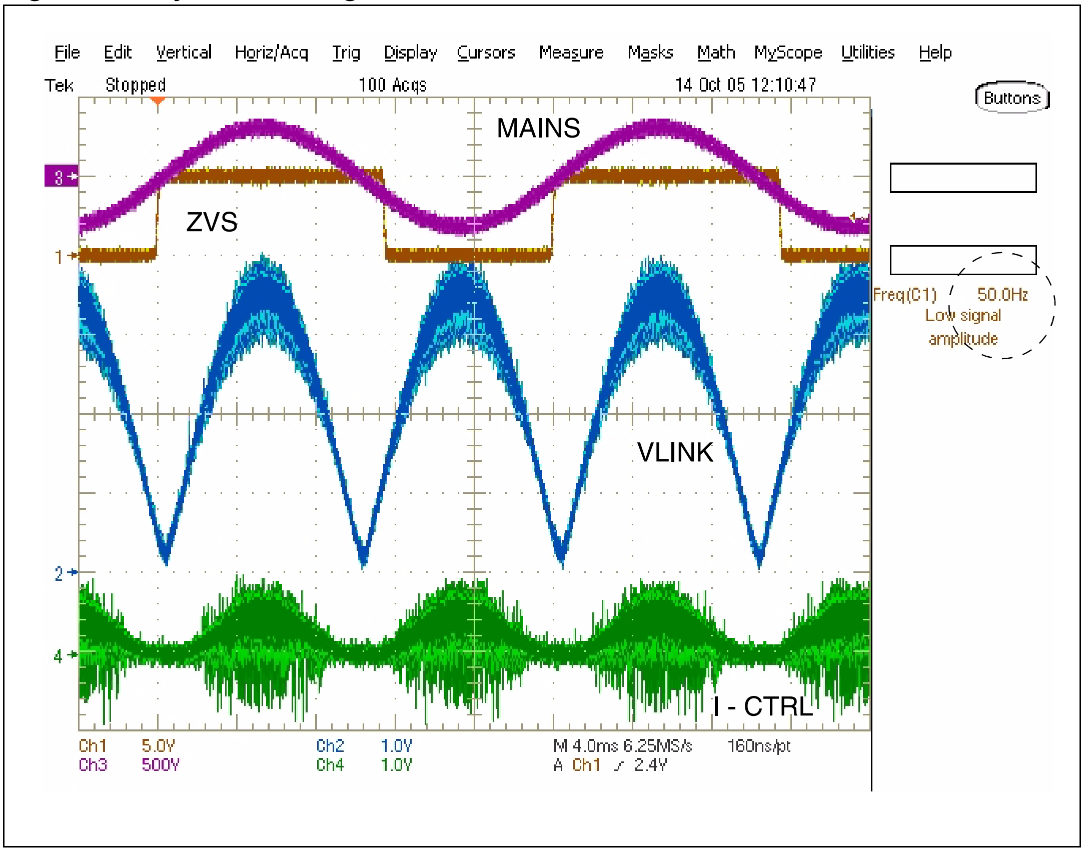
In this case, the pot is on the plate and the voltage drop is high enough to exceed the pot detection threshold (PDT), set by software at 500 mV. A certain current is now flowing through the plate.

The pot is detected, so the system can move to the first working level: level 1.

The waveform shown in *Figure 9* was taken while a 22 cm-diameter iron pot filled with water was placed on the plate.

5.4 Working level 1

Figure 10. System working at level 1



As soon as the pot is detected, the system moves to level 1, the lowest power working level. The PWM signal applied changes accordingly. The lower the working level, the higher the PWM frequency applied to the half-bridge driver, and vice-versa.

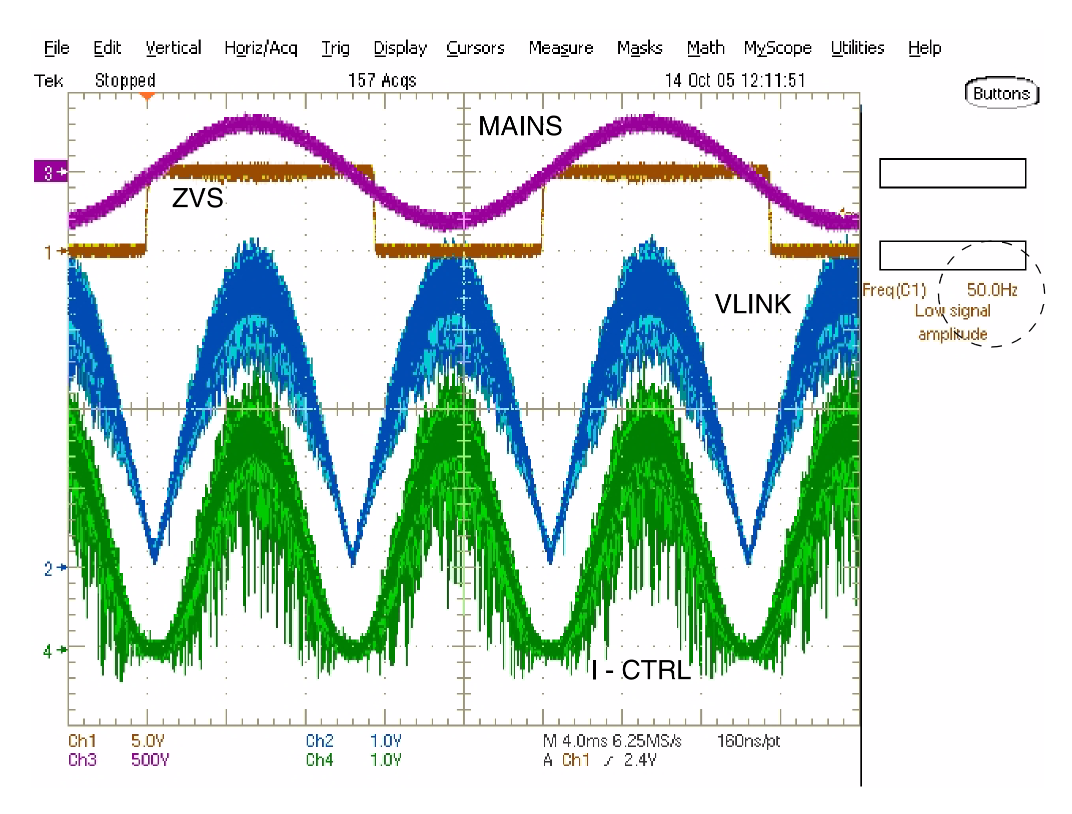
I-CTRL signal is an image of the current flowing through the plate and is sent to the MCU by the current transformer placed in series with the plate.

With the system working properly, there must be a certain current flowing through the plate, as the I-CTRL waveform shows in *Figure 10*. Even if we are talking about current, the waveform unit is expressed in volts and processed by the MCU as a voltage level.

The waveform shown in *Figure 10* was taken while a 22 cm-diameter iron pot filled with water was placed on the plate.

