

Diagnostic and Troubleshooting System for Electrical Appliances

Field of Invention

The present invention relates to a comprehensive diagnostic system and process for monitoring and troubleshooting electrical appliances. More particularly, the invention relates to a comprehensive diagnostic system and process configured to monitor and troubleshoot issues in electrical appliances such as air conditioners, refrigerators and washing machine.

Background

There exists a wide array of methods and tools used in electronic appliances for diagnosing and repairing that involve basic testing methods like continuity testers and clamp meters, brand-specific testing jigs, and hit-and-trial methods by service partners. These methods and tools are not limited to Air Conditioner, Refrigerator and other electronic appliances. There is an increased demand for efficient and effective diagnostic and repair solutions for appliances. Performance and maintenance cost is also questionable when there is any kind of such service given.

With the available solution of diagnosis tools, repair times are often prolonged, leading to inconvenience for the customer and increase in cost for the service provider. In addition, the repeated visits by the service provider, impacts the overall repair time and cost. There is another problem relying solely on hit-and-trial methods by service partners that may not always yield accurate results, leading to ineffective repairs and potential dissatisfaction among customers.

Additionally, the problem with poor customer service makes worse the situation, as customers may experience delays in getting their appliances repaired or receive inadequate support and thus impacts the reputation and trustworthiness of service provider. As such, addressing these issues and improving customer practices are crucial for enhancing the overall repair experience and maintain customer loyalty.

State of the art also suggested basic testing methods like continuity testers and clamp meters, brand-specific testing jigs, and hit-and-trial methods by service partners. However, these methods do not provide a comprehensive solution for diagnosis and rectification of the problems in electrical appliances. Some of the drawbacks include limited diagnostic capabilities, brand-specific solutions, and inefficient repair processes. It is difficult to use a single device which makes the diagnostic process easy for all models and brands universally.

Take, for example, the utilization of gas back pressure in certain diagnostic systems for detecting gas leakage within air conditioning systems. This method entails monitoring pressure variations within the system to flag potential leaks. While this approach yields results to some degree, its efficacy is not absolute, as it may fail to precisely pinpoint the exact location of leaks. Moreover, its accuracy can be compromised by external factors like temperature fluctuations, introducing the possibility of diagnostic inaccuracies. Among these tools, pressure gauges are the most often used. These devices, available in both analog and digital formats, are connected to different points within the HVAC system to track pressure variations over time. Additionally, manometers, refrigerant leak detectors, and combustible gas detectors are also utilized, either individually or in combination, to conduct comprehensive gas pressure detection tests. But, while gas pressure detection can be a valuable diagnostic tool, it should be complemented with additional methods for a comprehensive assessment of the system's integrity due to various external factors influencing the results.

In addressing these challenges, the industry has witnessed the emergence of brand-specific solutions also like the Samsung SmartThings HVAC Automation Kit, often referred to as the Hass Kit. This offering is tailored specifically for Samsung appliances, furnishing users with advanced control and automation capabilities for their heating, ventilation, and air conditioning systems. Through a dedicated smartphone app, users can remotely monitor and adjust settings. However, one drawback of the Hass Kit lies in its compatibility limitations, as it may not seamlessly integrate with non-Samsung HVAC systems, potentially impeding its widespread adoption across brands and different types of air conditioner types.

Summary

The present invention relates to a comprehensive diagnostic system and process configured to diagnose and troubleshoot issues in electrical appliances such as air conditioners, refrigerators and washing machine. The diagnostic system helps in reducing repair time and effort, empowering service partners, enhancing customer experience, and fostering transparency in diagnostics and repairs.

It is an object of the present invention to provide comprehensive diagnostic support for electrical appliances, not only based on the conventional technology but also based on the modern and latest technology appliances.

It is another object of the present invention to reduce repair time and effort by up to 80%.

It is yet another object of the present invention to provide step-by-step guidance, intuitive features, and the ability to handle complex diagnostics and repairs.

It is yet another object of the present invention to enhance transparency in diagnostics and repair processes to foster customer trust and satisfaction.

The aforesaid objects of the present invention are achieved by the present diagnostic system. The diagnostic system is a sophisticated diagnostic tool designed to cater to the needs of both inverter and non-inverter air conditioners (ACs), refrigerators (RW), and washing machines (WM). It integrates advanced features and functions to streamline the diagnostic process and facilitate efficient repairs.

According to an embodiment, the present invention discloses a refrigerant monitoring unit for an electrical appliance. The refrigerant monitoring unit comprises a current sensor for measuring a current value drawn by a compressor, a controller configured to process the current value and provide an output in relation to the refrigerant level, and a display for indicating a refrigerant level in the electrical appliance based on the current value drawn by the compressor. The display indicates that the refrigerant level is sufficient if the current value is equal a first predefined threshold, and the display indicates that the refrigerant level is insufficient if the current value is lower than a second predefined threshold.

In an embodiment, the display indicates that the refrigerant level is not optimal if the current value is between the first predefined threshold and the second predefined threshold. The display indicates that the refrigerant level is sufficient if the current value drawn by the compressor reaches the first predefined threshold and remains stable for a period of 10 to 20 seconds, preferably 15 seconds. The display indicates that the refrigerant level is insufficient if the current value drawn by the compressor remains below the second predefined threshold for a period of 5 to 15 minutes, preferably 10 minutes. The display indicates that the refrigerant level is not optimal if the current value drawn by the compressor remains between the first predefined threshold and the second predefined threshold for a period of 5 to 15 minutes, preferably 10 minutes.

In an embodiment, the controller compares the current value drawing by the compressor with the first predefined threshold and the second predefined threshold. The refrigerant monitoring unit is compatible with a variety of air conditioners. The variety of air conditioners comprise air conditioners with different tonnage, inverter air conditioners, non-inverter air conditioners and air-conditioners from different brands.

In an embodiment, the invention discloses a method for monitoring refrigerant in an electrical appliance. The method comprises measuring a current value drawn by a compressor, processing the current value, and providing an output in relation to a refrigerant level and indicating a refrigerant level in the electrical appliance based on the current value drawn by the compressor on a display. In an embodiment, the method comprises indicating that the refrigerant level is sufficient if the current value is equal a first predefined threshold and indicating that the refrigerant level is insufficient if the current value is lower than a second predefined threshold.

In an embodiment, the invention discloses a method for troubleshooting a motor of an air conditioner. The method comprises applying a trigger voltage and an input voltage to the motor for initiating rotation of a rotor, providing a feedback voltage to an optocoupler using a first microcontroller, detecting the rotation of the motor using a second microcontroller, and creating a closed circuit using a wire and indicating output on a display. In an embodiment, the method comprises indicating that the motor is defective if an input current is less than a third predefined threshold and indicating that the motor is not defective if the input current is greater than the third threshold. In an embodiment, the feedback voltage is generated at the time of rotation of the motor.

