# CONTACT

N°14 MEASUREMENT • NEWS WINTER 2000

## Special report:
## The "whys" and "wherefores" of measuring electrical insulation

- Differential input oscilloscopes

- Choosing a thyristor power switch

- Current shunts

CHAUVIN ARNOUX

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*Front cover :*
insulation measurment on a powered-down electrical installation


TECHNICAL INFORMATION JOURNAL

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Distributed free



WINTER 2000

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***To receive sales literature, fill out the Reader Service form between pages 8 and 9.***


# EDITORIAL

## WELCOMING INTO CONTACT

Our aim is to give you the most thorough and relevant information concerning our activities. For this reason we are including all brands of instruments marketed by the different divisions of the Chauvin Arnoux group in Contact Measurement News.

Now seems to be a suitable opportunity to clarify the organisation of our group into its basic areas of industry that are the divisions created at the end of 1998.

The **Test & Measurement** division, based in **Paris**, covers Chauvin Arnoux, Metrix and Oritel brands of portable instruments for use on site or in the laboratory.

The Enerdis Chauvin Arnoux **Power Measurement & Control** division, based in **Montrouge**, covers industrial systems and equipment for the measurement, control, metering and monitoring of electrical networks.

Then there is the Pyro-Contrôle Chauvin Arnoux **Temperature Measurement & Control** division, based in **Lyon**, for industrial systems and sensors for temperature measurement and control.

To provide you with a worlwide service, we have subsidiaries in Austria, Germany, Italy, Spain, Switzerland, the UK and the USA, as well as a vast network of sales representatives and distributors.

Chauvin Arnoux is an innovative company, the proof of which lies in the new products that are launched month after month, always better adapted and more innovative. Many new products were created in 1999, the very latest of which you can find in the following pages.

Demonstrating its interest in innovation, Chauvin Arnoux supports scientific research through a biennial prize from the Académie des Sciences: The Chauvin Arnoux Measurement Prize. We have the pleasure in announcing the 1999 prizewinner as being Mr. Pierre Delpierre.

We are ready for the year 2000 with a will to give you the best service possible.

Best regards,

**Axel Arnoux**
**Vice-president**

## The "Grand Prix de la Mesure"

©CNRS Photothèque, Photo Laurence Médard.

On the occasion of Chauvin Arnoux's centenary in 1993, we decided to make a special contribution to the scientific and technical community in the form of the Chauvin Arnoux "Grand Prix de la Mesure". This twice-yearly distinction, that comes with a handsome prize of 150,000 FF, is organised within the framework of the "Grands Prix de l'Académie des Sciences". It aims to reward research work and important innovations, in the field of environmental test and measurement achieved by electrical or electronic means. Mr. Pierre Delpierre was the winner of the prize at the "Institut de France" during the awards ceremony which took place on the 29th of last November, the third time this prize has been handed out.

Mr. Delpierre's work concerns mainly the detection, localisation and energy measurement of elementary particles. He stood out first of all on account of his work on the large Time Projection Chambers at Berkeley (USA) and at CERN (Geneva). Above all, it is his innovations in the field of silicon pixel detectors that have earned him international recognition.

***Mr. DELPIERRE inserting the pixel detectors during the DELPHI experiment.***

## Metrix - Chauvin Arnoux EMC laboratory has Cofrac accreditation

The electromagnetic compatibility (EMC) test characterises the ability of electrical and electronic instruments to function without significant interference on their environment or being affected by outside interference. The CE logo on an instrument certifies, among other things, this compatibility.

We are proud to announce that the Metrix - Chauvin Arnoux EMC laboratory at Annecy-le-Vieux (South-east of France) has just been accredited according to the EN 45001 standard by the Cofrac tests branch (French accreditation comity) under n°1-1036. This accreditation applies to the majority of immunity and emissions tests currently required by the CE mark and in accordance to the NF EN 50081-1:1992, 50081-2:1993, 50082-1:1998 and 50082-2:1995 generic standards.

The ISO 9001 certified laboratory at Annecy-le-Vieux ensures all the necessary EMC test services for the development of new Chauvin Arnoux and Metrix instruments. It has a 250 $m^3$ anechoic chamber equipped with a 500 kg rotating deck. It also has the means to carry out tests according to the safety standards required by the "low voltage" directive.

## Out and about

| | | |
|---|---|---|
| 06/03 – 09/03 | ELECTREX | Birmingham, England |
| 10/03 – 12/03 | ELETTRICITA' SICURA | Padova, Italy |
| 14/03 – 16/03 | SEIPRA | Nantes, France |
| 19/03 – 23/03 | LIGHT & BUILDING | Frankfurt, Germany |
| 20/03 – 25/03 | HANNOVER MESSE | Hanover, Germany |
| 28/06 – 30/06 | ELTEC | München, Germany |

For the first half of 2000 we will be participating in the industry fairs and exhibitions shown opposite.
We greatly appreciate opportunities like this to be able to talk with you and get your impressions on our latest innovations we will be presenting.

## Larger premises for the Spanish subsidiary...

In December '99, Chauvin Arnoux's Spanish subsidiary in Ibérica moved to more spacious and functional premises, allowing us to meet the increasing needs of a business in full growth. They are still to be found in the same building, but now the premises occupy the first floor at this address. Telephone and fax numbers remain the same.

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## ...and a move in Italy

At the end of December our Italian subsidiary, AMRA - CHAUVIN ARNOUX, also made a significant move. All of their staff, the factory and the maintenance centre as well as the sales agency, now occupy much more spacious premises at Barreggia di Macherio, near Milan. This new implantation results from the merger with the company MTI acquired by AMRA. The joint forces of MTI - AMRA - CHAUVIN ARNOUX have put them in pole position on the Italian industrial relay market.

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# Recording your measurements is simple with Simple Logger

***Simple Loggers™ are compact and inexpensive data loggers designed to give maximum ease of use. They automatically adjust and optimise their sensitivity (measurement range) and data sampling rate. Chauvin Arnoux supplies each Simple Logger™ with a Windows™ run software package so you can display and analyse recorded data as well print out graphs and lists of results. It's dazzlingly simple: See for yourselves!***

Using a Simple Logger™ is simplicity in itself. Plug the unit in, press the button (no need to look far, there's just the one) and it gets on and records data all on its own, no set-up necessary beforehand. This is the advantage of the internal data compression algorithm (TXR™ technology - Time Extension Recording), which automatically adapts the sampling rate to the signal being monitored and the length of the recording session. In other words your Simple Logger™ works with no time restrictions.

Simple Loggers™ have three operating modes. In RECORD mode data acquisition and recording takes place. In STAND-BY mode the unit stores data until it is downloaded onto a PC via a RS 232 link. In OFF the Simple Logger™ stops recording and clears the memory ready for the next session.

*Simple like child's play*

By their very nature, Simple Loggers™ are non-configurable, there are several models adapted to different applications. Choosing from amongst the range of models available you'll find models for measuring temperature, voltage or current, making a whole multitude of applications possible, see the table below for some examples.

- Sampling rate: 4096 values max /hour
- Memory capacity: 8192 measurements
- Battery-life: > 1 Yr. (9 V alkaline battery)
- Dimensions : 73 x 59 x 41 mm
- Weight : 140 g
- Unit is mounted with two screws.

The Simple Logger™ is, without a doubt, the simplest device for on site recording of measurements, allowing you to carry out the analysis at your leisure on PC.

