**Solar Electric Technician Training**

**Module 3: Measurement of electrical and solar parameter**

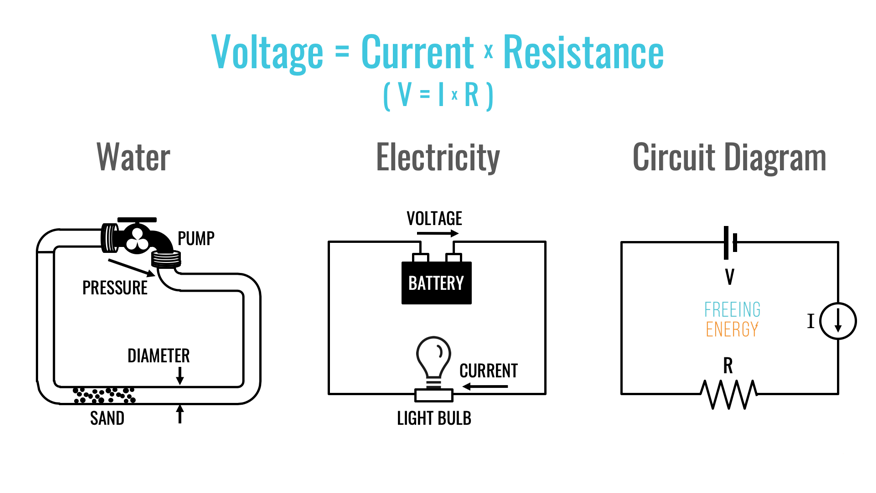
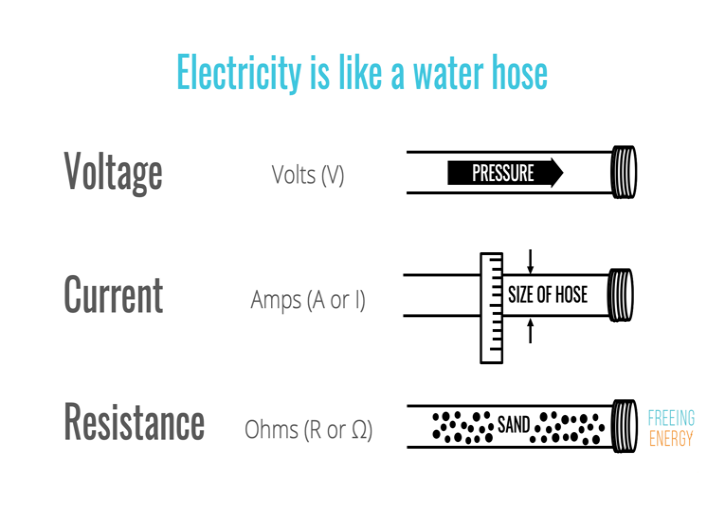
# ljB'tsf cfwf/e"t cjwf/0ffx¿ (Basics of electricity)

## ljB't

ljB't eg]sf] On]S6«f]gx¿sf] k|jfx xf] . h:tf] ls kfOkdf kfgLsf]] k|jfx x'G5, To:t} tf/df On]S6«f]gx¿sf] k|jfx x'G5 . tf/df x'g] On]S6«f]gx¿sf] k|jfxnfO{ wf/fsf] kfOkdf kfgLsf]] k|jfx ;+u t'ngf ug{ ;lsG5 .

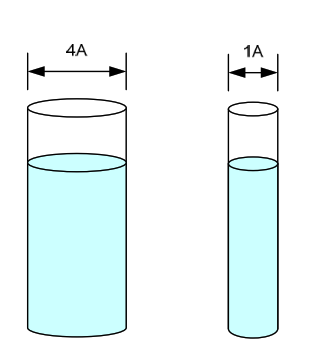
## ljB'tsf] cfwf/e"t tTjx¿

ljB'tsf] cfwf/e"t tTjnfO{ kfgLsf] pbfx/0fn] a'‰g ;lhnf] x'G5 . oxfF ljB'tsf] cfwf/e"t tTjx¿ voltage, current, / resistance nfO{ kfgL;Fu t'ngf u/]/ a'‰g] sf]lz; u/f}+}]{ . tnsf] lrqdf kfgLsf] kfOkdf ePsf] kfgLsf] bafa, kfOksf] axfj, / afn'jfnfO{ qmdzM ef]N6]h, s/]G6, / cj/f]w;Fu t'ngf ul/Psf] 5 . of] lrq;Fu} tnsf JofVofx¿n] oL tLgj6} cfwf/e"t tTjx¿nfO{ :ki6 kfb{5 .



**ef]N6]h -Voltage-V**\_

* kl/efiffM ljB't\ ;ls{6df, s/]G6 k|jflxt x'gsf] nflu ef]N6]h ;|f]t cfjZos x'G5 . ef]N6]h eg]sf] tf/ leq On]S6«f]gx¿nfO{ ws]Ng] an xf] . pbfx/0fM ef]N6]hnfO{ kfgLsf] kfOkdf /x]sf bafasf] (pressure) ¿kdf t'ngf ug'{xf]';\ . h:t}, kfOkdf a9L bafa x'Fbf kfgL a9L t]h aU5, ljB'tdf klg ef]N6]hn] On]S6«f]gnfO{ k|jflxt ug{ an lbG5 .
* o;nfO{ V åf/f hgfOG5 .
* ef]N6]h ef]N6 -V\_ df dfkg ul/G5 .

**s/]G6 -Current-I\_**

* kl/efiffM ha s'g} a:t' leqsf On]S6«f]gx¿ rN5g\, ta s/]G6 k|jfx -flow\_ x'G5 . To;}n] On]S6«f]gx¿sf] k|jfx x'Fbf s/]G6 k}bf x'G5 . h;/L kfOkdf kfgL alu/x]sf] x'G5, To;}u/L ljB't k|jfxdf On]S6«f]gx¿ alu/x]sf x'G5g\ . a9L On]S6|\f]gx?sf] k|jfx x'Fbf a9L s/]G6 au] h:t} kfOksf] Jof; (Diameter) 7"nf] xF'bf a9L kfgL aU5 . ctM oxfF s/]G6nfO{ kfOksf] Aof;;+u t'ngf ug{ ;lsG5 .
* o;nfO{ I åf/f hgfOG5 .
* s/]G6 PlDko/ -A\_ df dfkg ul/G5 .

**cj/f]w -Resistance-R\_**

* cj/f]wnfO{ kfOkdf /x]sf] afn'jf;+u t'ngf ug{ ;lsG5 . h;/L kfOkdf afn'jf /fVbf kfgLsf] k|jfx sd x'G5, To;}u/L ljB'tdf cj/f]wn] s/]G6sf] k|jfxnfO{ /f]S5 .
* o;nfO{ R åf/f hgfOG5 .
* cj/f]w cf]xd -Ω\_ df dfkg ul/G5 .

## ef]N6]h, s/]G6, / cj/f]wsf] ;DaGw

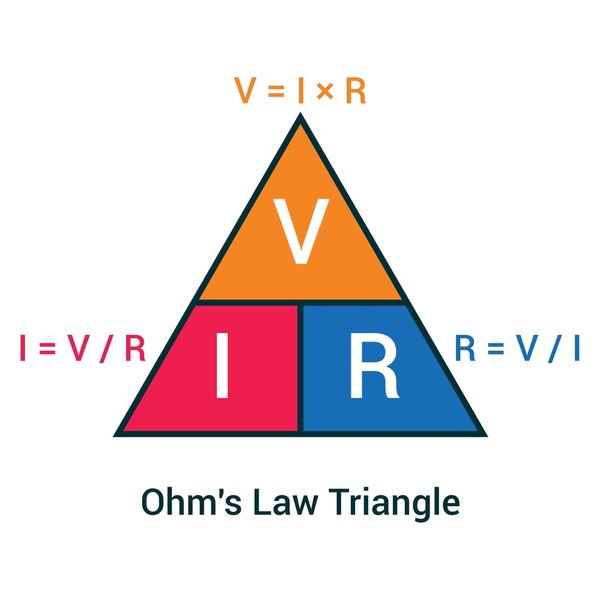
oL tLgj6} cfwf/e"t tTjx¿ Ps cfk;df ;DalGwt 5g\ . ljB't kl/kydf Pp6fsf] dfg kl/jt{g ubf{ csf]{sf] dfg klg kl/jt{g x'G5 . ljz]iftM s/]G6nfO{ cj/f]w;Fu u'0fg ubf{ ef]N6]hsf] dfg k|fKt x'G5 .

