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Choose the Right Cable

Wire Sizing, A Practical Guide

Properly sized wire can make the difference between inadequate and full charging of a battery system, between dim and bright lights, and between feeble and full performance of tools and appliances. Designers of low voltage power circuits are often unaware of the implications of voltage drop and wire size. In conventional home electrical systems (240 volts ac), wire is sized primarily for safe amperage carrying capacity (ampacity). The overriding concern is fire safety. In low voltage systems (12, 24, 48VDC) the overriding concern is power loss. Wire must not be sized merely for the ampacity, because there is less tolerance for voltage drop (except for very short runs). For example, a 1V drop from 12V causes 10 times the power loss of 1V drop from 240V.

Determining tolerable voltage drop for various electrical loads.

1. Work out how many amps are to be carried along the line (amps load)
2. Work out how many metres the cable needs to run and multiply by two for twin cable (length x 2).
3. Mutiply the figures above by any of the resistances listed below. This will give you the voltage drop, ie : amps load x length x 2 x resistance = Vdrop.
4. Check that the 'Nominal Current Rating' (at 1m) in the table is not exceeded. If it is, then you may need to select a larger wire size with an adequate rating. While the figures given are conservative, they must not be exceeded in 240V applications and may need derating in higher temperature situations.
6. A general rule is to size the wire for approximately 2 or 3% drop at typical load. Different electrical circuits have different tolerances for voltage drop.

Number & Size of Strands	Nominal Conductor Area (sq. mm)	Nominal Current Rating (Amps)	Maximum Resistance per metre (ohms 35‹C)	Nearest Equivalent AWG (B&S)
10 x 0.12	0.11	1.1	0.17	27
7 x 0.16	0.14	1.4	0.13	26
1 x 0.5	0.20	2.0	0.10	24
14 x 0.14	0.22	2.2	0.088	24
7 x 0.2	0.22	2.2	0.086	24
1 x 0.6	0.28	2.8	0.067	23
1 x 0.7	0.38	3.8	0.049	21
14 x 0.2	0.44	4.4	0.043	21
10 x 0.25	0.49	4.9	0.039	20
50 x 0.12	0.55	5.0	0.035	20
60 x 0.12	0.70	7.0	0.027	19
24 x 0.2	0.75	7.5	0.025	18
30 x 0.2	0.94	9.4	0.020	17
1 x 1.13	1.0	10	0.019	17
32 x 0.2	1.0	10	0.019	17
512 x 0.05	1.0	10	0.019	17
7 x 0.5	1.4	14	0.014	16
30 x 0.25	1.5	15	0.013	15
26 x 0.3	1.8	17	0.010	15
26 x 0.32	2.1	19	0.0091	14
7 x 0.67	2.5	22	0.0077	13
1 x 1.78	2.5	22	0.0076	13
252 x 0.127	3.2	29	0.0059	12
41 x 0.32	3.3	30	0.0057	12
315 x 0.12	3.6	30	0.0053	12
630 x 0.12	7.1	50 max.	0.0027	1
1666 x 0.12	18.8	120 max.	0.0010	-

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Information

OHM'S LAW

Ohm's law is a simple mathematical equation that establishes the relationship between voltage, wattage and current.

Ohm's law (in part) states that amps x volts = watts, watts divided by volts = current.

Some examples are: a 240 volt appliance rated at 1.4 amps = 1.4 x 240 = 336 watts, a 1500 watt 240 volt appliance connected to a 24 volt battery is drawing current from the battery at 1500/24 = 62.5 amps from the battery to the inverter. Note: this assumes 100% efficiency. This figure should then be corrected for inverter losses. (62.5 divided by inverter efficiency).

Refer to inverter efficiency data. A 1500 watt load is drawing 6.25 amps ac from the inverter. (1500/240 = 6.25, no efficiency correction needed). A 12 volt light rated at 1.2 amps is 1.2 x 12 = 14.4 watts.

The majority of common appliances have a current or wattage rating printed on them, which is of benefit for making calculations. When an appliance uses varying amounts of power this is usually the maximum.

DC Power Cable Selection

Cables that are used between your solar array, monitors, regulators and your batteries, for example, are an important part of your system. Tek Trek recommends the use of 6mm cables (or larger) where budget allows.

