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How to use this electronic textbook

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You will find them in German and English Language, structured in steps:
primary level
secondary level
scientific level
experiments
For a comfortable utilisation use the presentation mode for being able to take advantage of the hyperlinks leading to the corresponding text.

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December 2005

The risk for a human being exist when it is touching electrical voltage. Is it staying with one part of the body on the zero potential, then electric current flows through the body.
The level of the risk is dependent

- of the amperage
- of the duration of time of the current flow
- of the path of the current
- of the correlation between the peak of the alternating current and the activity of the sinuatrial node (vulnerable phase of the myocardium).

Special caution is demanded in watery room and wet areas:

- Switch should be in reaching area of the hands
- sockets
- electrical devices in reaching area of the hands

are dangerous current traps, because the transition resistance between a human being and the „surrounding“ due to the wetness is rather low.
Damaged Devices may not be mended, if thereby the insulation is affected.
Open heating wires and “old” plug connections are not allowed.
Unplugging of devices from socket using the cable is dangerous, because thereby die socket can be ripped out of the wall and respectively blank wires can be pulled out of their isolation.

Biomagnetic diagnostics:
The electrical function of the body consists of a batch of intracorporal current pulses in the area of mili seconds and is determined by the duration of time of the electrical potentials, which are either derived from the surface of the body or invasive from catheters or electrodes. The magnetic fields which are produced by current pulses allow it that the particular position and power of the power source can be defined.
Stimuli, which are caused by impulses, perception respectively morbidly process, lead to a synchronisation of the neural flows. Then they can be described as current dipole. A current dipole produces volume flows in the inner body, whose electrical potential can be touched on the surface of the body. The current dipole is furthermore surrounded by a magnetic field, which can be measured with an induction coil outside the body.
Measurements in the magnetic cardiogram above resulted above the heart (big surfaced coil) about 10 pT, brain streams (magnetic encephalogram) a factor 20 below.
Optical and acoustical stimuli cause fields on the body surface of about 1 fT, whereby these bio magnetic fields are 100 million fold weaker than the earth magnetic..
The big city noise lies at a frequency of 0,1 Hz at 10^7 fT and drops linear with the frequenca to the value 10^3 fT at 100 Hz.
Magnetic lung contamination lies at about 10^6 fT, the magnetic cardiogram provides 5.10^4 fT, the magnetic encephalogram about 10^3 fT, the evoked activity of the cortex of brain lies at about 90 fT and the geo magnetic activity ranges between 10^3 und 10^5 fT.
The field of the earth lies in the dimension of 5.10^{10} fT.

The usage of electric energy is common for approximately 150 years, the degree of application increases continuously. Although the state of art is presently at a very high level, more accidents caused by electric current happen, often with fatal consequences, because out of habituation and the invisibility of the danger safety regulations are ignored.
The special knowledge acquired on the basic level is sufficient in order to understand and also obey the reasonable danger warnings.
Even if in most cases when danger arises the contact with electric voltage is interrupted automatically and so the potential danger is switched off, still a residual risk remains since safety regulations granting a 100% protection, cause a decrease in the manifold usage of electric energy.
The most important preventive measurement I that only specialists, thus crtified licensed electricians, install and repair electrical devices.

If electric current flows through a resistance – each wire, each device is a resistance – a part of the electrical energy is converted into heat energy and that is why the wire and the device get hot. The bigger the amperage and the larger the resistance, the hotter gets the wire.
Too large amperage leads to an overheating of the wires and the bulb socket. In addition to that the bulb radiates too much warmth on a to high temperature level, so that the lamp shade can catch fire.
Since the resistance of a wire is the larger, the smaller the cross section is, a too thin wire overheats and smolders. Too thin wires unsuitable for the needed device power in Watts, conduct the electric current and put the device to function, but the wire overheats and gets in fact so hot that it can lead to the inflammation of e.g. insulating material, Then we talk about an electrically ignited fire. Copper which is used in wires is a very good conductor without large resistance. Other metals such as iron or also e.g. constantan have by far larger material dependent so called specific resistances, and serve for the heat production from electric current (“heating wires”, filaments). If such a material is used to “mend” a wire it inevitably causes fire, because the safety device (fuse) cannot switch off – the current which is conducted through the fuse is not too high, only the heat development is, due to the wrongly selected material too large.
Convoluted wires get hot rapidly, because one loop of the wire warms up the other one. Therefore and because of the additionally arising accumulation of heat: unreel wires always completely from the wire drum, do not hide convoluted wires under a carpet.

