Induction Stove

Repair Manual

UKaid from the British people

MECS Modern Energy Cooking Services

PEEDA

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Preface

Welcome to the repair manual for induction stoves. This comprehensive guide is designed to assist technicians and enthusiasts in understanding, troubleshooting, and fixing common issues with these essential kitchen appliances.

Induction stoves have become crucial tools in kitchens, offering efficiency, convenience, and precise cooking capabilities. However, like any complex machinery, they may encounter problems over time, ranging from minor malfunctions to more serious issues.

The manual was developed by drawing on the findings of the PEEDA-MECS study into the repair of eCooking appliances. This training manual and the larger repair study were funded by and received technical support from the UK Aid Modern Energy Cooking Services (MECS) Programme and were developed in close coordination with the Alternative Energy Promotion Centre (AEPC) and Renewable Energy for Rural Livelihood (RERL) programme.

The study surveyed institutions, service centers, trainers, technicians, suppliers, and households to assess the most common faults for induction stoves. Existing Council for Technical Education and Vocational Training (CTEVT) modules for electrical appliances were also reviewed to understand best how this module could most effectively be integrated into training courses. Inputs were also incorporated form the workshop with fruitful discussion gathering invaluable feedback from experts representing AEPC, CTEVT, and its technical institutions in Kathmandu, Banepa, Butwal, as well as major e-cooking technology suppliers, and other INGOs/NGOs and private institution working in similar fields.

In this manual, we aim to provide detailed explanations, diagrams, and step-by-step instructions to aid in diagnosing and repairing various issues that may arise with induction stoves. If you are a professional technician, this manual will equip you with the knowledge and skills needed to keep these appliances running smoothly.

We encourage users to read through this manual thoroughly before attempting any repairs, ensuring safety precautions are always followed. Additionally, referring to the manufacturer's guidelines and specifications specific to your appliance model is essential.

PEEDA is committed to working alongside organizations dedicated to leveraging technology for noble purposes and advancing knowledge. We are willing to work with any organization passionate about utilizing this resource for a generous cause to embark on a collaborative journey with us.

We hope this manual serves as a valuable resource in maintaining and extending the lifespan of your induction stove.

Biraj Gautam
Chief Executive Officer
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1. Introduction

An induction stove is a modern electric stove. It operates based on the principle of electromagnetic induction. Induction stoves have a circular coil made of high-frequency copper wire situated beneath the cooking surface. When the coil is energized with a frequency current, it generates an electromagnetic field. When a pot or pan made of ferromagnetic materials like iron or steel is placed on the stove's surface, the electromagnetic field induces eddy currents in the cookware, which in turn heats the cookware. This heat is then used to cook foods.

In comparison to other stoves, induction stoves quickly heat up and allow for precise control and adjustments of temperature. Since the stove itself doesn't produce heat, its surface doesn't heat up much even when it is operating. Not all utensils are compatible with induction stoves. It only works with pots and pans made of ferromagnetic materials like iron and steel.

Figure 1: Induction Stove

2. Parts of an Induction Stove

User Interface(UI) Board

The UI board (User Interface Electronics Board) assists in controlling the induction stove. It contains switches, LEDs, a display, and various other electronic components. Different buttons are used to change the cooking settings. These buttons transmit instructions to the microprocessor located on the power supply board, which, in turn, powers the stove and operates it according to those instructions. The display on the UI board shows the current status of the induction stove, such as power level or temperature, and also indicates how much time is remaining until the stove turns off.

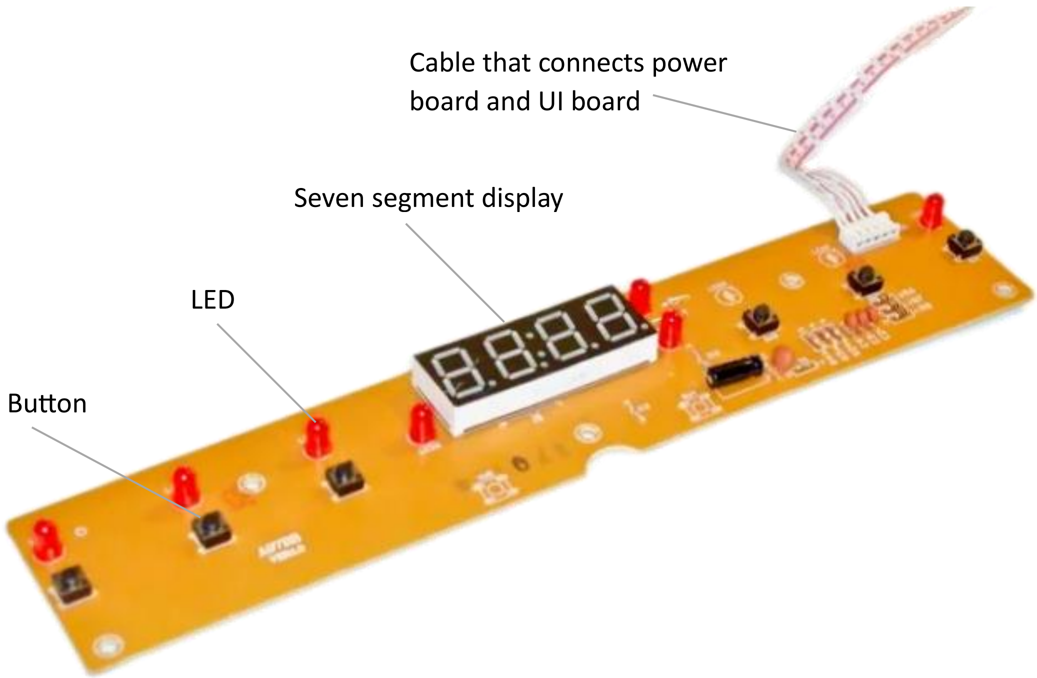


Figure 2: UI Board

Power Supply Board

The power board along with the induction coil is situated just beneath the cooking surface. It takes the AC power from the cable and transforms it into the right kind of voltage and current that various electronic parts need. It contains different electronic components like capacitors, inductors, transformers, fuses, transistors, rectifiers, etc. The components work together to perform various operations like turning AC power into DC power, adjusting the current and voltage levels, etc. To keep the induction stove safe from short circuits and very high temperatures, the power board also uses fuses and temperature sensors.

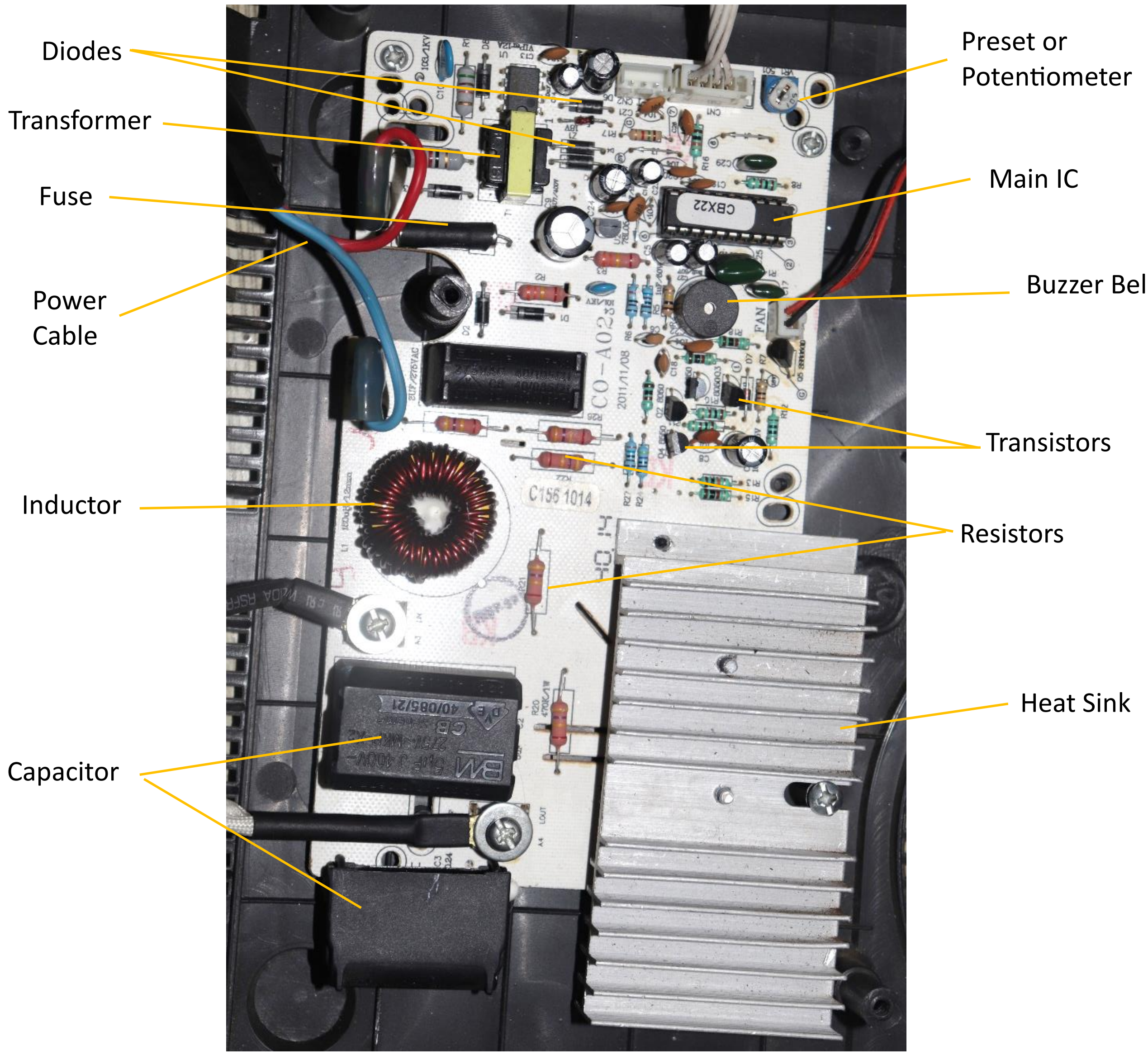


Figure 3: Power Board of an Induction Stove

Induction Coil

The induction coil is a crucial component of an induction stove. It is placed right below the cooking surface. When it receives a high-frequency AC current from the power board, it creates an electromagnetic field, which in turn generates an eddy current in the pot that heats up the cookware.

Figure 4: Induction Coil

Fan

When an induction stove is in operation, the fan directs the internal heat outside protecting the electronic components against extreme temperatures. It obtains the necessary energy from the power board. It is located near the induction coil.

Figure 5: Fan used inside Induction Stove

2.1 Components on the power board

Fuse

The fuse prevents the stove from operating in case of a short circuit or overload. If the current exceeds a certain limit, the fuse wire may melt and cannot carry current between the plug and the power board. In such cases, it is necessary to identify the cause of the short circuit, remove it, and replace the fuse with a new one. The capacity of the fuse used may also vary according to the capacity of the induction stove.

Figure 6: Fuse

Temperature Sensor

The temperature sensor is placed just above the induction coil. It measures the temperature of the surface and provides this information to the power board. Based on this information, the power board can make adjustments to the power supplied to the coil. Excessive temperatures can lead to the induction coil shutting down automatically. Different temperature sensors can also be used to measure the temperature of various electronic components. A thermistor is used in the temperature sensor. A thermistor is a type of resistor whose resistance changes according to temperature. When the stove is not in operation, the resistance of the thermistor is close to 100 kΩ and decreases as the stove heats up during operation.

Figure 7: Temperature sensor

Transistor

A transistor or bipolar junction transistor is an electronic device. It can be used as a switch or an amplifier. It can open and close thousands of times in a single second. Transistors come in two different types: NPN and PNP. Both types of transistors have three pins: emitter (E), base (Base), and collector (Collector). However, the positions of these pins can vary depending on the type of transistor. For example, in Model S8550, a PNP transistor is shown in Figure 8, when you handle it with its flat surface facing towards you, the pins are labeled from left to right as emitter (E), base (Base), and collector (Collector) respectively.

The best way to identify the pins is to search for the model number of the transistor on Google. For example, to find the pinout of the transistor shown in Figure 11, you can search 'S8550D pinout' on Google.