In an embodiment, the invention discloses a diagnostic system for an electrical appliance. The diagnostic system comprises a refrigerant monitoring unit configured to assess a refrigerant level in the electrical appliance, a motor troubleshooting unit configured to detect and troubleshoot a fault in at least one motor, a capacitance monitoring unit configured to detect a fault in at least one capacitor of the electrical appliance; and at least one PCB unit configured to detect a fault in one or more printed circuit boards (PCBs).

In an embodiment, the diagnostic system comprises a spare part testing unit configured to detect a fault in one or more spare parts of the electrical appliance. The spare parts comprises resistors, sensors, variable resistors and carbon composition resistors. The diagnostic system calculates electrical resistance of the one or more spare parts. If the calculated electrical

resistance value is greater than a predefined threshold value, the one or more spare part has no fault, and if the calculated electrical resistance value is less than a predefined threshold value, the one or more spare part has fault.

In an embodiment, the diagnostic system is equipped with various functionalities encapsulated within eight connector ports, namely, CN1 to CN8. Each connector port serves a specific function related to diagnosing and testing different components of the appliances.

RESISTANCE (CN1): CN1 is used for spare part cold testing (Open, Short, Ground). It facilitates the evaluation of components like power resistors, sensors, variable resistors and carbon composition resistors, by measuring their electrical resistance, which signifies the opposition to current flow. It can check resistance between 1 Ohm to 200 K Ohms.

It connects to test leads or probes, enabling direct contact with the component under examination. During testing, CN1 applies a known electrical stimulus and measures the resulting voltage across the component's terminals. Using Ohm's Law, the device calculates resistance based on the measured voltage and known current.

The measured resistance value is displayed in real-time on a dedicated device, with a specific indication of "SPARE PART OK" for resistance greater than 0.1 ohms or "SPARE PART NOT OK" for resistance less than 0.1 ohms. This threshold ensures accurate identification of faulty components.

AMPERE GAS CHECK (CN2): CN2 is used to test gas levels using ampere logic, to assess refrigerant levels in air conditioning units. By monitoring the current drawn by the compressor, we've established specific thresholds to ascertain whether there is enough gas or not in an air conditioner unit. Normal current draw suggests sufficient refrigerant, while deviations (higher or lower than normal levels) indicate potential issues. It displays if the gas level is sufficient, low or recommended. (Gas Low (< 70%): When the measured current draw falls below 70% of the expected range based on the ampere logic, it indicates that the refrigerant levels in the air conditioning unit are insufficient. This condition is labelled as "Gas Low" to signify that the system requires attention, likely indicating a need for refrigerant recharge or repair to address potential leaks. Gas Recommended (70-90%): Current draw falling within the range of 70-90% of the expected range signifies that the refrigerant levels are almost adequate and slightly below the recommended parameters. This

condition is labelled as "Gas Recommended" to indicate that the system is operating below par efficiency. It suggests that the refrigerant charge is slightly below sufficient for optimal performance)

CAPACITANCE (CN3): CN3 denotes a specific connector on the device dedicated to measuring the capacitance (in microfarads, MFD) of capacitors. Capacitors are tested for both fan and compressor units. To measure capacitance, a DC signal of 3.3V is provided across the terminals of the capacitor via the CN3 port, which charges the capacitor. During this process, the device monitors the capacitor's charging time, which is used to calculate the capacitance value. Based on the calculated capacitance value, the device determines whether the capacitor is functioning correctly or defective.

Additionally, as a part of our logic predefined acceptable ranges are provided for capacitors commonly used in air conditioners. For fan capacitors ranging from 1.5 MFD to 8 MFD and compressor capacitors ranging from 25 MFD to 70 MFD, specific thresholds are established. Capacitors falling within these predefined ranges are classified as "Capacitor OK," indicating their proper functionality. Capacitors falling outside these ranges are categorized as "Capacitor Weak," suggesting potential issues with their performance. Technicians are then guided to select the appropriate replacement capacitor based on the observed capacitance value, ensuring optimal performance and reliability of the air conditioning system.

COMMUNICATION (CN4): CN4 refers to a connector or a communication port on both the IDU (Indoor Unit) and ODU (Outdoor Unit) PCBs (Printed Circuit Boards). The communication between these PCBs is checked using a protocol or a test routine implemented in the system. If communication is functioning correctly, it indicates that the connection between the indoor and outdoor units is operating as expected. If defective, it suggests a fault in the communication pathway, which could be due to issues such as faulty hardware, loose connections, or software errors. The system will display either "PCB OK" if the communication is fine or "PCB DEFECTIVE" if there's an issue detected. Additionally, an LED will glow to indicate "Communication Pass" if the communication passes successfully, or remain off if it fails, signalling "Communication Fail".

PCB - DC OUTPUT (CN5): CN5 checks PCB DC output voltages for various components. "PCB OK" means everything is normal, "PCB DEFECTIVE" means there's an issue.

- Pcb Relay: Voltage range 5-14V for okay, below 5V for defective.

- BLDC Fan Voltage: Voltage range above 250V DC for okay, below 250V DC for defective.
- Low Volt Cap: Voltage range 4-20V DC for okay, below 4V for defective.
- High Volt Cap: Voltage range above 280V DC for okay, below 280V DC for defective.

UVW DRIVER (CN6): CN6 operates inverter compressors, UVW fan motors, and BLDC motors, displaying whether each component is working fine or defective.

- INV COMP: Okay if input current is $>1A$, not okay if current is $<1A$.
- INV MOTOR: Okay if input current is $>0.2A$, not okay if current is $<0.2A$.
- BLDC MOTOR: Okay if input current is $>0.2A$, not okay if current is $<0.2A$.

The system displays "INV COMP OK" or "INV COMP DEFECTIVE" for the inverter compressor, "INV MOTOR OK" or "INV MOTOR DEFECTIVE" for the inverter motor, and "BLDC MOTOR OK" or "BLDC MOTOR DEFECTIVE" for the BLDC motor, depending on the observed current.

BLDC MOTOR (CN7): CN7 manages BLDC 5-pin wire motors, indicating whether the motor is functioning properly or defective. It displays "BLDC MOTOR OK" if the input current is above 0.2A (okay), and "BLDC MOTOR DEFECTIVE" if the current is below 0.2A (not okay).

UVW ANALYSER (CN8): CN8 examines the Inverter PCB output for both the inverter compressor and motor windings, indicating whether each component is functioning properly or defective.

- INV PCB: "INV PCB OK" if all 6 LEDs glow, "INV PCB DEFECTIVE" if none of the LED's light up.

- MOTOR WINDING: "MOTOR WINDING OKAY" if all 6 LEDs glow, "MOTOR WINDING DEFECTIVE" if none of the LED's light up.