Voltage (V)= Current (I)× Resistance(R)

kfgL;+u t'ngf ubf{M

* olb kfOkdf bafa a9fOof] eg] kfgLsf] k|jfx a9\5 -ef]N6]h a9\bf s/]G6 klg a9\5\_ .
* olb kfOkdf afn'jf ylkof] eg], kfgLsf] k|jfx sd x'G5 -cj/f]w a9\bf s/]G6 36\5\_ .
* olb kfOksf] Jof; a9fOof] eg], a9L kfgL aUg]5 -s/]G6 a9\bf ef]N6]h klg a9\5\_ .

o;/L, kfgLsf] pbfx/0f k|of]u ubf{ ljB'tsf cfwf/e"t tTjx¿nfO{ a'‰g ;lhnf] x'G5 .

**Ohm's law**

Ohm's law lqsf]0fsf] dfWodaf6 ljB'tsf cfwf/e"t ;DaGwx¿nfO{ ;lhn};Fu a'‰g ;lsG5 . Ohm's law lqsf]0fn] ef]N6]h -Voltage\_, s/]G6 -Current\_, / cj/f]w -Resistance\_ aLrsf] ;DaGwnfO{ b]vfpF5 .

**lqsf]0fsf] efux¿**

* V -Voltage\_M lqsf]0fsf] dflysf] efudf -zLif{df\_ ef]N6]h n]lvPsf] 5 . ef]N6]hn] On]S6«f]gnfO{ rnfpg an lbG5 .
* I -Current\_M lqsf]0fsf] afofF tkm{ s/]G6 n]lvPsf] 5 . s/]G6 eg]sf] On]S6«f]gx¿sf] k|jfx xf] .
* R -Resistance\_M lqsf]0fsf] bfofF tkm{ cj/f]w n]lvPsf] 5 . cj/f]wn] On]S6«f]gx¿sf] k|jfxnfO{ /f]S5 .

**lqsf]0fsf] k|of]u**

* ef]N6]h kQf nufpgM olb tkfO{nfO{ ef]N6]h -V\_ yfxf kfpg' 5 eg], s/]G6 -I\_ / cj/f]w -R\_ nfO{ u'0ff ug{'xf];\ .

V= I \* R

* s/]G6 kQf nufpgM olb tkfO{nfO{ s/]G6 -I\_ yfxf kfpg' 5 eg], ef]N6]h -V\_ nfO{ cj/f]w -R\_ af6 efu ug{'xf];\ .

I= V / R

* cj/f]w kQf nufpg]M olb tkfO{nfO{ cj/f]w -R\_ yfxf kfpg' 5 eg], ef]N6]h -V\_ nfO{ s/]G6 -I\_ af6 efu ug{'xf];\ .

R= V / I

**pbfx/0fx¿**

* ef]N6]h kQf nufpgM olb tkfO{sf] ;ls{6df s/]G6 3 clDko/ -A\_ 5 / cj/f]w 5 cf]xd -Ω\_ 5 eg]M

V= I \* R = 3A \* 5 Ω = 15V

o;/L, ef]N6]h 15 ef]N6 x'g]5 .

* s/]G6 kQf nufpg]M olb tkfO{sf] ;ls{6df ef]N6]h 20 ef]N6 5 / cj/f]w 4 cf]d -Ω\_ 5 eg]M

I = V/ R = 20V/4 Ω = 5A,

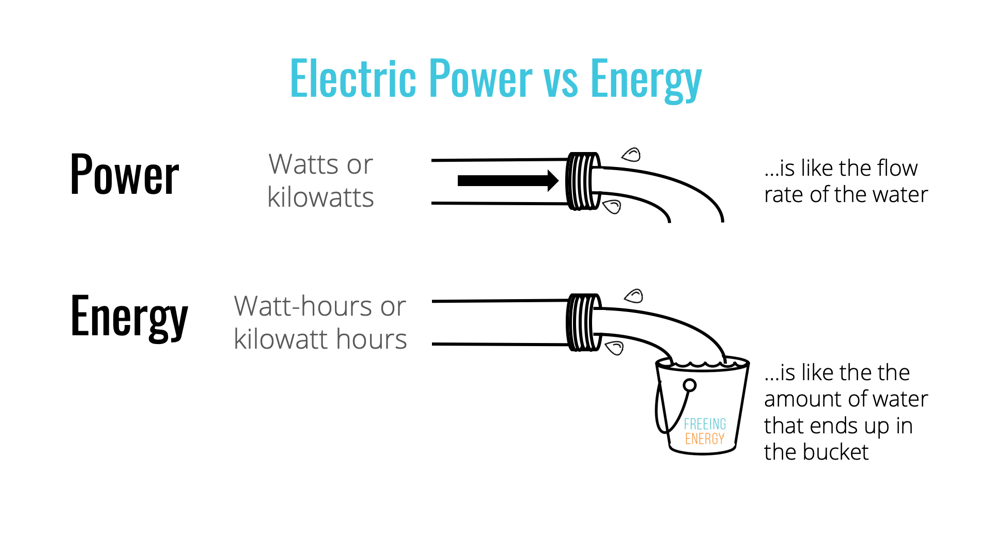
o;/L, s/]G6 5 clDko/ -A\_ x'g]5 .

* cj/f]w kQf nufpg]M olb tkfO{sf] ;ls{6df ef]N6]h 12 ef]N6 -V\_ 5 / s/]G6 3 clDko/ -A\_ 5 eg]M

R = V/ I = 12V/3A = 4 Ω,

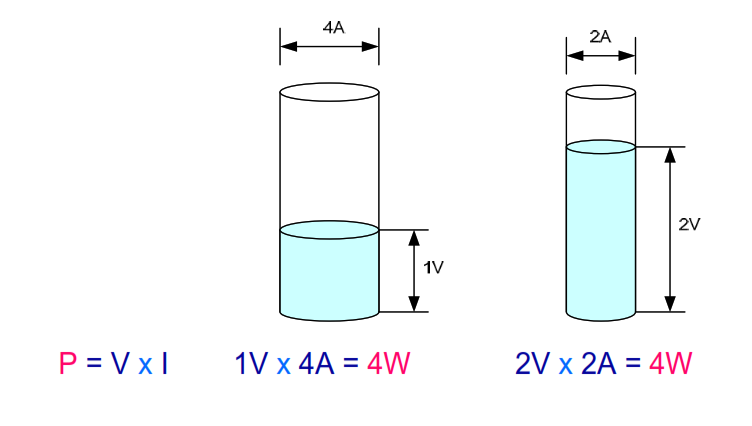
o;/L, cj/f]w 4 cf]d -Ω\_ x'g]5 .

;f/f+zM Ohm's law lqsf]0fn] ef]N6]h, s/]G6, / cj/f]wnfO{ ;lhn};Fu Pscsf{df ¿kfGt/0f ug{ d2t u5{ . o;n] s'g s'/f s;/L u0fgf ug]{ eGg] s'/f a'‰g ;lhnf] agfpF5 .



