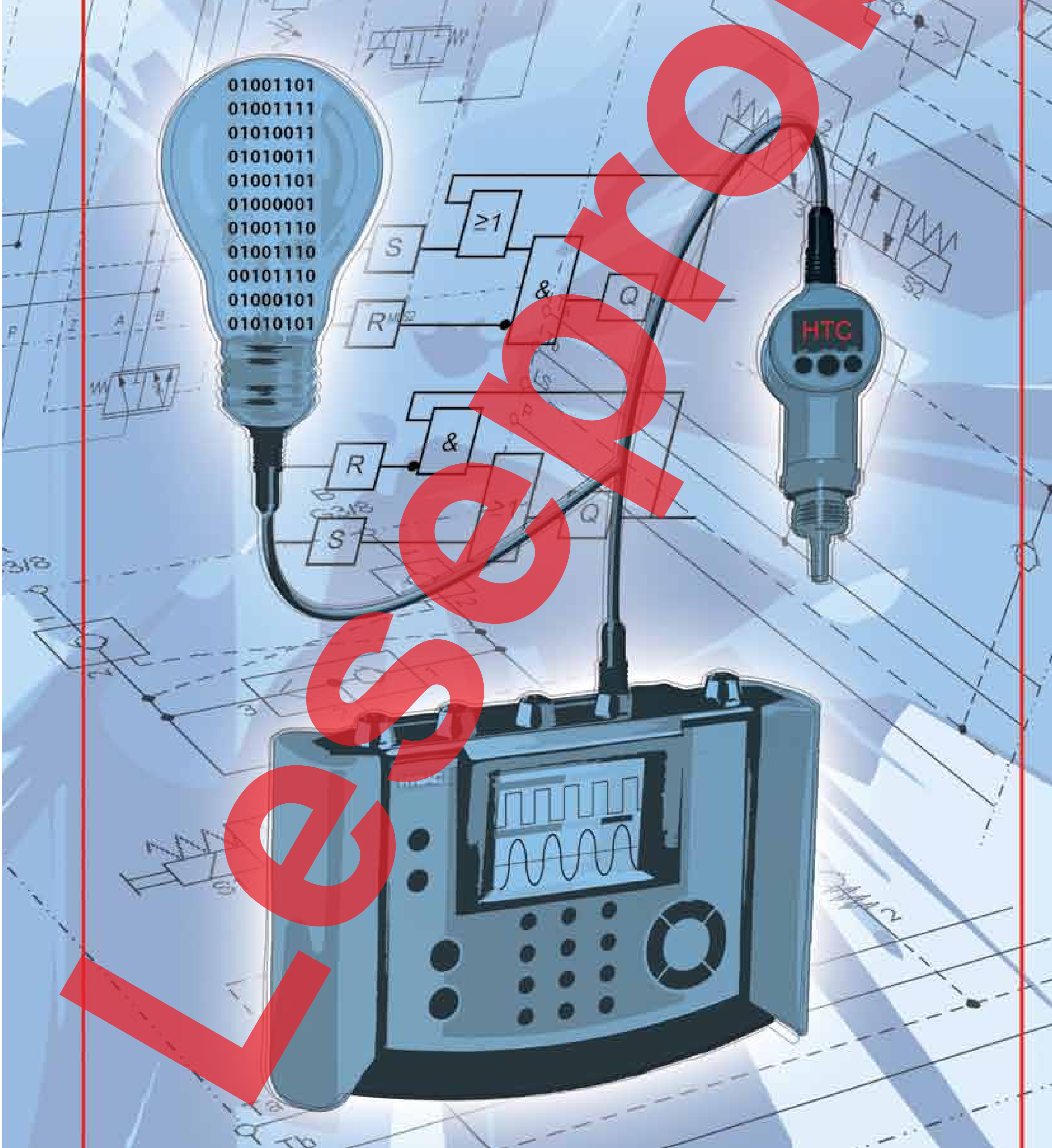
HYDAC TRAINING CENTER

Basics of electronics and measurement technology



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Publisher	HYDAC Service GmbH Training Center Hirschbachstrasse 2 D-66125 Dudweiler/Saar E-Mail: Training-Center@hydac.com SAP No. 3802481
Illustrations	Insofar as a differing reference source has not been noted: HYDAC International GmbH

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Preface

HYDAC is an internationally-active company with a wide product pallet concerning fluid technology.
The range of products extends from components through subsystems right up to complex, controlled and regulated drive units for mobile and stationary machines and systems.

