Application Note

# A Guide for Using PTM and The CIBANO 500 to test Circuit Breakers in North America


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CIBANO 500

Application Area

Circuit Breaker testing with PTM

Keywords

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Abstract

This application note is a step-by-step guide for users creating a test plan in the PTM software for testing circuit breakers. Important settings and tips for obtaining a good measurement are highlighted in the guide for each major test associated with the CIBANO 500 (Dead Tank Package).

# General information

OMICRON electronics GmbH, including all international branch offices, is henceforth referred to as OMICRON.

The product information, specifications, and technical data embodied in this Application Note represent the technical status at the time of writing and are subject to change without prior notice.

We have done our best to ensure that the information given in this Application Note is useful, accurate and entirely reliable. However, OMICRON does not assume responsibility for any inaccuracies which may be present.

OMICRON translates this Application Note from the source language English into a number of other languages. Any translation of this document is undertaken for local requirements, and in the event of a dispute between the English and a non-English version, the English version of this note shall govern.

# Table of content

# 1 Safety instructions

This Application Note may only be used in conjunction with the relevant product manuals which contain all safety instructions. The user is fully responsible for any application that makes use of OMICRON products.

Instructions are always characterized by a ▶ symbol, even if they are included in a safety instruction.

**DANGER**

**Death or severe injury caused by high voltage or current if the respective protective measures are not complied with.**

- ▶ Carefully read and understand the content of this Application Note as well as the manuals of the systems involved before taking them into operation.
- ▶ Please contact OMICRON support if you have any questions or doubts regarding the safety or operating instructions.
- ▶ Follow each instruction listed in the manuals, especially the safety instructions, since this is the only way to avoid the danger that can occur when working on high voltage or high current systems.
- ▶ Only use the equipment involved according to its intended purpose to guarantee safe operation.
- ▶ Existing national safety standards for accident prevention and environmental protection may supplement the equipment's manual.

Only experienced and competent professionals that are trained for working in high voltage or high current environments may implement this Application Note. Additionally, the following qualifications are required:

- Authorized to work in environments of energy generation, transmission or distribution, and familiar with the approved operating practices in such environments.
- Familiar with the five safety rules.
- Good knowledge/proficient in working with the CIBANO 500 and testing of MV/HV circuit breakers

# 2 PTM Test Procedure Document: Introduction

The purpose of the following document is to provide the user a step-by-step guide for successfully using PTM.  The document closely follows the PTM “workflow” concept.  The user will be guided through the following process,

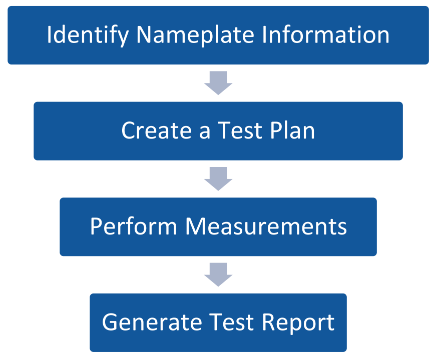



Figure 1: PTM Workflow Concept

In addition to providing a step-by-step guide for using PTM, the intention of this document is to also help the user develop good testing practices, which can help increase the accuracy and quality of the measurements performed, as well as decrease the likelihood of making safety related mistakes.

The home screen of the PTM software is shown in Figure 2, and can be used to complete the following tasks,

- Connect the OMICRON equipment to the laptop via an Ethernet cable
- Access the PTM Database via the “Manage” option
- Create a new test plan


Figure 2: PTM Home Screen

A new test plan can be created either by clicking the "New guided job" or "Manage" button; however, the "New guided job" button is a more direct way of creating a new test plan and allows the user to bypass the data manager. Therefore, to create a new test plan for a circuit breaker, select the "New guided job" button.

Once a new job is created, the user will have access to the five main sections of the PTM software, which include, the "overview", "location", "asset", "tests", and "report" section. The five sections can be found on the left panel of PTM (see Figure 3). The user should complete these sections from top to bottom, as shown in Figure 3.

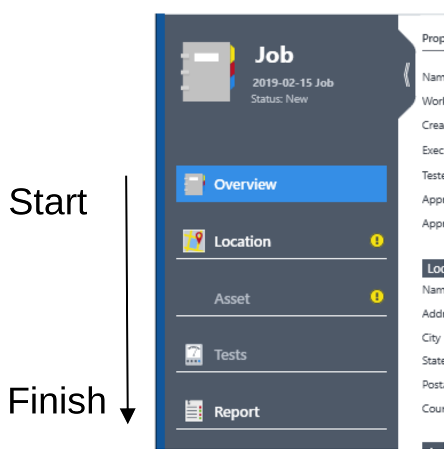



Figure 3: PTM Left Panel-Workflow

# 3 Overview

Once a new job is created, the first section that will automatically be displayed is the “Overview” section, as shown in Figure 4.  Please enter the information outlined in Figure 4.

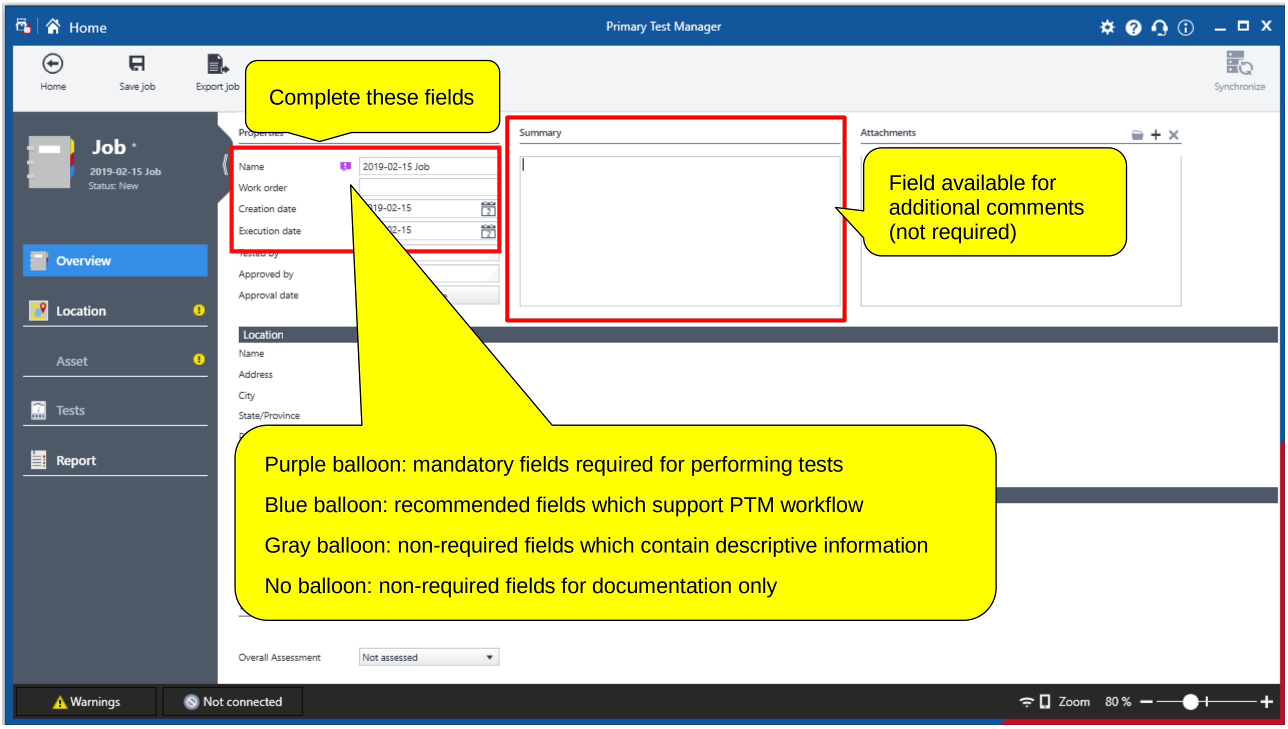



Figure 4: PTM Overview Section

# 4 Location

Once the overview section is complete, click on the “Location” tab on the PTM left panel, as shown in Figure 5. The “Location” is the name of the job site, substation, etc… The asset that you will eventually create within this test plan will be stored at this location within the PTM database.

Please enter the information outlined in Figure 5.

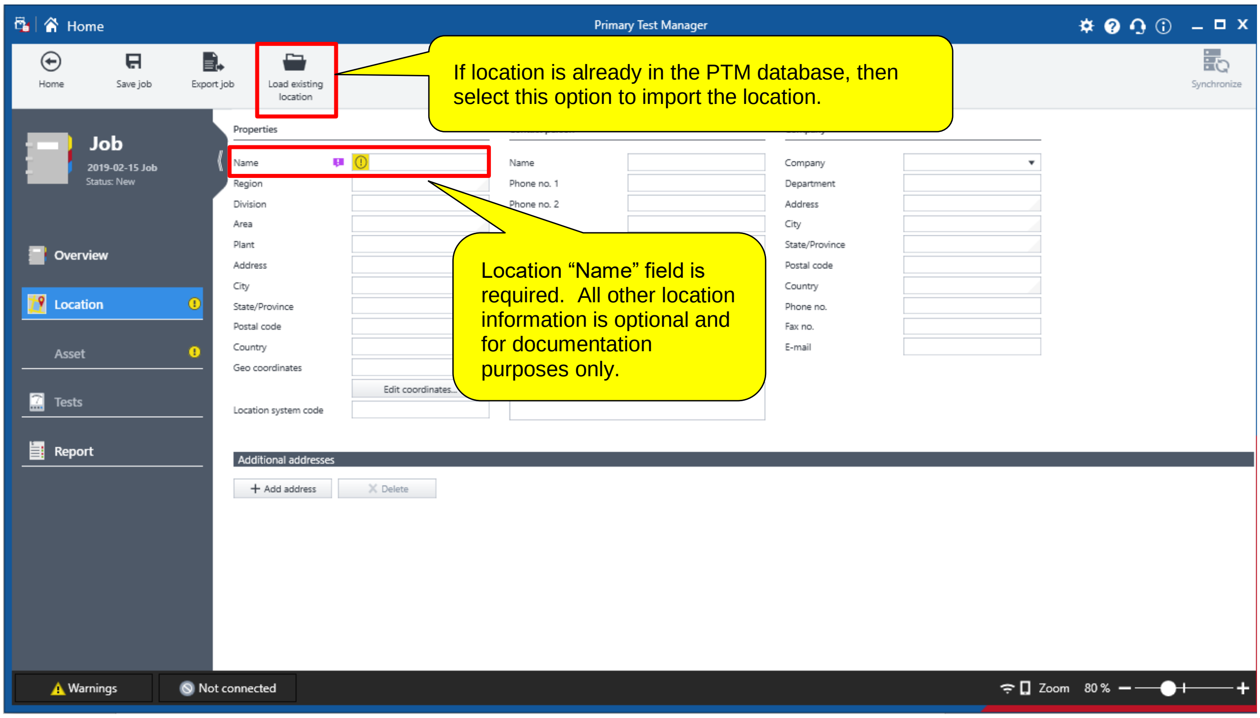



Figure 5: Location Section

# 5 Asset

Once the “Location” section is complete, click on the “Asset” tab on the PTM left panel, as shown in Figure 6. The “Asset” section of the software is where all the nameplate information of the asset under test and its ancillary equipment (e.g. bushings) will be entered.

**NOTICE**

**Complete fields from top-to-bottom**

- It is important that the “Asset” section of the software is completed from top-to-bottom. The “Asset” section may change based on a previous selection so it is important to enter the information accurately, and in order.

Please complete the sections outlined in Figure 6.

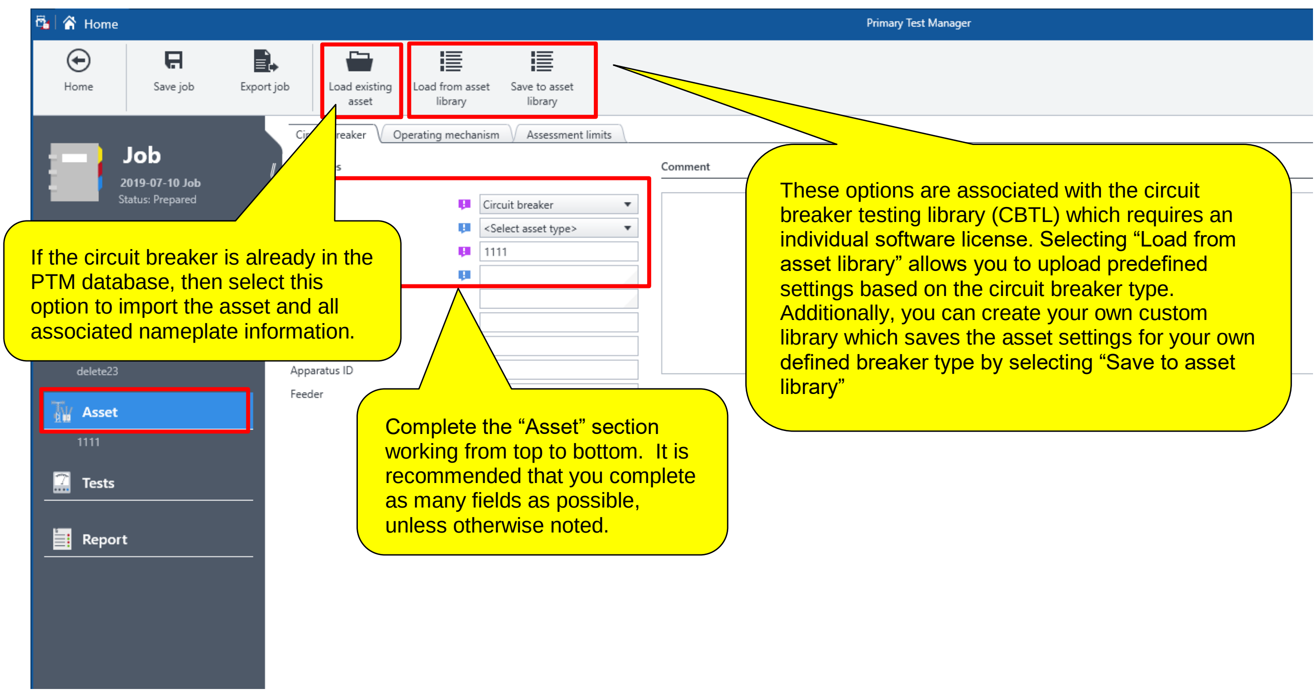



Figure 6: Asset Information

## 5.1 Asset: Circuit Breaker

After selection of the asset as circuit breaker and asset type, new settings will appear. The “Asset” section will expand into 4 tabs, “Circuit breaker”, “Operating mechanism”, “Bushings”, and “Assessment Limits” (Fig.7).. Complete the settings from top to bottom and left to right, starting with the circuit breaker settings (Fig.8). The data should be available from nameplate and manufacturer data sheets.

