LAB 6 : Precision of Voltage Measurements with the LV 25-P Transducer

Experimental Evaluation and Gap Analysis to Optimize Measurement Precision

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Programming on electronic card

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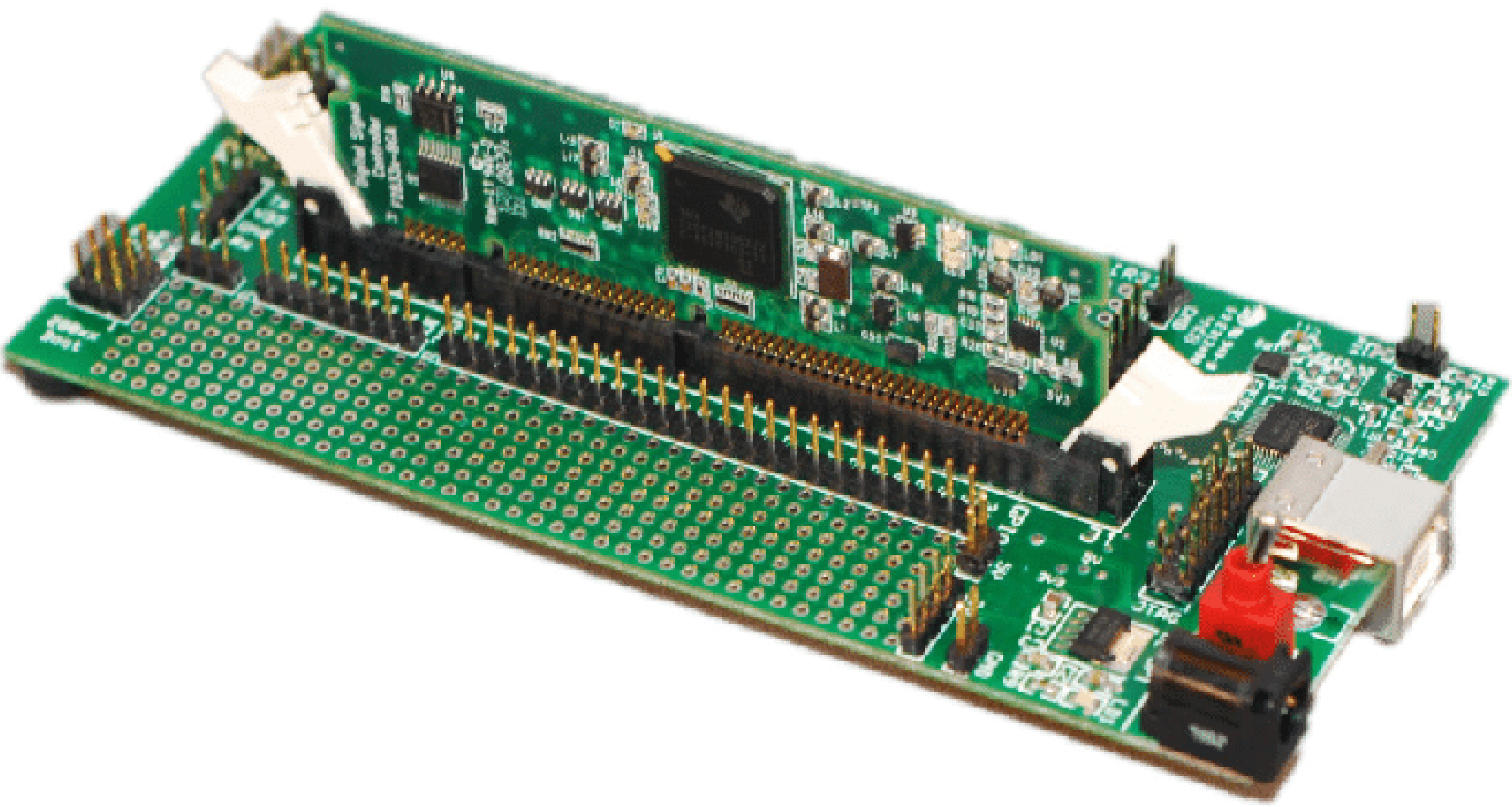


Contents

1 Introduction

1.1 Objectives of the Practical Work

This practical work (lab) is designed to deepen students' understanding of the LV 25-P voltage transducer and to familiarize them with methods of precise voltage measurement in controlled environments. Here are the detailed objectives this lab aims to achieve:

1. **Understand the Operation of the LV 25-P Transducer**:
    - Study in detail how the LV 25-P transducer measures high voltages and converts them into lower, usable voltages, based on solid electrical and electronic principles.
    - Explore the impact of the galvanic isolation offered by the LV 25-P and understand how it contributes to the safety and accuracy of measurements.
2. **Apply Electrical Theories in a Practical Context**:
    - Use the theoretical knowledge gained to set up and use the LV 25-P in an electrical circuit.
    - Calculate the necessary resistances (R_p and R_s) to obtain precise output voltages from known input voltages.
3. **Experimentally Verify Calculation Equations**:
    - Put theoretical equations into practice by conducting experimental measurements.
    - Compare the measured values with the calculated values to validate or adjust the theoretical models used.
4. **Develop Measurement and Analysis Skills**:
    - Gain practical experience in using voltmeters and other measurement instruments to observe the performance of the LV 25-P.
    - Learn to analyze and interpret data to identify deviations from theoretical predictions and understand potential sources of error.