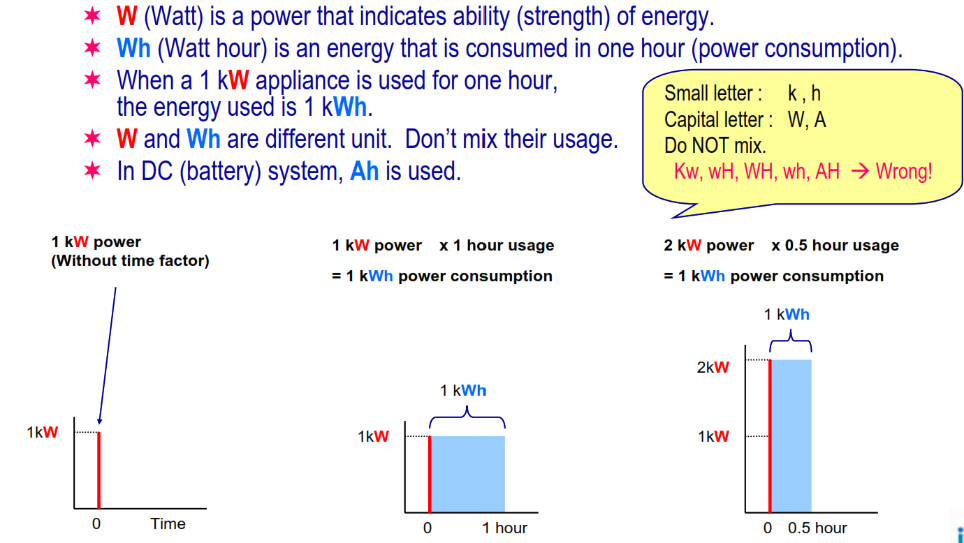
**zlQm -Power\_**

zlQm eg]sf] Ps ;dodf slt ljB't\ pmhf{ k|of]u eO/x]sf] 5 eGg] s'/f xf] . kfj/nfO{ tkfO{+n] kfOkaf6 aUg] kfgLsf] bjfa;Fu t'ngf ug{ ;Sg'x'G5 . hlt w]/} bjfa x'G5, Tolt l56f] kfgL aU5 . pRr zlQm eGgfn] k|lt PsfO ;do a9L pmhf{ k|of]u eO/x]sf] hgfpFb5 . kfgLsf] pRr k|jfx b/ eGgfn] kfOkaf6 k|To]s ;]s]G8 a9L kfgL aUb}5 eGg] a'lemG5 .

* ljB'tLo zlQm -jf6df\_ ef]N6]h / s/]06 u'0ff u/]/ -P = V × I\_ k|fKt ug{ ;lsG5 .
* o;nfO{ P åf/f hgfOG5 .
* **dfkgM** jf6 -W\_ df dfkg ul/G5. 7"nf k|0ffnLx¿df lsnf]jf6 -1 kW =1000 W\_ jf d]ufjf6 -1 MW = 1,000,000 W\_ df dfkg ul/G5 .
* zlQm -Power\_ eg]sf] ef]N6]hnfO{ s/]G6;Fu u'0fg ubf{ k|fKt x'g] dfg xf] .

Power (P)= Voltage (V)× Current(I)

**pmhf{ -Energy\_**

pmhf{ eg]sf] s'g} sfo{ ug{sf]nflu Ps lglZrt ;dosf] cjlwdf k|of]u ePsf] s'n zlQm xf] . **l**jB'tLo k|0ffnLdf **pmhf**{n] u/]sf] sfdsf] s'n dfqf jf ljB'tLo k|jfxsf] s'n dfqfnfO{ k|ltlglwTj ub{5 . kfgL k|0ffnL;+u t'ngf ubf{ pmhf{nfO{ lglZrt cjlwdf kfOkaf6 k|jfx ePsf] kfgLsf] s'n dfqfsf] ?kdf x]g{ ;lsG5 . h;/L nfdf] ;do;Dd kfgL aUg'sf] cy{ kfgLsf] s'n dfqf a9L x'G5, To;}u/L nfdf] ;do;Dd ljh'nLsf] k|jfx x'g'sf] cy{ s'n pmhf{ vkt a9L x'G5 .

Electrical energy (in joules) = power (watts) x time (seconds)

Volume of water would = flow rate (liters per second) x time (second)

* **ljB'tsf] pbfx/0fM** olb 1kW pks/0fnfO{ 1 306f k|of]u u/]df pmhf{ vkt 1 kW × 1 h Ö 1 kWh x'G5 To;}u/L 2 kW sf] pks/0f 0.5 h k|of]u ubf{ pmhf{ vkt 1 kWh x'G5 .
* o;nfO{ E åf/f hgfOG5 .
* **dfkgM** jf6 306f -Wh, kWh\_df dfkg ul/G5 .

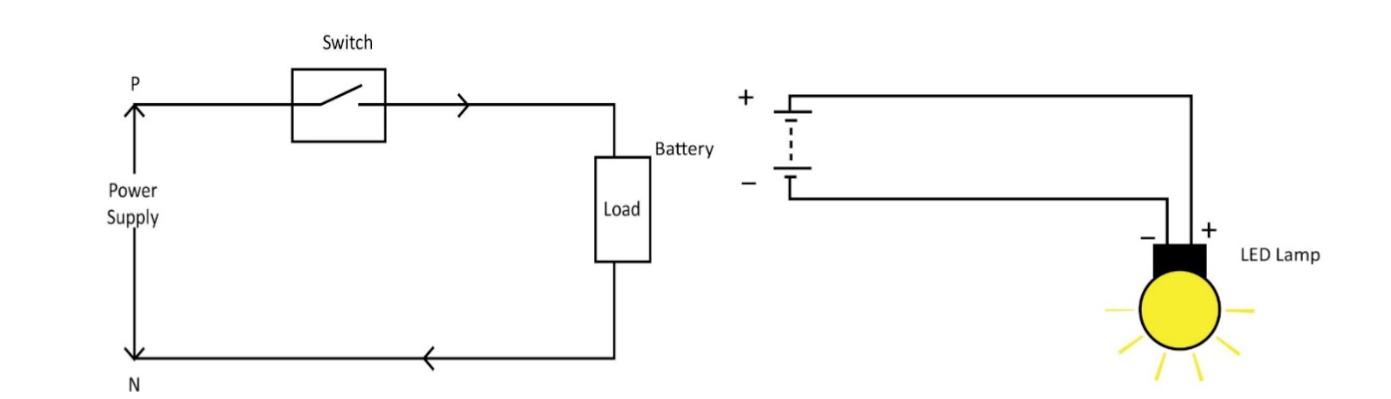
## On]lS6«sn ;ls{6 (Electrical circuit)

laleGg ljB'tLo sDkf]g]G6 jf pks/0fxx?sf] cGt/ ;DaGwnfO{ ljB'tLo jf On]lS6«sn ;ls{6 elgG5 . On]lS6«sn ;ls{6 eg]sf] ljB't\ k|jfxsf] nflu Ps aGb rqm (closed circuit) xf] . o;n] ljB't\ ;|f]taf6 nf]8;Dd / k'gM ljB't\ ;|f]tdf kms{g] dfu{ k|bfg ub{5 .

#### ;ls{6sf d'Vo efux¿

* **ljB't\ ;|f]t -Power source/supply\_M** of] ;ls{6sf] pmhf{ k|bfg ug]{ efu xf]. ;f}o{ Kofgn, Aof6«L, jf ljB't\ h]g/]6/ x'g ;S5 .
* **sG8S6;{ -Conductors\_M** sG8S6;{n] ljB't\ k|jfxnfO{ ;ls{6df n}hfG5g\ . ;fdfGotof tfdf -Copper\_ jf PNo"ldlgodsf tf/x¿ k|of]u ul/G5 .
* **nf]8 -Load\_M** nf]8 eg]sf] ljB't\ pmhf{ k|of]u ug]{ pks/0f xf], h:t} aNa, k+vf, jf cGo On]S6«f]lgs pks/0fx¿ .
* **l:jr** **-Switch\_M** ;ls{6nfO{ vf]Ng jf aGb ug{sf] nflu l:jr .

ha ;ls{6 aGb jf k"/f x'G5, ta nf]8 ;~rfngdf cfpg]5 . tnsf lrqx¿n] v'nf (open) / aGb (closed) ;ls{6nfO{ b]vfpF5g\M



