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**Diagnosis and Repair of Workshop Electro-Mechanical Systems**

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# DEDICATION

To my family,

for your endless love, constant support, and strong encouragement throughout my studies and the challenges of this thesis. Your belief in me has been my greatest motivation, your support is my key to show all my capabilities.

To my teachers,

who have guided my learning and inspired my curiosity. and contributed to building the skills I have today.

To my friends,

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And to all the good people who crossed my path and contributed, with their efforts big or small, to my growth and the completion of this work.

This thesis is dedicated to you all with my deepest gratitude

**KHAREZI FARES**

## DEDICATION

I would like to begin by thanking God, for His guidance, strength, and unwavering support have been my inspiration throughout this journey.

To my beloved parents, Youcef and Sabah, words cannot fully express my gratitude for your constant support and encouragement. You have been the bedrock of my achievements, instilling in me the values of hard work and perseverance. Your sacrifices and unwavering belief in my potential have inspired me to strive for excellence at every turn. From my earliest memories to this momentous occasion, you have been my guiding stars, illuminating my path and lifting me during challenging times. You are, and will always remain, the two people closest to my heart, and I am endlessly grateful for the love and wisdom you've shared with me.

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MEHDI QUODS

## ملخص:

تقدم هذه الأطروحة تحقيقًا منهجيًا في منهجيات تشخيص الأعطال وإصلاحها للآلات الكهروميكانيكية داخل ورشة عمل جامعية. باستخدام نهج عملي لتقييم السلامة الكهربائية يعتمد على الفحص المادي للمكونات (الأجهزة)، تفصل الدراسة التشخيص الأولي، وفحص الأعطال، والإصلاح المطبق أو التوصيات المتعلقة بالاختلالات الوظيفية في أربع آلات تجريبية متنوعة: منشاري قطع، وآلة اختبار الصدم، وآلة قطع دقيقة. من خلال عمليات الفحص البصري، والاختبارات الكهربائية المستهدفة، والإجراءات التصحيحية التي تعالج مشكلات مثل تلف الموصلات، وفشل إمدادات الطاقة، وأعطال دوائر التحكم، واختلالات أقفال الأمان، تمت استعادة القدرة التشغيلية لنصف الآلات المختارة، بينما تم عزل أعطال الألتين الآخرين لإجراء فحص وإصلاح متقدم. لقد أثبت البحث فعالية استراتيجية التشخيص الأساسية والعملية في تعزيز موثوقية الآلات ويقدم رؤى عملية لصيانة الورش والتعليم الهندسي.

## ABSTRACT

This thesis presents a systematic investigation into fault diagnosis and repair methodologies for electro-mechanical machinery within a university workshop. Employing a practical, hardware-based electrical integrity assessment approach, the study details the preliminary diagnosis, fault examination, and implemented repair / recommendation of malfunctions in four diverse experimental machines: two cut-off saws, an impact tester, and a micro-cutting machine. Through visual inspections, targeted electrical testing, and corrective actions addressing issues such as connector damage, power supply failures, control circuit faults, and safety interlock malfunctions, half of the selected machines were restored to operational functionality and the two others machines malfunctions have been isolated for advanced examination and repair. The research aligned the efficacy of a fundamental, hands-on diagnostic strategy in enhancing machine reliability and offers practical insights for workshop maintenance and engineering education.

## RÉSUMÉ

Cette thèse présente une investigation systématique des méthodologies de diagnostic et de réparation des pannes pour machines électromécaniques en atelier universitaire. Adoptant une approche pratique d'évaluation de l'intégrité électrique basée sur le matériel, l'étude détaille le diagnostic préliminaire, l'examen des pannes, et la réparation/recommandation pour les dysfonctionnements de quatre machines expérimentales : deux scies à tronçonner, une machine d'essai de choc, et une machine de micro-découpe. Via inspections visuelles, tests électriques ciblés, et actions correctives, la moitié des machines ont été remises en état de fonctionnement ; les pannes des deux autres ont été isolées pour examen et réparation approfondis. La recherche démontre l'efficacité d'une stratégie de diagnostic fondamentale et pratique pour améliorer la fiabilité des machines et offre des perspectives concrètes pour la maintenance et la formation en ingénierie.

## LIST OF ABBREVIATION

Abbreviation	Full Form
AC	Alternating Current
ASTM	American Society for Testing and Materials
CPU	Central Processing Unit
DC	Direct Current
DMM	Digital Multimeter
ENSTI	École Supérieure Nationale de Technologie et d'Ingénierie ( <i>National Higher School of Technology and Engineering</i> )
HMI	Human-Machine Interface
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
LOTO	Lockout-Tagout
VFD	Variable Frequency Drive

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## **GENERAL INTRODUCTION:**

Assuring the healthy state and maintainability of electro-mechanical systems are fundamental to productivity and safety across diverse industrial, experimental, and educational domains. However, the operational malconditioning stresses these systems endure which definitely leads to malfunctions, ranging from minor performance degradations to critical failures. Effective fault diagnosis—the systematic process of detecting, isolating, and identifying the root causes of such malfunctions—thus stands as a necessity of modern engineering maintenance and reliability practices. It enables targeted interventions that minimize downtime, optimize resource allocation for repairs, prevent catastrophic incidents, and extend the operational lifespan of valuable equipment.

This thesis explores the principles and practical application of fault diagnosis methodologies, focusing on developing and validating an approach suitable for addressing common failures encountered in a typical array of workshop machinery, which then contributes to both the theoretical understanding and the hands-on resolution of real-world engineering challenges.

# CHAPTER 1: PRESENTATION OF THE MECHANICAL WORKSHOP



Figure 1. 1: General View of the Technical Workshop Environment

## 1. Overview of the workshop and its equipment:

The mechanical workshop that is of the Higher National School of Technology and Engineering in Annaba, Algeria, is a dedicated space for mechanical engineering practical training. Professional-grade machines and tools cover cutting saws, high-temperature furnaces (up to 1200°C), universal testing machines, impact testers, hardness testers, and other specialized mechanical equipment. These machines serve roles that are necessary in laboratory sessions, and they enable students to carry out experiments that are real in material strength, thermal treatment, machining, and more. Work tables, chairs, boards, with utilities to support learning, the following table shows more details about the existing machines.

