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Design and Manufacture of Equipment to Test the Parameters of the Power Supply for the Inverter

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A B S T R A C T

During inverter operation, the power supply system plays an extremely important role in ensuring the performance and stability of the entire system. In order to ensure that the inverter operates in the best condition, the process of energizing and checking the power parameters has become an integral part and can even be said to be a basic principle before the inverter is put into operation.

In this context, the research and design of devices for measuring and checking power supply parameters become extremely important. These devices not only help to measure and record important parameters such as DC voltage, AC voltage, and frequency, but also ensure that these parameters are within acceptable ranges for the inverter. stable operation.

With the important role of checking and ensuring the quality of power supplied to the inverter, this paper focuses on presenting the results of the design process of the device to measure the power parameters for the inverter. Through analysis, testing, and a research approach, the article shares valuable information on how to design and implement these devices, helping to improve the performance and reliability of the inverter during operation. motion.

Keywords: Power supply, instrumentation, inverter, microcontroller

1. Introduction

In the context of today's inverter usage, supplying stable and high-quality power to the inverter system plays an exceedingly important role. Ensuring optimal inverter performance, especially under varying operating conditions, necessitates specific requirements for power supply parameters such as voltage and frequency.

The power parameters for the inverter encompass:

- DC voltage: 27V ± 10%

- 3-phase AC voltage: 208V ± 5%, frequency: 400Hz ± 2%

- Single-phase AC voltage: 115V ± 5%, frequency: 400Hz ± 2%

- 3-phase AC voltage: 36V ± 5%, frequency: 400Hz ± 2%

The inverter power supply system encompasses a wide range of critical tasks, from energizing control and starting systems to providing illumination and powering various other components. The stability and quality of the power supplied to the inverter wield significant influence over sustaining safe operations and system performance. Any malfunctions or failures related to the power supply can jeopardize the safety and proper functioning of the inverter. Therefore, comprehending and controlling power quality stands as a pivotal factor in ensuring the steady and secure operation of the inverter system.

Building upon this foundation, our team has successfully conducted research and designed a device for measuring power parameters within the inverter. This device boasts the following functions:

+ Measurement of power source parameters including DC voltage, AC voltage, DC current, AC current, and frequency.

+ Notification of measurement timing.

+ Indication when the measured values surpass specified thresholds.

+ Storage of all aforementioned information onto a memory card.

2. Calculation, simulation

Next, we proceed to calculate and simulate the power supply parameter measurement circuits on Proteus software. This process helps us better understand the working principles of the circuits and ensure that they work correctly before deploying them to the actual device.

The basic principle for measuring parameters such as DC voltage, AC voltage, DC current, and AC current is to convert and normalize the input value into a signal suitable for Arduino to read and process. To do this, we use a standard signal, which is a DC voltage varying between 0V and 5V.Simulation on Proteus software allows us to build virtual models of power parameter measurement circuits and test them in a virtual environment before deploying tests on real devices. This helps us identify potential problems, adjust parameters, and ensure that the device is working as intended before performing actual testing.

Calculations and simulations are an important part of the power supply parametric device development process. It helps us optimize the design and ensure the accuracy of the measurement data that the device will collect in real-world situations.

2.1. Simulation of a DC voltage measurement circuit

A DC voltage measuring circuit is designed with the specific purpose of accurately measuring and recording DC voltage values. The circuit's construction involves incorporating components that facilitate signal conversion and processing to achieve precise measurement outcomes.

- Basic Components:

+ DC Voltage Input: This serves as the power source under measurement, commonly the input voltage of the inverter or other power supplies.

+ Signal Conversion Circuit: This component transforms the input voltage signal into a suitable level that allows the microcontroller to read and process it.

- Main Functions:

+ Voltage Conversion: The signal converter circuit carries out the crucial task of converting and standardizing the input voltage signal into a range appropriate for data reading by the microcontroller.

+ Data Reading and Processing: The microcontroller, Arduino, reads the standardized signal, which is then processed to compute and exhibit the value of the DC voltage.

+ Display of Results: The measured results can be directly displayed on a screen or transmitted for display on a computer through communication protocols like UART or USB.

In summary, the DC voltage measurement circuit functions by transforming, standardizing, and processing the input voltage signal to yield a precise DC voltage measurement. The outcomes can then be displayed or transmitted for monitoring and scrutinizing voltage parameters within the system.