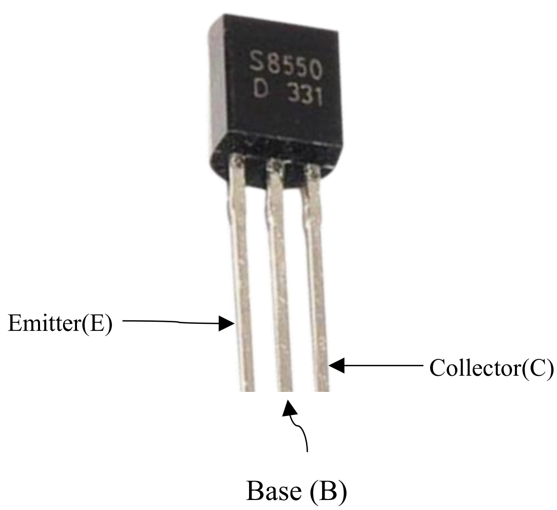


Figure 8: Transistor

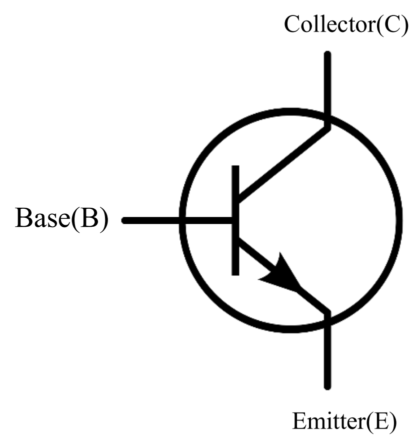


Figure 8 : Transistor Symbol

IGBT

Insulated Gate Bipolar Transistor (IGBT) is a special type of transistor that controls power flow in an induction coil. Like a transistor, it can also open and close thousands of times in a single second. By changing the opening and closing times, it can control the current going into the coil, which in turn can change the power produced by the coil.

IGBT has three pins. If you handle it with the labelled side facing upwards, these pins are called Gate, Collector, and Emitter from left to right.

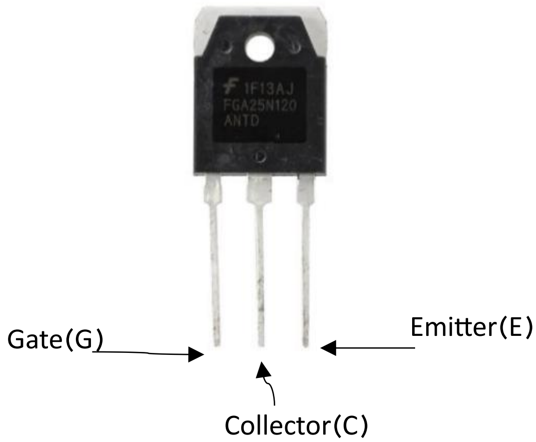


Figure 9: IGBT

Bridge Diode Rectifier

A bridge diode rectifier converts the AC current coming from the power cable into DC. It has four pins. AC voltage is provided at the middle two pins (2 & 3), while DC voltage can be obtained from the two extreme pins (1 & 4). The positive pin of the DC is located right below the cut part of the bridge diode, and the final or opposite direction pin serves as the negative pin of the DC. As shown in Figure 12, the distance between the DC+ pin and its nearest pin (pin 2) is the greatest as compared to the distance between other pins.

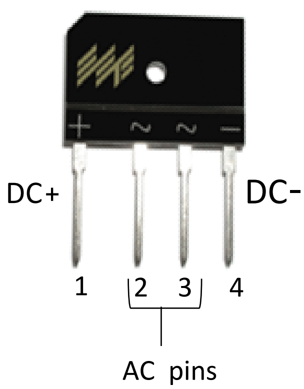


Figure 11: Bridge Diode Rectifier

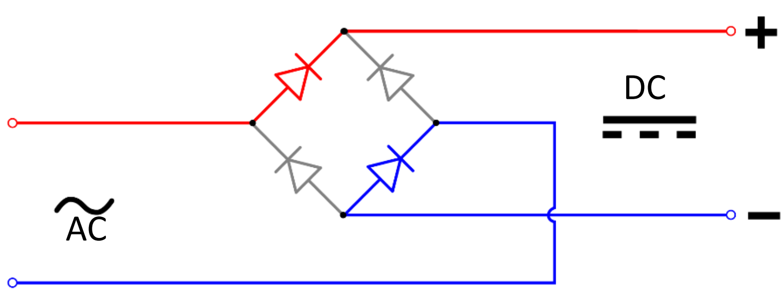


Figure 10: Bridge Diode Rectifier Symbol

Capacitor

Both the power board and the UI board use various types of capacitors for different purposes. Capacitors help the rectifier stabilize the DC voltage, protect electronic devices from momentary high voltages, and more. The value of a capacitor is measured in terms of capacitance and its unit is Farad.

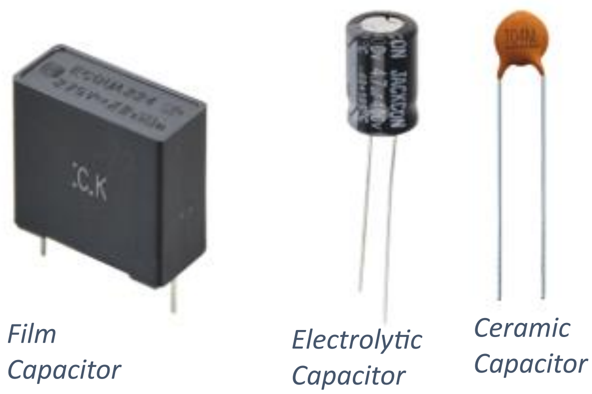


Figure 12: Different Types of Capacitors

Inductor

Inductors are used to convert the DC voltages produced by the rectifiers into pure DC voltage. An inductor is created by winding laminated copper wires around the laminated ferrite ring. The value of an inductor is measured in terms of inductance and its unit is Henry (H)

Figure 13: Inductor

Resistors

Both in the UI board and the power board, resistors are used in large numbers to control the current and change the voltage levels. Depending on applications, they can be used in different places. The value of a resistor is measured in terms of resistance and its unit is ohm(Ω).

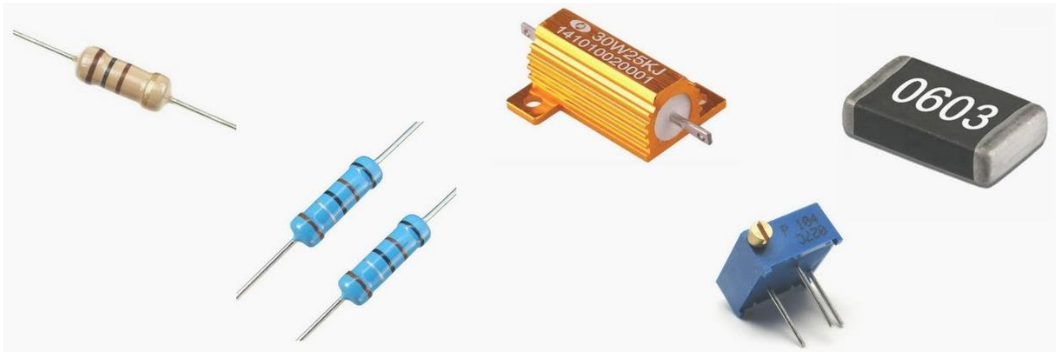


Figure 14: Different types of Resistors

Potentiometer or Preset

The preset or potentiometer is a variable resistor. It has three pins. The resistance between two extreme pins remains constant while the resistance between the middle pin and the extreme pins can be varied by rotating the knob.

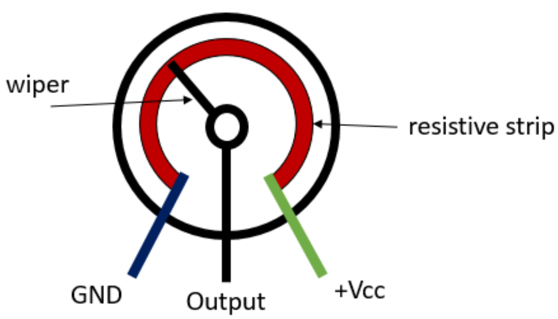


Figure 15: Functional diagram of potentiometer

Figure 16: Preset of potentiometer

Buzzer Bell

A buzzer is installed on the power board which rings when the timer expires or the when stove is turned on or off. If you leave the stove on without placing an induction-compatible utensil on the surface, the buzzer will continuously ring, and automatically turn off after some time (usually 1 minute). Similarly, the buzzer can also ring if the stove generates excessive heat or encounters any other issue.

Figure 17: Buzzer Bell

<u>Heat Sink</u>

Heat sink helps minimize heat produced on different electronic components. When current flows through IGBT and bridge diodes, they generate heat. If this generated heat cannot be easily dissipated, these components can fail in a short time. Therefore, to facilitate the heat transfer, IGBTs and bridge diodes are placed on a heat sink. In addition to using a heat sink, thermal paste is also used to further facilitate heat transfer between the heat sink and the components.

Figure 18: Heat Sink

3. Tools needed for repairing induction stove

1. Screwdriver

Screwdrivers are used to tighten and loosen the screws. Depending on the size of the screws, you may require different types of screwdrivers.

Figure 19: Screwdriver

2. Pliers

Pliers are used to cut or bend wires. They can also be used to handle objects.

Figure 20: Pliers

3. Wire Cutter/Wire Stripper

This instrument is used to cut or stripe wires of different sizes.

Figure 21: Wire cutter/Stripper

4. Soldering Iron

The soldering iron is required to connect various components to a PCB board. When the iron is supplied with electricity, its tip heats up. This heat is used to melt solder wire and attach the pins of components to the board.

Figure 22: Soldering Iron

5. Soldering Wire and Soldering Paste

The soldering wire is used to connect the pins of components to the board by melting it. After some time of use, the soldering iron tip may become oxidized. The soldering paste is used to remove this oxidation from the tip.

Soldering Wire *Soldering Paste*

Figure 23: Soldering wire and Soldering Paste

6. Desoldering Pump

To remove electronic components from a PCB board, a desoldering pump is used. The solder connection between the pins and the board is first melted using a soldering iron. Then, the molten solder is removed by using the pump.

Figure 24: Desoldering Pump

7. Multimeter

A multimeter is a versatile device. With its help, you can measure the voltage and current of DC and AC circuits. Additionally, it can be used to test various electronic components such as resistors, capacitors, diodes, transistors, and more. A control knob is used to adjust settings as per the requirement. For example, to measure the resistance of a resistor, the pointed head of the control knob is placed on the resistance measurement section. A detailed explanation on using a multimeter for testing various electronic devices is provided in chapter 6.

Figure 25: A Digital Multimeter

4. Precautions to be Taken Before Induction Stove Repair

4.1 Safety Precautions

As with any electrical work, you must consider your safety as the first priority. If you are not careful enough, there is a risk of electrocution which can cause injuries and sometimes be lethal. Therefore, it is strongly advised that you follow the instructions provided in this section before you begin any repair work.

- To prevent possible electrical accidents during repair work, disconnect the induction stove from the power socket.
- Work only in well-lit and properly ventilated areas where there is a smooth flow of air.
- Wear gloves, safety glasses, and insulated footwear.
- As the design and components of induction stoves can vary depending on the brand and model, it is advisable to first read the stove's manual before starting the repair work.
- When in contact with liquid substances such as water, there is an increased risk of electric shock, so it is necessary to stay away from contact with such substances.
- To prevent potential fire hazards, install a separate MCB of the appropriate rating for the repair workshop so that it trips in case of short circuits.

4.2 Proper Storage of Components

When disassembling an induction cooker for repair, small components like screws and buttons can easily get lost or misplaced if not properly stored. Further, accidental mechanical damage to the power board or control panel can make the situation worse. This can lead to frustrations and unnecessary delays. The following is a list of some instructions which can help you avoid this hassle.