In addition, we offer our customers a comprehensive package of technical services within the scope of HYDAC fluid engineering for media such as hydraulic oils, lubricants, cooling lubricants and water.
Our aims are exclusively to increase the availability of machines and systems and to lower the operating costs for our customers.

HYDAC has a worldwide competence network as well as high quality demands and customer orientation. and thus fulfils the high requirements placed on them by the international market.

The continual expansion of our global presences with strong local orientation makes it possible for us to attend to the needs of our customers at nearly any location in the world.
HYDAC is always close at hand with 12 Sales Offices in Germany, over 45 foreign subsidiaries, partially with their own Production or Assembly Departments, more than 500 Sales and Service Partners and over 7000 employees.

In order to ensure that our employees, service partners and customers remain capable of fulfilling the consistently increasing demands of their vocational environments, we provide training courses, seminars and practical training in our Training Center.

Here the term "Lifelong learning" is beginning to gain more and more importance.
Learning does not stop once you have finished school, training or studies, as learning is the most important tool for development, and therefore for the creation of individual chances in work and in life in general.

Lifelong learning breaks through the barriers of standard educational structures and the division into the strictly sequential sections of educational development, which is often concluded with school or further education qualifications. This also comprises of recognizing and utilizing education as a path to increased personal responsibility in your lives. Competency in lifelong learning will in future become a more and more important key for personal, economic and social success.

In order to adapt this innovative form of learning to individuals, we have decided on a learning concept which combines e-learning media with the advantages of classroom training sessions and practical training according to requirements.

This concept also includes the development of a series of books in which both basic hydraulics topics as well as more advanced hydraulic system topics are to be addressed.

This book can be utilized analog to our seminars and training courses and should at the same time serve as a reference book for further vocational practice.

Jürgen Ringle
Head of HYDAC Training Center

I Introduction to Physical Principles

This chapter explains the physical principles and effects of electrical engineering. It will focus in particular on the basic physical quantities and their units.

Notes:

1 Introduction

1.1 Basic SI quantities and units

Physical quantities are measurable characteristics of bodies or physical states. They consist of a numerical value and the unit of measure. Only SI units or units derived therefrom are used in technology (see table).

SI units:

Basic quantity	Basic unit	Unit symbol	Symbol
Length	Meter	m	l
Mass	Kilogram	kg	m
Time	Second	s	t
Electrical current	Ampere	A	I
Temperature	Kelvin	K	T
Quantity of material	Mol	mol	n
Light intensity	Candela	cd	I_V

Fig. Table of SI units

1.2 Unit prefixes

Very large and very small quantity values are expressed with a unit prefix.

The unit prefixes (a.k.a. SI prefixes) are based on orders of magnitude with whole number exponents and are used in the International System of Units (SI).

The SI prefixes are defined as follows:

SI prefixes	Name	Value	
T	Tera	$(10^3)^4 = 10^{12}$	1,000,000,000,000
G	Giga	$(10^3)^3 = 10^9$	1,000,000,000
M	Mega	$(10^3)^2 = 10^6$	1,000,000
k	Kilo	$(10^3)^1 = 10^3$	1,000
h	Hecto	10^2	100
da	Deca	10^1	10
Unit		10^0	1
D	Deci	10^{-1}	0.1
c	Centi	10^{-2}	0.01
m	Milli	$(10^{-3})^1 = 10^{-3}$	0.001
µ	Micro	$(10^{-3})^2 = 10^{-6}$	0.00.001
n	Nano	$(10^{-3})^3 = 10^{-9}$	0.00.000.001
p	Piko	$(10^{-3})^4 = 10^{-12}$	0.00.000.000.001
f	Femto	$(10^{-3})^5 = 10^{-15}$	0.00.000.000.000.001

2 Fundamental quantities and laws

2.1 DC circuit

A circuit consists of at least:

- A power generator (e.g. battery, generator)
- A consumer (e.g. bulb, motor)
- Go and return lines

