



# Prime 600 - Dynamic Micro Ohmeter



## Efficient, Fast and Easy way of knowing your Circuit Breaker's Status

### Introduction

The High Voltage Circuit Breakers are essential in the Electrical System, with the dedicated function they perform in interrupting the high current fault in a quick and safe way.

The importance of these Breakers in the Substations, it is essential to know its correct operation. In most cases, knowing the Circuit Breaker's status is to verify the contact resistance and the operation time. The main issue with this data, is that it is not able to reveal other aspects such as; misalignment of the arcing contacts or of its deterioration. By not detecting this information inside of the circuit breaker, can produce faults which could have severe consequences in the system continuity, in the system elements and the safety of the people around it.

For having a better concept the circuit breaker's status without performing the gas analysis in the circuit breaker, the Dynamic Resistencia Measurement or DRM test was developed.

SMC has created the necessary tool for obtaining the circuit breaker's status in a easy, fast and efficient way. For that, we have developed an equipment which integrates contact resistance and the dynamic resistance measurement (DRM), able to inject up to 600 A with pure DC current, with a smart control and with a Double Ground operation. This unit is called the **Prime-600**.

The **Prime 600** allows us to obtain the circuit breakers contact resistance, as well as, measures and plots a graph of the circuit breaker dynamic resistance from the opening operation and can compare the DRM's graph of the different circuit breakers. It also detects time changes during the opening operation between the different chambers of one circuit breaker or between different circuit breakers. All this without having to combine with a circuit breaker analyzer, thus providing an easy, fast and efficient solution with less cost.



1. External voltage detection measurement which allows to detect when voltage appears on the opening coil or an External Temperature Measurement.
2. Dual Ground Clamp measurement connection.
3. Voltage measurement inputs, to calculate the resistance tested.
4. Current injection output connectors



## Tudela's Substation - Spain

The example tests in this document, were made thanks to, one of the most important electric companies in Spain. They had a requirement to have an equipment which, first had simple and easy operation, and allowing to obtain the circuit breaker's status without the need to perform multiples connections, of course all this at an affordable price and able to work in aggressive environments such as high voltage substations.

In this case, the circuit breakers tested, were 400 kV SF6 double chamber single phase circuit breakers from ABB. Each phase tested is referred to in this document as Phase 0, Phase 4 and Phase 8 while each chamber as is referred to as C1 (chamber 1) and C2 (chamber 2). The three circuit breakers were connected to the ground in both extremes so the Double Ground Clamp was used.

In performing the tests, the connections were made to each phase and with both chambers. The external voltage detection measurement was connected for detecting the appearance of voltage in the opening coil of the circuit breaker and to plot the dynamic resistance measurement during the opening time (1) as well as the current injections connections (4), the voltage measurement connections (3) and the Double Ground Clamp (2).



Once all the connections are made, the following test and order were made :

- Phase 0: C1, C2 y C12
- Phase 4: C1, C2 y C12
- Phase 8: C1, C2 y C12

On the other hand, the tests order for each of the chambers were as follows:

- Static Resistance Measurement
- DRM



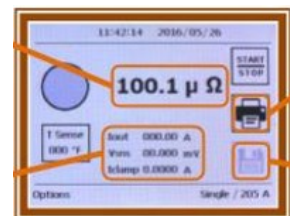
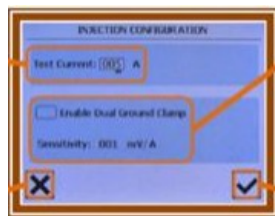
### - Phase 0, Phase 4 y Phase 8

The procedure analyzed each one of the chambers and both chambers, of each single phase circuit breaker starting by the static resistance measurement and consecutively the DRM test.

Prime 600's utilisation is easy and intuitive so each one of these tests only needs a couple of seconds to be configured.

#### Static Resistance

1. Select "Mode Configuration: Single" and the duration time of the current injection
2. Select the desired current value and Activate the Double Ground
3. Adjust the resistance range
4. Push "Start" to begin the test



Once the Static Resistance Measurement of the Circuit Breaker has been made, the results can be printed at the moment. In this case, they were saved on a USB to be visualized and analyzed later on with our computer. This is achieved to the powerful software provided: *PrimeSync*.

