



Amir Ammar

Electromechanical Endurance Test Bench Verification Instructions for SGS Fimko Oy

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Abstract

Author: Amir Ammar
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Heikki Valmu, Principal Lecturer (Metropolia UAS)

This thesis documents the verification process of a test bench used for electrical safety testing with a primary focus on IEC standards. This thesis is a base for a verification instruction document that was created for SGS Fimko Oy. The instruction document, the verification process and the verification document, which are mentioned were created by I, Amir Ammar.

The requirements for this machine are selected from relevant IEC standards, which define various properties necessary for ensuring standard compliance. Seven different requirements were chosen for this verification, as they were considered the most important for the company's operations.

This project is important for the company in enhancing trust and credibility. Standardization plays a key role in maintaining consistency, safety, and quality, which are essential for long-term success. The verification document serves as a quality improvement measure, helping the company align with regulatory requirements and best practices.

Additionally, this thesis provides insights into verification and standardization, aspects that are not covered in the verification instruction document. These explanations are necessary to better understand the purpose behind the creation of such a document.

As a result of this thesis, a verification instruction document was created for SGS Fimko Oy. A verification was performed on the test benches and the results were documented in the company's management database.

Keywords: verification, standardization, IEC, electrical safety, quality

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Tämä opinnäytetyö käsittelee sähköiseen turvallisuustestaukseen liittyvän testipenkin verifiointiprosessia, keskittyen pääasiassa IEC-standardeihin. Tämä dokumentti on perusta verifiointiohjeelle, joka on luotu SGS Fimko Oy:lle. Ohjedokumentti, verifiointiprosessi ja verifiointipohja, jotka mainitaan, ovat tämän opinnäytetyön tekijän laatimia.

Laitteen vaatimukset valitaan asiaankuuluvista IEC-standardeista, jotka määrittelevät erilaisia ominaisuuksia standardinmukaisuuden varmistamiseksi. Verifiointiin valittiin seitsemän eri vaatimusta, jotka katsottiin yrityksen toiminnan kannalta tärkeimmiksi.

Projekti on merkittävä yritykselle luotettavuuden ja uskottavuuden vahvistamisessa prosesseissaan. Standardisointi on keskeisessä roolissa ylläpitämässä johdonmukaisuutta, turvallisuutta ja laatua, jotka ovat olennaisia pitkäaikaisen menestyksen kannalta. Verifiointidokumentti toimii laadunparannustoimenpiteenä ja tukee yritystä parhaiden käytäntöjen noudattamisessa.

Lisäksi tämä opinnäytetyö tarjoaa selityksiä verifiointiin ja standardisointiin, joita ei käsitellä alkuperäisessä verifiointiohjeessa. Nämä selitykset ovat tarpeellisia, jotta dokumentin laatimisen tarkoitus ymmärretään paremmin.

Tämän opinnäytetyön tuloksena laadittiin verifiointiohje SGS Fimko Oy:lle. Kestotestipenkeille suoritettiin verifiointi ja tulokset dokumentoitiin yrityksen hallintajärjestelmän tietokantaan.

Avainsanat: verifiointi, standardointi, IEC, sähköturvallisuus, laatu

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Appendix 1: Completed Endurance Test Bench Verification Document

Appendix 2: Actuation Speed Measurements

List of Abbreviations

- AC: Alternating Current. A type of electrical current that periodically reverses direction.
- DUT: Device Under Test. An electronic or electrical device being tested to evaluate its performance, functionality or compliance with standards.
- IEC: International Electrotechnical Commission. An international organization that develops and publishes standards for electrical, electronic, and related technologies to ensure safety, efficiency and interoperability
- Inv. No.: Inventory Number. A unique identifier assigned to a device in an inventory system for calibration, tracking and organizing.
- SGS: Société Générale de Surveillance. A global company that provides inspection, verification, testing and certification services to ensure products meet regulatory or voluntary standards and quality requirements.
- TDS: Timed Delay Switches. Electrical switches that automatically activate or deactivate a circuit after a preset time interval, commonly used for energy-saving and convenience in lighting and ventilation systems.
- TUKES: Finnish Safety and Chemicals Agency (Finnish: Turvallisuus- ja kemikaalivirasto) The Finnish government agency responsible for supervising and promoting safety and compliance in areas such as chemicals, electrical equipment, industrial products and consumer goods.

1 Introduction

This thesis provides detailed instructions for verifying the electromechanical test bench device to ensure it meets defined standards and specifications, which also works as a base for the verification instruction document provided to SGS Fimko Oy. These instructions are applicable to the verification of devices when in use with below listed standards and other standards with similar requirements. This thesis only covers the verification and safety of the test bench, excluding the other parts of the system (electrical distribution board, variable ac autotransformers, electrical loads).

Additionally, a verification form was created for documentation of the results. A filled-out verification form can be seen in Appendix 1 with the measured results.

The purpose of this thesis is to enhance credibility and assist the company to be in line with best practises. These requirements come from the testing and calibration laboratory standard ISO/IEC 17025:2017, which accredited testing laboratories like the ones at SGS Fimko Oy must comply with. Referring to the mentioned standard [1], clause 6.4.4 states that “The laboratory shall verify that equipment conforms to specified requirements before being placed or returned into service.” This means that in order for a laboratory’s test method to comply with this standard, the testing equipment needs to be verified before being put into service.

The functional part of the verification procedure involves the verification of the X/Y actuation speeds, the load times and the cycle counter. The clauses that address the functional part of this thesis are found in chapters 6 Actuation Speed, 7 Load Times and 10 Cycle counter. The requirements come from the IEC standards that are listed in chapter 4 of this thesis. The electrical diagram of the test bench’s load and relay connections is shown in Figure 1.

The safety part of this verification goes through the safety enclosure and emergency stop button requirements which come from the internal safety document of SGS Fimko Oy. The clauses that address the safety part of this thesis are found in chapters 8 Enclosure Safety Switch and 9 Emergency Stop Buttons.

A verification document was created based on this thesis for SGS Fimko Oy and was added to the test bench device documentation.

Comma is used as the decimal separator in this document to ensure readability and maintain consistency with the quotes, snippets and values recorded in the original instructions document.

Most of the requirements for the tests are taken from the relevant standards and are marked in bold or highlighted with yellow.

2 Verification of Testing Equipment

Verification is a crucial process in safety testing. Accredited testing laboratories must comply with the requirements of ISO/IEC 17025:2017, a requirement of which is verification of testing equipment. This verification is done to prove that the testing equipment conforms to the specified requirements of the standards it is being used for. [1.]

Electrical devices are under high standard of safety regulation because of the various risks a poorly designed device can pose. For example, electrical shock, electrical burns, permanent injuries or even death can occur from a faulty electrical appliance or device.

Additionally, a device's quality and usability are also important for the end user. A customer can be sure that a product will withstand its intended use and work in the required environment, if the product is tested and certified by an accredited safety agency. For example, the tests conducted on the test bench of this thesis

are mainly designed for determining if the DUT's can withstand their intended use.

The verification process of a test bench usually consists of determining how it should function and identifying the required specifications. Understanding normal operation is crucial for assessing whether the test bench is suitable for continued safe use. Once the requirements have been established, the test bench undergoes verification in various predetermined operations and the results are documented. The results are compared to the desired results and appropriate actions are taken based on the findings. If the results are unsatisfactory the device must be corrected, adjusted, or repaired before it can be safely placed or returned into service. [9.]

3 Standardization in The Electrical Safety Field

Standardization is a key element in ensuring the safety and quality of electrical products. Standardization gives requirements for electrical appliances, creating a barrier for dangerous products. International standards also form the basis for testing and certification. [10.]

Although compliance with IEC International Standards is always voluntary, they are often adopted by countries as national or regional standards. Close to 80% of European electrical and electronic standards are based on IEC International Standards. These standards are often used by the national or regional authority. For example, in Finland the national authority is TUKES (Turvallisuus- ja kemikaalivirasto), which is the Finnish Safety and Chemicals Agency. They publish mandatory requirements for electrical appliances in Finland and are responsible for market surveillance. [10;12.]

Conformity assessments are a key factor in testing and certification. They are an activity of verifying that the design of a product has applicability to a standard or technical specification. [11.]

The reasons why conformity assessments are needed [11]:

- Governments have an easier way to verify the safety of their infrastructure and population.
- Insurers can get lower risks by confirming that proper considerations are included.
- Buyers have proof of a product's or system's safety, performance and reliability.
- Investors have a straightforward way of trusting companies with their investments.
- End users can be confident that the products are safe to use and will perform as expected.

4 Relevant Standards

This project only covers the reviewed parts of the standards listed below. The requirements of the standards were chosen due to a strong relevance to the test bench and the tests that are usually conducted. This thesis may also be applicable to other standards that are not on the list; in such cases, it can be utilized with technical judgment.

The list of reviewed standards:

- IEC 60320-1:2021 Appliance couplers for household and similar general purposes - Part 1: General requirements, clause 20
- IEC 60335-1:2020 Household and similar electrical appliances - Safety - Part 1: General requirements, clause 21.2
- IEC 60669-2-1:2021 Switches for household and similar fixed electrical installations - Part 2-1: Particular requirements - Electronic control devices, clauses 18.2; 19
- IEC 60884-1:2022 Plugs and socket-outlets for household and similar purposes - Part 1: General requirements, clause 21
- IEC 61058-1-1:2016 Switches for appliances - Part 1-1: Requirements for mechanical switches, clauses 17.2; 17.4; 17.5

- IEC 61058-1-2:2016 Switches for appliances - Part 1-2: Requirements for electronic switches, clauses 17.2; 17.4; 17.5
- IEC 62368-1:2023 Audio/video, information and communication technology equipment - Part 1: Safety requirements, clause G.13.6.2
- IEC 61058-1:2016 Switches for appliances - Part 1: General requirements. International Electrotechnical Commission, page 152

5 Beginning of Verification

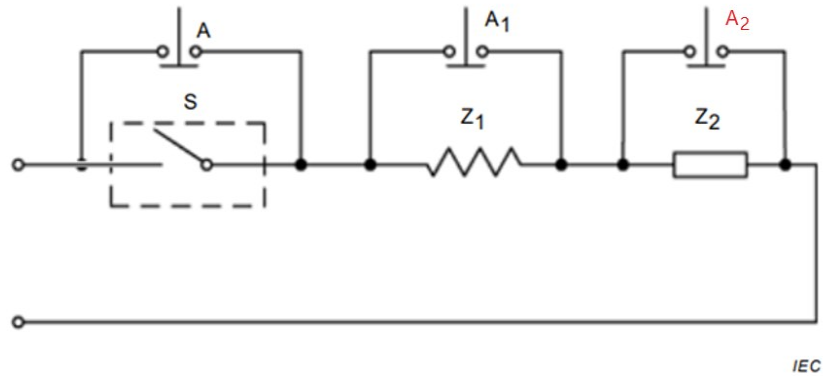
At the beginning of the verification document the information table is completed. The serial numbers of the actuation devices are located where the control cable connects to the motor. It is important to ensure that the inventory numbers of all devices are also included in the list.

An example of the information table taken from the completed verification document which is seen in full in Appendix 1 is found below in Table 1.

Table 1 Example of the "Information" table

Information	
Operator full name	Amir Ammar
Date	17.12.2024
Inventory number of test bench	11710
Serial numbers of the actuation devices	1234.83J.001 1234.83J.006
Inventory numbers of other devices used	11520, 11599, 8940, 4497, 241212A

A diagram of the endurance test device is given in the standard IEC 61058-1:2016 [14] that shows and explains the operation of the test bench. A list of components is also given under the diagram. A picture of the diagram can be found below.



Components

- A Auxiliary switch to set switch load
- A₁ Auxiliary switch to attain "break" current
- S Test specimen
- Z₁ Resistive load to attain "break" current
- Z₂ Load for "make" current

The "make" test load is set by closing the auxiliary switches A and A₁ and adjusting Z₂.

The "break" test load is set by closing the auxiliary switch A and adjusting Z₁ with the auxiliary switch A₁ open-circuited.

Figure 1 Diagram for endurance test from IEC 61058-1:2016 (A₂ added for clearance) [14,152]

Throughout the electrical endurance test, the auxiliary switch A remains open-circuited and is only used to adjust the test loads to desired values before the operation.

