Wiring Ampacity, Voltage Drop and Grounding

Class 4 for Solar Team 7



Wires, all different sizes.







Voltage = Current/Amperage x Resistance/Ω



Ohm's (Ω's) law defines the relationship between Voltage, Current and Resistance in any electrical circuit Voltage = Amps/Current/I x Resistance/Ω simply V = I x R

(I comes from the French, intensité)



Wires resist the the movement of electricity. and they have to be the right size or...

Amp

Volt

We have to size wires so they can carry Amps/Current without overheating. Amp Volt

Ampacity

is the current carrying capacity of a wire.

Ampacity

Wire ampacity is the maximum electrical current (Amperes or "Amps") that safely exist in a given size of conductor.

We use copper wire which has high ampacity.

Wire Gauges Size & Wire Ampacity Table										
3/0 Gauge	WWW.ELECTRICALTECHNOLOGY.ORG									
1/0 Gauge	150 AMPS									
3 Gauge	100 AMPS									
6 Gauge	55 AMPS									
8 Gauge	40 AMPS									
10 Gauge	30 AMPS									
12 Gauge	20 AMPS									
14 Gauge	15 AMPS									

Larger wires have smaller gauge numbers just to confuse us.

Here's your system again. # indicates American Wire Gauge/AWG Which wires are the largest?

These wires carry the most Current/Amps in your system. **#2 AWG**.

Your 1500W 120V inverter can be drawing

1500Watts from your **12V**olt battery.

How many amps are those wires carrying?

Watts Amps Volts

$1500W \div 12V = 125A$ from the battery

Actually it can be much higher when an appliance has a startup surge. The **150 amp** fuse allows surge to pass through before heating, melting and cutting off power.

Wire gauge ampacity and wattage reference chart

We use tables when we don't know the exact resistance of a wire Choose numbers that are closest ...

		Load Amperage – Power @ 12VDC													
		10A 120W	20A 240W	30A 360W	40A 480W	50A 600W	60A 720W	70A 840W	80A 960W	100A 1200W	120A 1440W	160A 1920W	200A 2400W	250A 3000W	
	2	16AWG	16AWG	14AWG	12AWG	10AWG	8AWG	8AWG	6AWG	4AWG	2AWG	2AWG	2/0AWG	3/0AWG	
	4	16AWG	16AWG	14AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	2AWG		2/0AWG	4/0AWG	
	6	16AWG	14AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	2AWC		10r		AWG	
	8	16AWG	14AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	2AWG	241	160/	VG	4/0AWG	
ength (feet)	10	16AWG	14AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	2AWG	241	1920\	N ^{VG}	4/0AWG	
	12	14AWG	14AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	2AWG	241	use	VG	4/0AWG	
	16	14AWG	12AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	2AWG	241	#2AW	G VG	4/0AWG	
ible L	20	14AWG	12AWG	10AWG	8AWG	6AWG	6AWG	4AWG	4AWG	2AWG	244.5	LUANO	wowvG	4/0AWG	
ບຶ	24	12AWG	12AWG	10AWG	8AWG	6AWG	4AWG	4AWG	2AWG	1AWG	1AWG	AWG 2/0AWG		4/0AWG	
	28	12AWG	10AWG	8AWG	8AWG	6AWG	4AWG	4AWG	2AWG	1AWG	1AWG	2/0AWG	4/0AWG	4/0AWG	
	33	10AWG	10AWG	8AWG	6AWG	4AWG	4AWG	4AWG	2AWG	1AWG	1AWG	2/0AWG	4/0AWG	4/0AWG	
	42	10AWG	8AWG	6AWG	6AWG	4AWG	4AWG	2AWG	1AWG	1/0AWG	1/0AWG	3/0AWG	4/0AWG	NR	
	50	8AWG	6AWG	6AWG	4AWG	4AWG	2AWG	2AWG	1AWG	1/0AWG	1/0AWG	3/0AWG	NR	NR	

wires can be #12, #14 or smaller. WHY?

Higher voltage, **120V AC**, from the inverter means less amperage needed for the rated wattage so wires can be smaller.

Watts Law V x A = W

We saw how Ohm's Law works for amperage and overheating of wires. Now lets look at how the size and length of wires affects Voltage and power.