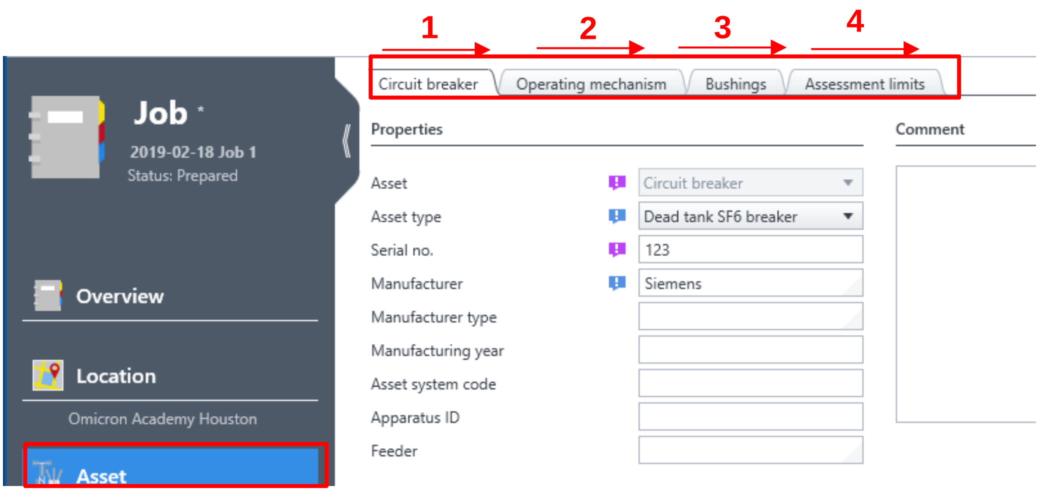



Figure 7: Asset Information Example

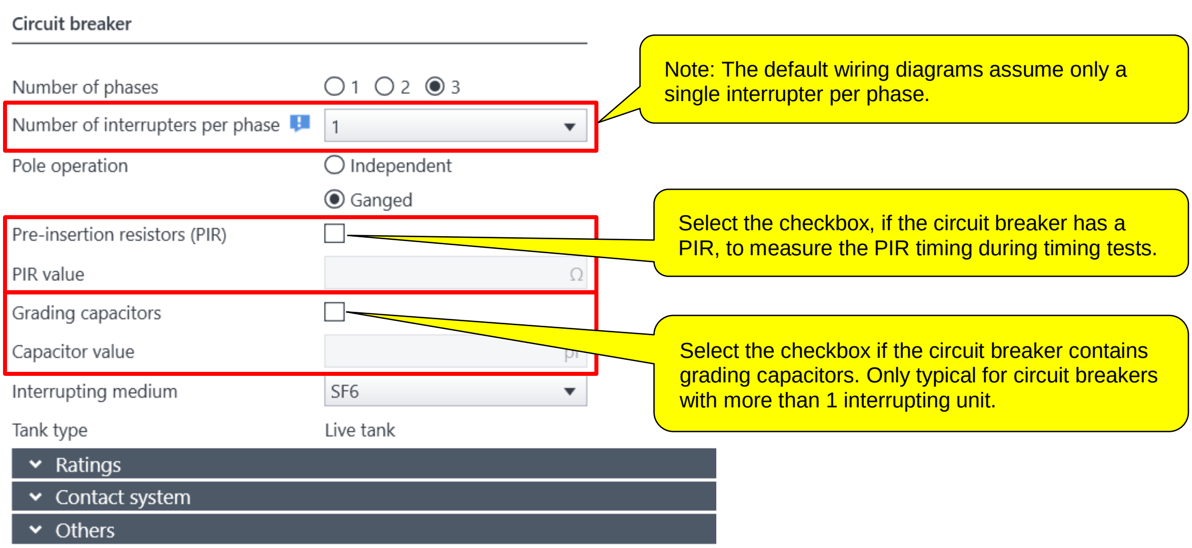



Figure 8: Circuit Breaker Settings

## 5.2 Operating mechanisms

Once the “Circuit Breaker” settings have been completed, we can proceed to the “Operating mechanism” tab. After selecting the “Asset type”, additional settings will appear in the “Operating mechanism” tab (Fig.9)

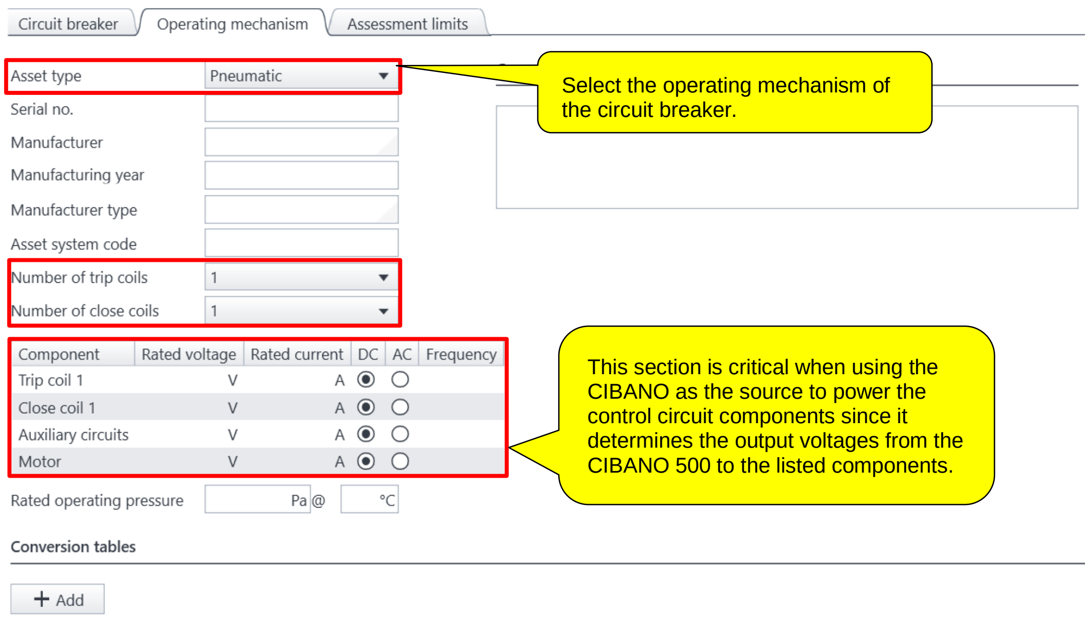



Figure 9: Operating Mechanism Settings

## 5.3 Bushings

If the circuit breaker has bushings that you would like to test, please click the “Bushings” tab (highlighted in Figure 10) to begin populating the nameplate information of the bushings. Otherwise, proceed to the next section. Note, the CIBANO 500 does not currently support testing of bushings.

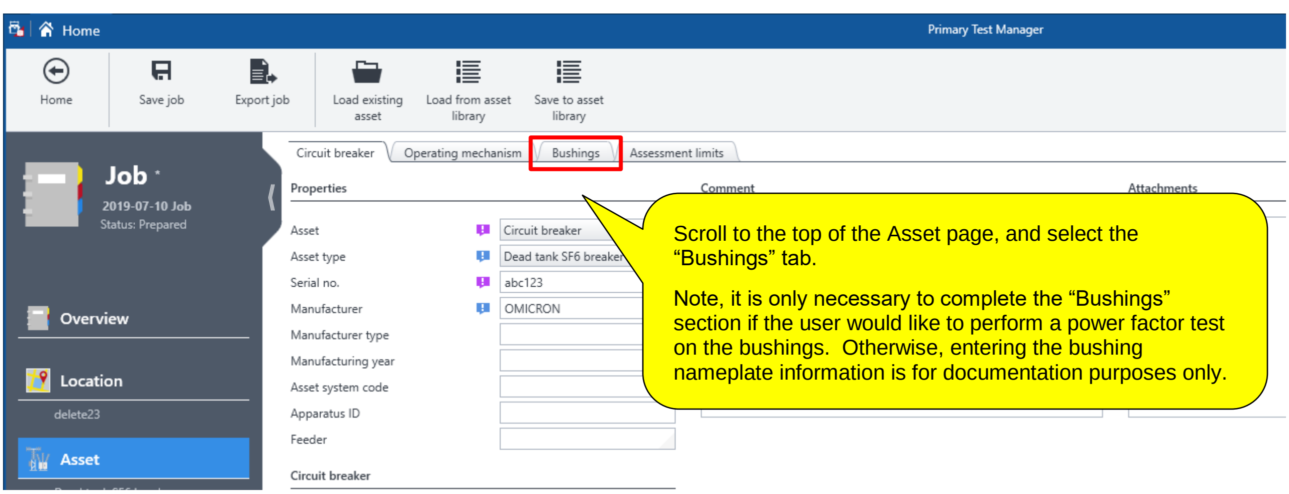



Figure 10: Asset- Four Main Tabs

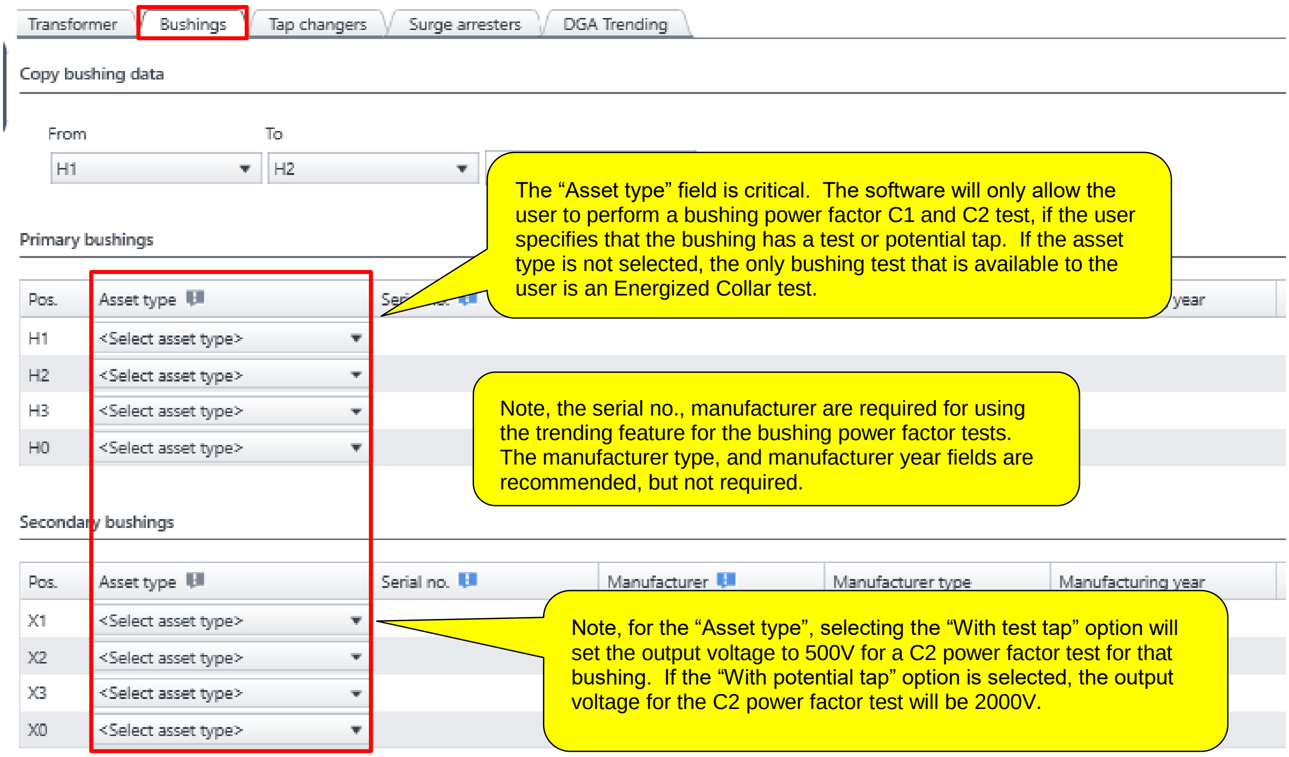



Figure 11: Bushing Nameplate- Part 1

Next, scroll to the right to view more bushing nameplate fields, as shown in Figure 12.

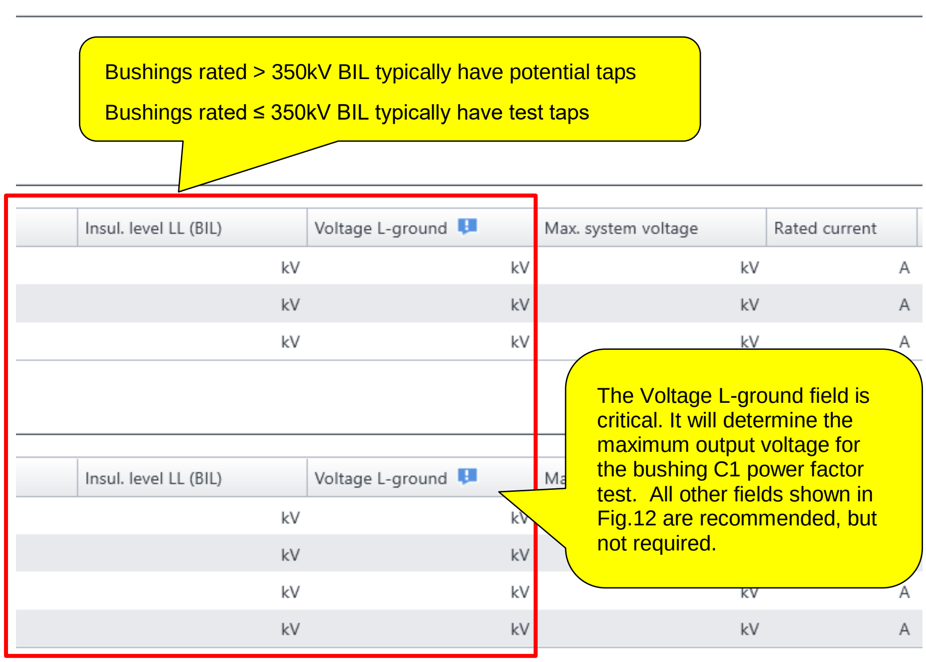



Figure 12: Bushing Nameplate- Part 2

Finally, scroll to the right to view the remaining bushing nameplate fields, as shown in Figure 13.