Brief Description of the Drawings

The present invention is described by way of embodiments illustrated in the accompanying drawings wherein:

Fig. 1 illustrates a complete block diagram of a diagnostic system comprising a first digital board (100), a second digital board (200) and a power board unit (300).

Fig. 2 shows a display of a diagnostic system with a result of a port CN1 according to an embodiment.

Fig. 3 shows a display of a diagnostic system with a result of a port CN2 according to an embodiment.

Fig. 4 shows a display of a diagnostic system with a result of a port CN3 according to an embodiment.

Fig. 5 shows a display of a diagnostic system with a result of a port CN4 according to an embodiment.

Fig. 6 shows a display of a diagnostic system with a result of a port CN5 according to an embodiment.

Fig. 7 shows a display of a diagnostic system with a result of a port CN6 according to an embodiment.

Fig. 8 shows a display of a diagnostic system with a result of a port CN7 according to an embodiment.

Fig. 9 shows a display of a diagnostic system with a result of a port CN8 according to an embodiment.

Description of the Invention

The present invention discloses a system and a process to provide a comprehensive diagnostic and repair solution for electrical appliances. In particular, the present invention provides a diagnostic system for diagnosing and troubleshooting issues, reducing repair time and effort, empowering service partners, enhancing customer experience, and fostering transparency in diagnostics and repairs of appliances.

In the present embodiment of the invention the diagnostic system as shown in Fig. 1 comprises a first digital board (100), a second digital board (200) and a power board unit (300). The first digital **comprises** a resistance port **101**, resistance circuit **102**, CT port

103, CT circuit **104**, capacitance port **105**, capacitance circuit **106**, and ADS1115 circuit **107**, DC voltage port **108**, DC voltage circuit **109**, AC voltage port **110**, AC voltage circuit **111**, ADS1115 circuit **112**, temperature port **113**, temperature circuit **114**, communication port **115**, communication circuit **116**, virtual register port **117**, potentiometer circuit **118**.

In an embodiment of the present invention, the first digital board includes resistance measurement circuit port **CN1**, which is the combination of resistance port 101 and resistance circuit 102, AC (alternate current) measurement circuit Port **CN2**, capacitance measurement circuit port **CN3**, communication circuit port **CN4**, DC voltage circuit port **CN5**.

In an embodiment of the present invention, second digital board (**200**) is configured to receive, process and analyse the information/signals received through ports of the first digital board **100**. Second digital board **200** comprises UVW Analyzer (201), FTDI Based Programmer Header (**202**), Master ESP32-Controller 2 (**203**), SLAVE ESP32-Controller 1 (**204**), 3 Tactile Buttons (**206**), Real Time Clock Module (**207**), 20 x 4 LCD display (**208**), and another FTDI Based Programmer Header (**209**). In particular, in an embodiment of the present invention the Second digital board (**200**) contains UVW Analyzer Port **CN8**.

In an embodiment of the present invention, power- board unit (**300**) in electrical communication with the second digital board (200). Power board unit (**300**) comprises power board (**301**), power board-child board (**302**), 10K potentiometer (**303**), relay on LED (**304**) AC mode on LED (**305**) DC mode on LED (**306**). Furthermore, the power-child board (**300**) contains UVW driver port **CN6** and BLDC motor port **CN7**.

In an embodiment of the present invention, resistance measurement circuit port **CN1** tests for any open, short, or ground issues in the spare parts/components. **CN1** mainly works under the principle of voltage divider, with the help of MOSFET switching. Each N-channel MOSFET is connected to a specific high-precision known resistance value with input and logic Voltage 3.3V. Whenever an unknown resistor is placed in the connector then the circuit gets completed and a voltage drop occurs and the result displays within 2 seconds which is being read by the microcontroller through the external ADC. The result is interpreted based on resistance readings and displays on the Diagnostic system to determine whether the component is functional or defective. The result displays SPARE PART OK, when resistance >0.1 ohms and displays SPARE PART NOT OK, when resistance <0.1 ohms using fixed display as shown in Fig. 2.

The AC Measurement circuit Port **CN2** tests gas levels of the electrical appliances using gas result functionality. This includes an ADC (Analogue to Digital Converter) hardware Circuit which helps to determine the ampere levels in the connected electrical appliances and provide an outlet based on the same. **CN2** mainly works with the Current Transformer where primary current induced in the primary coil induces a proportional amount of current in the secondary coil which gets converted into its equivalent voltage by connecting a burden resistor in parallel to its output. The RMS Voltage is then fed into AD736 which is a true RMS to DC Converter IC. Then the rectified DC output is fed into the external ADC for accurate voltage measurement. AC Current measurement ranges between 0.8 amps to 18 amps and Logic Voltage is 3.3V

To conduct the test, first, ensure that the wire is connected to the sensor when the ampere value is below 0.100 amps. Afterward, wait for the compressor to start, which typically happens when the ampere value is below 0.9 amps.

On a dynamic display, clicking on the button will change the tonnage capacity options. Select the appropriate tonnage capacity: 1 ton, 1.5 tons, or 2 tons, for both Inverter and Non-Inverter AC units.

Once selected, the display will show the peak reading result continuously for 30 seconds when the ampere value is above 0.9 amps. The display, will then continue to show this reading for a duration of 600 seconds.

For an appliance, like an Inverter AC up to 1 ton – the result is displayed as GAS OK, if the ampere reaches 4.75 amps and remains stable for 15 second. In case of overload, clean the outdoor unit (ODU) and check fan speed if the ampere exceeds 8 amps. If the gas level is between 70% and 90%, gas charging is recommended, and a 10-minute wait is required if the ampere is between 4.00 amps to 4.74 amps. For gas low, indicating less than 70%, gas charging is required, and a 10-minute wait is necessary if the ampere is below 4 amps.

Referring Fig. 3, for a 1.5-ton Inverter AC, the result is displayed as GAS OK, if the ampere is between 5.5amps and 11 amps and remains stable for 15 seconds. In case of overload, clean the outdoor unit (ODU) and check fan speed if the ampere exceeds 12 amps. For the gas level between 70% and 90%, gas charging is recommended, and a 10-minute wait is required if the ampere is between 4.75 amps to 5.49 amps. For gas low, indicating less than 70%, gas charging is required, and a 10-minute wait is necessary if the ampere is below 4.75 amps.

For a 2-ton Inverter AC, the result is displayed as GAS OK, if the ampere is between 7.00 amps to 15 amps and remains stable for 15 seconds. In case of overload, clean the outdoor unit (ODU) and check fan speed if the ampere exceeds 16 amps. For the gas level between 70% and 90%, gas charging is recommended, and a 10-minute wait is required if the ampere is between 6.2 amps to 7 amps. For gas low, indicating less than 70%, gas charging is required, and a 10-minute wait is necessary if the ampere is below 6.2 amps.