*Reader Service 1*

## Models and example applications

**L100 & L110**
AC current measurement by clamp-on current meter
- Monitoring energy
- Cable and transformer overload
- Metering C.T. re-dimensioning
- Power supply derivation

**L205**
AC voltage measurement up to 25 $V_{RMS}$
- Monitoring LV power supplies
- Testing protective earthing network potential

**L410 & L430**
DC current measurement up to 100 or 10 $V_{DC}$
- Profile curves of transducer outputs
- Monitoring process loop voltages
- Monitoring rechargeable batteries

**L230 & L260**
AC voltage measurement up to 300 and 600 $V_{RMS}$
- Monitoring mains voltages
- Recording of minimum and overvoltages
- Monitoring of alternators, generators, generator sets
- Monitoring of inverters, protected power supplies (IT)

**L320**
20 $mA_{DC}$ loop current measurement
- Profile curves of transducer output
- Monitoring process loop currents

**L600 & L605**
Temperature measurement from –20°C to +100°C by thermistor
- Recording ambient temperature
- Refrigerated storage
- Monitoring air conditioned rooms

**L610, L620 & L630**
Temperature measurement by J, K or T-type thermocouple
- Recording of industrial process temperatures
- Industrial process control

**C.A 601, C.A 605 & C.A 607**
These three models for high AC current measurement complete the Simple Logger™ range.
They differ from the others in the integration of their own unique current sensor linked to the acquisition electronics; model C.A 601 comes in current clamp form and models C.A 605 and C.A 607 have the flexible AmpFLEX™ current sensor.
The conductor to be measured is simply gripped in the clamp jaws, or by the AmpFLEX™, and the digital recording of the signal is underway on the simple press of a button. These 'turn-key' products come with everything needed for the user to get straight on with data recording and analysis (data logger, accessories, battery, leads, etc) without the user needing any special training beforehand.

# Oscilloscopes that make all the difference...

***Today, in electronics as other areas of industry, safety can no longer be overlooked. Oscilloscopes too are no exception to this rule. Are you sure that the voltage that you are measuring is earthed? And have you got a single reference potential for both channels? With Metrix differential input oscilloscopes you can look at signals superposed on the mains, observe two phases at once or look at a circuit output on top of the control voltage. All this without complicated set-ups and accessories.***

With its latest range of differential input oscilloscopes, Metrix is standing steadfast in its belief that oscilloscopes functions and features should come as standard, not as options. Ready to use from the word go, the OX 8062 and OX 8042 come with the FFT (Fast Fourrier Transformer) function and a harmonic analysis function, these days no longer a luxury but more of a necessity. Stemming directly from the FTT function, harmonic analysis is more detailed than a conventional bar display. The limiting frequency is the bandwidth of the oscilloscope (60 MHz on the OX 8062 and 40 MHz on the OX 8042), and the fundamental frequency is detected even on complicated signals such as pulse width modulated waveforms. In harmonics mode, the cursor jumps from harmonic to harmonic whilst the order, frequency and amplitude in relation to the fundamental are displayed on the screen.

## Wide dynamic range

Whether the signal is weak or strong, these four oscilloscopes give you a wide range of sensitivities (10 mV/div to 200 V/div), so most measurements can be carried out directly without the use of an attenuator. These oscilloscopes also give an exceptional level of user safety, including conformity with IEC 61010, Cat. III, 300 V. It is possible to make measurements up to 200 V/div., on unearthed signals. Each of the two channels can be used independently in differential or conventional mode, by simply pressing a button you can switch between modes at any given moment with no risk.

## The advantages of digital

Centronics and RS 232 interfaces come as standard on the OX 8062 and OX 8042. Why else would you want a digital oscilloscope if you couldn't make use of all the advantages it has to offer, like data handling, analysis on PC (SX-METRO software) or printing out graphs? Like the display, printouts are equally enhanced by the "Dot-join" function. This method of interpolation between sampled points improves the reading of results considerably, indispensable when the signal contains steep rising edges. Digital also means that aperiodic signals can also be observed. With their large memory capacity and high sampling rate these oscilloscopes are especially well adapted to monitoring small time-scale events as well as slow variations (up to 8 hours acquisition).

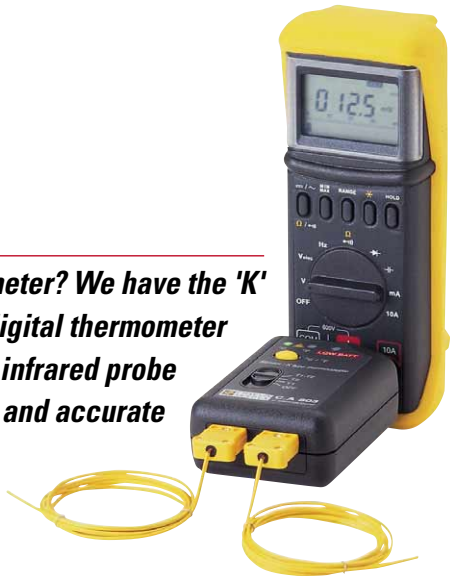
## Analogue differential oscilloscopes

The OX 832 (30 MHz) and OX 822 (20 MHz) are analogue models giving you all the advantages of differential inputs. No comparison can be made with the traditional oscilloscope and differential probe combination, whether on the grounds of price, ergonomics, not to mention ease of interpreting the display.

*Reader Service 2*

| | OX 8062 | OX 8042 | OX 832 | OX 822 |
|---|---|---|---|---|
| **Technology** | Analogue-digital | Analogue-digital | Analogue | Analogue |
| **Bandwidth** | 60 MHz | 40 MHz | 30 MHz | 20 MHz |
| **Number of channels** | 2 differential channels (600V max). (2 BNC/channel), impedance 1 MΩ / 12 pF | | | |
| **Sensitivity** | From 10 mV to 200 V per division | | | |
| **Operating modes** | CH1, CH2, ALT, CHOP, ADD, MULT, XY in conventional or differential | | CH1, CH2, ALT, CHOP, ADD, XY in conventional or differential | |
| **Time base** | From 20 ns to 200 ms/div. in analogue<br>From 5 ns to 200 s/div. in digital | From 50 ns to 200 ms/div. in analogue<br>From 5 ns to 200 s/div. in digital | From 50 ns to 200 ms/div.<br>- | |
| **Triggering** | CH1, CH2, ALT, LINE, EXT on AC, DC, LFR, HFR, frame or line coupling | | | |
| **Sample rate** | 100 MS/s single-shot<br>20 GS./s repetitive (ETS) | | -<br>- | -<br>- |
| **Memory capacity** | 1 Kb, 8 Kb or 16 Kb per channel | | - | - |
| **Specific features** | "GLITCH", "ENVELOPE" and "EADJ" (DOT-JOIN) modes<br>AUTOSET (automatic adjustment) for both channels<br>5 cursors and 17 automatic measurements<br>Digital links (RS232C and Centronics) and printer drivers as standard | | AUTOSET for both channels<br>RS232C link optional | |
| **Safety** | IEC 61010, Cat.III, 300 V / Cat.II, 600 V | | | |

# Plug-in Thermometers



***Want to make temperature measurements with your digital multimeter? We have the 'K' thermocouple adapter to make this possible. And if you already have a digital thermometer but you want to carry out remote temperature measurements then our infrared probe is all you need. These accessories make it possible to carry out reliable and accurate low temperature measurements without the cost.***

It is often necessary to measure temperature out on site, whether it's checking thermal insulation, fault finding, ensuring conformity with standards etc... The Test and Measurement division has a whole range of handheld digital thermometers for carrying out these measurements. Sometimes however it is inconvenient to carry around extra instruments, and this is where the K thermocouple adapter comes into its own. It fits into your multimeter case, waiting for any impromptu temperature measurements you may need to make. An infrared probe also proves to be an extremely handy auxiliary to have for measuring the temperature on moving or inaccessible parts.

## Two multimeter-thermometer adapters

The Test and Measurement division has two 'thermometer' adapters available, the choice between them depending on whether you wish to make a single temperature measurement at once (C.A 801 single input adapter), or make differential measurements (C.A 803 dual input adapter).

To start with you need a digital multimeter with a $mV_{DC}$ input and minimum impedance of 2 MΩ. The Ø 4 mm terminals must be 19 mm apart (this is the standard distance conforming to current standards) so as to plug the adapter straight in. The result is a unit that is just as easily handled as a thermometer, giving the same level of performance but at a more competitive price.

The robust design of these adapters and the variety of sensors that you can connect to them make them particularly well adapted to use out on site. Put them to use in all your measurement applications.

