OMICRON

CP CU1

Multi-purpose coupling unit for CPC 100

Measurement System for

Line Impedances and k-Factors
Mutual Coupling of Parallel Lines
Ground Impedances of Large Substations
Step and Touch Voltages
Coupling of Power Lines into Signal Cables

Variable Frequency

CP CU1 Applications

The System - CPC 100 & CP CU1

The multifunctional primary test system CPC 100, in combination with the coupling unit CP CU1, is a unique measurement system for:

- Line impedances and k-factors of overhead lines or power cables
- Mutual coupling of parallel lines
- Ground impedances of large substations
- Step and touch voltages
- Coupling of power lines into signal cables

This test system overcomes the problem of power system frequency interference that has previously made it necessary to use extremely large, high-power equipment to carry out these measurements.

The CPC 100 comes equipped with a high-performance power amplifier, which can generate output signals different from the mains frequency.

A variable frequency works as a filter against mains-related interference. The test system offered by OMICRON makes use of switched mode amplifiers and frequency shift techniques for accurate measurements, regardless of electrical interference.

A variable output frequency allows the use of test frequencies different from the mains frequency, which offers a very effective suppression of mains-related interference. When measurements are carried out at different frequencies it is also possible to gain more information about the items under test.

By generating signals and using selective measurements different from the power system frequency, the combination of CPC 100 and CP CU1 is able to obtain very accurate results.

The results are then automatically interpolated to the values at the power system frequency, with the results automatically calculated using the software provided.

Measurements on high voltage lines need special safety measures. The CP CU1 coupling unit is used to safely connect the inputs and outputs of the CPC 100 to the transmission line.

Measurement with CPC 100 and CP CU1

The unit has built-in coupling transformers which provide a safety measure for the operator in the event of voltage rises due to mutual coupling or other events occurring during the test.

The grounding box CP GB1 is used to make the connection between the CP CU1 and the overhead line and can be located at a safe distance from the operator. The grounding box allows the discharge of currents up to 30 kA once its voltage limit is exceeded.

Line Impedance and k-Factor Measurement

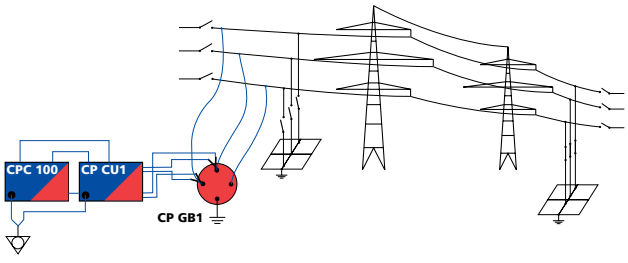
The correct setting of a distance relay requires the values of the positive and zero sequence impedance of the protected system. Incorrect settings may lead to zone over- or under-reaches.

Proper settings allow the fault duration times to be kept to a minimum, and allow the relay's fault location functionality to perform precisely.

The impedances and the k-factor are normally calculated from the results of a systems study. Due to the large variety of influencing factors (e.g. conductor types, spiraling and average sag of the wires, shield handling on cables, specific soil resistivity) these calculations can be prone to error. Actual measurement of the fault-loop impedance is the best way to ensure the distance relay settings are correct.

The combination of CPC 100 and CP CU1 operating at non-system frequency allows the user to measure all fault loop configurations (phase to ground, phase to phase and three phase to ground). It provides accurate measurement of impedance magnitude and phase angle for lines with lengths of up to 300 km (200 miles).

The test provides a practical, safe and effective method of obtaining the necessary data for the correct setting of distance relays. The parameters $\underline{Z}_1$ and $\underline{Z}_0$, as well as the residual compensation or k-factor in the format used by the relay, are calculated directly from the results of the measurements.



