
LAB 5 : Voltage and Current Measurement with LV 25-P and LA 55-P Transducers

Theoretical Analysis and Parameter Calculation with Hall Effect for LA 55-P and Direct for
LV 25-P

Work done by :

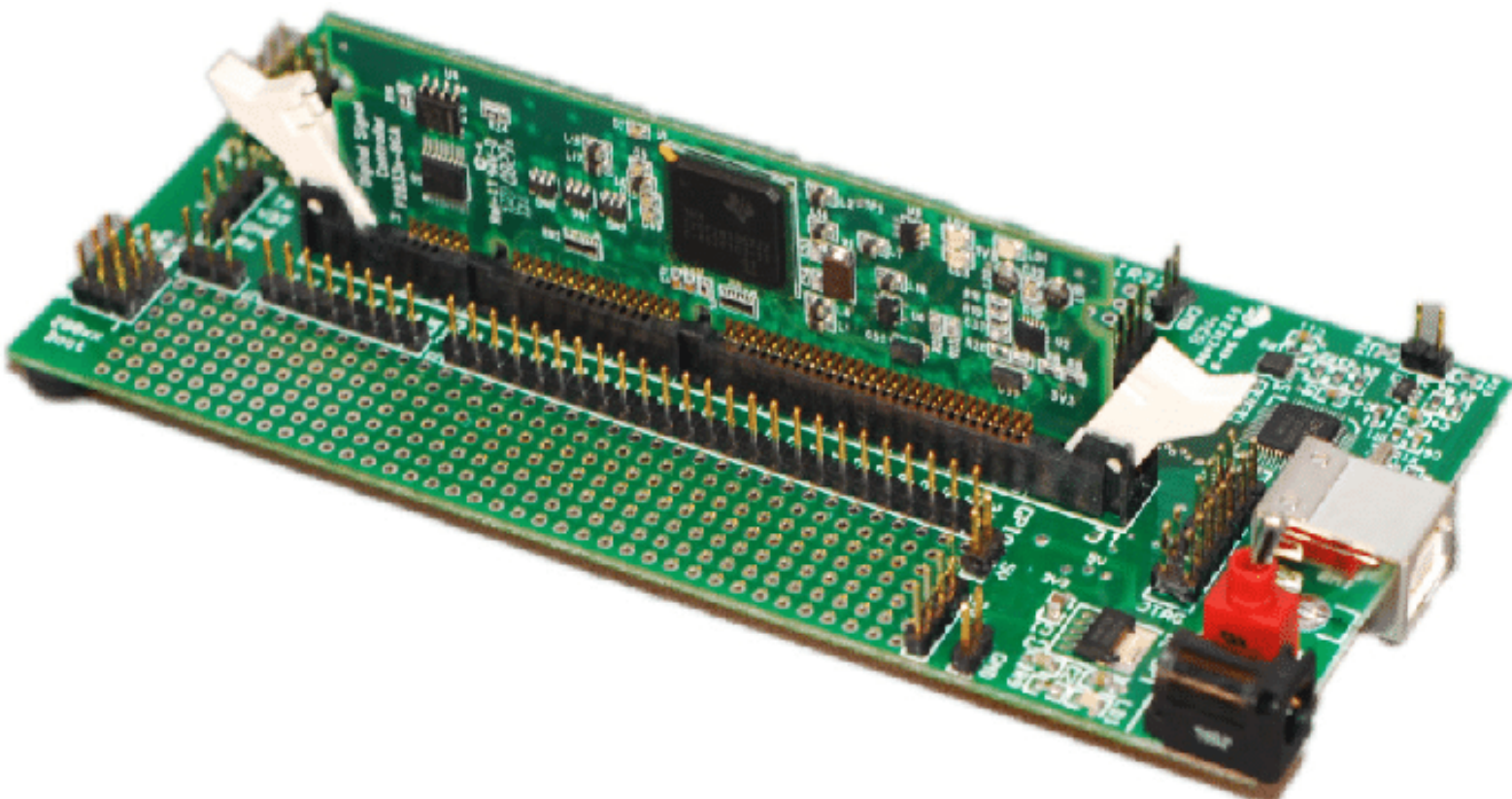
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1 Introduction