- Measurement range: -40 to +1000°C
- Sensitivity : 1 $mV_{DC}$ per K
- Typical accuracy: < 1%
- Battery life: 300 Hrs (9 V battery)
- Comes with sensor(s)

***The wide range interchangeable K sensors are available as accessories. With grip and compensated mini-plug they meet a variety of industrial applications.***

## IR probe for remote temperature measurement

Everybody knows of the advantages of infrared temperature measurement over the traditional method using a thermocouple or a Pt probe: namely its quickness and the absence of contact with the measurement target. Measurement using an 'optical pyrometer' is in fact virtually instantaneous as well as being carried out remotely from the target.

However, it should be remembered that the measured temperature corresponds to that of the surface temperature of the target area contained within the cone of the field of vision (fig. 1). This is why it is important to stay close to the target if you want to measure the temperature of a precise point without interference from the surface temperatures of surrounding elements, either those in close proximity of the targeted point or in between the probe and the target surface (frost, suspended dust, water vapour...). Consideration must also be given to the emissivity of the target material (see below) to which the measurement technology is based on. It is not suited to measurement on reflective surfaces without the application, beforehand, of a matt black coating (bold marker, adhesive patch,...).

The C.A 805 probe produces a signal that is identical to that produced by a K-type thermocouple, so it can be plugged into any thermometer (e.g. TK1000 or C.A 860) or K-type adapter (such as the C.A 801) via its thermo-compensated connector.

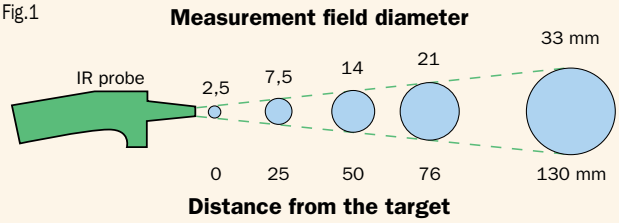
Temperatures of up to 260°C can be measured. Used wisely, it is a remarkable tool, capable of measuring temperature within the second. It is also true that some measurements would be highly difficult to carry out without the infrared sensor: imagine, for example, the problem one would have measuring the temperature of a moving part with a traditional thermometer! You're far better off using

the C.A 805.

- Measurement range: -18 to +260°C
- Typical accuracy: 2°C min
- Battery life: 50 Hrs (9 V battery)

*Reader Service 3*

Fig.1




**All objects above absolute zero (-273.15 K) give out infrared radiation. This radiated energy is emitted in all directions at the speed of light.**

**When the C.A 805 probe is pointed at an object, the lens picks up this energy and focuses it on an infrared detector. This detector reacts by giving out a voltage signal in proportion to the quantity of energy received, and hence in proportion to the temperature of the object. Some objects not only give out infrared energy, but also reflect it as well. Unlike matt surfaces, brilliant or highly polished ones tend to reflect energy. The coefficient of emissivity represents the level of reflection which can be anything from 0.1 for a very reflective surface, up to 1 for the theoretical 'black body'.**

**In the case of the C.A 805 probe, the coefficient of emissivity is preset to 0.95, the standard value which covers more than 90% of applications.**

# The "whys" and "wherefores" of measuring electrical insulation

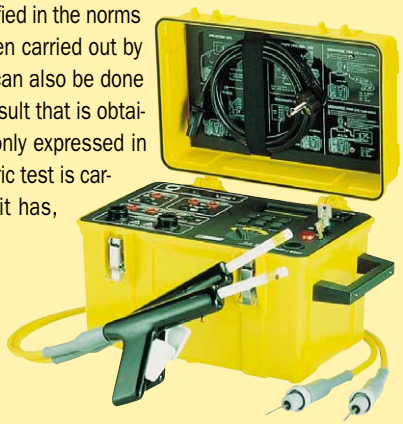
***It's an all too often told story: the second-hand dishwasher that you picked up for a bargain soon turns out to be more of a hindrance than a convenience when it starts tripping the circuit breaker every time you start a wash! It's times like this when an insulation check-over wouldn't go a miss.***

To ensure the good working order and safety of electrical appliances and installations, all the conductors must be insulated, that means sleeving on cables and insulative lacquering on windings. As the quality of these insulators becomes diminished, so leakage currents can flow from one conductor to another and, depending on the seriousness of the insulation fault (the worst case scenario being a short-circuit), cause varying degrees of damage.
Any equipment showing up as having an insulation fault could break down, catch fire or cause the malfunctioning of the installation itself, in turn triggering protective mechanisms which could include the powering down of the installation... Some installations that are particularly sensitive (hospital operating theatres, dangerous chemicals industry...) have an IT type neutral set-up (see IEC 60364 and NF C15-100) that tolerates a first phase-earth insulation fault and only cuts power to the installation upon a second fault occurring. To forewarn and hence protect against the risks linked to inadequate or worn insulation it is necessary to carry out insulation measurements. This is true not only of electrical equipment, but also of the mains network to which they are connected. These measurements are carried out as new or renovated equipment is being put into service and then periodically afterwards, so as to evaluate their insulative qualities with ageing.

## Insulation resistance measurement and the dielectric test

Often confused, it is worth clarifying once again these two different methods for determining the quality of an insulator.

■ ***The dielectric test*** expresses the ability of an insulator to stand up to an overvoltage of average duration without arking taking place (sparking). In a practical situation this overvoltage could be due to lightening, or induction generated by a fault on a power line for example. The main aim of the dielectric test is to ensure that the construction rules on creepage and air insulation distances are kept to, as specified in the norms and standards. The test is often carried out by applying an AC voltage, but it can also be done using a DC overvoltage. The result that is obtained is a voltage value, commonly expressed in kilovolts (kV). When the dielectric test is carried out on a faulty insulator it has, to varying degrees, a destructive nature depending on the power of the test instrument used. This is why this test is reserved for brand new or renovated equipment, and only those that pass the test are put into service.



***The C.A 6121 is a Machine Tester that carries out the 1000V, 1250V and 1500V dielectric test at 500VA according to the European directive EN 60204.***

■ ***Insulation resistance measurement*** is a non-destructive measurement method when carried out under normal test conditions. It is done by applying a DC voltage lower than that used for a dielectric test, and the aim is to produce a result in kΩ, MΩ or GΩ. This resistance value expresses the quality of insulation between two conductive elements and gives a good indication as to the risk of leakage currents flowing. The non-destructive nature of this method is useful when tracking the ageing of insulation on a piece of electrical equipment or on an installation as time goes on, so it can also be used effectively as a means of preventative maintenance. This measurement is carried out using an Insulation Tester, otherwise known as a **Megohmmeter.**

## How is the level of insulation measured?

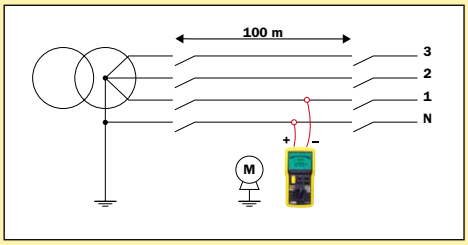
In practise, the installation or piece of equipment is first of all powered-down and then a DC test voltage is applied, from which we get an insulation resistance value. During insulation measurement in relation to the earth, it is advised to put the positive pole of the test voltage on the earth so as to avoid any problems caused by the polarisation of the earth when carrying out repeated tests.

All the standards concerning electrical installations and equipment specify the measurement conditions and the minimum thresholds for insulation measurements.

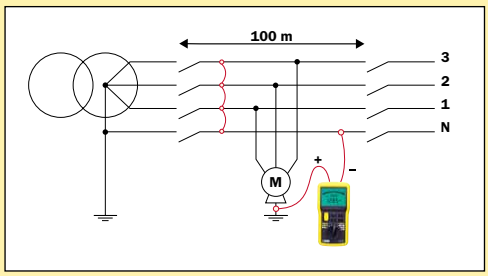
■ ***Insulation measurements on electrical installations***

The well known NF C15-100 standard concerning Low Voltage electrical installations specifies that the insulation resistance must be measured (the installation powered-down) on 100 m* long sections in the following way:

■ Before use, the receivers disconnected, between each active conductor (phase and neutral conductors), so as to check that none of them have suffered any physical damage during installation.