The order of operation goes as follows:

- 1 A₁ is closed while the specimen S is open
- 2 S is closed
- 3 A₁ stays closed for the time delay for "make" current
- 4 A₁ opens and A₂ closes, between which a short interruption of current flow usually occurs
- 5 S stays closed for the time delay for "break" current
- 6 S is opened, which gives the signal for A₂ to open
- 7 The operation starts over.

This order of operation may be repeated for a specified number of cycles. These cycles vary depending on the requirements of standards.

6 Actuation Speed

The speed is measured for X and Y axes separately. For X-axis, the encoder's line is attached straight to the motor. For Y-axis, the line is attached through a pulley to convert vertical movement into horizontal.

6.1.1 Requirements

The following requirements are found in standards for both X and Y linear actuation speeds.

In the section about actuation conditions of standards IEC 61058-1-2:2016 [7] and IEC 61058-1-1:2016 [6] a requirement can be found that states "The switches are operated by means of its actuating member either manually or by an appropriate apparatus which is arranged to simulate normal actuation." [6,15;7,10].

The appropriate apparatus in this case is the test bench that is being verified. Additionally, speed requirements can be found from the standards, which are listed below.

The speed requirement of the linear actuations from IEC 61058-1-2:2016 [7] is as follows:

For the tests of electronic switches:

- a) For very slow speed:
 - **approximately 0,5 mm/s for linear actuation.**
- b) For slow speed:
 - **approximately 5 mm/s for linear actions;**
- c) For high speed, the actuation member shall be actuated by hand as fast as possible or using the accelerated speed from the mechanical switch testing IEC 61058-1-1.
- d) for accelerated speed:
 - **approximately 20 mm/s to 25 mm/s for linear actions. [7.]**

And for IEC 61058-1-1:2016 [6] the requirement is below.

For the tests of mechanical switches:

- a) for very slow speed:
 - **approximately 0,5 mm/s for linear actuation.**
- b) for slow speed:
 - **approximately 20 mm/s to 25 mm/s for linear actuations.**
- c) for high speed, the actuation member shall be actuated by hand as fast as possible or using the accelerated speed.
- d) for accelerated speed:
 - **approximately 80 mm/s for linear actuations. [6.]**

The section 18 in IEC 60669-2-1 [4] gives a requirement for electronic TDS's, which are Timed Delay Switches. These are electrical switches that automatically turn on or off after a preset time delay.

The requirement is as follows:

For electronic TDS, 18.1, second paragraph (dashed list), of IEC 60669-2-3:2006 applies with the following conditions:

For electronic TDS whose rate of operation is limited by their application (for example, heat or light sensors), the rate of operation is as follows. The electronic TDS is set to the shortest cycle time possible. The electronic switch is re-activated at the end of each cycle within a time of $(2 \pm 0,5)$ s. [4.]

These switches are setup to be switched as fast as possible for the tests by lowering the time delay to the minimum.

Requirements given in operations per minute for these switches can be found from IEC60669-2-1:2021 [4]. The requirements in operations per minute are stated below:

All other electronic TDS are subjected to 200 operations at a uniform rate of:

- **30 operations per minute if the rated current does not exceed 10 A;**
- 15 operations per minute if the rated current exceeds 10 A but is less than 25 A;
- **7,5 operations per minute if the rated current is 25 A [4.]**

The speed of linear actuation would vary depending on the distance needed to travel to switch the TDS. Generally, based experience, the distance of actuation needed to travel can be assumed to be 10 mm. With this information the approximate speed can be calculated with the formula:

$$\text{Speed} = \text{Distance per operation} \times \text{Operations per minute} \quad (1)$$

For 30 operations per minute:

$$\text{Speed} = 10 \text{ mm} \times 30 \text{ operations per minute} = 300 \text{ mm/min} \quad (2)$$

$$= 300 \text{ mm/min} = \frac{300}{60} \text{ mm/s} = \mathbf{5 \text{ mm/s}} \quad (3)$$

For 7,5 operations per minute:

$$\text{Speed} = 10 \text{ mm} \times 7,5 \text{ operations per minute} = 75 \text{ mm/min} \quad (4)$$

$$= 75 \text{ mm/min} = \frac{75}{60} \text{ mm/s} = \mathbf{1,25 \text{ mm/s}} \quad (5)$$

The minimum calculated value falling above the minimum requirement and the maximum calculated value under the maximum requirement stated in standard IEC 61058-1-1:2016 [6]. Thus, it is decided that the actuation speed requirements from IEC 61058-1-1:2016 [6] give a good enough range of requirements for verification, for the TDS requirements to be overlooked.

For the scratch test mentioned in standard IEC 62368-1:2023 [8], the following speed requirement is given: “Scratches are made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a **speed of 20 mm/s \pm 5 mm/s [...]**” [8].

Additionally, the scratch test in the “Accessible parts” section of standard IEC 60335-1:2020 [3] gives the following requirement: “The scratches are made by drawing the pin along the surface of the insulation at a **speed of approximately 20 mm/s.**” [3].

The speeds 0,5 mm/s, 5 mm/s, 20 mm/s and 80 mm/s are chosen as general requirements for linear actuations for verification. The range of these speeds includes the minimum value and the maximum value as indicated in the reviewed standards. Additionally, frequently used speeds of 5 mm/s and 20 mm/s are chosen to be evaluated.

6.1.2 Setup for X-axis Movement

The following items are required:

- Incremental encoder (e.g. PT8150; inv.no. 4497)
- 2-axis motor setup
- Oscilloscope with pulse counter (e.g. Tektronix MDO34; inv.no. 11599).

An incremental encoder seen in Figure 2 is attached to the rails to be aligned with the linear movement of the motor. Linear single-axis movement is programmed at different speeds and the speed is referenced to the reading on the oscilloscope.

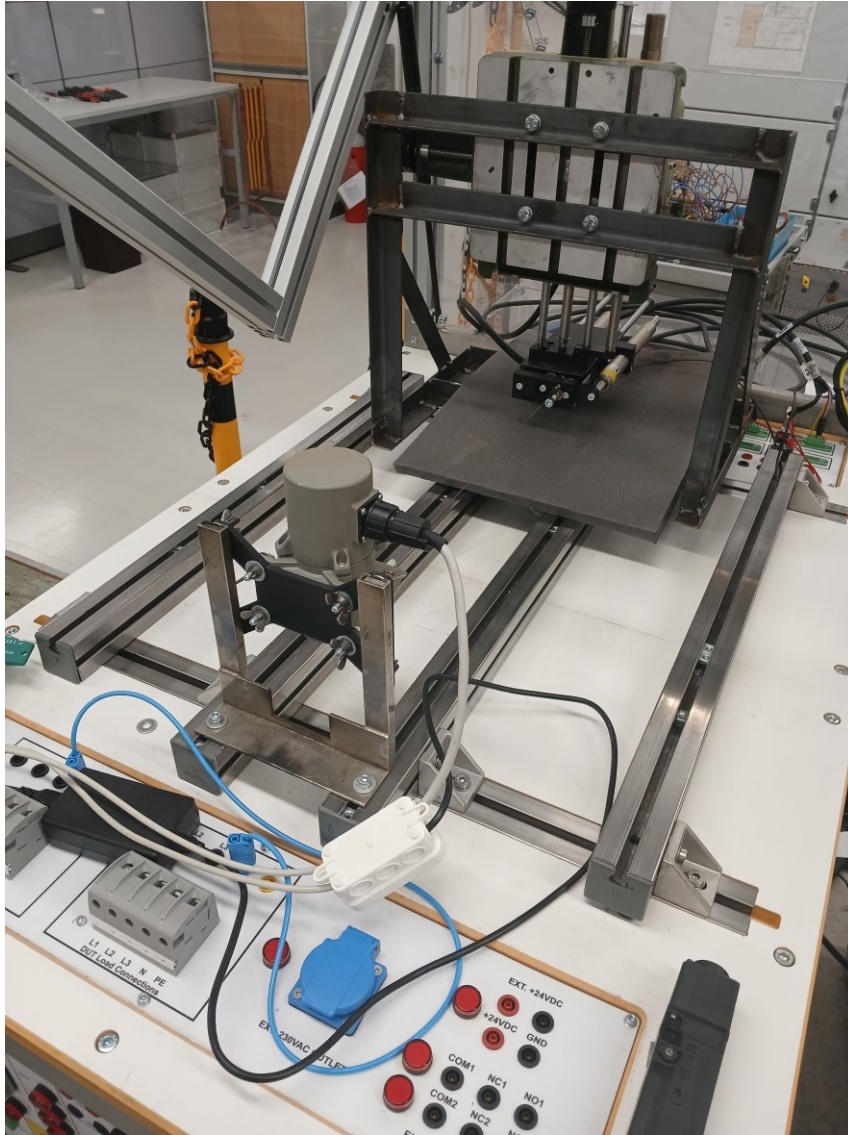


Figure 2 Incremental encoder aligned with the actuator

The encoder is connected to the oscilloscope with at least one connector as seen in the full picture of the setup in Figure 3.



Figure 3 Picture of the whole setup for X-axis speed measurement

All the specified speeds are measured to ensure conformity. The easiest way to measure the speed is to use the “Edge+” function for calculating the positive edges of the waveform shown on the oscilloscope screen with a resolution of 10 ms/div. The measurement gives a result that is one-to-one with mm/s since the encoder sends 10 pulses per mm. For the slowest speed of 0,5 mm/s the 10 ms/div resolution is too small to be measured this way, thus 100 ms/div is recommended.

The hook of the incremental encoder line is attached to the actuator as seen in Figure 4.

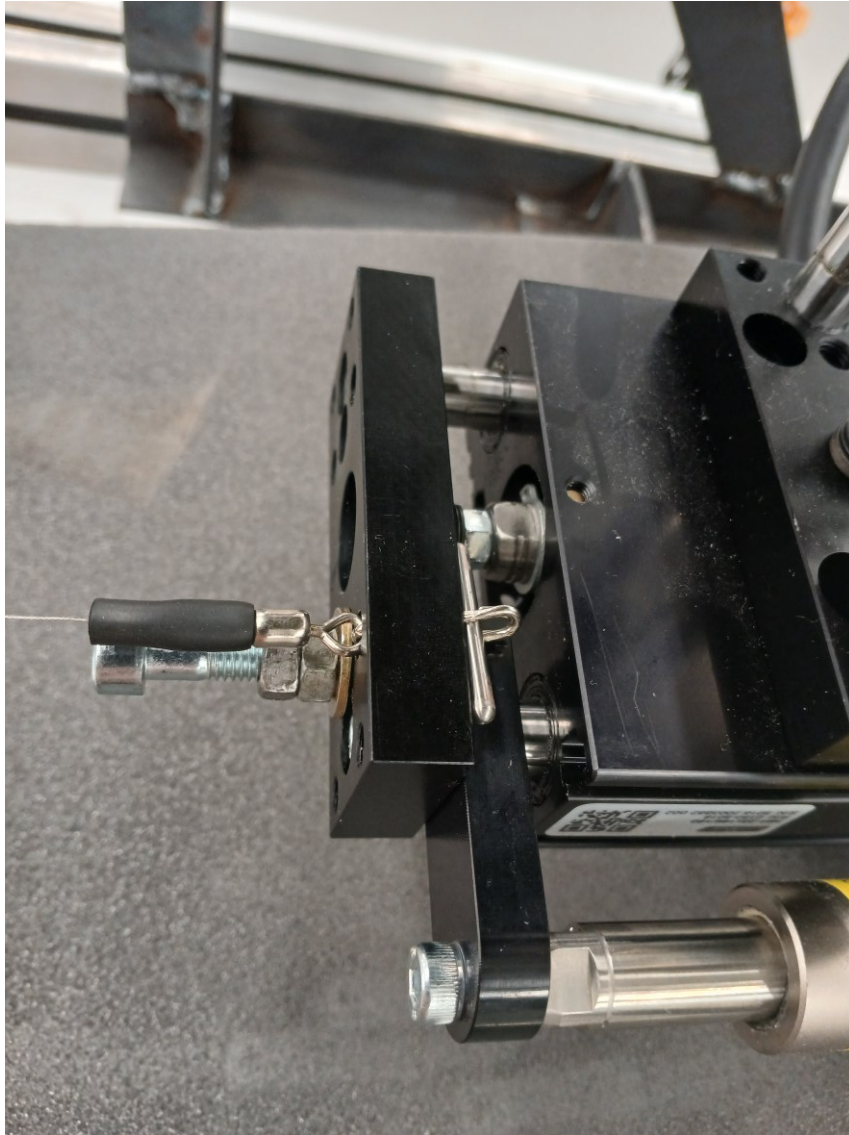


Figure 4 Encoder hook attachment to the actuator

Figure 5 shows an example of settings to acquire an X-axis linear movement measurement. The movement from horizontal max at the top to the max at the bottom is chosen to activate the switch and turn it from ON to OFF and back. The velocity of vertical motion is chosen to be 80,0 mm/s.

