HOLTEK
Induction Cooker Solutions

HOLTEK SEMICONDUCTOR INC.

www.holtek.com

Introduction

The induction cooker is a mature product using the electromagnetic induction heating technology. With the improvement of consumers' safety awareness and the demand for urbanization and environmental protection, the number and market of induction cookers are still growing and expanding. This is mainly due to their advantages such as high centralized heating efficiency, no open flame and less oily smoke, good safety, small size and easy to move, easy to clean the panel, and affordable. The application products derived from the electromagnetic induction heating technology also include IH rice cookers, IH milk frothers, IH electric teapots, etc.

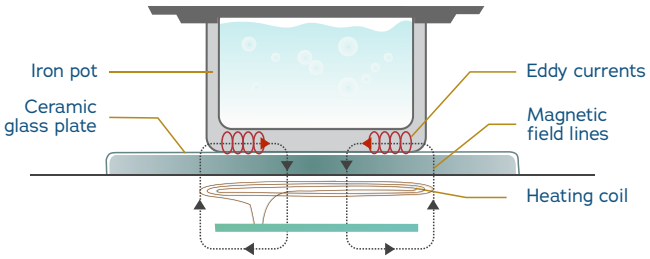
Induction Cooker Working Principle

The electromagnetic induction eddy current heating technology is derived from Faraday's law of electromagnetic induction. Figure 1 shows the induction cooker heating schematic and the detailed working principle is described as follows.

01 A medium or high frequency alternating current is generated at the power supply end and passes through the reel coil, i.g., heating coil, thereby generating an alternating magnetic field of the same frequency around the reel coil.

02 The alternating magnetic field lines have a relative motion with the metal conductor at the bottom of the iron pot on the ceramic glass plate, this means that the conductor cuts the magnetic field lines. At this time an induced electromotive force is generated in the metal conductor, resulting in countless low eddy currents.

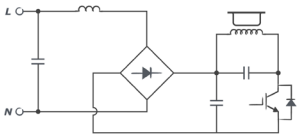
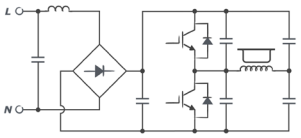
03 These countless low eddy currents pass through the conductor resistance to produce a thermal effect, causing the pot metal to heat up quickly, and then indirectly heating the food in the pot.



• Figure 1. Induction Cooker Heating Schematic

Induction Cooker Topological Technology

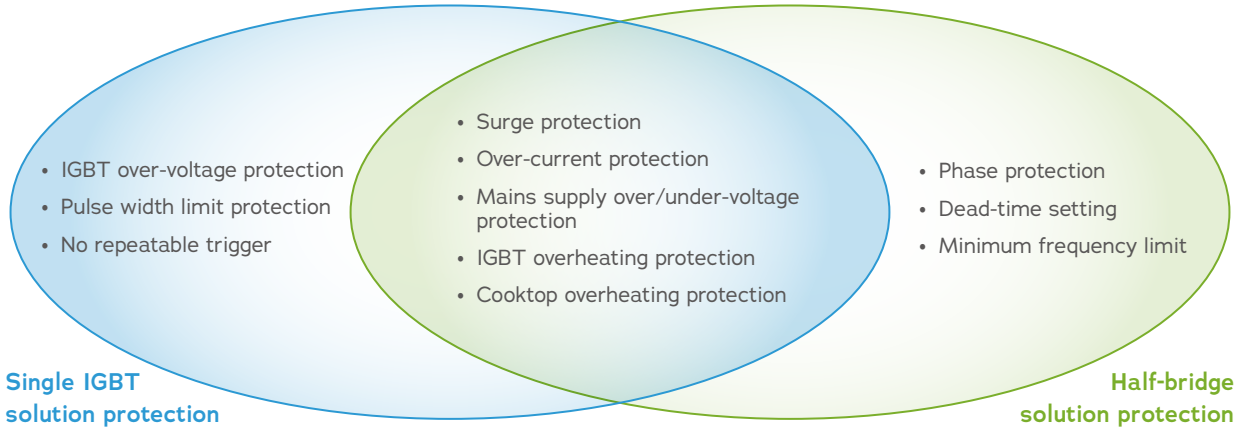
Common circuit topologies for electromagnetic induction heating mainly include: single IGBT topology, half-bridge topology and full-bridge topology. The full-bridge topology is characterized by higher power while requiring higher component costs, and is generally used for industrial heating. The single IGBT topology and the half-bridge topology both have a better balance between the heating power and component cost, and are most commonly used in household and commercial induction cookers. Table 1 shows the differences between the single IGBT induction cooker and the half-bridge induction cooker.

Induction Cooker Type	Single IGBT Induction Cooker	Half-bridge Induction Cooker
Topological Circuit		
Resonance	Single switch quasi-resonance	Half-bridge series resonance
Max. Power	Usually 2KW or lower (Note: 3.5KW is possible by parallel connection of two IGBTs)	Up to 15KW
IGBT Quantity	1	2
IGBT Rated Voltage	1200 ~ 1350V	600 ~ 650V
Features	• Low cost, simple structure • Small size of heat sinks and PCB • Lower power • Low power heating is usually achieved by intermittent heating • Low power continuous heating requires special support from MCU	• High cost, more complex structure • Larger size of heat sinks and PCB • Higher power (suitable for stir-fry function) • It is easy to achieve low power continuous heating (keep warm)
Market	Household induction cookers (single or multiple burners)	Household and commercial induction cookers
Recommended HT MCU Type	• HT45F0058/HT45F0006 (H/W frequency jitter) • HT45F0059/HT45F0036 (H/W frequency jitter, integrated IGBT driver, low power continuous heating)	• HT45F0074 • HT45F0074A/HT45F0075 (H/W frequency jitter)