For a Non inverter up to 1 ton AC, the result is displayed as GAS OK, if the ampere is between 4.8 amps to 7 amps and remains stable for 15 seconds. In case of overload, check cap and motor if the ampere exceeds 8 amps. For the gas level between 70% and 90%, gas charging is recommended, and a 5-minute wait is required if the ampere is between 4.00 amps to 4.8 amps. For gas low, indicating less than 70%, gas charging is required, and a 10-minute wait is necessary if the ampere is below 4 amps.

For a 1.5-ton Non-Inverter AC, the result is displayed as GAS OK, if the ampere is between 5.75 amps to 9 amps and remains stable for 15 seconds. In case of overload, check cap and motor if the ampere exceeds 11 amps. For the gas level between 70% and 90%, gas charging is recommended, and a 5-minute wait is required if the ampere is between 5.2 amps to 5.75 amps. For gas low, indicating less than 70%, gas charging is required, and a 10-minute wait is necessary if the ampere is below 5.2 amps.

For a 2-ton Non-Inverter AC, the result is displayed as GAS OK, if the ampere is between 7.00 amps to 14 amps and remains stable for 15 seconds. In case of overload, check cap and motor if the ampere exceeds 15 amps. For the gas level between 70% and 90%, gas charging is recommended, and a 5-minute wait is required if the ampere is between 6 amps to 7 amps. For gas low, indicating less than 70%, gas charging is required, and a 10-minute wait is necessary if the ampere is below 6 amps.

In order to develop and derive the refrigerant/gas monitoring using current, a structured approach was followed by gathering and analyzing over 700 data points. The step by step process for development the said monitoring of refrigerant is as follows:

1. **Data Collection:** Extensive data across various parameters was collected, focusing on the following:
 - **AC Brand:** The manufacturer of the AC unit.

- **AC Star Rating:** Energy efficiency rating of the AC.
 - **AC Type:** Inverter or Non-Inverter type.
 - **AC Model:** Specific model details.
 - **Tonnage:** The cooling capacity of the AC.
 - **CN Functions Checked:** Specific control and diagnostic functions tested.
 - **Year of Manufacturing:** The manufacturing year of the AC unit.
 - **Room Ambient Temperature:** The temperature of the environment in which the AC was tested.
 - **Peak/Max Ampere:** The maximum ampere recorded during operation
 - **Co-Pilot:** The diagnostic tool used during testing.
 - **Actual Result:** The outcome or reading obtained from the test.
2. **Analysis by Capacity and Brand:** The collected data was further analyzed, taking into account the capacity (tonnage) and the brand of each AC unit. This step was crucial in identifying how different ACs, based on their size and make, responded under similar conditions.
 3. **Testing Under Various Conditions:** Each AC unit was tested under multiple temperature conditions to observe how the ampere readings varied with changes in ambient temperature. This step ensured that our logic would be robust across a range of operating environments.
 4. **Deriving the underlying logic for measuring and monitoring of the refrigerant/gas level:** Based on the comprehensive data analysis, we derived specific ampere ranges that would accurately indicate the gas level and performance of each AC unit. The logic was tailored to ensure it could reliably identify issues like gas low, gas charging recommendation, and overload for each type of AC.
 5. **Validation:** The derived logic was validated against actual field results to ensure accuracy and effectiveness. This step involved cross-referencing the predicted outcomes with real-world scenarios, ensuring the logic would be practical and dependable.

This thorough and methodical approach enables measurement and monitoring of refrigerant/gas levels using current measurement relation for different AC units, ensuring reliable diagnostics and maintenance recommendations.

Derived relation between measured current and refrigerant/gas level to show result :

AC Type	Tonnage	Ampere_Low	Ampere_High	Output Result Displayed
Inverter	2 Ton	0	6.19	Gas Low
Inverter	2 Ton	6.2	6.99	Gas Recommended
Inverter	2 Ton	7	15.99	Gas Okay
Inverter	2 Ton	16	100	Gas Overload Error
Inverter	1.5 Ton	0	4.74	Gas Low
Inverter	1.5 Ton	4.75	5.49	Gas Recommended
Inverter	1.5 Ton	5.5	11.99	Gas Okay
Inverter	1.5 Ton	12	100	Gas Overload Error
Inverter	1 Ton	0	4	Gas Low
Inverter	1 Ton	4.01	4.74	Gas Recommended
Inverter	1 Ton	4.75	7.99	Gas Okay
Inverter	1 Ton	8	100	Gas Overload Error
Non-Inverter	2 Ton	0	6.2	Gas Low
Non-Inverter	2 Ton	6.21	6.99	Gas Recommended
Non-Inverter	2 Ton	7	15.99	Gas Okay
Non-Inverter	2 Ton	16	100	Gas Overload Error
Non-Inverter	1.5 Ton	0	5.19	Gas Low
Non-Inverter	1.5 Ton	5.2	5.74	Gas Recommended
Non-Inverter	1.5 Ton	5.75	12.99	Gas Okay
Non-Inverter	1.5 Ton	13	100	Gas Overload Error
Non-Inverter	1 Ton	0	3.99	Gas Low
Non-Inverter	1 Ton	4	4.79	Gas Recommended
Non-Inverter	1 Ton	4.8	8.99	Gas Okay
Non-Inverter	1 Ton	9	100	Gas Overload Error

Current Measurement Process:

For determining the gas level and overall performance of an AC unit, the Co-Pilot device focuses on the **maximum current drawn** by the device during its operation. This method involves monitoring the instantaneous current, with specific attention to how the current fluctuates over time. The logic is designed to capture key behaviors of the AC unit during its

operation, particularly the **peak current levels and their consistency over specific time intervals.**

1. **Instantaneous Current Measurement:** The Co-Pilot device measures the instantaneous current drawn by the AC unit. This is not an average over time but a real-time reading that allows the device to detect rapid changes in current draw, which are critical for diagnosing issues such as gas levels and potential overloads.
2. **Maximum Current Draw:** The logic primarily relies on the maximum current draw detected during the operation. The device monitors if the current reaches a specific threshold and stays consistent for a defined period (e.g., 10 seconds) before displaying a result. This ensures that transient spikes do not trigger false diagnostics.
3. **Time-Based Conditions:** Depending on the current levels detected, the device applies time-based conditions to determine the gas level status. For instance, if the current remains within a specific range for a set duration (e.g., 10 minutes), the device will suggest whether gas charging is required or if the gas level is low.

Additional Conditions :

Inverter AC Units

1. **1 Ton:**
 - **Gas OK:** 4.75A to 9A, immediate result if stable for 10 seconds.
 - **Gas Level 70-90%:** 4A to 4.74A within 10 minutes, result after 10 minutes.
 - **Gas Low:** <4A for 10 minutes.
 - **Overload:** >9A, alternating message "Overload - Gas OK" / "Check Con Fan & Dust."
2. **Conditions:**
 - **Drop to 0.1-0.9A from >1.5A after 150s:** Show "Gas Low," unless it recovers to "Gas OK."
 - **Drop to <0.9A within 150s:** Show "Restart Test" / "Check Sensor," or "Gas OK" if recovered.
3. **1.5 Ton:**
 - **Gas OK:** 5.5A to 12A, immediate result if stable for 10 seconds.
 - **Gas Level 70-90%:** 4.75A to 5.49A within 10 minutes, result after 10 minutes.