This lab is essential for helping students understand not only how voltage transducers work but also how they can be effectively used in practical applications, reinforcing the links between theory and practice in the field of electronics and electrical measurement.

1.2 Importance of Precision in Voltage Measurement with Transducers

Precision in voltage measurements is crucial, especially when using transducers like the LV 25-P. Here is why this precision is so important:

Safety and Reliability

- **Electrical Safety:** Precise measurements help prevent overvoltage risks and protect circuits against potential failures.
- **System Reliability:** Accuracy ensures the correct operation of electronic components, avoiding errors due to incorrect voltages.

Efficiency and Performance

- **Energy Efficiency:** Accurate voltage measurements allow for optimizing systems to reduce energy losses, essential in energy-efficient applications.
- **Process Optimization:** Accurate measurement is necessary for precise process control in automated systems, improving productivity.

Research and Development

- **Model Validation:** Accurate measurement is critical for testing and validating theories and innovations, supporting the development of new technologies.
- **Calibration:** Correct measurement enables proper calibration of transducers, ensuring reliable data for all uses.

In summary, accurate voltage measurement is at the heart of safety, efficiency, and innovation in many fields, enhancing the quality and performance of electrical and electronic applications.

2 Theory of LV 25-P Voltage Transducers

2.1 LV 25-P Voltage Transducer

This segment of the lab is designed to briefly recapitulate the theoretical principles of voltage transducers, specifically the LV 25-P, which we explored in detail in the previous lab. This will help to reinforce understanding before proceeding to practical experiments.

Fundamental Concepts

- **Voltage Transducers**: Devices used to convert a large input voltage into a smaller, proportional output voltage, thus facilitating the safe and precise measurement of high voltages.
- **LV 25-P**: A specific transducer that uses direct measurement to convert and reduce the input voltage, while maintaining galvanic isolation between the measurement circuit and the output circuit.

Operation of the LV 25-P

- **Measurement Principle**: The LV 25-P measures the applied voltage and produces an output voltage that is a fraction of the input, based on a ratio defined by internal resistances and the design of the transducer.
- **Galvanic Isolation**: Crucial for protection against high voltages and for minimizing electromagnetic interference, thus ensuring precise and reliable measurements.

Summary

This condensed recap of the theories related to the LV 25-P is intended to serve as a transition to the practical experiments, where these equations and principles will be applied to measure and analyze different input voltages. This ensures that all participants are on the same page and ready for the experimental phase of the lab.

In the following section, we will proceed to prepare the equipment and set up the circuit to begin practical measurements.

2.2 Theoretical Formulas and Calculations

In this part of the lab, we will briefly recap the formulas needed to calculate the primary and secondary resistances in the context of using the LV 25-P transducer. These reminders are fundamental for preparing experimental measurements and understanding the results obtained.

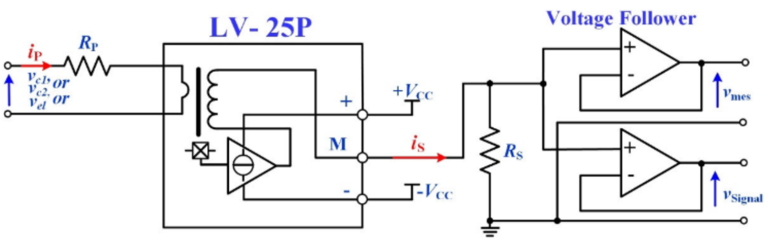


Figure 1: The primary resistance of 50 kΩ used in the setup.

Calculation of Primary Resistance (R_p):

- The primary resistance R_p is determined to limit the current through the transducer to its nominal primary current I_p, ensuring precise and safe voltage measurement.
- The formula to calculate R_p is given by:

$$R_p = \frac{V_{\text{in}}}{I_p}$$

where V_{in} is the maximum input voltage that the transducer needs to measure, and I_p is the nominal primary current.

Calculation of Secondary Resistance (R_s):

- The secondary resistance R_s is calculated to obtain the desired output voltage based on the nominal secondary current I_s.
- The formula for R_s is:

$$R_s = \frac{V_{\text{out}}}{I_s}$$

where V_{out} is the desired output voltage, and I_s is the nominal secondary current.