**l;l/h ;ls{6 jf** >[+vnfa4 -**Series circuit**\_ **Kof/fn]n** jf ;dfgfGt/ **;ls{6** -**Parallel circuit)**

d'VotM b'O{ k|sf/sf ljB't ;ls{6x¿ x'G5g\, >[+vnfa4 -Series\_ / ;dfgfGt/ -Parallel\_ ;ls{6, / ltgLx¿sf] ljz]iftfx¿ tnsf] tflnsfdf ;"rLa4 ul/Psf] 5M

|  |  |  |
| --- | --- | --- |
| What is the difference between series and parallel circuits? When can they  be combined? - Quora | | |
| **ljz]iftf** | **l;l/h ;ls{6 jf >[+vnfa4 ;ls{6 -Series circuit\_** | **Kof/fn]n** jf ;dfgfGt/ **;ls{6 -Parallel circuit\_** |
| **kl/efiff** | >[+vnfa4 ;ls{6df, Pp6f sDkf]g]G6sf] g]u]l6e 6ld{ng csf]{ sDkf]g]G6sf] kf]h]l6e 6ld{ng ;+u hf]l8Psf x'G5, h;n] Ps} s/]06 k|jfx x'G5 . | ;dfgfGt/ ;ls{6df ;a} sDkf]g]G6x¿sf] g]u]l6e 6ld{ngx? Ps 7fpFdf / kf]h]l6e 6ld{ngx? Ps 7fpFdf hf]l8Psf x'G5 / s/]06 k|jfx ljleGg dfu{x¿af6 aU5 . |
| **s/]G6** | >[+vnfa4 ;ls{6df ;a} sDkf]g]G6x¿df pxL s/]G6 k|jfx x'G5, lsgls o;df s]jn Ps ky jf dfu{ x'G5 .  I1= I2 = …= In | ;dfgfGt/ ;ls{6df s'n s/]G6sf] dfg ljleGg ;ls{6df k|jfx ePsf] s/]G6 sf] of]u x'G5 . o;df k|To]s sDkf]g]G6n] ;dfg ef]N6]h k|fKt u5{ .  Itotal= I1+ I2+ ……In |
| **ef]N6]h** | ;ls{6sf] s'n ef]N6]h, k|To]s sDkf]g]G6sf] ef]N6]hdsf] of]u x'G5 .  Vtotal= V1 +V2 +………+ Vn | ;dfgf+t/ ;ls{6df k|To]s sDkf]g]G6sf] ef]N6]h Ps} k|sf/sf] x'G5 / ;|f]t ef]N6]h;Fu d]n vfG5 .  Vacross each component = Vsource |
| **cj/f]w** | >[+vnfa4 ;ls{6sf] s'n cj/f]w 5'§f5'§} cj/f]wx¿sf] of]u xf] .  Rtotal = R1 +R2 +……. +Rn .  o;n] yk cj/f]wsx¿ hf]8\bf s'n cj/f]w a9fpF5 . | ;dfgf+t/ ;ls{6sf] s'n cj/f]w JolQmut cj/f]wx¿sf] t'ngf ug{'kb{5 .  of] ;"q k|of]u u/]/ km]nf kfl/G5M  1/Rtotal = 1/R1+1/R2+…………1/Rn  yk zfvfx¿ yKbf s'n cj/f]w 36fpF5 . |
| **cjlw** | >[+vnfa4 ;ls{6df h8fg ul/Psf] s'g} Ps sDkf]g]G6n] sfd gubf{ -h:t}, aNa lgEbf\_], ;Dk"0f{ ;ls{6 cj?4 x'G5 / ;a} sDkf]g]G6x¿ aGb x'G5 . | ;dfgf+t/ ;ls{6df h8fg ul/Psf s'g} Ps sDkf]g]G6n] sfd gubf{ afFsL sDkf]g]G6x¿ sfd ul//xG5 lsgls cGo ;ls{6x?df s/]G6 k|jfx eO/xG5 . |
| **pbfx/0f** | To;}n] >[+vnfa4 ;ls{6df h8fg ul/Psf] tLgj6f aNax¿ dWo] Po6f aNa lgEof] eg] ;a} aNax¿ lgEg]5g\ lsgls ;ls{6 6'6]sf] x'G5 . | To;'}n] ;dfgf+t/ ;ls{6df h8fg ul/Psf] tLgj6f aNax¿ dWo] olb Pp6f aNa lgEof] eg] cGo aNax¿ aln/xG5\ lsgls ltgLx¿ cnu–cnu ;ls{6df x'G5g\ . |

### AC / DC ;ls{6

;fdfGotof, ljB't pks/0fx¿df jf sDkf]g]G6x? b'O{ k|sf/sf s/]G6x¿ k|jfx u5{g\, / ltgLx¿sf] nflu ljleGg k|sf/sf ljB't ;ls{6x¿ k|of]u ul/G5 . ltgLx¿sf] ljz]iftfx¿ tnsf] tflnsfdf ;"rLa4 5g\ .

|  |  |  |
| --- | --- | --- |
| AC Circuit Vs DC Circuit - What is the Difference Between these Circuits? -  RAYPCBAC Circuit Vs DC Circuit - What is the Difference Between ... | | |
| **ljj/0f** | **AC ;ls{6 -Alternating current circuit\_** | **DC ;ls{6 -Direct current circuit\_** |
| **kl/efiff** | AC ;ls{6df ljB't\ k|jfxdf ;do cg';f/ lbzf kl/jt{g ub{5 . | DC ;ls{6df ljB't\ k|jfx l:y/ lbzfdf aU5 . |
| **k|of]u** | 3/]n' pks/0f, pBf]u, / Jofkfl/s k|lti7fgx¿df k|of]u ul/G5 . | On]S6«f]lgs pks/0f / ;fgf oGqx¿df k|of]u ul/G5 . |
| **pTkfbg** | j}slNks s/]G6 h]g/]6/ jf cN6/g]6/åf/f pTkfbg ul/G5 . | kmf]6f]ef]N6fOs ;]n (cell), / Aof6«Lx¿åf/f pTkfbg ul/G5 . |
| **pbfx/0f** | 3/df cfpg] lah'nL AC xf], h;n] 50 xh{df (50Hz) cfˆgf] lbzf kl/jt{g ub{5 . | Aof6«Laf6 cfpg] ljB't\ DC xf], h;n] Ps} lbzfdf ljB't\ k|jfx ub{5 . |
| **Ifdtf** | ;ls{6n] nfdf] b"/Ldf pmhf{ 6«fG;km/ ug{ ;Ifd x'G5 / o;nfO{ 6«fG;kmd{/ dfkm{t ef]N6]h kl/jt{g ug{ ;lsG5 . | DC ;ls{6 ;fwf/0ftof ;f}o{ Kofgnx¿, df]afOn kmf]g, / cGo kf]6]{an pks/0fx¿df k|of]u ul/G5 . |
| **ljz]iftf** | pRr ef]N6]hn] a9L vt/f k}bf ug{ ;S5 . of] nfdf] b"/Ldf k|of]usf nflu pko'Qm x'G5 . | ;fdfGotof sd ef]N6]hsf k|of]ux¿sf nflu ;'/lIft dflgG5 . of] 5f]6f] b"/Ldf k|of]usf nflu pko'Qm x'G5 . |

## ljB'tLo Kof/fld6/x?sf] dfkg

ljB'tLo Kof/fld6/x?sf] dfkgdf k|fo ef]N6]h (voltage), s/]G6 (current), cj/f]w (Resistance), / kfj/ (power) dfkg ul/G5 .

* dlN6ld6/ (Multimeter) / SNofDkld6/ (Clampmeter) ljB'tLo dfkb08x¿ h:t} ef]N6]h, s/]G6, / cj/f]w dfkg ug{ k|of]u ul/G5 . <https://www.youtube.com/watch?v=rYAgn1lwXRE>
* dlN6ld6/n] ef]N6]h, s/]G6, / cj/f]w h:tf ljleGg rLhx¿ dfkg u5{ .
* SNofDkld6/ eg], d'Vo ¿kdf tf/df k|jfx ePsf] s/]G6 dfkg ug{ k|of]u ul/G5, h;n] tf/nfO{ g5f]O{sg} dfkg ug{ ;lsG5 .

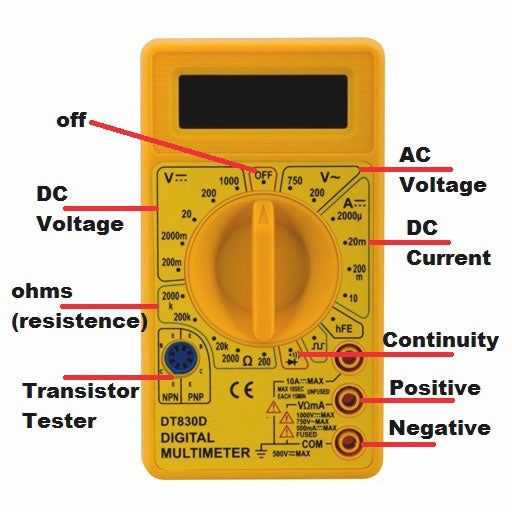




Figure 1: Multimeter & Clampmeter

dlN6ld6/sf] k|of]u s;/L ug]{ eg]/ r/0fa4 ¿kdf l;Sgsf] nflu, tn lbOPsf] tflnsf cg';f/ dfkg k|lqmof ;'? ug]{5f}+ .

