

 **studymate**

Name ELECTRICAL TRADES
Subject COLLEGE
Year _____ School _____

96 Page

A4 Botany Book

8mm Feint Ruled / Blank Pages
70gsm Premium Paper



2

HLTA 7 909

C00046

C00044

RE0022

RE0011

RE0016

EL0024

EL0026

Advanced Trade / Trade 2

- 1 UAFCA 0007 E101A OMC
- 2 UAFCA 0016 E137A OMS Risk
- 3 UAFCL 9003 Control / Protection G003
- 4 UAFCL 0012 Install LV wiring / eqpt G103 / 104
- 5 UAFCL 0014 Trouble L-V ckt G103
- 12 UAFCL 0018 Select wiring system cable G107
- ✓ 6 UAFCL 0024 Arculating Machine // G006
- ✓ 7 UAFCL 0025 Transformer
- 8 UAFCL 0039 Capacitors
- 9 UAFCL 0047 Shut down / Restart Alternator supply
- 10 UAFTR 0006 Rescue from Live L-V panel
- 11 UAFCL 0012 Select wiring system / cable G107
- 17 UAFCL 005 - Connect Control Electrical G109
Control ckt

HLTAID009 Provide cardiopulmonary resuscitation

Anxiety mental distress, emotional disturbance, and depression - safety, calm, connectedness, self efficacy group efficacy.

D-R-S-A-B-C-D - Danger, R-Response S-Send for help

A-Airways B-Breathing C-cardiopulmonary resuscitation

D-Defibrillation

CPR video www.igytechnicalcollege.com/electricaltrade
UAFCEE 001A LIFE SUPPORT CPR in 2022 hr
workplace

video 33, 34, 35, 36

video 33 - Adult Infant child basic Life Support (General)

Video 34 Two Rescuer BLS, CPR for Adult
CPR for Infant

video 35. AED.

Students will be required to give basic report on the victim including - injury - location of injury, scars or visible cuts or abrasion. severity of cuts and treatment time period when you first see the victims to when emergency service arrive

If any CPR has been provided, How long

- S - Send for help

CPR for Spinal Injuries

The victim's head should be kept it in neutral position while CPR is being performed. It is important to minimize the movement of spine.

Equipment

Adult + Infant Training manikin with CPR monitor
And AED Trainer

UEEC0019 Fabricate assemble and dismantle utilities industry components

UEEC0020 Fix and secure electro technology equipment

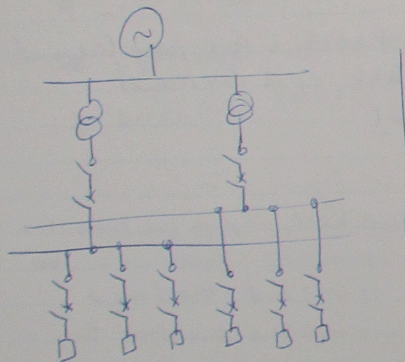
UEEC0044 Solve Problems in multi path circuit

UEEC0046 Solve Problems in single path circuits

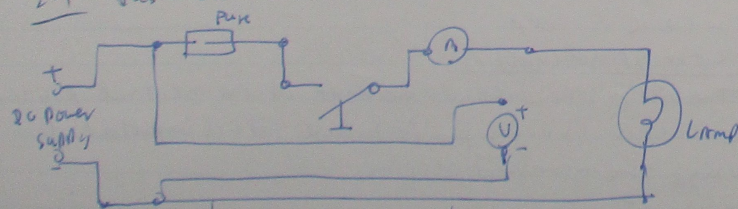
UEEC0046

1.1 Electricity supply Arrangement

1-1
 $I = \frac{Q}{t}$ $t = 40 \text{ min}$ $Q = I \times t = 5 \times 40 \times 60 = 12000 \text{ C}$
 $Q = 15000 \text{ C}$ $I = 2 \text{ A}$ $t = \frac{Q}{I} = \frac{15000}{2} = 7500 \text{ sec}$
 $\frac{7500}{3600} = 2.08 \text{ hr}$ $2.08 \text{ hr} \times \frac{300}{60} \rightarrow 2.08 \text{ hr}$



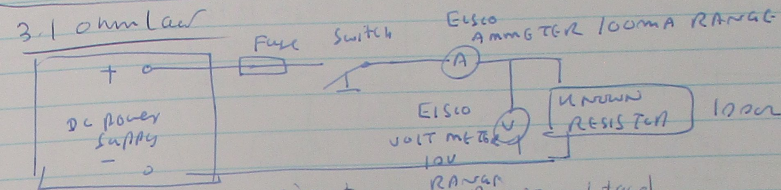
2.1 Basic Electrical circuit connection



Voltage setting	voltage	current	Lamp
1	5	0.75 A	Dark
2	10	1.05 A	Dim
3	30V	1.80 A	Bright

Table 2.1

Table 2.2	circuit condition	circuit voltage	Cut current	Lamp	Protection device
Circuit cut	Closed	1.2A 30V	1.2A	Bright	closed
	Open	30V	0A	Dark	closed
	Shorted	30V	6A	Dark	open



Settings	circuit current mA	Resistor voltage (V)
Settings	10	1
2	20	2
3	30	3
4	40	4
5	50	5

2.4.1 Replace the unknown resistor with known resistor close circuit switch adjust power supply to achieve the voltage across the resistor given by trainer