- Begin by gathering all parts and components required for the repair task.
- Keep the storage area clean and clutter-free for easy access to parts.
- Use designated containers or compartments for different types of parts.
- You can even label each container or compartment, indicating the contents and their respective locations.
- Handle small parts such as screws with care, to prevent loss or spillage.
- Store larger parts such as panels or circuit boards in protective cases or boxes to shield them from damage.

5. Troubleshooting

5.1 Common faults found in induction cookers

Induction cookers can encounter various technical issues. Some issues render the device no longer usable while others pose operational difficulties without halting the functionality. It is essential for any repairer to have an understanding of frequently found faults and the underlying causes behind them. Table 1 lists some most commonly found electrical and mechanical faults in induction cookers. In this manual, we will deal specifically with the electrical faults.

Table 1: Most commonly found faults in induction cookers

Electrical Faults	Mechanical Faults
1. Induction cooker does not turn on 2. Shuts off unexpectedly 3. Functions too slowly 4. Fan not moving 5. Broken power cord 6. Overheating 7. Buttons don't work or are too difficult to press 8. Burnt heating coils	1. Broken Cooktop 2. Blocked air vents

5.2 Error Codes

EPCs display error codes to indicate various problems or malfunctions. Typically, error codes are used to indicate the following technical problems:

- No utensil error: occurs when induction cooker does not detect an induction-compatible cookware.
- Issues with the internal circuitry
- Problem with the temperature sensor
- Overvoltage or undervoltage
- Excessive temperature on the surface
- Excessive temperature within the internal circuit

Error codes used to indicate a particular problem vary from one brand to another. Thus, it is essential to go through a particular induction cooker's user manual before conducting any repair work. Table 2 shows the error codes and problems indicated by them in some of the induction cooker brands found in Nepal.

Table 2: Error Codes of some induction cooker brands found in Nepal

Error Codes	Induction Cooker Brands		
	CG	**Philips**	**Prestige**
E0	No pot warning	-	-
E1	Supply voltage is too low	The main sensor* is in short circuit or open circuit condition	Coil sensor is in short short circuit or open circuit condition
E2	Supply voltage is too high		
E3	Coil sensor* error	The heat sink sensor** is in short circuit or open circuit condition	Coil sensor high temperature
E4	IGBT sensor error		IGBT open circuited
E5	Surface temperature is too high	Supply voltage is either too low or too high	IGBT short-circuited
E6	Circuit internal temperature is too high		IGBT overheat
E7	-	The fan has malfunctioned	Supply voltage too low
E8	-	The main sensor is not working	Supply voltage too high
E9	-	The fuse has malfunctioned	-
EB	-	-	Coil sensor failure, can't detect temperature

*Coil sensor/main sensor – Temperature sensor attached to the induction coil

**Heat sink sensor - Temperature sensor attached to the IGBT

In most cases, the faulty parts of the power board or control board of the cooker can be easily identified with the help of error codes. For example, if the cooker shows a high-temperature error even when the surface temperature is normal, there might be a short circuit in the temperature sensor. Knowing the relationship between the error codes and associated parts can significantly reduce the repair time.

5.3 Voltage, Current, and Power

Many of the troubleshooting steps involve the measurement and calculation of voltage, current and power flowing through the induction cooker. Knowing the relationship between these quantities and being able to calculate their values can be highly beneficial to any repairer. Therefore, in this section, we will learn to calculate these parameters.

In AC circuits, the relationship between current, voltage, and power is given by the following equation

$$\boldsymbol{Current} = \frac{\boldsymbol{Power}}{\boldsymbol{Voltage} * \boldsymbol{Power\ Factor}}$$

Current is measured in amperes (A), voltage in volts (V) and power in watts (W). The value of the power factor depends on the type of device used. Typically, it is taken as 0.95 for induction cookers**. In the case of Nepal, the nominal supply voltage is 230 volts and the voltage range of 220 to 240 volts is considered normal**. However, many induction cooker brands operate, although with compromised functionalities, from a voltage as low as 180 volts to as high as 250 volts.

Consider that an induction cooker is set to operate at 1000 watts and the supply voltage measured at the outlet is 220 volts, then the current flowing through the power cord should be nearly equal to 4.78 amperes.

$$Current = \frac{1000}{220 * 0.95} = 4.78\ A$$

If the current measured with a multimeter differs significantly from this value, either the power factor is too low (if the measured current is much higher than 4.78 volts) or the cooker has some issues.

5.4 Troubleshooting of Issues

There is a specific set of steps that need to be followed to reach the underlying causes of each fault. This section deals with the troubleshooting methods for some of the most commonly found faults in induction cookers. While the methods are not exhaustive and do not guarantee success every time, they should help you identify the problematic areas most of the time.

1. Induction cooker doesn't turn on

Troubleshooting method

Check the power supply: If the outlet to which the induction cooker is connected is not receiving consistent power, the induction cooker might not turn on. Check whether there is consistent normal voltage present at the outlet. If the supply voltage is too low or too high, wait until it restores to a normal level or connect the cooker to an outlet with a normal voltage supply.

Check the power cord: If the power cord is broken somewhere or has other problems, the power board does not receive power. Consequently, the induction cooker cannot turn on. Check whether the power cord is functioning properly. Troubleshooting of the power cord is given in section 6.8.

Check the fuse: Due to overload or a short circuit, the fuse in the power board can melt. Check whether the fuse is functioning or not. Testing and replacement of fuse is given in section 6.2.

Check the IGBT: The IGBT can get damaged due to various electrical, mechanical, or environmental factors. By following the procedure given in section 6.1 check whether the IGBT is working or not.

Check the bridge rectifier: The bridge rectifier can fail due to heat, overload or other reasons. Follow the methods given in section 6.4 to test whether the rectifier is functioning.

Check switches: Sometimes, the cooker might not turn on simply because the signal from the power switch is not reaching the main IC. This can happen due to the failure of the power switch. With the help of a multimeter check whether the switch shows continuity when pressed. If not replace it with a new one.

Check individual components: If you still cannot identify the issue, you might need to check the individual components on the power board and the control board. Check individual diodes, filter capacitors, transistors, resistors etc. You can refer to Appendix 1 to find the components to be tested.

2. Induction cooker automatically turns off

If induction-compatible cookware is not placed on the surface of the induction cooker, it automatically turns off within a minute or a few seconds. This is an inbuilt feature found in most induction stoves. However, if the cooker automatically turns off even in the presence of cookware, there might be some issues with the internal circuitry.

Troubleshooting method

Check Power Supply: If the power supply is not consistent, the induction cooker fails to operate continuously. With the help of a multimeter check whether the outlet is consistently supplying a normal voltage.

Check for error messages: If the induction cooker shows an error code before shutting off, it can indicate the problematic area. For example, if an excessive temperature is causing this problem, the cooker might indicate a high-temperature error.

Check the fan: If the fan is not moving or the air vent is blocked disrupting the proper ventilation, the temperature inside the cooker can exceed a permissible limit causing the processor to turn off the power supply. Clean the air vent if it is blocked. Clean and grease the fan if it is not moving properly. If it is not moving at all, you may need to check for breakage in its connection or replace it with a new one.

Check the temperature sensor: When there is a problem with the temperature sensor, it can report a high temperature to the processor even when the temperature is normal or when the cooker hasn't even started heating. When this happens, the power boards can cut off the power supply to the heating element. Depending on the brand of the induction cooker, the display might indicate an error. If it shows a high-temperature error even when the surface temperature is normal, you know that there is an issue with the temperature sensor. Testing and replacement of a temperature sensor is given in section 6.7.

3. Induction cooker functions too slowly

Sometimes it happens that the cooker turns on but takes too long to develop sufficient heat. For example, the cooker might heat the water but may not be able to boil it, leading to a subpar cooking experience. There are several reasons which can create such issues.

Troubleshooting method

Check power supply: If the supply voltage is too low, the induction cooker cannot develop sufficient power to generate the required heat. Check whether there is consistent normal voltage present at the outlet to which the induction cooker is connected.

Check the current flowing through the power cord: When the current flowing through the power cable is less than normal at specific settings, the induction coil cannot generate a strong enough magnetic field to heat the utensil to a desired degree. The method to calculate current at a given voltage and power is given in section 5.3.

Check deformation on PCB: Mechanical damages to the PCB or components can also lead to this issue. If you find any damaged components, replace them with a new one.

Check the preset: Deviation of the preset's default setting can be another reason behind this issue. Rotate the knob of the preset and check at different positions if it resolves the problem. If there are visible damages to the preset, replace it with a new one. The full range resistance of the new one should be equal to that of the older preset.

Try resoldering: Dry soldering of components could be another reason. Try resoldering the major components like IGBT, bridge rectifier, filter capacitor, etc. and see if it resolves the issue.

Check resistors and capacitors: Malfunctioning resistors and filter capacitors could also cause this problem. Test these components by following the method outlined in section 6.5 and section 6.6 Replace them if necessary.

4. Internal fan does not move

If the fan does not rotate, the internal temperature can quickly exceed the permissible limit causing the processor to cut off the power supply. Failure of the fan to rotate could be due to various reasons.

Troubleshooting

Clean and grease the fan: When the cooker has operated in a dusty environment for a long time without being serviced, it might get clogged up impeding the rotation. Clean and grease a dusty fan to ease its movement.

Check breakage in connection: check if the fan's cable or connector is broken somewhere. If there is no visible breakage, test continuity with a multimeter. If you indeed find discontinuity, replace the cable or connector with a new one.

Check the 18-volt port: Usually, the fan is connected to an 18-volt port on the power board. Measure the DC voltage between the two pins of this port. If there is no voltage or the voltage is significantly lower than 18 volts, you will need to check the fan's switching transistor.

Check the switching transistor: A bipolar junction transistor is used to switch the power to the fan. It is usually located beside the 18-volt port. If this transistor is damaged for some reason, the supply to the 18-volt port gets interrupted and consequently the fan cannot move. Following the instructions given in section 6.9 check the transistor and replace it if necessary.

Check the fan: If you haven't yet found the problem, probably the fan is damaged. If the 18-volt port is fine, tightly connect the fan's connector to the port and see if the fan moves.

5. Induction cooker overheats

Troubleshooting

Check the induction coil: Deformation in the shape of the induction coil can lead to uneven heating and potentially overheating. Try bringing the coil to its normal shape if you find such distortions. If the coil is distorted beyond recovery, you may need to replace it with a new one.

Check the temperature sensor: If the temperature sensor fails to send a reading to the processor or sends an inaccurate reading, the induction cooker can operate even in an overheated situation. Procedures for the testing and replacement of the temperature sensor are given in section 6.7.

Check the fan: If the fan is not moving, the cooker overheats due to improper ventilation. Go to the section 'internal fan does not move' to troubleshoot this issue.

6. Buttons don't work or are too difficult to press

If the buttons on the control panel are too hard to press, most probably they are damaged and you may need to replace them. On the other hand, If the cooker's settings don't change on pressing the buttons, the issue may be with the buttons or the cable that connects the control board to the power board.

Check the switches: If the switches are damaged, control signals cannot pass from the control board to the power board. Take the switches out of the control board and test the continuity between its pins with a multimeter. When the button is pressed the multimeter should indicate a short circuit whereas it should indicate an open circuit when the button is released. If this is not the case, replace the switch with a new one. If the buttons are too hard to press, replace the push button switches with new ones.

Check the connector cable: See if the connector cable between the power board and the control board has any breakage. Test continuity if the breakage is not visible from the outside. Replace the cable if it has a discontinuity.

6. Component Testing

In this chapter, we will discuss in detail the procedures for testing components and points to consider before their replacement. It is to be noted that the components to be tested should be detached from the PCB while testing. The results or values obtained when the component is connected to the PCB may differ from those obtained during testing conducted under detached conditions. Considering that a normal repair shop may not have access to sophisticated testing devices, the testing methods discussed in this chapter deal with the use of a multimeter in testing and troubleshooting. While a multimeter is good enough for testing components like fuses and resistors, it is not ideal for testing other components like capacitors. In such scenarios, the theoretical knowledge of these components could help a great deal.