1.1 Course Objectives

This course is designed to provide students with comprehensive and practical knowledge about voltage and current transducers, particularly the LV 25-P and LA 55-P models. Through this program, we aim to develop a complete understanding of the technical principles and applications of these essential devices in various industrial and research environments. Here are the key points that students will master by the end of this course:

1. Understanding of Fundamental Principles of Transducers

- Students will acquire a solid knowledge of the internal workings of voltage and current transducers.
- They will understand how transducers convert physical quantities (voltage and current) into measurable electrical signals.

2. Ability to Analyze Technical Specifications

- Participants will learn to interpret the technical specifications of transducers, including measurement ranges, accuracy, and configurations required for different applications.
- They will be able to select the appropriate transducer for a specific application based on its technical characteristics.

3. Proficiency in Calculations for Transducer Configuration

- Students will develop the skill to perform accurate calculations regarding the primary and secondary resistances needed for optimizing the performance of transducers.
- They will learn to adjust and calibrate transducers to ensure the accuracy and reliability of measurements.

In summary, this course aims to provide comprehensive training that will prepare students not only to understand but also to apply the knowledge gained on voltage and current transducers in their future technical or research careers.

1.2 Overview of Transducers

The LV 25-P and LA 55-P transducers are essential instruments designed to measure voltage and current in various industrial and commercial environments. These devices transform physical values of voltage and current into standardized electrical signals, thus facilitating their analysis and management in complex electrical systems.

Overview of Models LV 25-P and LA 55-P

- **LV 25-P:** Specialized in voltage measurement, the LV 25-P is suited for monitoring and regulating voltage in systems where measurement accuracy is crucial for performance and safety.
- **LA 55-P:** Designed to measure current using the Hall effect, this transducer is ideal for applications requiring accurate and safe current measurement without disturbing the main circuit.

Importance in Electrical Systems The role of the LV 25-P and LA 55-P transducers is fundamental in the control and management of modern electrical systems. They not only ensure the accuracy and reliability of measurements but also operational safety and efficiency through their ability to provide reliable and real-time data.

These transducers play a vital role by enabling efficient energy management, constant monitoring, and proactive maintenance of electrical infrastructures. Their use is widespread across various sectors, including manufacturing industries, energy infrastructure, and transport systems.

This introduction serves as a foundation for exploring in detail the specific functioning of each transducer in the following sections of the course.

2 Operating Principle

2.1 LV 25-P Voltage Transducer

Voltage Measurement Mechanism

The LV 25-P is a voltage transducer (or sensor) that utilizes a measurement method based on the direct measurement of voltage without performing a voltage transformation like that done by a transformer. This device is essential for converting high voltage magnitudes into lower values, which are easier to manage for electronic measurement and control systems. Here are the details of its operation:

1. Direct Voltage Sensor:

- The LV 25-P is designed to directly measure high voltages by sampling them safely. It uses internal components to reduce this voltage to a lower level, while maintaining proportionality with the original voltage.
- It incorporates a network of high-precision resistors to divide the input voltage to a more manageable scale. This method allows for accurate measurement without actively transforming the voltage via magnetic methods.

2. Signal Conversion and Output:

- The reduced voltage is then processed by an internal electronic circuit, which converts this measured voltage into a standardized output signal, typically a low output current or voltage (e.g., 0-10 V or 4-20 mA) that is linear relative to the measured voltage.
- This signal can be easily integrated into monitoring or control systems, allowing for precise and reliable reading of high voltages in a safe and isolated environment.

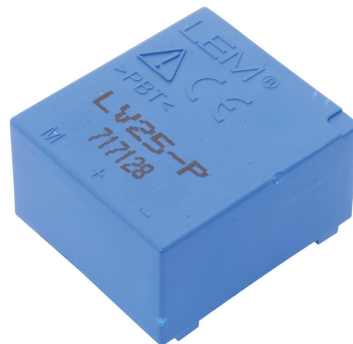


Figure 1: Current transducer model LV-25P.