The results obtained are showed below:



	Phase 0		Phase 4		Phase 8	
	Chamber 1	Chamber 2	Chamber 1	Chamber 2	Chamber 1	Chamber 2
Resistance ( $\mu\Omega$ )	37,8	38	39,9	39,9	63,4	47,5
Current Output (A)	299,84	299,79	300,15	299,85	298,17	299,52
Voltage Measurement( mV)	11,246	11,338	11,880	11,872	18,721	14,105
Ground Current (A)	2,5291	1,5568	2,1773	2,0171	2,6691	2,2918

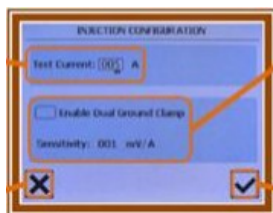
### Dynamic Resistance

Once the static resistance test has been made and knowing its value, to configure the test to dynamic resistance measurement is quick and easy step.

1. Select "Mode Configuration: Dynamic" and Introduce the opening time of the circuit breaker.



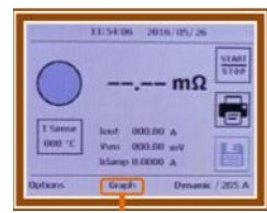
2. Introduce the desired current value and Activate the Double Ground Clamp



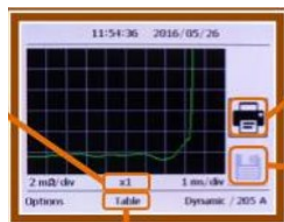
3. Select the resistance range



4. Push "Start" to begin the test



5. Press "Graph", the opening operation of the Circuit Breaker is shown.



6. Press "Table" the results obtained during the test are shown.

n	R(μΩ)	Iout(A)	Vmeas(mV)	Iclamp(A)
10	1.65	189.73	305.87	4.5373
9	1.65	189.65	304.93	4.6249
8	1.65	189.71	304.20	4.5926
7	1.65	189.61	304.62	4.6456
6	1.65	189.65	304.60	4.5730
5	1.65	189.55	304.60	4.5946
4	1.65	189.59	304.76	4.5388
3	1.65	189.51	304.74	4.5691
2	1.65	189.53	304.74	4.5240
1	1.65	189.45	304.68	4.6044

Each one of the dynamic resistance measurements made can be printed immediately. In this case, the measurements were saved ion a USB for analyzing and comparing the different points and graphs obtained during the tests.