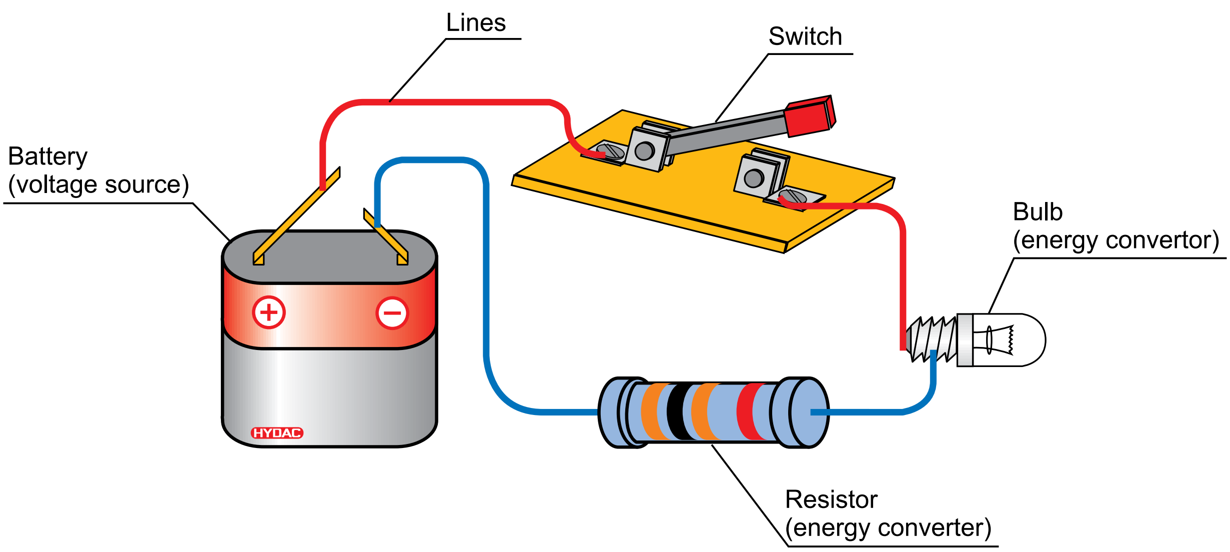

Fig. Graphic of DC circuit

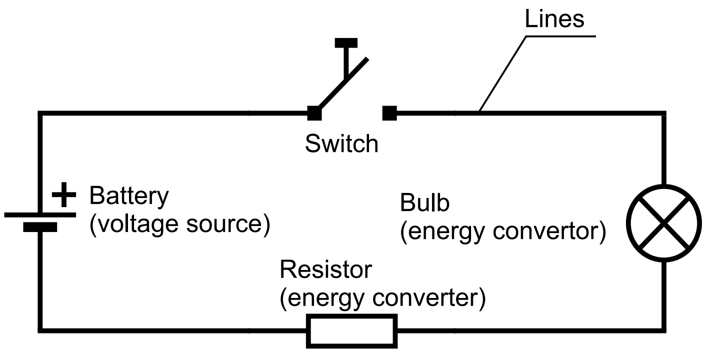

Fig. Symbolic view of DC circuit

2.2 Electrical charge, elementary charge

Symbol	Basic unit
Q	*C* = *As (Coulomb)*

All electrical phenomena can be attributed to a charge. A distinction is made between a positive (+) and negative (-) charge. There is electrostatic interaction between electrical charges (Coulomb's law). Charges with the same sign repel each other. Charges with opposite signs attract each other.

In physical terms, each charge quantity is an integral multiple of the elementary charge e (e = +/- 1.602 • 10^{-19} *C*). Electrons carry a negative elementary charge, protons carry a positive elementary charge. A deficit of electrons in matter causes the matter to have a positive charge, an excess of electrons causes it to have a negative charge.

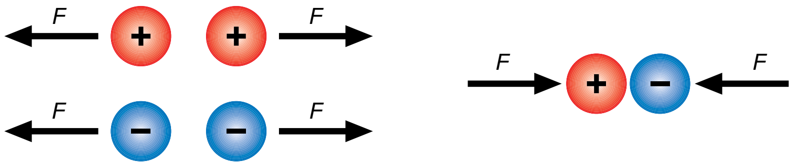

Fig. Attraction and repulsion of electrical charges

Note:
Work is needed to disconnect two charge carriers with different polarities.
Work = force • path ⇒ W = F • s

2.3 Electrical current

Symbol	Basic unit
I	*A (Ampere)*

The directed motion of the electrical charge carrier is referred to as electrical current. Electrical current only flows when there are enough free and moveable charge carriers between two different electrical charges. One example is in a conductive material (metal, liquid, etc.).

Example:

The current flow can be equated to flowing water in a tube. The more water in the tube, the more water comes out of the end of the tube. This is the same with electrical current.