Importance of Technical Specifications

• Measurement Range:

- The LV 25-P can measure voltages of several hundred volts, but it is crucial to select a model whose measurement range matches the specific requirements of the application to ensure accuracy.

• Accuracy and Reliability:

- With accuracy typically guaranteed by its design, the LV 25-P provides faithful voltage measurement, essential for critical systems where precise measurements are necessary for regulation and protection.

• Safety:

- The design of the LV 25-P provides electrical isolation between the measurement circuit and the output circuit, thereby protecting users and sensitive equipment against high voltages.

In summary, the LV 25-P voltage transducer is a precise and reliable tool for directly measuring high voltages and converting them into standard output signals. This capability makes it indispensable in many industrial and research fields, where accurate and safe voltage measurement is a necessity.

2.2 LA 55-P Current Transducer

The LA 55-P current transducer uses the Hall effect to accurately measure current in various industrial and commercial applications. The Hall effect is a phenomenon where an electrical voltage is induced in an electrical conductor, transverse to the electric current and the magnetic field passing through it.

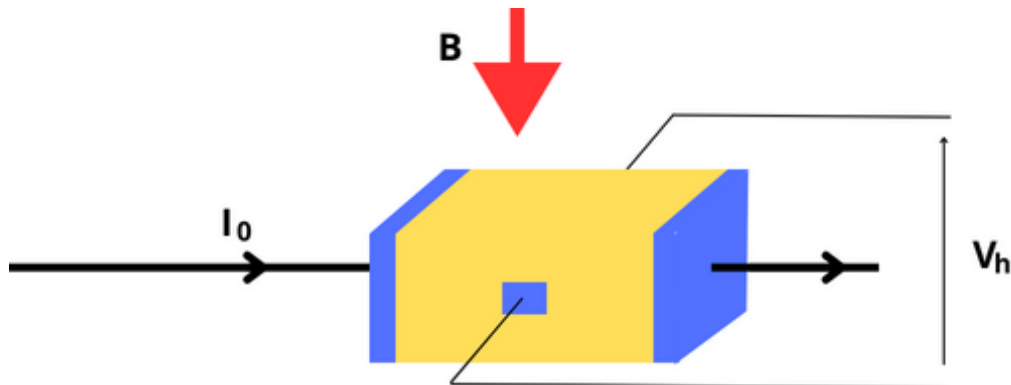


Figure 2: Diagram illustrating the Hall effect

Measurement Principle

If a current I_0 passes through a bar made of conductive or semiconductor material, and if a magnetic induction field B is applied perpendicularly to the direction of the current flow, a voltage V_h , proportional to the magnetic field and the current I_0 , appears on the lateral faces of the bar. This voltage is known as the Hall voltage and is given by the equation:

$$V_h = K_h \cdot B \cdot I_0$$

where K_h is the Hall constant, which depends on the material used.



Figure 3: Current transducer model LA-55P.

Application in the LA 55-P Transducer

1. Magnetic Field Detection:

- The current to be measured passes through a main conductor located inside the transducer, generating a magnetic field around it.
- A Hall effect sensor is placed perpendicular to the direction of the current, in an air gap of the magnetic core surrounding the conductor, to detect the created magnetic field.

2. Conversion of the Field into Electrical Signal:

- The Hall effect sensor converts the magnetic field into an electrical voltage, which is proportional to the intensity of the magnetic field, and thus to the current passing through the conductor.
- This voltage signal is then processed by integrated electronic circuits to produce a stable and accurate output signal, reflecting the intensity of the measured current.

This effect allows the LA 55-P transducer to accurately and isolatedly measure current without direct contact with the primary circuit, which is crucial for secure measurements in environments where currents can be high and electrical insulation is essential.

Importance of Galvanic Isolation

Galvanic isolation is a crucial aspect of the LA 55-P design, offering several important benefits for safety and performance of the device:

1. Protection Against High Voltages:

- Galvanic isolation between the measurement circuit (the main conductor and the Hall effect sensor) and the output circuit prevents the high voltages measured from propagating into the electrical system to which the transducer is connected. This protects sensitive equipment and users from potential risks of electric shocks or short circuits.