Theoretical Examples to Predict Output Voltage

To better understand how these calculations are applied, here are theoretical examples illustrating the process for different configurations:

Example for $V_{\text{in}} = 500V$, $V_{\text{out}} = 3V$:

- **Calculation of R_p:**
  - Suppose we want to measure an input voltage $V_{\text{in}} = 500V$ with $I_p = 10mA$,

$$R_p = \frac{500V}{10mA} = \frac{500V}{0.01A} = 50,000\Omega = 50k\Omega$$

  - This calculation indicates that R_p should be 50 kΩ for this configuration.
- **Calculation of R_s:**
  - If $I_s = 25mA$, for an output voltage $V_{\text{out}} = 3V$,

$$R_s = \frac{3V}{25mA} = \frac{3V}{0.025A} = 120\Omega$$

  - This indicates that R_s should be 120 Ω to achieve a 3V output.

Practical Use for $V_{\text{in}} = 50V$:

- With $R_p = 50k\Omega$ as this value is marked on the component. You can clearly see this indication on the component's photo in the document.

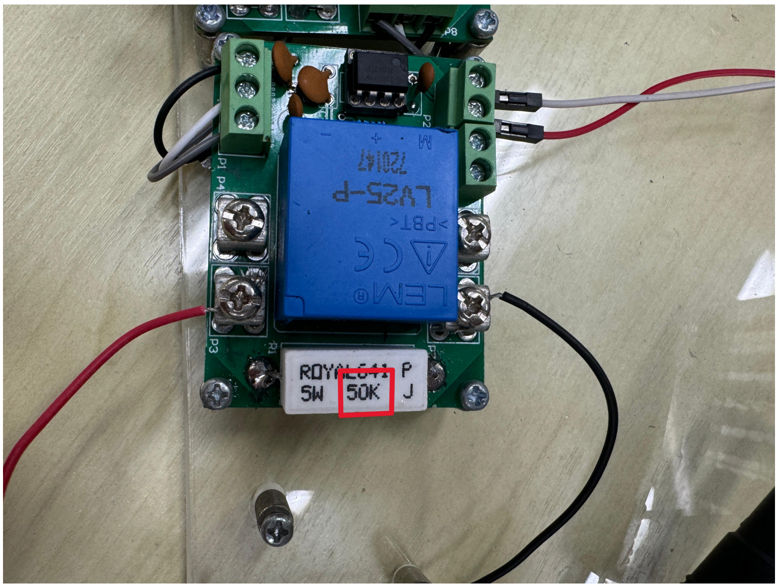


Figure 2: The primary resistance of 50 kΩ used in the setup.

- $R_s = 120\Omega$ a value determined using the resistor color code table available in the appendix. The photo of the resistor, showing the color bands clearly, will help you understand how this value is obtained.

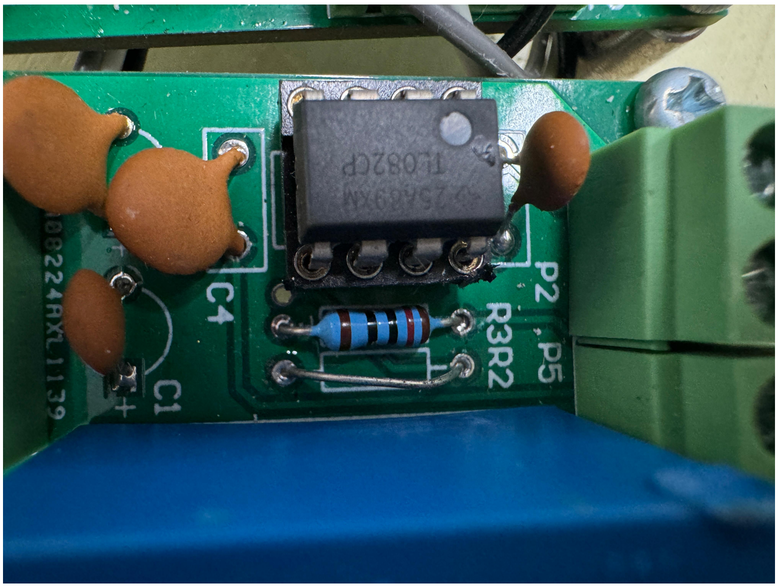


Figure 3: The secondary resistance of 120 Ω used in the setup.

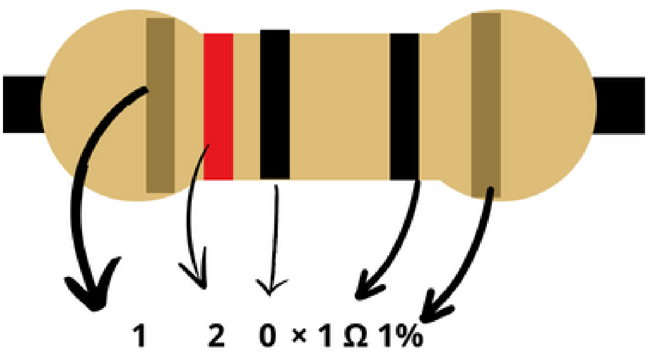


Figure 4: Detailed calculation of the primary resistance of 120 Ω.