• Table 1. Single IGBT Induction Cooker vs. Half-bridge Induction Cooker

Induction Cooker Protection Mechanisms

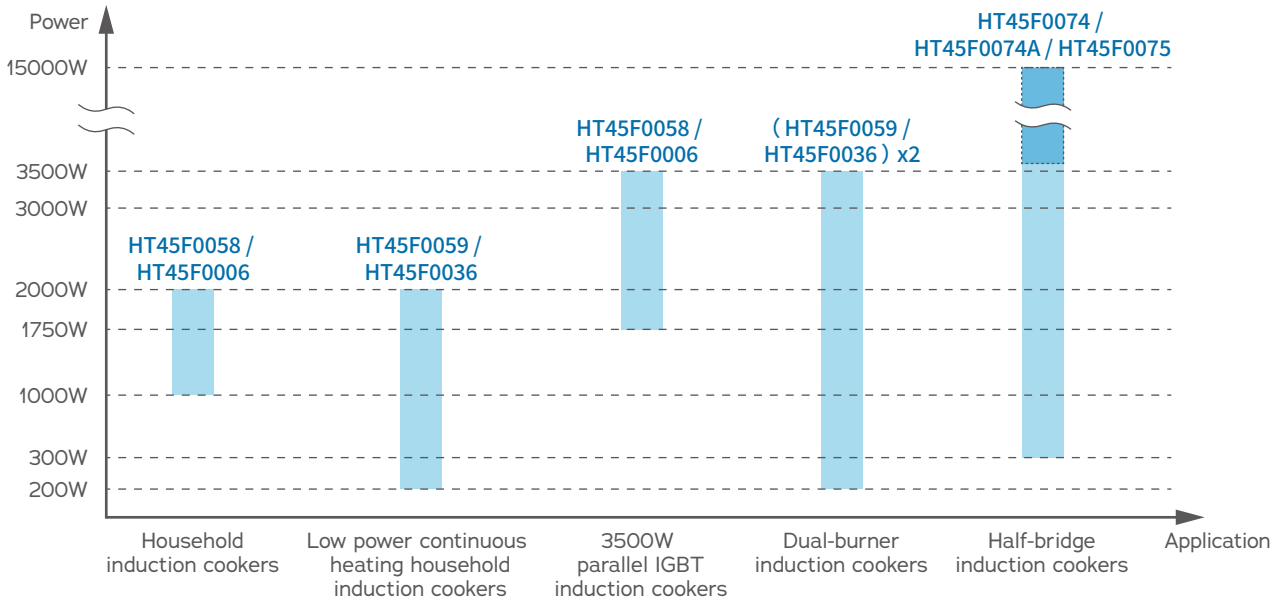
The internal circuits of IH electrical products operate with high voltages and high currents, so that the internal PCBA generally works in a high voltage and high temperature environment. In order to prevent electrical safety problems induced by factors such as aging of electronic components which is easy to cause increased IGBT reverse voltage, increased component temperature rise and other problems, or unstable power supply such as grid surge or mains supply fluctuation, induction cooker solutions should also have a variety of complete protection mechanisms in addition to the heating power control. Figure 2 shows the various protection mechanisms necessary for induction cooker solutions.



• Figure 2. Protection Mechanisms Necessary for Induction Cookers

HOLTEK Induction Cooker Solutions

Holtek's induction cooker ASSP MCUs have gone through several generations with constant evolution, accumulating a wealth of experience and mature technologies. Since its launch in 2009, the total number of cumulative shipments has exceeded 300KK as of 2022. Figure 3 shows the IH ASSP MCU types that Holtek has produced, the induction cooker applications covered by these MCUs and their heating power ranges.



• Figure 3. Holtek IH ASSP MCUs and Induction Cooker Applications

The induction cooker generally includes a power heating board and a display control board. Holtek not only supplies main control MCU choices for single IGBT control and half-bridge control power boards, but also display control MCU choices for tact key and touch key panels. Additionally, Holtek is also delighted to provide complete induction cooker application solutions and technical support. The complete solutions include low component cost single IGBT solution, low power continuous heating single IGBT solution and half-bridge induction cooker reference solution, which are introduced individually in the following chapters.