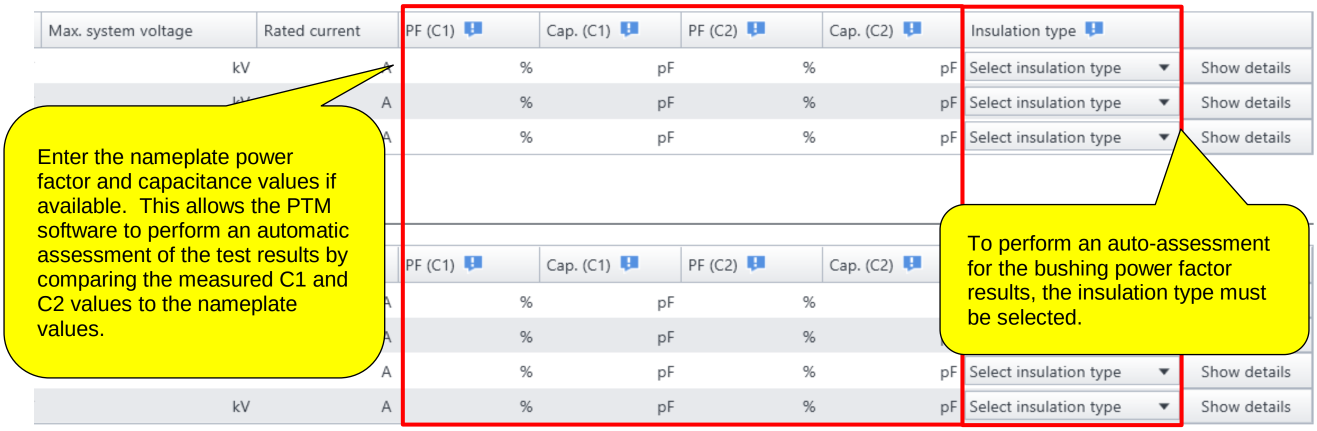
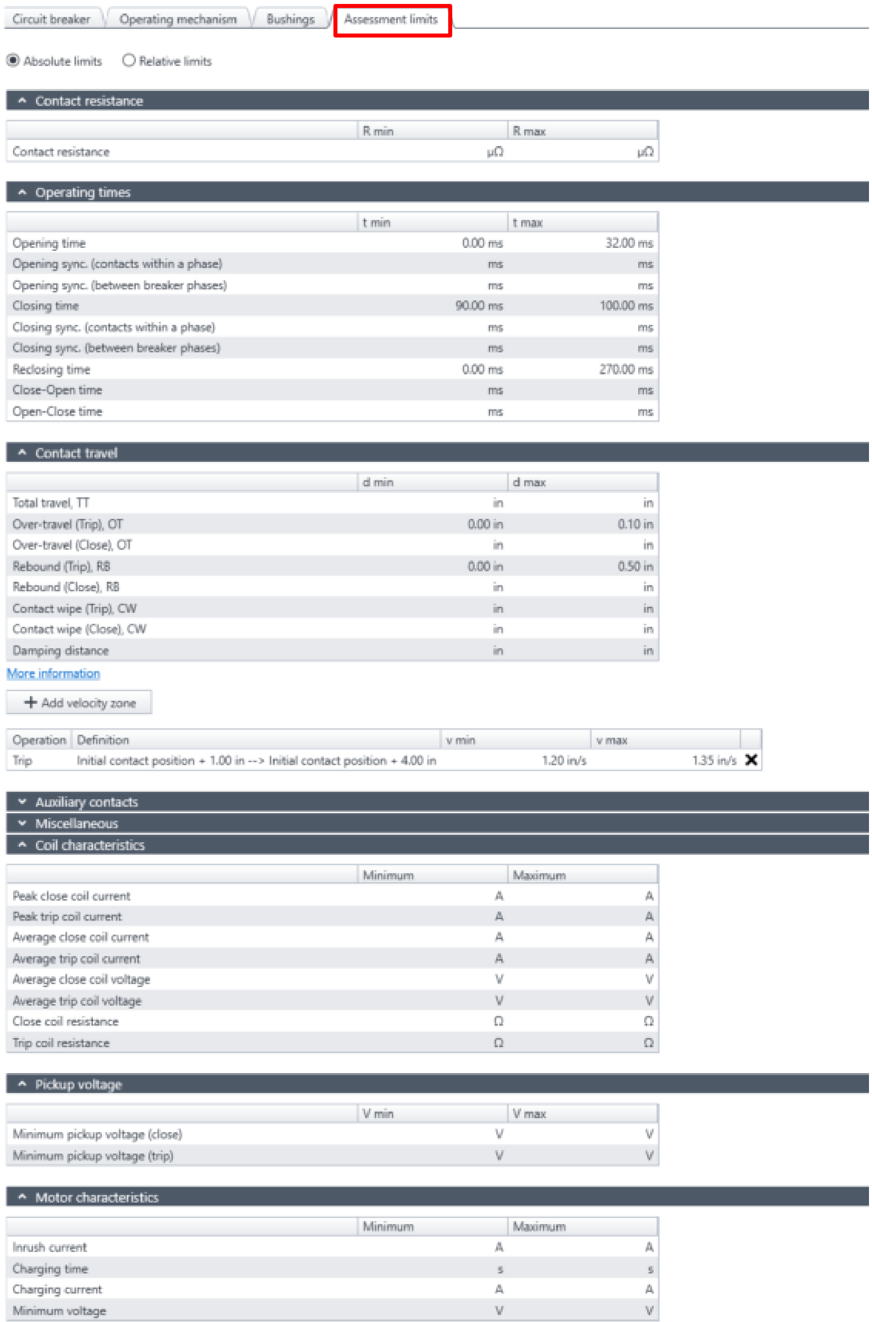



Figure 13: Bushing Nameplate- Part 3

## 5.4 Assessment Limits

The assessment limits (Fig.14) define the pass/fail criteria for the circuit breaker tests. This should be taken from the manufacturer specifications. If no limits are entered then PTM cannot assess a test as pass or fail. These values are transferred automatically to the individual tests, and can also be edited in the individual test tabs. Editing in the individual test tabs does not affect the values entered in the “Asset settings” section.



Circuit breaker | Operating mechanism | Bushings | Assessment limits

Absolute limits | Relative limits

Contact resistance

| | R min | R max |
|---|---|---|
| Contact resistance | µΩ | µΩ |

Operating times

| | t min | t max |
|---|---|---|
| Opening time | 0.00 ms | 32.00 ms |
| Opening sync. (contacts within a phase) | ms | ms |
| Opening sync. (between breaker phases) | ms | ms |
| Closing time | 90.00 ms | 100.00 ms |
| Closing sync. (contacts within a phase) | ms | ms |
| Closing sync. (between breaker phases) | ms | ms |
| Reclosing time | 0.00 ms | 270.00 ms |
| Close-Open time | ms | ms |
| Open-Close time | ms | ms |

Contact travel

| | d min | d max |
|---|---|---|
| Total travel, TT | in | in |
| Over-travel (Trip), OT | 0.00 in | 0.10 in |
| Over-travel (Close), OT | in | in |
| Rebound (Trip), RB | 0.00 in | 0.50 in |
| Rebound (Close), RB | in | in |
| Contact wipe (Trip), CW | in | in |
| Contact wipe (Close), CW | in | in |
| Damping distance | in | in |

More information

+ Add velocity zone

| Operation | Definition | v min | v max |
|---|---|---|---|
| Trip | Initial contact position + 1.00 in --> Initial contact position + 4.00 in | 1.20 in/s | 1.35 in/s |

Auxiliary contacts

Miscellaneous

Coil characteristics

| | Minimum | Maximum |
|---|---|---|
| Peak close coil current | A | A |
| Peak trip coil current | A | A |
| Average close coil current | A | A |
| Average trip coil current | A | A |
| Average close coil voltage | V | V |
| Average trip coil voltage | V | V |
| Close coil resistance | Ω | Ω |
| Trip coil resistance | Ω | Ω |

Pickup voltage

| | V min | V max |
|---|---|---|
| Minimum pickup voltage (close) | V | V |
| Minimum pickup voltage (trip) | V | V |

Motor characteristics

| | Minimum | Maximum |
|---|---|---|
| Inrush current | A | A |
| Charging time | s | s |
| Charging current | A | A |
| Minimum voltage | V | V |

Figure 14: Assessment limits

# 6 Test Plan Creation

Once all the information has been entered, click the "Tests" tab located on the left panel of the PTM software. Once the "Tests" tab is selected, the PTM software will automatically generate the "recommended" test plan, based on the nameplate information that was entered in the "Asset" section. Please populate the test plan by following the guidelines provided in Figure 15.

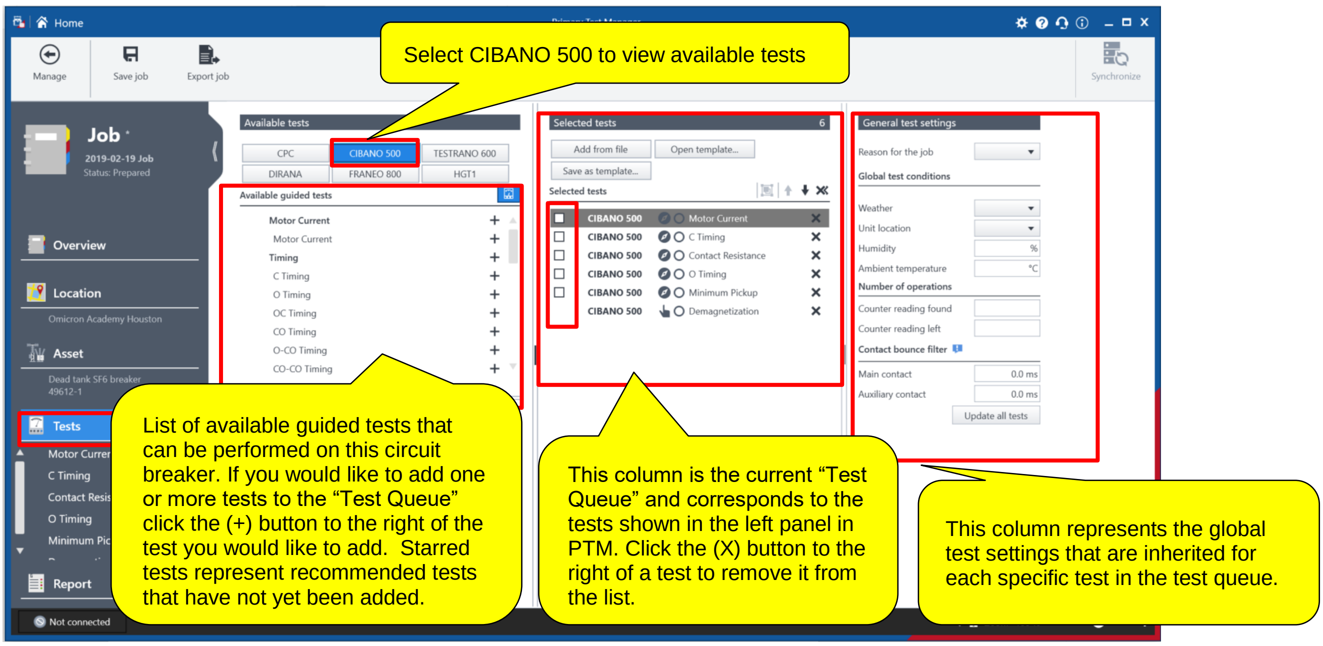



Figure 15: Test Section

Once the test plan has been created, we can begin testing. The following test settings assume the tests are individually run and not grouped together. Use the left panel of PTM to select which test you would like to perform first. Note, the tests can be performed in any order you would like. In addition, you can add more tests to the "Test Queue" at any time by clicking on the "Tests" tab and populating the desired tests.

# 7 Control Circuit Wiring Examples for Timing, Travel, and Minimum Pickup Tests

The timing/travel and minimum pickup tests require access to the control circuit of the circuit breaker with the CIBANO 500. Control circuit schemes can vary depending on the manufacturer. The following examples show to connect the CIBANO 500 to the control devices for a particular circuit breaker control panel when using the CIBANO 500 as the power source for all components. Note, an external source can be used (battery supply) but this is not covered in this guide.

**NOTICE**

**Safety Practice**

- Prior to connecting the CIBANO 500 test leads to the control circuit, open the knife switches that power the positive and negative rails of the control circuit. This ensures there is no potential at the terminals the user will connect leads to.
- Once the CIBANO 500 test leads are “landed”, the user can attempt to test/operate the breaker with the knife switches open.
- The knife switches can be closed after the CIBANO 500 leads have been removed from the control circuit.
- **Note**, some cases require the knife switches to be closed to power other components in the circuit for circuit breaker operation. If the circuit breaker does not operate for this reason, the knife switches may need to be closed and the test performed again. Study the connection plan well to ensure this is possible. Once the testing is complete and before the test leads are removed from the control circuit, open the knife switches that power the positive and negative rails of the control circuit. This ensures there is no potential at the terminals the user will remove the leads from.

**NOTICE**

**Common Practice**

- For many circuit breaker schemes, the Trip lead (B1) is connected to terminal 9, the Close lead to terminal 7, and the Neutral lead (BN) to the negative rail of the control circuit.
- Note, sometimes the negative rail of the Trip Coil and the negative rail of the Close Coil must be manually short-circuited together. The same may apply to the motor circuit. Study the connection plan and make sure this is possible, otherwise connect to each component separately to perform the individual tests.

### Close Coil Example

Connecting to the close coil in the control circuit will allow us to power the close coil via the CIBANO 500 and remotely operate the circuit breaker for all the applicable tests.