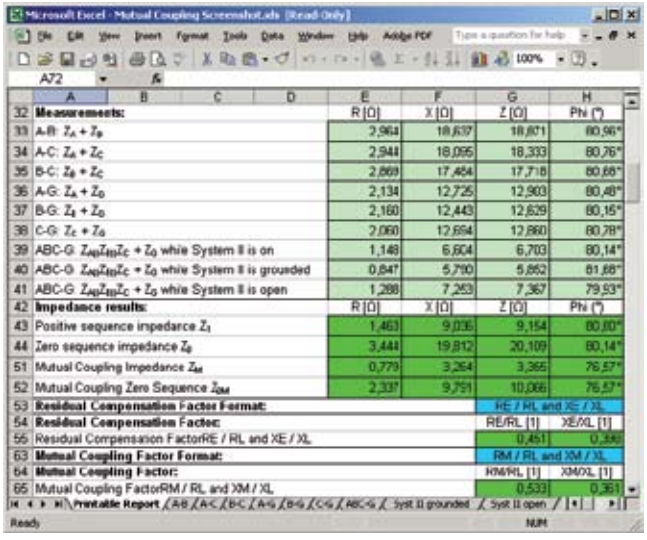
Line Impedance Measurement

Mutual Coupling Measurement

Distance protection relays protecting one of two parallel systems often allow compensation for induced currents between the systems. The setting needed for this is called the Mutual Coupling factor. The mutual coupling factor can be measured in the same way as the k-factor using the CPC 100 with the CP CU1 as well.

To calculate the mutual coupling factor, the zero sequence impedance of the system needs to be measured three times. First with the parallel system energized, then with the parallel system floating on one end and finally with the parallel system grounded.

An Excel™ Template makes the analysis of the results easy, once the measurement results are imported into Excel all calculations including positive sequence impedance, zero sequence impedance, k-factors and the mutual coupling factor are performed automatically.



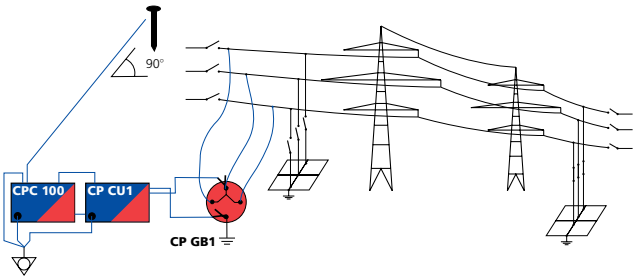
	A	B	C	D	E	F	G	H
32	**Measurements:**				R [Ω]	X [Ω]	Z [Ω]	Phi (°)
33	A-B: $Z_A + Z_B$				2,963	18,637	18,871	80,96°
34	A-C: $Z_A + Z_C$				2,944	18,095	18,333	80,76°
35	B-C: $Z_B + Z_C$				2,869	17,464	17,718	80,66°
36	A-G: $Z_A + Z_0$				2,134	12,725	12,903	80,46°
37	B-G: $Z_B + Z_0$				2,160	12,443	12,629	80,15°
38	C-G: $Z_C + Z_0$				2,060	12,694	12,860	80,78°
39	ABC-G: $Z_{M0}Z_{M0}Z_C + Z_0$ while System II is on				1,149	6,604	6,703	80,14°
40	ABC-G: $Z_{M0}Z_{M0}Z_C + Z_0$ while System II is grounded				0,847	5,790	5,852	81,66°
41	ABC-G: $Z_{M0}Z_{M0}Z_C + Z_0$ while System II is open				1,288	7,263	7,367	79,93°
42	**Impedance results:**				R [Ω]	X [Ω]	Z [Ω]	Phi (°)
43	Positive sequence impedance Z_1				1,463	9,036	9,154	80,80°
44	Zero sequence impedance Z_0				3,444	19,812	20,109	80,14°
51	Mutual Coupling Impedance Z_M				0,779	3,264	3,355	76,57°
52	Mutual Coupling Zero Sequence Z_{0M}				2,337	9,791	10,066	76,57°
53	**Residual Compensation Factor Format:**						RE / RL and XE / XL	
54	**Residual Compensation Factor:**						RE/RL [1]	XE/XL [1]
55	Residual Compensation FactorRE / RL and XE / XL						0,451	0,330
63	**Mutual Coupling Factor Format:**						RM / RL and XM / XL	
64	**Mutual Coupling Factor:**						RM/RL [1]	XM/XL [1]
65	Mutual Coupling FactorRM / RL and XM / XL						0,533	0,361

Mutual Coupling Factor Results

Ground Impedance

Under fault conditions, voltage rises in the vicinity of electrical installations can be very dangerous. Accurate knowledge of the ground impedance of substations is very important for their safe operation. The data available to calculate these values is often not precise, so direct measurement provides a superior method of determining them.

Conventional test methods using power system frequencies need enormous power and complicated methods to overcome the problems of interference. Varying the frequency and using narrowband digital filtering with the CPC 100 and CP CU1 reduces the required power to a minimum.