**r/0f !M dlN6ld6/ ;]6ck ug{]**

* sfnf] k|f]anfO{ ;w}+ æCOMÆ kf]6{df h8fg ug{'xf];\ .
* ef]N6]h / cj/f]w -Voltage & resistance\_ dfkg ug{ /ftf] k|f]anfO{ æVΩmAÆ kf]6{df h8fg ug{'xf];\ /
* s/]G6 -Current\_ dfkg ug{
  + yf]/} s/]G6 -200mA eGbf sd\_ dfkg ug{M /ftf] k|f]anfO{ æVΩmAÆ kf]6{df h8fg ug{'xf];\ .
  + w]/}] s/]G6 -200mA eGbf a9L\_ dfkg ug{M /ftf] k|f]anfO{ æ10AÆ kf]6{df h8fg ug{'xf];\ .

**r/0f @M ef]N6]h dfkg ug{**

* dlN6ld6/sf] 8fonnfO{ æVÆ -DC jf AC\_ ;]l6+udf ;]6 ug{'xf];\ -;ls{6sf] ef]N6]h k|sf/ cg';f/\_ .
* dfkg ug{ rflxPsf] ;ls{6df jf sDkf]g]G6x?df /ftf] k|f]anfO{ æ±Æ -kf]lhl6e\_ / sfnf] k|f]anfO{ æ–Æ -g]u]l6e\_ kf]OG6df /fVg'xf];\ .
* dlN6ld6/sf] l:qmgdf b]lvPsf] ef]N6]h dfg gf]6 ug{'xf];\ .

**r/0f #M cj/f]w dfkg ug{**

* dlN6ld6/sf] 8fonnfO{ cj/f]w -Ω\_ ;]l6+udf 3'dfpg'xf];\ .
* dfkg ug{ rflxPsf] sDkf]g]G6df /ftf] / sfnf] k|f]ax¿ /fVg'xf];\ .
* l:qmgdf b]lvPsf] cj/f]wsf] dfg gf]6 ug{'xf];\ .

**r/0f $M s/]G6 dfkg ug{**

* sfnf] k|f]anfO{ dlN6ld6/sf] COM kf]6{df hf]8\g'xf];\ / /ftf] k|f]anfO{ æ10AÆ kf]6{df hf]8\g'xf];\ .
* dlN6ld6/sf] 8fonnfO{ æAÆ -DC jf AC\_ ;]l6+udf ;]6 ug{'xf];\ .
* l:qmgdf b]lvPsf] s/]G6sf] dfg gf]6 ug{'xf];\ .

**r/0f $M kfj/ dfkg ug{**

* klxnf] r/0fM dfly dfkg ul/Psf ef]N6]h -V\_ / s/]G6 -I\_ sf] dfgx¿ n]Vg'xf];\ .
* bf];|f] r/0fM P Ö IV ;"q k|of]u u/]/ kfj/ dfg lgsfGg'xf];\ .

## dlN6ld6/ k|of]u u/]/ lg/Gt/tf -Continuity\_ hfFr ug]{ k|lqmof

lg/Gt/tf k/LIf0fn] ;ls{6sf] aLrdf s'g} cj/f]w 5}g eg]/ kSsf ug{ d2t ub{5 . olb ;ls{6df s'g} cj/f]w 5 eg], lg/Gt/tf k/LIf0fn] o;nfO{ lrlGxt ug{ d2t ub{5 . of] k/LIf0fn] tf/x¿sf] ;xL h8fg ePsf] 5 ls 5}g eg]/ yfxf lbG5, h;n] ubf{ tkfO{FnfO{ ;ls{6df ljB't k|jfxsf] cj/f]w kQf nufpg ;lhnf] x'G5 . o;n] b]vfpF5 ls sg]Szg l7s 5 / ljB't k|jfx ;xh ¿kdf ug{ ;S5 . of] ljz]if u/L tf/x¿, ˆo'hx¿, l:jrx¿, / cGo ;ls{6 sDkf]g]G6x¿ k/LIf0f ug{sf nflu k|of]u ul/G5 .

**lg/Gt/tf hfFr ug]{ r/0fx¿**

**r/0f !M** dlN6ld6/sf] ;]6ckM sfnf] k|f]anfO{ æCOMÆ kf]6{df h8fg ug{'xf];\ . /ftf] k|f]anfO{ æVΩmAÆ kf]6{df h8fg ug{'xf];\ .

**r/0f @M 8fonnfO{ ;]6 ug{'xf];\** .

* + dlN6ld6/sf] 8fonnfO{ æContinuityÆ ;]l6+udf 3'dfpg'xf];\ .
  + of] ;]l6ªsf] k|tLs ;fdfGotof 8fof]8sf] k|tLs jf Wjlg t/+usf] cfOsg -h;n] ;fgf] l:ks/ jf Wjlg t/+ux¿nfO{ k|ltlglwTj u5{\_ åf/f lrlGxt ul/Psf] x'G5.
  + olb lg/Gt/tf ;]l6+u gePsf] eP, æΩÆ -Ohms\_ ;]l6+udf ;]6 ug{ ;Sg'x'G5 .

**r/0f #M k|f]ax¿ ;ls{6df /fVg'xf];\** .

* + k|f]ax¿nfO{ tkfO{+;Fu hfFr ug{ rflxPsf] sDkf]g]G6 jf ;ls{6sf] b'O{ laGb'df /fVg'xf];\ .
  + hfFr ug{ rflxPsf] tf/, ˆo'h, jf cGo sDkf]g]G6nfO{ b'O{ k|f]a aLrdf /fVg'xf];\ .

**r/0f $M lg/Gt/tf hfFr ug{'xf];\** .

* + olb ;ls{6df lg/Gt/tf 5 eg], dlN6ld6/n] aLk Wjlg lgsfN5 -olb aLk ;]l6+u 5 eg]\_ jf :qmLgdf z"Go -0\_ jf Go"g cj/f]w -cf]d\_ b]vfpF5 .
  + olb ;ls{6df cj/f]w 5 eg], dlN6ld6/n] aLk ub}{g / pRr cj/f]w -cf]d\_ b]vfpF5 .

**lg/Gt/tf hfFr ubf{ Wofg lbg'kg]{ s'/fM**

* ;'/IffM;ls{6nfO{ kfj/ ckm u/]/ dfq lg/Gt/tf hfFr ug{'xf];\ . s'g} kfj/ /x]sf] ;ls{6df lg/Gt/tf hfFr ubf{ dlN6ld6/ jf ;ls{6nfO{ Iflt k'of{pg ;S5 .
* sDkf]g]G6x¿nfO{ ;xL ¿kdf h8fg ug{'xf];\M ;xL kl/0ffd k|fKt ug{ k|f]ax¿nfO{ ;ls{6sf] ;xL laGb'df /fVg'k5{ .

o;/L, dlN6ld6/ k|of]u u/]/ ;ls{6 jf sDkf]g]G6sf] lg/Gt/tf ;lhn};Fu hfFr ug{ ;lsG5 .