- **Gas Low:** <4.75A for 10 minutes.
 - **Overload:** >12A, alternating message "Overload - Gas OK" / "Check Con Fan & Dust."
4. **Conditions:** Same as for 1 Ton.
5. **2 Ton and Above:**
- **Gas OK:** 7A to 16A, immediate result if stable for 10 seconds.
 - **Gas Level 70-90%:** 6.2A to 6.99A within 10 minutes, result after 10 minutes.
 - **Gas Low:** <6.2A for 10 minutes.
 - **Overload:** >16A, alternating message "Overload - Gas OK" / "Check Con Fan & Dust."
6. **Conditions:** Same for 1 Ton.

Non-Inverter AC Units

1. **Up to 1 Ton:**
- **Initial Wait:** Ignore first 2 seconds of current. If >10A for 3s, show "Wait for Gas Result."
 - **Gas OK:** 3.9A to 8A, immediate result if stable for 10 seconds.
 - **Gas Level 70-90%:** 3.7A to 3.89A within 5 minutes, result after 5 minutes.
 - **Gas Low:** <3.69A for 5 minutes.
 - **Overload:** >8A to 12A, alternating message "Overload - Gas OK" / "Check CAP & Fan."
2. **Conditions:**
- **Drop to <1.2A after 150s:** Show "Gas Low."
 - **Drop to <1.2A within 150s:** Show "Restart Test" / "Check Sensor."
 - **After "Wait for Gas Result":** If current doesn't reach 2.5A in 120s, show "Gas Low" / "Gas Charging Req."
 - **Running Amp 0.1-1.2A within 4 minutes:** Show "Check PCB Relay" / "Check Comp."
3. **Up to 1.5 Ton:**
- **Initial Wait:** Ignore the first 2 seconds of current. If >15A for 3s, show "Wait for Gas Result."
 - **Gas OK:** 5.75A to 13A, immediate result if stable for 10 seconds.
 - **Gas Level 70-90%:** 5.2A to 5.74A within 5 minutes, result after 5 minutes.

- **Gas Low:** <5.2A for 5 minutes.
 - **Overload:** >13A, alternating message "Overload - Gas OK" / "Check CAP & Fan."
4. **Conditions:** Same as for 1 Ton.
5. **Up to 2 Ton:**
- **Initial Wait:** Ignore the first 2 seconds of current. If >17A for 3s, show "Wait for Gas Result."
 - **Gas OK:** 7A to 16A, immediate result if stable for 10 seconds.
 - **Gas Level 70-90%:** 6A to 6.99A within 5 minutes, result after 5 minutes.
 - **Gas Low:** <6A for 5 minutes.
 - **Overload:** >16A, alternating message "Overload - Gas OK" / "Check CAP & Fan."

Fig. 4 displays a result of the port number CN3 as shown on the display. In an embodiment of the present invention capacitance measurement circuit port **CN3** checks MFD values of capacitor to determine electrical appliances operational status. CN3 works on the basis of calculating the charging time of the capacitor through a known resistor value (connected in series acting as ESR). After the capacitor reaches 62.3% of its total charging capacity, the time elapsed for the entire process is calculated in the form of voltage drop via external ADC and the time constant is calculated on the firmware side. Select the fan capacitor (1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 8 MFD) and Comp capacitor (25, 30, 36, 40, 45, 50, 55, 60, 65, 70 MFD) button from the moving display and connects the wire till circuit closed, the capacitor measurement ranged between 1uF to 330uF and Logic voltage is 3.3V. After initiated test for 2 seconds result displays based on the given below range to identify status of capacitor whether capacitor is working properly or not

Fan Capacitor	Capacitor OK Range	Capacitor Weak Range	Select Right MFD
1.5MFD	>=1.3 to <=1.7	>= 0.5 to <1.3	> 1.7 MFD
2 MFD	>=1.8 to <= 2.2	>= 0.8 to <1.8	<0.8 or >2.2 MFD
2.5 MFD	>=2.3 to <=2.7	=>1.5 to <2.3	<1.5 or 2.7
3 MFD	>=2.8 to <=3.2	>=2.0 to 2.8	<2.0 or >3.2)
3.5 MFD	>=3.3 to <=3.7	>=2.0 to 3.3	<2.0 or >3.7
4 MFD	>=3.8 to <=4.25	>= 2.5 to <3.8	<2.5 or >4.25

4.5 MFD	≥ 4.25 to ≤ 4.75	≥ 2.5 to < 4.25	< 2.5 or > 4.75
5 MFD	≥ 4.75 to ≤ 5.25	≥ 3.5 to < 4.75	< 3.5 or > 5.25
5.5 MFD	≥ 5.25 to ≤ 5.75	≥ 4.0 to < 5.25	< 4.0 or > 5.75
6 MFD	≥ 5.7 to ≤ 6.3	> 4.0 to < 5.7	< 4.0 or > 6.3
7 MFD	≥ 6.6 to ≤ 7.4	> 5 to < 6.6	< 5 or > 7.4
8 MFD	≥ 7.6 to ≤ 8.4	> 5.5 to < 7.6	< 5.5 or > 8.4

Fig. 5 displays a result of the port number CN4 as shown on the display. In an embodiment of the present invention, communication circuit port **CN4** checks communication between IDU PCB to ODU PCB of the appliances. CN4 is connected internally to a 2-pin JST connector which gets connected to the digital board. In the external 4-pin connector, the IDU and ODU wires are connected. This pin ensures that communication is occurring between the indoor and outdoor units of the appliances, if communication is pass between the appliance's PCBs using the Diagnostic system the diagnostic system then LED Glow else LED Off, to get the result using fixed display connect the wire till circuit closed and initiate the test for 60 seconds and the result displays PCB OK when communication is pass and PCB DEFECTIVE when communication fails.

Fig. 6 displays a result of the port number CN5 as shown on the display. In an embodiment of the present invention, DC voltage circuit port **CN5** checks the DC output voltages of the appliance's PCBs using Diagnostic system. CN5 works using the principle of voltage divider. Whenever any voltage is fed through the input terminals of this circuit, then a proportional amount of voltage drop is created across the resistor divider which is 990K and 5.1K. This voltage divider's output is measured using an external 16-bit ADC, where DC Input Voltage ranged between 1VDC to 600 VDC and Logic Voltage is 3.3V. Communication is functioning OK when PCB relay voltage is in between 5 to 14 volt , BLDC fan voltage > 250 volt DC, Low Volt Cap voltage in between 4 to 20 volt DC), High Volt Cap voltage > 280 volt), and NOT OK if PCB relay voltage < 5 VOLT, BLDC fan voltage < 250 volt DC, Low Volt Cap voltage < 4 and High Volt Cap voltage < 280 , and displays the result by selecting button PCB Relay, BLDC Fan Voltage, Low Volt Cap, High Volt Cap on moving display. To initiate the test, connect wire till circuit closed and result displays PCB OK or PCB DEFECTIVE for 2 seconds.