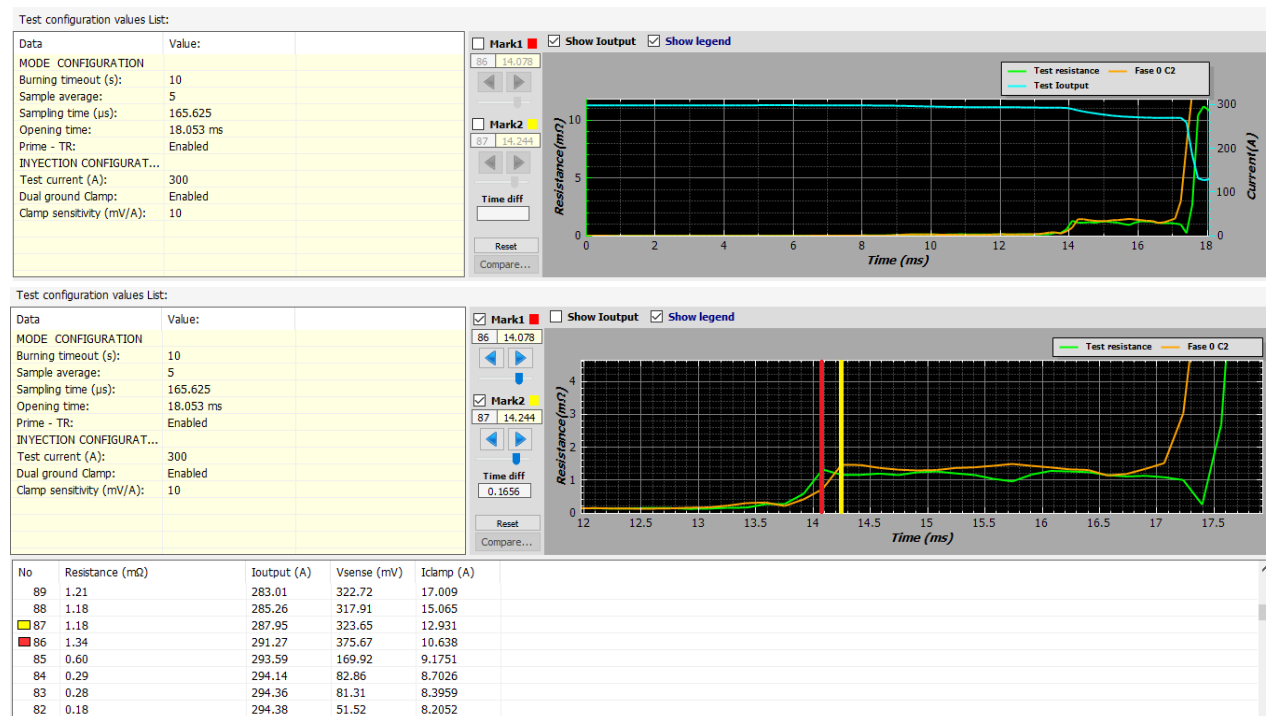
## PrimeSync - Software

Thanks to this powerful tool, the results obtained during the test can be compared between them. Analyzing the variation of time which exists between the opening of both chambers, if the circuit breakers are synchronizing with one another and to know the behaviour of each chamber of the circuit breaker based on the manufactures characteristics.

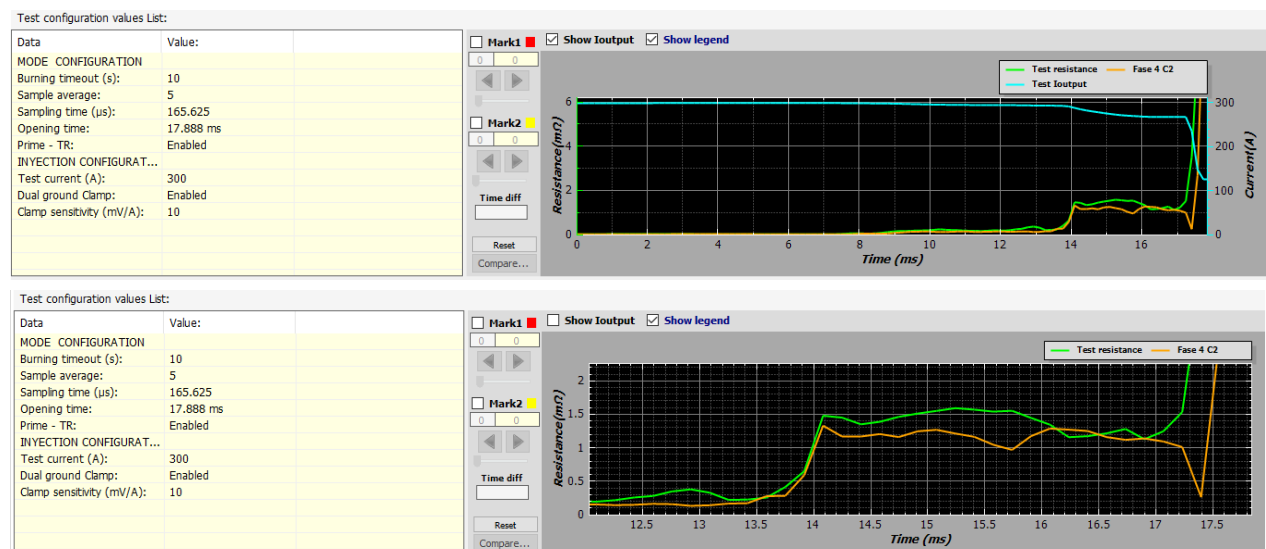
The standard which has served for the comparison of each one of the circuit breaker's chambers is taken from what the manufacture has guaranteed with the results of the circuit breaker being tested.