On the surface of a 100 W bulb temperatures of 200 ^oC can be easily reached. At this temperature also dry dust can easily ignite (excess of the ignition temperature).
Spotlights have a very small filament and besides a concave casing. This combination focuses infrared radiation, that means heat radiation on near objects. During this process the ignition point of paper and drapery can be reached and exceeded. Therefore keep at least half a meter distance.

From the technical point of view it is matter of fact that all devices must be paralleled into an electric circuit, so that each device gets the rated voltage of usually 230 ACV. Due to parallel connection amperages and rating summate.
Using too large amperage – there would be risk of fire – the fuse interrupts the electric circuit. In case too thin wires are used it cannot do this – the wires overheat prematurely.

If we have more than 1000 ACV we talk about high voltage. The special dangers of the high voltage are:

already proximity is enough to develop a spark which hits you and thus causes deadly surges as well as burns, cardiac arrest and respiratory paralysis which all mainly led to a quick death.

assistance can only be provided after switching off the high voltage, unless the concerned person is hurled from the electric circuit.

Fires can be ignited by electricity if the maximum permitted current densities are exceeded. This situation mainly arises by
- using flexible leads with a cross-sectional area which is too small
- extension cables,
- unauthorised replacement of fuses with those of a higher rating,
- crushing the ends of conductors during assembly and
- tearing out flexible leads during assembly.

The second cause is related to heat radiation or heat accumulation:
- disregarding the minimum distances from heating equipment and spot lamps etc.
- using powers which are too high,
- using a cable while still reeled up on the cable drum,
- tangled cables or
- laying an extension lead under a carpet (or behind boxing etc.), cables are left coiled up and are in addition to that covered with a carpet for example. (heat accumulation).

In resting state the concentration of the potassium ions in the cell is thirty times higher than outside, that of the sodium ions ten times higher outside than inside. With energy input (ATP) the sodium ions are transports to the outside against the concentration decline. The living cell membrane is an ion selective permeable membrane.
The rest potential can be calculated with the equation of Nernst, it is dependent of ln of the concentration proportion of the ions inside and outside of the cell, in addition to that the temperature is dependent in directly proportional percentage.
Is a certain determined negative resting potential exceeded, then the sodium channels open, the inflowing sodium ions lead from hyperpolarisation to depolarisation (- 70 mV ➔ + 40 mV). In this state the transport channels open fort he potassium ions, through which the state of the potential is reversed (repolarisation). Is the initial state rebuilt, then the sodium ions and also the potassium ions transport channels close, the carrier is cut out.
During this period of time („Death time“) the cell cannot percept any stimulus.
The regulation of the sodium channel:

The positive charges of the positive charged side chains from the amino acids let only particles like water molecules pass through. In the same way hydrated potassium ions are passed through.
Sodium ions are too small to be able to accumulate water molecules and are therefore excluded from the entry to the cell.
Is a cell affected by a stimulus, then the positive charges side chain turn similar to a switch and lets sodium ions influx.
Are nerves affected the channels open through which cell membrane and the sodium ions can flow in. The pumping out of the sodium ions from the inner cell is connected with energy input. The sodium-potassium-pump needs a very big part of the energy which is provided as ATP.
Beating of the heart:
Signal releasers are pace maker cells in the sinuatrial node. In the internal cell there lies a resting potential of – 70 mV (hyper polarisation). Through the opening of the sodium channels the sodium ions can flow out for the purpose of compensating the concentration gradient. Therefore the potential of the cell drops, under – 50 mV the calcium ions-channels open, they release the action potential, the actual electric pulse (big cusps red). A depolarisation follows, the sign reverses. During the closing of the sodium channels the potassium channels open. The potassium ions which flow through the cell membrane lead to the initial state of the cell (repolarisation).
Starting from the sinuatrial node the electric impulse flows through the left atrium and activates a first reaction there. The electrical impulses run in the consequence through the partition wall of the heart to the apex of the heart and along the outer wall of the heart back. They incorporate the myocardial which contracts. drives the oxygenated blood through a high pressure system in the body and therefore has a threefold as thick musculature as right ventricle, which transports the blood into the lung.
The right ventricle has to transport blood against the blood pressure in the artery pulmonalis (25/10 mm Hg – 3,3/1,3 kPa)and the left ventricle against the blood pressure in the aorta (120/80 mm Hg – 16/10,7 kPa). A total blood amount of 6 litres is transported a minute. In case of excitement the transported blood amount can be increased to the double, in case of intense corporal activity even to the six fold.
Especially striking is the there is only little work of the heart needed compared to the average energy amount of 10 MJ, which is absorbed every day.
Comparatively there are 30 MJ of energy in one litre of petrol.
In this comparison it is obvious how efficient the human vitally important drive works.

The advantage is founded in the circumstance that even at low energy transformation and respectively energy supply the heart is still operating and because of energetic reasons even if other sense organs drop out it can be still adhered.
The heart works in a pulse mode, the flowing speed is exactly that big that still laminar flow exists.
Stenosis bring about vortisity and therefore increased flowing resistance which has to be balanced by the myocardial through increased labour.
The pulse mode lower to a steady streaming on the one hand the extra stretchable aorta, and on the other hand the venous system takes over, which is only filled up to 20% as a rule, the position of the equalising pot at the end of the way of transportation.
Power of 3 watt per beating of the heart, the energetic effort of 1 Joule within 1/3 second according a frequency of 1 Hz.
The aorta is stretchable and compensates the not continuous pumping impulses to a more constant flow.

So that the organism reacts on magnetic respectively electric fields, a certain height of signals has to exceed the hissing, therefore a defined signal-hissing-proportion is necessary.
The hissing of the human organism is denoted by Jonson´s noise:

$$\left\langle v_n^2 \right\rangle = 4 \cdot k \cdot T \cdot B \cdot R$$

with v_n^2 as average square of the electrical potential, R as resistance and B as band width.
Furthermore it is essential for the induced current density j:

$$j = ó \cdot E = \partial \cdot ó \cdot r \cdot f \cdot B_0 \cdot \sin ù\, t$$

with r as transversal radius of man.
The force, which a magnetic field H (indent with B in the air) performs on the bimolecular dipoles, is proportional to H², therefore F ~ H².

The electrical resistance of a human being is basically defined by the skin transition resistance and the insulation on the sole of foot (shoes, ground).
Most dangerous because most common is the current path hand–foot, especially if it leads through the area of the myocardial. The hand-hand-path is dangerous at direct contact with electric voltage.
The effect of electric current is dependent on the frequency: high frequencies are less dangerous nearly not dangerous at all because they cannot endanger the myocardial frequency due to the mass inertia, in addition to that resonant influences are missing.
The skin resistance at voltages in the volt area is up to 100 kOhm und drops with increasing voltage of total less than 500 Ohm.
The diagram shows the impact of body amperages in mA in contrast o the duration of the effects.
The usual barrier is about. Above it is the area in which the operating amperage is feel able but has no consequent damaging. With increasing duration of the effects the value for the amperage drops.
The releasing border and with growing duration of the effects the probability of myocardial fibrillation is I = 220 mA. In some areas aspects occur which concern the stimuli guidance, however they are reversible there.
Above I = 500 mA the slightest impact can already be lethal.