## 8fof]8 k/LIf0f ug]{ tl/sf

* **r/0f !M** dN6LdL6/ tof/ ug{'xf];\ . cfˆgf] dN6LdL6/nfO{ æ8fof]8 6]:6 df]8Æ df /fVg'xf];\. olb of] df]8 5}g eg], æcf]D;Æ df]8df /fVg'xf];\ .
* **r/0f @M** 8fof]8nfO{ ;ls{6 jf ;f}o{ Kofgn af6 5'6fpg'xf];\, tfls k/LIf0f ubf{ ;xL glthf k|fKt ug{ ;lsof];\ .
* **r/0f #M** dN6LdL6/sf] /]8 -Positive\_ k|f]anfO{ 8fof]8sf] nfdf] tf/ -Anode\_ df / ANofs -Negative\_ k|f]anfO{ 5f]6f] tf/ -Cathode\_ df /fVg'xf];\ . olb 8fof]8 l7s 5 eg], dN6LdL6/n] s]xL ef]N6]h -0.5V b]lv 0.7V\_ b]vfpg]5 .
* **r/0f $M** k|f]ax¿ pN6fpg'xf];\ . k|f]ax¿nfO{ pN6fP/, /]8 k|f]anfO{ 5f]6f] tf/ -Cathode\_ df / ANofs k|f]anfO{ nfdf] tf/ -Anode\_ df /fVg'xf];\ .o; cj:yfdf, dN6LdL6/n] æOLÆ -Over limit\_ b]vfpg'k5{ . olb b]lvG5 eg], 8fof]8 lalu|Psf] xf] .
* **r/0f %**M 8fof]8nfO{ km]l/ ;ls{6df /fv]/ sfd ug{ lbg'xf];\ .
* **r/0f ^**M glthf ljZn]if0f ug{'xf];\ . olb 8fof]8 Ps lbzfdf sfd u5{ / csf]{ lbzfdf sfd ub}{g eg], of] 7Ls 5 . olb b'j} lbzfdf sfd u5{ jf s'g} lbzf sfd ub}{g eg], 8fof]8 lalu|Psf] 5 .
* o;/L, tkfO{+n] 8fof]8nfO{ ;lhn} k/LIf0f ug{ ;Sg'x'G5 .

o; ln+sdf lSns u/]/ yk ljj/0f k|fKt ug{ ;Sg'x'G5M

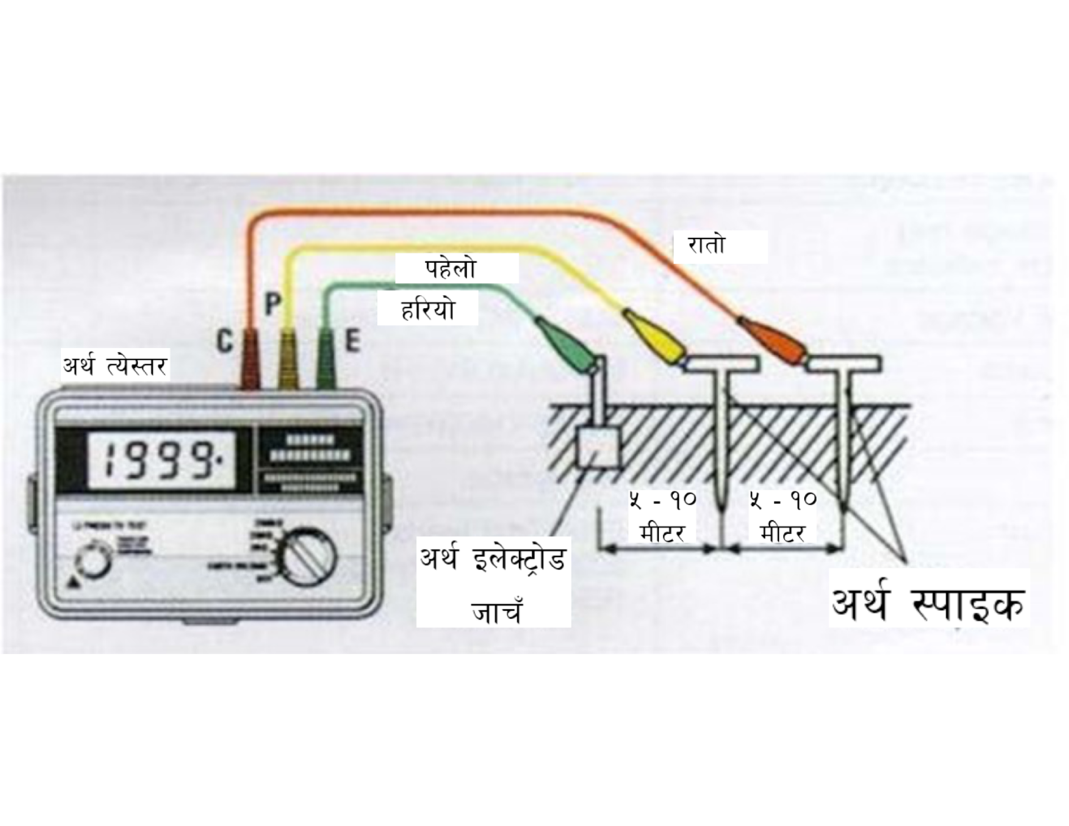
* <https://www.electricaltechnology.org/2019/10/blocking-bypass-diode-solar-panel-junction-box.html#google_vignette>
* o; ln+sn] ;f}o{ Kofgndf Anlsª / afOkf; 8fof]8x¿sf] pkof]u, ltgLx¿sf] sfo{, / Kofgnsf] bIftf ;'wfg{sf] nflu ltgLx¿ s;/L d2t ug{ ;S5g\ eGg] af/]df hfgsf/L lbG5 .

## d]u/ -Megger\_ k|of]u u/]/ Earth resistance dfkg ug]{ tl/sf

d]u/ -Megger\_ Ps ljz]if pks/0f xf] h;nfO{ k[YjLsf] cj/f]wsf] (earth resistance) dfkg ug{ k|of]u ul/G5 . o;n] k[YjLsf] cj/f]wsf] ;xL dfkg ug{ d2t k'of{pF5 / ljB't k|0ffnLsf] ;'/Iff ;'lglZrt ub{5 . oxfF d]u/sf] k|of]u u/]/ k[YjL cj/f]w s;/L dfkg ug]{ af/]df r/0fa4 ljlw k|:t't ul/Psf] 5M

**cly{ËnfO{ cy{ 6]:6/ (earth tester) k|of]u h/L hfFr ug]{ tl/sf**

* cly{Ë u/]sf] :yfg klxrfg ug{],
* cly{Ësf] nflu lk6 k|of]u ePsf] eP, lk6 vf]Ng],
* cy{ 6]:6/df ePsf s]annfO{ kfFr / bz dL6/df hf]8\g] . tnsf] lrqdf b]vfOP cg';f/ ug{] .



* cy{ 6]:6/df b]vfPsf] dfkgnfO{ sflkdf n]V\g]
* obL dfkg !) cf]d (10 ohm) eGbf w]/} ePdf, tnsf pkfox? ug{] .
  + g'lgnf] kfgL cly{Ësf]] vfN8f]df xfNg],
  + ;do ;dodf kfgL cly{Ësf] vfN8f]df xfNg],
  + hfFr u/L ;s]kl5 cly{Ë lk6 aGb ug{] .

#### nfO{6lgª c/]:6/sf] cly{ËnfO{ cy{ 6]:6/ k|of]u h/L hfFr ug]{ tl/sf

* nfO{6lgª c/]:6/ h8fg u/]sf] 5 ls 5}g x]g{] . nfO{6lgª c/]:6/sf] nflu 5'§} cly{Ë x'g'k5{ .
* nfO{6lgª c/]:6/sf] nflu lk6 k|of]u eP, lk6 vf]Ng],
* cy{ 6]:6/df ePsf s]annfO{ kfFr / bz dL6/df hf]8\g],
* dflysf] lrqdf b]vfOP cg';f/ ug{]
* cy{ 6]:6/ cg (earth tester ON) ug{]
* cy{ 6]:6/df b]vfPsf] dfkgnfO{ sflkdf n]Vg],
* obL dfkg !) cf]d (10 ohm) eGbf w]/} ePdf, tnsf pkfox?
  + g'lgnf] kfgL cly{Ësf]] vfN8f]df xfNg],
  + ;do ;dodf kfgL cly{Ësf] vfN8f]df xfNg],
  + hfFr u/L ;s]kl5 cly{Ë lk6 aGb ug{] .

## cgnfOg 8f6fsf] k|of]u u/L ;f}o{ ljls/0f -Solar radiation\_ lgwf{/0f ug]{ k|lqmof

tn pNn]v ul/Psf] j]a;fO6df uP/ :yfg rog u/L ;f}o{ ljls/0f gS;f jf 8f6f 8fpgnf]8 ug{ ;lsG5 . To;dWo] oxfF Global Solar Atlas sf] dfWodaf6 map data lgsfNg] tl/sf JofVof ul/Psf] 5 .

* Global Solar Atlas sf] search location df cfk"mnfO{ cfjZos k/]sf] :yfgsf] cIff+z / b]zfGt/sf] dfg bzdnj k5fl8 ^ c+sdf sdf -,\_ n] 5'6\6ofO{ vf]hL ug'{xf];\ .
* Open detail df click u/L cfjZos map data lng'xf];\ jf cGo cfjZos ;"rgf k|fKt ug'{xf];\ .
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* of] k|lqmofn] ;f}o{ k|fljlwsx¿nfO{ s'g} klg :yfgsf nflu ;f}o{ ljls/0f lgwf{/0f ug{ d2t ug]{5 .