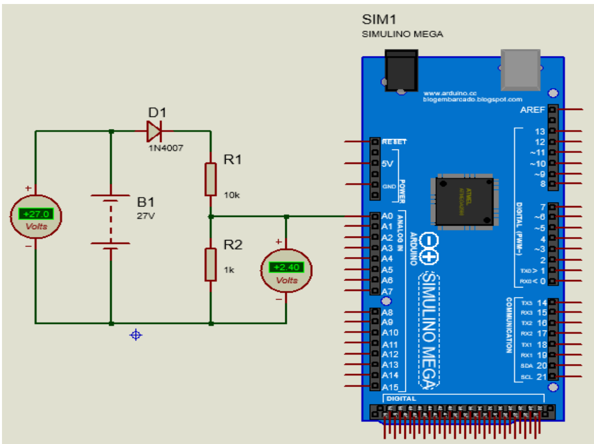

Fig.1. Simulation of a DC voltage measurement circuit

2.2. Simulation of an AC voltage measurement circuit

An AC voltage measuring circuit was developed with the purpose of measuring and recording AC voltage values accurately.

- Basic components:

+ AC voltage input: This voltage is usually the mains power supply and needs to be measured to ensure that it is within the desired value range.

+ Signal converter circuit: The converter converts the AC voltage signal into a DC voltage of a suitable level that can be read and processed by the microcontroller.

- Main function:

+ AC voltage converter: The signal converter circuit converts the AC voltage into a DC voltage of a suitable level that can be read and processed by the microcontroller.

+ Read and process data: a normalized signal will be read by the microcontroller, Arduino. This data can then be processed to calculate and display the AC voltage value.

+ Display of results: Measured results can be displayed directly on the screen or transmitted for display on a computer via communication protocols such as UART or USB.

The AC voltage measuring circuit is created to perform the conversion, normalization, and processing of the AC voltage signal from the power supply. This helps collect and display results to test and monitor voltage parameters in an AC system accurately.

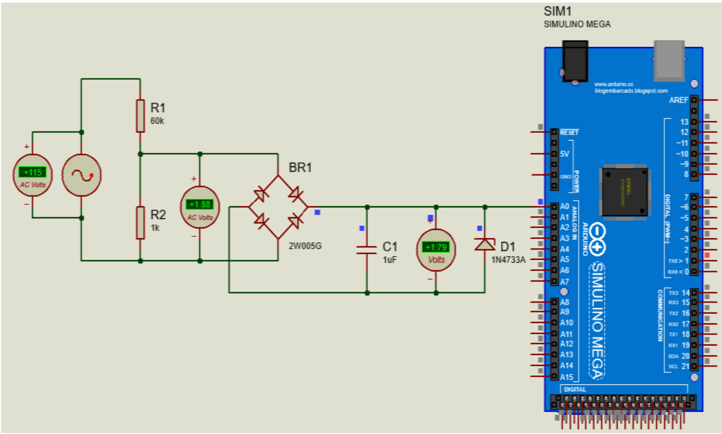

Fig.2. Simulation of an AC voltage measurement circuit

2.3. Simulation of a DC current measurement circuit

The DC current meter circuit is created to perform the conversion, normalization, and processing of the DC signal from the power supply. This helps collect and display results to test and monitor DC current parameters in the system accurately.

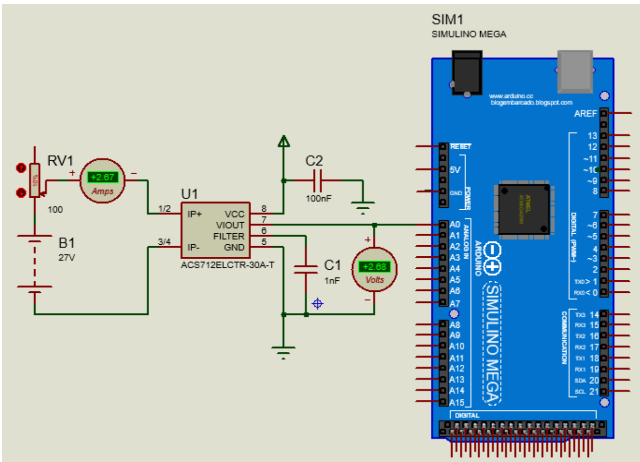

Fig.3. Simulation of a DC current measurement circuit

2.4. Simulation of an alternating current measurement circuit

The AC current measurement circuit is created to perform the conversion, normalization, and processing of the AC current signal from the power supply. This helps collect and display the results to test and monitor the AC current parameters in the system accurately.