2. Reduction of Electrical Interferences:

- By electrically isolating the sensor from the rest of the circuit, the LA 55-P minimizes electromagnetic interferences that could affect the accuracy of the measurements. This is particularly important in industrial environments where many devices can generate electromagnetic interferences.

3. Enhancement of Reliability:

- Galvanic isolation ensures that the performance of the transducer is not affected by variations or disturbances in the connected circuit. This improves the reliability and lifespan of the transducer, avoiding potential damage from voltage surges or electrical imbalances.

In conclusion, the LA 55-P current transducer offers an accurate and reliable method of measuring current using the Hall effect, while ensuring optimal system safety and integrity through its galvanic isolation. These features make the LA 55-P a preferred choice for applications requiring precise current measurements in demanding environments.

3 Technical Characteristics and Specifications

3.1 Specifications of LV 25-P

The LV 25-P voltage transducer is designed to measure DC, AC, and pulsed voltages, with galvanic isolation between the primary and secondary circuits. Here is a detailed presentation of the technical specifications organized in tables for easy and clear reading.

Measurement Range and Accuracy

Parameter	Value	Unit
Nominal Primary Current (IP N)	10	mA
Current Measurement Range (IP M)	0 – ±14	mA
Measurable Voltage (UP N)	10 - 500	V
Total Error at TA = 25°C	±0.9% (@ ±12...15 V)	%
Linearity Error (L)	<0.2	%

Resistance Configuration

Description	Min. Value	Max. Value	Unit
Measurement Resistance (RM)	30	350	Ω
Primary Resistance (RP)	250	—	Ω
Secondary Resistance (RS)	110	—	Ω

Dynamic Response and Performance

Parameter	Value	Unit
Response Time (tD 90)	40	μs
Offset Current at TA = 25°C (IO)	±0.15	mA
Temperature Variation of IO	±0.06 to ±0.35	mA

General Characteristics

Parameter	Value	Unit
Operating Temperature (TA)	0 – +70	°C
Weight (m)	22	g

Advantages and Applications

The LV 25-P is valued for its high accuracy, excellent linearity, low thermal drift, rapid response time, and wide bandwidth. These qualities make it an optimal choice for a variety of applications:

- AC variable speed drives and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Power supplies for welding applications

These specifications show that the LV 25-P is perfectly suited for industrial environments requiring precise voltage measurements with excellent reliability.

3.2 Specifications of LA 55-P

The LA 55-P current transducer uses the Hall effect for the accurate measurement of DC, AC, and pulsed currents, with galvanic separation between the primary and secondary circuits. Here is a structured review of the technical specifications of the LA 55-P, presented in tables.

Electrical Characteristics

Parameter	Value	Unit
Nominal RMS Primary Current (IP N)	50	A
Current Measurement Range (IP M)	0 to ± 70	A
Measurement Resistance at 70°C (RM)	10 min – 100 max	Ω
Nominal RMS Secondary Current (IS N)	50	mA
Transformation Ratio (NP/NS)	1 : 1000	-
Supply Voltage (UC)	± 12 to ± 15	V
Current Consumption	10 (at ± 15 V) + IS	mA

Accuracy and Dynamic Performance

Parameter	Value	Unit
Error at IP N, TA = 25 °C	± 0.65 to ± 0.90	%
Linearity Error (L)	< 0.15	%
Offset Current (IO)	± 0.2	mA
Temperature Variation of IO	± 0.1 to ± 1.0	mA
Frequency Bandwidth (BW)	DC to 200 kHz	-

Safety and Isolation Characteristics

Parameter	Value	Unit
AC Isolation Voltage, 50 Hz/1 min	2.5	kV
Impulse Withstand Voltage	5.7	kV
Creepage and Clearance Distance	5	mm

Environment and Generalities

Parameter	Value	Unit
Operating Temperature (TA)	-40 to +85	°C
Storage Temperature (TS)	-40 to +90	°C
Secondary Winding Resistance at 70°C	80	Ω
Mass	18	g

These technical specifications highlight the capability of the LA 55-P to provide precise and reliable current measurements across a wide range of industrial applications.