<b>Equipment Category</b>	<b>Type / Main Model</b>	<b>Quantity</b>	<b>Primary Use</b>
<i>Heat Treatment</i>	<i>Nabertherm Furnaces, Carbolite ELF 11/14B</i>	<i>6 total</i>	<i>Thermal treatment, high-temperature heating</i>
<i>Mechanical Testing</i>	<i>Universal Testers (WDW-50), Impact Tester (JBW-300N), INNOVATEST Hardness/Micro Testers</i>	<i>7 total</i>	<i>Material strength, toughness, hardness testing</i>

<i>Material Cutting &amp; Sectioning</i>	<i>Horizontal Band Saws (G7125), Cut-Off Saws (Hitech, PRESI T210)</i>	<i>5 total</i>	<i>Bulk cutting, precision sample preparation</i>
<i>Machining (Material Removal)</i>	<i>Column Drills (ZJ5125), Conventional Lathes (RUNMASTER), Manual Milling Machines</i>	<i>9 total</i>	<i>Drilling, turning, milling operations</i>
<i>Welding</i>	<i>Arc Welders (BX1-400, Helvi)</i>	<i>2</i>	<i>Joining and fabrication of metallic components</i>

Table 1. 1 : Overview of Key Workshop Equipment

## **2. Motivation:**

We chose this topic since our studies gave us technical knowledge we wanted to apply to a real problem we noticed in our school environment. Some machines are partly functional or totally inoperative at the ESNTI mechanical workshop. Our goal for this project is to find practical solutions to repair and restore these machines so students can use them again during laboratory sessions. and to face real technical challenges as well as improve our diagnostic skills plus maintain equipment then solve problems, skills important for our future careers as engineers.

## **3. Problem Statement:**

Several machines in the ESNTI mechanical workshop are currently non-functional due to technical failures or lack of maintenance, which reduces their availability for educational purposes. This affects the quality of hands-on learning and students' ability to engage with practical applications. The central question is: how can we accurately diagnose the malfunctions of these experimental machines and propose effective and sustainable repair solutions within a safe and educational framework?

# **CHAPTER 2: THEORETICAL BASE ON FAULT DIAGNOSIS**

## **1. Introduction:**

The reliability of modern control systems is increasingly critical for ensuring product quality, operational safety, and sustained performance. As these systems are composed of components susceptible to various forms of degradation and failure, the ability to diagnose and compensate for fault conditions is essential [1]. This chapter outlines the foundational methods for fault diagnosis, establishing a framework for understanding how malfunctions in complex systems are identified and characterized.

## **2. Overview of Fault Diagnosis Techniques:**

Fault diagnosis methodologies aim to determine the type, size, location, and detection time of a fault using available system measurements [1]. These techniques are broadly classified into three primary categories: model-based, hardware-based, and history-based fault diagnosis, each employing distinct principles to achieve fault detection and isolation

### **2.1 Model-based methods:**

Model-based methods utilize a mathematical or qualitative representation of the system's normal behavior. Faults are inferred by comparing the system's actual measured outputs against those predicted by the model, with significant deviations, or residuals, indicating a fault condition [1].

### **2.2 Hardware-based techniques:**

Hardware-based approaches do not primarily rely on a mathematical model of the system's physics. Instead, they employ techniques such as hardware redundancy, limit checking of process variables, or specialized sensor hardware to detect operational anomalies and component failures [1].

### **2.3 History-Based Fault Diagnosis:**

History-based methods derive a model of the process from known and measured input-output data rather than from a fundamental understanding of the system's physics. This data-derived model is then used, often in a manner similar to model-based approaches, to generate residuals and identify faults [1].

## **3. Selection of Diagnostic Methodology**

For the experimental machinery in this study, a Hardware-Based Electrical Integrity Assessment Methodology was selected. This choice is driven by the educational context, resource availability within the university workshop (standard Digital Multimeters (DMMs), basic safety equipment), and the practical need for straightforward, hands-on fault localization.

This approach aligns with fundamental industrial maintenance and electrical testing practices, emphasizing direct measurement and verification of electrical parameters [1]. It provides a valuable foundation for understanding equipment condition without immediate reliance on complex modeling or advanced signal analysis.

## **4. Diagnostic Procedure**

The following procedure integrates visual inspection, electrical measurements, and basic signal verification to systematically identify and isolate faults. Each step includes specification of test parameters and acceptable tolerance ranges in accordance with relevant standards.

### **4.1 Visual Inspection and Symptom Documentation:**

Initial assessment begins with documenting operational symptoms—such as anomalous noise, unexpected stoppage, or circuit-breaker tripping—and conducting a thorough visual inspection. Wiring harnesses, terminal connections, and component surfaces are examined for signs of wear, corrosion, discoloration, or mechanical damage. Mechanical elements (bearings, blades, shafts) are checked for misalignment or obstruction. Abnormal heat (indicated by discoloration or unusual warmth) and fluid leaks in cooling circuits are noted. These observations help narrow potential fault categories before proceeding to measurements.

### **4.2 Safety Measures and De-Energization:**

Prior to any electrical testing, the machine is de-energized following lockout-tagout (LOTO) procedures. The main supply is switched off, isolated, and locked with a tag indicating “Do Not Operate.” A calibrated DMM—verified on a known live source—is used to confirm zero voltage at motor terminals and control inputs (IEC 60947-1:2016) [4]. Stored energy in capacitors (e.g., inverters) is discharged according to manufacturer guidelines to prevent accidental shock.

### **4.3 Continuity and Resistance Testing:**

#### **4.3.1 Continuity Verification**

With power isolated, continuity tests are performed using a DMM in continuity mode. An audible buzzer indicates intact circuits when resistance is  $<5\ \Omega$  [2]. This test confirms electrical paths in:

- Motor windings (phase-to-phase and phase-to-neutral)
- Control circuits (safety interlocks, contactor coils)

#### **4.3.2 Resistance Measurement**

Winding resistance is measured phase-to-phase using DMM low-resistance ranges ( $20\ \Omega/200\ \Omega$ ). Acceptable values are within  $\pm 5\%$  of manufacturer's nominal specification [3].