■ Before use, with the active conductors linked up and the receivers connected, so as to check over the insulation on all the conductors in relation to the earth. If the installation contains sensitive electronic mechanisms, it advisable to check that the phase and neutral conductors are well connected during the measurements.

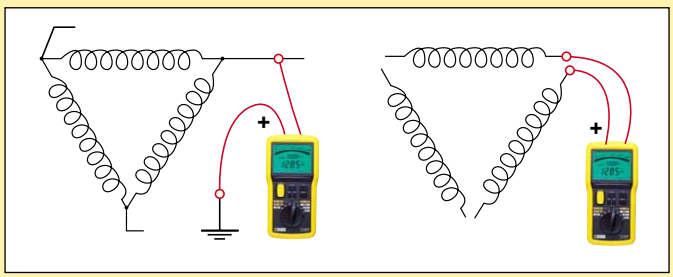


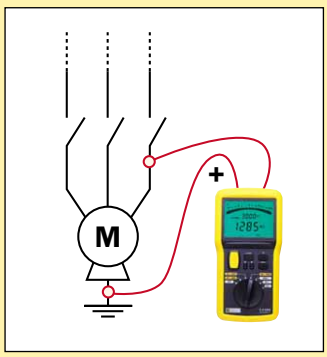

These measurements are also periodically made on tertiary or industrial installations.

**It is possible to carry out measurements on shorter sections, however the insulation value becomes inversely proportional to the length, e.g. for a 50 meter section,* $R_{\text{insulation 50 m}} = 2 \times R_{\text{insulation 100 m}}$

## ■ Insulation measurement on a rotating machine

The insulation quality can be checked in relation to the earth or between individual windings




We can also check the insulation, in relation to the earth, on the motor connected to the installation.

500 V and 1000 V test voltages are the most widely used during testing on Low Voltage (<1000V) rotating machines. On those rotating machines that operate above 1000 V (Medium Voltage), the insulation test voltages are commonly 2500 V or 5000 $V_{DC}$.

***Insulation Testing on electric motor windings***

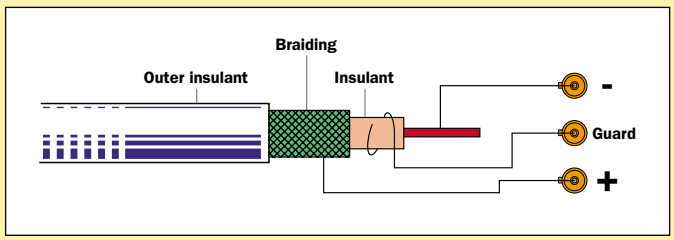
## ■ Insulation measurement on telephone cables

Insulation measurements are carried out on brand new cables (not yet in use) at 250 V or 500 V, then at 50 V or 100 V for line fault reading on cables already in service. Measurements can be made between pairs of lines and the screening connected to the earth, or between the metal screening and the earth.

***Designed for "telecom measurements", the C.A 6531 has measurement ranges at 50V or 100V to check the insulation between a bundle of free pairs and the screening connected to the ground. Cleverly, it displays the length of a telephone line directly in km's, because the linear capacitance (nF/km) can be programmed in.***

## ■ High insulation measurement: using a guard circuit

In the case of high levels of insulation, (above 1GΩ), measurements can sometimes be erroneous due to the flow of leakage currents across damp and dusty insulator surfaces. Often the technician only wants to check the intrinsic quality of insulation, so in order to make an exact measurement the surface leakage currents (that would otherwise reduce the resistance value measured) must be eliminated so that only the transverse current flowing in the insulation is retained. This procedure is simply carried out by connecting the insulation measuring device's guard terminal to a point between the " + " and " - " test points. The guard terminal shorts-out the measurement circuit and redirects the surface current so it is not measured. The guard terminal is connected to a spot where surface currents are thought to be prevalent, (insulation surface on a cable or transformer etc...), so the technician needs to have a good idea of possible current flow across the test element in order to best position the guard terminal.




***The use of a guard terminal as well as the positive and negative test terminals allows you to refine high insulation measurements.***

## Minimum values of insulation resistance

The values of insulation resistance are defined according to the rated voltage of the test circuit.

## ■ Electrical Installations

The minimum values shown in the table below correspond to the regulations of the NF C15-100 standard.

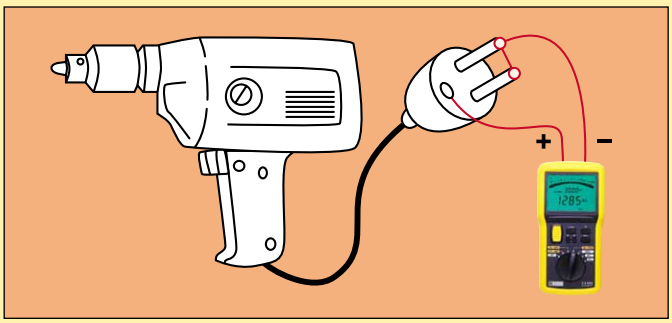
| Rated voltage of the circuit | Test voltage | Minimum insulation resistance * |
|---|---|---|
| Below 50V | 250 $V_{DC}$ | 0.25 MΩ |
| From 50 to 500V | 500 $V_{DC}$ | 0.5 MΩ |
| Above 500V | 1000 $V_{DC}$ | 1.0 MΩ |

** Note: the insulation thresholds correspond to 1000 Ω per Volt*

If the value measured in relation to the earth is less than the minimum resistance that is imposed by the regulations, the installation receivers are disconnected and each conductor's insulation is checked separately in relation to the earth.
For specific applications the thresholds can vary. For heating cables embedded in the walls of a building, the minimum insulation resistance values according to NF C15-100 are 250 kΩ for a rated voltage of 230 V, and 400 kΩ for a rated voltage of 400V.

### ■ *Electrical appliances and motors*

There are as many standards relating to electrical appliances as there are different kinds of appliances themselves. The 500 $V_{DC}$ test voltage is the most common and can be applied to machines (EN 60204 standard), household appliances (EN 60335), electrical switchboards (EN 60439) and to lighting fittings (EN 60598). The minimum thresholds can vary from one standard to the next but here again, the 1000 Ω/V ratio serves as the reference point.




### ■ *Telephone installations*

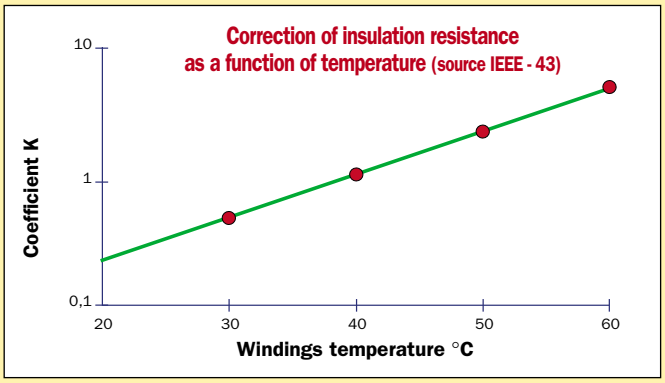
On telephone lines, the insulation resistance on empty new cables less than 2 km's in length should be at least 1000 MΩ (and 2000 MΩ/km if the longer than 2 km's). For filled cables, the respective values are 750 MΩ and 1500 MΩ/km.

On lines that are in use, the insulation resistance permitted is less than that on new cables but should never fall below by more than half.

## The influence of climatic conditions

Two environmental factors come into play when making insulation measurements:

■ Changes ***in temperature*** can cause insulation resistance to vary almost exponentially. If carrying out maintenance work on an installation containing several motors, it is important that all the measurements are carried out in similar temperature conditions. Otherwise, it is advisable to correct all the results so that they are all based on a fixed reference temperature. For example, the IEEE 43 standard on rotating machines says, as an approximation, you should divide the insulation resistance by 2 for every 10°C increase in temperature (and vice-versa). Below is a correction curve showing this guideline:




■ ***The humidity*** influences insulation depending on the level of contamination on the insulation surface. Care must always be taken not to carry out the measurement if the temperature is below the dew point.
Keeping an eye on these two factors during insulation measurement allows you to obtain reliable and comparable results and thus carry out prognostic maintenance of a high quality, ensuring that you get the most use out of electrical equipment.