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;f}o{ ljls/0fM of] ;"o{af6 lg:sg] pmhf{ xf], h'g k[YjLsf] ;txdf cfOk'U5. o;nfO{ ;fdfGotof kWh/m²/day df dfkg ul/G5 . tn oL kf]6{nx¿df tkfO{+n] ljZjJofkL ;f}o{ ljls/0fsf] hfgsf/L kfpg ;Sg'x'G5, h'g ;f]nf/ k|f]h]S6x¿df ;f}o{ ljls/0f -Solar radiation\_ lgwf{/0f ug{sf nflu dxTjk"0f{ x'G5 .

cgnfOg ;|f]tx¿

* **Global Solar Atlas:** ljZje/sf ;f}o{ ljls/0f 8f6f k|bfg u5{ . <https://globalsolaratlas.info/>
* **NASA POWER Data Access Viewer:** ljZje/sf ;f}o{ ljls/0f 8f6f k|bfg u5{ . <https://power.larc.nasa.gov/data-access-viewer/>
* **PVGIS:** o'/f]k / clk|msfsf] nflu k|d'v 8f6f, t/ ljZje/sf nflu klg pknAw 5 . <https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html>
* **SolarGIS:** ljZjJofkL :yfgx¿sf nflu ;f}o{ ljls/0f gS;f / 8f6f k|bfg u5{ . <https://solargis.com>
* **NREL NSRDB:** cd]l/sf s]lG›t pRr–l/hf]No';g ;f}o{ ljls/0f 8f6f . <https://nsrdb.nrel.gov>

lgb]{zgx¿

lgDg lnlvt k|lqmof dfly lbPsf] x/]s kf]6{ndf ;fdfGo ¿kdf nfu" x'G5 / of] k|lqmofn] ;f}o{ k|fljlwsx¿nfO{ s'g} klg :yfgsf nflu ;f}o{ ljls/0f lgwf{/0f ug{ d2t ug]{5 .

* dfly lbOPsf lnÍx¿df lSns ug{'xf];\ .
* j]a;fO6 v'Ng] lalQs} cfˆgf] :yfg jf If]q 5gf}6 ug{'xf];\ hxfF tkfO{+ ;f}o{ ljls/0fsf] 8f6f vf]Hg rfxg'x'G5 .
* ;f}o{ ljls/0fsf] 8f6f x]g{sf] nflu pknAw ljsNkx¿ -h:t}M :yfg, dfkb08\_ 5gf}6 ug{'xf];\ .
* tkfO{+n] rflxPsf] ;dofjlw jf cGo dfkb08 cg';f/ 8]6f lkmN6/ ug{'xf];\ .
* glthfx¿ gS;f, rf6{, jf tflnsfsf ¿kdf x]g{'xf];\ .
* cfjZostf ePdf, 8]6f 8fpgnf]8 ug{ jf l/kf]6{ agfpgsf] nflu pknAw 8fpgnf]8 ljsNkdf lSns ug{'xf];\ . CSV, Excel h:tf kmfOndf 8f6f 8fpgnf]8 ug{'xf];\ .

# Understanding single phase and three phase systems

As a solar technician, understanding single-phase and three-phase electrical systems is crucial for successful solar installations. This section provides a clear overview of both systems, their wiring configurations, and practical applications in solar energy systems.

**Single phase electrical system**

A single-phase electrical system commonly found in residential settings. It consists of two wires: one live (phase) wire and one neutral wire.

Key Features:

1. **Wiring configuration**

* Live wire: Carries the current to the load.
* Neutral wire: Completes the circuit by returning current.

1. **Voltage levels:** Typically operates at 230V in Nepal.
2. **Power capacity:** Generally, supports loads up to about 5 kW.
3. **Working procedure:** In single-phase wiring, electricity flows from the live wire to the appliance and back through the neutral wire. This system is suitable for smaller loads like lights and household appliances.
4. **Example applications**

* Residential homes: Most homes use single-phase power for everyday appliances like refrigerators, air conditioners, and lighting.
* Small shops: Small businesses often use single-phase systems when their power needs are low.

**Three phase electrical system**

A three-phase electrical system is used mainly in commercial and industrial settings. It consists of three live wires (phases) and often includes a neutral wire.

Key features

1. **Wiring configuration**

* Three live wires: Each carries current and is spaced 120 degrees apart in terms of voltage phase.
* Neutral wire: Used to balance the load across the phases.

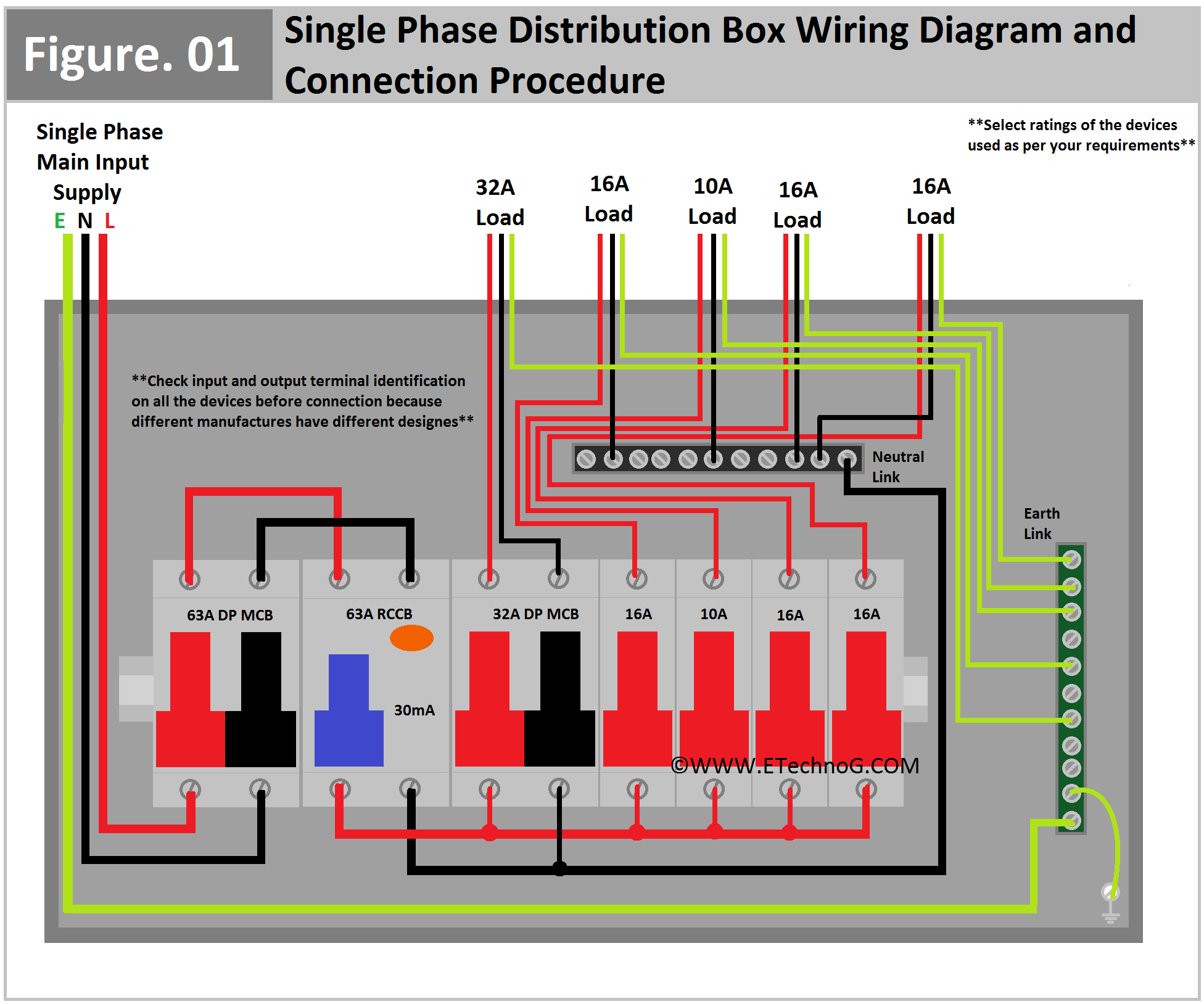
1. **Voltage levels:** Commonly operates at 208V, 380V, or 415V.
2. **Power** **capacity:** Can handle larger loads, often exceeding 15 kW.
3. **Working procedures:** In three-phase wiring, electricity flows through three separate live wires. This setup allows for a more stable and continuous power supply because the phases work together to provide a steady flow of power.
4. **Example applications**

* Industrial machinery: Factories often use three-phase wiring to run heavy machinery efficiently.
* Commercial buildings: Shopping malls and office buildings with high energy demands typically rely on three-phase power.