Reference Solution 1 : Low Component Cost Single IGBT Induction Cooker Solution

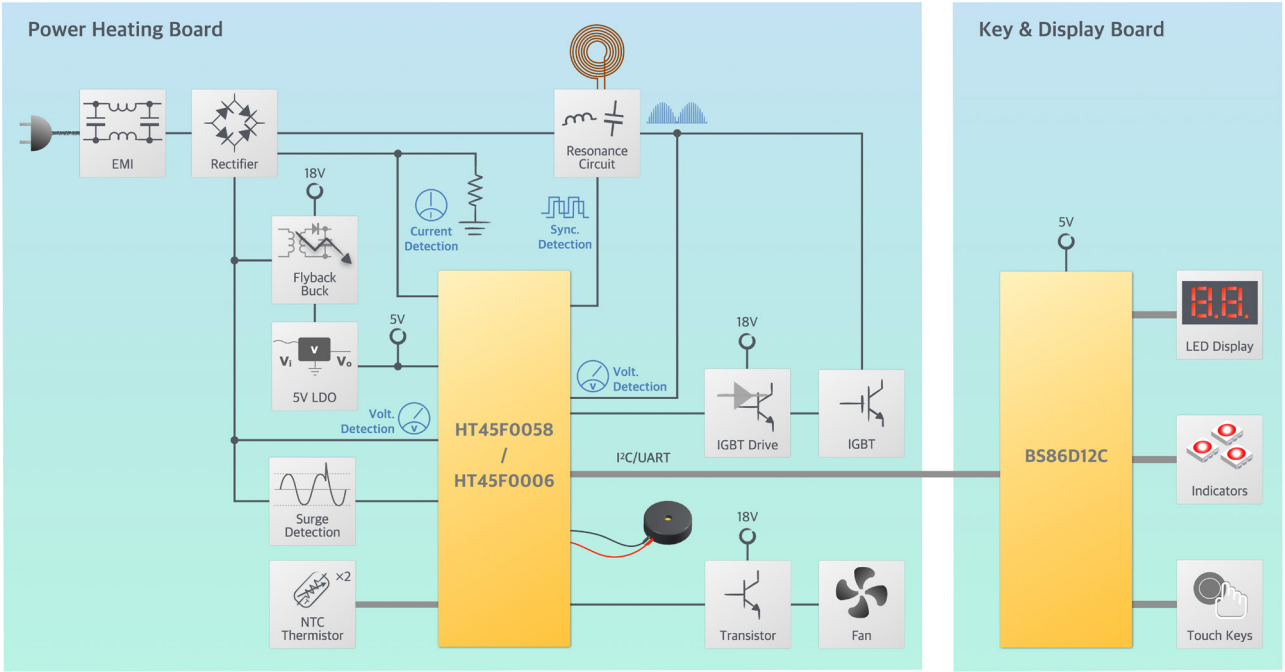
Solution Description

This single IGBT household induction cooker prototype is designed using an HT45F0058/HT45F0006 IH ASSP MCU and a BS86D12C touch key control MCU. It can be applied to scenarios where the mains supply is 220V/50Hz and the power requirement is up to 2000W. Customers can modify the design to fit it into wider product ranges.

This solution consists of a power heating board and a touch key & display board, which are connected through I²C or UART communication. The power heating board contains a power supply circuit and an MCU-based driving circuit that drives an IGBT which in turn controls the solenoid coil to implement heating. The various protection mechanisms in the circuit are a strong guarantee for the stable operation of the product. The touch key & display board controls the human-machine interface and LED display. Customers can customize the development basing on the current solution architecture, accelerating the introduction of products into mass production.

- PCBA and Prototype Appearance

Application Block Diagram



Characteristics

This power heating board solution is characterized by the following features.

- **Dedicated PPG (Programmable Pulse Generator) hardware frequency jitter circuit :**
  Using hardware frequency jittering can reduce software burden and provide finer control effects.

  > Generally, using software frequency jittering to achieve finer control effects will occupy part of program space and CPU resources. However, in actual product development it is often unable to achieve good control effects due to software resource limitations.

  > The MCU of this solution includes a PPG hardware frequency jitter circuit, where the timer counting is triggered by a zero-crossing comparator. The PPG width is automatically changed by the hardware during the corresponding counting period, without requiring additional software frequency jittering program. This will not only ensure good control effects but also reduce the software running time, program space and development difficulty.

- **Highly-integrated single IGBT IH ASSP MCU – HT45F0058/HT45F0006 :**

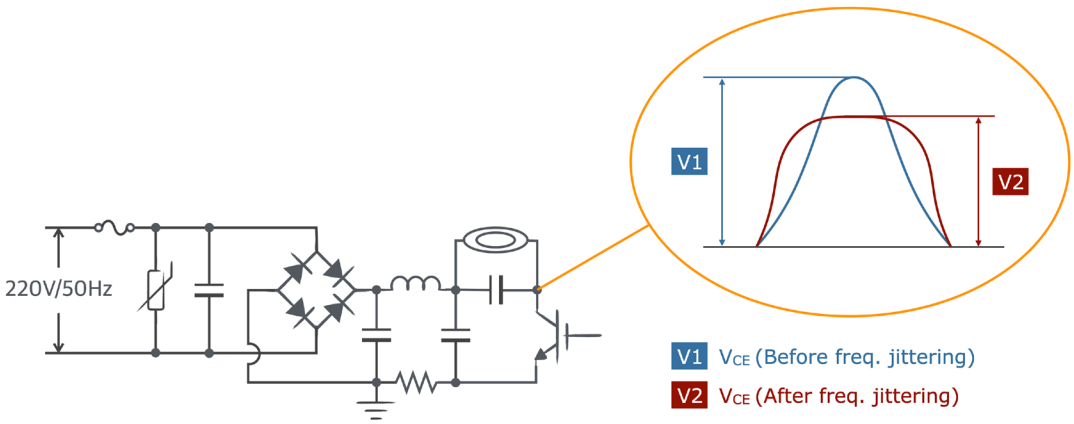
  > Multiple integrated comparator and OPA circuits: these are used for over-voltage and over-current protection, reducing the number of external components and allowing for more simplified PCB traces.

  > Integrated PPG hardware frequency jitter circuit: turning on this function at the maximum power will effectively reduce the IGBT V_{CE} reverse voltage and EMI. Therefore, safety capacitors with lower capacitance values can be utilized to achieve the low-cost benefits produced by this solution.

- **Hardware frequency jitter characteristics :**

  The MCU of this solution has an integrated PPG hardware frequency jitter circuit, which not only improves the software execution efficiency, but also achieves finer control effects. In high power (>1600W) conditions, frequency jittering can effectively reduce the IGBT V_{CE} voltage to improve the IGBT stability, and reduce the EMI by dispersing the EMI with larger energy to other frequency spectrums.

  For more detailed principle, refer to the document: HT45F005x Frequency Jittering Applications.
  https://www.holtek.com/page/applicationNotes/AN0563



Website Link

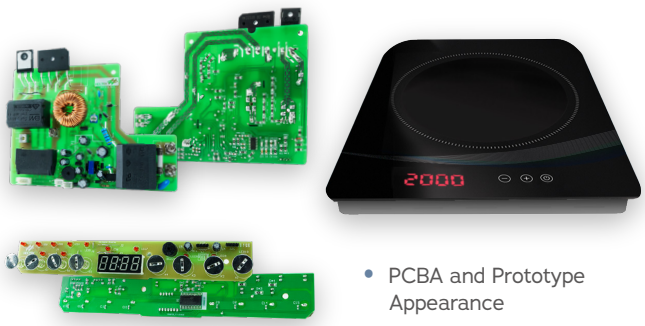
- **Website link of low component cost single IGBT induction cooker solution**
  https://www.holtek.com/page/applications/detail/WAS-2041