- Let's calculate V_{out} for $V_{\text{in}} = 500V$.
- The primary current I_p would be:

$$I_p = \frac{V_{\text{in}}}{R_p} = \frac{500V}{50,000\Omega} = 0.01A = 10mA$$

- The output voltage V_{out} would be:

$$V_{\text{out}} = I_s \times R_s = 25mA \times 120\Omega = 3V$$

Analysis of Conversion Factors:

- With the calculated values:
  - $500V \to 3V$
- The theoretical conversion factor found is 166.67.

3 Preparation for Experimentation

3.1 Materials and Tools Required

To successfully carry out experiments with the LV 25-P transducer and perform precise measurements, you will need various equipment and tools. Here is the detailed list of materials needed for this practical work.

List of Equipment

1. **Variable Voltage Supply (Supply)**

Figure 5: Variable Voltage Supply used for the experiments.

   - **Description:** A device capable of providing adjustable voltage and controlled current. This source is essential for powering the test circuit and varying the input voltage applied to the LV 25-P transducer.
   - **Usage:** Allows for fine adjustment of the input voltage V_{in} to observe the impact on the output voltage V_{out} and verify theoretical calculations.

2. **LV 25-P Voltage Transducer**

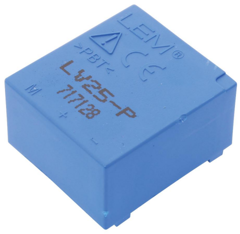


Figure 6: LV 25-P Transducer.

- **Description:** The heart of our practical work, this transducer is used to convert high voltages into lower, measurable voltages by standard instruments.
- **Usage:** It will be connected in the circuit to directly measure the reduced voltages as the input voltage varies.

3. **Voltmeter**

Figure 7: Digital multimeter used for measuring output voltages accurately.

- **Description:** A measuring instrument that allows for the precise measurement of the transducer's output voltage.
- **Usage:** Used to read the output voltage V_{out} from the LV 25-P and compare it with the expected theoretical values.

4. **Oscilloscope (Optional)**

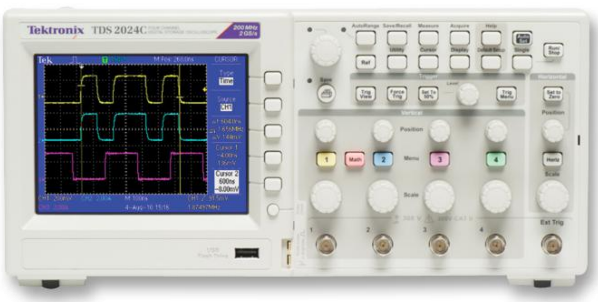


Figure 8: Oscilloscope used to observe voltage waveforms during the experiments.

- **Description:** A tool capable of visualizing electrical signals, showing their waveform over time.
- **Usage:** Can be used to observe the variations in the output voltage V_{out} from the transducer in real-time, offering a more detailed perspective than a simple voltmeter.

5. **Cables and Connectors**

- **Description:** Various cables and connectors are needed to assemble the circuit and connect the different components.
- **Usage:**
  - **Connection Cables:** To connect the voltage source to the circuit containing the LV 25-P.

  - **Measurement Cables:** To connect the voltmeter and the oscilloscope (if used) to the circuit for voltage measurements.

6. **Precision Resistances**
   - **Description:** Resistances with specific values, used to calibrate the circuit according to the calculations of R_p and R_s.
   - **Usage:**
     - **Primary Resistance R_p:** Will be chosen based on the maximum input voltage and nominal primary current.
     - **Secondary Resistance R_s:** Will be adjusted to achieve the desired output voltage from the secondary current.

Equipment Preparation

Before starting the experiments, ensure that:

- The variable voltage source is correctly set up and functional.
- The LV 25-P is inspected for any signs of damage or malfunction.
- The voltmeter and oscilloscope, if used, are calibrated and ready for measurements.
- All cables and connectors are in good condition, with no signs of degradation or potential short circuits.

By gathering and preparing this equipment, you are now ready to move on to the circuit assembly phase and begin experimental measurements, applying the theoretical knowledge acquired to obtain precise and reliable results.

3.2 Safety and Protocols

Here are some essential safety instructions to follow to ensure safe handling of transducers and electrical circuits during this lab:

1. **Turn Off Power Before Assembly:**
   - Ensure that the power supply is turned off before beginning to assemble the circuit to prevent any electrical hazard.
2. **Read Instructions and Datasheets:**
   - Take the time to carefully read the lab instructions and the datasheets of the components to understand their operation and limits.
3. **Use Appropriate Measuring Instruments:**
   - Use correct and well-maintained measuring instruments, such as voltmeters and oscilloscopes, to obtain reliable results.
4. **Do Not Exceed Component Limits:**
   - Adhere to the maximum voltages and currents specified for all components, particularly the LV 25-P transducer, to avoid overloads.
5. **Check Connections:**
   - Ensure that all connections are securely made and properly insulated before powering the circuit.
6. **Continuously Monitor Measurements:**
   - Stay alert to the measurements during the experiments. If an abnormal reading occurs, immediately stop and check the setup.
7. **Ask for Help if in Doubt:**
   - Do not hesitate to ask for help from an instructor if you are uncertain or have questions about the assembly or operation of the circuit.