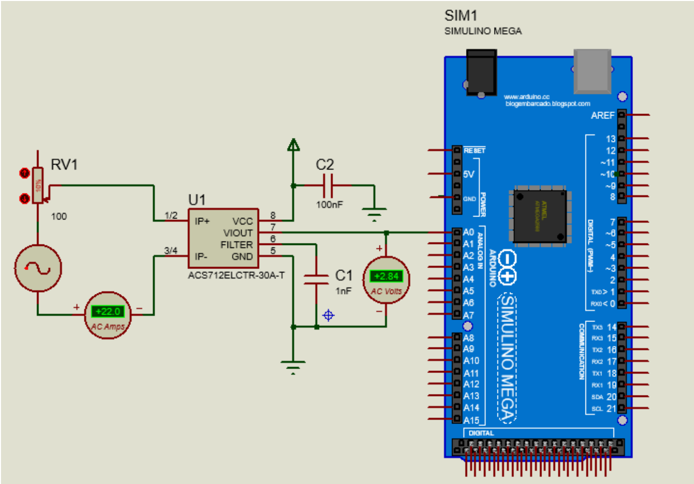

Fig.4. Simulation of an alternating current measurement circuit

2.5. Simulation of a frequency measuring circuit

During the simulation of the frequency measurement circuit, the operational principle is rooted in the conversion of alternating voltage into a square pulse signal with a constant frequency. This transformation involves converting the AC voltage signal into a square pulse signal with an amplitude below 5 volts. The resulting square pulse signal is then directed to a digital pin on the Arduino microcontroller to quantify the frequency of these pulses.

The frequency measurement circuit operates by introducing an AC input voltage to the converter circuit. This circuit alters the AC voltage into a square pulse signal, ensuring that its amplitude remains below 5 volts. Subsequently, this square pulse signal is conveyed to one of the digital pins on the Arduino. The Arduino undertakes the task of tallying the number of square pulses over a specific interval. Based on this tally, the microcontroller computes and showcases the frequency of the initial AC signal.

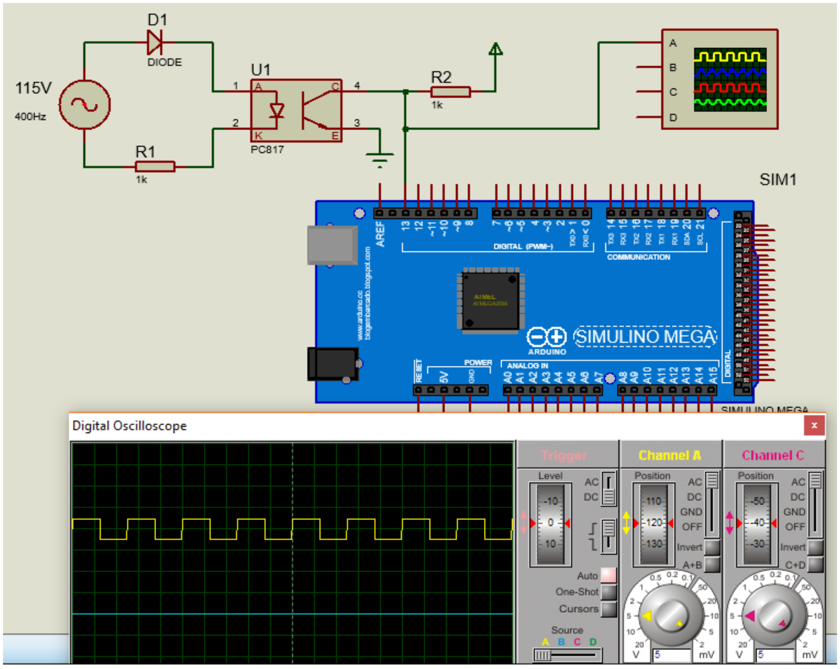

Fig.5. Simulation of a frequency measuring circuit

2.6. Display circuit simulation

Connect the pins of the LCD component to the corresponding pins on the Arduino microcontroller. Usually, you will need to connect the data pins (D4–D7) and control pins (RS, RW, and E) from the LCD to the Arduino microcontroller. Also, you need to write code in Arduino to control the LCD display.