Reference Solution II : Low Power Continuous Heating Single IGBT Cooker Solution

Solution Description

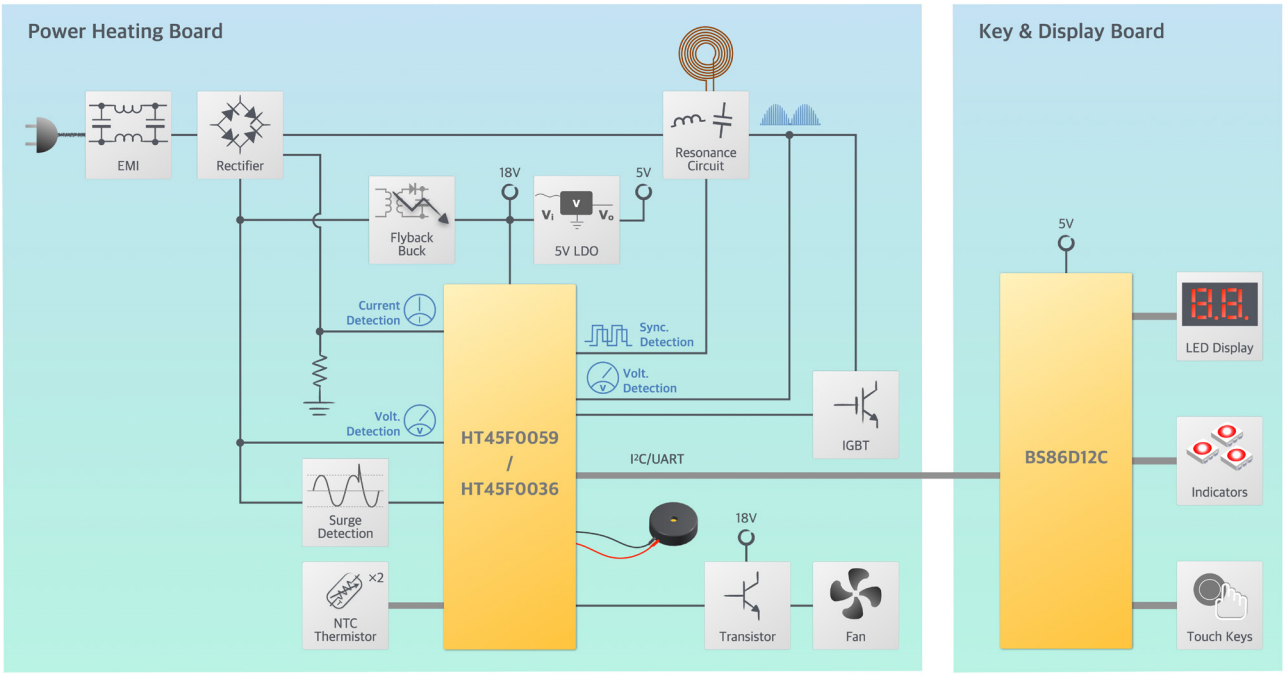
This single IGBT houshold induction cooker prototype is designed using an HT45F0059/HT45F0036 IH ASSP MCU and a BS86D12C touch key control MCU. This solution can be applied to scenarios where the mains supply is 220V/50Hz and the power requirement is up to 2000W. The prototype supports low power continuous heating with a power of 1000W or less. Customers can modify the design to fit it into wider product ranges.

This solution consists of a power heating board and a touch key & display board, which are connected through I²C or UART communication. The power heating board contains a power supply circuit and an MCU-based driving circuit that drives an IGBT which in turn controls the solenoid coil to implement heating. The various protection mechanisms in the circuit are a strong guarantee for the stable operation of the product. The touch key & display board controls the human-machine interface and LED display. Customers can customize the development basing on the current solution architecture, accelerating the introduction of products into mass production.



- PCBA and Prototype Appearance

Application Block Diagram



Characteristics

This power heating board solution is characterized by the following features.

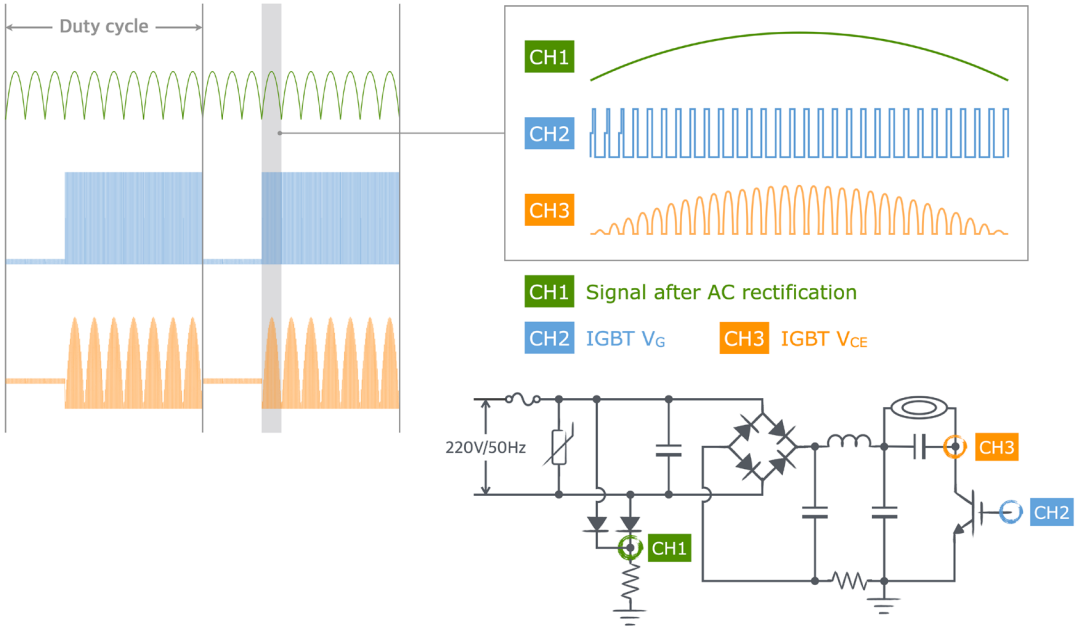
- **Low power continuous heating :**
  - > When the power is lower than 1000W, a drop-wave method is used to achieve low power continuous heating function, and there will be no intermittent heating phenomenon.
  - > The heating effect is closer to that of traditional firewood simmering and the heating power is uniform and efficient, providing better user experiences.
  - > The continuous heating power can be as low as 200W.