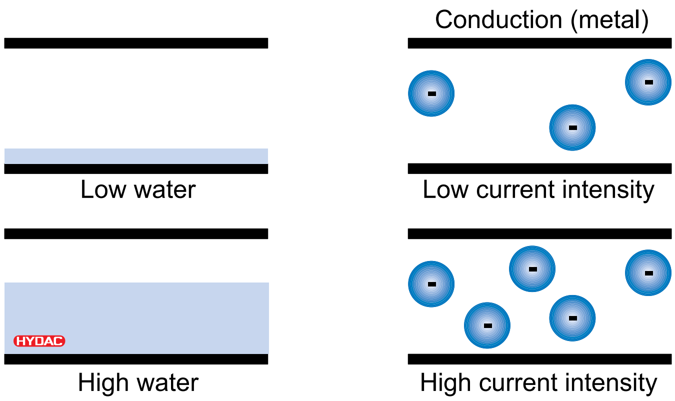

Fig. Comparison of water flow and electrical current

The more free charge carriers available, the greater the intensity of the electrical current through the conductor. In metallic conductors, electrons are the charge carriers.

Open and closed circuit:

In general, charges always move in a circuit. That means the current always flows in a closed cycle. Thus if the switch is open, no current can flow. Only when the switch is closed can current flow, since the circuit is closed.

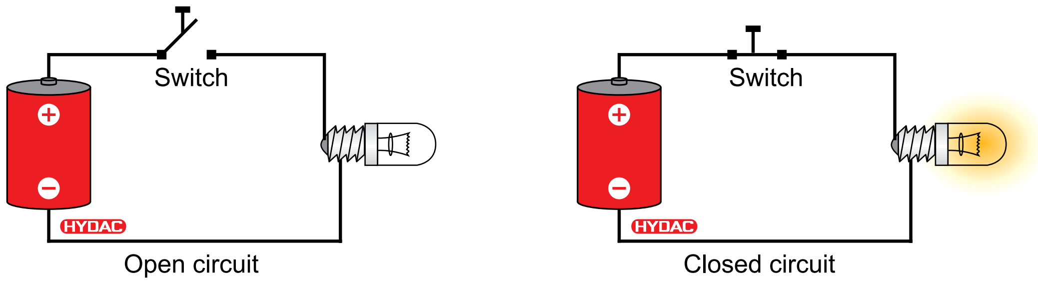

Fig. Circuit diagram for electrical circuit

2.4 Voltage and potential

Voltage symbol	Basic unit for voltage
U	*V (Volt)*

Electrical voltage is the difference in charges between two poles.

Voltage sources have at least two poles with different charges. One pole is positive with a deficit of electrons. The other pole is negative with an excess of electrons. The difference in the amount of electrons is referred to as electrical voltage. When the poles of the voltage source are connected to each other, current flow is created (discharge). Here the current always flows from the voltage source's positive pole to its negative pole (technical direction of current). Electrical voltage is thus the driving force that causes charge motion.

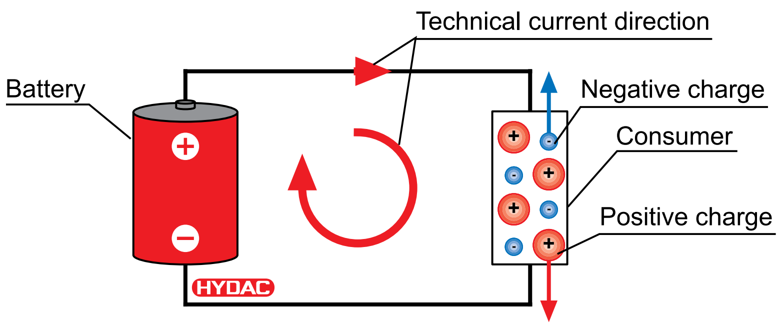

Fig. Battery voltage

Note:
Voltage arises from separation of charge. The tendency to re-equalize separated charges is electrical voltage, with the symbol U. Voltage is the work toward separation per charge.

Potential symbol	Basic unit for potential
φ (Phi)	*V (Volt)*

The potential φ of a point is equal to the voltage in comparison to a specific reference point (e.g. mass $\varphi_0 = 0\ V$).

When measuring a positive value, the potential is more positive than the reference point and the prefix is positive (φ_2, φ_3). When measuring a negative value, it is the opposite (φ_1).

In a circuit diagram, the voltage's direction of operation is shown by an arrow. In general, the voltage arrow is from positive to negative or from a higher voltage value (potential) to a lower voltage value (potential).

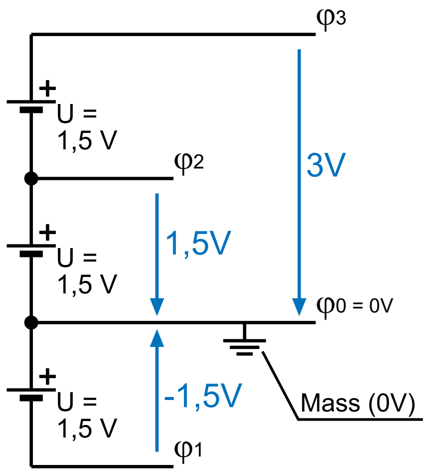

Fig. Battery potential

2.5 Current and voltage types

Direct current (DC):

Direct current is a current that flows with the same strength in the same direction (polarity). Typical DC sources are batteries, solar cells and fuel cells. DC technology is used e.g. in amplifiers or circuits with semiconductor elements and relays.