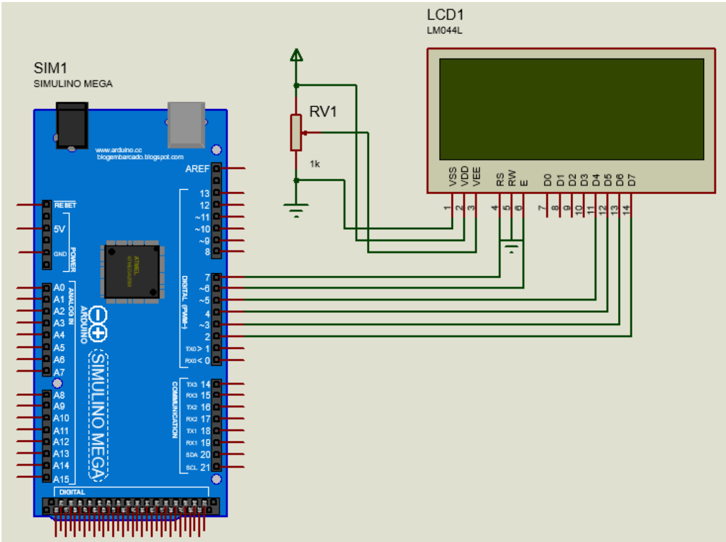

Fig.6. Display circuit simulation

3. Components of the measuring device

3.1. Arduino Mega 2560 Circuit

The Arduino Mega 2560 is a powerful and multifunctional version of the Arduino family of microchips. Developed by Arduino.cc, this version can work with more complex applications and requires more I/O pins than the smaller versions.

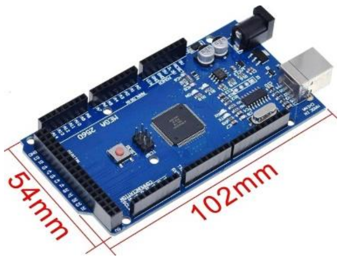

Fig.7. Arduino Mega 2560 Board

3.2. The 20×4 LCD display screen

The 20x4 LCD display screen is a peripheral device widely used in electronic projects to display text and character information. With the ability to display four lines and each line containing up to 20 characters, it provides a large space to display information in detail.

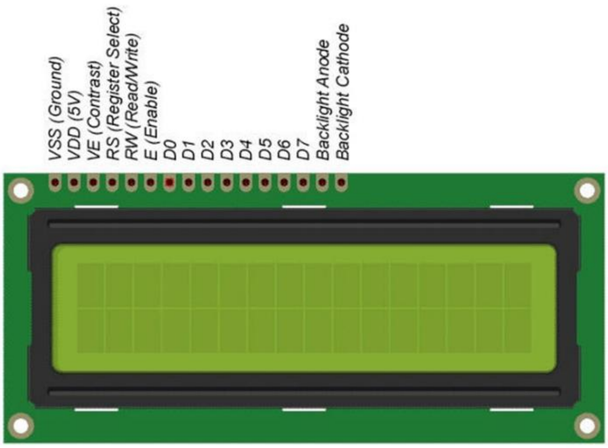

Fig.8. The 20x4 LCD display screen

3.3. Real-Time Module DS1307

The DS1307 real-time module is a popular peripheral used to maintain time and date in electronic applications. DS1307 is capable of communicating via the I2C protocol, making it easy to connect with microcontrollers and other devices. The DS1307 is an RTC chip that is capable of storing hour, minute, second, day, month, and year information even when power is lost.

Fig.9. The DS1307 real-time module

3.4. Micro SD Card Module

The Micro SD memory card module is an external device that allows storing and accessing data from a Micro SD memory card. The Micro SD memory card module allows the storage of data types such as images, videos, audio, text, and other files. The Micro SD memory card has a compact size, which saves space in the design.

Fig.10. Micro SD Card Module

3.5. ACS 712 Current Sensor

The ACS712 sensor allows you to measure the current passing through it. The current is converted into a corresponding voltage signal for measurement and processing. The ACS712 sensor can have an analog or digital output, allowing current to be read via analog pins or converted to digital data for use in microcontrollers.