5.5 Working level 9

Figure 11. System working at level 9



At level 9, the system delivers the maximum output power. I-CTRL rises accordingly.

The waveform shown in *Figure 11* was taken while a 22 cm-diameter iron pot filled with water was placed on the plate.

5.6 Real-time current adjustment

As seen, the induction cooking system works on the principle of a series L-C resonant circuit. When the size of L and C are set, the resonant frequency is set as well. Unfortunately, this value does not depend only on the resonant tank. In fact, the size and material of the pot affect the resonant frequency too. This causes the system to have an oscillating resonant frequency strongly dependent on the type of pot placed on the plate at different times.

Therefore the 9 working levels cannot be based on constant frequency levels. The PWM frequency must be adjusted to the selected level in order to work with the pot placed on the plate at that moment.

So each working level does not work on a constant PWM frequency, but a constant current. By reading the I-CTRL feedback signal, the MCU smoothly adjusts the PWM frequency in order to keep the current constant for the selected working level. Each level has a corresponding constant value of current.

5.7 Removing the pot

A pot placed on the plate may be removed at any time, including when the system is working.

As seen before, the voltage drop present in the VLINK signal determines whether a pot is placed on the plate or not. The VLINK signal is captured continuously while system is working.

Lifting the pot up from the plate causes the voltage drop in the VLINK signal to decrease. As soon as the voltage drop rises over the pot detection threshold (PDT), the MCU recognizes that the pot has been removed.

The PWM signal is not stopped at once, but smoothly increased until the 50 kHz frequency is reached, and then stopped. This procedure avoids current spikes on the resonant tank line and prevents the power stage burning or being damaged.

At this point, the system is still on, without a pot on the plate. The MCU powers on the plate 5 times with a break of 10 seconds between one powering sequence and the other. If no pot is placed back on the plate during this time, the system returns to standby mode.

This feature is very useful in cases where the user removes the pot and forgets to turn off the induction cooking system.

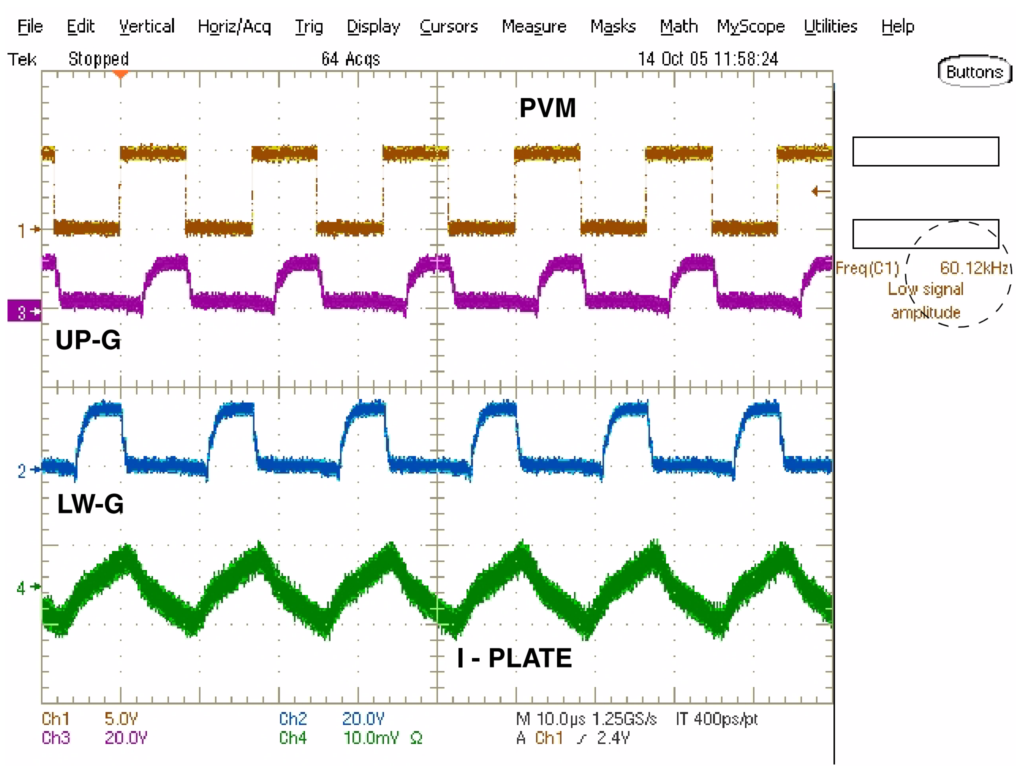
6 Measurements at PWM frequency

The following scope waveforms were taken during the different working phases. These signals are synchronized with the PWM signal, therefore running at PWM signal frequency.

The waveforms shown in *Figure 12* and *Figure 13* were taken while a 22 cm-diameter iron pot filled with water was placed on the plate.

6.1 Powering the plate (with pot)

Figure 12. Plate power-on (with pot on the plate)

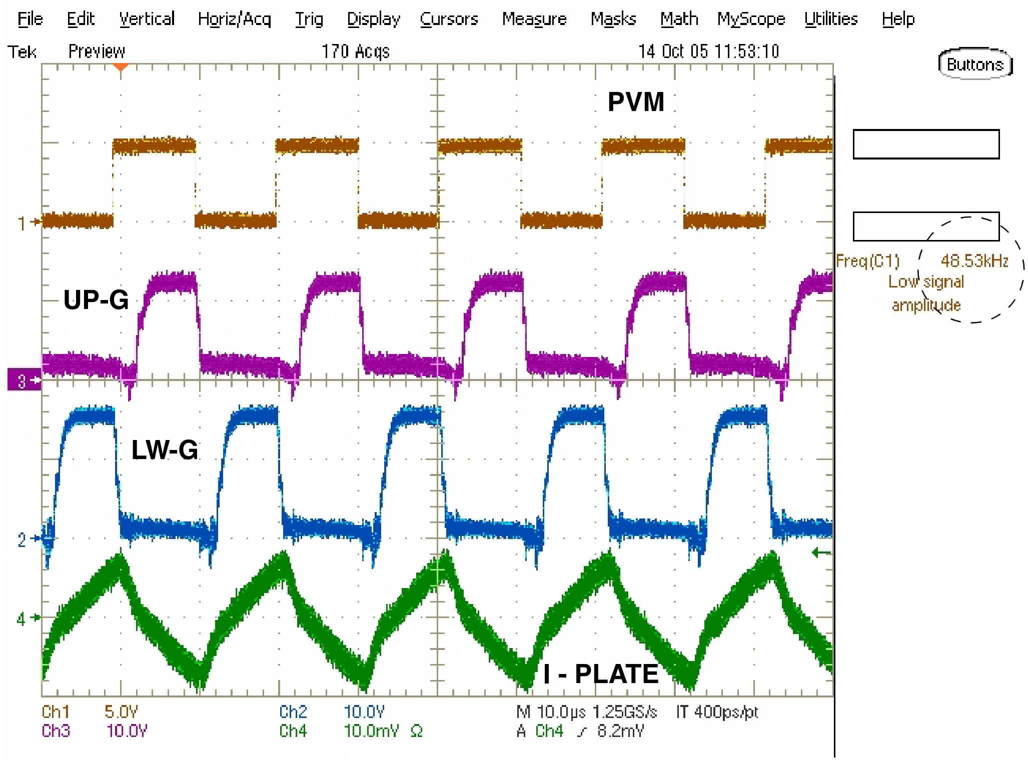


The DC link voltage is applied to the plate and the 60 kHz PWM signal with 50% duty cycle is applied to the half-bridge driver for half a second. UP-G and LW-G are the upper side gate signal and the lower side gate signal, respectively. Of course they must be complementary and there must be a certain dead time between the upper gate pulse and the lower one. The dead time is set by hardware (L6384, resistor on pin 3).