### - Comparison between the chambers of each phase of the circuit breaker

#### Phase 0: Comparison C1 - C2



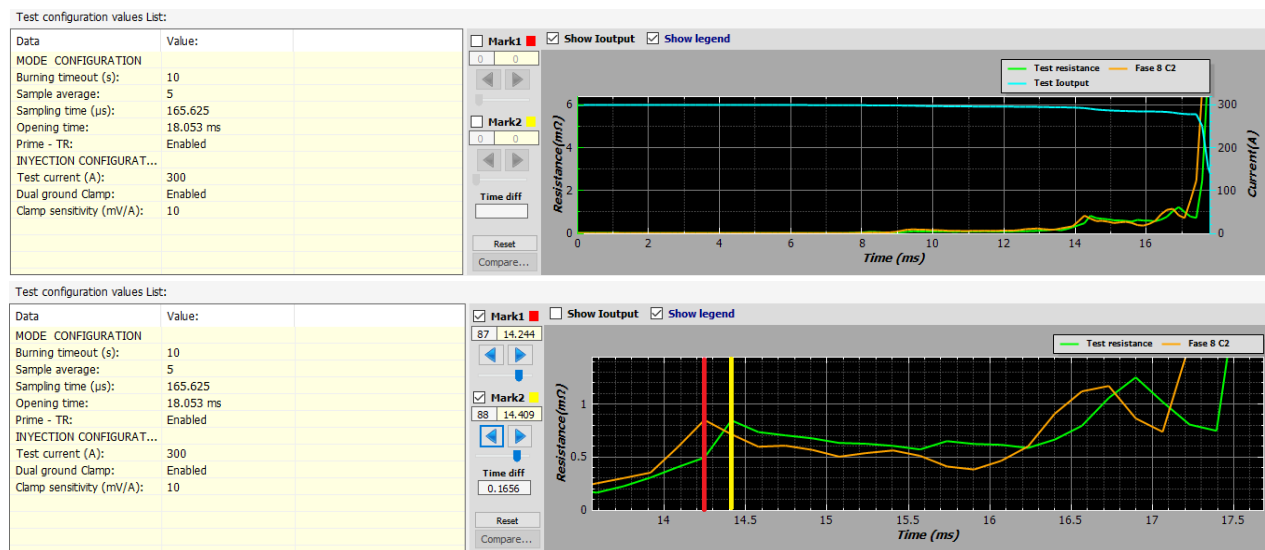
Thanks to the *PrimeSync* software, the DRM plot by the two chambers is almost identical. Trying to perform better comparison about what happens in the chambers, it is zoomed and two cursors are established. The cursors allow to difference the behaviour of the chamber sin a better way. These marks allow to verify the small variation between both chambers. Being the chamber 1 (green) which reaches before than chamber 2 (orange) the moment where the change is produced from the main contact to the arcing contact.





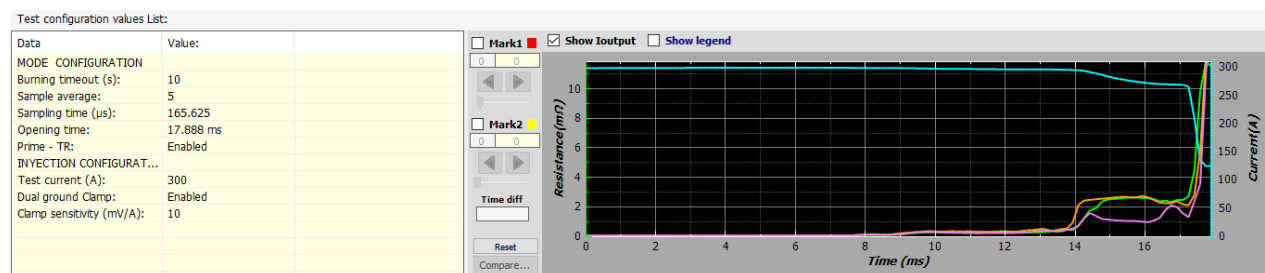
It can be observed the total synchronism between the circuit breaker's chambers. Thanks the software's possibility of being able to zoom any area of the DRM test, it is easy to know each detail of the test.

### Phase 8: Comparison C1 - C2



Also In this phase, the chambers are completely synchronized.

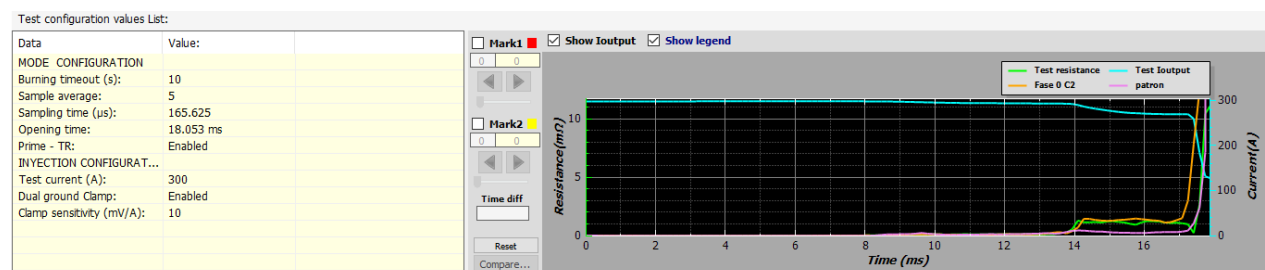
### - Comparison between circuit breakers



During the beginning of the opening of the poles, the three circuit breakers are synchronized completely. It can be seen that during the arc moment that the behaviour of the circuit breakers of the Phase 0 and Phase 4 are similar while Phase 8 does not have such a high resistance.