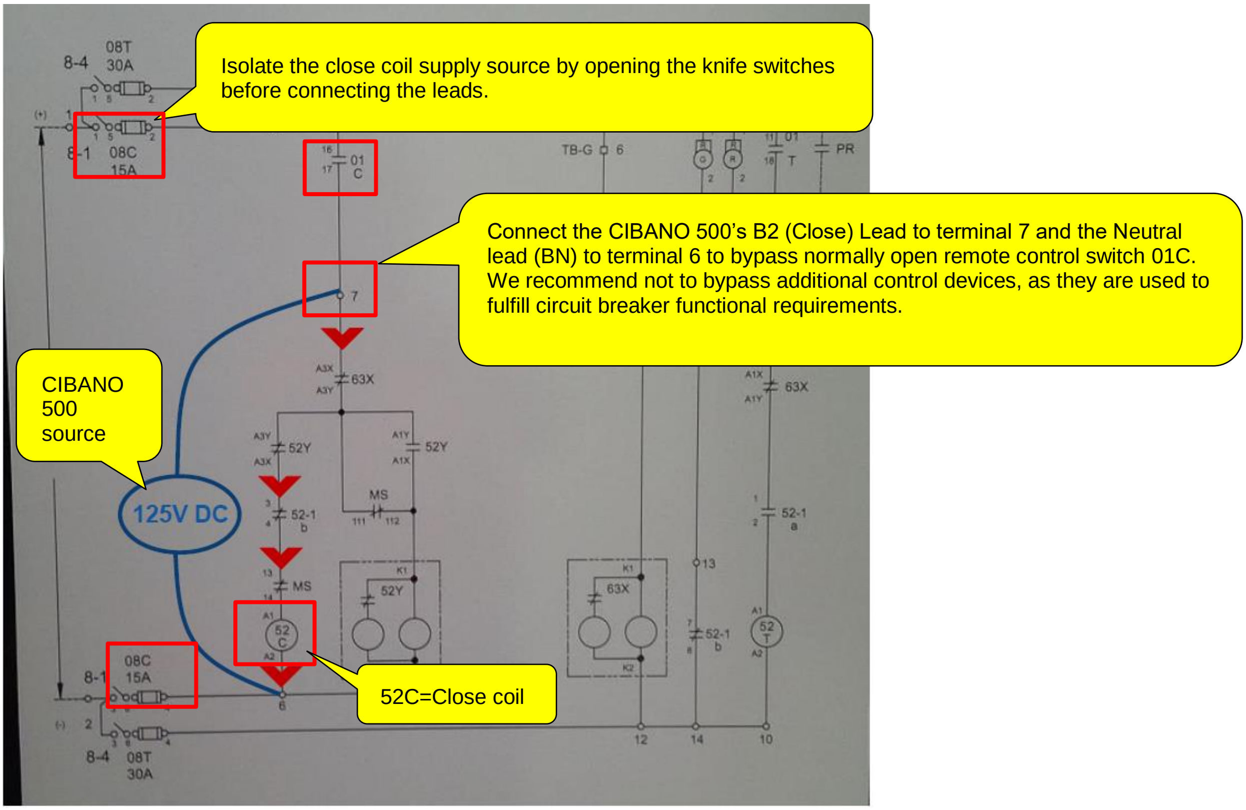



Figure 16: Example connection of CIBANO 500 outputs to Close coil

### Trip Coil Example

Connecting to the trip coil in the control circuit will allow us to power the trip coil via the CIBANO 500 and remotely operate the circuit breaker for all the applicable tests.

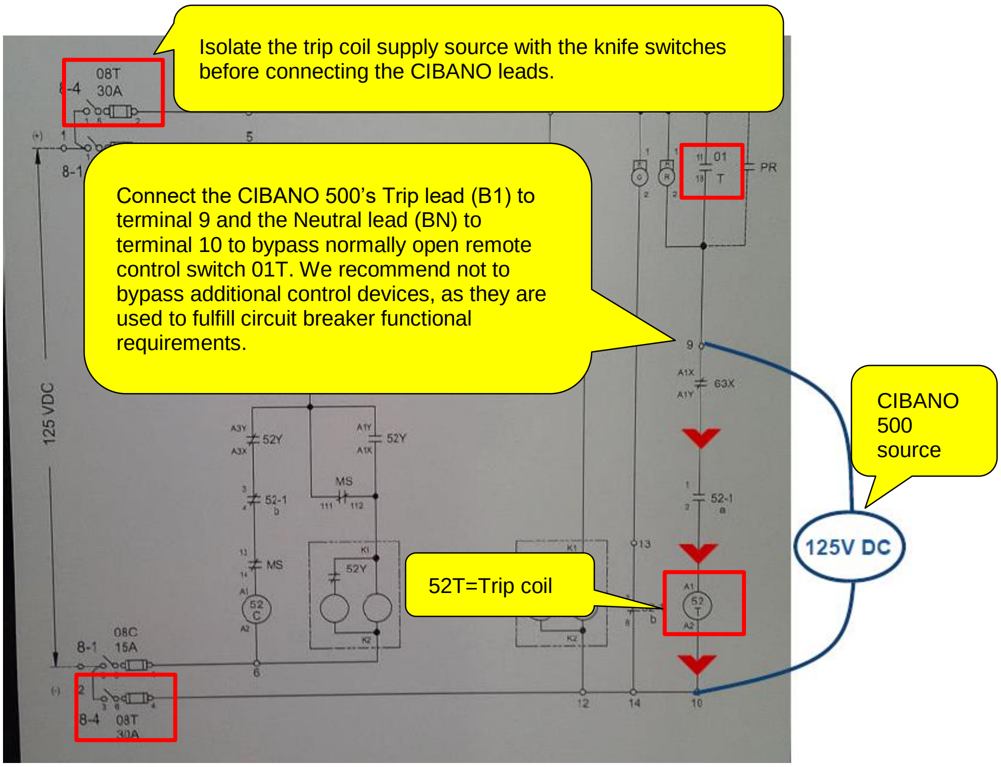



Figure 17: Example connection of CIBANO 500 Outputs to trip coil

### Motor Example

Connecting to the motor in the control circuit will allow us to power the motor via the CIBANO 500 and measure the current for the motor current test.

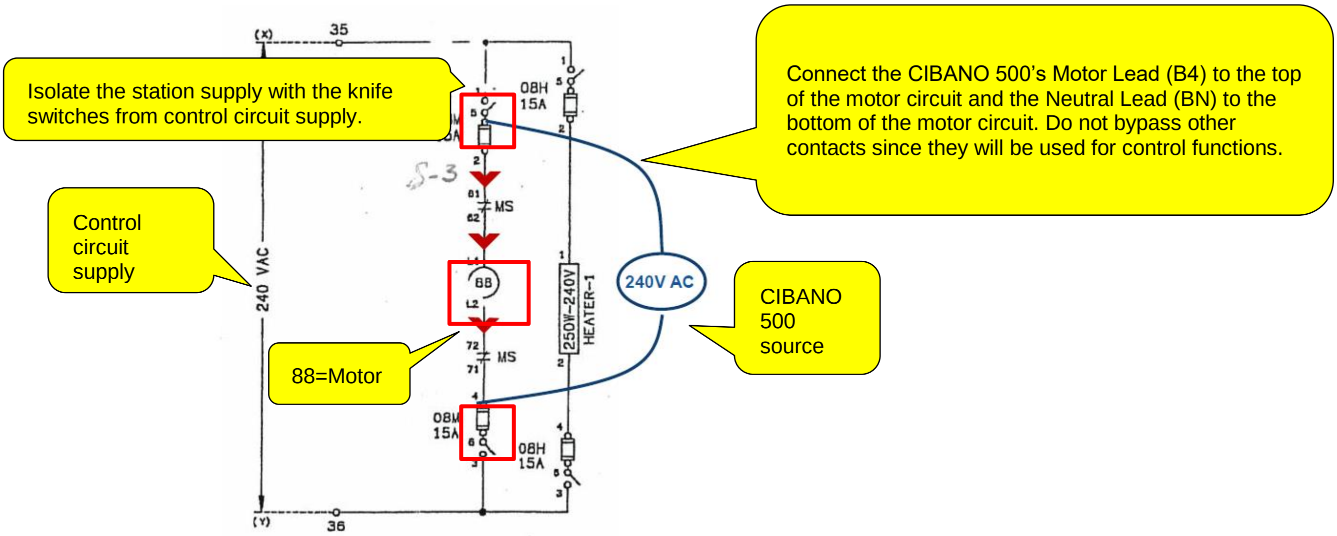



Figure 18: Example connection to motor

### Auxiliary Contacts Example

The auxiliary contacts protect the command coils from being energized too long by blocking the command signal. The 52a auxiliary contact is in series with trip coil and follows the state of the main circuit breaker contacts while the 52b is in series with the close coil and follows the opposite state of main contacts.

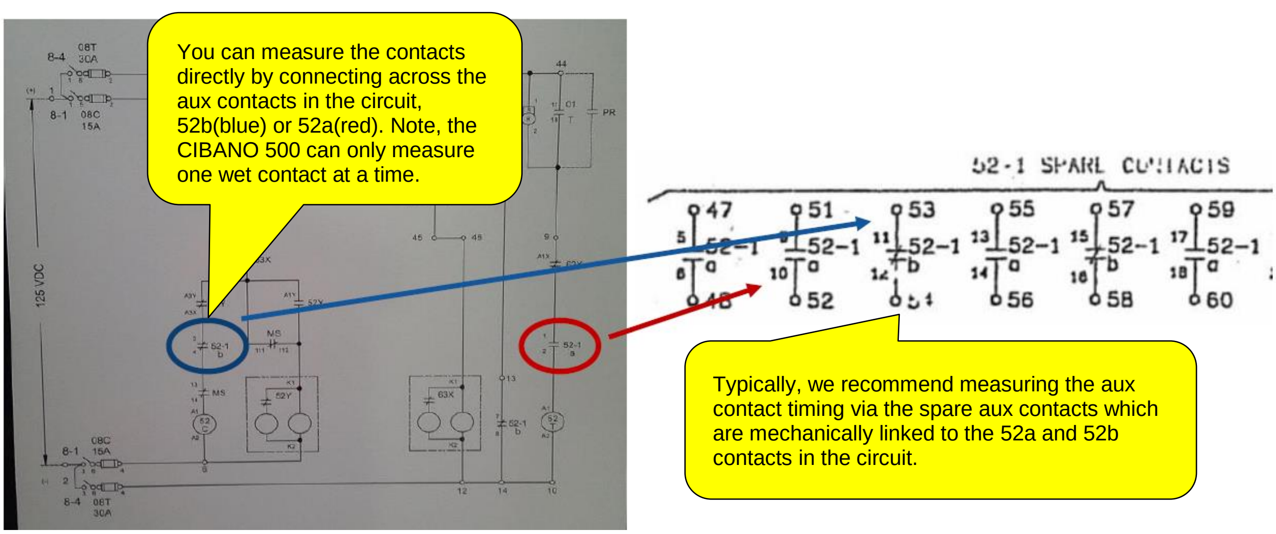



Figure 19: Example Connection of CIBANO 500 Outputs to Auxiliary contacts

# 8 Tests

## 8.1 Motor Current

The motor current test verifies the performance of the charging motor which makes up the operating mechanism. Mechanical issues such as lubrication can be identified.

Test Preparation

- Note, the following setup assumes the CIBANO will be used as the supply source and the default hardware configuration and wiring will be used.
- Please consider the wiring examples and safety precautions in Section 7: “Control Circuit Wiring for Timing, Travel, and Minimum Pickup Tests” when connecting the CIBANO leads to the control circuit.