Since the pot is on the plate, a certain current starts to flow through the plate (I-PLATE). The unit in *Figure 12* is expressed in volts, but the current probe connected to the scope is set at 20 amperes per division. This means that at plate power-on the system is already delivering a 20 ampere peak-to-peak current.

6.2 Working level 1

Figure 13. System working at level 1



Level 1 is the first and the lowest power working level. The PWM signal frequency, previously set to 60 kHz, smoothly decreases until the working current for level 1 is reached.

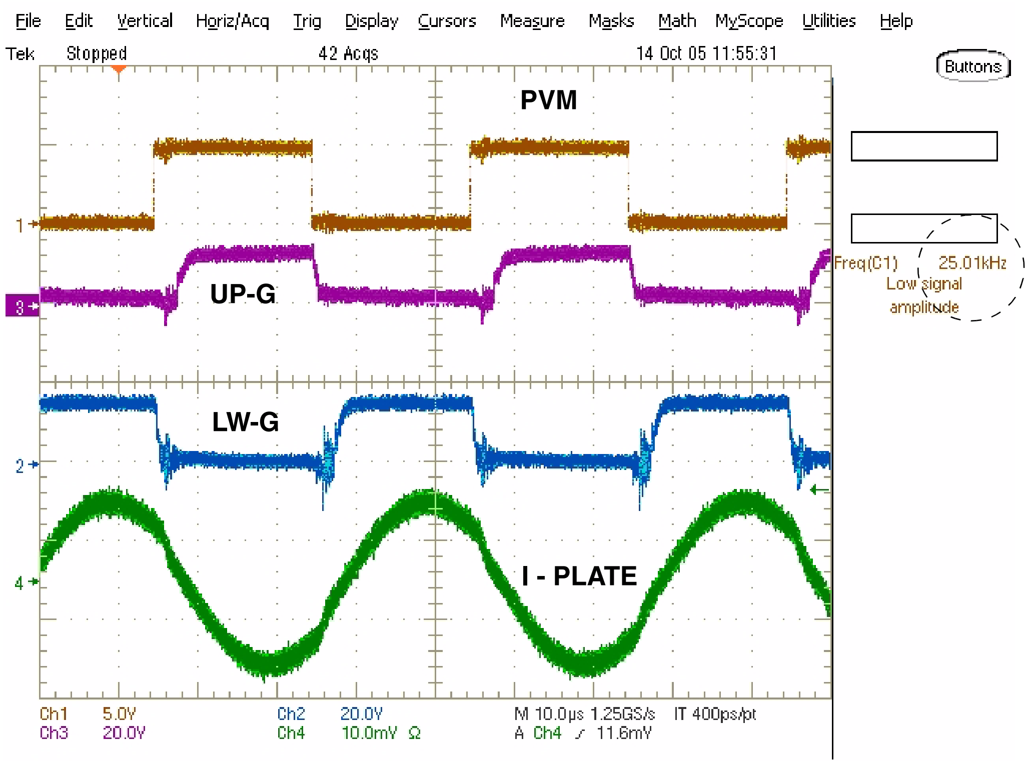
As seen before, the PWM frequency is not constant and is adjusted in real-time to keep the current level constant. Natural changes such as the iron dilatation or the water warming up, slightly modify the resonant frequency and therefore the current delivered.

For the 22 cm-diameter iron pot used for the test, level 1 means a PWM frequency of around 48.5 kHz, but variations of several kilohertz are possible and necessary in order to keep the current level constant.

In this test, level 1 features a 40 ampere peak-to-peak current (I-PLATE, 20 ampere per division).

6.3 Working level 9

Figure 14. System working at level 9

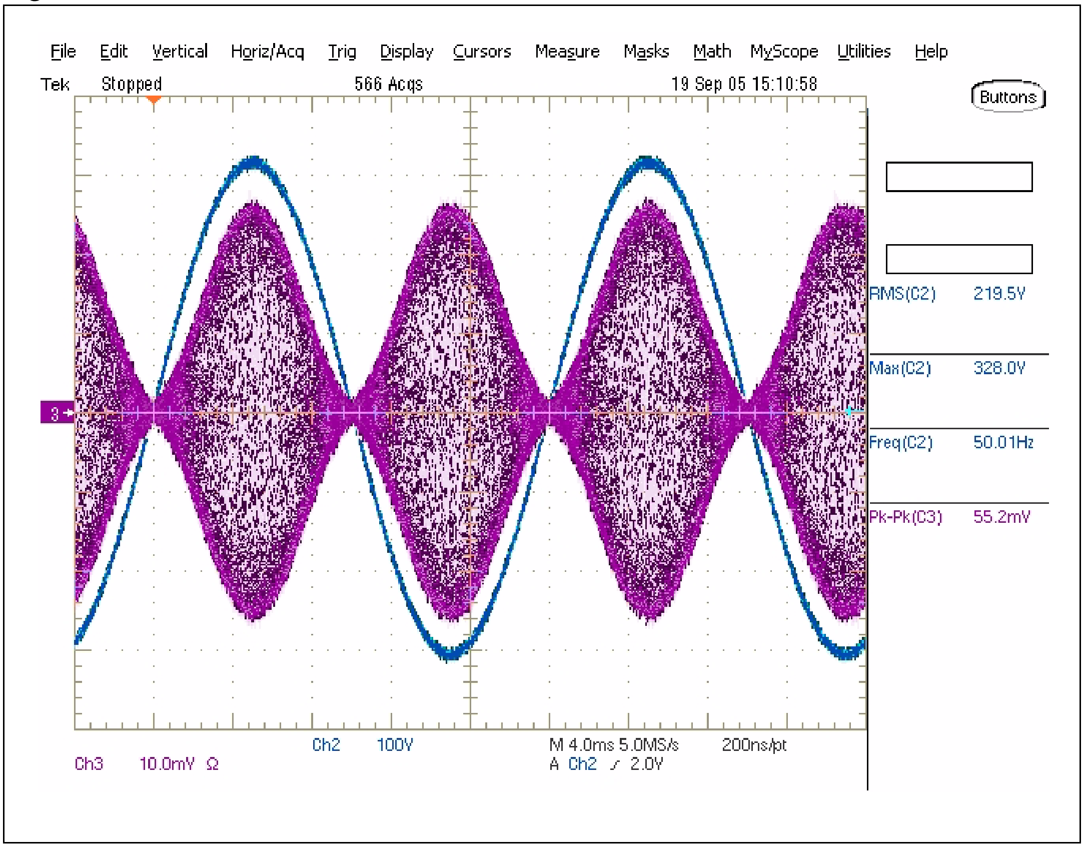


Level 9 is the highest working level, with the system delivering maximum output power. To increase output power, the PWM frequency must be decreased. Moving the working levels up or down corresponds to a smooth increase or decrease of the PWM frequency, until the current level for the selected working level is reached.