8. **Unplug After Use:**
   - After the experiments, turn off and unplug the power supply before disassembling or modifying the circuit.

These instructions are concise but cover the essential aspects of working safely and efficiently with the LV 25-P transducer and electrical circuits.

3.3 Circuit Assembly

Follow these instructions to correctly connect the components and prepare your work environment for experimentation with the LV 25-P transducer.

Preparation of Components and Equipment:

- Ensure you have all the necessary components: the circuit with the LV 25-P already mounted, a variable voltage supply (supply), a voltmeter, and an oscilloscope.
- Verify that the LV 25-P and the resistances $R_p = 50\text{k}\Omega$ and $R_s = 120\Omega$ are already integrated into the circuit.

Connection of the Voltage Supply (Supply):

1. Connect the variable voltage supply to the circuit, but leave it turned off for now.
2. Set the voltage and current to the minimum values before connecting the circuit.

Connection of Measuring Instruments:

Connection of the Voltmeter:

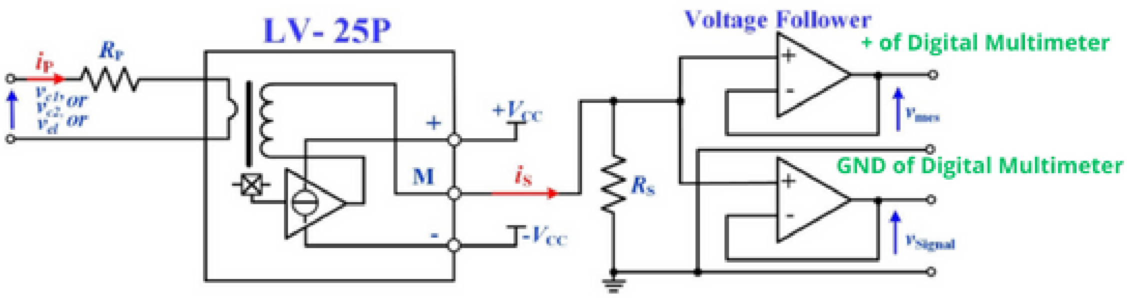


Figure 9: Schematic of the LV-25P detailing where to connect the positive and ground leads of the digital multimeter.

- Connect the voltmeter to measure the output voltage of the circuit. Ensure that the voltmeter is set to measure direct current (DC) voltage.
- Place the red wire of the voltmeter on the positive terminal located to the right of the secondary resistance R_s, and the black wire on the ground (GND) terminal, located just below this resistance on the circuit. See the image below for clarity.

Figure 10: Connecting the voltmeter cables to the circuit for accurate voltage measurements.

Connection of the Oscilloscope:

- If you are using an oscilloscope, connect one channel of the oscilloscope in the same way as the voltmeter to observe V_{mes}.
- Ensure that the oscilloscope is correctly set up to observe voltage signals.

Connection of the Circuit to the Supply:

- Locate the connection terminals of the circuit with the LV 25-P where you will connect the supply, using the following image to identify the different poles of the LV 25-P:

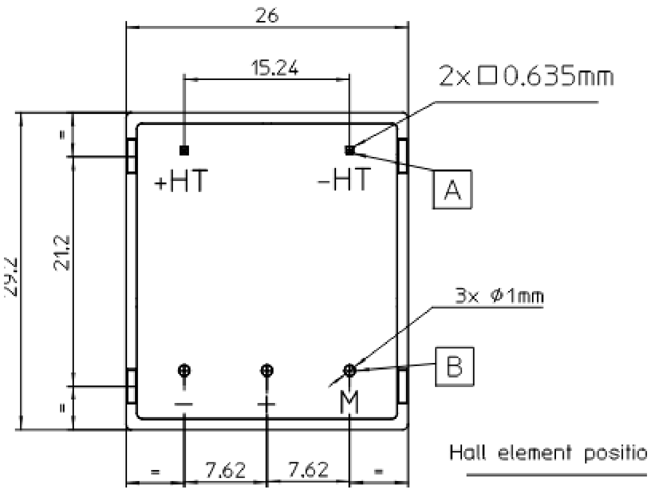


Figure 11: Different poles of the LV 25-P.

- With the primary resistance R_p facing you, and the LV 25-P nearby, you will see screws on gray terminals on both sides of the LV 25-P:
  - **Positive Terminal (+):** On the left side of the LV 25-P, connect the positive wire of the supply.
  - **Negative Terminal (-):** On the right side, connect the negative wire of the supply.