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Too long and too thin a wire means **Voltage Drop**

Use Ohm's Law **V= IR** Voltage Drop = Amps x Resistance

Voltage Drop

is a function of the following three parameters: Wire gauge, Length of wire, Current flow in the wire

The greater a wire's length, the greater the resistance to current flow. Excessively long wire will result in a loss of power to the load and lower system efficiency. It will also reduce the life expectancy of most appliances and equipment.

So which are going to be the longest wires in your system?

Probably the wire from your PVs to the controller and back, a complete circuit. How big a wire do you need to get every bit of Solar Power into your house?

Quality is important

Gallup Solar uses good quality weatherproof and waterproof **#10** MC4 cables pre-cut at 15 ft. or 25 ft.

How many Amps are those wires going to carry?

How many Amps do your panels produce?

windynation												
	www.windynation.com											
100 Watt Monocrystalline Photovoltaic Solar Panel												
Part #:	SOL-100M-01											
Maximum Power (Pmax): Open Circuit Voltage (Voc): Short Circuit Current (Isc): Max Power Voltage (Vmp): Max Power Current (Imp): Max System Voltage:	100 Watts 21.45 Volts 6.09 Amps 18.15 Volts 5.51 Amps 1000 VDC (600 VDC UL)											
Dimensions: Weight: Max Series Fuse Rating: Nom Operating Cell Temp:	39.2" x 21.3" x 1.0" [995mm x 540mm x 25mm] 13.3lbs [6.0kg] 8 Amps 48°C [+/-2]											
CE 🗆 🗎	RoHS											

Multiply Max Power Current by 2 panels in parallel. 5.51 x 2 = 11.02 amps* x 1.25 = 13.8 amps* x 1.25 = 17.2 amps* Use 18 amps*

*For safety multiply the current by 125%. National Electric Code requires an additional 125% be added to the current from PV to batteries in case of exceptionally cold sunny days.

How far can you go with Gallup Solar's #10AWG?