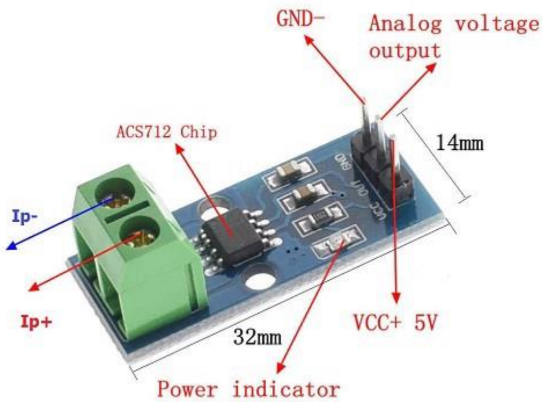

Fig.11. ACS712 Current Sensing Module

3.6. PC817 Optical Isolator IC

The PC817 optical isolator IC is an integrated circuit commonly used in the electronics field to create voltage signal isolation between two different circuits or devices. It is an important device for ensuring safety and reliable signal transmission in applications where signal isolation is required.

Fig.12. PC817 Optical Isolator IC

4. Construction process

After grasping the fundamental components and understanding the operational principles of the power supply parameter measuring device for inverters, we can now delve into the construction process, outlined as follows:

Fig.13. External image of the measuring device

Step 1: Equipment and Component Preparation

- Gather all necessary components, including the DC voltage measuring circuit, the AC voltage measuring circuit, the DC current measuring circuit, the AC current measuring circuit, and the frequency measuring circuit.

- Identify appropriate locations for circuit installation and ensure an adequate supply of wires and connections.

Step 2: Circuit and Component InstallationProceed to install the DC voltage measuring circuit, the AC voltage measuring circuit, the DC current measuring circuit, the AC current measuring circuit, and the frequency measuring circuit, making sure to establish the required connections. Ensure correct wiring and confirm that the connections correspond accurately with the control circuit to maintain a safe setup.

Step 3: Connection and Adjustment

- Establish connections between the circuits and the microcontroller using the designated connector pins.

- Fine-tune the circuits and related parameters to guarantee precision during measurement and display.

Step 4: Operational Testing

- Integrate the circuits with the necessary power supply.

- Execute operational tests on each measuring circuit using test signals to verify the accurate and proper display of all parameters.

Step 5: Operation and Evaluation

- Conduct real-world tests to validate the stable and accurate functionality of the measuring device within authentic environments.

- Evaluate the performance and accuracy of the measuring equipment by comparing the measured results against reference values.

Included below is an actual depiction of the external appearance of the measuring device.

5. Testing and evaluation of measuring equipment

After the design phase, the measuring device went through testing to evaluate accuracy and performance. The test results show that the measuring device has reached high accuracy and even surpassed the performance of the reference device.

Errors in the measurement of quantities are calculated using the following relative error formula:

$$E_X\% = \frac{|X_{\text{read}}\text{-X}_{\text{ref}}|}{X_{\text{ref}}}.100$$

In there:

Ex% is the percentage error between measured values.

X_ref is the reference value.

X_read is the value read from the crafting device.

During testing, the reference device used was a Fluke 87V digital display multimeter, a highly accurate and widely used device on the market.

Table 1. Measurement test results of Udc (V)

Measurement Round	1	2	3	4	5
Fluke 87V	30	25	20	15	5
Measuring device	30.15	25.1	20.05	15.02	5.01
E_{Udc}%	0.5	0.4	0.25	0.13	0.2

Table 2. Measurement test results of Uac (V)

Measurement Round	1	2	3	4	5
Fluke 87V	300.5	220.15	110.2	50	26.3
Measuring device	300	220.1	110.1	50	26.2
E_{Uac}%	0.17	0.02	0.09	0	1.38

Table 3. Measurement test results of Idc (A)

Measurement Round	1	2	3	4	5
Fluke 87V	4.28	4.23	4.25	4.27	4.35
Measuring device	4.2	4.15	4.25	4.26	4.33
E_{Idc}%	1.87	1.89	0	0.23	0.46

Table 4. Measurement test results of Iac (A)

Measurement Round	1	2	3	4	5
Fluke 87V	3.23	5	6.52	4.58	5.5
Measuring device	3.2	4.95	6.47	4.55	5.45
E_{Iac}%	0.92	1.0	0.76	0.66	0.91

Table 5. Measurement test results of Fac (Hz)

Measurement Round	1	2	3	4	5
Fluke 87V	50.5	50.3	30	30.5	30.8
Measuring device	50.25	50.15	30	30.25	30.55
E_{Fac}%	0.49	0.3	0	0.82	0.81

During measurements, the system interacts with the user through the LCD display. On this screen, important information will be displayed clearly and conveniently.