- $\downarrow$  Low resistance: Shorted turns [2]
- $\uparrow$  OL reading: Open circuit [2]

### 4.3.3 Control Circuit Assessment

Component resistance is evaluated per industrial standards:

- Healthy contacts:  $<0.5 \Omega$  [4]
- Faulty contacts:  $>1 \text{ M}\Omega$  [2]

### 4.4 Insulation Resistance Assessment:

Insulation resistance tests use a megohmmeter applying 500 V DC between each winding and the machine frame . Measurements must exceed  $1 \text{ M}\Omega$  at  $20^\circ\text{C}$  ambient temperature; values obtained at other temperatures require correction using standard coefficients . Readings below  $0.5 \text{ M}\Omega$  indicate severe insulation deterioration or moisture ingress. For preliminary screening only, a DMM on high-resistance range ( $>10 \text{ M}\Omega$ ) may detect gross faults but provides no safety certification due to insufficient test voltage and accuracy limitations [2].

### 4.5 Operational Verification:

After insulation testing, the machine is re-energized under controlled conditions. AC voltages are measured at supply terminals:

- Three-phase systems:  $400 \text{ V} \pm 5\%$  (380-420 V) [5]
- Single-phase equipment:  $230 \text{ V} \pm 5\%$  (220-242 V) [5]

Control circuit voltages are verified against nominal design values. Inrush and running currents are measured using a clamp ammeter; phase current imbalance  $\leq 10\%$  indicates healthy windings, while  $>10\%$  imbalance suggests internal shorts or mechanical binding [2].

### 4.6 Fault Analysis and Documentation:

All measurements and observations are recorded in a standardized log: date, time, instrument settings, and measured values. From this data, potential fault hypotheses—such as open winding, shorted turn, or insulation breakdown—are formulated. Confirmatory tests may include sensor bypass or component substitution. If operation is restored under bypass, the original element is confirmed faulty [2].

## 5. Chapter Summary:

This chapter outlined key fault diagnosis methods and diagnostic parameters for electro-mechanical systems. It then described the methodology used in this research, emphasizing simplicity and reliability. The approach provides a solid foundation for detecting faults in experimental machines. These foundational techniques provide the necessary background for the more specific diagnostic practices employed in later chapters.

# **CHAPTER 3: PRELIMINARY DIAGNOSIS OF THE SELECTED MACHINES**

## **1. Introduction**

Experimental machines in university workshops serve a dual purpose: they underpin hands-on learning for students and support research projects that advance mechanical knowledge. Because these machines are used intensively and often by trainees, they are prone to faults that can interrupt both teaching and research activities. In this chapter, we leverage the theoretical fault-diagnosis framework developed in Chapter 2 to investigate four machines, with the goal of formulating well-founded hypotheses about their failure modes and clarifying their current condition. By applying practical inspection and electrical testing techniques, we intend to narrow down each machine's likely fault sources, thereby simplifying subsequent maintenance work and guiding deeper research in Chapter 4.

## **2. Methodology Recap and Specific Application**

The preliminary diagnostic investigations presented in this chapter adhere to the Hardware-Based Electrical Integrity Assessment Methodology detailed in Chapter 2. This systematic approach encompasses several key phases: initial symptom documentation and visual/sensory inspection; rigorous equipment de-energization and safety verification (Lockout/Tagout); comprehensive de-energized electrical testing including continuity and resistance measurements; conditional energized electrical parameter verification; and finally, hypothesis formulation, fault isolation, and documentation. For the practical application of this methodology across the four selected machines, standard diagnostic instruments were employed, primarily consisting of a digital multimeter (DMM) and basic hand tools sourced from the workshop's tool storage.

### 3. Machine A – Macro Cut-Off Saw 1 (Hitech Europe 300 A)



Figure 3. 1: The Hitech Europe 300 A Macro Cut-Off Saw

#### 3.1 Machine Description and Function:

Machine A is a heavy-duty bench-mounted cut-off saw designed for sectioning large metal or composite specimens in a teaching workshop. It is powered by a 3000 W, 7.5 A, three-phase (380 V) inverter motor driving a 300 mm abrasive wheel. It includes a control panel with an Human-Machine Interface (HMI) for operational commands and status display. Power switching components ( main power switch, contactors, relays). A mechanism for feeding the cutting wheel into the workpiece, which involves automated movement. An integrated water-cooling circuit minimizes heat and preserves blade life, while an electromagnetic brake stops the wheel immediately after each cut. A polycarbonate safety guard and automatic shutdown logic ensure operator protection during educational demonstrations [6].

#### 3.2 Operational failure symptoms:

Upon attempting to operate the machine, it was observed that it did not respond to commands input via the HMI, specifically for initiating the movement of the cutting wheel assembly. Furthermore, the main drive motor would operate briefly after startup but would then shut down and could not be restarted without a full power cycle (restarting) of the entire machine. These symptoms indicated a significant operational fault requiring systematic diagnosis.

### 3.3 Preliminary Diagnostic Findings:

A general visual inspection of the machine exterior indicated it was clean, with no immediate signs of gross physical damage to the casing, frame, or guards. All covers and guards appeared to be in place and properly secured.

The main power cable and its connection to the workshop supply were observed to be in good condition. The external appearance of the control panel and HMI was also satisfactory, with no obvious damage to buttons or the screen, and no unusual fault indicator lights were illuminated during the observed fault conditions.

During the brief periods when the main motor ran, no overtly abnormal operational sounds were noted. Similarly, no unusual odors, such as burning insulation, were detected.

The coolant system, when its activation button was pressed (prior to the main fault manifestation or as a separate check), appeared to function correctly, indicating its standalone circuit was likely operational.

*A critical observation: the multi-pin connector linking the control panel to the motor's control enclosure found faulty. Specifically, one wire within this connector was dislodged from its terminal, resulting in an open connection.*