In an embodiment of the present invention, the UVW driver port **CN6** checks for inverter compressor and UVW fan working conditions. The input side of this section is 220VAC. This voltage is being rectified using a bridge rectifier and supplied to 6 IGBTs. The ATmega8A controller controls the PWM (Pulse Width Modulation) signal at each phase of the Driver section. The driver section contains 3 Bootstrap circuitries comprising 2 IGBTs each (High Side and Low Side each). Each of the bootstrap circuitry is dedicated to each phase of the BLDC motor. The PWM frequency at each phase is generated at a difference of 120 degrees. At the same time to make the entire device a closed loop system, voltage and current feedback is given which will shut down the PWM generation from the microcontroller when any surge is detected. **CN6** Port also deploys Frequency variation-based driving mechanism. **CN6** Port has 3 pairs for 2-2 IGBTs and drives a 3-phase inverter compressor by simultaneous ON/OFF operation of these 3 IGBTs with a phase difference of 120 degrees. The voltage out of these three IGBTs depends on the frequency of supply voltage at each IGBT gate. By varying this frequency, the output voltage can be changed leading to a variation in speed of the compressor. In **CN6** port, 2 main push buttons are allotted each for both AC and DC motor. Pressing of any one of the buttons powers the motor and error types are indicated by blinking patterns of AC and DC LED in the Power child board. In case of AC LED blink pattern of 2 indicates overload, 3 indicates low input voltage, 4 indicates IGBT overheat and invalid key, 5 indicates rotational fail. On the other hand, DC LED blink pattern of 2 indicates overload, low input voltage and IGBT overheat and the blink pattern 4 indicates invalid key and rotational fail. The result is displayed as INV COMP OK - INV COMP DEFECTIVE or INV MOTOR OK - INV MOTOR DEFECTIVE or BLDC MOTOR OK - BLDC MOTOR DEFECTIVE.

Fig. 7 displays a result of the port number CN6 as shown on the display. In an embodiment, the moving display contains the buttons for compressor, inverter motors, 6 pin BLDC motor. The test is conducted by connecting a wire till circuit is completely closed and after a wait of 10 seconds the result is displayed. For inverter compressors input current readings >1 AMP indicates compressor working properly whereas, <1 AMP indicates issues with the compressor. Similarly, in case of inverter and BLDC motor input current > 0.2 AMP indicates motor working properly whereas, <0.2 AMP indicates fault issues with the motor.

Fig. 8 displays a result of the port number CN7 as shown on the display. In an embodiment of the present invention, the port **CN7** checks the working of BLDC 5 pin wire motors

functioning. BLDC motor works on 300VDC at its input pin along with a trigger voltage of 15 VDC at its Trigger or speed circuit. Once the trigger voltage and 300V of input voltage are applied to these BLDC motors. The BLDC motor starts rotation. At the time of rotation of the BLDC motor, a feedback voltage is generated at its feedback pin which is fed to an optocoupler with the help of microcontroller, Master ESP32-Controller (203), SLAVE ESP32-Controller (204) that detects the rotation of the BLDC motor. The test is conducted by connecting a wire till circuit is completely closed and after a wait of 10 seconds the result is shown on a fix display. The value of input current > 0.2 AMP indicates BLDC motor working properly whereas, <0.2 AMP indicates fault issues with the motor. The result is displayed as BLDC MOTOR OK or BLDC MOTOR DEFECTIVE.

Fig. 9 displays a result of the port number CN8 as shown on the display. In an embodiment of the present invention, the port **CN8** checks the inverter PCB output for inverter compressor and motor windings. The port comprises of 8 optocouplers. When UVW motor is connected to the input terminals of the circuit or rotated manually, a voltage is generated from the coils of the motor which is sensed by the primary optocouplers. The optocouplers sends the voltage to Master ESP32 – Controller 2 and Slave ESP-32 Controller 1 for sensing the coil voltage. This ensures that all the coils are working inside the UVW motor. If any one of the coils is not working voltage will not be induced into the Master ESP32 – Controller 2 and Slave ESP-32 Controller 1. The moving display contains the buttons for inverter PCB and motor. The test is conducted by connecting a wire till circuit is completely closed for the duration of 3.15 seconds for inverter PCB and for 5 seconds for motor, the result is shown on a fix display. The result is displayed as INV PCB OK - INV PCB DEFECTIVE or MOTOR WINDING OKAY - MOTOR WINDING DEFECTIVE. Glowing of all 6 LED lights suggest that the PCB and motor windings are faultless.

In an embodiment of the present invention, additional functionalities other than above-described ports are also present that helps in complete diagnosis of the issues in electrical appliances. The additional functionalities include Virtual Resistance Circuit (118), Real Time Clock Module (RTC) (207), Temperature circuit (114), and AC voltage circuit (111).

In particular, in an embodiment of the present invention Virtual Resistance Circuit (118), involves a variable resistor connected to a 47K potentiometer. This potentiometer acts as a simulated resistive sensor with a range from 1K to 47K. Essentially, by adjusting the

potentiometer within its range, it mimics the behaviour of a resistive sensor with varying resistance values.

The HW-111 RTC (207) module is a small electronic device that accurately keeps track of time even when the main power is turned off. It usually contains a battery backup to maintain the timekeeping functionality when external power is disconnected.

Temperature Circuit (114) contains a resistance-based temperature sensor which provides digital signal output. The digital signal output is directly fed into the microcontroller for measuring the temperature. The temperature measurement is ranged between -55°C to $+125^{\circ}\text{C}$ and the logic voltage is 3.3V.

AC Voltage Circuit (111) works using the principle of voltage divider and AC to DC conversion using a bridge rectifier. Whenever AC voltage is fed through the input terminals of the circuit, MB10S bridge rectifier IC converts the AC voltage into equivalent DC voltage. After filtering the pulsating DC voltage, this voltage is fed into a resistor divided into 990K and 5.1K. The output of this divider is directly fed into the external ADC. The input voltage is between - 50 VAC - 700 VAC and logic voltage is 3.3V.