4 Theory of Calculations and Settings

4.1 Calculations for LV 25-P

For the LV 25-P voltage transducer, correct sizing of the primary and secondary resistances is crucial to ensure optimal and safe performance. These resistances play a key role in regulating the current flowing through the transducer, and therefore in the accuracy of the voltage measurement.

Description of the LV-25P Transducer Circuit

Here is a detailed illustration of the internal circuit of the LV-25P voltage transducer, including a configuration with a voltage follower to stabilize the output voltage.

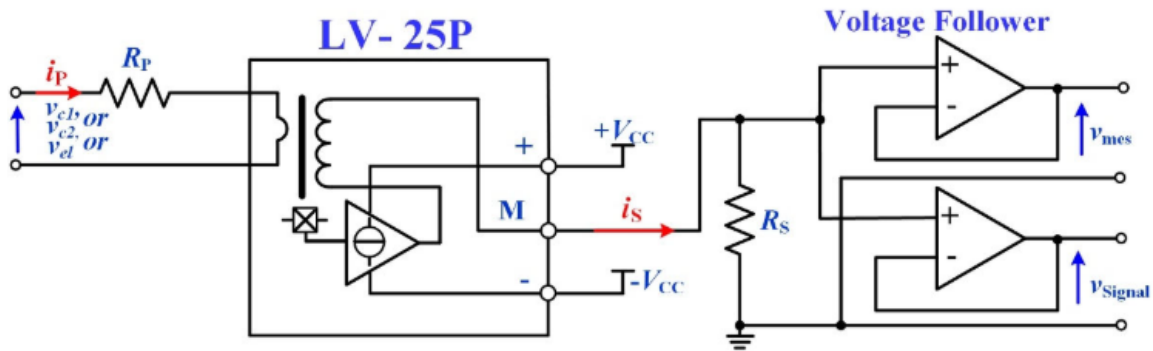


Figure 4: Circuit diagram of the LV-25P transducer

Objectives of the Calculations

- Limit the primary current to its nominal level to protect the transducer and ensure the accuracy of the measurement.
- Adapt the output voltage to the specifications of the measurement systems being used.

Key Parameters

- **Nominal primary current** (I_p): 10 mA
- **Nominal secondary current** (I_s): 25 mA
- **Maximum voltage to be measured** V_{c1} , V_{c2} , or V_{el} : each equivalent to 120 V
- **Desired output voltage** (V_{Signal}): 10 V

Calculation of Primary Resistance (R_p)

The primary resistance R_p should be calculated to ensure that the current does not exceed the nominal primary current of 10 mA, regardless of the maximum measured voltage.

Formula

$$R_p = \frac{V_{c1} \text{ or } V_{c2} \text{ or } V_{el}}{I_p}$$

Application of the Formula

$$R_p = \frac{120 \text{ V}}{10 \text{ mA}} = 12,000 \Omega (12 \text{ k}\Omega)$$

This resistance value ensures that the current remains within safe limits while allowing the transducer to measure up to 120 V.

Calculation of Secondary Resistance (R_s)

The secondary resistance R_s is adjusted to obtain the desired output voltage of 10 V from the nominal secondary current.

Formula

$$R_s = \frac{V_{Signal}}{I_s}$$

Application of the Formula

$$R_s = \frac{10 \text{ V}}{25 \text{ mA}} = 400 \Omega$$

This resistance allows converting the sensor current into a usable output voltage for other electronic equipment.

By correctly applying these formulas to calculate R_p and R_s , the LV 25-P can measure high voltages accurately and safely, while providing a suitable output signal for subsequent applications. This calculation process ensures that the transducer operates efficiently in its intended operational environment.

4.2 Calculations for LA 55-P

To effectively use the LA 55-P current transducer and obtain the desired output voltage, it is crucial to correctly calculate the resistances based on the datasheet specifications. Here is a detailed procedure for determining these resistances.