6.1 IGBT

The IGBT can fail due to high voltage, high current, excessive heat, and other factors. This can lead to IGBT short circuits, or it may not function properly. Additionally, problems with IGBT can occur due to the accumulation of dust or moisture. The majority of problems seen in induction cooktops (more than 80%) are caused by faults in IGBT.

Testing of IGBT through visual inspection

A broken, burnt, melted, or cracked IGBT can be identified just by looking at it from the outside. In addition, any loosened or broken pins can also be detected through external inspection.

Figure 26: Damaged IGBTs

Testing of multimeter using IGBT

There are three pins in an IGBT: Gate (G), Collector (C), and Emitter (E). The process of testing IGBT using a multimeter is given below:

First, correctly identify the pin configuration of the IGBT. Usually, when you hold the IGBT with the raised portion facing towards you, the pins from left to right are Gate(G), Collector(C), and Emitter(E) respectively.

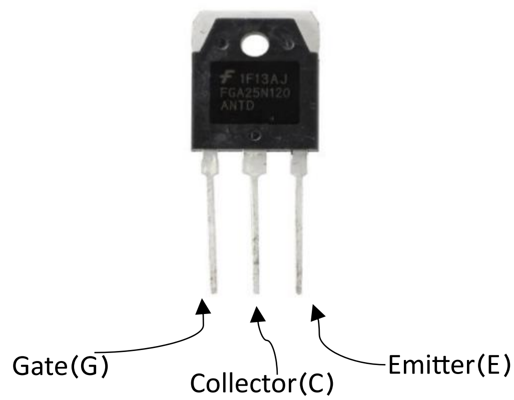


Figure 27: IGBT Pinouts

However, the best way to find out the correct pins is to Google search for the model number of the IGBT. The model numbers are written on the surface of IGBTs. For example, if the model number of your IGBT is 'KGF25N120KDA', you can Google search for 'KGF25N120KDA pinouts'.

1) Connect the black probe of the multimeter to the voltage port (VΩ) and the red probe to the common port (COM), and set the multimeter to diode mode.

2) Now, connect the red probe of the multimeter to the emitter pin (E) of the IGBT, and the black probe to the collector pin (C) of the IGBT. Doing this, if you see a specific reading on the multimeter (usually between 300 and 800), as shown in Figure 29, will ensure a proper connection between the C and E pins of the IGBT. For additional testing procedures, refer to process number 4. Otherwise, if the multimeter indicates an open circuit as shown in Figure 32, or a continuity as shown in Figure 33, it means the IGBT is faulty. When indicating continuity, the multimeter will produce a 'beep' sound and the LED will also light up. In the case of an open circuit, the multimeter will display 'OL' or '1' on the screen.

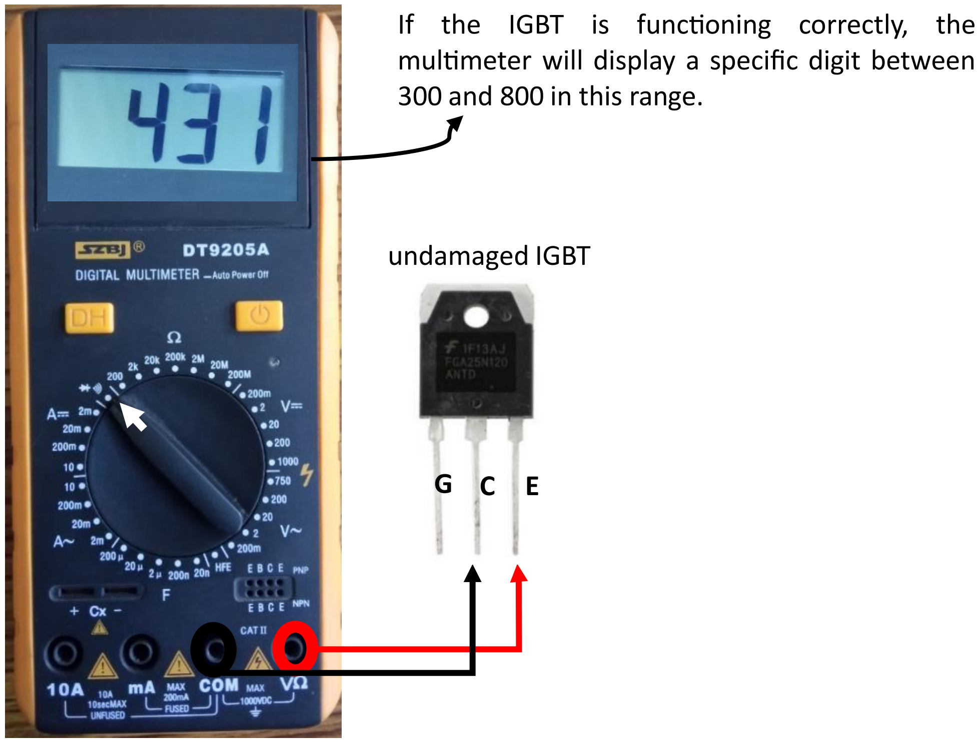


Figure 28

Please note that the number seen on the display is voltage in millivolts. So, if a different multimeter is used that shows diode voltage in volts instead of millivolts, this number can fall between 0.3 and 0.8.

1) Now, connect the red and black probes of the multimeter to any other two pins of the IGBT. If the IGBT is functioning properly, the multimeter will indicate an open circuit, as shown in Figure 32. If you see any numbers on the multimeter's display or if the multimeter indicates continuity, it means the IGBT is defective and needs to be replaced.

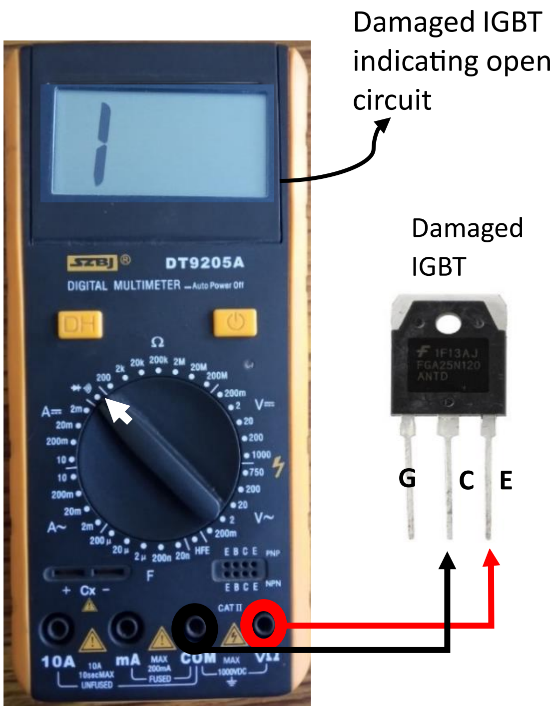


Figure 29

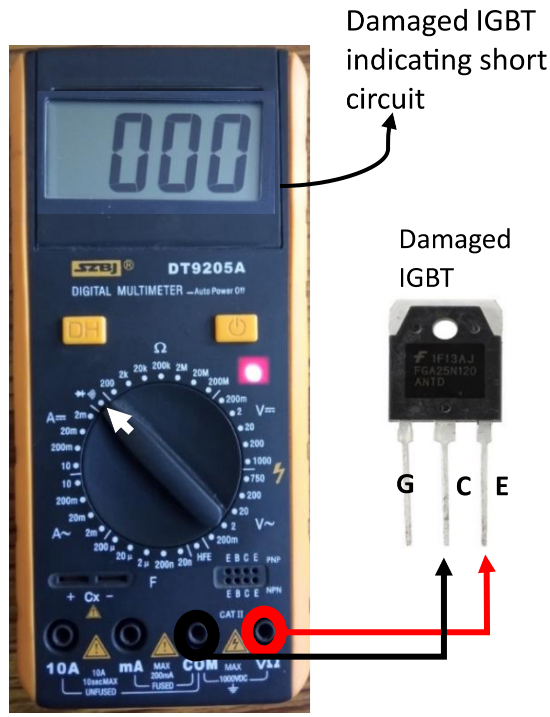


Figure 30

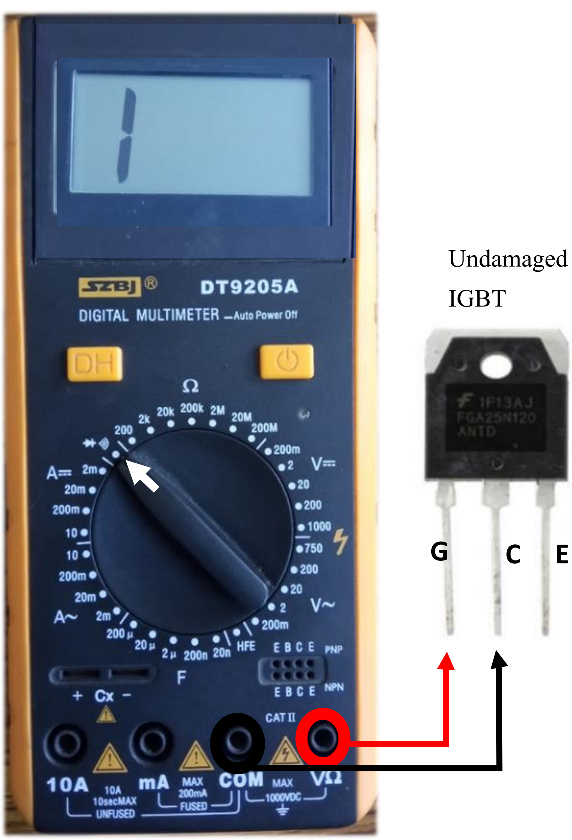


Figure 32

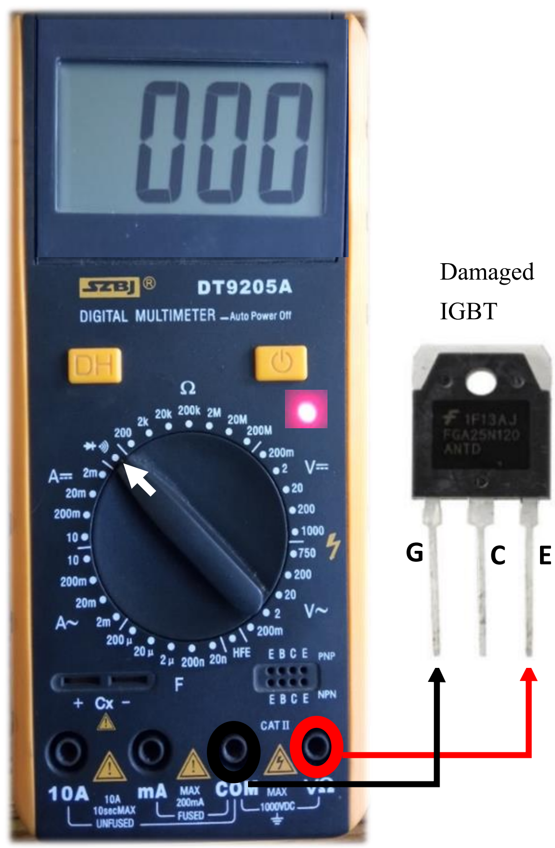


Figure 33

Points to be considered when replacing an IGBT

1) Before replacing a damaged IGBT, take note of its ratings. Ensure that the rating of the new IGBT matches or is better than the old one. Typically, you should check the voltage, current, and power ratings of the IGBT. For example, if the current rating of the old IGBT is 20 amperes, the new one should also have a current rating of 20 amperes or higher.
2) While most IGBTs have the same sequence of G, C, and E pins, there can be variations. Therefore, ensure you verify the pin configuration of the IGBT you have on hand before making the replacement.
3) Apply a sufficient amount of thermal paste between the surface of the IGBT and the heat sink. This helps in efficient thermal dissipation, allowing the IGBT to dissipate heat generated during operation more effectively.

6.2 Fuse

When an overload or short circuit occurs, fuses can potentially blow. Often, a melted fuse can be identified from external inspection. In a blown fuse, the wire inside may have melted or disconnected, and there could also be a black mark inside the fuse holder glass.