Ground Impedance Measurement

The current is fed into the ground at a remote point, using a cable or an overhead line that is grounded at the far end. The measurements are performed according to international standards including DIN VDE 0101, CENELEC HD637S1, IEEE Std 80-2000 and IEEE Std 81-1983.

The distance between the grounding system under test and a remote grounding point used as an auxiliary injection point should be greater than 5 km (3 miles); hence a de-energized transmission line is used as the connection to the remote point. Using a grounding probe and the fall-of-potential (IEEE) or the current-voltage-method (CENELEC) allows the measurement of the potential gradient.

Step & Touch Voltage Measurement

The safety of utility staff and the public, requires electrical plant to be properly installed and commissioned in accordance with the applicable standards. To detect potential hazards when touching a fence or tower during a fault in the substation, Step & Touch voltage measurement can be made on all exposed locations.

Injecting a current into a power line towards the next star point to ground connection allows the simulation of a real fault.

Normally, such measurements are performed at, or close to, the mains frequency. This requires very expensive measures to suppress interference such as the beat method or the phase reversal method, as interference is not necessarily constant over time.

CP AL1 with Adapter

Using the CPC 100 in conjunction with the CP CU1, it is possible to generate and inject a range of frequencies to the lines. These frequencies can be easily measured at the test point using the Fast Fourier Transformation (FFT) voltmeter CP AL1.

The specified testing resistors for body and shoe resistances, as defined in the standard, are already integrated in the connection adapter of the CP AL1, therefore facilitating the measurement procedure.

Footprint electrodes conforming to the relevant standards are also available. Since these electrodes must have a weight of 25 kg (55lbs), they are designed as light weight water containers which can be filled on-site making transport easy.

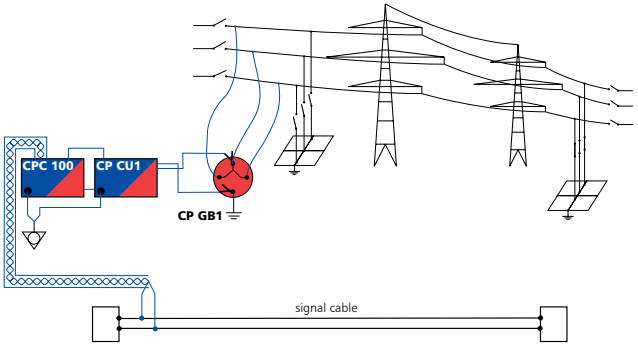
An accessory kit is available for use with the CP CU1 when performing step & touch voltage measurements.

Touch Voltage Measurement Using the CP AL1, CPC 100 and CP CU1

Coupling of Power Lines into Signal Cables

Inductive coupling between a power system and adjacent cables is a common phenomenon. Where the adjacent cable is used for carrying relatively low-level signals, the level of coupling can lead to problems in the associated equipment. This coupling impedance $\underline{Z}_k$ can be measured using the CPC 100 and CP CU1 test system.

The principle of frequency selective measurement of the test system allows the identification of interference from a specific power line to the signal cable under test or any other conducting material that might be affected by interference caused by induction from electrical power lines.



Measurement of Coupling between Power Lines and Signal Cables

OMICRON Test Templates

GENERAL

OMICRON offers ready-made test templates for numerous common applications. They always consist of file pairs for the CPC 100 and Microsoft® Excel™.

TEMPLATES FOR CABLES AND TRANSMISSION LINES

Line Impedance
This template allows the measurement of the positive and zero sequence impedance of three-phase overhead wires or underground cables.

Mutual Coupling
This template is used to calculate the mutual coupling impedance as well as the mutual coupling factor for different relays from measurements of the overhead lines.

Coupling into Signal Cables
This template supports coupling measurements between overhead wires, or underground cables, and signal cables.

TEMPLATES FOR GROUNDING SYSTEMS

Ground Impedance
The ground resistance measurement template is intended for assessing the quality of a grounding system. It displays the results in relation to the distance from the grounding system in a graphical format.

If appropriate measuring points are selected, an evaluation can be made of the step voltage.

Touch Voltage
This template is for measurements made with the CPC 100 alone. A wired connection from the location of the test back to the CPC is needed. The touch voltage template can also be used for evaluating step voltage. An Application Note explains the details of the measuring process.