- **Highly-integrated single IGBT IH ASSP MCU – HT45F0059/HT45F0036 :**
  Integrated high voltage IGBT driver circuit, hardware jitter circuit and multiple protection circuits.
  - > Integrated high voltage IGBT driver: it can directly drive the IGBT. This not only reduces the number of external components and hardware costs, but also allows for more streamlined PCB traces and consequently reduces the PCB design difficulty.
  - > Integrated hardware jitter circuit: the frequency jittering function can effectively reduce the IGBT V_{CE} voltage and EMI.
  - > Multiple integrated comparator and OPA circuits: these are used for over-voltage and over-current protection functions.

- **Unique patented technology :**
  Holtek's low power continuous heating techonology patent has been approved, enabling IH heating technology upgrade for customers.

- **Low power continuous heating characteristics :**
  The low power continuous heating solution ultilizes the drop-wave principle to achieve power control. As shown below, a fixed number of AC waveforms are taken as a power period, during which the IGBT is turned on for only part of waveforms and turned off for the rest waveforms, so as to achieve different power control.

  For more detailed principle, refer to the document: HT45F0059 Low Power Continuous Heating Induction Cooker Application Note.
  https://www.holtek.com/application-notes/an0591



Website Link

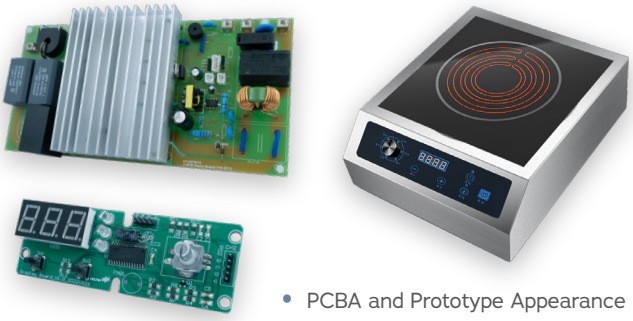
- **Website link of low power continuous heating single IGBT induction cooker solution**
  https://www.holtek.com/page/applications/detail/WAS-21A1

Reference Solution III : Half-Bridge Induction Cooker Solution

Solution Description

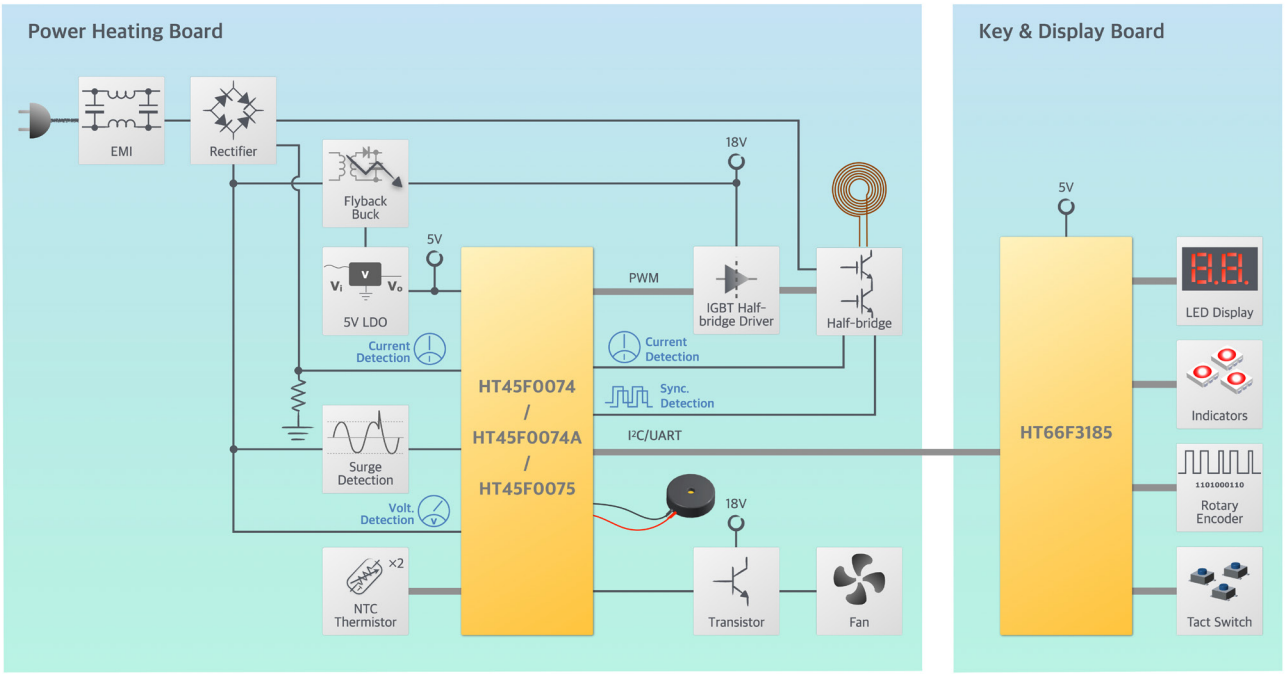
This half-bridge induction cooker prototype is designed using an HT45F0074/HT45F0074A/HT45F0075 half-bridge IH ASSP MCU and an HT66F3185 tact key control MCU. This solution can be applied to scenarios where the mains supply is 220V/50Hz and the power requirement is up to 3500W. The prototype supports continuous heating and linear power adjustment in a range of 300~3500W. Customers can also modify the design to fit it into wider product ranges.