					18 mps					10% V	oltage	Drop	at 12	Volts
Long		Curr	ent (A	mps)	20	25	20	40	60	70	00	00	100	
Leng		3	10	10	20	25	30	40	50	10	10	10	10	100
10	3 m	18	18	18	16	16	14	14	12	12	10	10	10	10
15	5 m	18	18	16	14	14	12	12	10	10	8	8	8	8
20'	6 m	18	16	14	14	12	12	10	10	8	8	8	6	6
25'	8 m	18	16	14	12	12	10	10	8	8	6	6	6	6
30'	9 m	18	14	12	12	10	10	8	8	6	6	6	6	4
40'	12 m	16	14	12	10	10	8	8	6	6	6	4	4	4
50'	15 m	16	12	10	10	8	8	6	6	4	4	4	2	2
60'	18 m	14	12	10	\wedge	8	6	6	4	4	2	2	2	2
70'	21 m	14	10	8			6	6	4	2	2	2	2	1
80'	24 m	14	10	/#1	0AW	$G \setminus$	6	4	4	2	2	2	1	1
90'	27 m	12	10	8		6	6	4	2	2	2	1	1	1/0
100'	30 m	12	10	8	6	6	4	4	2	2	1	1	1/0	1/0
110'	33 m	12	8	8	6	6	4	2	2	2	1	1/0	1/0	1/0
120'	36 m	12	8	6	6	4	4	2	2	1	1	1/0	1/0	2/0
130'	40 m	12	8	6	6	4	4	2	2	1	1/0	1/0	2/0	2/0
140'	43 m	10	8	6	6	4	2	2	1	1	1/0	2/0	2/0	2/0
150'	46 m	10	8	6	4	4	2	2	1	1/0	1/0	2/0	2/0	3/0
160'	49 m	10	8	6	4	4	2	2	1	1/0	2/0	2/0	3/0	3/0
170'	52 m	10	6	6	4	2	2	2	1	1/0	2/0	2/0	3/0	3/0
	Leng 10' 15' 20' 25' 30' 40' 50' 60' 70' 80' 90' 100' 100' 100' 110' 120' 130' 140' 120' 130' 140' 150' 140'	Length10'3 m15'5 m20'6 m20'6 m25'8 m30'9 m40'12 m50'15 m60'18 m70'21 m80'24 m90'27 m100'30 m110'33 m120'36 m130'40 m140'43 m150'46 m160'49 m170'52 m	Length Curr 10' 3 m 18 15' 5 m 18 20' 6 m 18 20' 6 m 18 20' 8 m 18 30' 9 m 18 30' 9 m 18 40' 12 m 16 50' 15 m 16 60' 18 m 14 70' 21 m 14 80' 24 m 14 90' 27 m 12 100' 30 m 12 110' 33 m 12 130' 40 m 12 130' 40 m 12 140' 43 m 10 150' 46 m 10 160' 49 m 10 160' 49 m 10 160' 49 m 10 160' 49 m 10 170' 52 m 10	Current (ALength51010'3 m181815'5 m181820'6 m181620'6 m181620'8 m181620'9 m181440'12 m161450'15 m161260'18 m141050'21 m141080'24 m141090'27 m1210100'30 m128120'36 m128130'40 m128140'43 m108150'46 m108160'49 m108170'52 m106	Current (Amps)Length5101510'3 m18181815'5 m18181620'6 m18161425'8 m18161425'8 m18161430'9 m18141240'12 m16141250'15 m16121060'18 m14121070'21 m1410#190'27 m12108100'30 m1288120'36 m1286130'40 m1286140'43 m1086150'46 m1086160'49 m1086170'52 m1066	Length 5 10 15 20 10' 3 m 18 18 18 16 15' 5 m 18 18 16 14 20' 6 m 18 16 14 12 20' 6 m 18 16 14 12 20' 6 m 18 16 14 12 30' 9 m 18 14 12 12 40' 12 m 16 14 12 10 50' 15 m 16 12 10 10 60' 18 m 14 12 10 10 60' 18 m 14 10 # 10AW 90' 27 m 12 10 8 6 110' 30 m 12 8 8 6 120' 36 m 12 8 6 6 120' 36 m 12 8<	18 amps Length 5 10' 3 m 18 18 18 16 15' 20' 6 m 18 16 14 12 10' 3 m 18 18 18 16 14 14 20' 6 m 18 16 14 14 12 12 25' 8 m 18 16 14 12 12 10 40' 12 m 16 14 12 10 10 8 60' 18 m 14 12 10 10 8 6 6 10' 21 m 14 10 # 10 8 6 6 100' 30 m 12 10 8 6 6 4 10' 32 m 12 8 6 6 4 10' 30 m 12 8 6 6 4 10'	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	18 ampsLength510152025304010'3 m18181816161414121220'6 m181614141212101025'8 m1816141212101030'9 m181412121010840'12 m16141210108850'15 m1612101088660'18 m14121086670'21 m1410#10AWG6490'27 m1210866490'27 m1210866410'30 m121086642120'36 m12866442130'40 m12866442140'43 m10866442150'46 m10864422160'49 m10664422160'49 m1066442	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	18 amps10% VLength5101520253040506010'3 m181818161614141212101020'6 m18161414121210108820'6 m18161414121210108820'6 m1816141212101088620'6 m1816141212101088630'9 m181412121010886640'12 m1614121010886650'15 m161210108866442290'27 m1210866442221100'30 m121086644221110'33 m12866442211130'40 m12866442211140'4	18 amps10% VoltageLength510152025304050607010'3 m1818181616141412121015'5 m1818161414121210820'6 m1816141412121010820'6 m18161414121210108825'8 m1816141212101088630'9 m181412121010886640'12 m16141210108866650'15 m161210108866442270'21 m1410 #10AWG 644221110'30 m121086644221110'30 m121086644221110'30 m121086644221110'30 m12866442211 <th>18 amps 10% Voltage Drop Length 5 10 15 20 25 30 40 50 60 70 80 10' 3 m 18 18 16 16 14 14 12 12 10 10 15' 5 m 18 18 16 14 14 12 12 10 10 8 8 20' 6 m 18 16 14 12 12 10 10 8 8 8 20' 6 m 18 16 14 12 12 10 10 8 8 6 6 20' 6 m 18 16 14 12 10 10 8 8 6 6 6 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4<th>18 amps 10% Voltage Drop at 12 Length 5 10 15 20 25 30 40 50 60 70 80 90 10' 3 m 18 18 16 16 14 14 12 12 10 8 8 6</th></th>	18 amps 10% Voltage Drop Length 5 10 15 20 25 30 40 50 60 70 80 10' 3 m 18 18 16 16 14 14 12 12 10 10 15' 5 m 18 18 16 14 14 12 12 10 10 8 8 20' 6 m 18 16 14 12 12 10 10 8 8 8 20' 6 m 18 16 14 12 12 10 10 8 8 6 6 20' 6 m 18 16 14 12 10 10 8 8 6 6 6 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 <th>18 amps 10% Voltage Drop at 12 Length 5 10 15 20 25 30 40 50 60 70 80 90 10' 3 m 18 18 16 16 14 14 12 12 10 8 8 6</th>	18 amps 10% Voltage Drop at 12 Length 5 10 15 20 25 30 40 50 60 70 80 90 10' 3 m 18 18 16 16 14 14 12 12 10 8 8 6

Notice we are accepting a 10% voltage drop.