Step & Touch Voltage using CP AL1
This template is for measurements made with the CPC 100 together with the CP AL1 FFT voltmeter. No connection from the location of the test to the CPC is needed.
An Application Note explains the details of the measuring process.

For OMICRON customers the latest templates for the CPC 100 can be downloaded from the Customer area of our website - **www.omicron.at** or **www.omicronusa.com**.

Technical Data

CP CU1

Current Output Ranges

Current range	Compliance voltage
0 ... 10 A rms	500 V rms
0 ... 20 A rms	250 V rms
0 ... 50 A rms	100 V rms
0 ... 100 A rms	50 V rms

Measuring Transformers

VT	600 V : 30 V class 0.1
CT	100 A : 2.5 A class 0.1

Mechanical Data

Protection	IP 20
Dimensions (w × h × d)	450 x 220 x 220 mm (17.7 x 8.7 x 8.7 inch)
Weight	28.5 kg / 63 lbs

CP GB1

Electrical Data

Nominal ac spark-over voltage	<1000 V rms
Short circuit proof	up to 30 kA for 100 ms

Mechanical Data

Dimensions (Ø × h)	200 x 190 mm (7.9 x 7.5 inch)
Weight	6.8 kg / 13.2 lbs (including grounding cable)

CP AL1 & CP AL1 Adapter

Input Voltage:	3 V/30 V @ Crest <1.5
Frequency range:	10 Hz ... 20 kHz
Switchable input resistance:	~20 kΩ / 1 kΩ / 1+1kΩ
Batteries:	3 x 1.5 V LR6/AA typical life time >16 h
Weight/Dimensions:	350 g / 0.78 lbs 220 x 86 x 42 mm (8.7 x 3.4 x 1.6 inch)

Overall System

Output Power[1]

5000 VA, cos φ < 1.0 for 8 s @ 230 V ac mains voltage
5000 VA, cos φ < 0.4 for 8 s @ 115 V ac mains voltage

Accuracy[1]

Measured value range	Typical accuracy	Current
0.05 ... 0.2 Ω	1.0 ... 0.5 %	100 A
0.2 ... 2 Ω	0.5 ... 0.3 %	100 A
2 ... 5 Ω	0.3 %	50 A
5 ... 25 Ω	0.3 %	20 A
25 ... 300 Ω	0.3 % ... 1.0 %	10 A

Environmental Conditions

Operating temperature	-10 ... +55 °C / 14 ... 131 °F
Transport & storage Temperature	-20 ... +70 °C / -4 ... 158 °F
Relative humidity	5 ... 95 %, non condensing
Safety	EN 61010-1
Prepared for	IEEE 510, EN 50191 (VDE 104), EN 50110-1 (VDE 105 Part 100), LAPG 1710.6 NASA

[1] At an ambient temperature of 23 °C ± 5 °C / 73 °F ± 10 °F

Ordering Information

CP CU1, coupling unit **VEHZ0671**
including: CP GB1, grounding box (VEHZ0672) with 16 mm cylindrical, 20 and 25 mm / 1 inch ball studs
Equipotential grounding cable for CP GB1 (2 m / 95 mm²) and for CP CU1, (6 m / 6 mm²)
Connection cables (6 m) - CPC 100 to CP CU1 and CP CU1 to CP GB1 including cables with Kelvin clamps
Replacement kit with 3 CP GB1 surge arrestors (VEHZ0676)
CP CU1 reference manual (VESD0671)
Transport case with wheels (VEHP0063)

Optional Accessories:

Clamp on Ammeter for up to 400 A AC **VEHZ0675**

Step & Touch Voltage Accessory Set for CP CU1 **VEHZ0625**
including: CP AL1-FFT Voltmeter including adapter for 1kΩ resistors, test peak, cables, and ground rod (VEHZ0626)
Pair of foot electrode water cans. Weight: empty 6 kg / 13.2 lbs each, filled > 25 kg / 55.1 lbs each according to HD637S1 & 1EEE 81.2 (VEHZ0627)

Ground Impedance Set for CP CU1 **VEHZ0622**
including: GPS Garmin eTrex for distance measurements (VEHZ0624)
Rogowsky coil with a length of 190 cm / 75" - 20/200 A ranges (VEHZ0623)
6 cable reels 100 m x 0.75 mm² black and 3 ground electrodes