Figure 31: Blown Fuse

Testing of fuse using a multimeter

1) Connect the black probe of the multimeter to the voltage port (VΩ) and the red probe to the common port (COM) of the multimeter. Set the multimeter to continuity mode.
2) Now, as shown in Figure 36, place the black and red probes of the multimeter on the two terminals of the fuse. If the fuse is intact, the multimeter will indicate continuity. If the multimeter detects an open circuit or displays any significant reading, it means the fuse has melted.

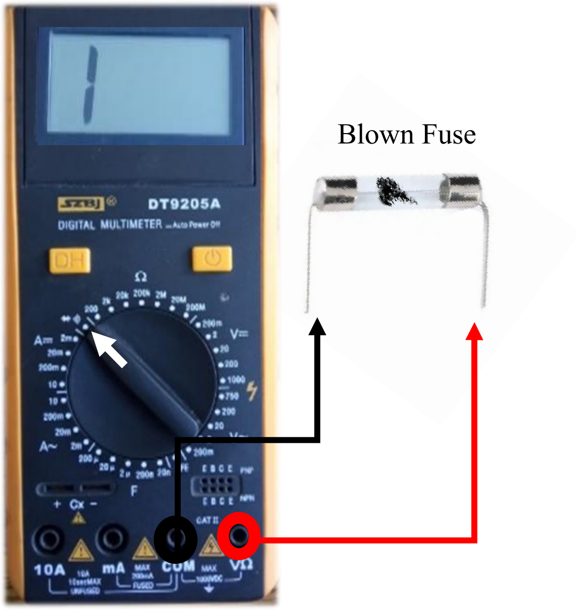


Figure 33

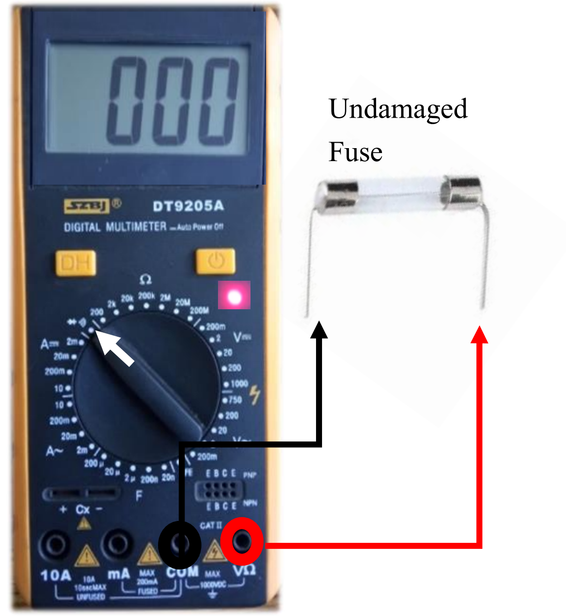


Figure 32

<u>Points to be considered when replacing a fuse</u>

The current rating of the new fuse should be equal to that of the old fuse. For example, if the old fuse has a rating of 10 Amp, the new fuse should also have a rating of 10 Amp. If the rating is lower than the old one, unnecessary fuse-blowing problems may occur. On the other hand, if the rating is higher than the old one, the fuse may not blow even when an excessive current flows through.

6.3 Induction Coil

Most of the time coils inside the induction stove burn due to excessive heat. A burnt coil can usually be identified from external inspection. Also, the coil may not function if its two terminals are short-circuited. Additionally, loose connections between the coil and the power board can lead to terminal overheating or a coil not functioning properly. The coil may appear fine upon external inspection but if there are concerns about it being broken or damaged somewhere, a multimeter can be used for testing.

Figure 34: Burnt Induction Coil

Testing of Coil Using a Multimeter

1) Connect the red probe of the multimeter to the voltage port (VΩ) and the black probe to the common port (COM), then set the multimeter to continuity mode.
2) Now, as shown in Figure 38, place the red and black probes of the multimeter on the two terminals of the coil. If the coil is functioning properly, the multimeter will indicate continuity. If the multimeter signals an open circuit or displays a large number on the screen, it indicates that the coil is broken.

Figure 35: An undamaged coil indicating a short circuit

6.4 Bridge Diode Rectifier

Causes such as overloading or excessive heat can lead to the failure of bridge diodes. Damaged, corroded, or burnt, bridge diodes can be identified from external inspection alone.

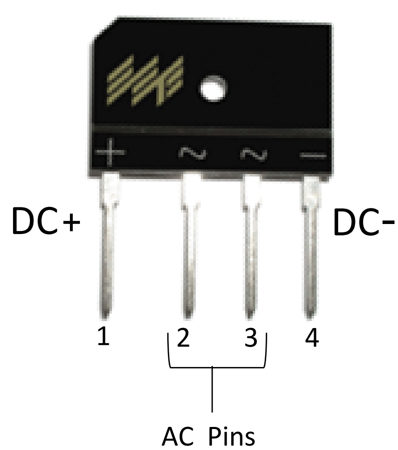


Figure 36: Pins of a Bridge Diode Rectifier

Testing a Bridge Diode Rectifier Using a Multimeter

Bridge diodes have four pins. The middle two pins (2 and 3) provide AC voltage, while the outer two pins (1 and 4) deliver DC voltage. The process for testing the rectifier using a multimeter is as follows:

1) Connect the red probe of the multimeter to the voltage port (VΩ) and the black probe to the common port (COM), then set the multimeter to diode mode.
2) Place the red probe of the multimeter on pin number 2 of the bridge diode and the black probe on pin number 3. If the diode is functioning correctly, the multimeter will indicate an open circuit.
3) Next, place the black probe of the multimeter on pin number 2 of the bridge diode and the red probe on pin number 3. If the diode is functioning correctly, the multimeter will indicate an open circuit.

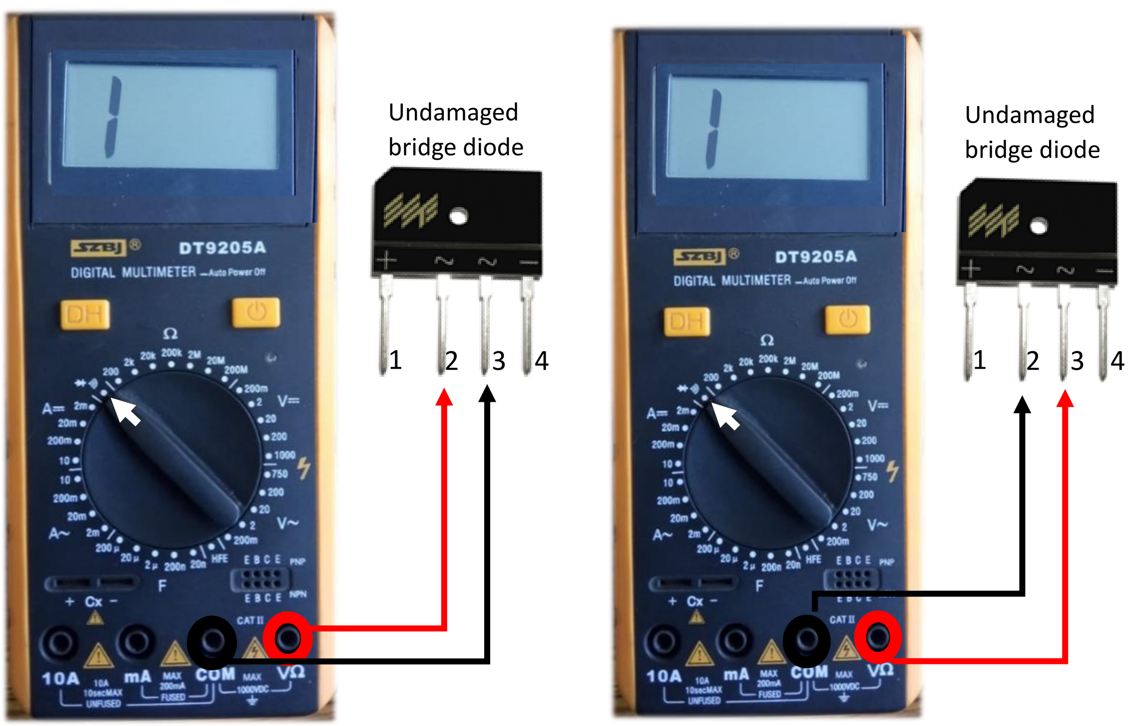


Figure 37: Undamaged rectifiers indicating the open circuit between the AC pins

4) Now, place the red probe of the multimeter on pin number 1 (+) of the bridge diode and the black probe on pin number 4 (-). If the rectifier is not damaged, the multimeter will indicate an open circuit, as shown in Figure 31.

Figure 38

1. Now, place the red probe of the multimeter on pin number 4 (-) of the bridge diode and the black probe on pin number 1 (+). If the diode is not damaged, the multimeter will display a

Figure 39

specific number, as shown in Figure 42. Typically, this number falls within the range of 800 to 1500.

2. The rectifier can also be tested by performing the diode test between the DC and AC pins. By doing so, the multimeter will indicate an open circuit in one direction, while in the other direction, it will display a specific reading (typically between 300 and 800).
   For example, if you place the red probe of the multimeter on pin 1 (+) of the bridge diode and the black probe on pin 2, the multimeter will show an open circuit. Conversely, if you place the black probe on pin 1 (+) of the bridge diode and the red probe on pin 2 (-), the multimeter will display a specific reading.

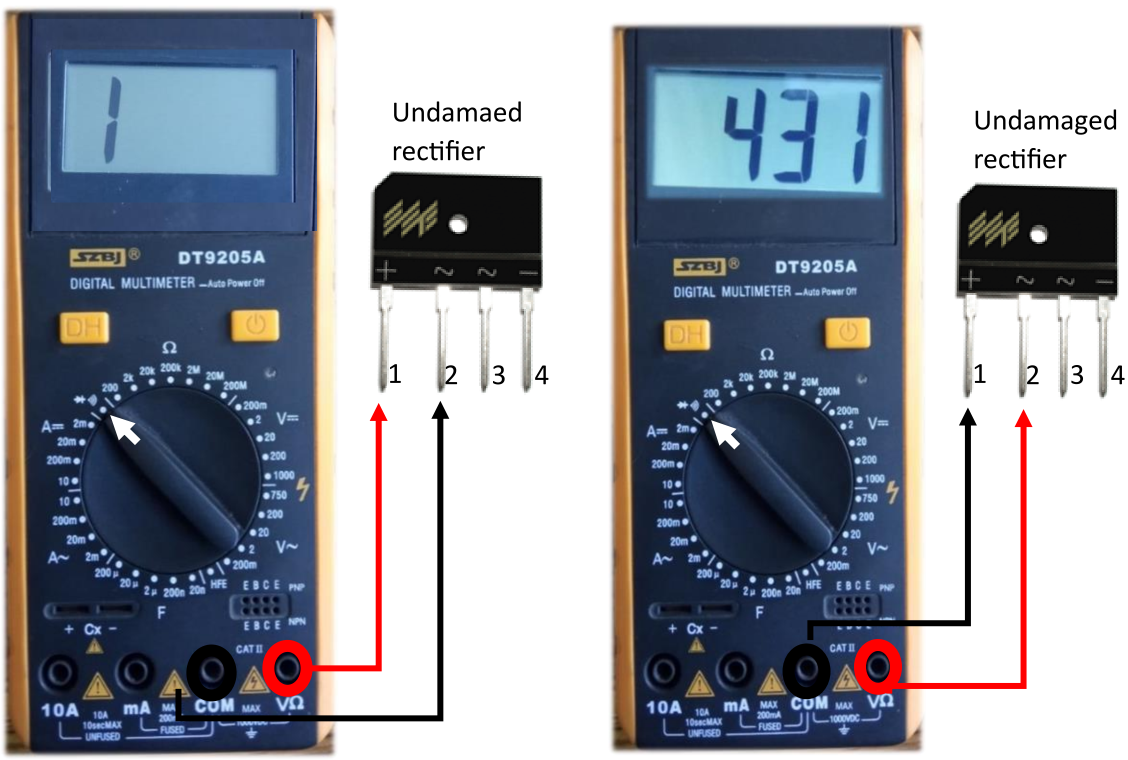


Figure 40: Testing of rectifier using DC and AC pins

Points to be considered when replacing a bridge diode rectifier

1) When replacing a new rectifier, its rating should be the same as or better than the old one. Rectifiers typically have voltage, current, and power ratings. For example, if the old rectifier has a current rating of 20 amperes, the new rectifier should also have a current rating of 20 amperes or higher.