For the 22 cm-diameter iron pot used for the tests, level 9 means a PWM frequency of around 25.0 kHz and a corresponding 100 ampere peak-to-peak current (I-PLATE, 50 ampere per division).

6.4 Current waveform at 50 Hz

Figure 15. Current waveform at 50 Hz



In the waveforms in *Section 6.1* through *Section 6.3*, the signals were shown at PWM frequency.

Now, if we keep the system working and increase the scope time scale to observe a 50 Hz frequency, the shape of the current delivered to the plate is different. As shown in *Figure 15*, in phase with the mains, the current peak changes following the 50 Hz frequency, while the current switching frequency runs at the PWM frequency.

The result is a double wave with a 100 ampere peak-to-peak current (20 ampere per division).

With a 22 cm-diameter iron pot on the plate, the system delivers about 2500 watts.

7 Alarm management

The alarm circuitry is necessary for monitoring any possible malfunctions, and to prevent the IGBTs, the driver, or any other circuitry from burning or being damaged.

The application described here features 4 different alarms: overtemperature on the heatsink (H), overtemperature on the plate (t), overcurrent (C) and wrong pot on the plate (P).

An alarm is generated when the heatsink temperature exceeds 115 °C, or when the plate reaches a temperature of 200 °C.

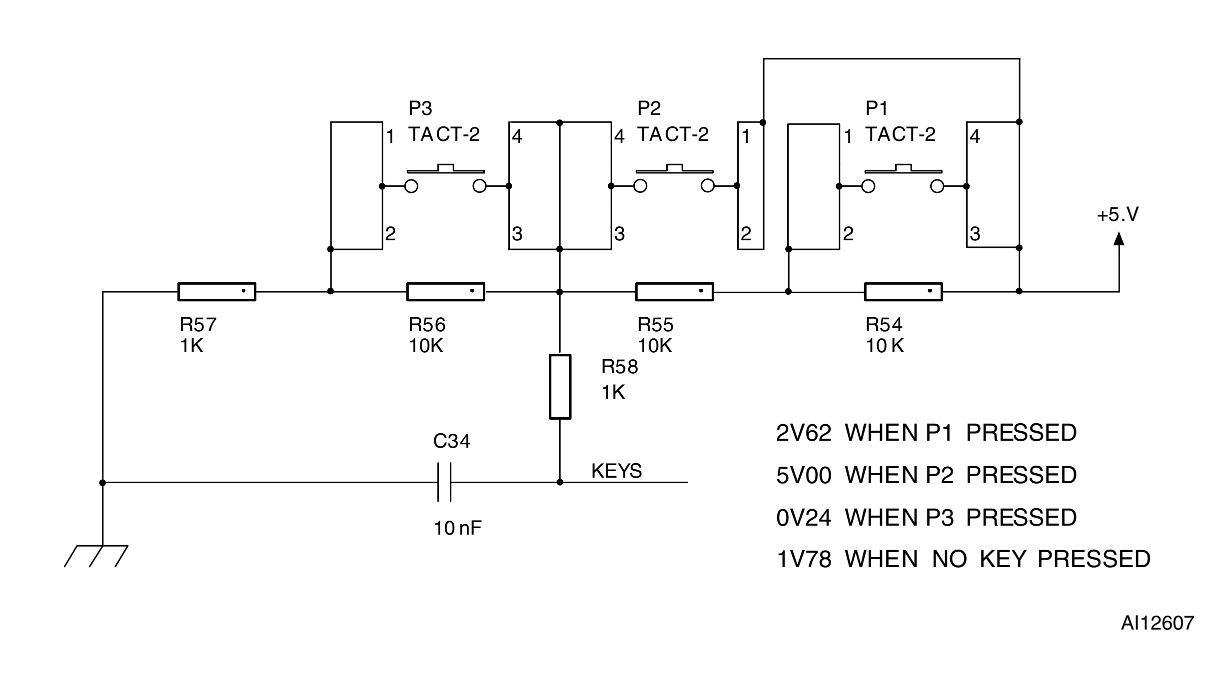
If for any reason the current flowing through the plate goes over the limit, an alarm occurs. Similarly, while in the power-on sequence, if a non-magnetically conducting material is placed on the plate, an alarm occurs. In alarm condition, the PWM frequency is immediately set to 30 kHz, and then smoothly increased to 50 kHz. The system is put in standby mode and the display shows which alarm occurred (refer to the letters in brackets).

8 User interface

The user interface is implemented on a second PCB vertically soldered on the front side of the induction cooking application. It features a 3-button keyboard and a 7-segment display.

8.1 Keyboard schematic

Figure 16. The analog keyboard



The keyboard is designed with the primary intention of saving MCU pins. The KEYS pin is directly connected to the analog input pin of the ST7FLITE09Y0.

The keys are placed in parallel with resistors, which means that every time a key is pressed, it short-circuits its own resistor (P2 two resistors). This causes the voltage on the KEYS pin to change as shown in *Figure 16*. Every individual keyboard status has its own related voltage level.

The analog-to-digital converter of the MCU reads the status of the pin every 20 milliseconds. Software sets a key-window for each key in the range of 0.5 V. For example, P2 is pressed if the voltage applied to the KEYS pin is higher than 4.5 V.