The list below shows the range of cables we have available:

Cat. No.	Description	Roll Size	Area	Conductor	
WH3064	25mm2 DC POWER Cable (4G) OFC RED	50 mtrs	2.77 sq mm	7x7x34/0.127mm	
WH3066	25mm2 DC POWER Cable (4G) OFC BLACK	50 mtrs	2.77 sq mm	7x7x34/0.127mm	
WH3080	2.90mm^2 (12G) DC Power Cable RED	100 mtrs	2.90 sq mm	41/0.30mm	
WH3082	2.90mm^2 (12G) DC Power Cable BLACK	100 mtrs	2.90 sq mm	41/0.30mm	
WH3070	35mm2 (2G) Power Cable RED	30 mtrs	5.93 sq mm	145x19/0.12mm	
WH3072	35mm^2 (2G) Power Cable BLACK	30 mtrs	5.93 sq mm	145x19/0.12mm	
WH3078	Fig.8 DC Power Cable, 26/0.3mm	100 mtrs	1.97 sq mm	2x26/0.3mm	
4DS-100	4mm Twin Double Sheath	30m	1.84 mm^2	26/0.3mm	
4DS-100	4mm Twin Double Sheath	100m	1.84 mm^2	26/0.3mm	
6DS-30	6mm Twin Double Sheath	30m	4.59 mm^2	65/0.3mm	
6DS-100	6mm Twin Double Sheath	100m	4.59 mm^2	65/0.3mm	

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Items affected by voltage drop

LIGHTING CIRCUITS, INCANDESCENT AND QUARTZ HALOGEN (QH): Don't cheat on these! A 5% voltage drop causes an approximate 10% loss in light output. This is because the bulb not only receives less power, but the cooler filament drops from white-hot towards red-hot, emitting much less visible light.

LIGHTING CIRCUITS, FLUORESCENT: Voltage drop causes a nearly proportional drop in light output. Flourescent lights use ½ to1/3 the current of incandescent or QH bulbs for the same light output, so they can use smaller wire. We advocate use of quality fluorescent lights. Buzz, flicker and poor color rendition are eliminated in most of today's compact fluorescents, electronic ballasts and warm or full spectrum tubes.

DC MOTORS may be used in renewable energy systems, especially for water pumps. They operate at 10-50% higher efficiencies than AC motors, and eliminate the costs and losses associated with inverters. DC motors do NOT have excessive power surge demands when starting, unlike AC induction motors. Voltage drop during the starting surge simply results in a "soft start". The only drawback with DC motor pumps is that they are brushed and once worn down generally cannot be replaced requiring a new pump to be installed.

AC INDUCTION MOTORS are commonly found in large power tools, appliances and well pumps. They exhibit very high surge demands when starting. Significant voltage drop in these circuits may cause failure to start and possible motor damage.

SOLAR DIRECT SOLAR WATER PUMP circuits should be sized not for the nominal voltage (ie. 24V) but for the actual working voltage (in that case approximately 34V). Without a battery to hold the voltage down, the working voltage will be around the peak power point voltage of the solar array.

SOLAR BATTERY CHARGING CIRCUITS are critical because voltage drop can cause a disproportionate loss of charge current. To charge a battery, a generating device must apply a higher voltage than already exists within the battery. That's why most solar modules are made for 16-18V peak power point. A voltage drop greater than 5% will reduce this necessary voltage difference, and can reduce charge current to the battery by a much greater percentage. Our general recommendation here is to size for a 2-3% voltage drop. If you think that the solar array may be expanded in the future, size the wire for future expansion. Your customer will appreciate that when it comes time to add to the array. We have seen too many installations where the original cable has to be torn out because it couldn't accommodate a larger solar array.

WIND GENERATOR CIRCUITS: At most locations, a wind generator produces its full rated current only during occasional windstorms or gusts. If wire sized for low loss is large and very expensive, you may consider sizing for a voltage drop as high as 10% at the rated current. That loss will only occur occasionally, when energy is most abundant. Consult the wind system's instruction manual.

More techniques for cost reduction

ALUMINIUM WIRE may be more economical than copper but we do not recommend it. Aluminium wire has attributed to more house fires than any other single cause due to its high resistivity and basically inflexible nature. It is now banned for house wiring in Australia, New Zealand, USA & UK.

HIGH VOLTAGE SOLAR MODULES: Consider using higher voltage modules to compensate for excessive voltage drop. In some cases of long distance, the increased module cost may be lower than the cost of larger wire.

WATER WELL PUMPS: Consider a slow-pumping, low power system with a storage tank to accumulate water. This reduces both wire and pipe sizes where long lifts or runs are involved. A solar direct pumping system may eliminate a long wire run by using a separate solar array located close to the pump.