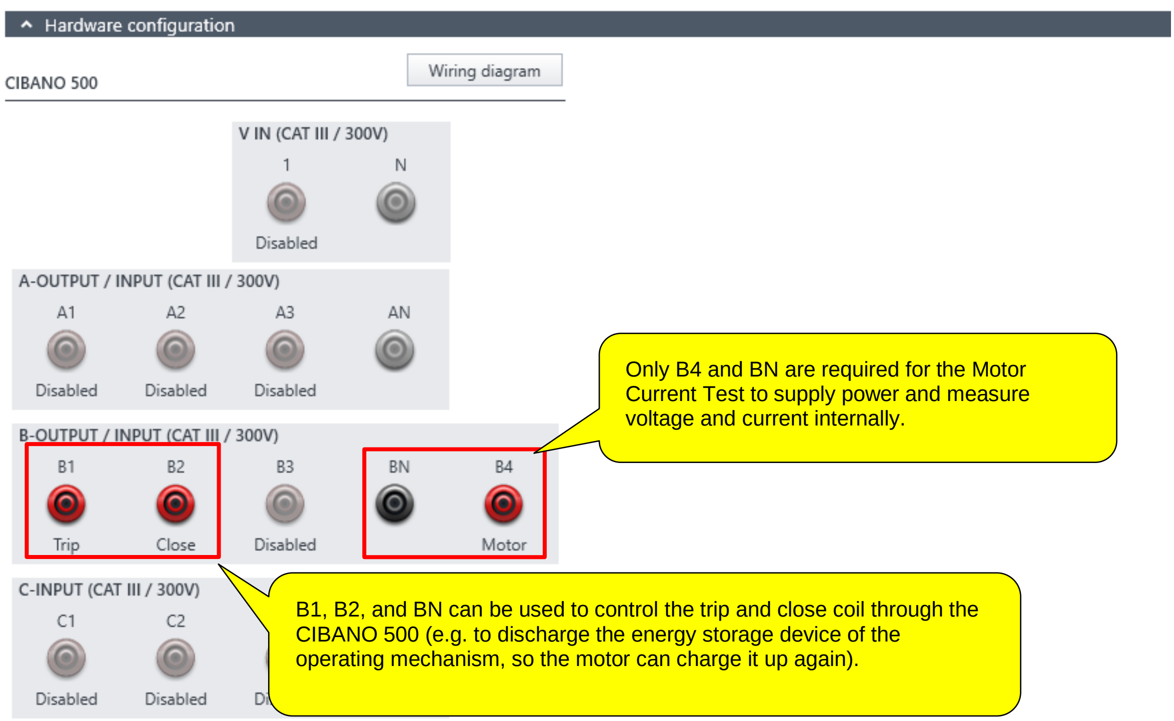



Figure 20: Default Hardware configuration for single motor

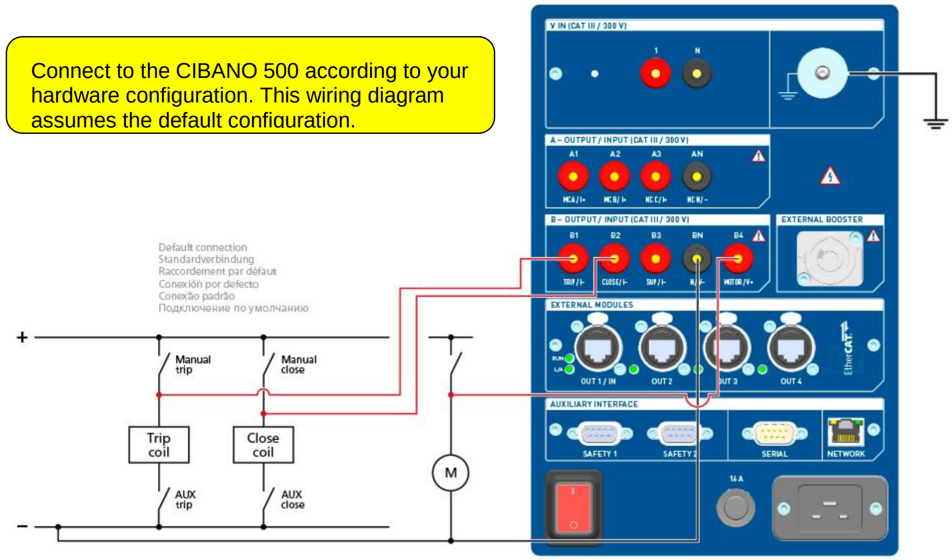



Figure 21: Wiring Diagram of Motor Current Test

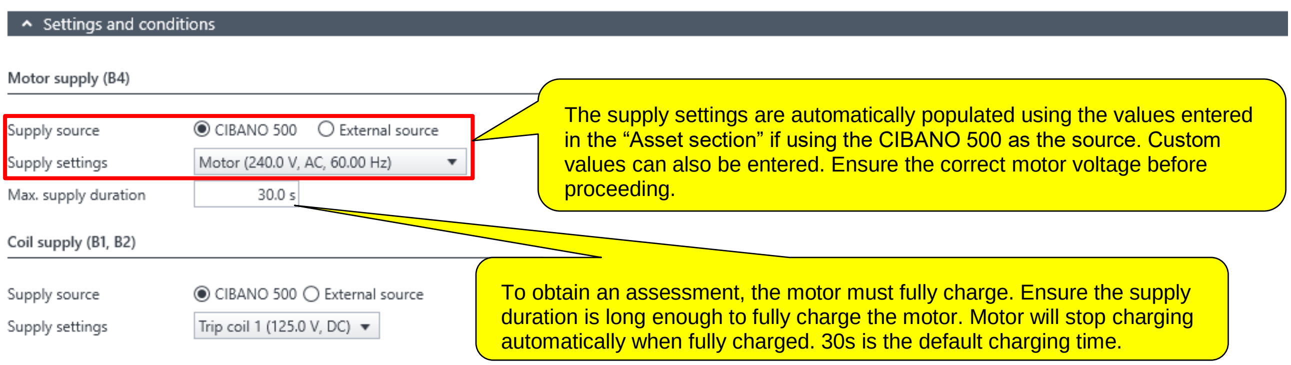



Figure 22: Settings and Conditions Section - Motor Current Test

## NOTICE

### Enabling Assessments

- If the assessment section is completed, PTM can assess the measurement as pass or fail according to the motor characteristics (fig.23)

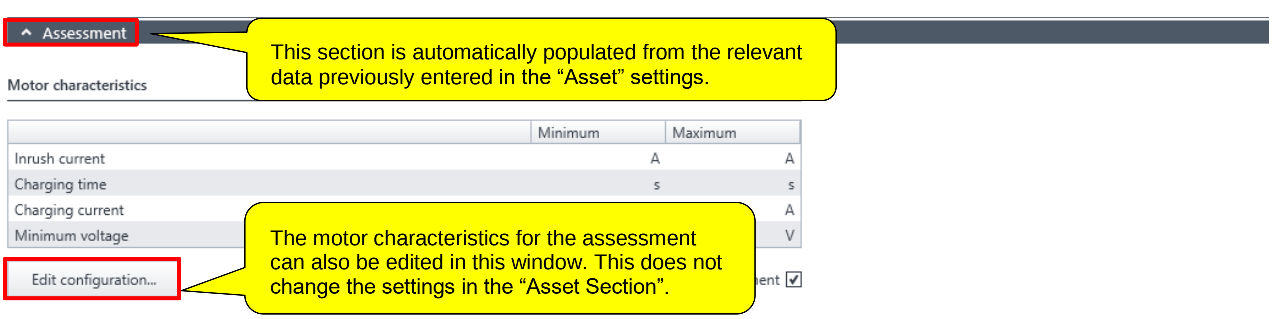



Figure 23: Assessment Section - Motor Current Test

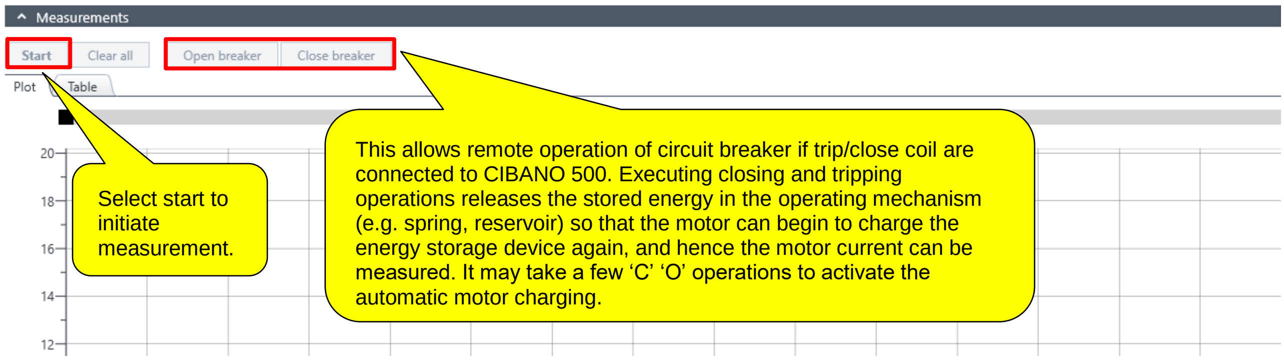



Figure 24: Measurement Section - Motor Current Test

Once the motor automatically stops charging, numerical results along with a plot of the motor current and voltage will be available (Fig. 25 & 26). The plot pattern of the motor current varies depending on the driving mechanism that charges the stored energy device. If the test is stopped prematurely, numerical results and assessment shown in Fig.25 and 26 will not be available. In the measurement section, we can visually assess the motor current by comparing the shape to a previous measurement.

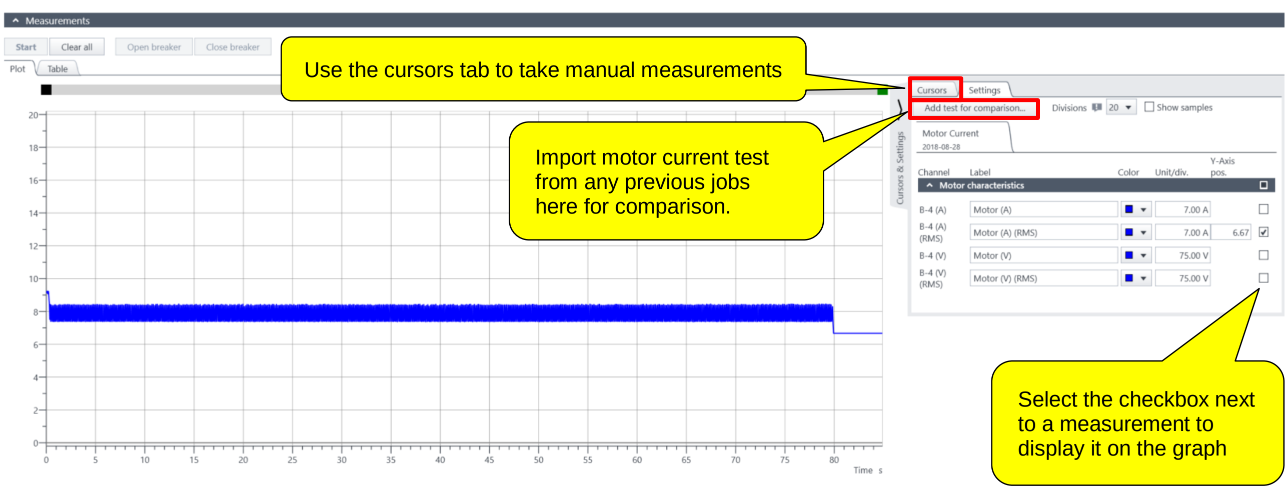



Figure 25: Measurements Results - Motor Current Test

The pass/fail assessment on motor current is based on the limits entered in the assesment section which is populated automatically by the data entered in the "Asset" settings.

Motor characteristics

| | Inrush current | Charging time | Charging current | Minimum voltage | Assessment |
|---|---|---|---|---|---|
| Motor | 22.77 A | 79.90 s | 7.67 A (RMS) | 154.67 V (RMS) | Pass |

Figure 26: Measurements Table - Motor Current Test

## 8.2 Timing Tests

The timing tests helps assess the integrity of the kinematic chain. Recording main contact and auxiliary contact state, command coil currents, and travel distance of circuit breaker contacts can help in assessing all circuit breaker components which are mechanically linked together.

Test Preparation

- Note, the following setup assumes the CIBANO will be used as the supply source and the default hardware configuration and wiring will be used.
- Please consider the wiring examples and safety precautions in Section 7: “Control Circuit Wiring for Timing, Travel, and Minimum Pickup Tests” when connecting the CIBANO leads to the control circuit.

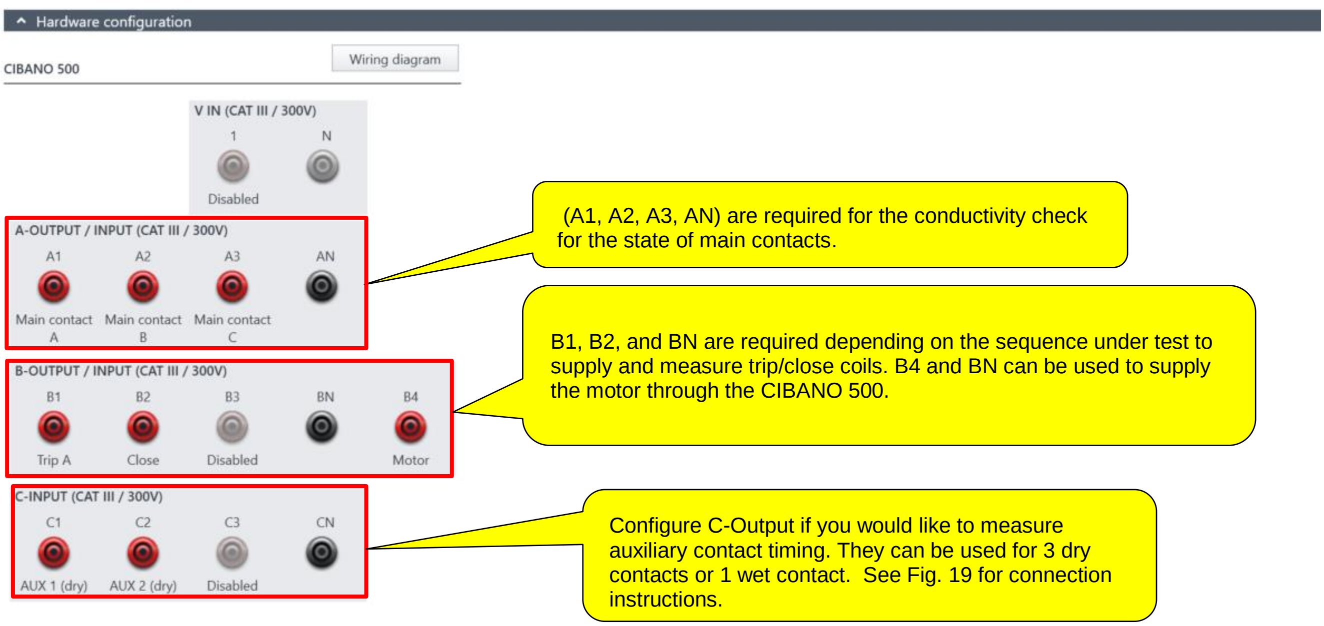



Figure 27: Default Hardware Configuration – Timing Test

If you are also interested in travel measurements, see pg. 30 for the additional configuration and settings required.

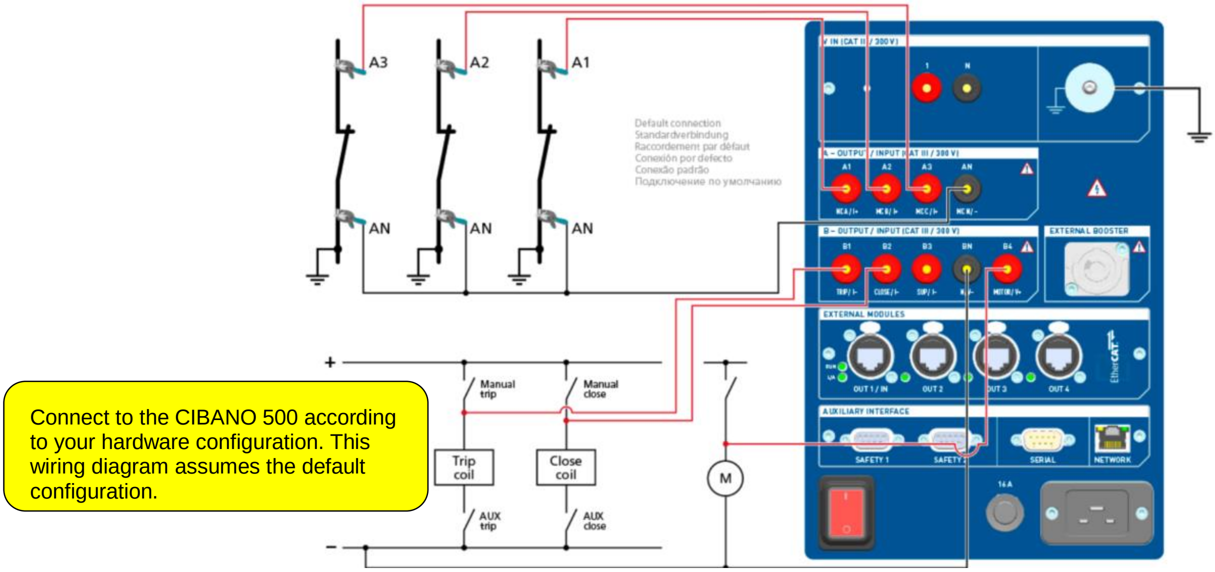



Figure 28: Timing Wiring Diagram

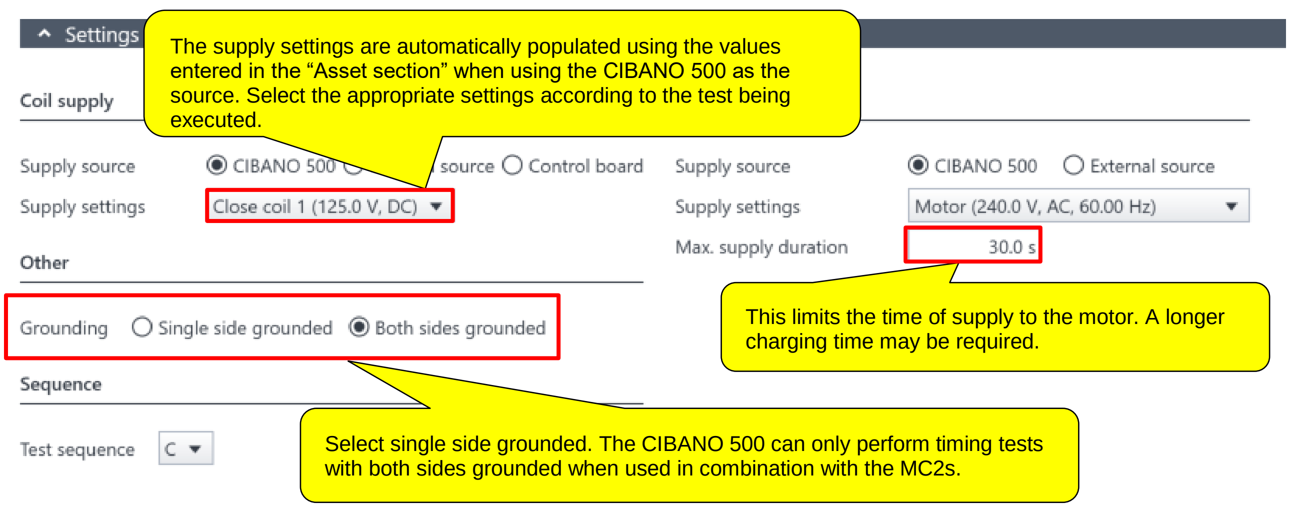



Figure 29: Settings and Conditions – Timing Test

In the "Advanced settings", the test sequences can be edited (Fig.30). The typical timing command signals are shown in figures 31-34. Select the appropriate sequence depending on the test to be executed.