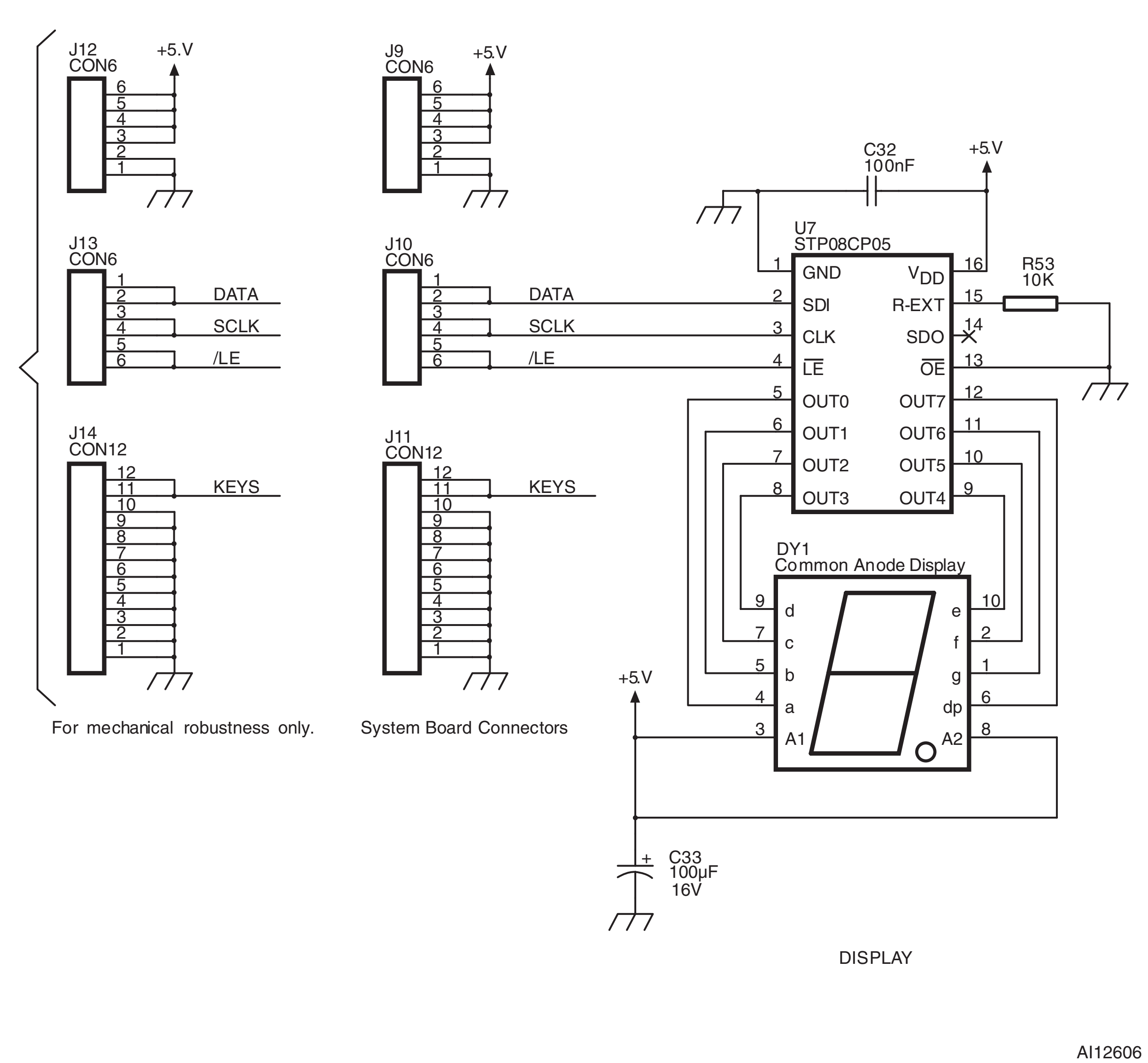
If two or even all the keys are pressed together, there is an automatic priority selection.

For example, P2 has the highest priority. This is because this key, when pressed, connects the KEYS pin directly to +5 V without passing through any resistor.

In addition, if the voltage applied to the KEYS pin does not fit any key-window, the voltage is ignored and no action is taken.

8.2 Display schematic

Figure 17. Display circuitry



Although the initial design approach was to implement a user interface with a couple of classic LEDs, the introduction of an 8-bit constant current LED sink driver in the display circuitry improved the user interface, while still keeping the number of MCU pins used relatively low.

The STP08CP05 needs just 3 pins to drive the display properly: DATA, SCLK, and /LE.

The display refreshing frequency is set at 50 Hz. Since the driver keeps the output signals latched until the next refresh is performed, a lower frequency would not cause any flickering. The display luminosity is set by an external resistor.

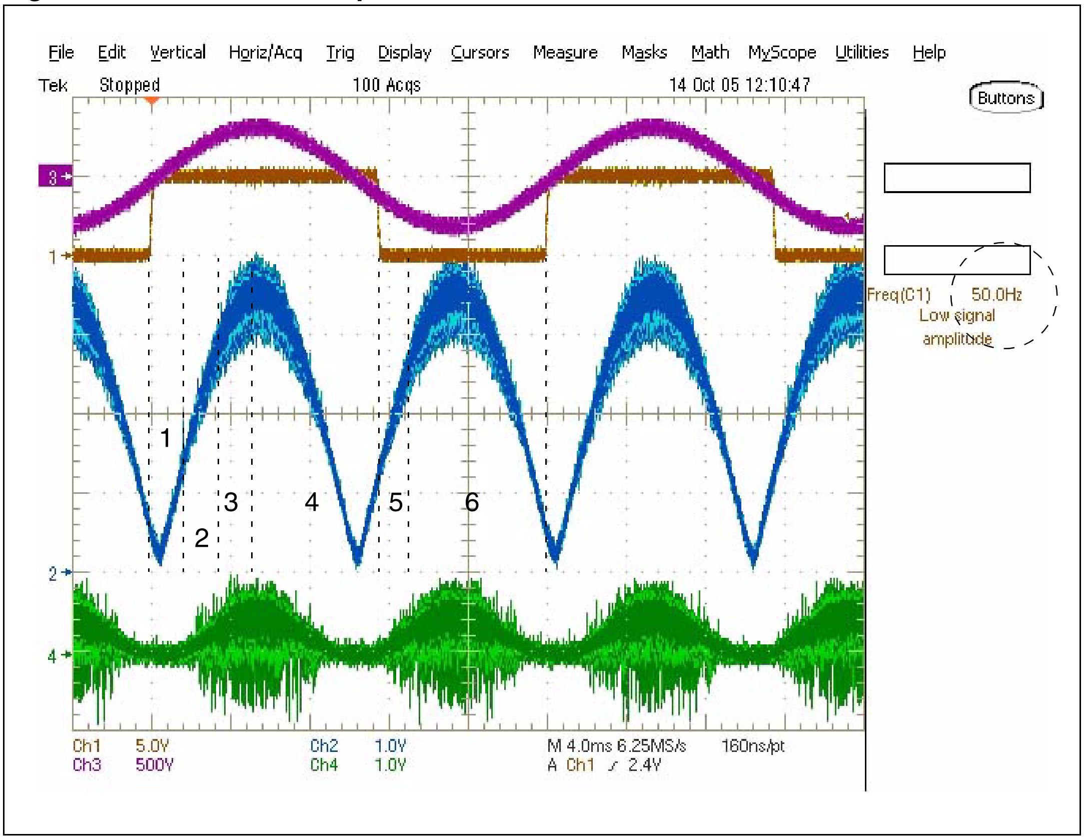
Connectors are duplicated solely for mechanical robustness, left side connectors are parallel to the right ones.