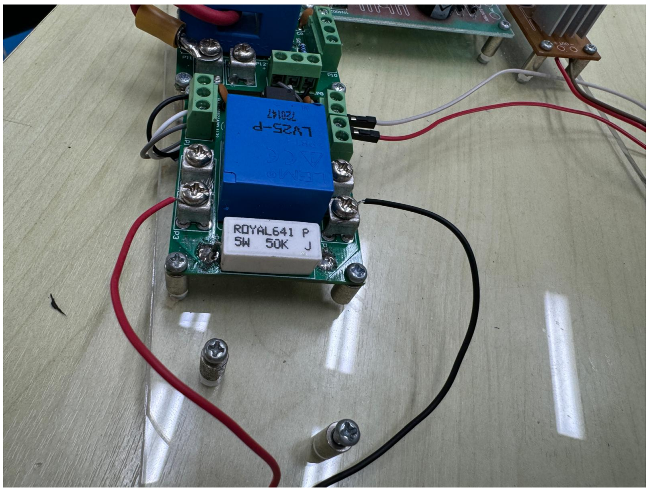


Figure 12: Actual connection of the supply cables to the circuit.

Verification and Safety Before Powering On:

- Double-check all your connections to ensure they are correct and secure.
- **Call the Professor:** Before powering on, ask a professor to check your connections.

4 Experimental Procedure

4.1 Initialization and Setup

After setting up the circuit and verifying the connections, you can begin experimental measurements in two phases: at low voltage and then at higher voltage.

- After performing these measurements at different voltages, analyze the results to validate or adjust your understanding of the behavior of the LV 25-P transducer.
- The measurements taken at various voltages allow you to plot a more complete profile of the transducer's operation, and to verify the linearity and accuracy of your initial calculations.

By following these steps, you can systematically explore and understand the behavior of the LV 25-P transducer under various voltage conditions, thereby enriching your experimental analysis.

4.2 Phase 1: Low Voltage Measurements

1. **Measuring the Output Voltage for Low Input Voltages**:
   - Start with a low voltage on your voltage supply (supply). For the initial measurements, set the supply to 10V.
   - Observe and note the output voltage V_{mes} displayed on the voltmeter. This measurement should be made accurately to validate your previous calculations.
2. **Preliminary Analysis of the Results**:
   - Analyze the measurements obtained for these low input voltages. Compare V_{mes} with the theoretical values based on the calculations for R_p and R_s.
   - For example, if you have $V_{\text{in}} = 10V$, with a theoretical factor of 166.67, you should get $V_{\text{mes}} \approx \frac{10V}{166.67} \approx 0.06V$. Note any discrepancies and consider their possible causes.

4.3 Phase 2: Higher Voltage Measurements

1. **Extending Measurements to Higher Voltages**:
   - Gradually increase the input voltage in steps (20V, 50V, etc.), monitoring and recording the output voltage V_{mes} for each step.

- These measurements help to see how the transducer reacts to a wider range of input voltages.

2. **Compiling Results into a Table**:
   - Organize your results in a structured manner to facilitate analysis. Here is an example of a table where you could compile your measurements:

Input Voltage V_{in} (V)	Output Voltage V_{mes} (V)
10	0.05
20	0.09
50	0.27
...	...

3. **Data Analysis and Comparison with Theoretical Values**:
   - Once all measurements are completed, calculate the average conversion factor from your data and compare it with the theoretical factor of 166.67.
   - Discuss any discrepancies observed to understand if they arise from the imprecision of the instruments, losses in the circuit, or other factors.

4.4 Data Analysis

- After conducting these measurements at various voltages, analyze the results to validate or adjust your understanding of the behavior of the LV 25-P transducer.
- The measurements taken at different voltages allow you to draw a more complete profile of the transducer's operation and to verify the linearity and accuracy of your initial calculations.

By following these steps, you can systematically explore and understand the behavior of the LV 25-P transducer under various voltage conditions, thereby enriching your experimental analysis.

5 Analysis and Discussion

5.1 Interpretation of Results

After conducting experimental measurements with the LV 25-P transducer, it is important to analyze the data to understand the transducer's performance and identify deviations from theoretical predictions.

Discussion on the Discrepancies between Theoretical and Experimental Results

For each input voltage V_{in}, compare the measured output voltage V_{mes} with the theoretical value calculated using the conversion factor of 166.67.

Here are the details of the calculations and the comparison:

V_{in} (V)	Theoretical $V_{mes} = \frac{V_{in}}{166.67}$ (V)	Measured V_{mes} (V)	Deviation (%)
10	$\frac{10}{166.67} \approx 0.06$	0.05	$((0.06 - 0.05)/0.06) \times 100 \approx 16.67$ %
20	$\frac{20}{166.67} \approx 0.12$	0.09	$((0.12 - 0.09)/0.12) \times 100 \approx 25.00$ %
50	$\frac{50}{166.67} \approx 0.30$	0.27	$((0.30 - 0.27)/0.30) \times 100 \approx 10.00$ %

The results show significant deviations between the theoretical and measured values. These discrepancies can be due to several factors, detailed below.