***In the accessories bag that comes with the ISOL 5003, the user has a digital thermometer with an ambient air probe to optimise measurement of test conditions***

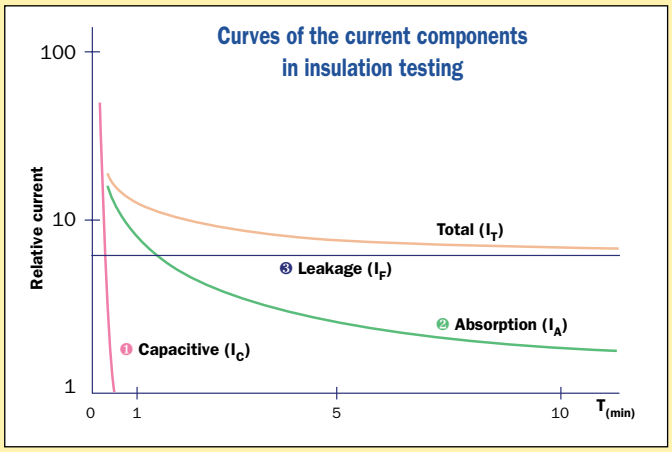
## Interpreting insulation measurements

Understanding the results is an important part of any measurement. As we have seen, ad-hoc reading of measurement values can give you uncertain results if, for example, the temperature variation is not accounted for even when the humidity conditions are assumed to be stable.

The two methods described below aim to make interpreting measurements and spotting deterioration in the quality of insulation over time an easier process.

### ■ *Method based on the duration of test voltage application*

This method has the advantage of not being significantly influenced by temperature (owing to its comparative nature), which means it can be easily implemented without having to correct the results. It is particularly suited to the prognostic maintenance of rotating machines and the monitoring of their insulation. In order to use this method, remind yourself of the different currents that flow during a resistance measurement on an insulating material (see graph).



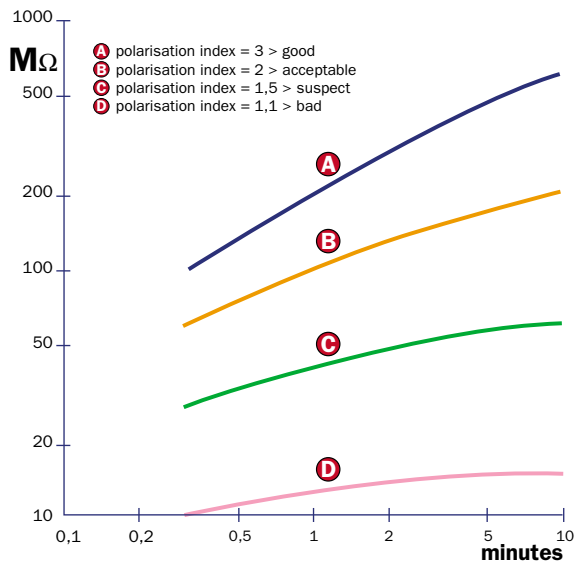

**Curve ❶ :** this corresponds to the charging current of the capacitive element of the tested circuit. This transient current drops rapidly after a few seconds, going on 10 or so, becoming negligible in relation to the leakage current 'IF' being measured.
**Curve ❷ :** the absorption current of the dielectric decreases much more slowly. It provides the energy necessary for the insulation molecules to orient themselves according to the electric field applied.
**Curve ❸ :** this last curve represents the leakage current that is characteristic of insulation resistance.

*There are two case scenarios when a test voltage is applied for a long time:*
**a. The insulation is excellent (insulating material is in a good state, clean and dry).** In this case, the leakage current is very low and the measurement is strongly influenced by the capacitive charge currents and dielectric absorption. The measurement of insulation resistance thus increases over the

duration that the test voltage is applied since the eddy currents decrease. The time it takes for the measurement on good insulating material to become stable depends on the nature of the insulating material itself. With old kinds of insulation a stable value is generally reached after 10 or 15 minutes. With some recent kinds of insulating material (e.g. .epoxy-mica or polyester-mica), the measurement may become stable after approximately 2 or 3 minutes.

**b. The insulation is bad (insulating material is damaged, dirty and damp).** In this instance the leakage current is high (and constant) and outclasses the capacitive charge and dielectric absorption currents. The measurement of insulation resistance reaches a steady and constant value very quickly.

**Typical variations in insulation resistance as a function of measurement time**




From the curves showing the variation in insulation as a function of the duration of the test voltage applied, we can see it is possible to not only take the "absolute" measurement of the insulation but also to express the quality of the insulation as a ratio. For example, the quotient of the insulation resistance value measured after 10 minutes of test voltage application divided by the value after just 1 minute gives us what we call the " Polarisation Index (PI) ". However, this index is not enough on its own. It only goes to complement the absolute insulation values set out in the standards, or defined by manufacturers of rotating machines.

**PI = $R_{insulation\ at\ 10\ minutes}$ / $R_{insulation\ at\ 1\ minute}$**

| | |
|---|---|
| If PI < 1 | The insulation is dangerous |
| If PI < 2 | The insulation is suspect |
| If PI < 4 | The insulation is good |
| If PI > 4 | The insulation is excellent |

As we mentioned before, the dielectric absorption current drops much more quickly in the latest insulating materials than in their predecessors. Consequently, the measurement can stabilise after 2 or 3 minutes in some cases. The "Dielectric Absorption Ratio (DAR)" , the ratio of insulation resistance values after 1 minute and that after 30 seconds, can also be used to assess the condition of some recent insulating materials.

**DAR = $R_{insulation\ at\ 1\ minute}$ / $R_{insulation\ at\ 30\ seconds}$**

| | |
|---|---|
| If DAR < 1.25 | The insulation is inadequate |
| If DAR < 1.6 | The insulation is good |
| If DAR > 1.6 | The insulation is excellent |

Variations in the PI and DAR ratios can make prognostic maintenance a much easier task when a lot of equipment needs to be looked at.

### ■ *Method based on the influence of variation of the test voltage (measurement in steps)*

The presence of contaminants (dust, incrustations of fouling matter...) or dampness on the surface of insulating materials generally shows up in measurements based on the duration of test voltage application (DAR, PI...). However, the ageing of some insulating materials and certain kinds of damage can sometimes get passed this kind of test unnoticed, where the test voltage is low compared to the dielectric voltage of the insulating material being tested. However, increasing the test voltage significantly could incur the rupturing of a weak point, bringing about a marked drop in the insulation value measured.

In order for this method to work, an adequate test voltage (5 to 1) is applied in one or more stages of equal duration (e.g. 1 minute) whilst remaining below the usual test voltage values (2Vr + 1000V). The results of this method are entirely independent of the nature of the insulating material and of the temperature since it is not based on the intrinsic value of the insulating material measured, but on the effective reduction in its resistance after tests of the same duration but at a different voltage. A drop of 25 % or more in the insulation resistance between the first and the second test indicates deterioration in the insulating material.

**Criteria for choosing an Insulation Tester**

Here are a few criteria to think about to help you choose an insulation tester that is best suited to your needs.

■ **Application.**

What kind of equipment is it for: electrical installations, appliances, telephony... ? Rated voltage, manufacturer's regulations, standards?
What test voltage: 50, 100, 250, 500, 1000, 2500, 5000 $V_{DC}$ ?
What measurement range: kΩ, MΩ, GΩ?

■ **Ease of use.**

What kind of display: needle dial with logarithmic scale, digital LCD, analogue bar graph?
Utility: programmable threshold alarms, back lighting, remote-control probe?

■ **Mode of use.**

What frequency and what operating conditions? Equipment needs to always be at hand? Need for long battery-life...? Power supply: magneto-generator, rechargeable battery?
What other measurements are to be carried out: continuity, current, voltage...? Single or multi-function instrument for machine or installation testing?