9 Software management

The MCU has to process six types of events: pot-on-plate detection, temperature, keyboard scan, display refresh and current control. These events are processed every 20 milliseconds; in fact, they are synchronized with the zero voltage switching signal.

The ZVS circuitry generates a square wave with a frequency of 50 Hz. The signal is sent to the ei1 MCU pin, which is configured as an external interrupt input for both rising and falling edges. Therefore, an MCU interrupt is generated every time a falling edge or a rising edge occurs on the pin.

Figure 18. The six most important software events



The first event, shown in *Figure 18* as number 1, takes place as soon as the interrupt triggered by a rising edge on the ZVS signal occurs. Pot-on-plate detection is performed by sampling the voltage drop on the VLINK signal during this time.

Before another interrupt occurs, there is still a lot of time to handle three other events.

Events 2 and 3 monitor the temperature of the heatsink and the plate respectively. During event number 4, the keyboard is scanned to check if a key has been pressed (or released). A software anti-bounce has been implemented to avoid undesired conditions.

Event number 5 takes place immediately after the interrupt generated by a falling edge of the ZVS signal occurs. The display refresh routine is performed.

During the last event, number 6, the I-CTRL signal is scanned and compared to the look-up table that the software refers to for each working level. If any discrepancy appears between the sampled value and the table, the MCU adjusts the PWM frequency. The adjustment process is performed step-by-step each period, resulting in a smooth current change.

The dotted lines in *Figure 18* indicate the sequence in which the routines are performed, but not the precise timing.

Events 2 and 3 together last less than 1 ms, and a similar time is needed for event 5.

10 Thermal conditions

The induction cooking system described in this document can deliver up to 2500 W at its maximum working level.

The IGBTs need to be mounted on a heatsink, as does the power diode bridge.

Tests performed in laboratory conditions demonstrate that even when delivering the maximum power for a long duration, the temperature of the components does not exceed the safe working area. The board was placed in an open space without an enclosure.

In a real application, the board would be placed inside a box. And, to save space, the plate is usually placed over the circuitry. Therefore, the heat dissipated by the heatsink has no easy way out, and the cooking process worsens the thermal conditions. The heatsink is no longer sufficient to dissipate the heat. For this reason, a fan is implemented in the system which is driven directly by the MCU.

Tests have demonstrated that while delivering the maximum power, the temperature reaches a stable value below 90 °C, which can still be considered safe.

The fan starts as soon as the temperature on the heatsink reaches 55 °C. The fan stays on for at least one minute, whether the system is on or in standby mode.

Fan management can be modified by software. An NTC mounted directly on the heatsink, between the IGBTs, improves control efficiency. Working as a thermostat controlled by an MCU, the sensor turns the fan on or off when necessary.

Any increase in the induction cooking system performance (for example, if higher output power is required), would result mainly in adapting the cooling system, resizing the heatsink, using a more powerful fan, or all three.

The system itself is capable of handling up to 3000 watts of power.

11 Bill of material

Table 1. Bill of material (part 1 of 3)

Item	Quantity	Reference	Part	Supplier
1	2	C30, C38	100 µF 35 V	
2	1	C33	100 µF 16 V	
3	3	C1, C4, C5	1 µF 275 VAC X2	
4	1	C15	1 µF ceramic	
5	2	C2, C3, C41	3,3 nF 250 VAC X1 Y1	
6	4	C6, C18, C19, C20	22 nF 50 V ceramic	
7	6	C8, C21, C24, C28, C31, C32	100 nF 50 V ceramic	
8	3	C9, C34, C39	10nF 50 V ceramic	
9	1	C10	3 µF 400 V	
10	2	C11, C12	680 nF 1000 V	
11	2	C13, C14	33nF 1000V	
12	1	C16	2,2 nF 50 V ceramic	
13	3	C17, C25, C29	10 µF 35 V	
14	2	C22, C23	10 µF 400 V	
15	1	C26	330 µF 35 V	
16	1	C27, C40	330 nF 50 V	
17	1	C35	220 µF 16 V	
18	2	C36, C37	47 nF 50 V ceramic	
19	1	DL1	LED red d. 3	
20	1	DY1	Com. anode display	
21	2	D1, D3, D13	1N4007	
22	1	D2	Diode bridge 25 A	
23	8	D4, D5, D6, D7, D8, D9, D17, D18	STTH102	ST
24	1	D10	STPS2H100	ST
25	1	D14	BAT46	ST
26	1	D15	PKC-136	ST
27	1	D16	Diode bridge 1.5 A	
28	3	FST1, FST2, FST3	Faston vertical 6.3 mm	
29	2	FST4, FST5	Screw	
30	8	J1, J2, J4, J5, J9, J10, J12, J13	CON6	
31	4	J3, J6, J11, J14	CON12	
32	1	J7	CON10A	

Table 2. Bill of material (part 2 of 3)

Item	Quantity	Reference	Part	Supplier
33	1	J8	Fan 12 V 1,9 W	
34	1	L1	TDK_TF2510H customized	TDK
35	1	L2	80 µH SF1-800Y10A-01-PF	TDK
36	1	L3	330 µH	
37	1	NTC1	NTC 47 k	
38	1	NTC2	PT1000	
39	1	PT1	50 k vertical	
40	3	P1, P2, P3	TACT-2 normally open	
41	2	Q1, Q2	STGY40NC60VD	ST
42	1	Q3	BC337	
43	1	Q5	STS5NF60L	ST
44	5	R3, R52, R53, R37, R50	10K 5% ¼ W	
45	5	R20, R23, R54, R55, R56	10K 1% ½ W metal oxide	
46	1	RL1	12 V (16 A 250 VAC)	
47	1	RV1	460 V	
48	1	RV2	275 V	
49	3	R1, R5, R19	470 k 2 W	
50	6	R2, R10, R28, R46, R48	4K 17 5% ¼ W	
51	1	R36	4K7 1% ½ W metal oxide	
52	1	R4	8K2 5% ¼ W	
53	1	R9	8K2 1% ½ W metal oxide	
54	3	R11, R12, R13	4K3 1% ½ W metal oxide	
55	3	R6, R7, R26	220K 1% ½ W metal oxide	
56	1	R8	270K 1% ½ W metal oxide	
57	3	R14, R15, R17	4K3 1% ½ W metal oxide	
58	1	R16	2K2 5% ¼ W	
59	1	R35	2K2 1% ½ W metal oxide	
60	1	R18	100R 2W	
61	2	R21, R24	47R 1% ½ W metal oxide	
62	2	R22, R25, R29	11R 1% ½ W metal oxide	
63	5	R27, R38, R39, R43, R58	1K 5% ¼ W	
64	1	R57	1K 1% ½ W metal oxide	
65	1	R30	n. c.	