### - Comparison of each one of the circuit breaker's chambers with the patron

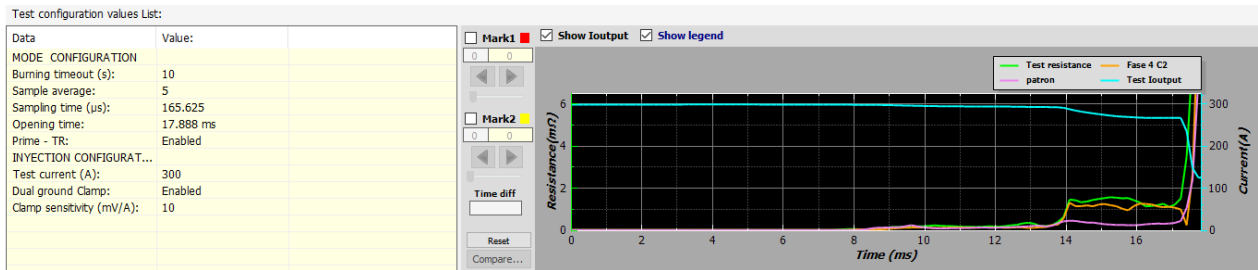
### Phase 0: Patron - C1, C2



Thanks to the comparison between the chambers with the template from the circuit breaker manufacture, it shows that at the beginning when the poles are opening in both chambers and at the same time there is a difference between both chambers with the template at the moment the arc appears.

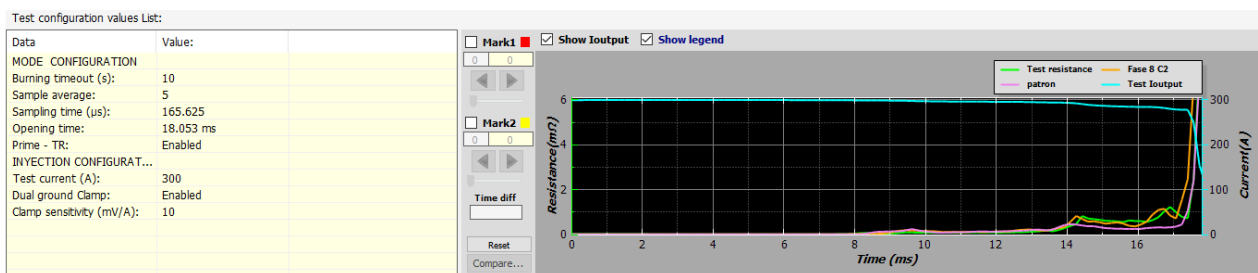


### Phase 4: Patron - CI, C2



Shown is how the synchronism of the standard are with both chambers since the movement of the poles as well as the moment of the arc is very similar. The only variation at the moment of the arcing where the resistance measured in both chambers is higher than the resistance of the standard.

### Phase 8: Patron - CI, C2



As in the previous cases, the synchronism between the movement of the poles and the arcing contact is similar between the both chambers and the standard. In this case the value of the resistance is not as higher as in the other cases.

## Conclusion

This document is focused on the use of the Dynamic Resistance Measurement (DRM) to obtain more the circuit breaker's status.

The execution of this measurement is not an easy task in an aggressive environment, due to the noise and to the induction which exists in a substation. That is why, it is necessary that the equipment can be able to inject high currents for a significant voltage drop and can perform measurements of resistance for a very short time (33 μs in this cases) As well as, its electronic is able to support these environments, as not all test equipment are capable to do.

Finally, to highlight the enormous use of having a software which allows to compare different plots of DRM. Providing this capacity with the results obtained give us the information such as:

- To know the time variation between the opening of each of the chambers of the circuit breaker or between each phase of the circuit breaker.
- To Compare the synchronism between the chambers and the circuit breakers
- To Compare the status of the chambers or circuit breakers in relation to the manufacturers specification.