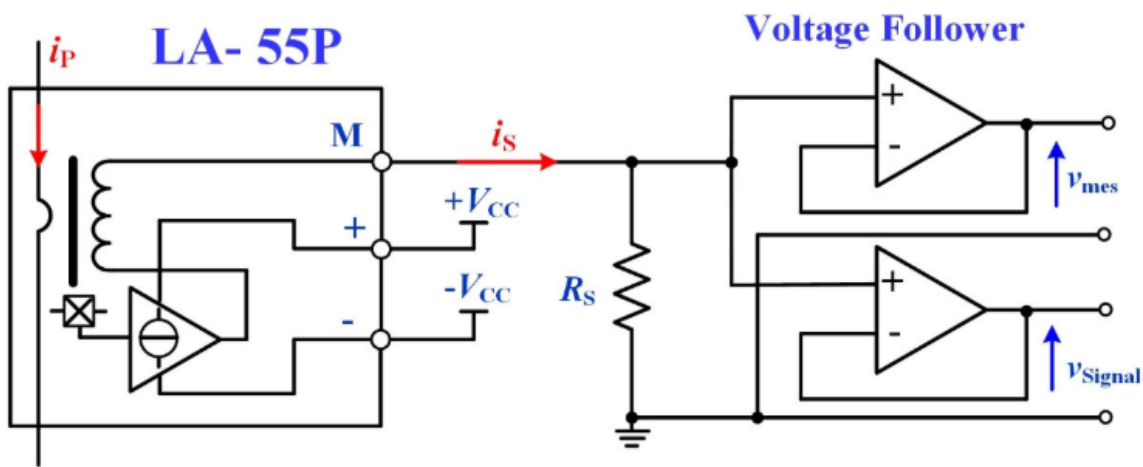


Figure 5: Circuit diagram of the LA-55P transducer

Key Parameters for Calculations

- Nominal RMS secondary current (I_S): 50 mA
- Transformation ratio (N_P/N_S): 1 : 1000
- Current measurement range (I_P): 0 to ± 70 A
- Supply voltage (UC): ± 12 V to ± 15 V

Objective

Determine the value of the measurement resistance (R_M) to obtain a specific output voltage based on the current measured by the LA 55-P.

Basic Formulas

Explanation of the Transformation Ratio in a Current Transducer

In a current transducer, the transformation ratio N_P/N_S depends on the number of times the primary conductor passes through the magnetic core relative to the total number of turns of the secondary conductor wire around this core. If N_P represents the number of passes of the primary wire through the core and N_S the number of turns of the secondary wire around the core, then the transformation ratio is calculated as follows:

Configuration of the Transformation Ratio

- **One secondary turn** ($N_S = 1$): If the primary wire passes once through the core and the secondary wire is wound once around the core, then $N_P/N_S = 1/1 = 1$.

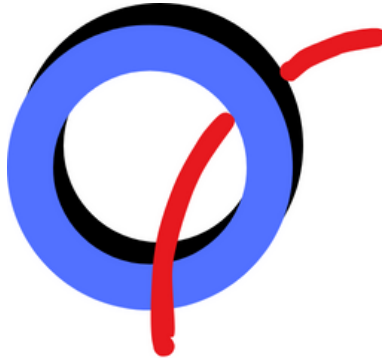


Figure 6: Configuration with one secondary turn: Ratio 1.

- **Two secondary turns** ($N_S = 2$): If the primary wire passes once through the core and the secondary wire is wound twice, then $N_P/N_S = 1/2$.

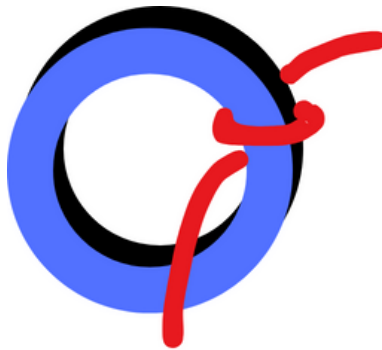


Figure 7: Configuration with two secondary turns: Ratio 1/2.