This solution consists of a power heating board and a tact key & display board, which are connected through I²C or UART communication. The power heating board contains a power supply circuit and an MCU-based driving circuit that drives two IGBTs which in turn control the solenoid coil to implement heating. The various protection mechanisms in the circuit are a strong guarantee for the stable operation of the product. The tact key & display board controls the human-machine interface and LED display. Customers can customize the development basing on the current solution architecture, accelerating the introduction of products into mass production.



- PCBA and Prototype Appearance

Application Block Diagram



Characteristics

This power heating board solution is characterized by the following features.

- **High reliability and high power :**
  > This solution adopts a half-bridge LC series resonance architecture design, resulting in lower IGBT reverse voltage compared with the signle IGBT architecture, therefore IGBTs with a lower withstand voltage can be used.

  > This solution has the advantages of high conversion efficiency and low power consumption, and the maximum power is about 3500W, which can meet the needs of household stir-fry cooking. Developers can refer to this solution and adjust the design to expand the power to 15000W, which can meet most commercial heating and cooking purposes.

- **Linear and wide range of power outputs :**
  The continuous power range is 300W~3500W.

- **Low power continuous heating :**
  The low power continuous heating supports a power that is 10% below the highest power point or as low as 300W, which can be applied to maintain boiling point and keep cooking warm.

- **Complete protection mechanisms :**
  This solution has integrated hardware over-voltage and phase protection circuits, and a 12-bit A/D converter with the function of 2-channel auto conversion to measure important parameters such as the voltage, current and temperature of the induction cooker, which have relevant protection mechanisms.

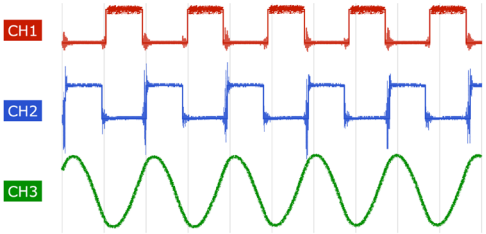
- **Highly-integrated half-bridge IH ASSP MCU – HT45F0074/HT45F0074A/HT45F0075 :**
  > 12-bit PWM complementary outputs with dead-time control. The figure below shows the PWM control diagram of the complementary architecture. The dead-time can be set separately, making the device compatible with various IGBT specifications.

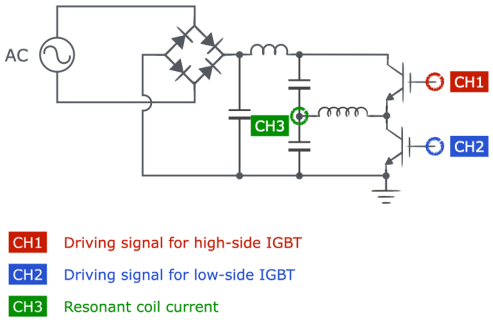
  > One OPA circuit is used to measure the AC current for power calculation.

  > Multiple sets of over-voltage protection (OVP) circuits: two sets for AC surge protection and over-current protection; two sets for LC resonance over-current protection; two sets for positive and negative half-cycle LC resonance current phase detection; one set for AC voltage zero-crossing detection.

  > Integrated hardware jitter circuit (HT45F0074A/75): the frequency jittering function can effectively reduce the IGBT V_{CE} voltage and EMI.

  > Integrated hardware protection circuits (HT45F0074A/75): use different protection levels depending on the urgency of the situations. Execute power adjustment for less urgent situations. Turn off the power immediately for more urgent situations.





Website Link

- **Website link of half-bridge induction cooker solution**
  https://www.holtek.com/page/applications/detail/WAS-2291

- **Application note :**
  AN0523E_HT8 MCU Half-Bridge Induction Cooker Application Note
  https://www.holtek.com/page/applicationNotes/AN0523

HOLTEK Induction Cooker MCU Selection

HOLTEK Induction Cooker MCU Selection Guide

Induction Cooker Flash MCU

Part No.	Max. Freq.	VCC (HV)	VDD	Program Memory	Data Memory	Data EEPROM	Stack	I/O	Timer	ADC	PPG	Comparator	OVP	OPA	LDO	HVO	Interface	Package
HT45F0058	16MHz	—	3.3V~5.5V	4K×16	256×8	32×8	8	13	8-bit×3	12-bit×10	9-bit×1	4	1	1	—	—	—	16NSOP
HT45F0005A*	16MHz	—	3.3V~5.5V	4K×16	512×8	128×8	8	17	8-bit×4	12-bit×14	9-bit×1	1	5	1	—	—	I^2C×1	20SOP
HT45F0006	16MHz	—	3.3V~5.5V	8K×16	512×8	512×8	8	17	8-bit×4	12-bit×14	9-bit×1	1	5	1	—	—	I^2C×1 UART×1	16NSOP 20SOP
HT45F0059	16MHz	16V~20V	3.3V~5.5V	4K×16	256×8	32×8	8	12	8-bit×3	12-bit×9	9-bit×1	4	1	1	5V	1	I^2C×1	16NSOP
HT45F0035A*	16MHz	16V~20V	3.3V~5.5V	4K×16	512×8	128×8	8	16	8-bit×4	12-bit×13	9-bit×1	1	5	1	—	1	I^2C×1	20SOP
HT45F0036	16MHz	16V~20V	3.3V~5.5V	8K×16	512×8	512×8	8	16	8-bit×4	12-bit×13	9-bit×1	1	5	1	—	1	I^2C×1 UART×1	16NSOP 20SOP

* Under development, available in 1Q, 2024.