2) While most bridge diodes have the same sequence of DC and AC pins, there can be variations. Therefore, verify the pin configuration of the diode you have on hand before making the replacement.
3) When installing a new rectifier, ensure to apply enough thermal paste between it and the heat sink. This helps dissipate the heat generated by the rectifier.

6.5 Capacitor

In a broken capacitor, it can be seen whether it is bulging or leaking from the outside.

The process of determining the value of a capacitor from external inspection

Electrolytic capacitors have their value written on the surface. For example, in the capacitor shown in Figure 44, the value is marked as 1800 microfarads (µF).

Figure 41: Electrolytic Capacitor

Figure 42: Ceramic Capacitor

Similarly, for ceramic capacitors, you need to calculate the value based on the number written on the surface. For example, in Figure 45, the ceramic capacitor is marked as 103. In this case, if you place a number of zeros indicated by the third digit behind the numbers indicated by the first two digits, you will determine the value of the capacitor in picofarads (pF). Therefore, the value of this capacitor is 10,000 picofarads (pF) or 10 microfarads (µF).

Testing Capacitors using a Multimeter

Some multimeters have a special feature that allows you to test capacitors directly. As shown in Figure 46, if there are ports for testing capacitors in the multimeter, you can insert the two pins of the capacitor into these two ports (matching the polarity in case of electrolytic capacitor). By doing this, the multimeter measures and displays the capacitance of the capacitor, and if the measurement approximately matches the value written on the capacitor, it means the capacitor is working correctly. However, if there is a significant difference between the two measurements, it indicates that the capacitor is faulty.

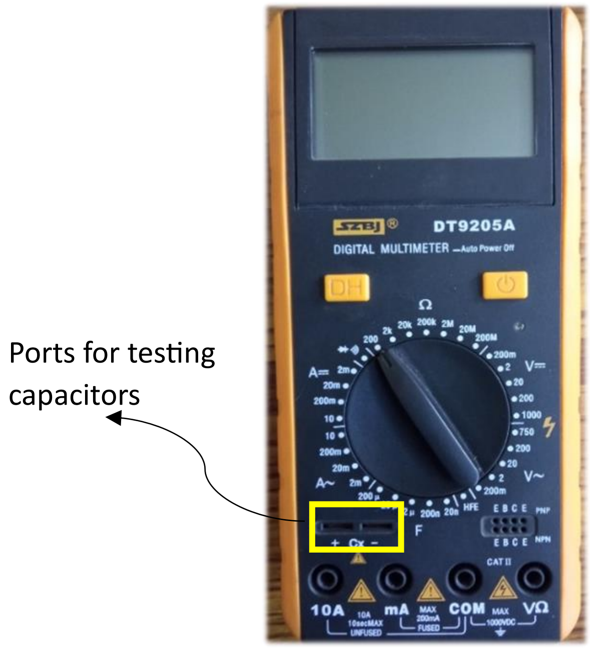


Figure 43: Multimeter with a feature for testing Capacitors

If the multimeter does not have the capability to directly test capacitors, you can still troubleshoot using the resistance test method. However, this method may not accurately determine whether the capacitor has undergone a change in value or not. Therefore, even if it appears that the capacitor is intact using this method when it is actually faulty, it may cause the power board or the UI electronics board to deviate from their normal operation and also cause the stove to malfunction.

Testing a capacitor from resistance testing method

1) Connect the red probe of the multimeter to the voltage port (VΩ) and the black probe to the common port (COM) of the multimeter. Set the multimeter to the resistance mode so that it can measure a high resistance (typically above 1 MΩ).
2) Place the red and black probes of the multimeter on the two pins of the capacitor. When you do this, if the capacitor is functioning correctly, the multimeter will initially display a number that increases over time. After some time, the rate of change of the displayed number decreases, and eventually, it will settle on a single value.

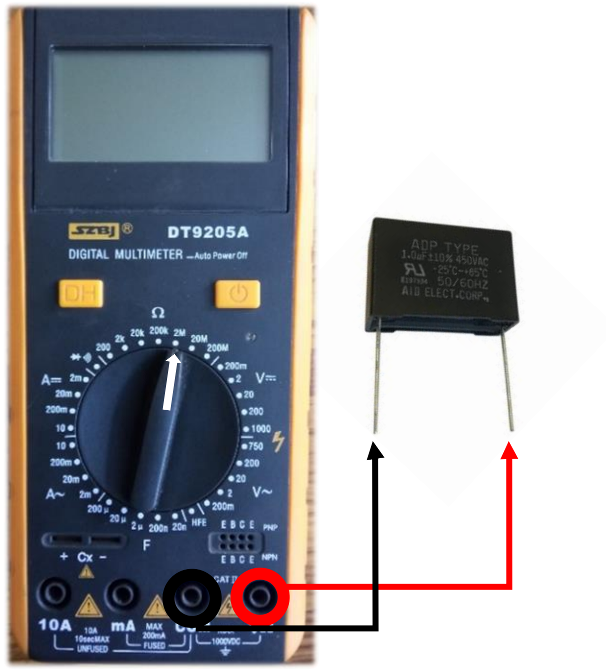


Figure 44: Testing of capacitor using resistance method

Points to be considered when replacing a capacitor

1) The capacitance value of the new capacitor should be equal to or very close to the value of the old capacitor. Capacitance is measured in microfarads (µF), nanofarads (nF), or picofarads (pF).
2) The voltage rating of the new capacitor should be equal to or higher than the old one. Using a capacitor with a lower voltage rating can lead to failure or safety hazards.
3) If the old capacitor has + and - pins marked, make sure to replace the new capacitor that also has the polarity mentioned. Ensure that the new capacitor's pins are in the correct positions.

6.6 Resistor

Resistors that are burned or broken can be identified from external inspection.

Testing resistors using a multimeter

If you already know the resistance value of the resistor you are testing, you can easily test it using the multimeter. However, if you do not know the resistance value, you need to determine it by examining the color bands on the resistor.

Determination of resistance from color bands

Resistors have four or five color bands. Each color corresponds to a specific numerical value, as shown in figure 48.

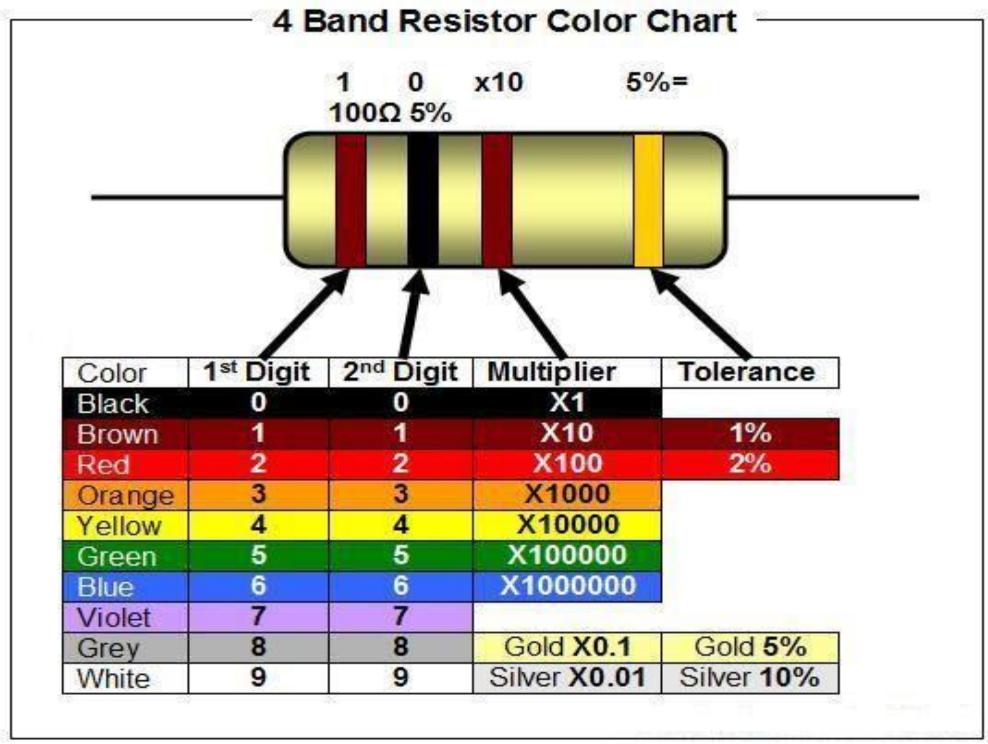


Figure 45: Resistor Color codes

Image Source: https://in.pinterest.com/pin/414401603183261574/

Now you can calculate the resistance value using the following procedure:

1) Handle the resistor with a silver or gold color band on the right. If the resistor doesn't have these bands, you need to measure the distance between the extreme color bands to their nearest pins. As shown in Figure 48, the gap between the last band and its nearest pin is greater than the gap between the first pin and its nearest pin.
2) Now, starting from the left, write down the digit represented by the first color band. In Figure 46, the first band is brown, so write down the digit '1'. Then, for the second band, which is black in this case, write down '0' because black represents '0'. Next, multiply this number by the value represented by the third band. In the example shown, since the third band is brown, multiply the number by '10'. In the example shown, multiplying '10' by '10' gives you a value of '100Ω', which is the actual value of the resistor.
3) The fourth band indicates how much the actual value of the resistor may vary from the calculated value using the above method. In the example shown, the last band is gold,

indicating that the actual value of the resistor can vary by 5% (from 95Ω to 105Ω if the calculated value is 100Ω).

Once you have determined the actual value of the resistor, the process for checking its value using a multimeter is as follows:

1) Connect the red probe of the multimeter to the voltage port (VΩ) and the black probe to the common port (COM) on the multimeter. Set the multimeter to the resistance mode (ohms or Ω). When in the resistance mode, set the meter to measure a value just above the actual resistance of the resistor.
2) Place the red and black probes of the multimeter on the two pins of the resistor. When you do this, if the resistor is not damaged, the multimeter will display a value close to the actual resistance value. If the resistor is damaged, the multimeter will indicate a short circuit, an open circuit, or a resistance value that is significantly different from the actual value of the resistor.

Figure 46: Measurement of resistance using a multimeter

<u>Points to be considered when replacing a multimeter</u>

1) The resistance of the new resistor should match that of the old resistor.
2) The power rating of the new resistor should be equal to or greater than the power rating of the old resistor.

6.7 Temperature Sensor

Temperature sensors can get damaged due to ageing, physical erosion, or electrical surges. If you detect physical defects, replace it with a new one. If not, you can test with the help of a multimeter.

Testing thermistor with the help of a multimeter

1) Connect the black probe of the multimeter to the voltage port (VΩ) and the red probe to the common port (COM) of the multimeter. Set the multimeter to continuity mode.
2) Now, as shown in Figure 50, place the black and red probes of the multimeter on the two terminals of the thermal fuse. If the multimeter indicates continuity, the thermistor is short-circuited from the inside and needs replacement.

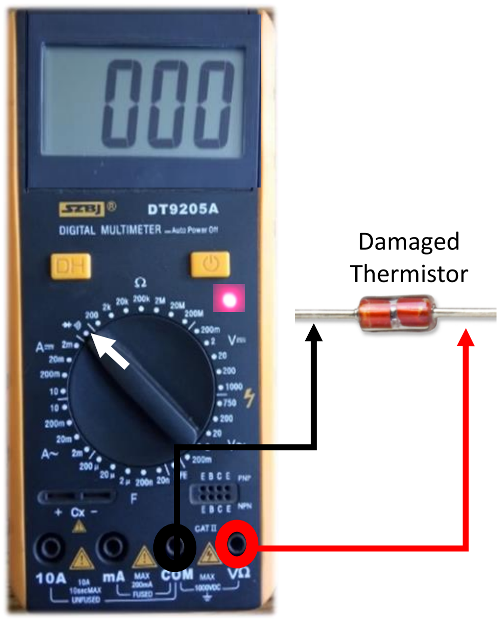


Figure 47: A damaged thermistor indicating a short circuit

3) Now, set the multimeter in resistance mode (typically above 100K) and place the black and red probes of the multimeter on the two terminals of the thermistor. If the thermistor is not damaged, the multimeter should display a certain resistance. While keeping the probes of the multimeter at its two terminals, gently heat the surface of the thermistor with a lighter (however, avoid the flames touching its surface). In doing so, its resistance should start falling sharply. If the resistance value doesn't change or changes very slowly, the thermistor is probably damaged and needs replacement.