The measurement procedure can be made by pressing “Start” in the “Adjust movements” menu seen in Figure 5; no actual operation is needed to be started. Manual adjustment of the motor assembly can be done with the roller handles located on the side and top of the assembly.

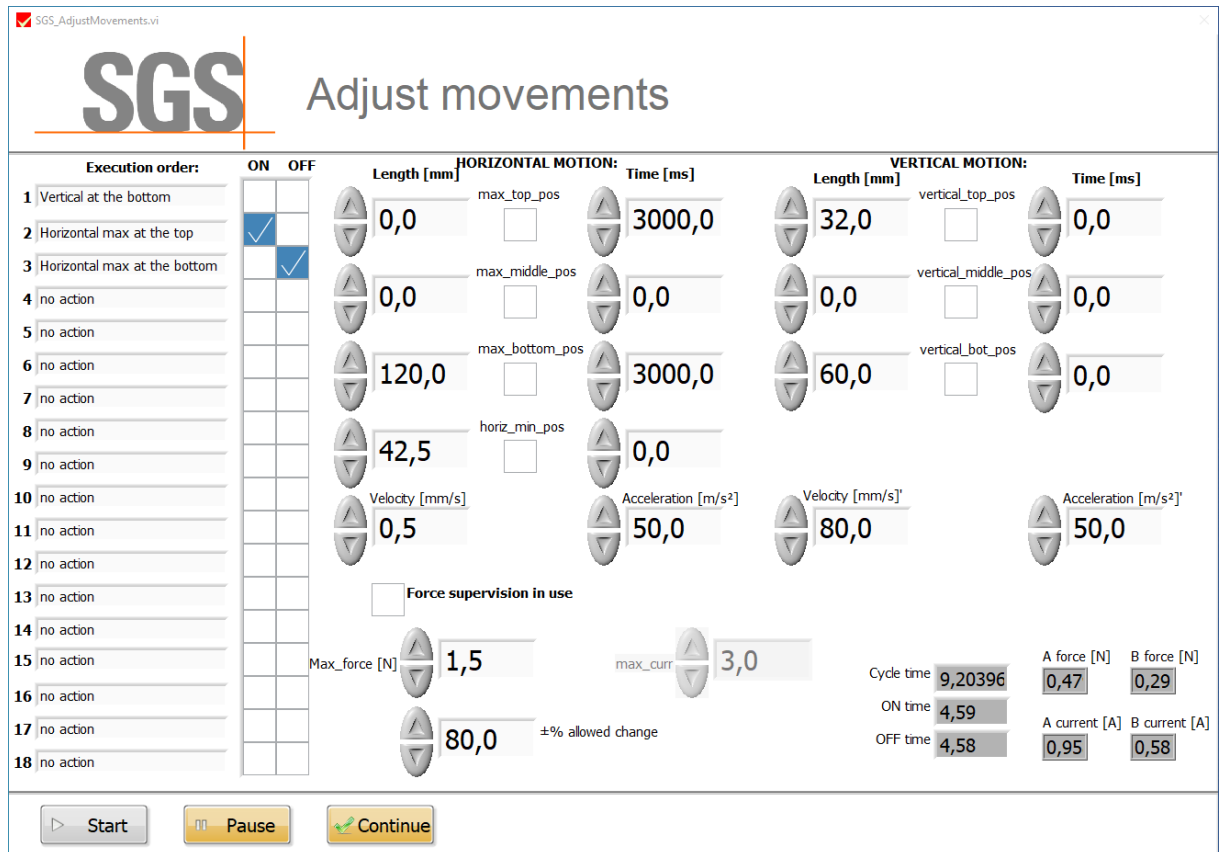


Figure 5 Settings for X-axis movement (Indicative)

After the setup is built the actuation speed can be measured. The desired results can be seen in part 6.1.4 Results.

6.1.3 Setup for Y-axis Movement

The following items are required:

- Incremental encoder (e.g. PT8150; inv.no. 4497)
- 2-axis motor setup
- Oscilloscope with pulse counter (e.g. Tektronix MDO34; inv.no. 11599)
- Pulley.

The setup that can be seen in Figure 6 is otherwise similar to the X-axis measurement setup, other than a pulley is needed to transfer the horizontal actuation motion into vertical.



Figure 6 Pulley setup for Y-axis measurement

A closeup of the attachment can be seen in Figure 7 along with the pulley. The encoder line can be seen curving 90 degrees up to be aligned with the Y-axis linear actuator.



Figure 7 Closeup of the hook attachment with pulley

Figure 8 located below shows an example of settings to acquire a Y-axis linear movement measurement. The movement from vertical at the top to the bottom is chosen to move a sufficient distance for the measurement. The velocity of vertical motion in this example is chosen to be 80,0 mm/s.

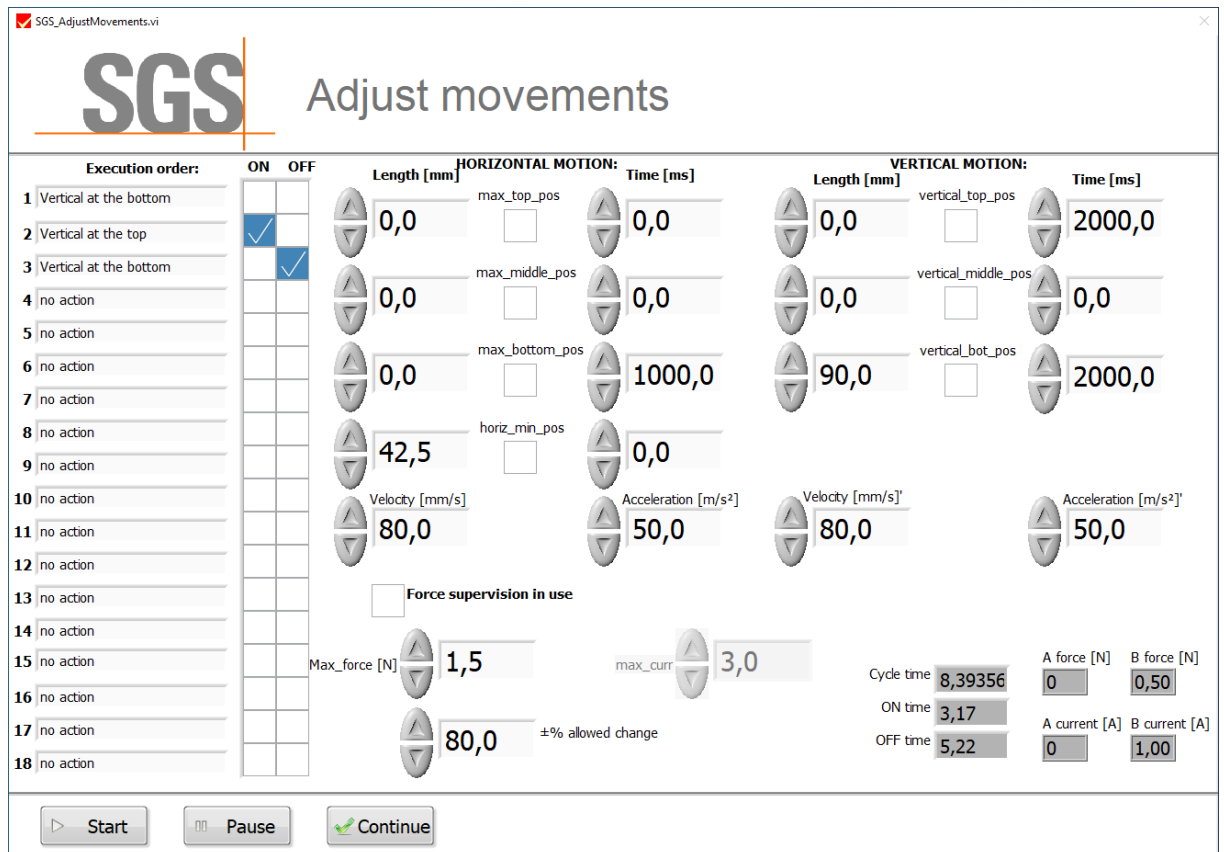


Figure 8 Settings for Y-axis movement (Indicative)

Similar to the X-axis measurement, the speed can be measured once the setup is built and the desired results can be seen in part 6.1.4 Results.

6.1.4 Results

A picture of each setup needs to be taken for documentation. The setup pictures are added to the end of the verification document. All the required speeds shall be measured for both axes. The actuation speeds of 0,5 mm/s, 5 mm/s, 20 mm/s and 80 mm/s, making eight measurements in total. The results are given with the same number of digits as the requirement. The examples of the captures of the measurement results can be found in Appendix 2.

All the measurements are done with an oscilloscope counting positive edges of the encoder's pulses. For the 80 mm/s, 20 mm/s and 5 mm/s the oscilloscope in

the examples was set to have 10 ms/div division to see a total of 1 second on the horizontal axis, thus giving the reading of positive edges a one-to-one reading with millimetres per second. For the 0,5 mm/s measurement the oscilloscope's division needs to be set to 100 ms/div because the speed of the linear movement is too slow for the encoder's resolution which is 10 pulses per millimetre.

Based on this information, it can be concluded that the measured value of 5 positive pulses per second of the example in Figure 25 of Appendix 2 should be divided by ten to correspond to the actual linear actuation speed of 0,5 mm/s.

7 Load Times

The load times are also known as the “make” and “break” current times, which are mentioned in section 5 Beginning of verification, under Figure 1 of this thesis. The lead times are essentially delays for which the current of each load is held. Additionally, the time between the two loads has a requirement which needs to be met.

The setup for measuring all the load times is the same and can be done at once by moving the cursors on the oscilloscope to the specified positions.

7.1 Setup

The following items are required:

- On/Off switch with a stand
- 2-axis motor setup
- Oscilloscope (e.g. Tektronix MDO34; inv.no. 11599)
- Current clamp for oscilloscope (e.g. Fluke i310s; inv.no. 8941).

The clamp is setup to measure the AC current from one of the wires of the switch. The AC current waveform is displayed on the oscilloscope screen and the time is measured with cursors. The current clamp can be seen in Figure 9 setup to

measure from one of the wires of the On/Off switch. The wires of the switch are connected from the L1 output to the L1 input terminals of the test bench.