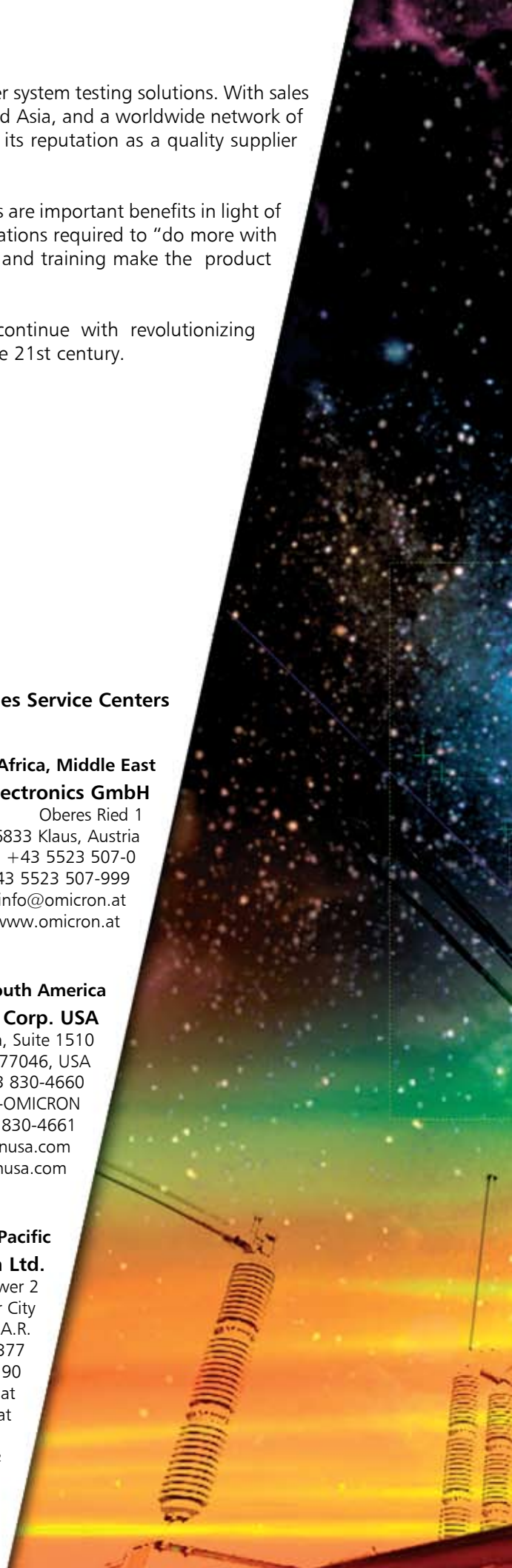
MV-cable set **VEHK0627**
including: three cables (2m / 95mm²) with clamps on both ends to connect the CP GB1 to MV-cable installations *(available on request)*

Minimum CPC 100 Requirements:
CPC 100 (VE0006XX) and CP Sequencer Test Card (VESM0635)

OMICRON is an international company providing innovative power system testing solutions. With sales in more than 120 countries, offices in Europe, North America, and Asia, and a worldwide network of distributors and representatives, OMICRON has truly established its reputation as a quality supplier of leading edge technology with highest customer orientation.

OMICRON's automated primary and secondary testing capabilities are important benefits in light of the changing market conditions resulting in restructured organizations required to "do more with less". Services in the area of consulting, commissioning, testing, and training make the product range complete.

Specialization and visionary leadership allows OMICRON to continue with revolutionizing developments for its solutions to meet the customer needs of the 21st century.



OMICRON Sales Service Centers

Europe, Africa, Middle East

OMICRON electronics GmbH
Oberes Ried 1
A-6833 Klaus, Austria
Phone: +43 5523 507-0
Fax: +43 5523 507-999
info@omicron.at
www.omicron.at

North and South America

OMICRON electronics Corp. USA
12 Greenway Plaza, Suite 1510
Houston, TX 77046, USA
Phone: +1 713 830-4660
1 800-OMICRON
Fax: +1 713 830-4661
info@omicronusa.com
www.omicronusa.com

Asia, Pacific

OMICRON electronics Asia Ltd.
Suite 2006, 20/F, Tower 2
The Gateway, Harbour City
Kowloon, Hong Kong S.A.R.
Phone: +852 2634 0377
Fax: +852 2634 0390
info@asia.omicron.at
www.omicron.at