Half-bridge Induction Cooker Flash MCU

Part No.	Max. Freq.	VDD	Program Memory	Data Memory	Data EEPROM	MDU	Stack	I/O	Timer	ADC	PWM	OVP	OPA	CRC	Interface	Package
HT45F0074	16MHz	4.5V~5.5V	8K×16	512×8	128×8	√	8	20	10-bit CTM×3 10-bit PTM×1	12-bit×8	12-bit×1	7	1	√	UART/SPI/I^2C×1	20NSOP 24SOP
HT45F0074A	16MHz	4.5V~5.5V	8K×16	1024×8	512×8	√	8	20	10-bit CTM×3 10-bit PTM×1	12-bit×11	12-bit×1	9	1	√	UART/SPI/I^2C×1	16NSOP 20/24SOP
HT45F0075	16MHz	4.5V~5.5V	16K×16	1024×8	1024×8	√	8	24	10-bit CTM×4 10-bit PTM×1	12-bit×11	12-bit×1	9	1	√	UART/SPI/I^2C×1	16NSOP 20/24/28SOP

HOLTEK Touch Key MCU Selection Guide

Touch A/D Flash MCU

Part No.	Max. Freq.	VDD	Program Memory	Data Memory	Data EEPROM	Stack	IAP	I/O	Timer	ADC	Touch Key	High Current LED Driver	Interface	Package
BS84C12CA	16MHz	1.8V~5.5V	4K×16	512×8	512×8	6	√	26	10-bit CTM×1 10-bit PTM×1	12-bit ×8	12	26	UART×1 SPI/I^2C×1	16NSOP 20/24/28SOP/SSOP
BS84D20CA	16MHz	1.8V~5.5V	8K×16	768×8	512×8	8	√	46	10-bit CTM×1 10-bit PTM×1 16-bit STM×1	12-bit ×12	20	46	UART×1 SPI/I^2C×1	28SOP/SSOP 48LQFP

Touch I/O Flash MCU with LED/LCD Driver

Part No.	Max. Freq.	VDD	Program Memory	Data Memory	Data EEPROM	Stack	I/O	Timer	LCD	Touch Key	RTC	High Current LED Driver	LVD	Interface	Package
BS82C16CA	16MHz	1.8V~5.5V	4K×16	512×8	512×8	6	26	10-bit CTM×2 10-bit PTM×1	(SCOM/SSEG) ×26	16	√	26	√	UART×1 I^2C×1	24/28SOP/SSOP
BS82D20CA	16MHz	1.8V~5.5V	8K×16	768×8	512×8	8	42	10-bit CTM×2 10-bit PTM×2	(SCOM/SSEG) ×34	20	√	42	√	UART×1 I^2C×1	28SOP/SSOP 48LQFP

Touch A/D Flash MCU with LED Driver

Part No.	Max. Freq.	VDD	Program Memory	Data Memory	Data EEPROM	Stack	IAP	I/O	Timer	ADC	Touch Key	High Current LED Driver	RTC	LVD	Interface	Package
BS86C12CA	16MHz	1.8V~5.5V	4K×16	512×8	512×8	6	√	26	10-bit CTM×4 10-bit PTM×1	12-bit ×8	12	26	√	√	UART×1 I^2C×1	24/28 SOP/SSOP
BS86D20CA	16MHz	1.8V~5.5V	8K×16	768×8	512×8	8	√	26	10-bit CTM×1 10-bit PTM×2	12-bit ×8	20	26	√	√	UART×1 SPI/I^2C×1	24/28 SOP/SSOP
BS86E20CA	16MHz	1.8V~5.5V	16K×16	1024×8	1024×8	12	√	46	10-bit CTM×2 10-bit PTM×2	12-bit ×8	20	46	√	√	UART×1 UART/SPI/I^2C×1	28SOP/SSOP 44/48LQFP

HOLTEK Tact Key MCU Selection Guide

Flash MCU with EEPROM

Part No.	Max. Freq.	VDD	Program Memory	Data Memory	Data EEPROM	Stack	IAP	I/O	Timer	ADC	SCOM/SSEG	CMP	RTC	High Current LED Driver	Inter-face	Package
HT66F3185	16MHz	1.8V~5.5V	4K×16	256×8	128×8	8	√	26	10-bit PTM×1 16-bit CTM×1 16-bit STM×1	12-bit ×12	(SCOM/SSEG)×22 SSEG×4	1	√	26	SPI/I^2C×1 UART×1	16/20NSOP 20/24/28SOP 20/24/28SSOP 24/28QFN
HT66F3195	16MHz	1.8V~5.5V	8K×16	512×8	128×8	8	√	26	10-bit PTM×1 16-bit CTM×1 16-bit STM×1	12-bit ×12	(SCOM/SSEG)×22 SSEG×4	1	√	26	SPI/I^2C×1 UART×1	20NSOP 24/28SSOP/QFN

HOLTEK AC-DC Power Converter Selection Guide

AC to DC Converter

Part No.	Topology	Power MOS (BV)	Input Voltage	$R_{DS(ON)}$	Operation Current	Typical Power Capability	Frequency	Protections	Package
HT7A6312	Flyback (SSR), Buck, Buck-Boost	730V	9V~38V	19Ω	0.7mA	8W/13W*2	60kHz	UVLO, OTP, OVP, OCP	8DIP/SOP
HT7A6322				12Ω		12W/20W*2			

Note: 1. All of ICs operate from $85V_{AC}$ to $265V_{AC}$.
2. Max. output power from $85V_{AC}$ to $265V_{AC}$/$176V_{AC}$ to $265V_{AC}$.

Please refer to the official website for product selection information

Development Tools

Online Debug Adapter

- **Hardware** : e-Link
- **Software** : HT-IDE3000

https://www.holtek.com/page/ice

- **Functions** :

✓ Supports online debug for EV devices that have an OCDS interface.

✓ Provides debug operations such as single step, full speed, stop, breakpoints during the debug process.