The electric resistance of a human being is basically created by the skin transition resistance and the insulation on the foot soles (shoes, floor).
The most dangerous one because the most common one is is the current path hand – foot especially if it leads through the area of the myocardial. The hand – hand – path is dangerous if one is directly dealing with electric voltage.
Furthermore the impact of the electrical current is dependent on the frequency: High frequency is less dangerous because it cannot endanger the myocardial due to the mass inertia, another reason is the lack of resonant influences.
The skin resistance is at voltages in the voltage are of 100 kOhm and drops with increasing voltage of all in all lower than 500 Ohm.
At a power supply frequency of 230 ACV the human resistance is estimated with 1,3 kOhm.
The following table shows the specific resistance ρ in Ωm for a human being:

Frequency in Hz	Muscle	Heart	Lung	Brain	Fat tissue	Blood	Plasma
10	9,6	9,6	11				
100	8,9	9,2	11			1,6	
1.000	8,0-9,8	7,0-13`	`10 - 19	4,5-8,0	`6 - 25	1,2-1,8	0,6
10.000	7,6-8,8	6	9,7			1,5	

For electrical needs the human body is displayed as calm-shelled rotation ellipsoid in an axle proportion of 1:5 . In the following „iS“ means inner layer, therefore outer shell and „iK“ inner core layer, therefore inner shell. Basically the influence of the outer electrical field of the field density S inside the body causes the development of an electrical field E by means of polarisation and displacement of charge

$$\vec{E} = \tilde{n} \cdot \vec{S}$$

For „specific body values“ σ = 50 mS/m (σ - specific conductivity in millisiemens per metre) and for the field frequency f = 50 Hz are these approximation formulas resulting:

$\frac{E_{iS}}{E_a} = 10^{-6}$ (outer layer) and $\frac{E_{iK}}{E_a} = 0{,}2 \cdot 10^{-6}$ for the core layer.

Damages to persons arise from touching voltages and the following current flow through the human being.
At body circuit the touching voltage is avoided by disconnecting the electric circuit in the area of the fuse after short circuit current with help of the protective wire. Only protective insulated devices which are marked with double squares do not need a protective earthing, therefore no PEN - plug, they show a contour plug.

In any case, the current-operated earth-leakage circuit breaker (RCB) which compares the upstream current with the downstream current helps in the event of single-pole contact. RCB is triggered if the fault current or current leakage is through a person (i.e., this portion of current is missing from the return line).
Two-pole contact treats a person as an electrical resistance carrying a current. There is no way of preventing this risk.
A fault-to-frame short circuit is the connection between a live component of the current circuit and a non-live component of the equipment such as the cabinet housing. This fault-to-frame short circuit enables the electrical voltage to reach metallic surfaces which can be touched.
This voltage which can be touched by people is called a touch voltage. If a person touches the surface, the electrical current will flow though that person's body to the ground.
The following measures may help to prevent touch voltages from occurring:
Protective insulation
Standing surface insulation
Insulated gloves and insulated footwear
Protective earthing and fusing – if there is a touch voltage, the current is immediately conducted to earth and triggers or blows the circuit breaker or fuse which interrupts the source of the current in the circuit.

The action potential which emerges from nerve cells is passed on over the longihshed appendages of the nerve cells dendrits and axons. The axon is the branch which leads away from the cell, it to the synapse. On the way there the transmission is carried out by an electrical impulse. In the synapse messenger are set free, which activate the adjoining dendrit of the neighbouring nerve cell. The dendrit is sort of supply pipe of the nerve impulse to the next neutron.
The synaptic system heightens the transferrate, but is also the target of nearly all measurements which aim for the paralysation of the nervous system (military struggle material, which effects the nervous system).