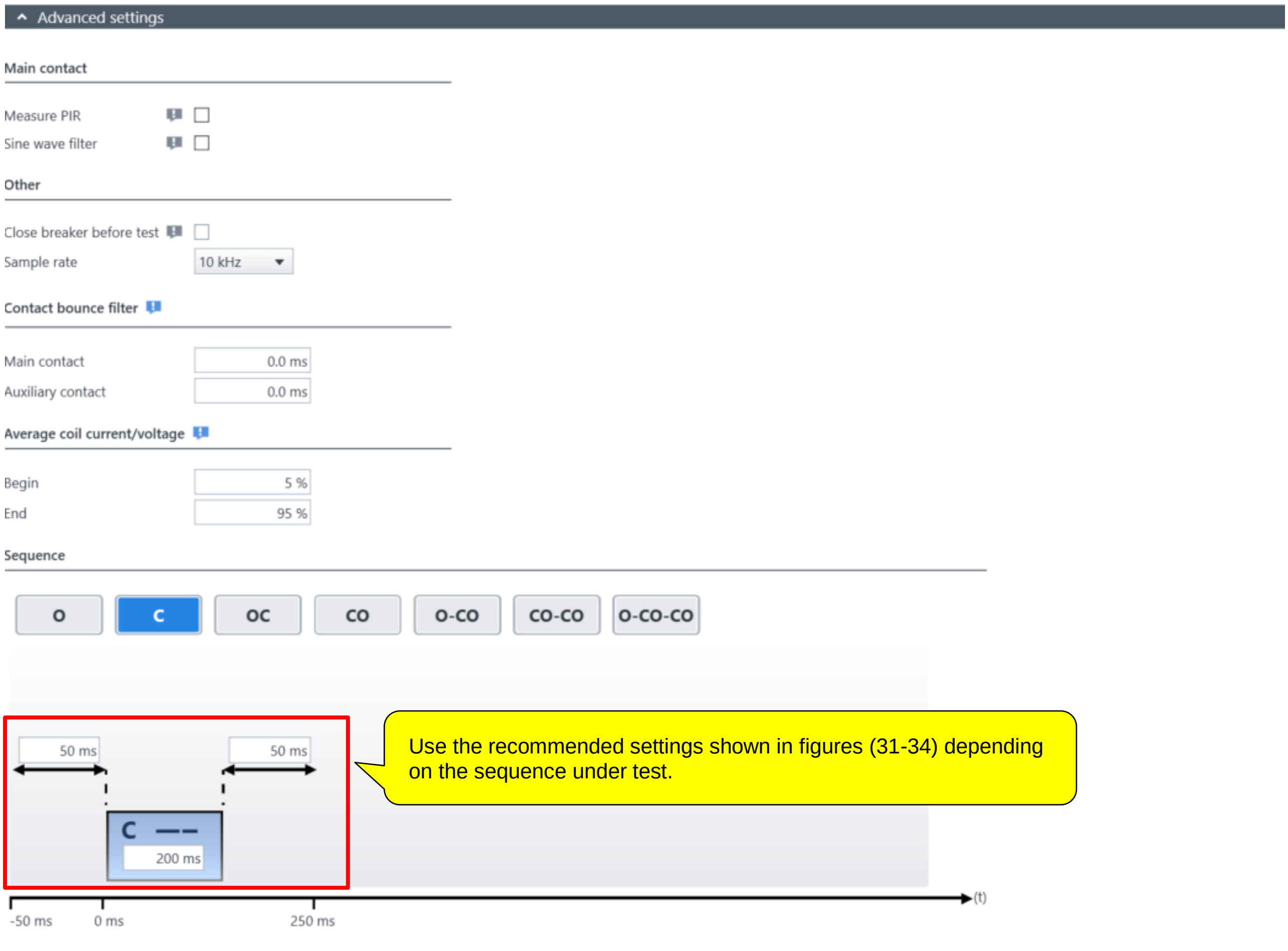



Figure 30: Advanced Settings – Timing Test

The recommended settings for the sequences are depicted below. These are typical control signal timing values used in performing the timing test.

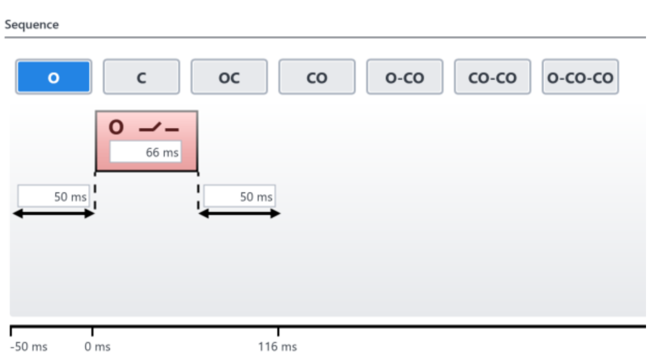



Figure 31: Open Test (O) Sequence Setting

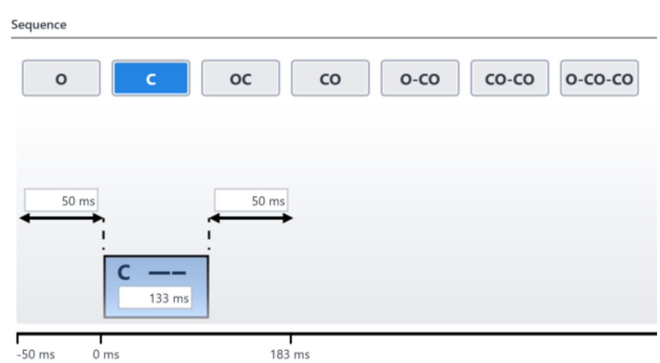



Figure 32: Close Test (C) Sequence Setting

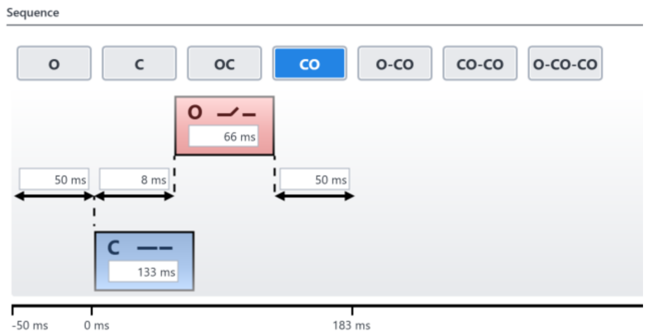



Figure 33: Trip Free (CO) test Sequence Setting

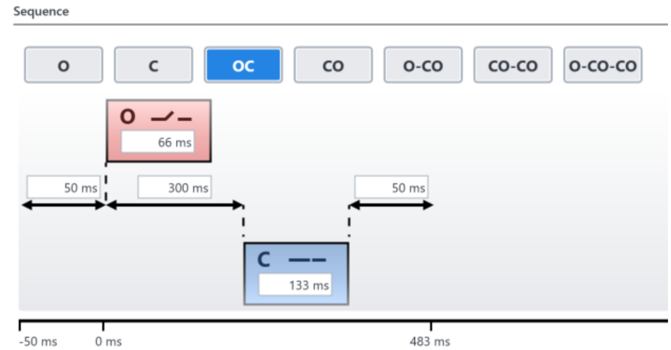



Figure 34: Reclose (OC) Test sequence Setting

**NOTICE**

**Verifying the Anti-Pump circuit**

- The CO sequence can be used to not only test the trip-free functionality (circuit breaker tripping after closed under a fault condition) but also to verify the anti-pump system. To test the anti-pump the circuit breaker must first be open before the test is started. The close command is then sent, and during the close operation an open command is sent opening the circuit breaker as fast as possible (fig.33). Due to the open time being shorter than the closing time, the close command will still be on after the open command ends, but the circuit breaker should not "pump", or close again for a successful test.

If the assessment section (Fig.35) is completed, PTM can assess the measurements.

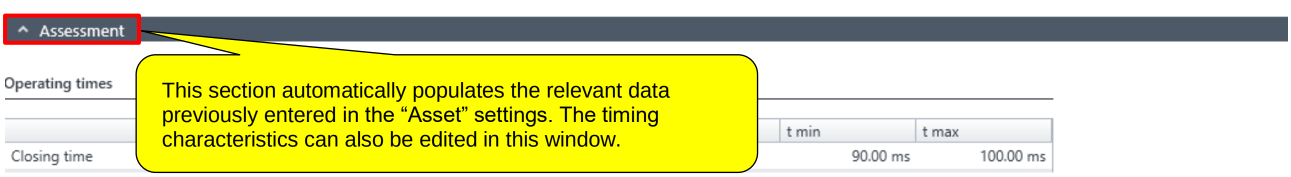



Figure 35: Assessment Section – Timing Test

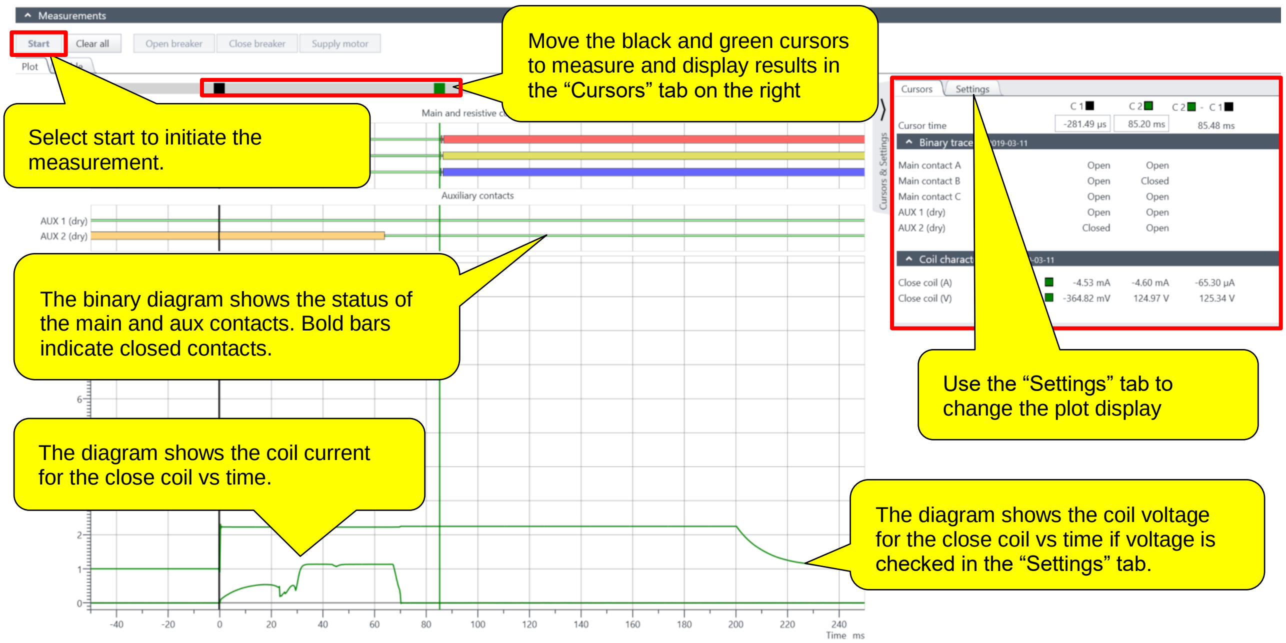



Figure 36: Measurement Section C-Timing Example

The pass/fail assessment (Fig. 37) of the timing values and coil characteristics are based on the limits entered in the assesment section which are populated automatically by the data entered in the "Asset" settings.