Best Modules Online Shop

Programmer

- **Hardware** : e-WriterPro
- **Software** : HOPE3000

https://www.holtek.com/page/programmer

- **Functions** :

✓ The e-WriterPro is a programmer designed for programming of the Holtek MCUs.

✓ This programmer supports an Online Programming Mode that needs to connect with a PC and an Offline Programming Mode that does not require a PC connection.

Best Modules Online Shop

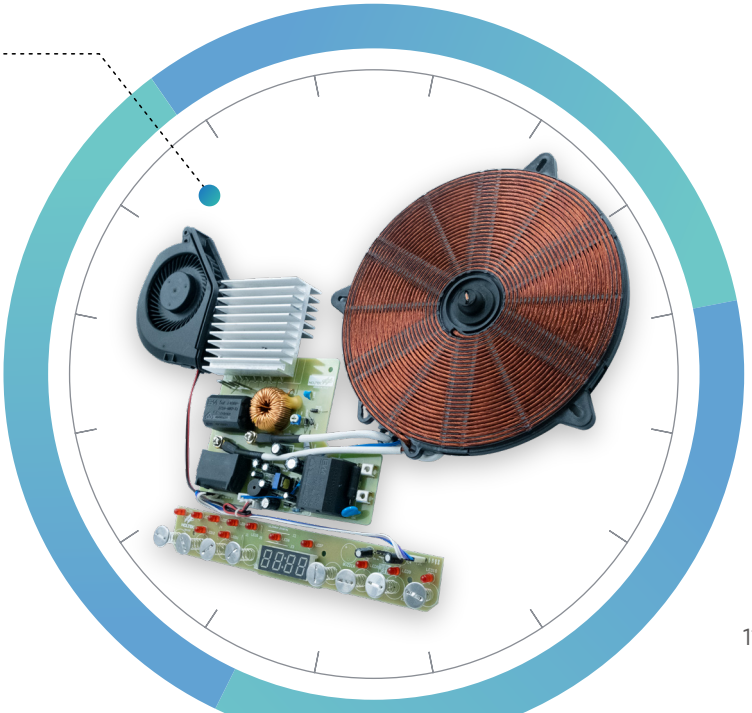
EV Board

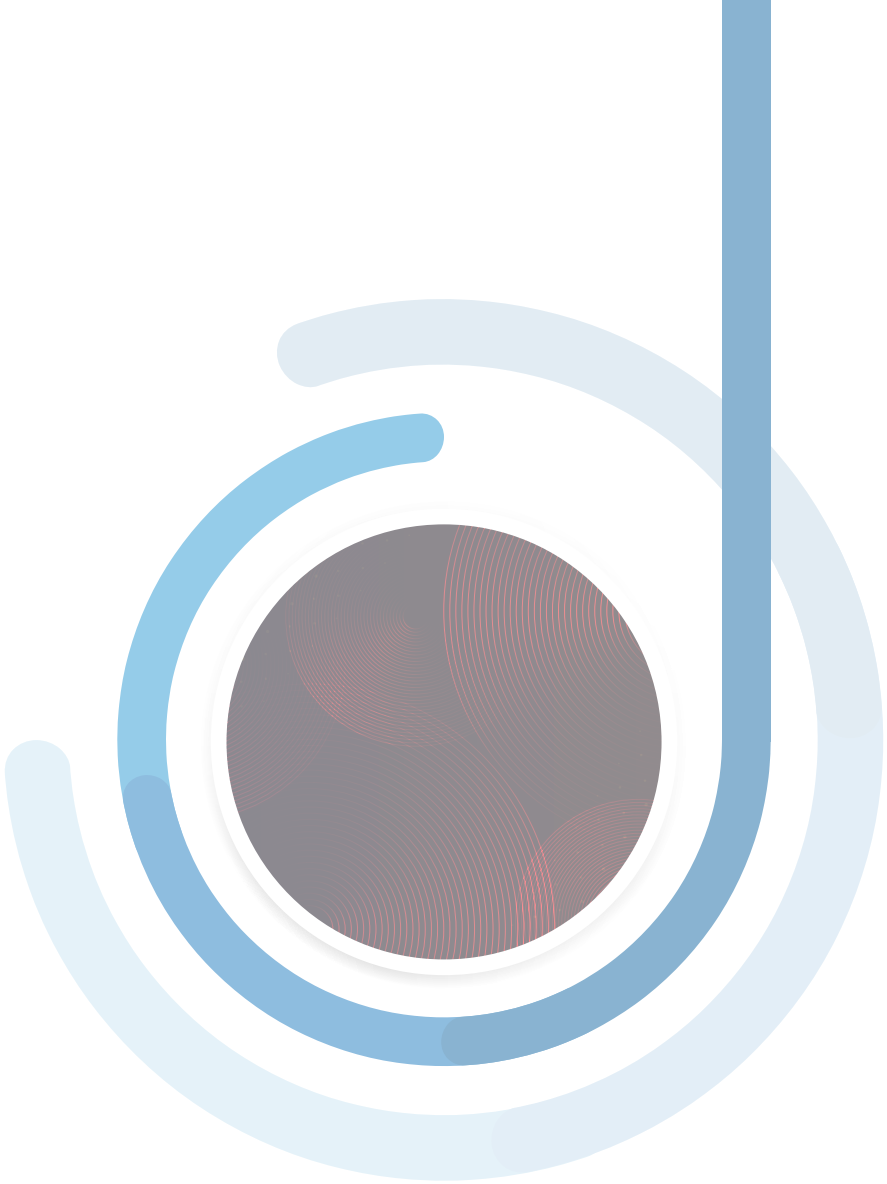
Refer to the application solution information aforementioned for the demo board PCBA of the HT45F0059 low power continuous heating induction cooker solution. For hardware acquisition, please contact the agents or Holtek businesses.

Purposes of the HT45F0059 low power continuous heating induction cooker solution :

✓ It accelerates the functional evaluation of MCU resources for customers.

✓ It can be used as a reference during customers' development.





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