In the air conditioning industry, brands typically employ either BLDC or CSR motors in their units. The main distinction between manufacturers lies in the arrangement of wire pins, known as the interchange between Front and Back (F/B). For instance, in one brand/model, the speed and F/B wire pins might be swapped compared to others. This variation in F/B wiring configuration can influence how technicians need to connect the motor for proper operation. The innovation presented here involves using flexible connectors for motor testing, enabling technicians to adjust wire connections as needed for each motor type. For example, in one brand/model, the speed and F/B wire pins are interchanged compared to other brands. The present invention uses flexible connectors to test motors, allowing personnels to switch the wires according to the motor. This makes it compatible to run all type of BLDC motors. Furthermore, as CSR motors run on AC 220V with starting torque, a 3-pin connector is added in the present diagnostic system. Two pins receive AC 220V which connects to the common and running of the motor, and the third wire connects to the starting wire, which is linked to the start push button. The personnels can initiate the starting torque through this button to start the motor.

The diagnostic system is effectively works with various types and kinds of motors commonly found in air conditioning units. Described hereinbelow is how it functions with different motor types.

1. BLDC 3-phase Motors (CN6): The diagnostic system operates with BLDC (Brushless Direct Current) 3-phase motors commonly used in air conditioners. These motors operate using electronic commutation rather than brushes, offering improved efficiency and performance. The working principle of BLDC 3-phase motors is explained above through the CN6 port of the diagnostic system, providing technicians with guidance on testing and diagnosing these motors. By following the instructions provided in the CN6 port, technicians can accurately assess the operational status of BLDC 3-phase motors and troubleshoot any issues encountered.
2. BLDC 300VDC Motors (CN7): The diagnostic system accommodates BLDC 300VDC motors, which are utilized in certain air conditioner models. These motors have similar working principles to standard BLDC motors but operate at a higher voltage. In the CN7 port, the diagnostic system explains the working principle of BLDC 300VDC motors and addresses the variation in wiring configurations among different brands. To ensure compatibility with various BLDC 300VDC motors, the diagnostic system features flexible connectors that allow technicians/personnels to interchange the speed and feedback wires as required. For example, connectors can be adjusted to match the wiring specifications of Panasonic models.
3. CSR Motors: The diagnostic system is also compatible with CSR (Capacitor Start-Run) motors commonly found in air conditioners. These motors operate on AC 220V and utilize a starting capacitor to provide additional torque during startup. To accommodate CSR motors, the diagnostic system includes a specialized 3-pin connector designed for AC 220V operation. Two pins receive AC 220V power, connecting to the common and running terminals of the motor. The third wire in the connector is dedicated to the starting wire, which connects to the start push button of the motor. Technicians can initiate the starting torque through this button to initiate motor operation.

In summary, the diagnostic system is engineered to work seamlessly with a variety of motor types, including BLDC 3-phase motors, BLDC 300VDC motors, and CSR motors commonly found in air conditioning units. Its versatile design and specialized connectors enable

technicians to accurately diagnose and troubleshoot motor-related issues across different brands and models.

In an embodiment, the detailed motor troubleshooting steps according to present invention are described below:

- **Motor and Compressor Testing Using a Simulator Driver:**

- A simulator driver is designed to mimic the operation of air conditioner motors, particularly the compressor motor.
- This simulator includes an internal current monitoring circuit that measures the motor's current consumption against its specifications.
- The test results are displayed, indicating the operational status of the motor.

- **Fault Identification Process:**

- Faults are identified by applying both a trigger voltage and an input voltage to the motor.
- The simulator driver helps in determining the motor's working condition by analyzing the current draw and other operational parameters.

- **Methods for Fault Rectification:**

- The troubleshooting process primarily involves simulation techniques.
- The simulation method allows for the detection and rectification of faults by providing controlled operational conditions similar to those in an actual air conditioner.

Applicability to Other Appliances

- **Broad Applicability of Troubleshooting Method:**

- The troubleshooting method is not limited to air conditioner motors; it can also be applied to other appliances such as refrigerators and washing machines.
- The device supports a wide range of voltage outputs, from 30V to 330V, making it versatile for various appliances.

- **Adaptations for Different Appliances:**

- The method may require specific adjustments depending on the type of appliance being tested, but the underlying principles remain consistent across different devices.

Troubleshooting via CN7 and CN6 Ports

- **CN7 Port Methodology:**
 - The CN7 port is used to troubleshoot air conditioner compressors by measuring the current, analyzing the compressor load, and evaluating the gas percentage within the compressor.
 - AI logic is applied to interpret the data and provide results on the display.
- **CN6 Port Differences:**
 - While the CN6 port is similar to CN7, it specifically simulates the compressor and checks the gas levels.
 - The CN7 port, on the other hand, is focused on simulating BLDC motors to assess their functionality.

Verification of Method Steps

- **Accuracy of Troubleshooting Steps:**
 - The method involves applying a 300 VDC voltage to the BLDC motor, causing it to rotate.
 - Feedback voltage is generated within the BLDC motor, with hall sensors producing positive or negative trigger voltages based on the direction of rotation.
- **Clarification of Voltage Application and Feedback Mechanism:**
 - The sequence of applying trigger and input voltages, along with the feedback mechanism via the optocoupler, is crucial for accurate diagnostics.
 - Corrections and clarifications on the steps emphasize the role of feedback voltage generated by the motor's hall sensors.

Wire Connection Specifics

- **Detailed Wire Connection Instructions:**
 - The BLDC motor port involves connecting five wires: 300VDC, GND, 15V, 5V, and Feedback (Fb).
 - Proper connection of these wires is essential for creating a closed circuit and ensuring accurate diagnostics.
- **Impact on Diagnostic Outcome:**

- The correct wire connections directly influence the diagnostic results, as improper connections can lead to incorrect readings or failure to detect faults.

Feedback Voltage Generation and Its Significance

- **Feedback Voltage Generation:**

- The feedback voltage is generated at the BLDC motor end when it begins to rotate.
- Hall sensors inside the motor generate positive trigger voltages during clockwise rotation and negative trigger voltages during counterclockwise rotation.

- **Role in Troubleshooting:**

- The feedback voltage is vital for determining the motor's condition.

It helps in identifying whether the motor is functioning correctly or if it is defective, based on the signals sent to the optocoupler.

In an embodiment, the diagnostic system is capable of working for both inverter and non-inverter AC's. The diagnostic system functionality for both inverter and non-inverter air conditioners (ACs) is based on understanding and distinguishing the working principles of these two types of AC systems. Described hereinbelow is how the apparatus works for both types.

Working of Inverter and Non-Inverter ACs:

1. **Inverter ACs:** These systems utilize variable-speed compressors driven by inverters to regulate the speed of the compressor motor. Inverter ACs adjust the compressor's speed based on the cooling demand, resulting in precise temperature control and energy efficiency. The frequency of the electrical signal to the compressor motor varies continuously to match the cooling load.
2. **Non-Inverter ACs:** In contrast, non-inverter ACs have fixed-speed compressors that operate at a constant speed regardless of the cooling demand. The compressor cycles on and off to maintain the desired temperature, leading to temperature fluctuations and higher energy

consumption compared to inverter ACs. The electrical signal to the compressor motor operates at a fixed frequency.