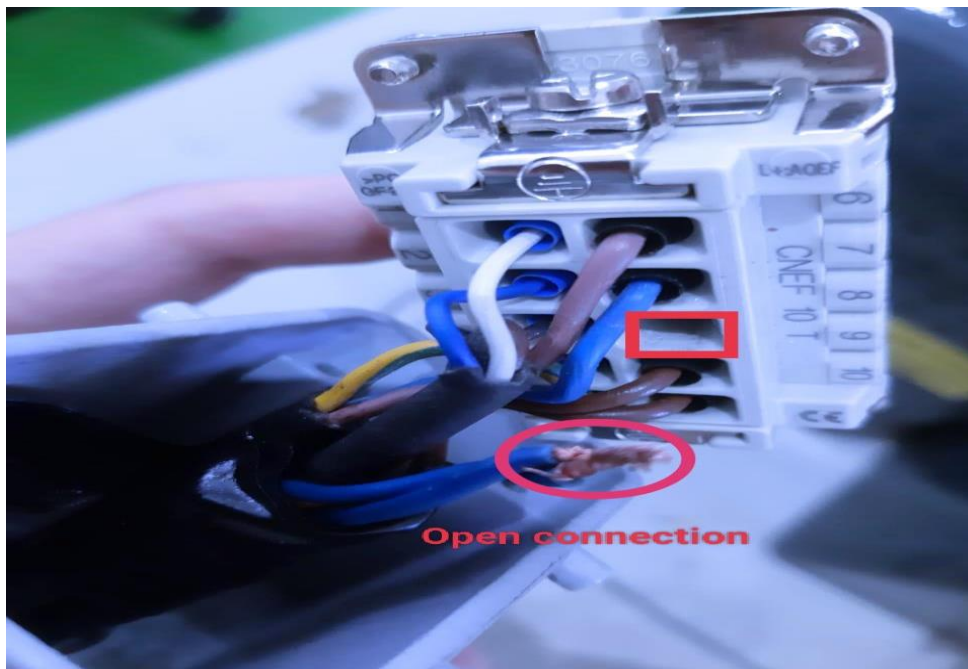


Figure 3. 2: The connector and the dislodged wire

#### 4. Machine B – Macro Cut-Off Saw (Hitech Europe 250 B)



Figure 3. 3: The Hitech Europe 250 B Macro Cut-Off Saw

##### 4.1 Machine Description and Function:

Machine B serves a similar function to Machine A but at a slightly lower power rating. It features a 2200 W, 6 A, three-phase (380 V) motor coupled to a 250 mm blade for medium-duty specimen cutting. Its water-cooling system and electromagnetic brake match those of the 300 A model, and a manual control panel consisting of physical buttons for power, motor start/stop, and potentially coolant system activation. A manually operated lever or handle mechanism used to feed the cutting wheel assembly into the workpiece. The machine's robust housing and simple control panel make it suitable for repeated use in laboratory courses [6].

##### 4.2 Operational failure symptoms:

The investigation of Machine B was prompted by reports from workshop personnel indicating an abrupt shutdown during a sample cutting operation. Upon attempting to restart the machine, it was found that pressing the '**Motor On**' button failed to start the main drive motor. However, it was noted that the coolant system could be activated independently and was functioning normally when its respective button was pressed. This selective failure pointed towards an issue primarily affecting the motor, its main power or control circuit.

### 4.3 Preliminary Diagnostic Findings:

A visual examination confirmed the integrity of the machine's main power cable, its plug, and all externally visible wiring to the motor and coolant pump; there were no signs of damage. The control panel and its constituent buttons are physically intact, with no evidence of overheating, arcing, or other damage. The external casing of the main motor appeared free from immediate defects. Furthermore, the manual cutting wheel feed handle could be operated smoothly through its full range of motion, no apparent mechanical jamming of the feed mechanism.

During attempts to activate the main motor via its 'On' button, no discernible sounds (such as contactor clicks or motor humming) were produced. Similarly, no unusual smells indicative of electrical burning or overheating were detected from the control panel, motor, or associated wiring.

*An accumulation of cutting debris and coolant residue. A notable observation was that an abrasive cutting wheel was not installed on the machine at the time of inspection.*

## 5. Machine C – Impact Testing Machine (JBW-300N)



Figure 3. 4: The Impact Testing Machine (JBW-300N)

### 5.1 Machine Description and Function:

Machine C is a Charpy/Izod impact tester (model JBW-300N) conforming to ASTM E23 and ISO 148 standards. It features 0.7 kW. It uses a pendulum with selectable energy (150 J and 300 J) to measure material toughness, achieving an impact velocity of 5.2 m/s. A 380 V three-phase drive lifts the pendulum, and a computer interface records energy-absorption curves. This

unit is widely used in metallurgical labs for student training and research on fracture behavior [7].

### **5.2 Operational failure symptoms:**

The diagnostic investigation for Machine C was initiated due to a severe electrical fault: the main workshop circuit breaker was reported to trip instantaneously whenever the machine's main power cable was connected to the electrical supply. which indicates a major fault condition, such as a direct short circuit or a very significant overload, within the impact testing machine.

### **5.3 Preliminary Diagnostic Findings:**

A visual inspection of the machine's main power cable was conducted. This included an internal check of its plug/connector, where the wire terminations were confirmed to be secure after re-tightening. The cable itself showed no signs of external damage, cuts, or abrasions. The workshop-side power supply socket also appeared intact.

To further isolate the fault, the main power switch on the JBW-300N machine itself was turned to the '**OFF**' position. The machine's power cable was then reconnected to the workshop supply. Under this condition, the main workshop circuit breaker did not trip. This observation strongly suggested that the fault was located within the machine, downstream of its main power switch, rather than in the power cable or its immediate connection.

there are no physical damage, arcing, or overheating. No unusual odors were detected.



Figure 3. 5: Electrical Control Panel and Motor Assembly within the JBW-300N Impact Testing Machine.

## 6. Machine D – Micro Cut-Off Saw (Presi SA Mécatome T210)



Figure 3. 6 : Micro Cut-Off Saw (Presi SA Mécatome T210)

### **6.1 Machine Description and Function:**

Machine D is a precision micro-cutting saw (Mécatorme T210) used for fine sectioning of small samples ( $\leq 55$  mm) before microscopic analysis. Its a Monophase ( 230V), 1.5 kW variable-speed motor (300–6000 rpm) drives a 200 mm blade, and a six-nozzle coolant system prevents thermal damage. Operation modes include manual, automatic, and programmable, with a motorized X-axis for serial cuts. Swappable stainless-steel pallets accommodate diverse sample geometries in research and teaching settings [8].

### **6.2 Operational failure symptoms:**

The diagnostic process for Machine D was initiated due to a clear operational failure: the main cutting motor would not turn when commanded via the Human-Machine Interface (HMI). Attempts to alter operational parameters, such as cutting speed, through the HMI yielded no response from the motor. This indicated a fault preventing the motor drive system from engaging.

### **6.3 Preliminary Diagnostic Findings:**

An external visual inspection of the machine, its power cable, control panel, and accessible wiring did not reveal any immediate signs of physical damage, loose connections, or overheating that could explain the fault. No unusual sounds or odors were present.

Upon obtaining authorization and following appropriate safety procedures to access the machine's internal components, the variable frequency drive (VFD) or motor drive unit was inspected. It was observed that the drive's display indicated "0 Hz" (zero frequency output) and subsequently showed an error code "SA."