*Reader Service 4*

# Test earth resistance in a flash, from 0.1 Ω upwards

***As the world leader in current clamp manufacturing and a specialist in electrical installation test and control, it wasn't hard to come up with an original concept for quick earth resistance measurement. The three clamp-on earth resistance testers in this new range make for unbeatably quick testing of parallel or interconnected earthing networks without using any extra rods.***

The clamp-on earth resistance tester is designed to carry out measurements on installations with parallel polyphase earthing, without having to disconnect the earth being tested. The procedure is carried out simply by clamping the earth conductor, or the earthing rod itself. The clamp jaws themselves open up to a full clamping diameter of 32 mm on these three models. Measurement is thus carried out quickly and with the minimum of fuss, even in difficult environmental conditions. The real strong point of these new clamps is their impressively wide measurement range, which extends from 0.1 Ω right up to 1.2 kΩ, so you can find the best earth with the least resistance.

Because this method of measurement is carried out directly on the installation and doesn't involve disconnecting the earthing rod or other time-consuming procedures (loosening rusty bolts etc...), it gives a highly accurate representation of the real earthing situation. Any decisions that are consequently made can be confidently based on reliable and accurate assessment.

As well as measuring earth resistance, this measurement technique also makes it possible to check over the continuity of the connections and links to the earth (defective welds, conductive oxides, loose nuts,...), which is all useful information to have when carrying out maintenance.

## Current measurement function

Models C.A 6412 and C.A 6415 integrate a current meter function. The current probe is highly sensitive, able to measure leakage currents flowing to the earth (or in earth loops), from 1 mA up to 30 $A_{AC}$. The extra data given by these measurements is highly useful, especially if the earthing networks is suffering from high noise or harmonic 'pollution' that has a knock on effect on the power supply quality.

The battery level is indicated every time the clamp is switched on so as to prevent the user from being caught out whilst on site. There is also an automatic switch-off function if no button is pressed for over five minutes. This function can be deactivated if the user so desires.

## "Alarm" and "memory" functions

The top of the range C.A 6415 model comes with these two advanced functions.

In ALARM mode, a threshold value can be entered which triggers an audible or visual alarm if exceeded (the audible beep signal can be deactivated). The user chooses the triggering mode best suited to his or her application, either by setting a higher value (for a resistance value that is thought to be too high), or a lower value (for the continuity test). The alarm is particularly useful when conducting an On-Off test.

In MEMORY mode, 99 values (resistance or current) can be recorded. This function allows the user to carry out a series of measurements and then analyse the saved results later on.

The alarm threshold value and those values recorded in the memory are stored, even after the instrument has been switched off. This data will only be wiped if the user wants to clear the memory.

*Reader Service 5*

| Overview of the range | C.A 6410 | C.A 6412 | C.A 6415 |
|---|---|---|---|
| $R_{earth}$ measurement range | 0.1...1200 Ω | 0.1...1200 Ω | 0.1...1200 Ω |
| Frequency limit | 2400 Hz | 2400 Hz | 2400 Hz |
| Current measurement | - | 0.002...30 A | 0.002...30 A |
| Audible continuity signal | - | - | Yes |
| Programmable alarm | - | - | Yes, high or low |
| Memory | - | - | 99 measurements |
| Standards conformity | IEC 61010, CE | IEC 61010, CE | IEC 61010, CE |

# 5 questions to ask yourself when choosing a thyristor power switch

***In the last edition of Contact Measurement News (no°13) we introduced you to our solid-state relay, the THYRITOP 1. Following on from this article, here is a five-step guide to help you choose the thyristor switching device best suited to your temperature control process.***

*From left to right, THYRITOP 1, THYRITOP 2, THYRITOP 3 and THYRITOP 4*

In the temperature control chain it is the sensor that informs the controller of the process temperature. Depending on the difference between the temperature observed and the temperature instructed, the controller sends out the order to correct the difference (a burst of heat in the case of an oven). This order is addressed to what we will refer to as a power-switching device. These are electronic thyristor modules, giving complete (solid-state relay) or partial (ac phase controller) current conduction across the load (oven resistance in our example). The load could equally be inductive, as is the case when heating is carried out by induction (aluminium bath), or when there is a transformer involved (low voltage controlled resistances, arc welding).

So when choosing the most appropriate power switching device from amongst the selection in the Temperature Measurement and Control catalogue, due consideration should be given to the type of load to be controlled and its operating environment.

Heating elements used in industrial ovens are grouped into four main families:

| Family | Materials | Temperature limit | Observations |
|---|---|---|---|
| Iron-Nickel-Chrome | Fe-20%Ni-25%Cr | 900°C | Comes as a wire or sliver. The wires are generally coiled or bent into waves. |
| | Fe-45%Ni-23%Cr | 1050°C | |
| | Fe-65%Ni-15%Cr | 1100°C | Little variation in resistivity as a function of temperature. |
| | Fe-70%Ni-30%Cr | 1150 to 1200°C | Often used because of their low price. |
| | Fe-80%Ni-20%Cr | 1150 to 1200°C | Operating atmosphere : oxidant. |
| Iron-Chrome-Aluminium | Fe-22%Cr-5%Al | 1350°C | Comes as a wire or sliver. Used because of their price (equivalent to that of Fe-Ni-Cr) but for a higher temperature. Low variation in resistivity as a function of temperature. Warning: brittle after first heating. Operating atmosphere: oxidant. |
| Non metallic resistances (Cermet and ceramics) | SIC (Silicon carbide) | 1600°C | Comes in heating bar form. The resistivity of this material varies greatly with temperature and age. Operating atmosphere: oxidant or de-oxidant. |
| | $MoSi_2$ (Molybdenum disilicide) | 1700 to 1800°C | Comes in pin form. Great variation in resistivity as a function of temperature. Brittle below 800°C. Operating atmosphere: oxidant. |
| | $Cr_2O_3La_2O_3$ (lanthanum chromite) | 1800 to 1900°C | Comes in heating bar form. Mechanically brittle and sensitive to thermal shocks. Operating atmosphere: oxidant |
| | Graphite | 2500°C | Comes in heating bar form. Higher cost. Only used in a neutral, de-oxidant or vacuum atmosphere. |
| Noble metals | Tantale | 2000°C | Comes as a wire or wafer (thermal screens). Great variation in resistivity. Use in neutral, de-oxidant or vacuum atmosphere. Very high cost. |
| | Molybdène | 2300°C | |
| | Tungstène | 2500°C | |

## 1. Is the load ohmic, inductive, or both at the same time?

**Ohmic load.** Is the load resistance constant with variation in temperature? This comes back to the well know $R_{hot}$ / $R_{cold}$ ratio that depends on the materials from which the heating resistances are made (see table 1). If the ratio is " 1 ", as in the simplest case, then we can suggest a simple product. If this is not the case however, and depending on the range of values, then we can offer you advanced current limitation features and special algorithms.

**Inductive load.** Do you know what the induction is, in Tesla (1T = 10000 gauss), of your transformer or inductive load? This value is extremely important to us when it comes to offering you the most suitable product.

## 2. What is the specification of your electrical network?

Is the supply single or three-phase? What is the rated voltage? The most common voltages are 230 V and 400 V. In industry this could be 500 V and even 690 V.

## 3. What operating mode do you want? (the answer to this question will have been already answered in part by your previous answers)

**On-Off.** The load is only fed when there is a voltage applied at the control input on the thyristor switch. It is opened and closed at zero volts. This operating mode is adapted to the most simple of installations where there is a certain amount of inertia in the system and it is tolerable to have a slight amount of variation on either side of the instructed temperature. The thyristor power switches bring the temperature up to that instructed, and then comes into play again when it has dropped sufficiently below.

**Full wave-switching mode (TAKT).** This mode controls the average power applied to the load by removing whole AC cycles on the load supply. This is the control mode that is recommended for most applications. The voltage is only applied to the load when the AC goes through zero volts.

**Phase angle (VAR).** Here, the average power applied is controlled by shortening each AC alternation by removing certain phase angles as needed. This operating mode is recommended for inductive loads (coils, transformers...). Phase angle power control can allow very fine adjustments to be made since a voltage is constantly being applied to the load. However, the downside to this method is that it generates disturbances (harmonics) on the electrical network.