Alternating current (AC):

Alternating current is a current that periodically alters its quantity and direction (polarity). Since AC is more operationally efficient than DC, our power supply is run on sinusoidal alternating current. Another application area is telecommunications engineering.

Undulatory current:

Undulatory current is a current in which portions of DC and AC overlap. Undulatory current is used in modulation, AC amplification and telephone networks.

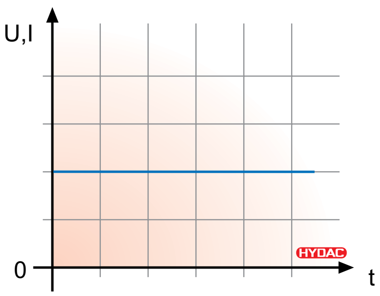

Fig. DC performance

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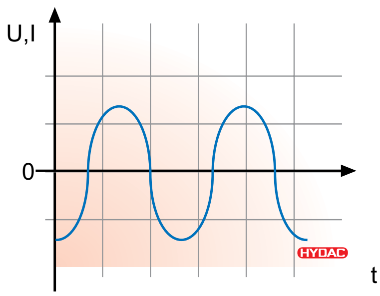

Fig. AC performance

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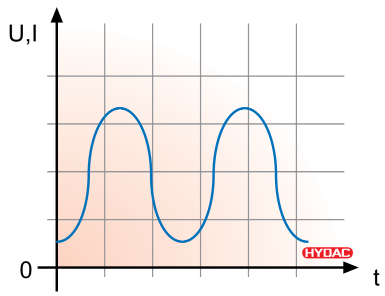

Fig. Pulsating current performance

Note:

All other physical views are based on a DC source.

2.6 Root mean square

The root mean square U_{eff} is the root mean square of a signal changing over time.

It corresponds to the value of a DC voltage that converts the same energy in an oHMGc consumer in the same amount of time. Its quantity depends on the peak value $\hat{U}$ (amplitude) and wave form of the signal.

Most often the root mean square voltage is given in the AC voltage that can be drawn from the power grid. This sinusoidal voltage, with a frequency of 50 Hz (60 Hz in the United States and other countries) and a peak value of 325 V, delivers the same output to a consumer (e.g. a toaster) as a DC voltage of 230 V in the average amount of time. However, peak output at peak value time is double.

Using the root mean square from the periodic current and voltage paths, the laws of direct current can be applied to oHMGc consumers instead of those of alternating current. The root mean square of a sinusoidal AC voltage is calculated using the following formula.

Formula:

$$U_{eff} = U = \frac{\hat{U}}{\sqrt{2}}$$

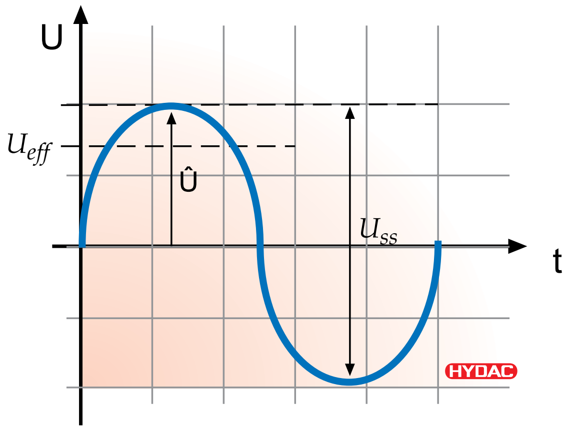

Fig. Root mean square performance

Note:

U_{eff} = root mean square
U = DC voltage
$\hat{U}$ = peak value of AC voltage
U_{ss} = Top peak value of AC voltage

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HYDAC Headquarters
HYDAC Companies
HYDAC Distributors and Service Partners

HYDAC INTERNATIONAL

HYDAC Service GmbH
TRAINING CENTER

Hirschbachstraße 2
66125 Dudweiler/Saar
Germany

Phone:
+49 (0) 68 97 / 509 - 1022

Fax:
+49 (0) 68 97 / 509 - 1014

Internet: www.hydac.com
E-Mail: Training-Center@hydac.com

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