Consultation of the drive's technical manual revealed that the "SA" error code signifies a "Safety Stop" condition. This code indicates that a safety input to the drive is active (or perceived as active), preventing the drive from outputting power to the motor. The manual specifically recommended checking the wiring of safety input terminals, often designated as S1, S2, or PC [10] particularly if the dedicated safety stop function connected to these terminals was not intentionally being used or had malfunctioned.

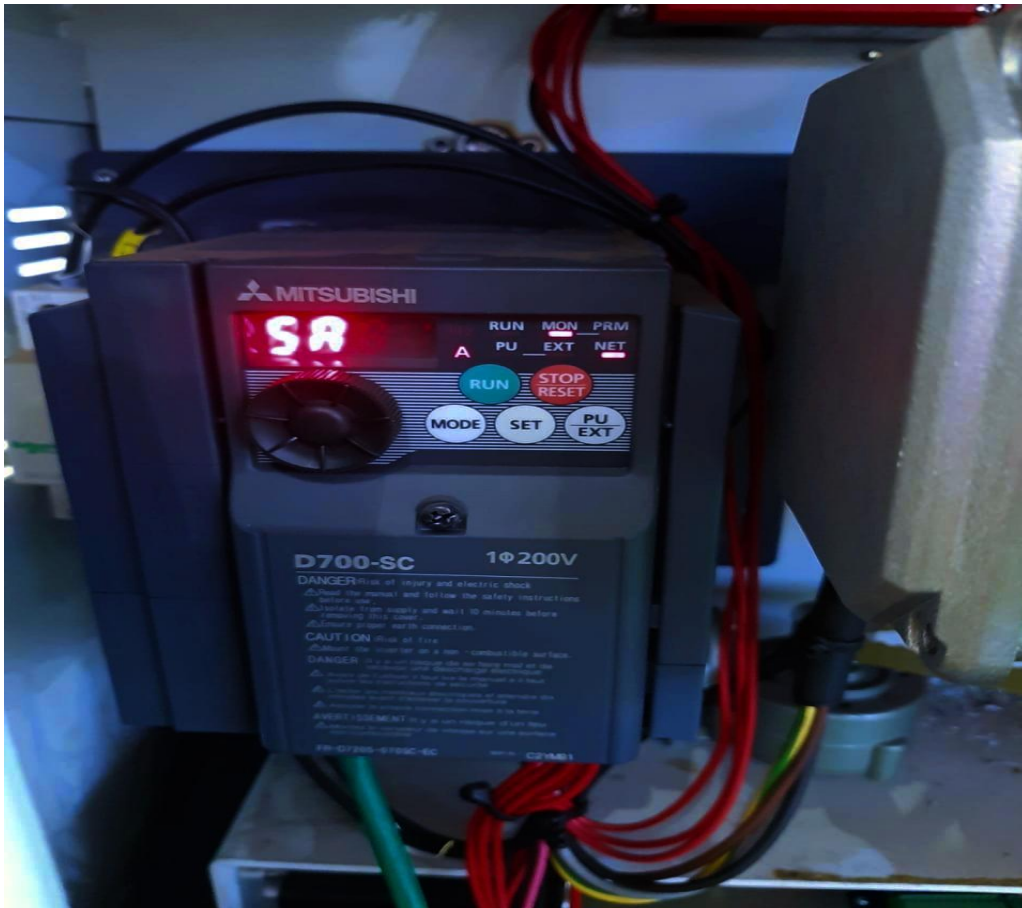


Figure 3.7: the drive display shows the "SA" error code

## 7. Chapter Summary

This chapter aligned a preliminary diagnosis on four workshop machines: two cut-off saws (Hitech 300A, Hitech 250B), an impact tester (JBW-300N), and a micro cut-off saw (Presi Mécatorne T210). Initial investigations, primarily involving symptom documentation and visual/sensory inspections, which identified probable fault areas for each machine. Key preliminary findings included a damaged connector (Machine A), a suspected control circuit issue (Machine B), an internal short circuit (Machine C), and a safety system error indicated by a drive code (Machine D). These initial diagnoses formed the basis for the detailed examinations and repairs detailed in Chapter 4

# CHAPTER 4: DETAILED FAULT DIAGNOSIS AND POSSIBLE REPAIR OF SELECTED MACHINES

## 1. Introduction

This chapter builds upon the preliminary diagnostic assessments conducted in Chapter 3, which identified potential or confirmed fault areas in four selected experimental workshop machines. The primary objective herein is to detail the in-depth examinations undertaken to precisely determine the root causes of these malfunctions. Subsequently, the specific repair strategies implemented for each machine are described, followed by post-repair verification tests designed to confirm the restoration of full operational functionality and the efficacy of the corrective actions taken.

## 2. Case Study 1: Hitech Europe 300 A Macro Cut-Off Saw

### 2.1 Fault Examination and Findings:

These figures represent the control unit components and scheme wish is mainly defected.