**Soft Start/Soft Down (SSSD).** This method is a combination of the two previous methods. It starts off with phase angle control and then goes to full wave switching. The start-up time is adjustable from 10 ms (1/2 alternation) up to several hundred milliseconds. This method is a good alternative to the previous, since it only generates harmonics during the start-up phase. The MOSI algorithm improves further still this method for loads having a high Rh/Rc ratio. When cold, the resistance is controlled using the phase angle method, and then goes into full wave switching mode once the resistance has gone down.

## 4. What is the load-coupling set-up? What is the overall power necessary to feed the load?

There are two kinds of set-up, delta and star (with or without neutral for star set-up). Knowing the type of set-up and its rated power allows you to calculate the current passing through the thyristors, allowing us to suggest the most appropriate product. For three-phase for example, you could have a "two-phase cut-off" product. This is a lower cost alternative to a "three-phase cut-off" product. However, we would never recommend this product in the following cases:

- Presence of a neutral in the star set-up, since there is always a current flowing in the load.
- Phase angle operating mode, since the 3rd phase cannot be controlled.

## 5. What advanced features do you need for your application?

Thyristor power switches incorporate a number of features that help towards ensuring safety and monitoring the installation. These features are indispensable for the stability and the longevity of the temperature control process:

- **Monitoring the load:** in the event of a break in one or several of the loads, the power controller detects the fault and notifies this via a relay contact.
- **Current limiting:** limits current overload when starting up the installation, or current peak in the inductive loads.
- **Voltage limiting:** as in "phase angle" mode and when you want to limit the voltage to a fixed value.
- **Power limiting:** combination of the above.
- **Copying measurements:** to display or trace out the voltage, current or power values in real time using recording devices or a digital network.
- **Synchronisation:** in the case of an installation controlling several loads in "full wave switching" mode, synchronisation makes it possible to stop the units from all switching at the same time, allowing energy distribution to be finely controlled across the installation.
- **Communication:** direct connection to a central system which allows supervision and control of your heating units from a single location (control room).

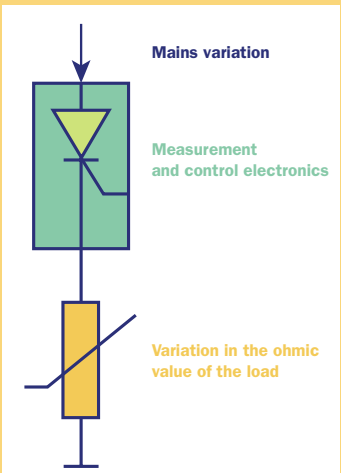
## Power controllers with regulating functions

Power switching devices have greatly evolved along with the need to increase the precision of temperature control processes. Thyritop 3 & 4 controllers give precise control over the electrical variables in a temperature control process (current, voltage and power). Any variation in the mains supply or the ohmic value of loads (through heating or ageing) are automatically compensated for. Nowadays these power controllers act as a complementary element to the temperature control process.

- Our sales teams are at hand to answer any questions you might have regarding the subjects covered in this article, helping you choose the product that is the best suited to your application. The right choice of power switching device pays off in a number of ways, for both you and your customers:
- It gives a better understanding off your energy needs
- No more need for parts that just wear out, ditto for maintenance and repair work
- You have a product that is precisely adapted to the type of load that is being controlled
- Constant monitoring of the state of loads
- Diagnostic functions on the state of your installation
- A substantial increase in the stability with which temperature is regulated, knowing the exact value of mains voltages
- Fewer electrical constrains imposed on the installation owing to the synchronisation of the power controllers
- The MOSI algorithm calculates the optimum warm-up time whilst ensuring the optimum longevity of costly molybdenum disilicide heating resistances.

*Reader Service 6*

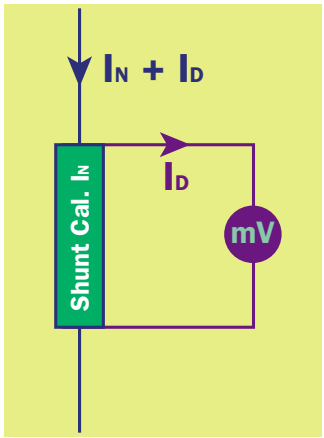
**The "power controller" constantly measures the mains and the current in the load. At any given time it can deduce the ohmic value of this load. Because it is permanently reading all the electrical values it can adjust the parameter of your choice: current, voltage or power.**



# Shunts available for your current measurements

***The current shunt is an all too often overlooked component. It is, however, an indispensable device in electrical installations when low frequency AC or DC current measurements are to be made on a permanent basis. Radio Contrôle, part of the Power Measurement & Control division, has three ranges of current shunts in its catalogue, each one with its own specifications.***

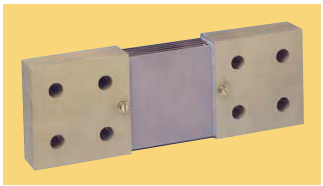
A current shunt is a conductive element whose electrical resistance is very precisely gauged. Following Ohm's law, the flow of current in the shunt generates a proportional potential difference at its terminals. This voltage can then be read by a measurement instrument to get a value of the measured current. The nominal current ($I_N$), the potential difference and the accuracy of this transfer function make up the main shunt's main characteristics. There are, however, a few others.




As current flows through the shunt it can be caused to heat up considerably. The material from which it is made should therefore give the lowest temperature ratio possible so as to ensure high accuracy at raised temperatures. The user should make sure that the shunt is suitably ventilated. The shunt's resistance to corrosion as well as the stability of the material over time are other essential factors. Another important consideration is the value of the current drawn by the measurement instrument connected to the shunt's terminals ($I_D$), which should always be much lower than the nominal current ($I_N$) range, at the risk of making false measurements. In practice, our current shunts are designed for a standard branching-off current of 5 mA.

Current shunts are generally mounted on bus bars in electrical installations. Lower current models may be mounted separately on insulated panels, blocks or in insulated casing that can even be clipped onto DIN rails.

## The SHMI range

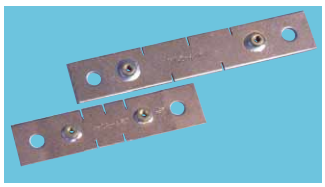


The "**engineerings**" models in this range have two brass connecting blocks on either side. Its **high temperature resistance** (up to +145°C sustained) makes this current shunt favourable for many applications.

They cover 1 A to 6000 A and come in 50, 60, 100, 150, 200 or 300 mV models with class 1 or class 0.5 accuracy. The 10 to 600 A models are in stock, they are both class 1 and give 100 mV.

## The SHEL range

This range is aimed at manufacturers of machines and electrical and electro-technical power equipment. Cost is kept down because connection



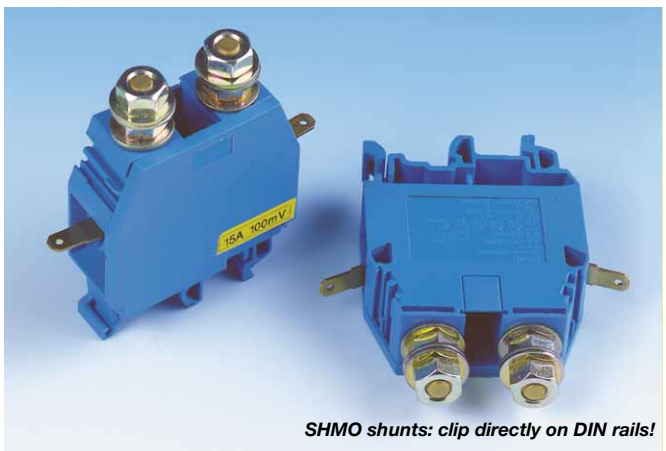
is made directly to the shunt's manganin plate (taking a few precautions). The range covers 10 to 300 A, the models are all in class 1, and give out 50, 60, or 100 mV. The 100 mV models are held in stock.

## The SHMO range

The shunts in this range have a modular casing design that may be clipped straight onto a 4267 or 50022 DIN rail. They have small ranges going up to 60A, have class 1 accuracy, and are aimed at switchboard engineers or installation specialists who appreciate the ease with which they are installed. Each SHMO module takes up one unit on the DIN rail.