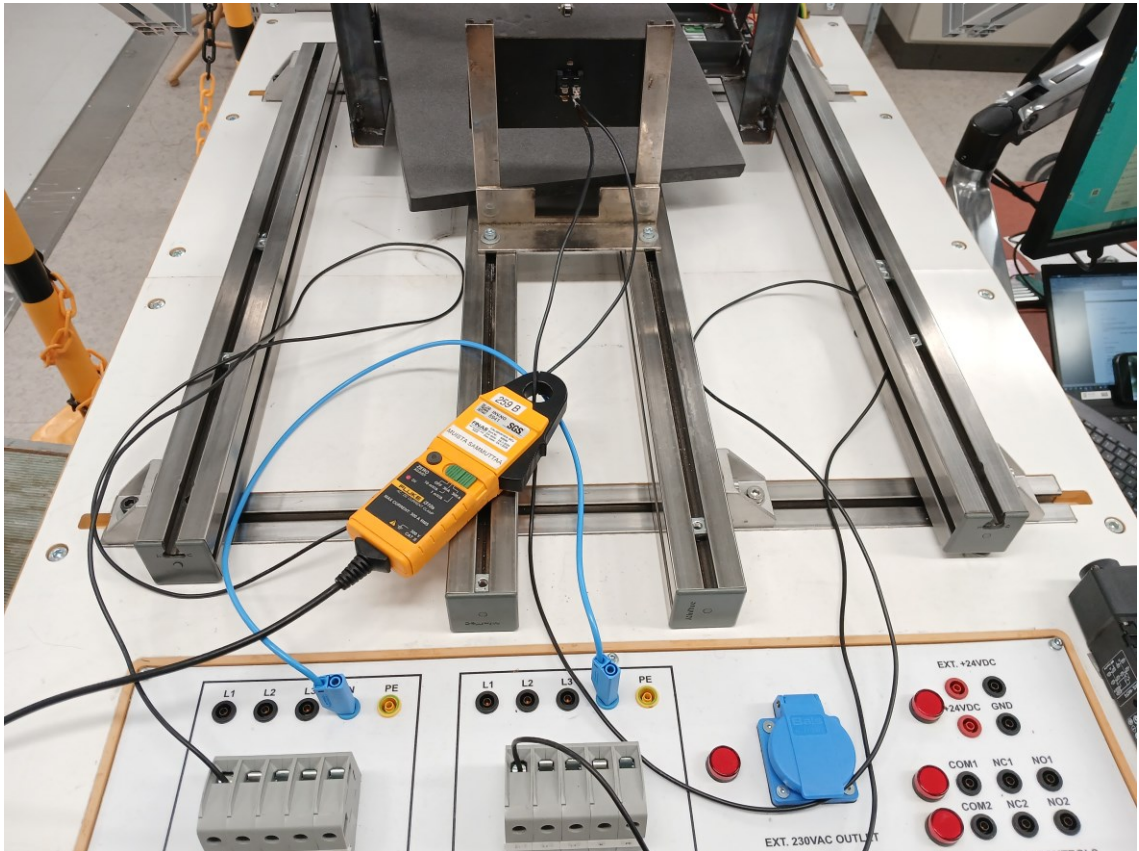


Figure 9 Current clamp measuring from a wire

The full setup can be seen in Figure 10 with the oscilloscope near on the table next to the test bench and the current clamp connected to the oscilloscope. Additionally, the switch stand can be seen attached to the rails of the test bench



Figure 10 Full setup of load time measurement

A closeup of the switch in the stand is shown in Figure 11. The actuator arm has a bearing attached to the tip to reduce friction between the arm and the switch during operation.

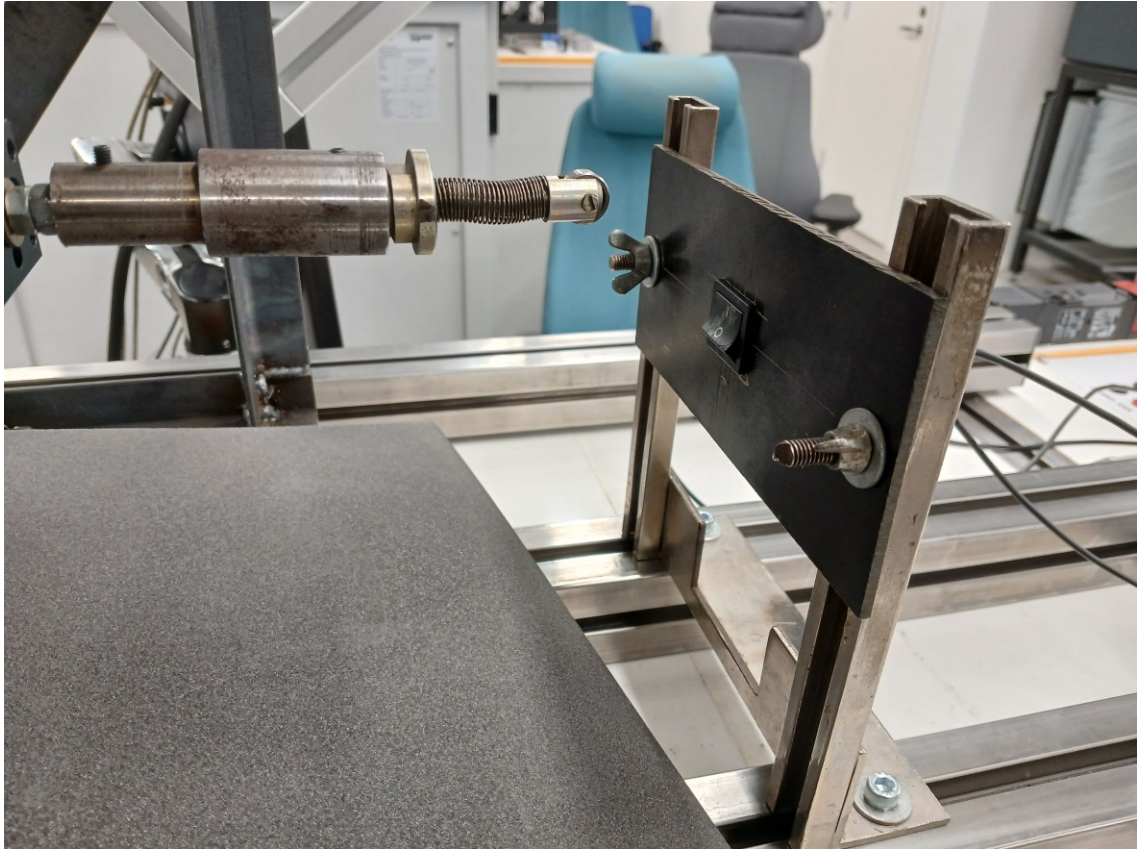


Figure 11 Close-up of the On/Off switch

The DUT testing menu, example of which can be seen in Figure 12 is set up to have the “Load A ON time [ms]” and “Load A OFF time [ms]” set to 0. This is done to check the minimum time of the loads. The time can be later adjusted while testing to achieve the proper length of the current waveform, meaning that the time measured for verification can be lower than the requirement. The “Load verification” should be turned on for this test, which can also be seen in Figure 12.

The loads should be set up to be purely resistive with no inductive parts. Due to the nature of inductors, AC current may be filtered or smoothed out when passing through them. Thus, the inductive parts of the loads may interfere with the times that are measured.

Testing menu.vi

SGS DUT Testing Menu

Project ID: Verifointi 1

Operator: AAm

Date & Time: 2024/11/25 17:34:08

Test Bench NO: OITECWS02

Customer: [Empty]

Notes / Informations: [Empty]

Test Type Parameters

Test Mode: Switch XY | Phases: L1+N | Load selection: A+B | Test Cycles: 10

Load A ON time [ms]: 0

Load A OFF time [ms]: 0

Clear notes

Test Parameters: Load B | Load A

Use Load verification:

Reset | Continue | Cancel

Figure 12 DUT Testing Menu

The actuation is setup to trigger the switch as quickly as possible. This is done to have the full waveform on the screen of the oscilloscope. Furthermore, the delay of the “Load B ON-time” is directly affected by how fast the switch is switched off at the end of the operation. A picture of the indicative setup parameters can be seen in Figure 13. These parameters can be used as a reference but may be adjusted for a better actuation path.

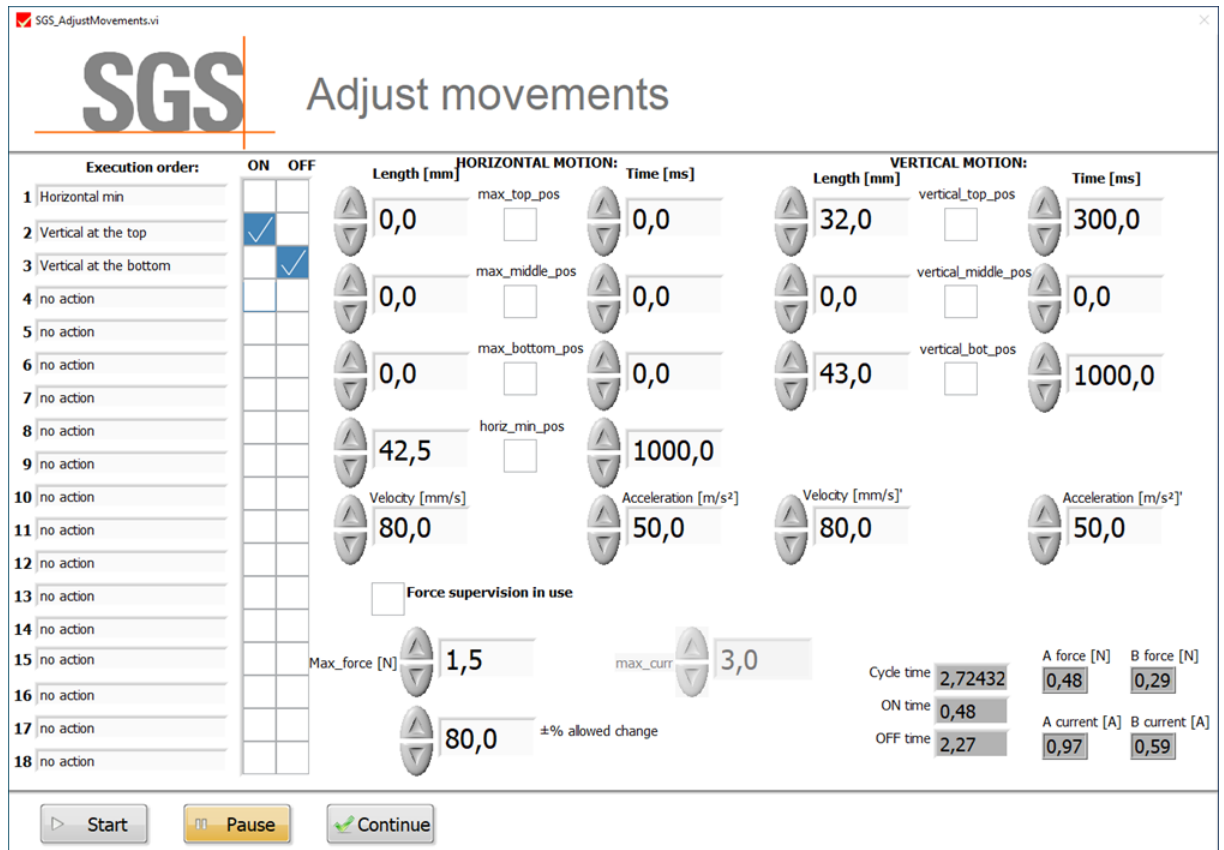


Figure 13 Settings for time measurement (Indicative)

After the setup is completed, the measurement can be done right away.

7.2 Load A ON-time

The Load A ON-time represents the delay of the “make” current mentioned in section 5 Beginning of verification, under Figure 1 of this thesis. This current can be seen as the first sine wave with a higher amplitude in Figure 14.

7.2.1 Requirements

The requirement of the contact mechanism for motor control circuits is given in section 18.101 of IEC 60669-2-1:2021 [4]. The standard states that:

The contact mechanism is subjected to tests of 50 cycles of operation, each at rated voltage and at the rate of operations specified in 18.1:

- a) the contact mechanism closes a circuit through which a current of $9 I_n$ ($\cos \varphi = 0,8 \pm 0,05$) passes, this current being interrupted by means of an auxiliary switch **50 ms to 100 ms** after each closure; [4.]

A similar requirement can be found in clause 17.2 of IEC 61058-1-1:2016 [6]. The requirement is as follows: “b) The specified making conditions are maintained for a period between 50 ms and 100 ms, and are then reduced by an auxiliary switch to the specified breaking conditions.” [6].

These requirements are for the “make” current, a reference of which can be found in Figure 1. The example of the waveform of the “make” current can be seen in Figure 14.

7.2.2 Results

A picture of each setup needs to be taken for documentation. The setup pictures are added to the end of the verification document. Additionally, a capture of the oscillogram with the measured time of the load A waveform is taken. The measured time in milliseconds is also documented for the verification document.

An example picture of measured oscillogram for load A measurement can be seen in Figure 14.