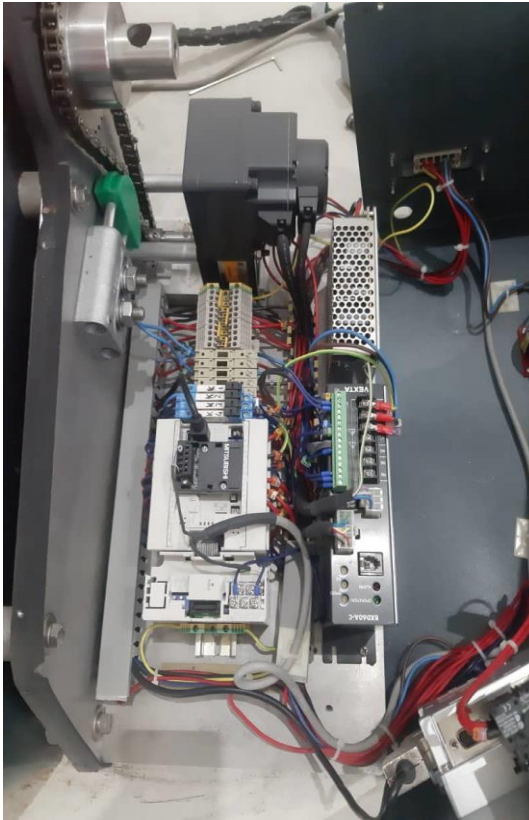


Figure 4. 1: The control unit components

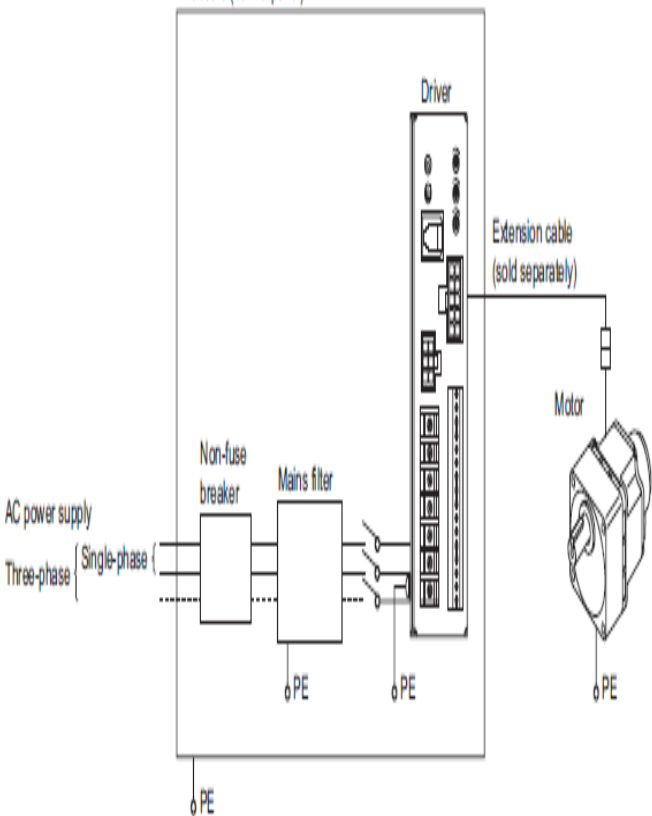


Figure 4. 2: A scheme of DC motor supply circuit [9]

The detailed examination is presented by the following table

Diagnostic Step & Action	Key Observation(s)	Conclusion(s)
<b>1. Connector Pin Repair</b>	Pin re-seated in previously identified damaged connector.	<ul style="list-style-type: none"> <li>● Motor no longer shut down prematurely.</li> <li>● positioning commands remained unresponsive. Further faults suspected.</li> </ul>
<b>2. Control Unit Inspection</b>	Checked continuity of Motor Position Sensors via manual actuation & manual Command Mechanism (for positioning).	<ul style="list-style-type: none"> <li>● Motor Position Sensors: Intact</li> <li>● Command Mechanism: No continuity; component damaged.</li> </ul>
<b>3. Control System drive</b>	<p>-CPU lamps indicate when executing positioning orders.</p> <p>-DC motor works when supplying it separately.</p> <p>-Drive Input: 232.5V AC; - Drive Output: 0V DC.</p>	<ul style="list-style-type: none"> <li>● Control system drive unit identified as failed (correct input, no output).</li> </ul>

Table 4. 1: Diagnostic Examination for Machine A

## 2.2 Final Diagnostic Conclusion and Recommendations for Machine A

- **Final Diagnostic Conclusion:**

The primary faults preventing full operation were:

1. A **failed control system drive unit** (0V DC output).
2. A **damaged manual command mechanism** for positioning .

The initial connector pin issue was a contributing factor to instability.

- **Recommendations:**

1. More advanced examination on the faulty control system drive unit.
2. Repair or replace the damaged manual command mechanism.

### 3. Case Study 2: Hitech Europe 250 B Macro Cut-Off Saw

#### 3.1 Fault Examination and Findings:

The detailed examination is presented by the following table

<b>Diagnostic Step &amp; Action</b>	<b>Key Observation(s)</b>	<b>Conclusion(s)</b>
<b>1. Control Circuit Integrity Checks</b>	-Verified continuity of all components in the motor start circuit: 'motor on' pushbutton, wiring, fuses, and motor contactor coil.	<ul style="list-style-type: none"> <li>● All circuit components are intact.</li> </ul>
<b>2. Motor Relay / Overload Inspection</b>	- A fault indication (trip) was visible on the overload relay. - After pressed the reset the motor ran correctly	<ul style="list-style-type: none"> <li>● overload occurred when motor was functioning.</li> </ul>
<b>3. Motor Braking System Check</b>	- the motor stop function was tested, the motor braking system is not functioning. -tests electrical braking system , it appears intact.	<ul style="list-style-type: none"> <li>● Braking system is faulty.</li> <li>● mechanical system inspection is necessary.</li> </ul>
<b>4. Mechanical Brake Inspection</b>	- Inspected the mechanical braking disc assembly. its not reacting to orders.	<ul style="list-style-type: none"> <li>● The braking disc mechanism was found to be non-operational</li> </ul>

Table 4. 2: Diagnostic Examination for Machine B



Figure 4. 3: The motor overload relay

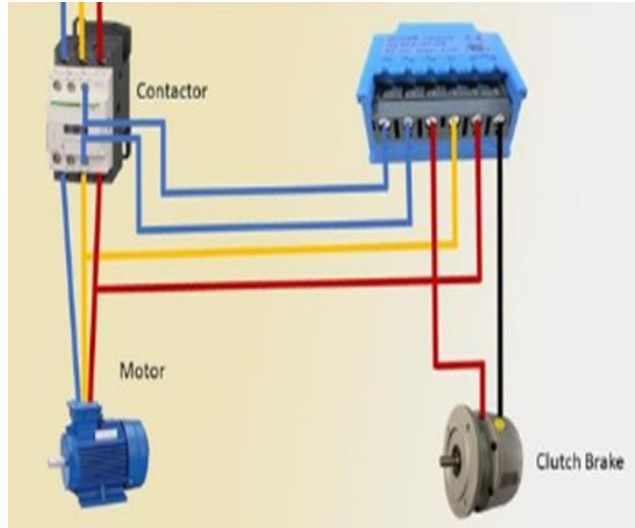


Figure 4. 4: A representation of the braking system circuit

### 3.2 Final Diagnostic Conclusion and Repair for Machine B

- **Final Diagnostic Conclusion:**

Two distinct faults were identified and confirmed:

- 1- The failure of the motor to start was caused by a tripped motor thermal overload relay.
- 2- The subsequent failure of the motor to brake effectively was caused by a maladjusted mechanical braking disc .