Study Through Oscilloscope

Oscilloscope analysis provides insights into the electrical signals driving the compressors in inverter and non-inverter ACs. For inverter ACs, oscilloscope readings reveal variable-frequency signals corresponding to the varying compressor speeds. In non-inverter ACs, the oscilloscope captures fixed-frequency signals indicative of the constant compressor speed.

Replication on ACs:

The AC diagnostic system replicates the electrical signals observed through oscilloscope analysis to diagnose and troubleshoot both inverter and non-inverter ACs. By understanding the frequency characteristics of the electrical signals required for each type of AC, the Diagnostic system generates signals tailored to the specific requirements of inverter and non-inverter systems.

For inverter ACs, the diagnostic system generates variable-frequency signals to simulate the varying compressor speeds, allowing for comprehensive diagnostics and testing.

For non-inverter ACs, the diagnostic system generates fixed-frequency signals to mimic the constant compressor speed, facilitating accurate diagnosis and analysis.

Min/Max Frequencies:

The diagnostic system is programmed to generate electrical signals within the minimum and maximum frequency ranges supported by both inverter and non-inverter AC systems.

These frequency ranges are determined based on the specifications of various AC models and manufacturers, ensuring compatibility and accurate replication of compressor operation.

Images of Oscilloscope:

Visual representations from oscilloscope readings serve as reference data for understanding the electrical signal characteristics of inverter and non-inverter ACs.

The Diagnostic system's embedded C is used as programming language over visual studio IDE, that incorporates insights from these images to generate signals that replicate the operational behaviour of both types of AC systems effectively.

Frequency variation-based driving mechanism

1. This device has 3 pairs for 2-2 IGBTs and drives a 3-phase inverter compressor by simultaneous on/off operation of these 3 IGBTs with a phase difference of 120 degrees. The voltage at the out of these three IGBTs depends on the frequency of supply voltage at each IGBT gate.
2. By varying this frequency, the output voltage can be changed which leads to a variation in the speed of the compressor and example of this frequency can be seen in below mentioned image

Advantages of the AC diagnostic system system's compact design with eight ports are Individual ports for each function where each port is designed to serve a specific function independently, optimizing space utilization, Integrated Circuits where advanced integrated circuitry consolidates electronic components, minimizing physical footprint while maintaining performance, Efficient PCB layout where meticulous PCB layout maximizes space efficiency, accommodating multiple ports without compromising functionality, Multi-Functional Connectors where connectors support diverse diagnostic tasks, eliminating the need for additional physical ports, Optimized Component Size where compact components are selected and sized to fit within the device's form factor, maximizing performance in minimal space, Space-saving enclosure where enclosure design balances compactness and durability, ensuring portability without sacrificing protection.

We claim:

1. A refrigerant monitoring unit for an electrical appliance, comprising:
 - a current sensor for measuring a current value drawn by a compressor;
 - a controller configured to process the current value and provide an output in relation to the refrigerant level; and
 - a display for indicating a refrigerant level in the electrical appliance based on the current value drawn by the compressor, wherein:
 - the display indicates that the refrigerant level is sufficient if the current value is equal a first predefined threshold, and
 - the display indicates that the refrigerant level is insufficient if the current value is lower than a second predefined threshold.
2. The refrigerant monitoring unit as claimed in claim 1, wherein the display indicates that the refrigerant level is not optimal if the current value is between the first predefined threshold and the second predefined threshold.
3. The refrigerant monitoring unit as claimed in claim 1, wherein the display indicates that the refrigerant level is sufficient if the current value drawn by the compressor reaches the first predefined threshold and remains stable for a period of 10 to 20 seconds, preferably 15 seconds.
4. The refrigerant monitoring unit as claimed in claim 1, wherein the display indicates that the refrigerant level is insufficient if the current value drawn by the compressor remains below the second predefined threshold for a period of 5 to 15 minutes, preferably 10 minutes.
5. The refrigerant monitoring unit as claimed in claim 1, wherein the display indicates that the refrigerant level is not optimal if the current value drawn by the compressor remains between the first predefined threshold and the second predefined threshold for a period of 5 to 15 minutes, preferably 10 minutes.

6. The refrigerant monitoring unit as claimed in claim 1, wherein the controller compares the current value drawing by the compressor with the first predefined threshold and the second predefined threshold.
7. The refrigerant monitoring unit as claimed in claim 1, wherein the refrigerant monitoring unit is compatible with a variety of air conditioners.
8. The refrigerant monitoring unit as claimed in claim 6, wherein the variety of air conditioners comprise air conditioners with different tonnage, inverter air conditioners, non-inverter air conditioners and air-conditioners from different brands.
9. A method for monitoring refrigerant in an electrical appliance, comprising:
 - measuring a current value drawn by a compressor;
 - processing the current value and providing an output in relation to a refrigerant level; and
 - indicating a refrigerant level in the electrical appliance based on the current value drawn by the compressor on a display, wherein:
 - indicating that the refrigerant level is sufficient if the current value is equal a first predefined threshold, and
 - indicating that the refrigerant level is insufficient if the current value is lower than a second predefined threshold.
10. A method for troubleshooting a motor of an air conditioner, comprising:
 - applying a trigger voltage and an input voltage to the motor for initiating rotation of a rotor;
 - providing a feedback voltage to an optocoupler using a first microcontroller;
 - detecting the rotation of the motor using a second microcontroller; and
 - creating a closed circuit using a wire and indicating output on a display, wherein:
 - indicating that the motor is defective if an input current is less than a third predefined threshold, and

indicating that the motor is not defective if the input current is greater than the third threshold.

11. The method as claimed in claim 10, wherein the feedback voltage is generated at the time of rotation of the motor.
12. A diagnostic system for an electrical appliance, comprising:
 - a refrigerant monitoring unit configured to assess a refrigerant level in the electrical appliance;
 - a motor troubleshooting unit configured to detect and troubleshoot a fault in at least one motor;
 - a capacitance monitoring unit configured to detect a fault in at least one capacitor of the electrical appliance; and
 - at least one PCB unit configured to detect a fault in one or more printed circuit boards (PCBs).
13. The diagnostic system as claimed in claim 12, wherein the diagnostic system comprises a spare part testing unit configured to detect a fault in one or more spare parts of the electrical appliance.
14. The diagnostic system as claimed in claim 12, wherein the spare parts comprises resistors, sensors, variable resistors and carbon composition resistors.
15. The diagnostic system as claimed in claim 12, wherein the diagnostic system calculates electrical resistance of the one or more spare parts.
16. The diagnostic system as claimed in claim 12, wherein if the calculated electrical resistance value is greater than a predefined threshold value, the one or more spare part has no fault, and if the calculated electrical resistance value is less than a predefined threshold value, the one or more spare part has fault.