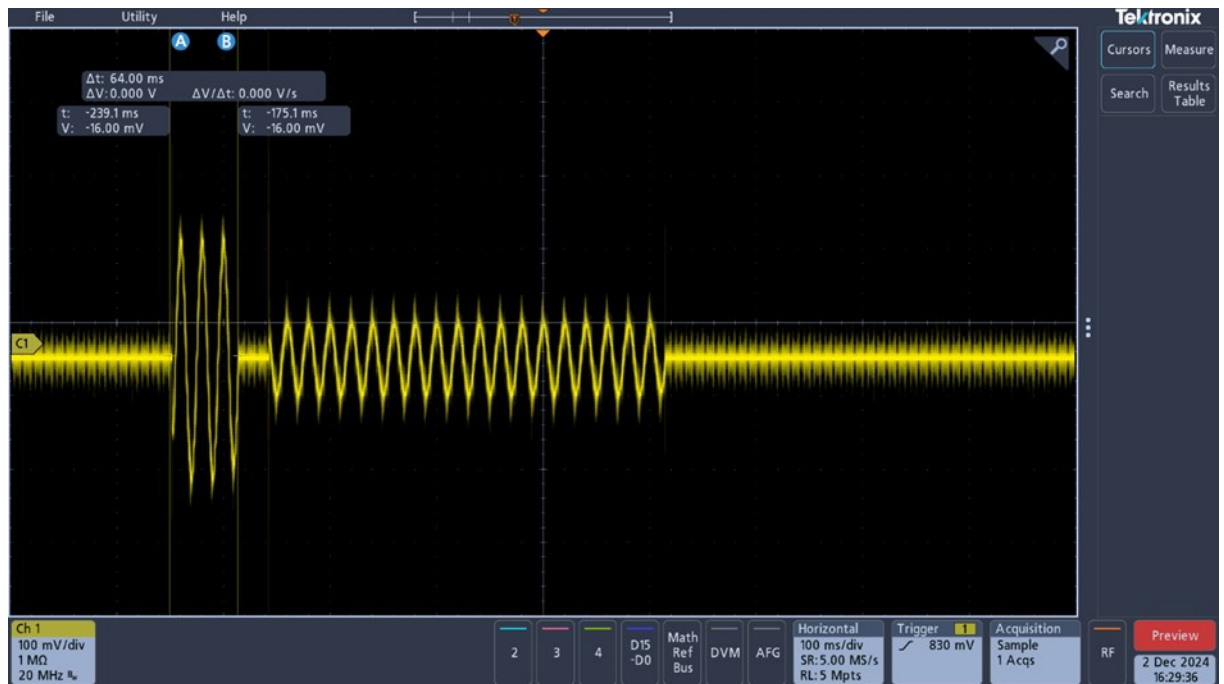


Figure 14 Load A ON time displayed as Δt between cursors as 64 ms

7.3 Time Between Load A and Load B

The time between load A and load B is a delay between the switching from one first load to the second one. This delay occurs due to the nature of the test bench hardware. The loads are switched with contactors, which have delays when switching between states.

7.3.1 Requirements

A requirement is given in clause 17.2 of IEC 61058-1-1:2016, which states that “For mechanical switches the test current may be reduced to I-R by introducing a resistor in the circuit. Short interruptions of the test current during the reduction to I-R **not exceeding a period of 50 ms to 100 ms are permitted.**” [6].

This requirement essentially means that the delay between the loads must be at maximum 100 milliseconds. The 50 milliseconds mentioned in the requirement

is irrelevant because the requirement has the words “not exceeding” and gives an option to “not exceed” from 50 to 100 milliseconds. By not exceeding 100 milliseconds, the range is automatically set to exceed 50 milliseconds. Thus, the requirement is simplified, and 100 milliseconds is chosen to be the upper limit for this verification.

7.3.2 Results

A capture of the oscillogram with the cursors between the two load waveforms is sufficient to display the result. The measured time in milliseconds is also documented for the verification document.

An example picture of the oscillogram measurement can be found below in Figure 15.

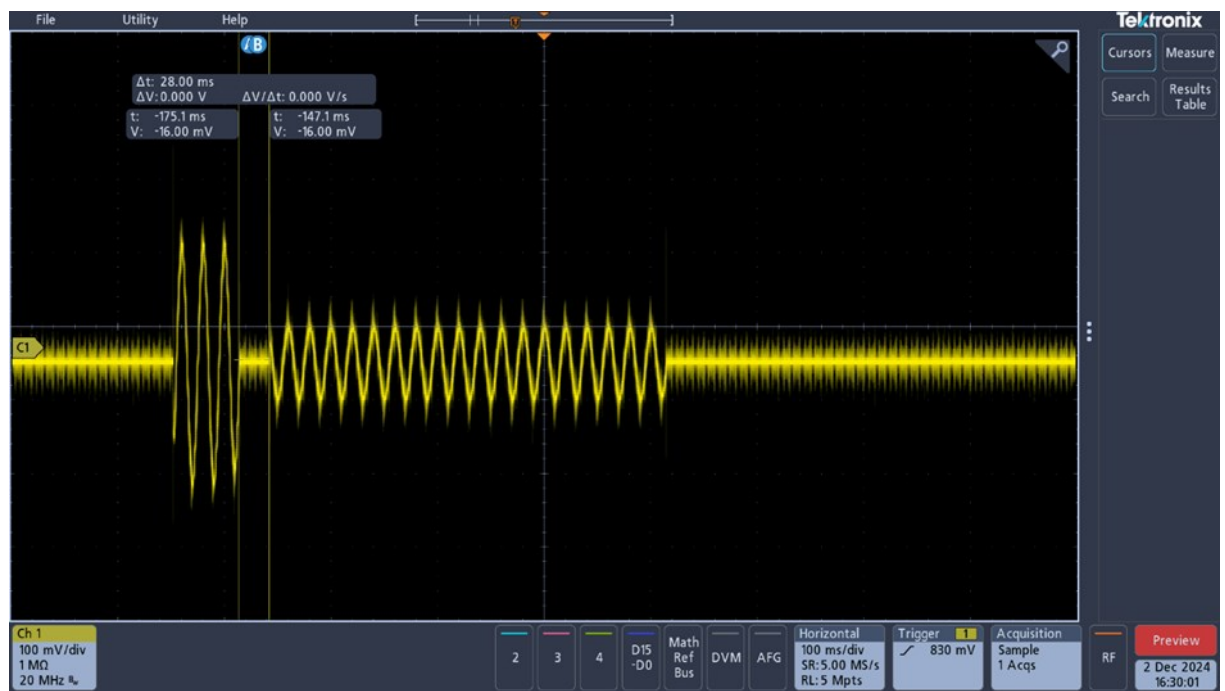


Figure 15 Time between Load A and Load B displayed as Δt between cursors as 28 ms

7.4 Load B ON-time

The load B ON-time represents the delay for the “break” current explained in section 5 Beginning of verification, under Figure 1 of this thesis.

7.4.1 Requirements

The following requirement for the load B ON-time is given IEC 60669-2-1:2021 [4]:

The contact mechanism is subjected to tests of 50 cycles of operation, each at rated voltage and at the rate of operations specified in 18.1:

- b) the circuit through which a current of $6 I_n$ ($\cos \varphi = 0,6 \pm 0,05$) passes is closed by an auxiliary switch and opened by the contact mechanism **300 ms to 500 ms** after each closure. [4.]

7.4.2 Results

A capture of the oscillogram with the cursors measuring the waveform of load B is sufficient to display the result. Due to ability to add more “ON-time” to the load **any result lower than 500 ms is acceptable.**

The result can vary depending on the movement path and time delay set for the actuator. Increasing the length of movement or delay in the “Adjust movements” menu can have an impact on the result. Thus it is recommended to adjust the length of the movement path as short as possible and set the time delay between the actuations to zero.

An example picture of oscillogram measurement can be seen in Figure 16.

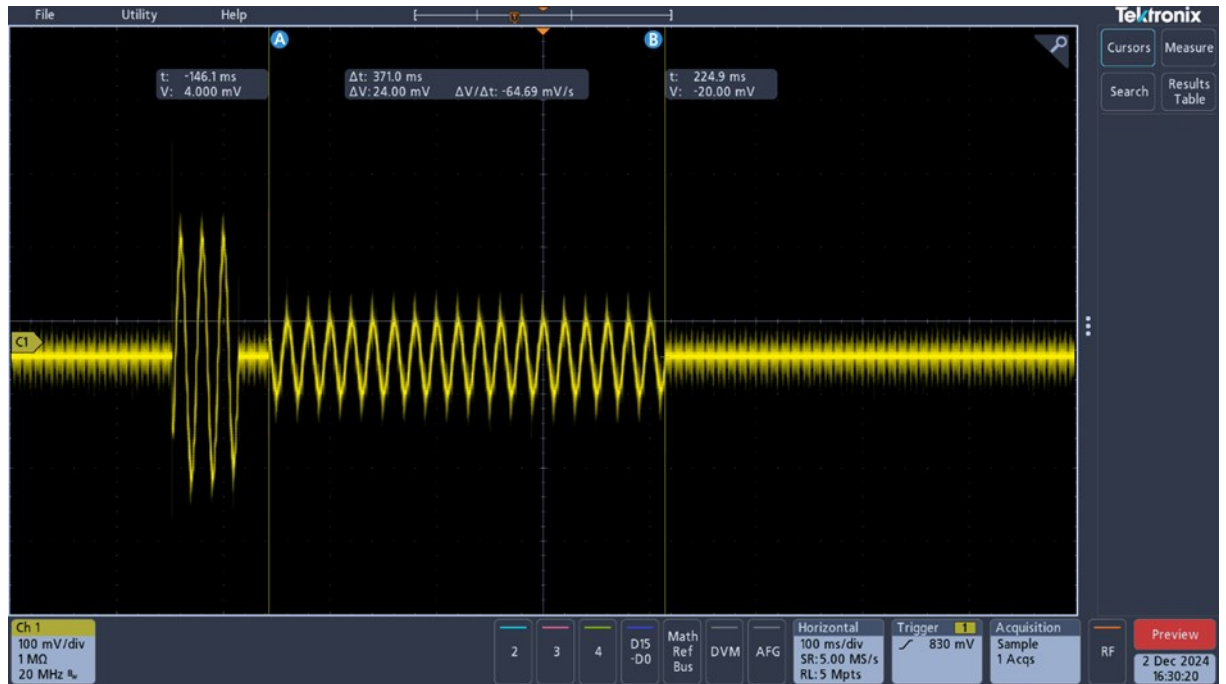


Figure 16 Load B ON time displayed as Δt between cursors as 371 ms

The verification of the enclosure safety switch found in chapter 8 of this thesis can be done right after this part due to the setup being the same. The verification of the emergency stop buttons found in chapter 9 of this thesis can be done after verifying the enclosure safety switch because of the setup is also unchanged. The cycle counter verification in chapter 10 of this thesis is recommended to be done last.

8 Enclosure Safety Switch

The requirement for the enclosures for tests with exposed live parts comes from an internal safety document of SGS Fimko Oy. This requirement applies to test setups that are left without active supervision. Since testing with this test bench is mostly unsupervised, this requirement is applicable.

8.1 Requirements

To reduce the risk of accidental electric shock to the personnel, the enclosure safety switch must work as a cutoff to the ongoing process. When the safety

switch is disengaged, the machine must stop and voltage at the terminals must be switched off. The safety switch must latch so that the enclosure cannot be opened by hand while operation with loads is in progress. [13.]

8.2 Setup

The following items are required:

- 1 On/Off switch with a stand
- 2-axis motor setup.

The operation with loads is started without the safety switch engaged to see if starts. After that, another test is performed with the safety switch key inserted. The actuators are setup the same way as in the load time setup in chapter 7.1 of this thesis. The key that can be seen in Figure 17 is pulled by hand to test the safety switch latching mechanism.