One of the key pieces of information is the measurement time, which allows the user to know the time at which the measurement is being performed. This can be useful for defining standard times for each measurement and for effective work-time management.

In addition, the LCD will also provide a warning if the measured value is outside the set threshold. This enables the user to immediately recognize if there is a significant change in the measured value and to be able to take the necessary measures to ensure the safety or stability of the system.

Another important feature of the system is the ability to store data. All measured results, along with the time and associated parameters, will be saved on the memory card. This facilitates the tracking and analysis of information over time. This can assist in assessing the performance of the power system and detecting faults and changes over time.

The LCD display screen is not only an interface to convey information but also an important tool to help users interact with the measuring system and ensure safe and efficient operation.

6. Conclusion

Through experiments and evaluation, it can be confirmed that the power supply parameter measuring device for inverters has achieved high accuracy, efficiency in use, and safety assurance.

The remarkable aspect of the device is its high accuracy. Ease of use is also a strong point, allowing operators to take measurements easily and quickly.

Not only limited to accuracy and ease of use, the device is also equipped with a display of measurement time. This helps in tracking the time taken to measure and manage time effectively. At the same time, the ability to store measurement information on a memory card is an important strength, facilitating the monitoring and analysis of data over time.

With these outstanding advantages, the measuring device has great potential for practical application. In particular, for the application of the device in testing and monitoring the power supply, the device has a number of notable advantages over existing measuring equipment such as the Fluke 87V:

- Customize according to need.

- Suitable for specific environments: When building a measuring device, it is possible to customize it to suit a specific measuring environment. This includes selecting high-quality components to ensure stable operation in harsh environments or at special frequencies such as 400Hz.

- Performance optimization: Instrument design and fabrication can be optimized to provide maximum accuracy and reliability through a selection of the finest components.

Multi-function integration: Various functions can be integrated into one self-made device, such as high-frequency measurement along with voltage and current measurement.

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REFERENCES

Nicola Femia. *A cost-effective technique for dynamic testing of DC-DC power supplies*. 2017 IEEE International Conference on Industrial Technology (ICIT). DOI: 10.1109/ICIT.2017.7912590.

Karim Arabi, Resve Saleh, Xiongfei Meng. *Power Supply Noise in SoCs: Metrics, Management, and Measurement*. IEEE Design & Test of Computers. DOI: 10.1109/MDT.2007.79. Page(s): 236 - 244. Date of Publication: 13 August 2007.

C. Patel, F. Muradali, J. Plusquellic. *Power supply transient signal integration circuit*. ISBN:0-7803-7169-0. DOI: 10.1109/TEST.2001.966691. 06 August 2002.

Wenqiang Xie. *Design of Detection System for Mine DC Stabilized Power Supply Based on Virtual Instrument*. 14 December 2020. DOI: 10.1109/ICIBA50161.2020.9277413.

Yuwei Shang, Huayang Li, Jinhua Wang. *Analysis and design of a current transformer fed power supply from high AC voltage cable*. 12 July 2012. DOI: 10.1109/ISIE.2012.6237080. ISBN:978-1-4673-0159-6.

Earl Crandall. *Power Supply Testing Handbook: Strategic Approaches in Test Cost Reduction*. Springer; 1998. ISBN-13: 978-0442238452.

Smith, J. M., & Johnson, A. B. (2019). *Power Supply Testing Techniques: Tips and Strategies for Effective Testing*. Power Electronics Handbook (2nd Edition), 141-152.

Chen, X., & Wu, Y. (2017). *Design and Implementation of a High-Precision Power Supply Testing System*. IEEE Transactions on Industrial Electronics, 64(9), 7036-7045.

Lee, C., & Park, J. (2018). *Design and Implementation of a Real-Time Power Supply Testing Platform for Industrial Applications*. International Journal of Control, Automation, and Systems, 16(5), 2267-2276.