- **Implemented Repairs:**

- 1- **Motor Overload:** The motor overload relay was **reset**.
- 2- **Mechanical Brake:** The loose bolts on the mechanical braking disc assembly were tightened to restore proper engagement. and **the braking system back to be functioning correctly**.

## 4. Case Study 3: JBW-300N Impact Testing Machine

### 4.1 Fault Examination and Findings:

The detailed examination is presented by the following table

Diagnostic Step & Action	Key Observation(s)	Conclusion(s)
<b>1. Internal Control unity Inspection</b>	- A wiring issue was identified: a direct connection between a neutral conductor and the equipment ground.	<ul style="list-style-type: none"> <li>• An immediate correction to the wiring is a necessary.</li> </ul>
<b>2. Correction of Wiring Fault</b>	-The incorrect wiring (neutral-to-ground short) was rectified and when re-powered up the main circuit breaker no longer tripped.	<ul style="list-style-type: none"> <li>• The immediate short circuit fault was resolved.</li> </ul>
<b>3. Pendulum Control Functionality Test</b>	-Release and impact pendulum functions are not executing..	<ul style="list-style-type: none"> <li>• A circuit control fault or electrovalve damaged.</li> </ul>
<b>4. Pendulum Lift &amp; Release Circuit Examination</b>	- When bypassing the relay , the system run correctly.	<ul style="list-style-type: none"> <li>• Relay’s power supply is faulty.</li> </ul>

Table 4. 3 : Diagnostic Examination for Machine C



Figure 4. 5: The protection relays

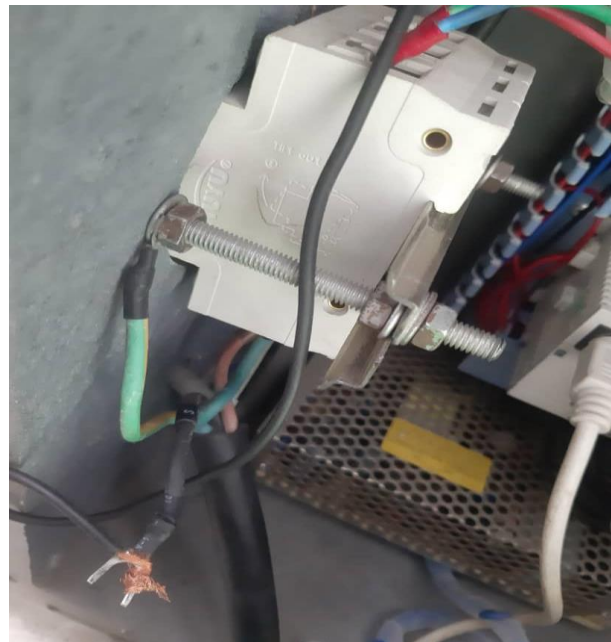


Figure 4. 6: The wire connection after separation

## **4.2 Final Diagnostic Conclusion and Recommendation for Machine C**

- **Final Diagnostic Conclusion:**

Two distinct faults were identified:

- 1- The primary cause of the workshop circuit breaker tripping was a **direct short circuit** between a neutral conductor and the equipment ground within the machine's control unit.
- 2- The failure of the pendulum to respond to Impact and release commands was traced to issues to **the control relay circuit** .

- **Recommendations & Implemented Repairs:**

- 1- Neutral-Ground Short: The issue was permanently corrected by separating the conductors and ensuring proper termination.
- 2- Pendulum Control Relays:
  - Implemented Action (based on bypass test): The successful operation via bypass confirmed the downstream actuators were likely functional.
  - Recommendation: Conduct an advanced examination of the suspected control relays .

## **5. Case Study 3: Prési SA Mecatome T210 Micro Cut-Off Saw**

### **5.1 Fault Examination and Findings:**

The following figures show the scheme of the wiring connection diagram of the safety relay module .

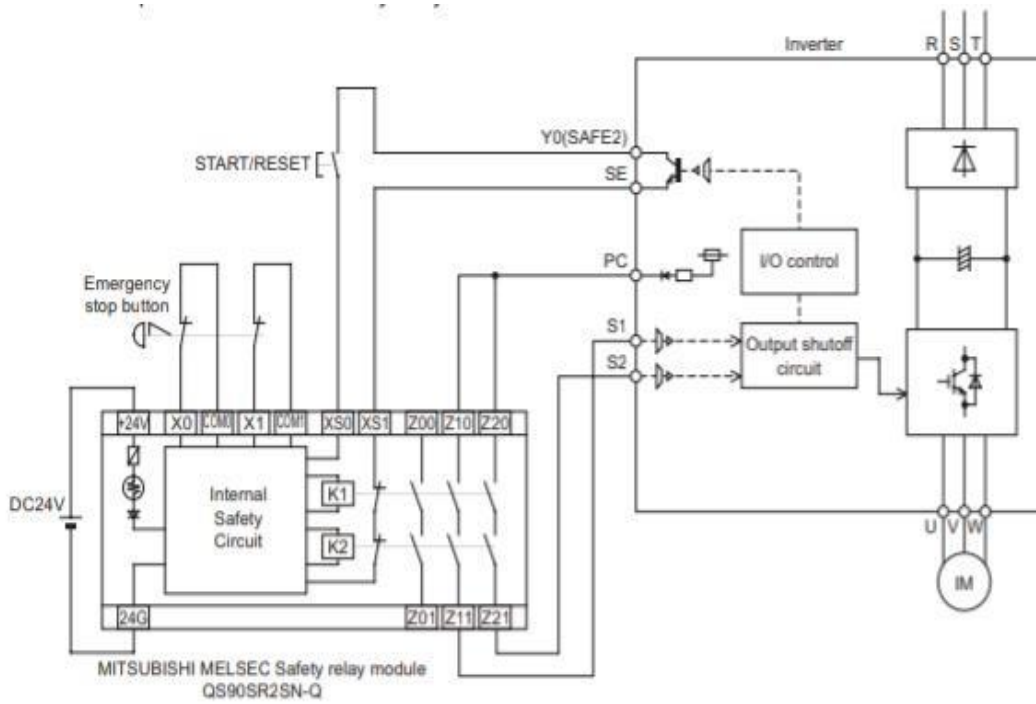


Figure 4. 7 : The wiring diagram scheme of safety stop function [10]



Figure 4. 8: The safety relay module and its mechanical actuator.