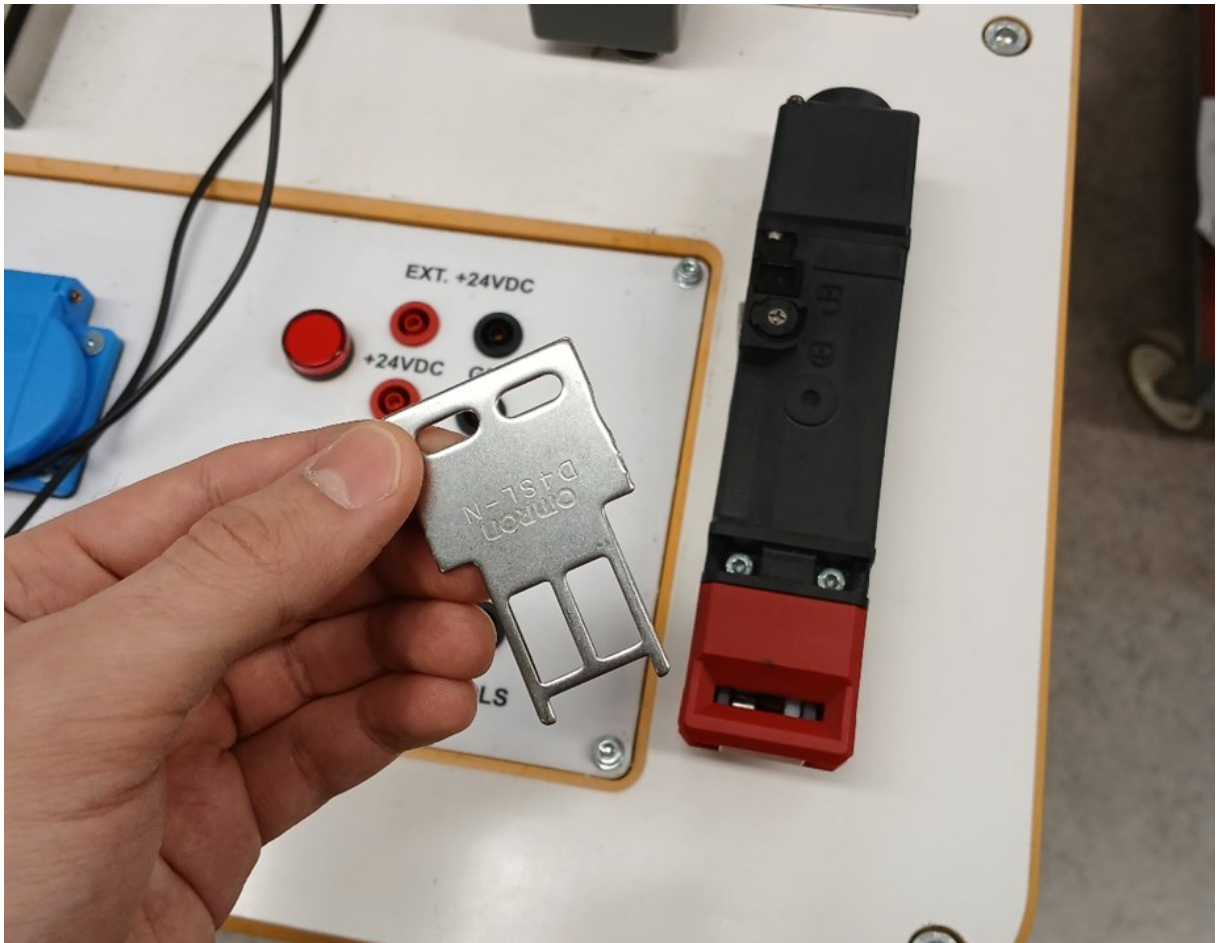


Figure 17 Picture of the enclosure safety switch key

8.3 Results

The operation should not start without the switch key engaged. If it does, the machine must abort and stop the operation. The latching mechanism must work so the operator cannot pull the key out by hand. The safety switch test is marked as “PASS” for both sections of the verification document, an example of which can be seen in Appendix 1.

After verifying the enclosure safety switch, the verification of the emergency stop buttons in chapter 9 of this thesis can be completed during the same operation.

9 Emergency Stop Buttons

The requirements for the functionality of emergency stop buttons on testing devices are given in SGS Fimko Oy's internal safety decision document. The emergency stop buttons are an essential safety feature of all the testing devices of this company.

9.1 Requirements

The emergency buttons on the device must immediately shut down the machine and halt the process. Once the button is reset, the power should not automatically restore [13].

9.2 Setup

The following items are required:

- 1 On/Off switch with a stand
- 2-axis motor setup.

The emergency stop buttons are pressed while the machine is in operation with loads. The first button can be tested right after verifying the enclosure safety switch in chapter 8 of this thesis. After testing the first button, the operation is restarted, and the second button is tested while in operation. The order of testing the buttons does not matter for this test because both buttons must perform the same action. A picture of the buttons on the machine, circled in red, can be seen in Figure 18.

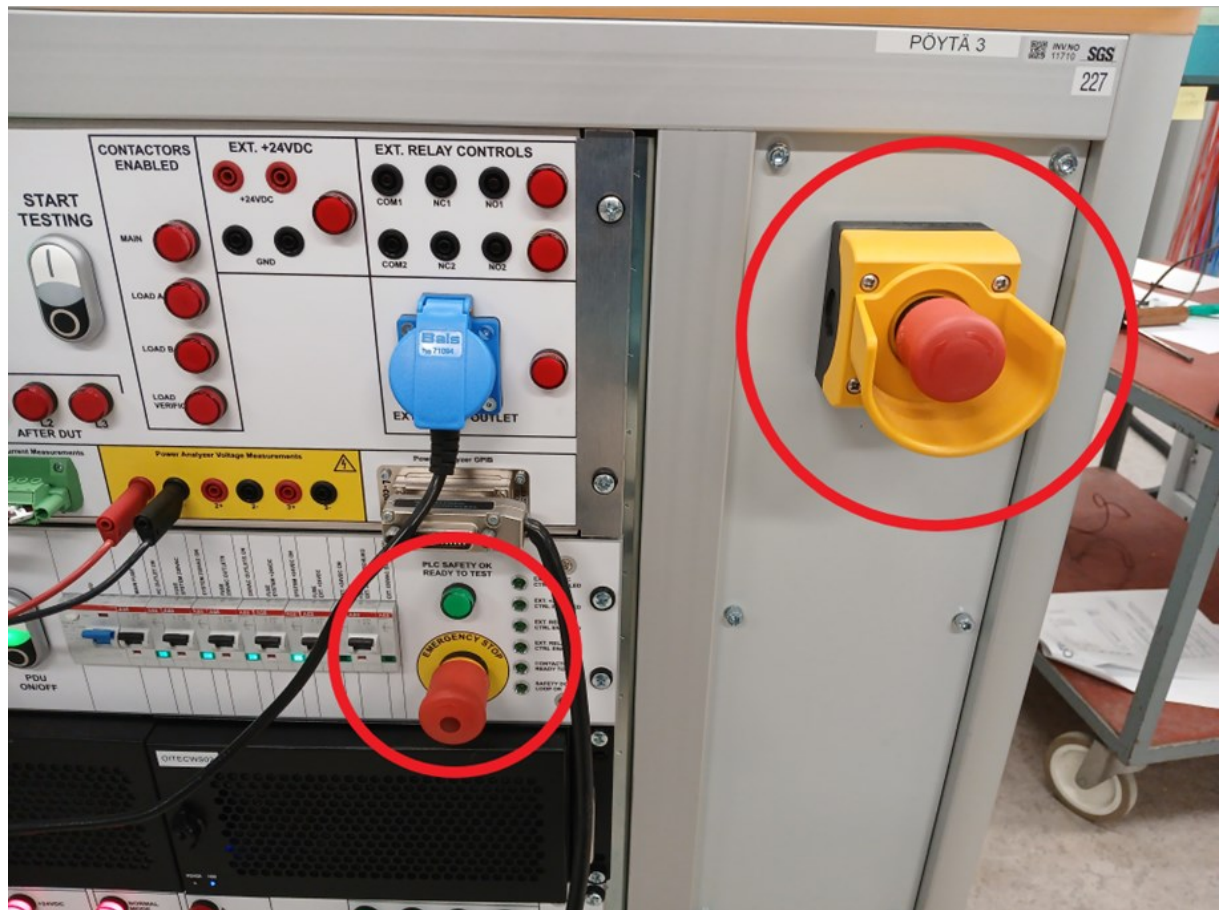


Figure 18 Picture of the emergency stop buttons

9.3 Results

The operation must stop immediately after a button is pressed. Both buttons must be marked as “PASS” in the verification document as seen in Appendix 1.

10 Cycle Counter

The cycle counter calculates the number of cycles the test bench has executed and displays it in the user interface. Many standards give a minimum requirement for the number of operating cycles. Thus, it is important for the test bench to display the number of cycles accurately because it is often left unsupervised while in operation.

10.1 Requirements

Many requirements can be found in most of the standards listed, but some of the more general ones are added to this thesis.

The recommended number of cycles to be tested is 10000 but a smaller amount can be chosen in the range of thousands. For example, 3000 cycles.

It is necessary to acknowledge that the test bench software performs a dry run of the actuator movements at the start of operation. As a result, the cycle counter will display one additional cycle when measured with a counting device. Therefore, the cycle counter should indicate the total number of cycles plus one.

A requirement can be found in Annex C of IEC 60884-1:2022 [5], the requirement applies to switches incorporated in portable socket-outlets. The requirement for the minimum number of operating cycles in this standard is 10 000, which can be seen below in Figure 19.

Annex C (normative)

Switches incorporated in portable socket-outlets

Switches incorporated in portable socket-outlets shall comply with the relevant part of the IEC 60669 series or IEC 61058 series.

The rating of the switch shall not be lower than the lowest rating of the socket-outlet or the incorporated overcurrent protective device.

Switches marked with OFF state shall be of normal gap construction and shall disconnect all the live poles.

Switches complying with IEC 61058-1 shall have the following minimum classification:

Pollution degree:	2
Rated impulse withstand voltage	2 500 V
Level of resistance to fire with test according to glow wire temperature	750 °C
Number of operating cycles	10 000

Figure 19 Annex C of IEC 60884-1:2022 with minimum requirements [5,154]

Table 7 of IEC60320-1:2021 also specifies many different minimum numbers of strokes for different ratings, ranging from 2 000 to 6 000 strokes or cycles. These requirements can be seen below in Table 2.

Table 2 Ratings for tests from Table 7 of IEC 60320-1:2021 [2,36]

Rated current A	Test voltage V	Test current A	Power factor (cos ϕ)	Minimum number of strokes
$\leq 0,2$	–	no current	–	4 000
$> 0,2$ to < 10	rated voltage	rated current	$0,6 \pm 0,05$	2 000
	–	no current	–	6 000
≥ 10	rated voltage	rated current	$0,95 \pm 0,05$	2 000
	–	no current	–	6 000

Strokes are applied 28 to 30 per minute with continuous movement.

Current flow period: $1,5^{+0,5}_0$ s.

A stroke is an engagement or a disengagement of the sample under test into the counterpart.

The test sample is fully inserted into and withdrawn from its counterpart during each cycle.

Additionally, more requirements for various electromechanical appliances can be found in clause 24.1.4 of IEC 60335-1:2020 [3] and presented as follows:

The number of cycles of operation [...] shall not be less than the following:

- thermostats
10000
- temperature limiters 1000
- self-resetting thermal cut-outs 300
- voltage-maintained non-self-resetting thermal cut-outs 1000
- other non-self-resetting thermal cut-outs 30
- timers 3000
- energy regulators 10000

[...] [3.]

10.2 Setup

The following items are required:

- 1 cycle counter
- 2-axis motor setup.

First the actuator path needs to be set up to push the counter lever. After this setup the operation is restarted without “dry running” the actuator, but with the settings saved. Before starting the operation, the counter is zeroed and operation started.

As soon as the operation is started, the “Start” button needs to be pressed in the program interface for the software to begin counting cycles. If the “Start” button is not pressed immediately, the mechanical cycle counter and the software cycle counter will be out of sync.

The software adds one cycle of actuation when it finds the desired position at the start, thus the cycle counter will always show one extra cycle compared to the setting.

The number of cycles can be chosen freely in the range of thousands, but 10000 is recommended.

An example of the setup can be seen in Figure 20 and mechanical cycle counter in Figure 21.