Table 3. Bill of material (part 3 of 3)

Item	Quantity	Reference	Part	Supplier
66	1	R31	33R 2W	
67	1	R32	2K7 1% ½ W metal oxide	
68	1	R33	n. c.	
69	1	R34	1K8 1% ½ W metal oxide	
70	1	R40	62K 1% ½ W metal oxide	
71	2	R41, R42	100K 1% ½ W metal oxide	
72	2	R44, R51	1M 1% ½ W metal oxide	
73	1	R45	12K 5% ¼ W	
74	1	R47	24K 1% ½ W metal oxide	
75	1	R49	100 5% ¼ W	
76	1	TH1	Thermostat connection	
77	19	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19	Test point	
78	2	ISO1, ISO2	PC817 optocoupler DIP4	
79	1	TR1	1.5KE	ST
80	1	T1	Customized trafo	Tronic (CZ)
81	1	T2	TDK_CT034	TDK
82	1	U1	ST7FLITE09Y0	ST
83	1	U2	L6384	ST
84	1	U3	LM258	ST
85	1	U4	VIPer22A	ST
86	1	U5	TL431I	ST
87	1	U6	L7805CV	ST
88	1	U7	STP08CP05	ST

12 Demonstration board

Figure 19. Demonstration board photo (no cooking plate connected)

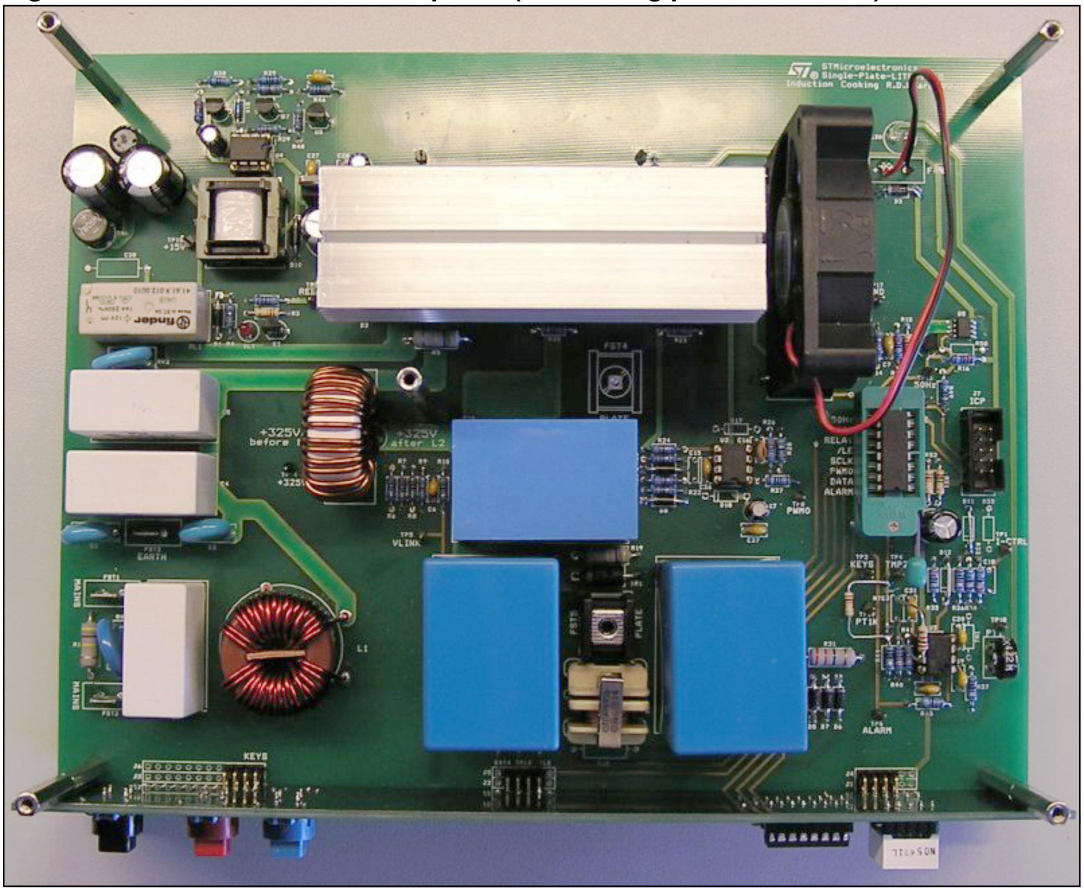


Figure 20. User interface

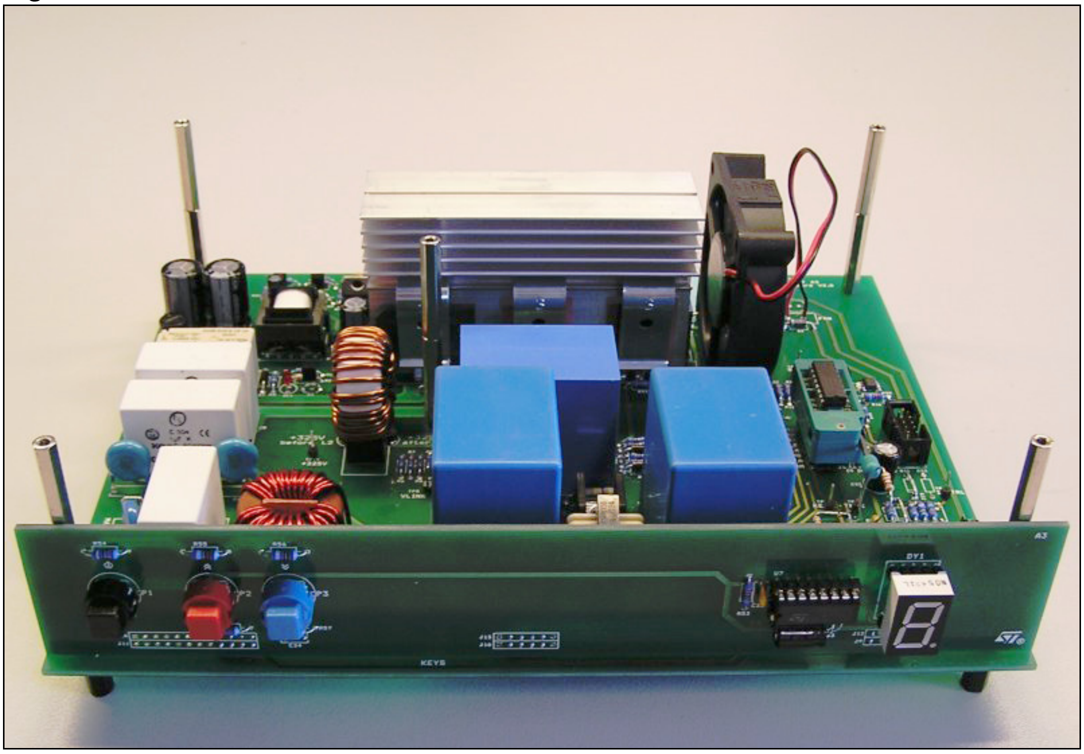


Figure 21. Resonant capacitors (in blue)