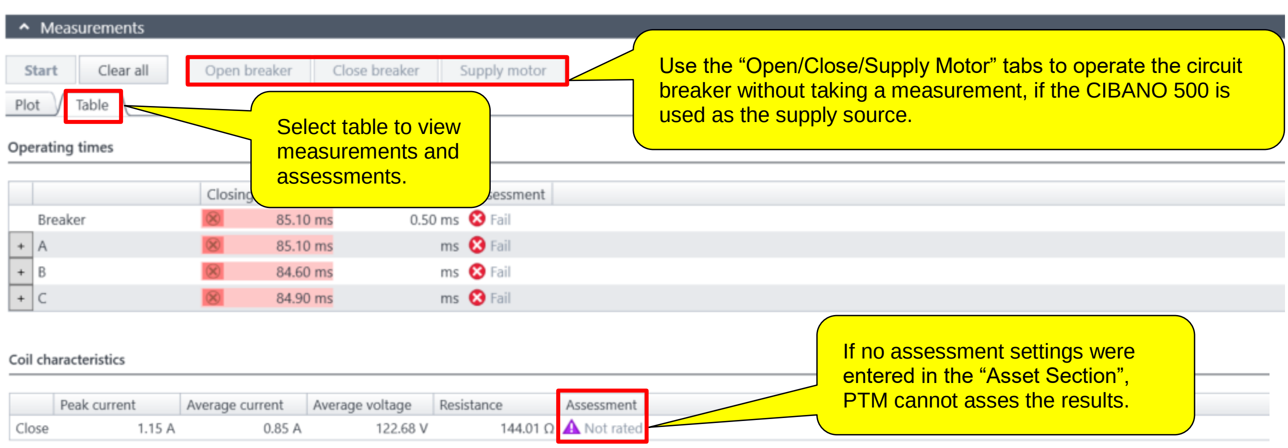



Figure 37: Measurement Table C-Timing Example

## Coil Current

The coil current allows us to test the performance of the control circuit. It helps identify insufficient lubrication (e.g. sticky plunger), assess command coil performance, auxiliary contacts, and latch operation. We can use the plot to visually assess the "Coil Signature" by comparing to a previous measurement as shown below and trending any change over time (Fig.38).


Figure 38: Measurement Section C-Timing Comparison Example

## Under-voltage

The under-voltage test, allows us to test the performance of the control circuit. The timing tests should pass at the minimum voltage designated in the operating voltage range of the trip or close coil (see circuit breaker nameplate for voltage range). To perform this test, repeat the (O) or (C) timing tests at a reduced voltage to check the timing performance with under-voltage. For a visual comparison you can import the previous test using the comparison tool as shown in (Fig.38). An example of the results at different voltages is shown in Fig.39.

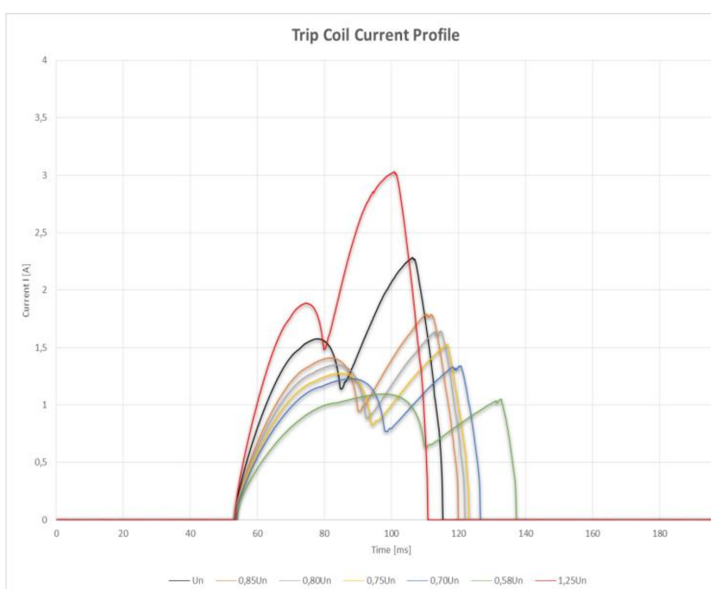



Figure 39: Example of results of under voltage test for Trip Coil

## Travel

The travel measurement helps assess the integrity of the components which are mechanically linked together including the operating mechanism, main contacts, and damping system. The travel measurement is done as part of the timing test but requires the TN3 accessory in addition the CIBANO 500. The TN3 connects to different transducer types mounted on the circuit breaker and interprets/transfers the data to the CIBANO 500. To complete this test, we have to configure the hardware again as shown in fig. 40 for the timing test and connect the TN3 according to the user manual.

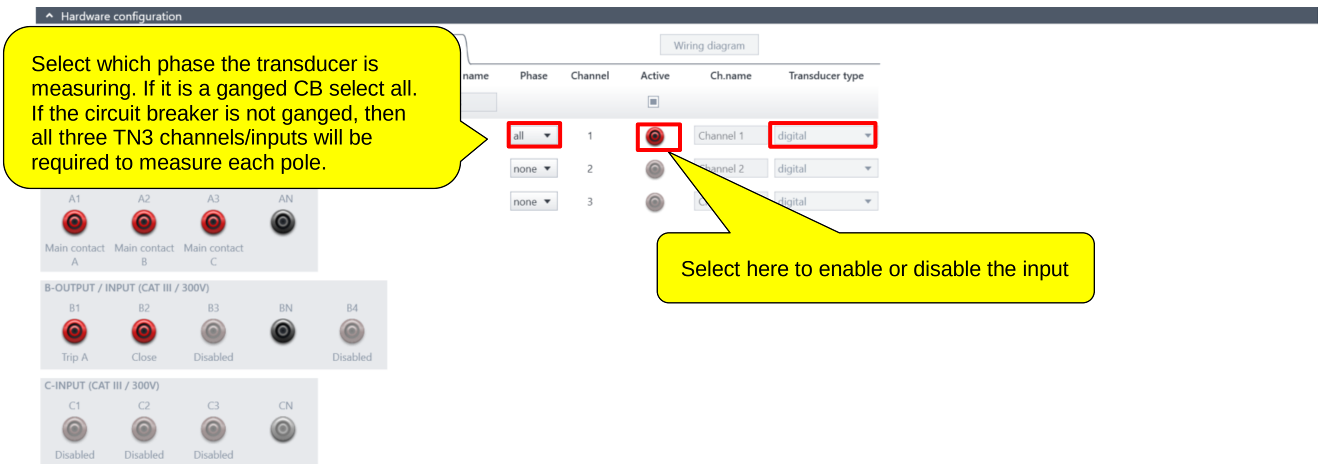



Figure 40: Default CIBANO 500 Hardware Configuration + Example TN3 hardware configuration

In addition, complete additional settings in the “Advanced settings” section.

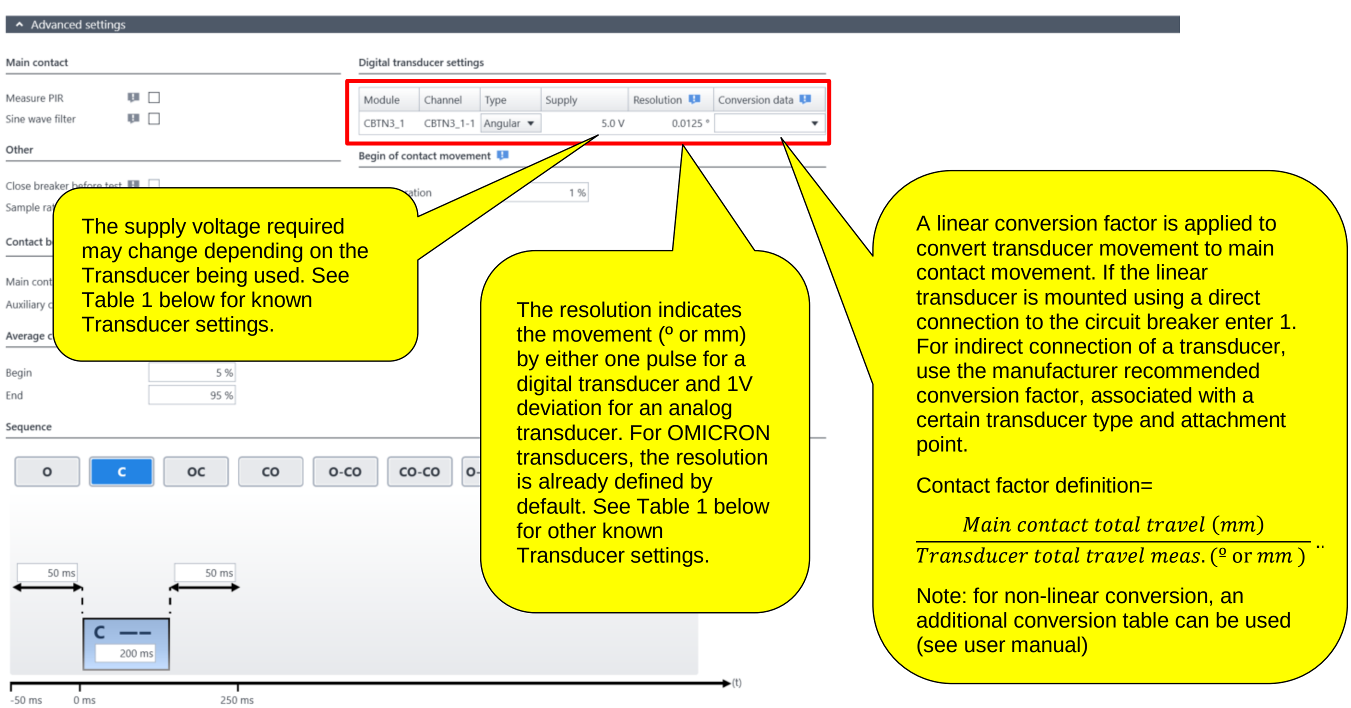



Figure 41: Advanced Settings for Travel Measurement

Table 1: Motion Transducer Settings by Product and Type

| | | Angular | Linear | |
|---|---|---|---|---|
| | **Supply** | **Rotary (°) (Resolution for angular resolution setting)** | **Linear (mil) (Resolution when PTM settings are in inches)** | **Linear (um) (Resolution when PTM settings are in mm)** |
| OMICRON Rotary Transducer | $5\ V_{DC}$ | 0.025 (3600) | - | - |
| OMICRON Digital Linear Dead Tank Transducer 300 mm | $5\ V_{DC}$ | - | 1.9223 | 48.8281 |
| Doble | $5\ V_{DC}$ | 0.1 (4000) | 1.25 | 31.75 |
| Vanguard | $15\ V_{DC}$ | 0.06 (6000) | 1.25 | 31.75 |


Figure 42: Results with travel measurement

In addition to the timing measurements shown in fig.36, the travel measurements shown in fig.42 will be available. The software automatically calculates the travel characteristics and assesses them if assessment limits were available. (Fig. 43). Note the velocity is only calculated if a “velocity zone” is define in the assessment limits.

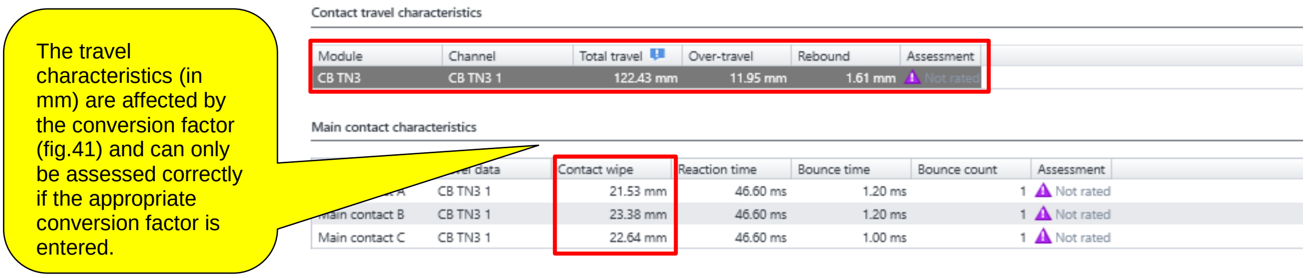



Figure 43: Measurement table C-timing example with travel measurement

## 8.3 Minimum Pick-up

The minimum pick-up test is used to test the performance of the control circuit and can help identify insufficient lubrication (sticky plunger), assess electrical command coil performance, and latch/valve operation.

Test Preparation

- Note, the following test setup assumes the CIBANO will be used as the supply source and the default hardware configuration and wiring will be used.
- Please consider the wiring examples and safety precautions in Section 7: “Control Circuit Wiring for Timing, Travel, and Minimum Pickup Tests” when connecting the CIBANO leads to the control circuit.