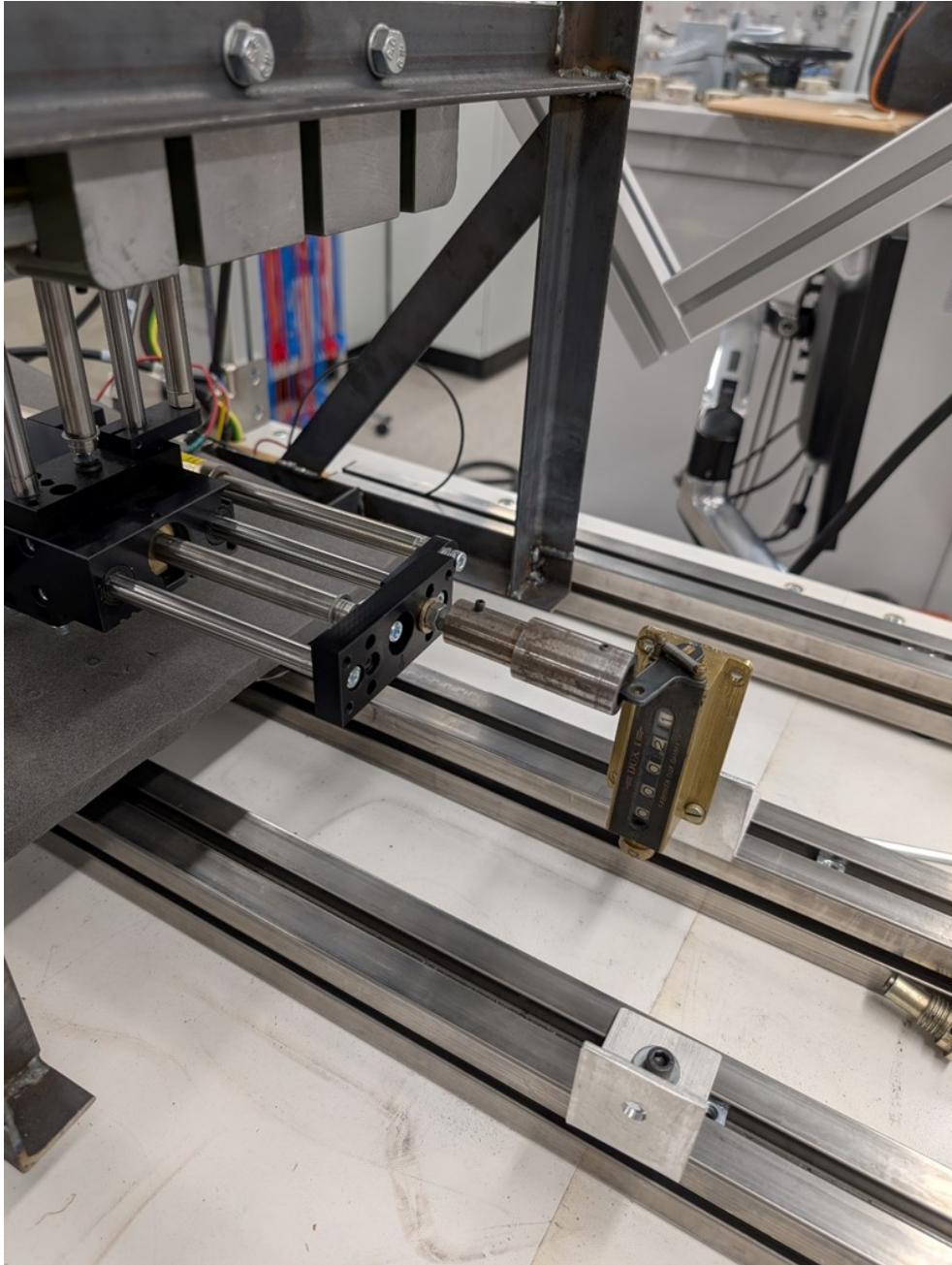


Figure 20 Cycle counter setup



Figure 21 Mechanical cycle counter

10.3 Results

A picture of the setup is taken and uploaded to the verification document. An acceptable result for the number of cycles is 1 cycle more than the amount seen in the user interface. For example, **a setting of 3000 cycles is expected to be measured as 3001 cycles.** The number of cycles is documented in the verification document as seen in Appendix 1.

11 Verdict of the Verification

Any fail to meet the requirements shall be recorded, the root cause must be analysed, and the steps must be taken for correction as well as the date of failure documented. A re-verification of the failed parameters must be conducted after

the issue is fixed. Old verification data may be examined to determine the condition of the device due to wear over time.

A fail to pass a verification test shall be documented and explained in the “Additional information” text field of the verification document. An example of the text field can be seen in the “Verdict” part of Appendix 1 of this thesis.

12 Conclusions

This project has successfully met its goals and determined that the relevant testing equipment is in shape for safe and reliable testing. These instructions have worked as a quality improvement measure for this testing method. After conducting the verification on one of the machines, it was deemed to be in working condition and the results were satisfactory as seen in Appendix 1.

Further verification was conducted on the other testbenches, which were also deemed to be compliant with the requirements. This verification is recommended to be done annually to ensure the conformity of the test benches over time.

The instruction document made for SGS may be modified or updated, depending on the scope of the testing devices and the applicable standards. For example, a verification of rotational actuation could be implemented if a test of that kind would be relevant.

Many of the standards used for this project had to be learned first to understand the requirements found in them. Also, the practical side of the verification was not easy to do, because there were no similar projects available to use as an example. Although the topic of this project is unique and uncommon, it was still important for the company.

References

- 1 ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories. International Organization for Standardization; International Electrotechnical Commission.
- 2 IEC 60320-1:2021 Appliance couplers for household and similar general purposes - Part 1: General requirements. International Electrotechnical Commission.
- 3 IEC 60335-1:2020 Household and similar electrical appliances - Safety - Part 1: General requirements. International Electrotechnical Commission.
- 4 IEC 60669-2-1:2021 Switches for household and similar fixed electrical installations - Part 2-1: Particular requirements - Electronic control devices. International Electrotechnical Commission.
- 5 IEC 60884-1:2022 Plugs and socket-outlets for household and similar purposes - Part 1: General requirements. International Electrotechnical Commission.
- 6 IEC 61058-1-1:2016 Switches for appliances - Part 1-1: Requirements for mechanical switches. International Electrotechnical Commission.
- 7 IEC 61058-1-2:2016 Switches for appliances - Part 1-2: Requirements for electronic switches. International Electrotechnical Commission.
- 8 IEC 62368-1:2023 RLV Audio/video, information and communication technology equipment - Part 1: Safety requirements. Redline version. International Electrotechnical Commission.
- 9 Ikonix USA. Electrical Safety Tester Verification [Internet]. [cited 2025 Jan 15]. Available from: <https://www.ikonixusa.com/whitepapers/electrical-safety-tester-verification>
- 10 International Electrotechnical Commission. Understanding standards [Internet]. Geneva: IEC; [cited 2025 Feb 1]. Available from: <https://www.iec.ch/understanding-standards>
- 11 International Electrotechnical Commission. What is conformity assessment [Internet]. Geneva: IEC; [cited 2025 Feb 1]. Available from: <https://www.iec.ch/conformity-assessment/what-conformity-assessment>
- 12 Finnish Safety and Chemicals Agency (TUKES). Surveillance [Internet]. Helsinki: TUKES; [cited 2025 Feb 1]. Available from: <https://tukes.fi/en/do-this/surveillance>
- 13 SGS Fimko Oy. Internal safety decision document. [Unpublished].
- 14 IEC 61058-1:2016 Switches for appliances - Part 1: General requirements. International Electrotechnical Commission.

Appendix 1: Completed Endurance Test Bench Verification Document

Endurance Test Bench Verification

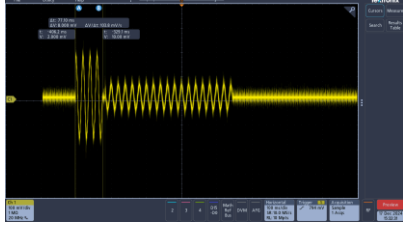
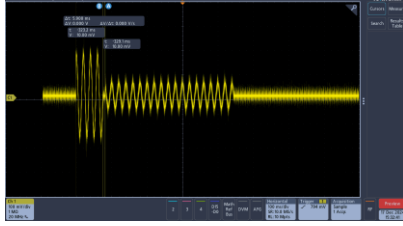
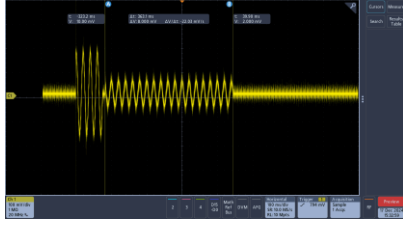
1. Information		
Operator full name	Amir Ammar	
Date	17.12.2024	
Inventory number of test bench	11710	
Serial numbers of the actuation devices	1234.83J.001	1234.83J.006
Inventory numbers of other devices used	11520, 11599, 8940, 4497, 241212A	

Scope

- This document is meant to be read with the verification procedure “P-CRS-TE-7 Verification instructions for electromechanical test bench.docx”.
- Save this document with a name “Endurance_test_bench_verification_ *inventory number* _*date in YYMMDD format*” as a verification instance to PM equipment database according to procedure “P-CRS-GEN-236 PM – Laitetietokanta”.

Results

Clause	Test	Result				
2.1	X-axis Motor Speed	Setting	0,5 mm/s	5 mm/s	20 mm/s	80 mm/s
		Measured (mm/s)	0,5	5	20	80
2.2	Y-axis Motor Speed	Setting	0,5 mm/s	5 mm/s	20 mm/s	80 mm/s
		Measured (mm/s)	0,5	5	20	80

3.	Load A ON-time	Requirement	50 ms to 100 ms			
		Measured (ms)	77			
			Picture of graph			
						
4.	Time between Load A and Load B	Requirement	Max. 100 ms			
		Measured (ms)	6			
			Picture of graph			
						
5.	Load B ON- time	Requirement	Max. 500 ms			
		Measured (ms)	363			
			Picture of graph			
						
6.	Enclosure Safety Switch	Test	Operation while open		Locking mechanism	
			PASS <input checked="" type="checkbox"/>	FAIL <input type="checkbox"/>	PASS <input checked="" type="checkbox"/>	FAIL <input type="checkbox"/>
7.	Emergency Stop Buttons	Button	Large button		Small button	
			PASS <input checked="" type="checkbox"/>	FAIL <input type="checkbox"/>	PASS <input checked="" type="checkbox"/>	FAIL <input type="checkbox"/>

8.	Cycle Counter	Number of cycles	Measured
		3000	3001

Verdict

All tests passed


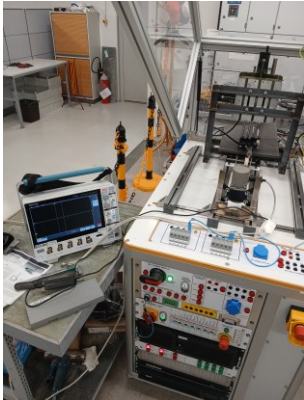

Tests failed

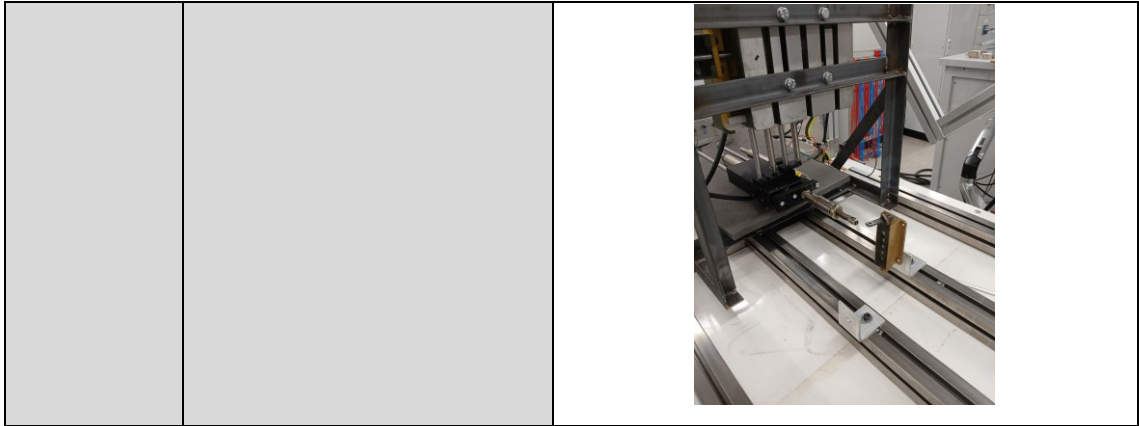
Clause	1.1	1.2	3.	4.	5.	6.	7.	8.
Fail	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Additional information:

Click or tap here to enter text.