Points to be considered when replacing a temperature sensor

1) The type of a new thermistor should be the same as that of the old thermistor. For example, if the old thermistor is of negative temperature coefficient type(NTC), the thermistor must also be of NTC type.
2) The resistance value of a new thermistor should be equal to that of the old thermistor at normal temperature and both of them should have the same operating range.

6.8 Power Cable

Using a multimeter, you can easily test whether the power cable is functioning correctly or not. In instances where the cable is burnt, disconnected from the power board, or damaged in any way, such issues can be identified through external inspection.

Procedure for Testing the Power Cable Using a Multimeter

In most power cables the live pin is marked as 'L' and the neutral pin is marked as 'N'. Similarly, on the other end of the cable, the live wire is indicated by a red wire, while the neutral wire is indicated by a black wire. Test continuity between the two ends of the live wire and the neutral wire. If the multimeter shows an open circuit, it indicates that the cable is broken somewhere in between.

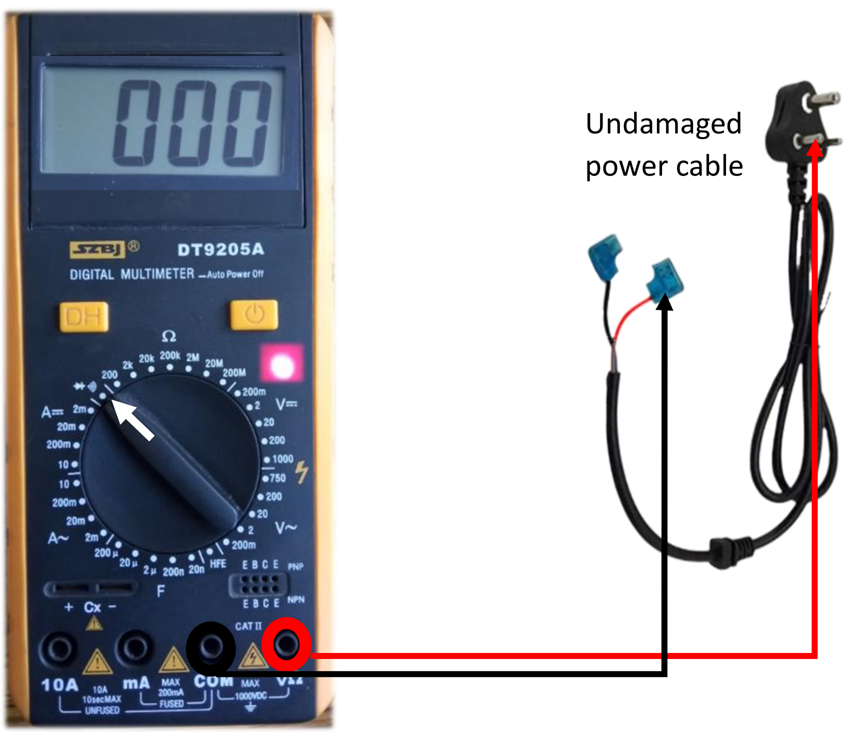


Figure 48: Multimeter indicating continuity when testing an undamaged power cable

6.9 Transistor

High voltage, high current, high temperature, and various other factors can cause the transistor to be damaged. A burnt, melted, or broken transistor can be identified from external inspection alone. In case of internal short circuits and other issues, identification may not be possible from external inspection.

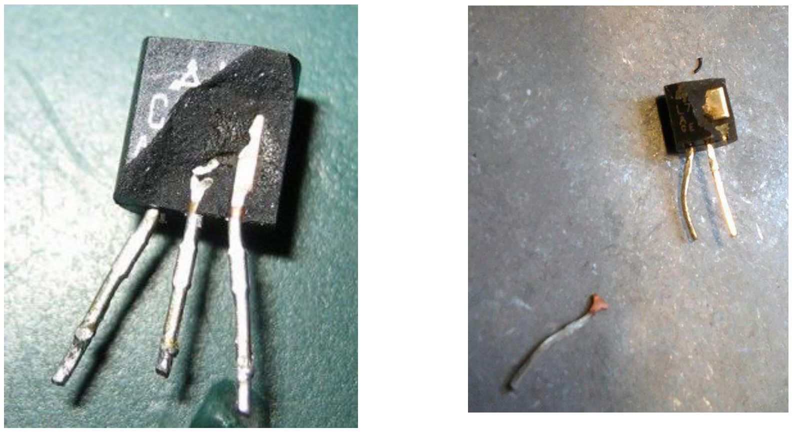


Figure 49: Damaged Transistors

<u>Testing transistor using a multimeter</u>

1) Before testing a transistor, its type and pins should be identified. Use the method provided in the introduction of the components to determine whether the transistor is NPN or PNP and also identify its base, collector, and emitter pins.
2) Connect the red probe of the multimeter to the voltage port (VΩ) and the black probe to the common port (COM) of the multimeter, and set the multimeter to diode mode.
3) If the transistor to be tested is NPN, then the result of placing the red and black probes of the multimeter on different pins of the transistor should be as given in the following table:

Red Probe 	Black Probe 	Expected Result
Base	Emitter	The multimeter should show a particular number (Fig. 50). If the transistor is damaged, the multimeter will indicate a short circuit or an open circuit.
Base	Collector	The multimeter should show a particular number (Fig. 51). If the transistor is damaged, the multimeter will indicate a short circuit or an open circuit.
Emitter	Base	The multimeter should indicate an open circuit (Fig. 52)
Emitter	Collector	The multimeter should indicate an open circuit (Fig. 53)
Collector	Base	The multimeter should indicate an open circuit
Collector	Emitter	The multimeter should indicate an open circuit

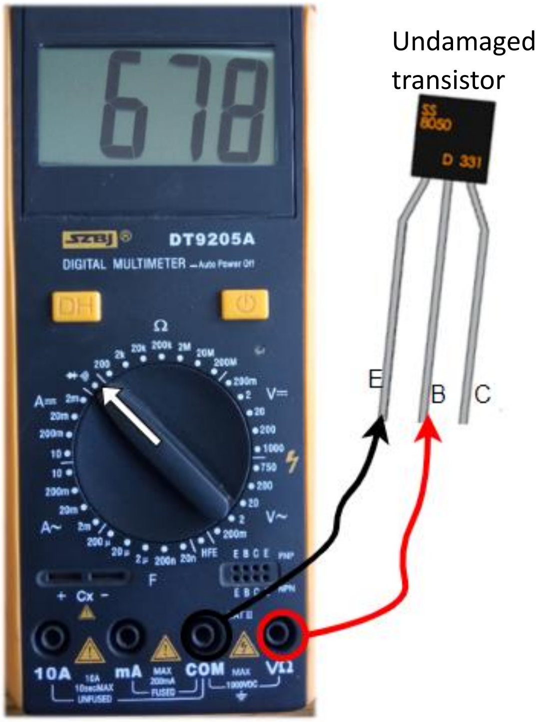


Figure 50

Figure 51

Figure 52

Figure 53

4) If the transistor to be tested is PNP, then the result of placing the red and black probes of the multimeter on different pins of the transistor should be as given in the following table:

Red Probe	Black Probe	Expected Result
Emitter	Base	The multimeter should show a particular number (Fig. 54). If the transistor is damaged, the multimeter will indicate a short circuit or an open circuit.
Collector	Base	The multimeter should show a particular number (Fig. 55). If the transistor is damaged, the multimeter will indicate a short circuit or an open circuit.
Base	Collector	The multimeter should indicate an open circuit (Fig. 56)
Emitter	Collector	The multimeter should indicate an open circuit (Fig. 57)
Base	Emitter	The multimeter should indicate an open circuit
Collector	Emitter	The multimeter should indicate an open circuit

Figure 54

Figure 55

Figure 56

Figure 57

<u>Points to be considered when replacing a multimeter</u>

1) If possible, use a transistor with the same model number as the old diode. If you can't find the same model number, use a new transistor with similar or better ratings than the old one. Check for specific parameters such as voltage, current, and power ratings. You can search for alternative parts on the website <u>https://alltransistors.com/</u>
2) If the old transistor is NPN, the new one should also be NPN, and if the old one is PNP, the new one should be PNP as well.
3) When placing the transistor on a PCB, ensure that the emitter, base, and collector pins are connected to their respective positions.

6.10 Diode

A diode can break down due to various reasons like excessive current flow, connecting a high voltage in the opposite direction, operating at high temperature, etc. A burnt or broken diode can be identified from external inspection.

<u>Testing of Diode using Multimeter</u>

A diode has two terminals. The terminal with a silver-colored band is called the cathode, and the other terminal is called the anode. The procedure to test the diode using a multimeter is given below:

1) Connect the red probe of the multimeter to the voltage port (VΩ) and the black probe to the common port (COM) of the multimeter. Set the multimeter to the diode mode.
2) Place the red probe of the multimeter on the anode pin of the diode and the black probe on the cathode pin. If the diode is undamaged, the multimeter should display a number between 300 and 800. If the multimeter shows an open circuit or a short circuit, it means the diode is faulty and needs to be replaced.

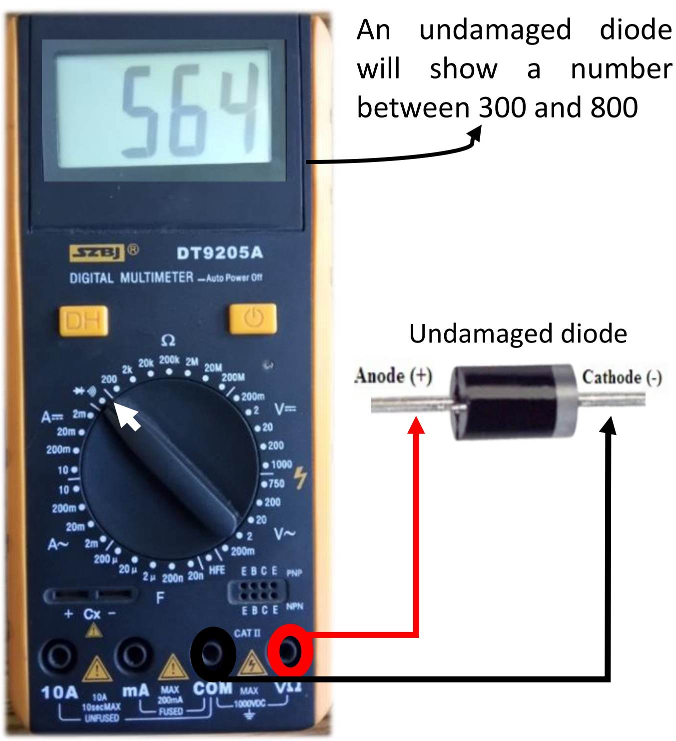


Figure 58: Test of an undamaged diode showing a specific number

3) Now, connect the black probe to the anode pin and the red probe to the cathode pin. Doing this, a good diode should indicate an open circuit.