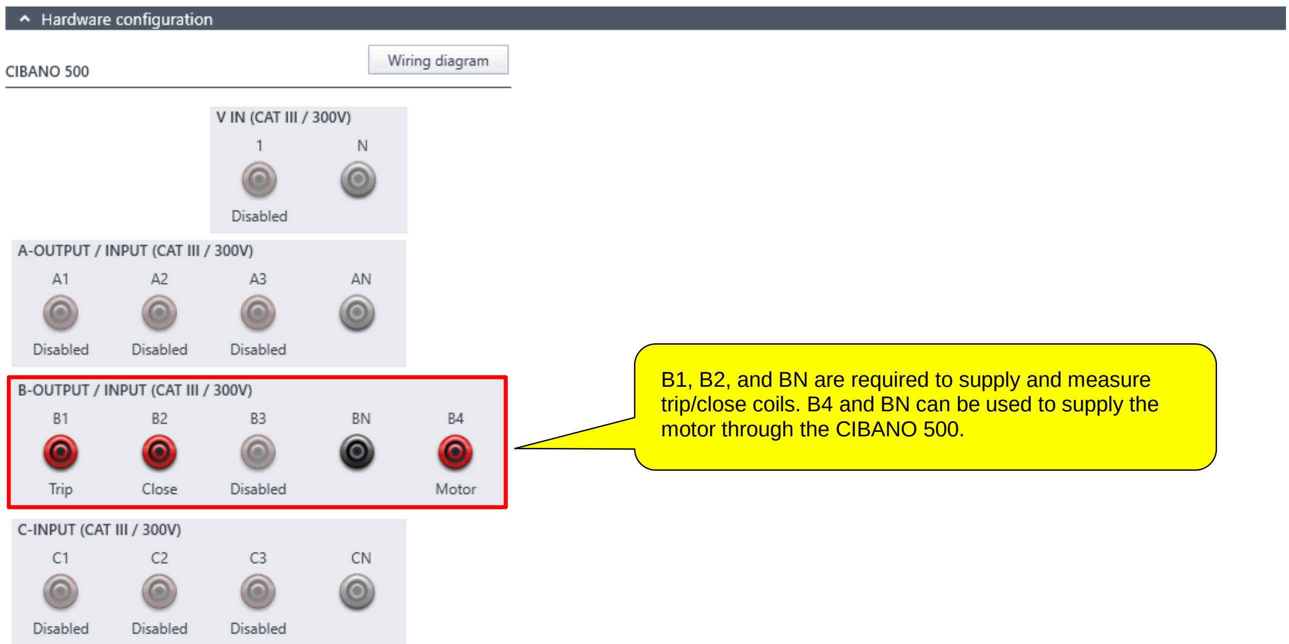



Figure 44: Default Hardware configuration – Minimum Pick-Up Test

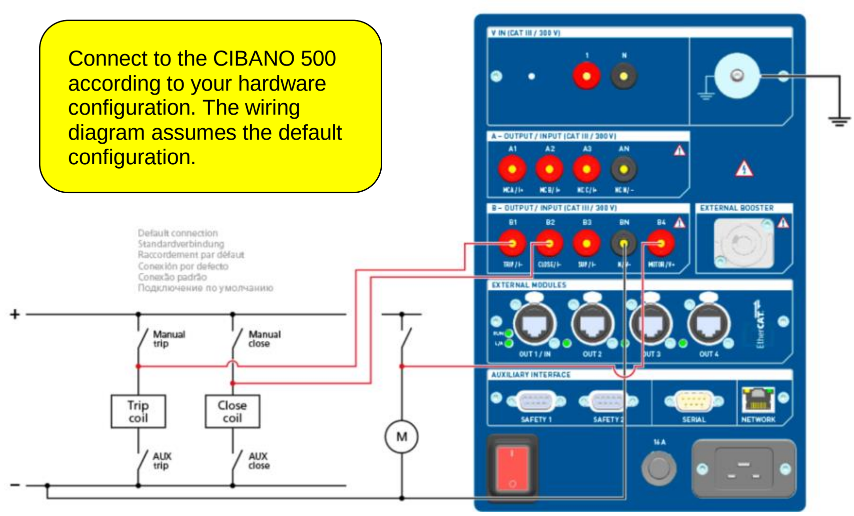



Figure 45: Wiring Diagram – Minimum Pick-Up Test

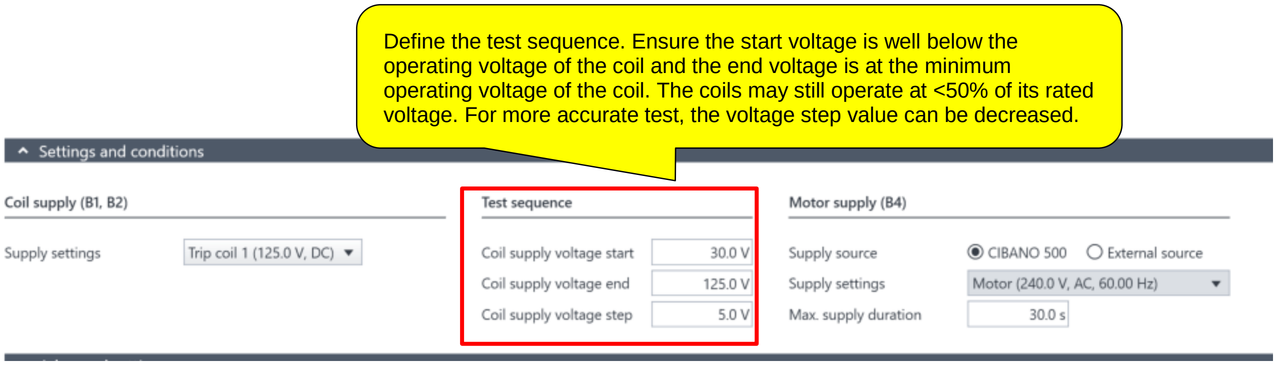



Figure 46: Settings and Conditions – Minimum Pick-Up Test

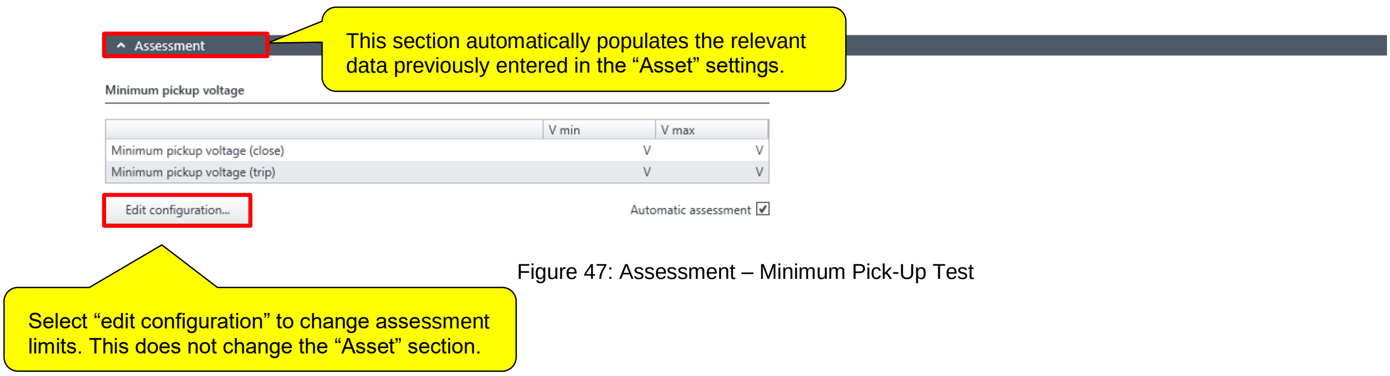



Figure 47: Assessment – Minimum Pick-Up Test

The trip and close operation are run independently in the Measurement section. In addition to the assessment (fig.47), these measurements should be documented and trended over time to identify any abnormal change in voltage.

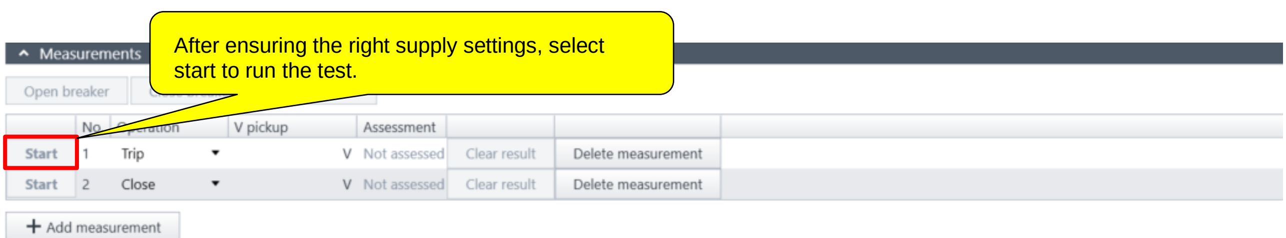



Figure 48: Measurement – Minimum Pick-Up Test

## 8.4 Static Contact Resistance

The contact resistance test identifies issues with the main contacts of the circuit breaker. Failure could indicate improper alignment of contacts, improper pressure on contacts, damaged contact surfaces, or poor bushing connections.

Test Preparation

- Verify that circuit breaker is closed

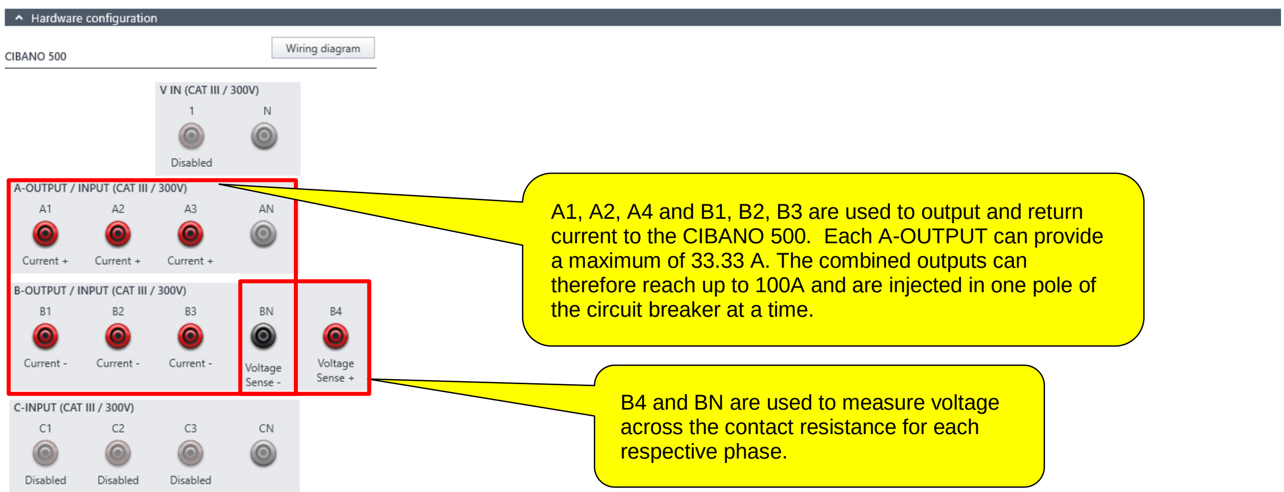



Figure 49: Required Hardware Configuration- Contact Resistance

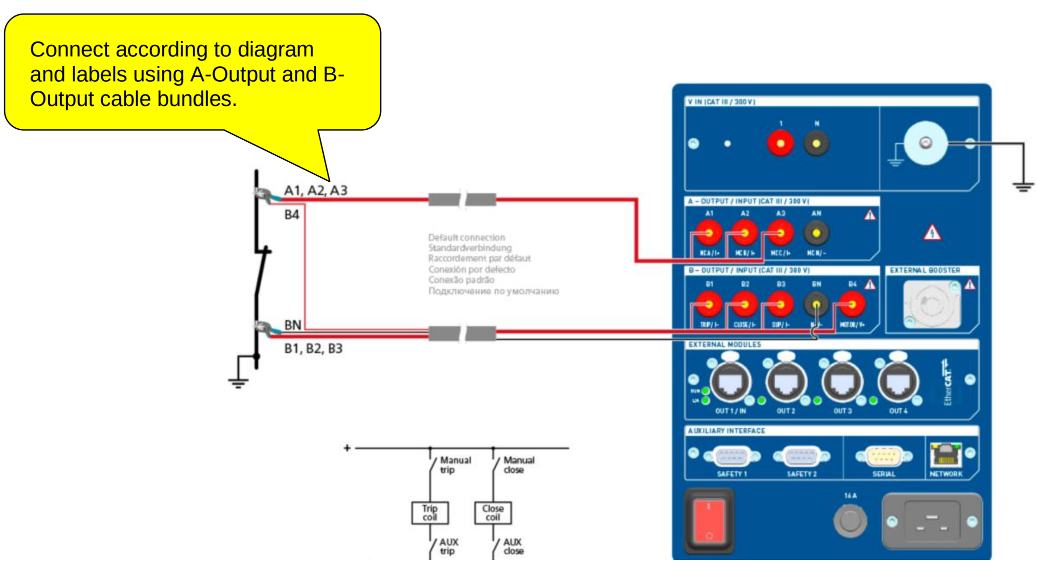



Figure 50: Contact Resistance Wiring

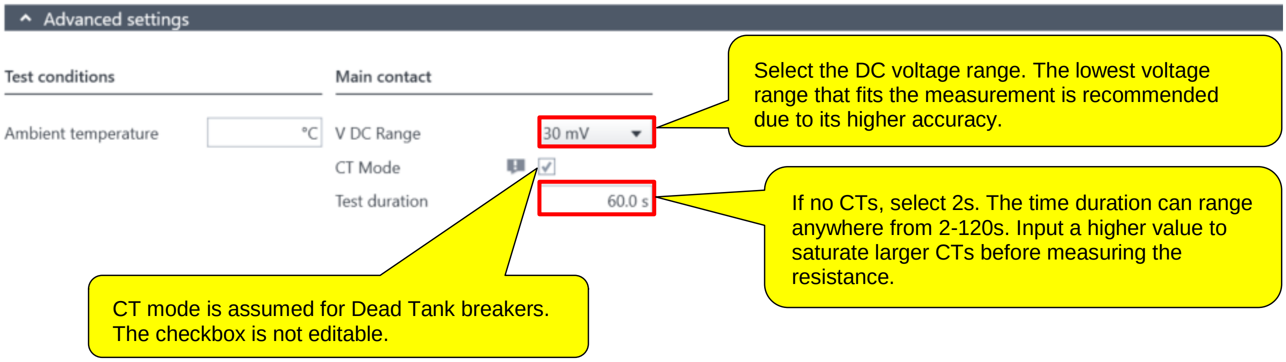



Figure 51: Settings - Contact Resistance

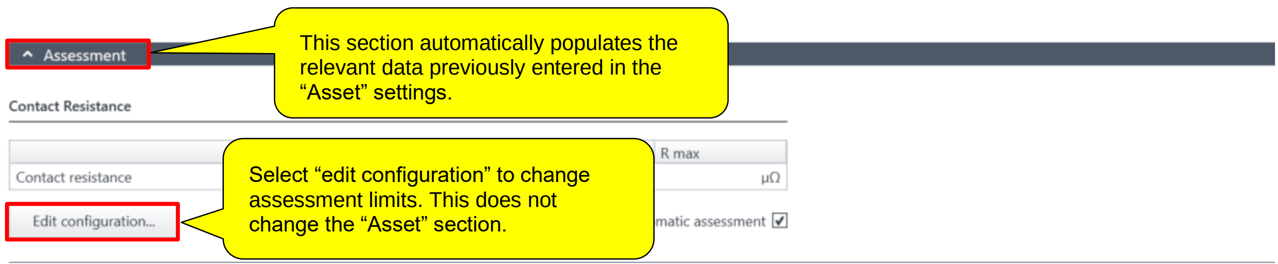



Figure 52: Assessment - Contact Resistance

From the voltage and current measurements, we can calculate the contact resistance. The test will stop automatically after finishing the test. Once the measurement of one pole is completed, move clamps to the next pole and click start in the measurement section until all measurements are complete.

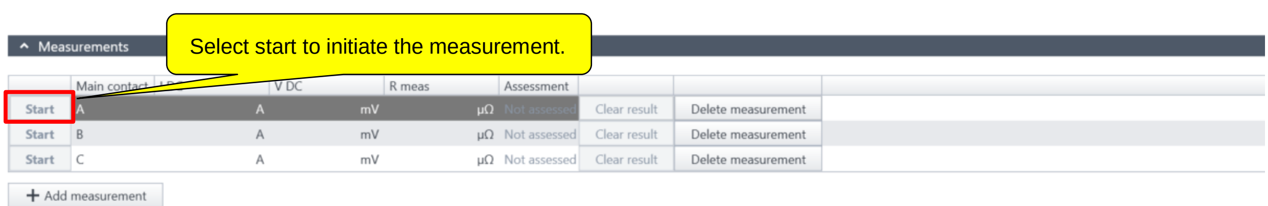



Figure 53: Measurements - Contact Resistance

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