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Can you tolerate a 10% Voltage Drop?

windy	nation
	www.windynation.com
100 Watt Monocrystallin	e Photovoltaic Solar Panel
Part #:	SOL-100M-01
Maximum Power (Pmax): Open Circuit Voltage (Voc) Short Circuit Current (Isc): Max Power Voltage (Vmp): Max Power Current (Imp): Max System Voltage:	100 Watts 21.45 Volts 6.09 Amps 18.15 Volts 5.51 Amps 1000 VDC (600 VDC UL)
Dimensions: Weight: Max Series Fuse Rating: Nom Operating Cell Temp:	39.2" x 21.3" x 1.0" [995mm x 540mm x 25mm] 13.3lbs [6.0kg] 8 Amps 48°C [+/-2]
CE [] 2	RoHS

Yes, because your two panels in parallel produce about 18 Volts.

But your 12V Battery only needs a little more than 12 Volts to keep charging.

A **50ft** circuit with only 3% voltage drop would require a **4AWG** wire, pretty expensive.

Wire Gauges for a 3% Voltage Drop in a DC 12-Volt System																				
		Leng	gth of	Cond	luctor	from	Se re	eofC	urren	t to D	evice	and B	lack to	o Sou	rce (fe	eet)	- 2000		antes a	340.047
		10	15	20	25	1	_/	50	60	70	80	90	100	110	120	130	140	150	160	170
	5	18	16	14	12	12	0	10	10	8	8	8	6	6	6	6	6	6	6	6
	10	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
du	15	12	10	10	8	8	6	6	6	4	4	2	2	2	2	2	1	1	1	1
(ar	20	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
Init	25	10	8	6	6	6	4	\wedge	2	2	2	1	1	0	0	0	2/0	2/0	2/0	2/0
Ğ	30	10	8	6	6	4	4		2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
ы	40	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
ant	50	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				
urre	60	6	4	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0	4/0						
Ū.	70	6	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0								
ota	80	6	4	2	2	1	0	3/0	3/0	4/0	4/0									
	90	4	2	2	1	0	2/0	3/0	4/0	4/0										
	100	4	2	2	1	0	2/0	3/0	4/0	4/0									-	

Grounding

Grounding offers excess electricity the most effective and safest route from an appliance back to the ground by way of a wire to a grounding rod *and not through you*.

Grounding is usually done at two levels: system grounding and equipment grounding.

Your System

System Grounding is achieved when one of the conductive wires is intentionally given a direct path to the earth. This is accomplished by running a wire to a ground rod.

In systems smaller than **50V** like yours, **Equipment Grounding** is all that is required. The grounding wire goes from the **equipment** to the ground rod, a long copper rod driven directly into the soil.

System Grounding

Solar systems, over 50 volts, not yours, are required to be grounded by having one of the current-carrying conductors connected to a grounding electrode.

Equipment Grounding

An equipment-grounding conductor is a conductor that does not normally carry current except under fault conditions. It connects exposed metal surfaces of electrical equipment together and then to ground. 32

Equipment Grounding

Only your solar panels and inverter need Equipment Grounding.

Grounding Solar Panels

This 4 ft. copper rod is an equipment ground attached to a pre-drilled hole in the frame of the solar panels.

Please do not drill holes in PV frames, voids warranty and one slip can start a crack in the glass.

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Grounding the Inverter

Your inverter has a built-in ground fault safety feature that shuts down if there is a short in the wire from the battery. Grounding is optional.

You are ready to wire!

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Terms for Discussion

Ampacity Intensité Conductor Startup Surge Rated Wattage Voltage Drop Complete Circuit

Grounding Max Power Current National Electric Code System Grounding Equipment Grounding Ground Rod Ground Fault