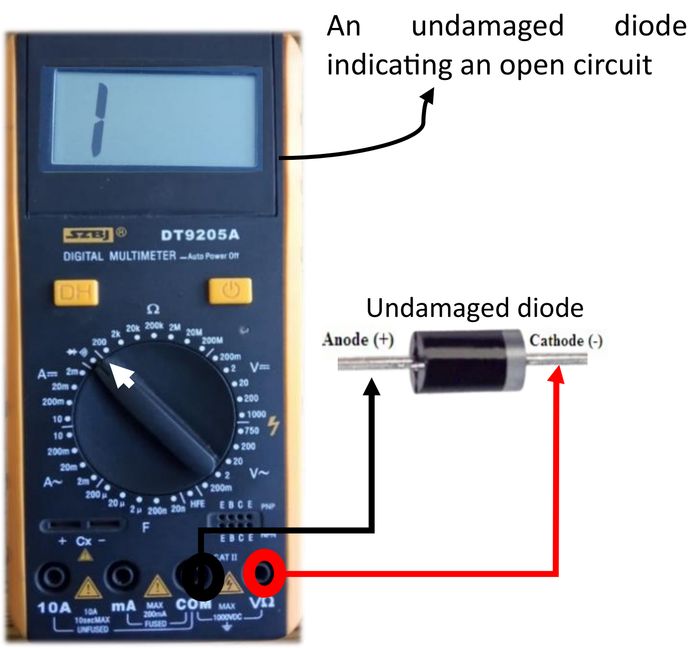


Figure 59: Undamaged diode indicating an open circuit

Points to be considered when replacing a diode

1) When possible, the model number of the new diode should match that of the old diode. If the model numbers do not match, the ratings of the new diode should be similar to or better than the old one. Diode specifications, such as voltage, current, and power ratings, should be checked.
2) Pay attention to the orientation of the diode pins. The anode and cathode pins of the new diode should be connected to the same locations as the old diode wherever they were originally connected.

7. End of Life

Electronic waste (or E-Waste) is a growing problem around the world, with more and more everyday items containing circuit boards and micro-processors. In Nepal alone, an estimated 28 kilotonnes tonnes of e-waste was generated in 2019, and this total will only increase, with the shift to e-cooking potentially adding to this burden. Any E-waste can contain materials and substances that are hazardous to both humans and the environment, but they also contain valuable resources that have the potential to be reused or sold.

Ideally, any electrical appliances (not just eCookstoves) that have malfunctioned should follow the following hierarchy:

- Repair,
- Refurbish (when several aspects of the device need attention),
- Dismantle and collect useful components for reuse in other devices,
- Separate different materials (metals, plastics, circuit board, batteries),
- Sell to material recyclers.

The next few sections explain what can be done to minimise the negative impact of e-waste and support repair and recycling in Nepal.

1. Identify and create a recommended inventory of spare parts to keep.

When undertaking repairs of e-cooking devices, keep accurate records of what the fault was, how it was repaired, and any components that needed replacing. Identifying the correct size of resistor, or capacitor and replacing like with like will reduce the likelihood of a cascade of faults that may ultimately leave the device unrepairable. For example, replacing a resistor with one of a smaller capacity may enable higher current to flow though the circuit, causing further damage or potential danger to users. A larger resistor may generate too much heat, leading to further faults in the electronic system, or potentially cause a fire.

Recording faults and knowing which are most common also helps to identify the spare parts worth keeping from broken devices to support future repairs in other devices (see table below). This requires developing the skills necessary to remove useful items from broken devices so that they can be used again, e.g. use soldering iron to melt solder to remove items from circuit boards rather than cutting them off. Circuit boards can be kept intact until spare parts are required and removed as necessary.

Useful spare parts to keep for common repairs and sales
Induction Stove
- IGBT - Push button switch - Coil - Universal board

2. Extraction of valuable components and raw materials.

Single materials can be sold on to material recyclers at a higher price, so it is good practice to separate materials where possible. For example, different metals (copper, aluminium, steel) have different market values. Stripping off the plastic covering for wire using wire strippers (not burning) can also help reduce toxic air pollution.

- Magnets can be useful for identifying most steel items (they are magnetic),
- Aluminium can be identified through its lighter weight, and it is non-magnetic,
- Magnesium can be identified by putting a small drop of a mild acid (like vinegar) on the surface, it will bubble and fizz. Aluminium will not fizz.
- Copper, by its colour

3. Good practices for the environment.

There are a few activities that can reduce impact on the environment as follows:

- Create a community database of common part failures to inform the wider local repair network of best practise in repair. Overtime, it will become clear which components most usually need repair/replacement and suitable stockpiles can be created.
- Combine local repair network resources to purchase more expensive repair items, such a wire stripping tools, small plastic shredders and multi-meters.
- Consider combining waste materials within the repair network, to get a better bulk price from material suppliers.
- Be careful when dismantling cooking devices and minimise breakages to external components when accessing inner workings/parts. This will increase the number of devices that can be returned to useful service.
- Make sure all the screws and components are replaced correctly in re-assembly, as this will reduce opportunity for other failures to occur.
- If a device cannot be repaired, strip all useful components and separate materials. Do not throw a device away, or attempt to burn it. Inappropriate disposal of e-waste can contaminate Nepal's environment and drinking water and cause health issues.

4. Contact points for advice.

There are a number of places where further information regarding end of life disposal can be found.

- Local government waste operators
- Device Manufacturers
- Doko Recyclers:
  - E-waste Research and Project Team: 9801104497
  - E-waste Management Team:
  - 9802330381, 9802330382

Appendix 1

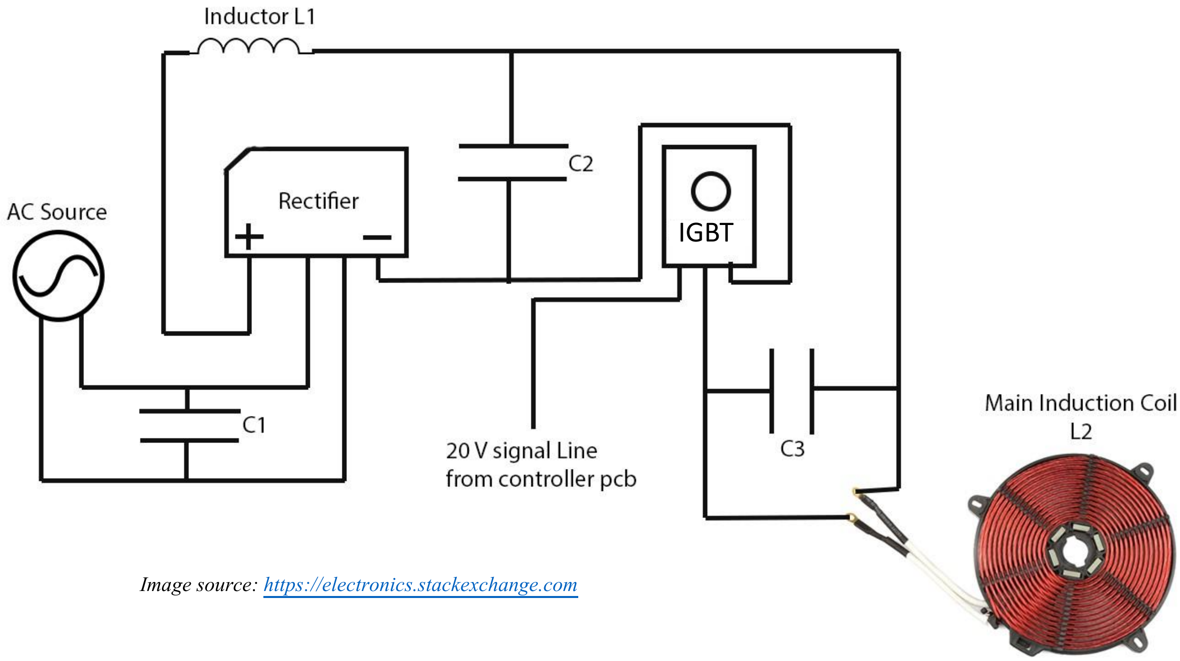
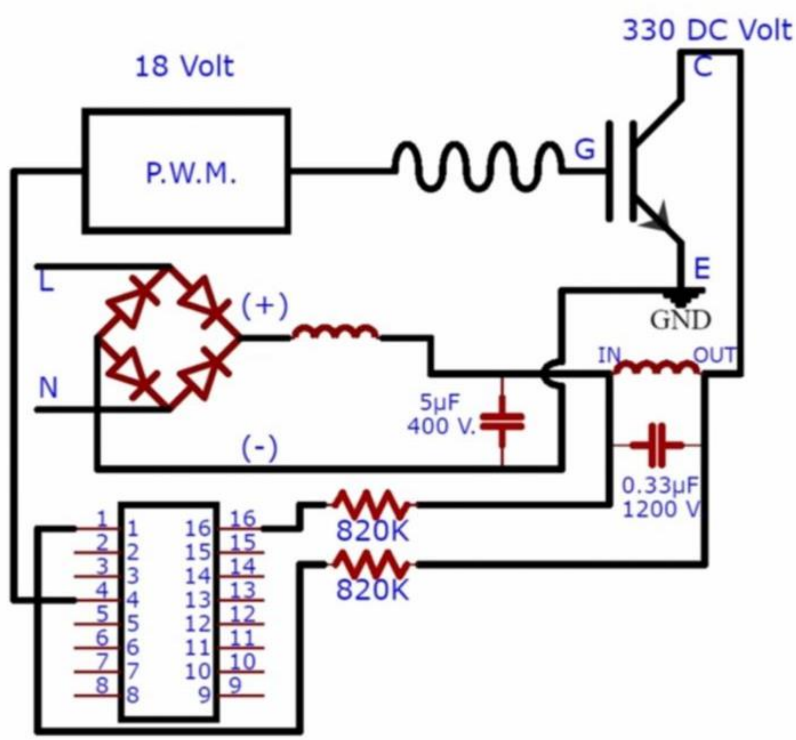


Image source: https://electronics.stackexchange.com

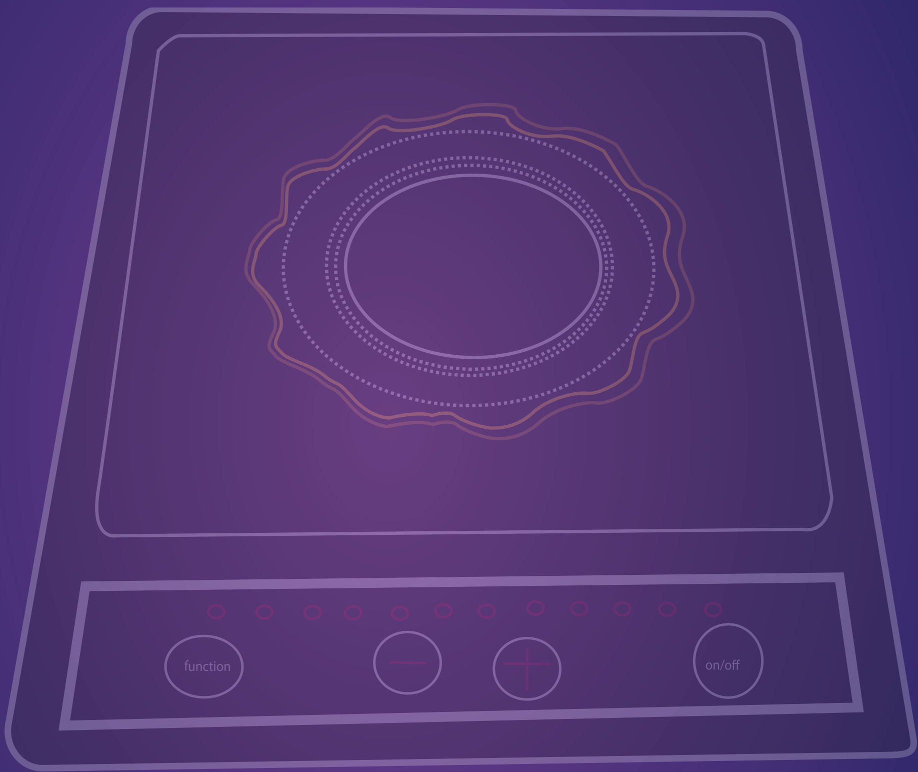
Appendix 1(a): A block diagram depicting the connection among the major components of the induction cooker's internal circuit.



Appendix 1(b): Connection among the main IC and other components of the power board

ABOUT PEEDA

People, Energy & Environment Development Association (PEEDA) is an NGO established in 1997 for the enhancement of the renewable energy sector in Nepal. PEEDA aims to mobilize local as well as external resources to harness the indigenous resources of the country and promote rural economic development. PEEDA focuses mainly on institutional development, participation with stakeholders at the grass root level in development activities, research, and lobbying for policy change



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