The detailed examination focused on the motor drive's safety circuit and associated components,

<b>Diagnostic Step &amp; Action</b>	<b>Key Observation(s)</b>	<b>Conclusion(s)</b>
<b>1. Drive Safety Input Terminal Check</b>	-After jumpering drive's safety input terminals S1, S2, and PC as indicated by the drive manual[10] , the motor run correctly	<ul style="list-style-type: none"> <li>● The motor and drive are intact.</li> <li>● inspection to the safety relay module is necessary.</li> </ul>
<b>2. Inspection of External Safety Circuit</b>	-The insulation on the wiring was found to be in a critical, damaged condition.	<ul style="list-style-type: none"> <li>● A necessary correction to the wiring insulation .</li> </ul>
<b>4. Door Safety relay and Mechanism Examination</b>	-The door's mechanical actuating mechanism for the safety relay was found to be misaligned	<ul style="list-style-type: none"> <li>● A Mechanical Issue is preventing proper relay engagement even if the wiring was intact.</li> </ul>

Table 4. 4: Diagnostic Examination for Machine D



Figure 4. 9: The wiring before correcting its insulation.

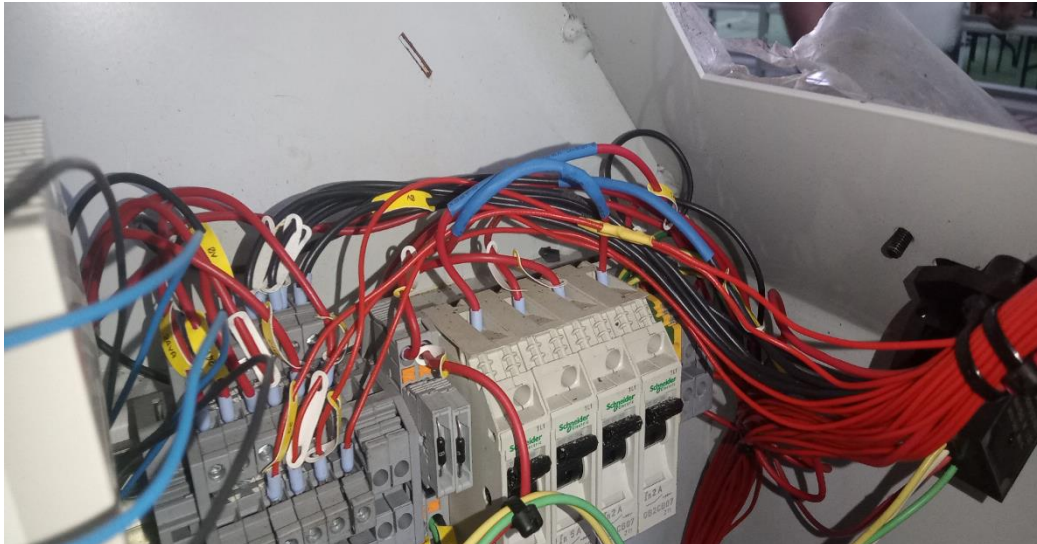


Figure 4. 10: The wiring after correcting its insulation.

## 5.2 Final Diagnostic Conclusion and Repair for Machine D

- **Final Diagnostic Conclusion:**

The indication "SA" (Safety Stop) error on the motor drive was due to a malfunctioning door safety interlock circuit. This malfunction was caused by a combination of:

1- **Damaged wiring insulation** for the safety relay module.

2- **Mechanical misalignment** of the door's actuating mechanism, preventing proper engagement of the safety relay.

These issues resulted in the safety circuit remaining open, triggering the safety stop function of the drive.

- **Implemented Repairs:**

1- **For the Wiring:** The damaged insulation wiring was repaired.

2- **Door Mechanism Alignment:** The mechanical alignment of the door and its safety relay actuating mechanism was corrected to ensure proper engagement and functioning.

## **GENERAL CONCLUSION**

In this thesis, we have presented a comprehensive study and practical approach to the diagnosis and repair following a hardware-based diagnostic framework, detailed in this thesis, which led to the successful identification and rectification of critical faults in four diverse pieces of university workshop equipment, including cut-off saws and testing machine.

By systematically addressing and isolating issues such as wiring faults, component failures, and misadjusted safety mechanisms, and also repairing and restoring Healthy operational state of half of the case studies we worked on which are Machine B and Machine D, demonstrating the value of fundamental troubleshooting skills in real cases.

This work contributes a documented set of case studies and a validated diagnostic procedure beneficial for improving workshop maintenance practices and enhancing the practical learning experience for engineering students.

## REFERENCES

- [1] A. Mouzakitis, "Classification of Fault Diagnosis Methods for Control Systems," *Measurement and Control*, vol. 46, no. 10, pp. 303–308, Dec. 2013.
- [2] IEEE Std 43-2013, *IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery*. New York, NY, USA: IEEE, 2014.
- [3] A. H. Bonnett, "Understanding motor winding resistance," *IEEE Trans. Ind. Appl.*, vol. 51, no. 1, pp. 6–10, Jan. 2015.
- [4] IEC 60947-1:2016, *Low-voltage switchgear and controlgear - Part 1: General Rules*. Geneva, Switzerland: IEC, 2016.
- [5] IEC 60038:2009, *IEC Standard Voltages*. Geneva, Switzerland: IEC, 2009.
- [6] Tecmet 2000 (for Hitech Europe), "C251K / C321K Series – Hitech Europe," Tecmet 2000, [Online]. Available: <https://tecmet2000.it/en/prodotti/c321k-series-hitech-europe/> [Accessed: Jun. 01, 2025].
- [7] Hydraulic Universal Testing Machine, "JBW-300N Charpy and Izod Impact Testing Machine," [Online]. Available: <https://www.hydraulicuniversaltestingmachine.com/jbw-300n-charpy-and-izod-impact-testing-machine.html> [Accessed: Jun. 01, 2025].
- [8] Presi SA, "Mécátome T210 – Precision Automatic Micro-Cutting Machine," [Online]. Available: <https://www.presi.com/en/product/mecatome-t210/> [Accessed: Jun. 01, 2025].
- [9] Oriental Motor Co., Ltd., "Brushless DC motor and driver package BX Series: Operating Manual," Tokyo, Japan, 2010.
- [10] Mitsubishi Electric Corporation, *FR-E700 Series Inverter Instruction Manual*, FR-E700 Series, Document No. IB-0600398ENG-A, Tokyo, Japan: Mitsubishi Electric Corp., 2011.