# Understanding single phase and three phase distribution board

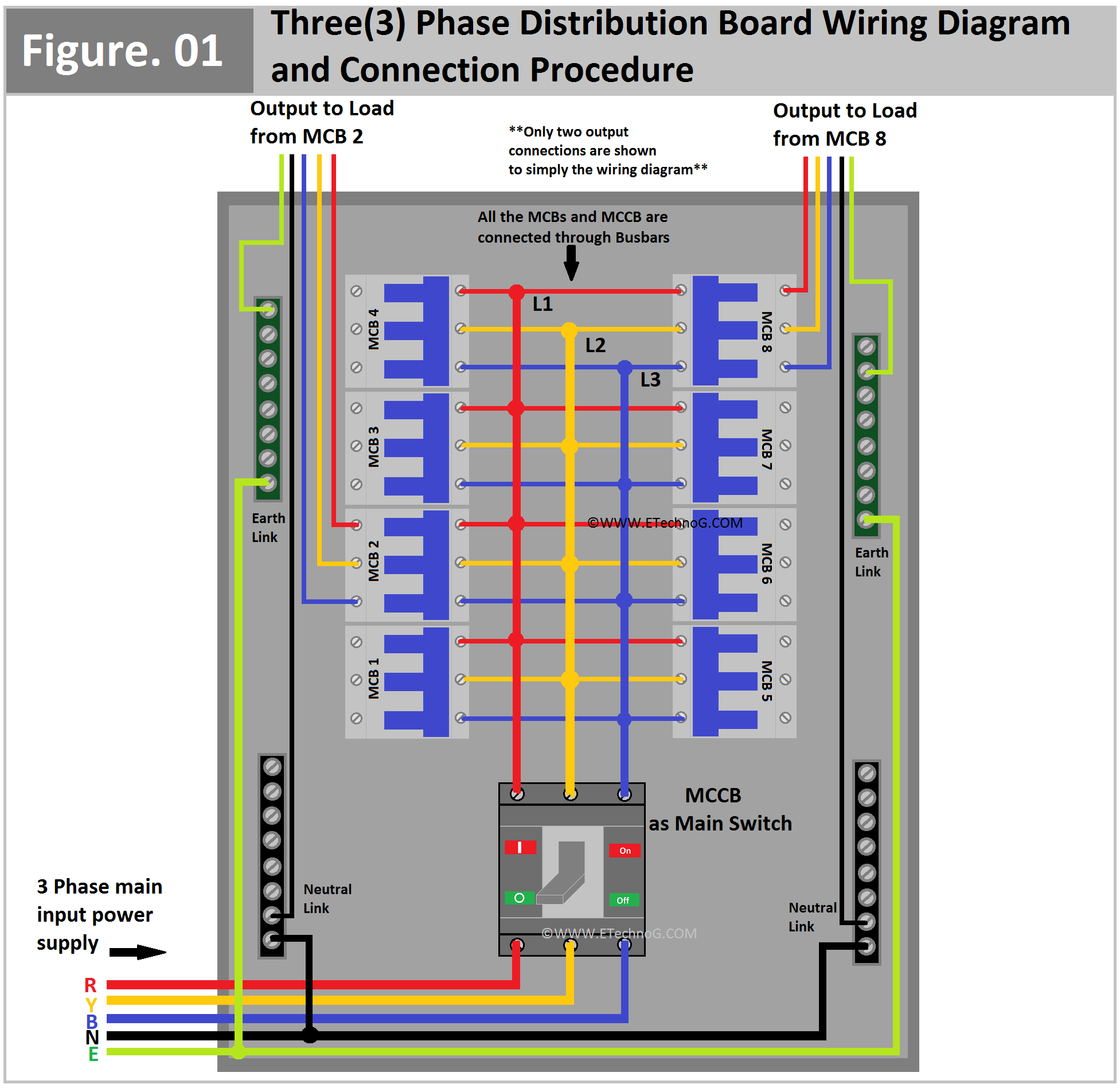
A screenshot of a computer

Description automatically generated



A diagram of a three phase wiring

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# Wiring considerations for solar systems

When installing solar energy systems, understanding how to wire them correctly for both single-phase and three-phase systems is essential:

Single phase solar inverters:

* Ideal for residential setups where energy needs are moderate.
* The inverter converts DC from solar panels into AC suitable for home use.
* Wiring involves connecting the inverter to the main service panel using appropriate cables that meet safety standards.

Three phase solar inverters:

* Best suited for commercial installations because they can manage higher loads efficiently.
* A three-phase inverter distributes power evenly across all three phases, ensuring stable energy delivery.
* Wiring requires careful consideration of load balancing and compatibility with the electrical grid.

# Load balancing/ distribution in three-phase systems

**Overview:** Load balancing in three-phase systems is crucial for efficient energy distribution from solar installations, ensuring even current distribution among phases.

**Key points:**

1. **Three-phase system basics**
   * Consists of three conductors with alternating current (AC) 120 degrees out of phase.
   * Balanced loads draw equal current in each phase.
2. **Importance of load balancing**
   * Reduces neutral current: Prevents overheating of wire and improves safety.
   * Enhances equipment performance: Protects motors and transformers from damage.
   * Stabilizes voltage: Maintains consistent voltage levels across phases.
3. **Balancing techniques**
   * Redistribution of loads: Shift loads to achieve equal current on all phases.
   * Monitoring: Use current and voltage sensors to detect imbalances.
   * Smart technologies: Implement demand response and smart grid solutions for real-time adjustments.
4. **Detection of imbalances**
   * Monitor current in each phase.
   * Check voltage levels to identify issues.
5. **Consequences of imbalance**
   * Overloading can lead to equipment failure.
   * Increased harmonic distortion affects power quality.
   * Reduced overall system efficiency.

Here are some examples that illustrate the importance of balancing loads in three-phase systems for solar technicians, along with brief explanations for each:

1. **Residential solar systems**

Example:A residential solar installation with a three-phase inverter connected to various household appliances (e.g., air conditioners, refrigerators, and lighting).

Explanation: If the air conditioner is connected to one phase while the refrigerator and lighting are connected to the other two phases, the load becomes unbalanced. This can cause the phase with the air conditioner to draw significantly more current, leading to overheating of wires and increased energy losses. Balancing the load by distributing appliances evenly across all three phases ensures optimal performance, reduces energy costs, and prevents equipment damage.

1. **Commercial buildings**

Example: A commercial building with multiple floors, each with its own set of electrical loads (e.g., elevators, HVAC systems, and office equipment).

Explanation: In a three-phase system, if one floor has a heavy load (like multiple elevators), while other floors have lighter loads, the phase supplying that floor will experience higher current. This imbalance can lead to overheating of transformers and circuit breakers, increasing maintenance costs and reducing system reliability. By ensuring that loads are balanced across all floors, the building can operate more efficiently and safely.

1. **Industrial facilities**

Example: An industrial facility using large motors for manufacturing processes.

Explanation:If one motor is significantly larger than others and is connected to only one phase, it will draw more current than the other motors. This unbalanced load can cause excessive wear on electrical components and transformers. To mitigate this, technicians can distribute motors across all three phases based on their power requirements, ensuring that each phase carries a similar load. This balance enhances efficiency and prolongs equipment life.

1. **Data centres**

Example: A data centre with numerous servers and cooling units.

Explanation: Data centres require a stable power supply to maintain operations. If cooling units are concentrated on one phase while servers are distributed unevenly across others, it creates an unbalanced load. This can lead to voltage fluctuations and increased harmonic distortion in the power supply. By balancing server racks and cooling units across all three phases, data centres can ensure stable operation, reduce energy losses, and enhance overall system reliability.