- **Three secondary turns** ($N_S = 3$): If the primary wire passes once through the core and the secondary wire is wound three times $N_P/N_S = 1/3$.

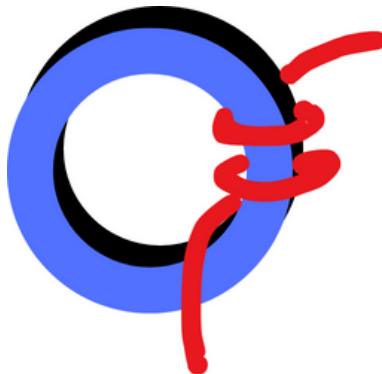


Figure 8: Configuration with three secondary turns: Ratio 1/3.

The logic remains the same if the primary wire passes multiple times through the core or if the secondary wire makes more turns.

Calculation of the Output Voltage Based on the Primary Current

The output voltage (V_{out}) of the LA 55-P is directly proportional to the primary current (I_P) measured, according to the formula:

$$V_{Signal} = \left(\frac{N_P}{N_S} \right) \times I_P \times R_M$$

where:

- N_P/N_S is the transformation ratio of the transducer (1 : 1000)
- I_P is the primary current
- R_M is the measurement resistance

Simplifying for the LA 55-P where $N_P/N_S = 1/1000$:

$$V_{Signal} = \frac{I_P \times R_M}{1000}$$

Solving for R_M

To achieve the desired output voltage $V_{Signal(desired)}$ for a primary current I_P , the resistance R_M must be:

$$R_M = \frac{V_{Signal(desired)} \times 1000}{I_P}$$

Example Calculation

Suppose you want to obtain an output voltage of 5 V for a primary current of 50 A:

- **Data:**

- $V_{Signal(desired)} = 5 \text{ V}$
- $I_P = 50 \text{ A}$

- **Calculation of R_M :**

$$\begin{aligned} R_M &= \frac{5 \times 1000}{50} \\ R_M &= \frac{5000}{50} \\ R_M &= 100 \Omega \end{aligned}$$

To obtain an output voltage of 5 V when the primary current is 50 A, you must use a measurement resistance R_M of 100 Ω with the LA 55-P current transducer.

This method allows you to configure the LA 55-P for various applications by adjusting R_M to achieve the necessary output voltage based on the measured current, ensuring precise and flexible use of the transducer in your measurement system.

5 Conclusion

At the conclusion of this course dedicated to the LV 25-P voltage transducer and the LA 55-P current transducer, participants have gained a thorough understanding of these essential devices for the precise measurement of electrical quantities in various industrial applications. Here are the main points we covered and the skills the students developed:

1. Understanding Voltage and Current Transducers:

- Students learned the detailed operation of the LV 25-P voltage transducer, which uses a direct method to measure high voltages and convert them into usable output signals, without requiring major transformation of the initial voltage.
- For the LA 55-P current transducer, participants explored how the Hall effect is used to measure current accurately, providing an efficient solution with galvanic isolation for optimal safety.

2. Mastery of Technical Specifications:

- The technical characteristics of both transducers, including measurement ranges, accuracy, and resistance configuration, were studied in detail. This knowledge allows for optimal selection and use of these transducers in various contexts.

3. Calculations and Configuration:

- Students learned how to calculate the necessary resistances to configure the transducers according to the specific needs of their application. This skill is crucial for adjusting the output voltage and ensuring that the measurements are both accurate and consistent with expectations.

4. Importance of Precise Measurements:

- The importance of precise measurements for the safety, efficiency, and reliability of industrial systems was a major theme. Transducers like the LV 25-P and LA 55-P are shown to be essential for these objectives, helping to monitor and control processes with great accuracy.

In summary, this course not only reinforced the technical understanding of voltage and current transducers but also prepared students to apply them effectively and safely in their future career. The knowledge and skills acquired here will serve as a solid foundation for their continued professional development in the field of power electronics and industrial automation.