Exploration of Possible Causes of Divergences

- **Inaccuracy of Instruments**: The imprecision of the voltmeter, especially at low voltages, can introduce a significant error.
- **Losses in the Circuit**: The resistance of the connecting wires and inherent losses in the circuit can cause a reduction in the measured voltage.
- **Calibration of the Transducer**: If the LV 25-P is not perfectly calibrated, or if manufacturing variations affect its performance, the measured results may differ from theoretical calculations.
- **Temperature and Ambient Conditions**: Temperature can influence the measurements. An increase in temperature can affect the resistance of components.

5.2 Optimization and Suggestions

To enhance the accuracy of future measurements and reduce errors, here are some recommendations:

1. **Improvement of Instrument Precision**:
   - Use a high-precision voltmeter to reduce measurement error.
   - Calibrate the instruments regularly to maintain their accuracy.
2. **Minimization of Circuit Losses**:
   - Use higher quality connecting wires and check the solder joints.
   - Tighten the connections to minimize contact resistance.
3. **Stabilization of Experimental Conditions**:
   - Perform the experiments in a temperature-controlled environment.
   - Allow the components to reach a stable temperature before starting measurements.
4. **Use of Improved Measurement Techniques**:
   - Adopt differential measurement techniques to compensate for noise.
   - Consider digital data acquisition for enhanced accuracy.
5. **Re-evaluation and Calibration of the Transducer**:
   - Check and recalibrate the LV 25-P if possible, especially if deviations continue to be observed.
   - Document the specific characteristics of your transducer to adjust your calculations.

By implementing these improvements and continuing to explore the causes of discrepancies, you can refine your measurement techniques and achieve results closer to the expected theoretical values.

6 Conclusion

Summary of Activities and Key Findings

At the end of this practical work with the LV 25-P transducer, we have carried out a series of methodical measurements to assess the performance of the transducer under various input voltage conditions. Here is a summary of the activities conducted and significant discoveries:

1. **Setup and Initialization**:
   - The circuit was correctly set up with the LV 25-P and the specified resistances ($R_p = 50k\Omega$ and $R_s = 120\Omega$), and all necessary measuring instruments were prepared and verified.
   - Safety precautions were strictly followed, and the connections were checked by an instructor before proceeding with the measurements.
2. **Measurements and Analysis**:
   - Output voltage measurements V_{mes} were taken for input voltages V_{in} ranging from low to high (10V, 20V, 50V).
   - We observed discrepancies between the theoretical and experimental results, with notable differences at each voltage level.
3. **Key Discoveries**:
   - The experimental measurements showed deviations from the theoretical values, indicating an average conversion factor of 202.47, compared to the theoretical factor of 166.67.
   - Possible causes of these discrepancies were identified, including the imprecision of measuring instruments, losses in the circuit, and potential variations in the transducer's characteristics.

Suggestions for Future Application of the Concepts and Techniques Studied

To move forward and make the most of the concepts and techniques studied in this practical work, here are some suggestions:

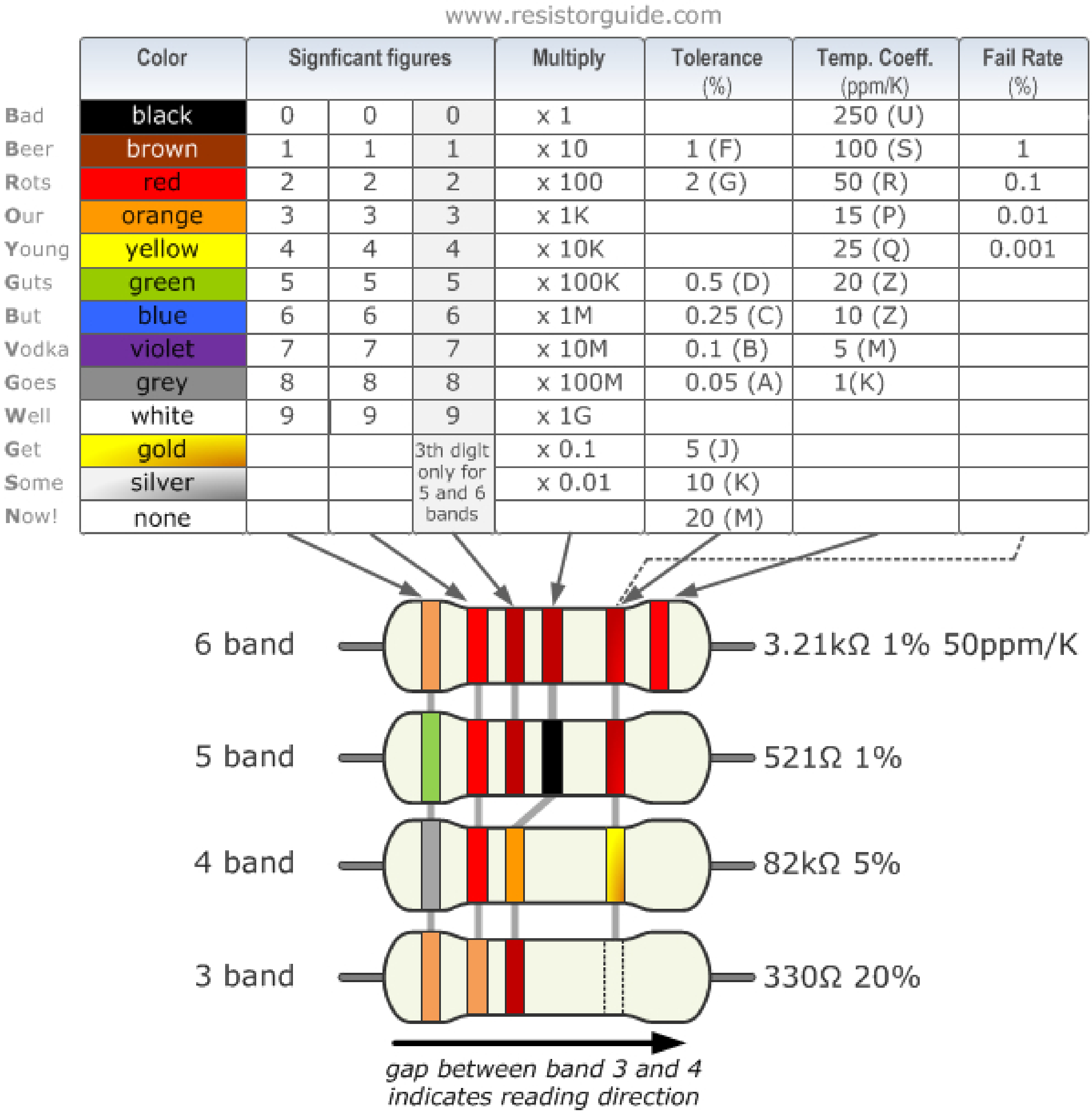
1. **Continuous Improvement of Measurements**:
   - Continue to use high-precision measuring instruments and consider digital acquisition for more stable and accurate measurements.
   - Implement differential measurement techniques and temperature-controlled environments to reduce variations and enhance the reliability of the results.
2. **Deepening of Analyses**:
   - Conduct more in-depth analyses over a wider range of voltages to better understand the behavior of the LV 25-P transducer and refine the theoretical model based on experimental observations.
   - Explore calibration corrections for the transducer and adjust the calculations according to the specific characteristics of your equipment.
3. **Practical and Interdisciplinary Application**:
   - Apply the knowledge gained in real and interdisciplinary projects, such as the development of measurement systems for solar energy or other applications requiring precise voltage measurement.
   - Encourage the integration of these experiences into study or research projects to confront theory and practice in diverse and real conditions.
4. **Sharing of Knowledge and Collaboration**:
   - Document your procedures, results, and analyses to share with other students or researchers. Collaboration can open up new perspectives and improve working methods.
   - Organize workshops or seminars to teach these techniques to others, thereby strengthening the culture of knowledge sharing and ongoing collaboration.

In conclusion, this practical work has not only enabled a detailed understanding of the functioning of the LV 25-P transducer but also identified avenues for enhancing measurement and analysis techniques. The discoveries and experiences here will serve as a basis for future explorations and innovations in the field of electronics and precise measurement.

Annexes

A Resistor Color Code Table

Below is the table of resistor color codes, used to determine the values of resistors based on the colored bands.



www.resistorguide.com

	Color	Signficant figures			Multiply	Tolerance (%)	Temp. Coeff. (ppm/K)	Fail Rate (%)
Bad	black	0	0	0	x 1		250 (U)	
Beer	brown	1	1	1	x 10	1 (F)	100 (S)	1
Rots	red	2	2	2	x 100	2 (G)	50 (R)	0.1
Our	orange	3	3	3	x 1K		15 (P)	0.01
Young	yellow	4	4	4	x 10K		25 (Q)	0.001
Guts	green	5	5	5	x 100K	0.5 (D)	20 (Z)	
But	blue	6	6	6	x 1M	0.25 (C)	10 (Z)	
Vodka	violet	7	7	7	x 10M	0.1 (B)	5 (M)	
Goes	grey	8	8	8	x 100M	0.05 (A)	1(K)	
Well	white	9	9	9	x 1G			
Get	gold			3th digit only for 5 and 6 bands	x 0.1	5 (J)		
Some	silver				x 0.01	10 (K)		
Now!	none					20 (M)		

Figure 13: Table of resistor color codes. Source: www.resistorguide.com