VOLTAGE DROPS

v.1.0

Calculating voltage drop for the feeding line (pair of cords).

1. Theory.

The basic problem in feeding devices with low voltage are voltage drops on feeding cables.
The maximum distance of the receiver from the feeding source and cable cross-section determines the voltage drops.

Equations for relative voltage drops are presented below:

- **FEEDING WITH DIRECT CURRENT DC:**

$$\frac{\Delta U}{Un} = \frac{2 * In * l}{\delta * Un * s} * 100\%$$

- **FEEDING WITH ALTERNATING CURRENT AC:**

$$\frac{\Delta U}{Un} = \frac{2 * In * l * \cos\varphi}{\delta * Un * s} * 100\%$$

where:
- Un - feeding voltage [V],
- ΔU relative voltage drop [V],
- In rated current [A],
- l line length [m],
- s cable cross-section [mm²],
- σ conductivity [S*m / mm²] (for copper = 58),
- cosφ coefficient of phase shift

- **ACTIVE POWER OF THE DEVICE:**

In case when the manufacturer states the nominal power and supply voltage, it is necessary to calculate the power consumed by the device, by means of the following formula.
The above-mentioned formula may be also used in case of calculating power losses on feeding cables when elaborating feeder power balance (which means that feeder power must be greater or equal to the sum of power of all receivers and losses in sending electric energy)

P= U x I *(for the DC voltage)*

P= U x I x cos φ *(for the AC voltage, in case of* cosφ *=1, P=U*I)*
after conversion: I=P/U or I=P/(U x cosφ)
where:
- *P* active power [W],
- *U* nominal supply voltage [V],
- *I* nominal current [A],
- cosφ phase shift coefficient

2. table of voltage drops for standard copper cords (Cu), for 100 running metres length with direct load current.

Cross-section		Diameter (Φ)	Rated current (DC or AC cosφ =1)			
mm²	**AWG**	**mm**	**0.1 A**	**0.5 A**	**1 A**	**5 A**
			voltage drop ΔU [V] @100 running metres			
5.26	10	2.59	**0.07**	**0.34**	**0.68**	**3.42**
4.17	11	2.3	**0.09**	**0.43**	**0.87**	**4.33**
3.31	12	2.05	**0.11**	**0.55**	**1.09**	**5.46**
2.62	13	1.83	**0.14**	**0.68**	**1.37**	**6.85**
2.08	14	1.63	**0.17**	**0.86**	**1.73**	**8.63**
1.65	15	1.45	**0.22**	**1.09**	**2.18**	**10.91**
1.31	16	1.29	**0.28**	**1.38**	**2.76**	**13.78**
1.04	17	1.15	**0.35**	**1.73**	**3.47**	**17.34**
0.82	18	1.02	**0.44**	**2.20**	**4.41**	**22.04**
0.65	19	0.91	**0.55**	**2.77**	**5.54**	**27.69**
0.52	20	0.81	**0.70**	**3.49**	**6.99**	**34.95**
0.41	21	0.72	**0.88**	**4.42**	**8.85**	**44.23**
0.33	22	0.64	**1.12**	**5.60**	**11.20**	**55.98**
0.26	23	0.57	**1.41**	**7.06**	**14.02**	**70.58**
0.2	24	0.51	**1.76**	**8.82**	**17.63**	**88.16**

3. Exemplary calculations.

Example 1.
Calculating maximal length of the supply cable.
Assumptions:
- supply voltage 13.8V/DC (f. ex. typical buffer feeder)
- power consumption 1A
- minimal device supply voltage 12V/DC (at the end of the line)

formula:
(max length)= [(real current)/(table current*)] x {[(feeding voltage) – (minimal voltage.)]/(voltage drop. table)} x 100
** see cut; cable cross-cut -> voltage drop = current column*

result: L= (1/1) x ((13.8-12)/3.47) x 100= (1.8/3.47) x 100= 0.52 x 100 = 52 [m]
maximal distance of the receiver for 2x1 mm² cable equals 52m

result: L= (1/1) x ((13.8-12)/1.37) x 100= (1.8/1.37) x 100= 1.31 x 100 = 131 [m]
maximal distance of the receiver for 2x2.5 mm² equals 131m.

Example 2. Calculation of minimal feeder voltage to compensate voltage drops.
Assumptions:
- 2x0.5 mm² cable
- cable length – 150 m
- power consumption 0.6A
- minimal device supply voltage 10V/DC (at the end of the line)

formula:
(supply voltage)= (minimal voltage) + {[(actual length)/100] x [(real current)/(table current*)] x (table voltage drop)}
** see cut; cable cross-cut -> voltage drop = current column*

result:
U= 10 +((150/100) x (0.6/0.1) x 0.7)= 10 + (1.5 x 6 x 0.7)= 10 + 6.3 = 16.3 [V]
minimal initial voltage of the feeder equals 16.3V

Example 3. Calculation of power consumed by the device basing on the power.
Assumptions:
- power of the device (f. ex. camera) 20W
- supply voltage 12V/DC

formula:
(current of the device)= (power of the device) / (supply voltage)

result:
I= 20 / 12 = 1.67 [A]
power consumed by the device with nominal 12V supply voltage equals 1.67A.

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