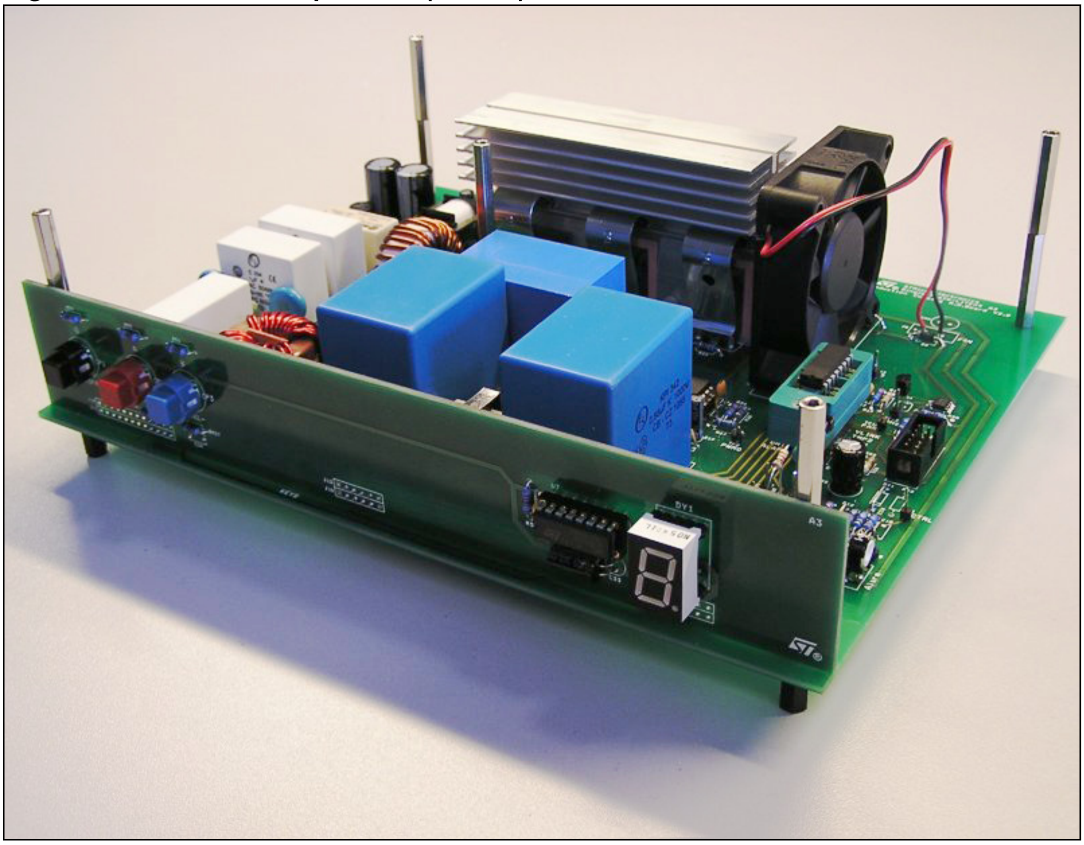
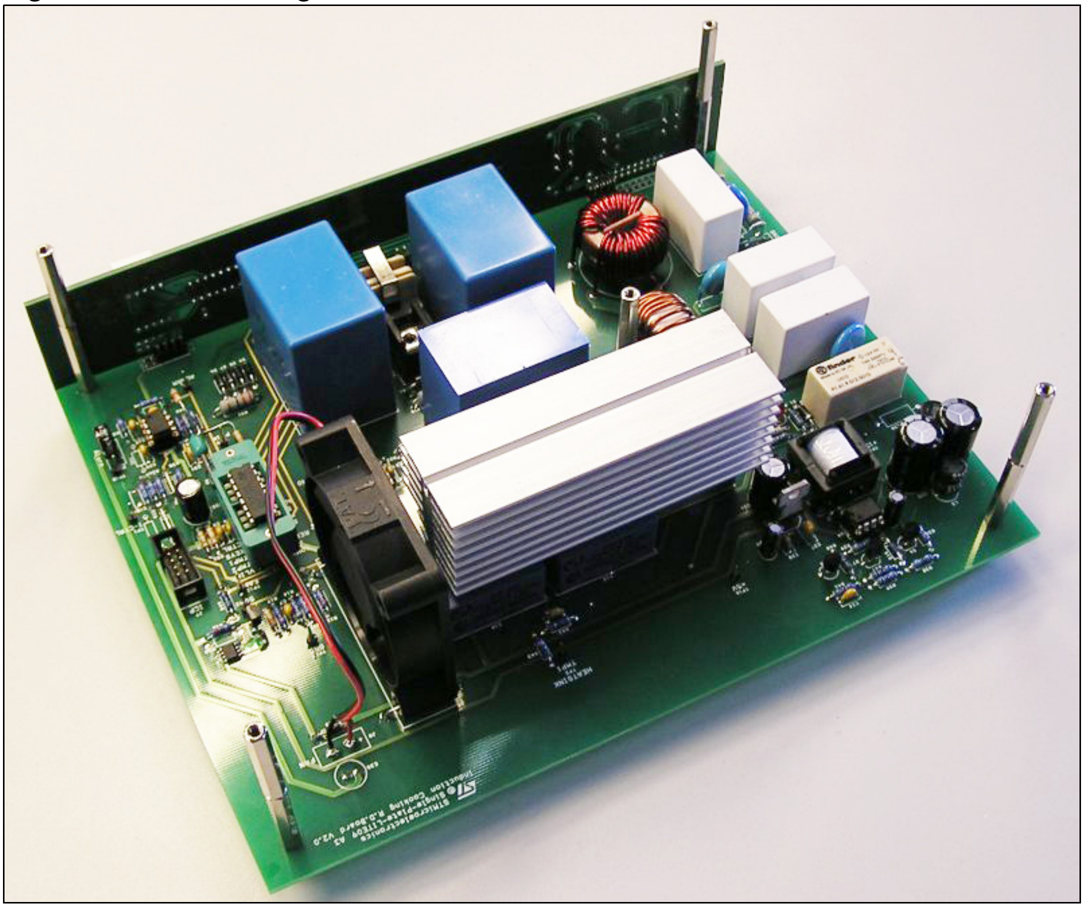


Figure 22. Reverse angle



13 References and related materials

For further information related to the basic functionality of each integrated circuit, please refer to the following documents, which are available at www.st.com:

1. ST7FLITE09Y0 datasheet
2. L6384 datasheet
3. VIPer22A datasheet
4. L7805CV datasheet
5. STGY40NC60VD datasheet
6. LM258 datasheet
7. STS5NF60L datasheet

14 Revision history

Table 4. Document revision history

Date	Revision	Changes
05-Sep-2006	1	Initial release.
22-Feb-2007	2	Introduction, *Section on page 1*, updated
23-Sep-2009	3	Removed demonstration board ordering information. All references to part number STP08C596 have been replaced with STP08CP05. Minor text changes.