Connection to power is done vertically via M6 threaded terminals, and the measurement connection is via 5.05 mm eyelet terminals set back slightly on the same wiring plane.

Our engineers will give you advice on the (mainly thermal) limitations for use. They can also offer solutions "upon request" for your specific measurement system models.




***SHMO shunts: clip directly on DIN rails!***

| SHMO MODULES : THE RANGE | | |
|---|---|---|
| | 50 and 60 mV | 100 mV |
| **1 A** | on request | in stock |
| **5 A** | on request | in stock |
| **10 A** | on request | in stock |
| **15 A** | on request | in stock |
| **20 A** | on request | in stock |
| **25 A** | on request | in stock |
| **30 A** | - | in stock |
| **40 A** | - | in stock |
| **50 A** | - | in stock |
| **60 A** | - | in stock |

*Reader Service 7*

## Stabilised laboratory power supplies


The AX 501, 502 and 503 are new single, dual and triple output (respectively) stabilised power supplies for laboratory use. Linear technology ensures greater stability and lower noise, in a smaller and lighter design that is also easier on the wallet! This 2-page leaflet gives further details on these advanced specifications.

*Reader Service 8*

TEST & MEASUREMENT

## 100 kHz to 50 GHz microwave power meter

The ORITEL MH 600 is a portable digital instrument for use on site and in the laboratory for the measurement of L.F. to S.H.F. transmitter powers, between 100 pW and 25 W, in dBm or in mW. With an extra wide dynamic range of 50 dB, this instrument proves to be multipurpose, exactly what is needed for applications that include radar, hertzian beam, etc.

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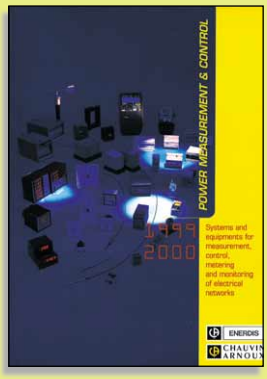
TEST & MEASUREMENT

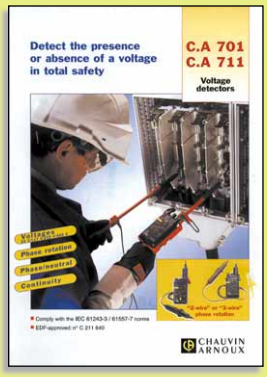

## Power Measurement & Control

The Power Measurement and Control division is there to serve companies that design and integrate, for themselves or others, fixed equipment on MV/LV electrical switchboards and industrial machines. You will find all the details on the product range available in this 120 page catalogue.

*Reader Service 10*

POWER MEASUREMENT & CONTROL




## EDF accredited voltage testers

The C.A 701 and C.A 711 voltage and phase order testers (Pfisterer license for original two-wire method using model C.A 701) conform with IEC 61243-3. They have also received EDF accreditation n° C 211 640.

*Reader Service 11*

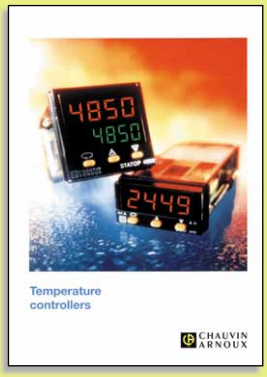
TEST & MEASUREMENT

## The best in temperature control

The STATOP range is broadening its horizons with new performance levels: new formats, new communication software, IP 50 to IP 65 front panel spec.,... This 8-page document helps you choose an analogue or digital controller.

*Reader Service 12*

TEMPERATURE MEASUREMENT & CONTROL





## Testing components, cables and antennae

Designed for use out on site as well as in the laboratory, the ORITEL RO600 scalar tester is highly ergonomic in design, easy-to-use, and the user interface is in the user's language. The guarantee of precision measurement. This 4-page leaflet gives further information.

*Reader Service 13*

TEST & MEASUREMENT

## Multimeter for explosive atmospheres


The MX 51 ExB is a 5000 count digital multimeter for use in dangerous or explosive atmospheres (Ex ib IIc T6). Specifications include MIN and MAX functions, bar graph display (x5 zoom and centre-zero), logic signal measurement, an adapter input and a robust casing design with IP 66 watertightness rating. This two-page colour sales leaflet details all these specifications and more for this intrinsically safe DMM.

*Reader Service 14*

TEST & MEASUREMENT

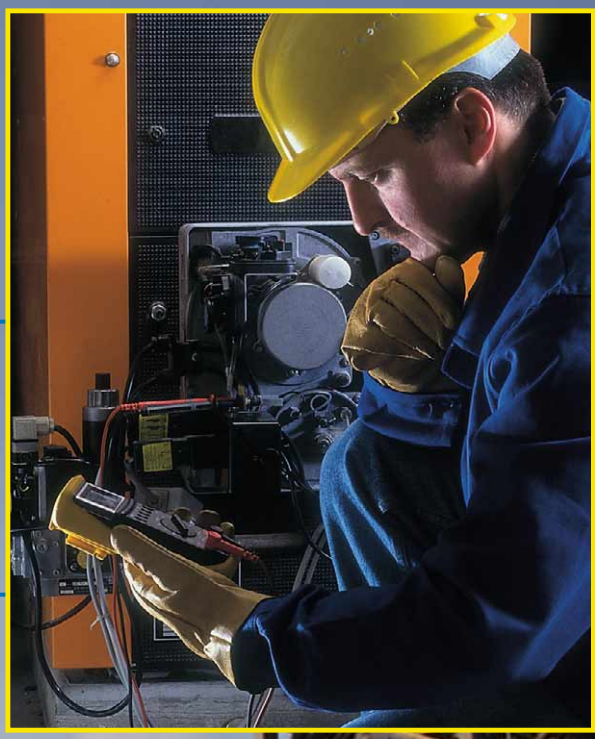
## Out-and-out power monitor

The recdigit NODUS has all the functions indispensable for measurement, metering and monitoring of LV three-phase networks. Compact (DIN 96x96 casing), it works in the four quadrants as standard, and has qualimetry functions: total harmonic distortion on V and I, and neutral current measurement. The menu can be set in English, as well as in German, Spanish or French.

*Reader Service 15*

POWER MEASUREMENT & CONTROL

# We have the industrial answer to your electrical measurement needs



The electrician's profession has become more and more complex as a result of an increasingly technological environment. So whether it's test, control or general instrumentation equipment that you need, our distribution network brings our expertise straight to you. All of which helps you to go about your business, whether it's in installation, maintenance...

## Industrial maintenance

## Manutenzione industriale

## Industrielle Wartung

## Mantenimiento industrial

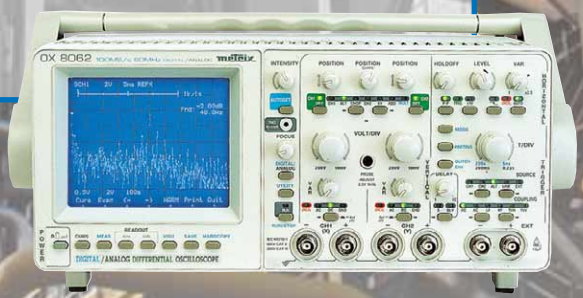
## Maintenance industrielle

**Electrical Installation Tester**
**C.A 6115**
Test electrical safety with a single instrument

**Megohmmeters**
**C.A 6521/23/25**
Insulation measurements have never been so easy

**Clamp-on power and harmonic meter**
**F27**
Analyse quality of electrical networks with ease

**Differential input oscilloscopes**
**OX 8062/8042/832/822**
Are you sure your measurements are earthed?
Got a single reference potential for both channels?
Happy with just 5 V/div?
Better think metrix differential oscilloscopes



**Clamp-on earth resistance testers**
**C.A 6410/12/15**
Test earth loop resistance in a flash, from 0.1 Ω upwards

**Metrix Multimeters**
**MX Concept Series**
Need a TRMS multimeter?
A straightforward low-cost instrument?
Then choose metrix!

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***The best in measurement***

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