Pictures of the setup

Clause	Test	Picture
1.1	X-axis Motor Speed	<p data-bbox="1034 367 1262 398">Picture of setup</p> 
1.2	Y-axis Motor Speed	<p data-bbox="1034 844 1262 875">Picture of setup</p> 
2.-4.	Load time	<p data-bbox="1034 1321 1262 1352">Picture of setup</p> 
8.	Cycle Counter	<p data-bbox="1007 1798 1289 1830">Picture of the setup</p>



Appendix 2: Actuation Speed Measurements

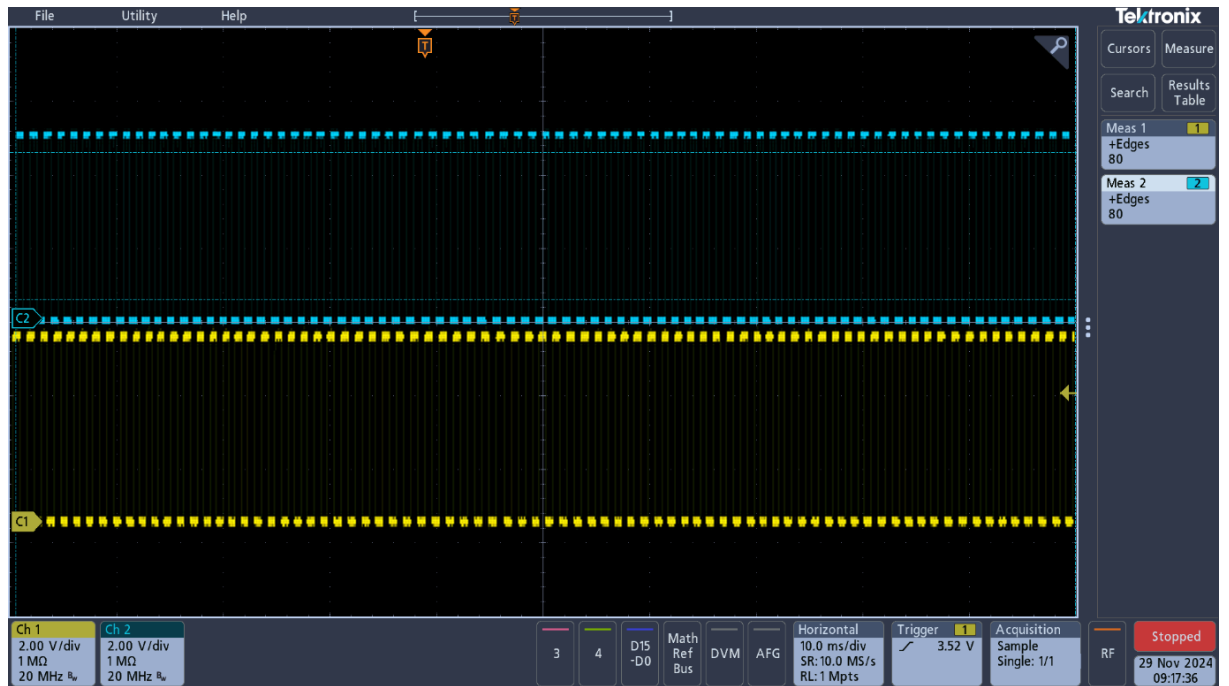


Figure 22 Example of oscilloscope screen measuring 80 mm/s

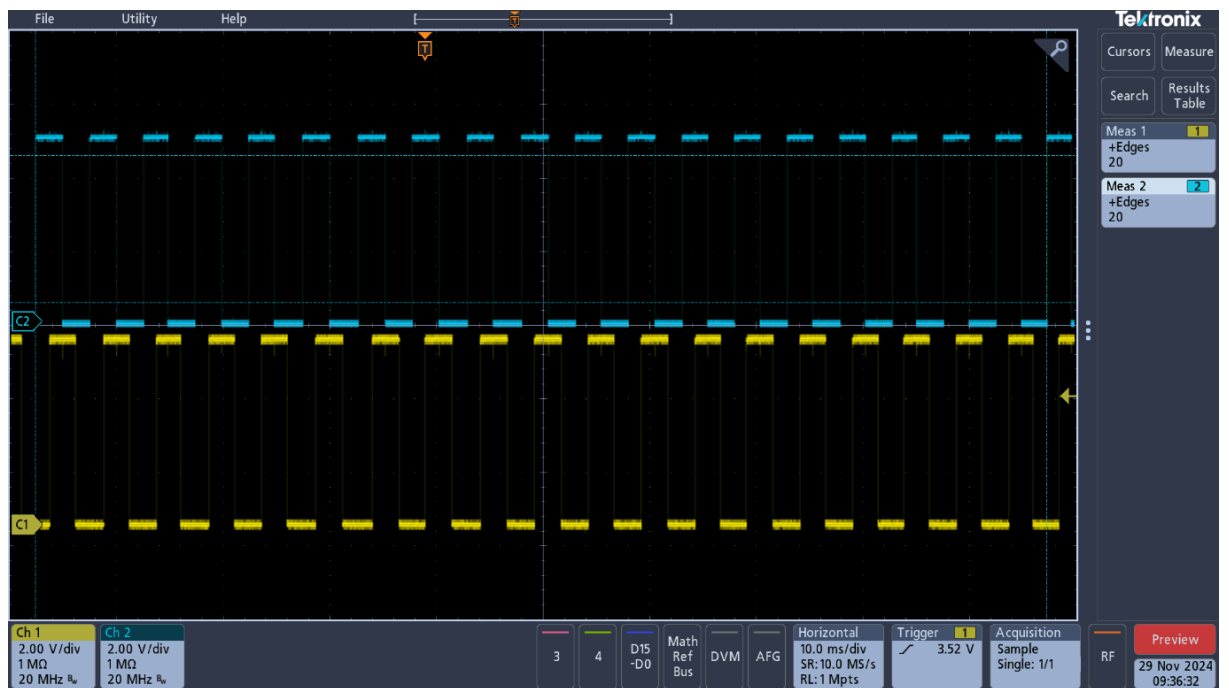


Figure 23 Example of oscilloscope screen measuring 20 mm/s

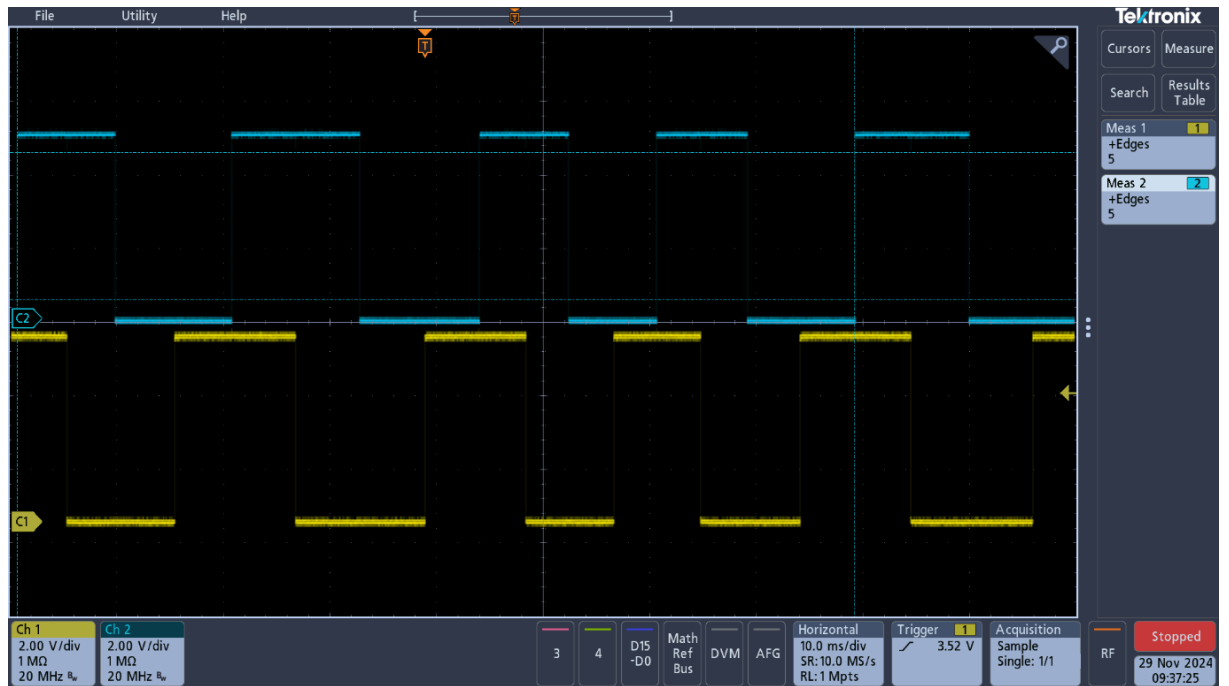


Figure 24 Example of oscilloscope screen measuring 5 mm/s

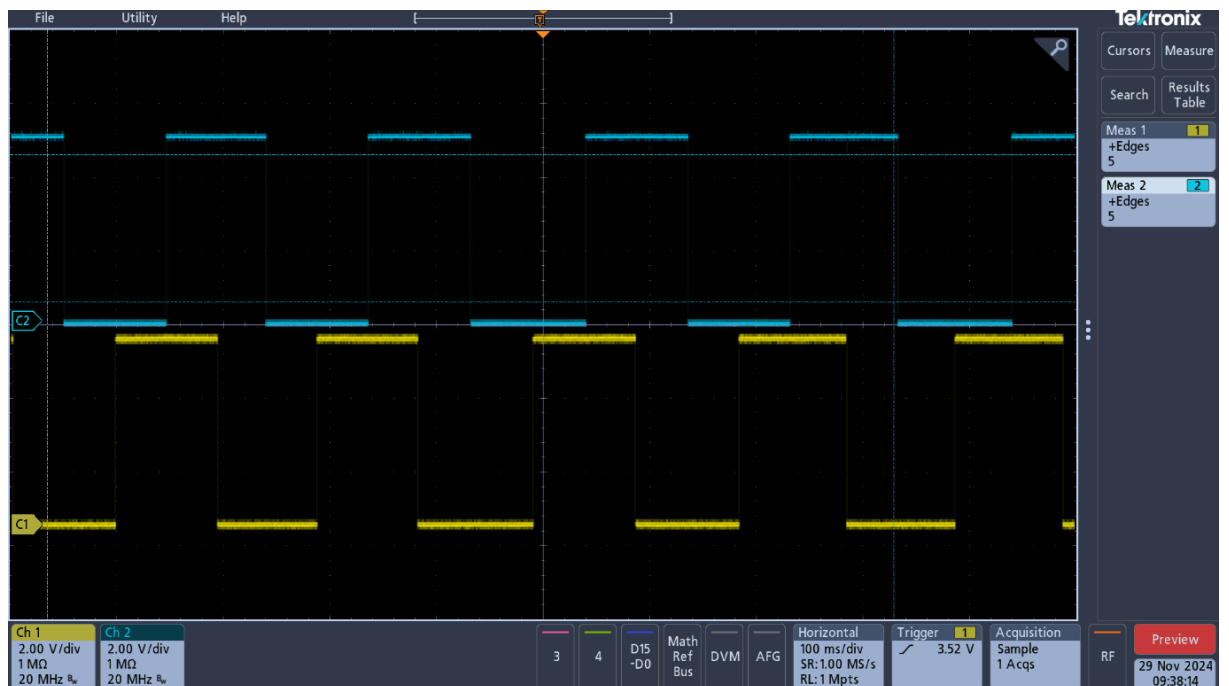


Figure 25 Example of oscilloscope screen measuring 0,5 mm/s