Man realizes danger in a relative slow way, because the transmission frequency of the nerve impulses is relative low and in addition to that a relative high detail recognition rate is also necessary for the realisation of a safe impression.
On principle man saves pictures and sequences and compares them with the real arriving signals.
Man also learns from saved experience and has on contrary to the animal the ability to carry out abstract connections.
To be able to recognize risks (e.g. any venomous snake is faster with reaction than man) a human being has a sort of bypass in the recognition system. If the first information gives the possibility of threat (the formation has the shape of a snake), man reacts knee-jerk, only then he compares further the saved picture and reality (if he works on further information he realizes that there is only a harmless root).

Mostly a short circuit is caused by a defect of the insulation generating a short circuit current passing a device, which is out of the circuit. Exactly it is ment, that because of the short circuit the device is not switched in series, but paralleled to the uninsulated piece of the wire. By this the total resistance rapidly sinks. The intensity of this short circuit current enormously increases in the moment. Short circuit current means, that the device, better its resistance, is bridged.
Overload happens by switching more and more devices into the circuit. By this paralleling of the devices the intensity of current increases step by step and finally exceeds the maximum rate over which danger of inflammation starts existing because of the electric heat.
Overload protection means, that if the maximum nominal rate is exceeded the circuit is interrupted by a overcurrent device. This is managed by an magnetic effect of a coil and by a bending bimetal or by a fuse based on a thin melting wire.
Any fused circuit is characterized by a maximum nominal rate of electric current and by also by a minimal cross section of the wires. If the cross section is too small, the wire overheats and in consequence and electrically caused ignition will happen.
Furthermore bulbs with a power exceeding the maximum nominal rate being indicated in the socket lead to generation of a fire.

Step voltages come about from high voltages reaching the ground (from lightning strikes or broken overhead power cables hanging down and touching the ground).
These produce a zone where there is a potential gradient with its maximum at the touch point.

The potential drops towards the zero earth potential with increasing distance from the touch point (follow the rules).
The effect of the step or distance between the feet is that a potential difference is set up between the legs which causes a current to flow through the body. The larger the distance between the feet, the greater the electrical voltage.
Animals with very large distances between their fore and hind legs are particularly at risk from lightning strikes.
When there is an accident involving high-voltage power lines hanging down and touching the ground, those who are within the potential gradient must move with their legs as close together as possible.

Shaving sockets in bath rooms are not directly connected with the supply voltage
An isolating transformer is switched between power system and socket. Has no wire of the secondary coil an earthing, then the two poles of this socket have a voltage of 230 Volt but only against each other. The secondary electric circuit of the isolating transformer is disconnected from the other power system and the ground. An endangerment is only then possible, if both poles of the socket which is connected with the isolating transformer are touched at the same time.

It is called power protection cut out or residual current circuit breaker (RCB).
In case of overload the installed bimetal bends and moves a lever, through which a safety catch is opened, the spring breaks the current contact.
For low over current amperage the magnetic force of a coil is not sufficient to aim an effect on the lever.
For short circuit amperage the magnetic field of a coil reacts much quicker than the inactively reacting bimetal. The coil ropes the lever into the coil, thereby the safety catch is opened.

The advantage of the four-wire system is that it provides power at two different voltages: U = 230 V AC is available between the phase conductors and the neutral conductor and U = 400 V AC is available between each of the phase conductors.
Only the phase conductors are live. The thickness of the conductors (measured by the amperes (or kiloamperes) or kilowatts that they are capable of carrying) is determined by the power which is to be drawn.
Circuit closure is not only achieved by direct contact with a live voltage carrying socket.
During a short-circuit event (fault-to-frame) caused by a live conductive component with defective insulation touching a non-live conductive component, the mains voltage can be touched in the non-live conductor – the term used for this is ‘shock hazard voltage’.
With appropriate protective measures in place, if there is a short circuit caused by a live component touching a non-live component, the fuse or circuit breaker trips immediately.