390Ω, 2V → 5.1mA $R = \frac{2}{5.1 \times 10^{-3}} = 390\Omega$
 3V → 7.6mA $R = \frac{3}{7.6 \times 10^{-3}} = 390\Omega$
 1V → 2.6mA $R = \frac{1}{2.6 \times 10^{-3}} = 390\Omega$

Table 3.2

- 9/ 4.5V → 4.5mA
 10/ direct proportional 11/ resistor open → zero current
 12/ Resistor short - fuse blown by short current

B.2.1 Series circuit Resistance relationships measured values

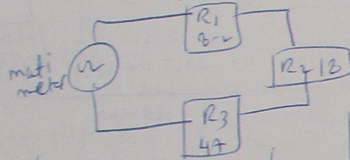
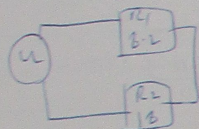
Resistor	Analog meter (Ω)	Digital meter (Ω)
R ₁	7.5Ω — 8Ω	8Ω — 8.4Ω
R ₂	13Ω — 18Ω	18.2Ω — 18.5Ω
R ₃	40Ω — 42Ω	47.5Ω — 48Ω

$$R_1 + R_2 = 8.2 + 18 = 26.2\Omega$$

$$R_1 + R_3 = 8.2 + 47 = 55.2\Omega$$

$$R_2 + R_3 = 18 + 47 = 65\Omega$$

$$R_1 + R_2 + R_3 = 8.2 + 18 + 47 = 73.2\Omega$$



Series connected	measured
R ₁ + R ₂	24 → 24Ω
R ₁ + R ₃	52 → 58Ω
R ₂ + R ₃	61 → 69Ω
R ₁ + R ₂ + R ₃	69 → 77Ω

R₁ open ∞
R₃ short 24 → 28Ω

B.2.2 R₁ = 8.2Ω, R₂ = 18Ω, R₃ = 47Ω

Resistor (Ω)	measured values - digital meter (Ω)
R ₁ (8.2Ω)	7.5Ω — 8.7Ω
R ₂ (18Ω)	17Ω — 19Ω
R ₃ (47Ω)	44Ω — 50Ω

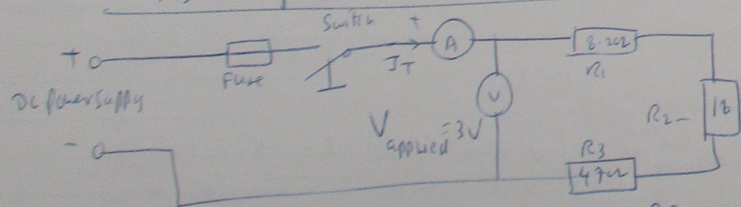


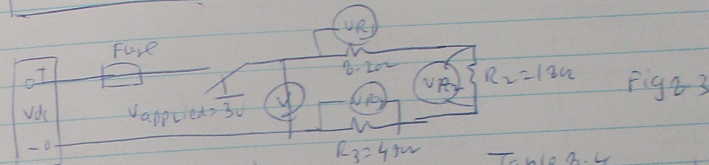
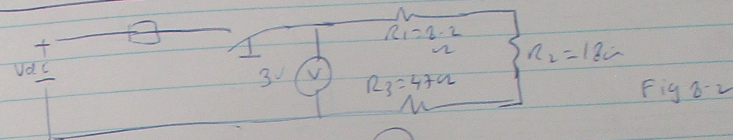
Table B.2

Total Resistance Ω	Total Current (mA)	Voltage across R ₁	Voltage across R ₂	Voltage across R ₃	Total Voltage drop
73.2	41 mA	336 mV	738 mV	1.93 V	3V

V_T = 3V dc

Table B.3

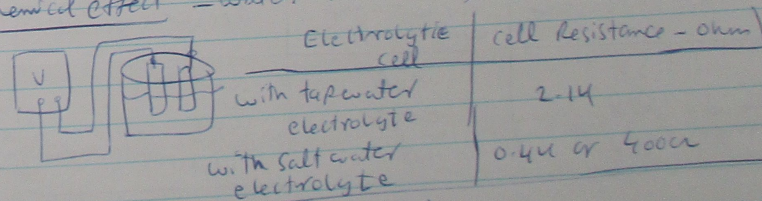
circuit condition	Total circuit current (mA)	current through R ₁ (mA)	current through R ₂ (mA)	current through R ₃ (mA)
Normal	38-43	38-43	38-43	38-43
open R ₂	0	0	0	0
Short circuit R ₃	108-121	108-121	108-121	0



circuit condition	voltage across R ₁ V _{R1}	voltage across R ₂ V _{R2}	voltage across R ₃ V _{R3}	Total V _T V _{R1} + V _{R2} + V _{R3}
Normal	0.319 — 0.353 V	0.7 — 0.8 V	1.8 — 2.1 V	2.9 — 3.1 V
open circuit R ₂	0	3 V	0 V	2.9 — 3.1 V
Short circuit R ₃	0.6 — 1 V	1.9 — 2.2 V	0 V	2.9 — 3.1 V

S.2 Effect of Electrical current

Chemical effect — water in battery, put salt. use electrode



measure the resistance of clean water
put the salt in to water / measure the resistance of salt water.

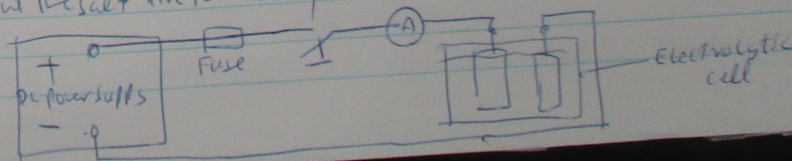
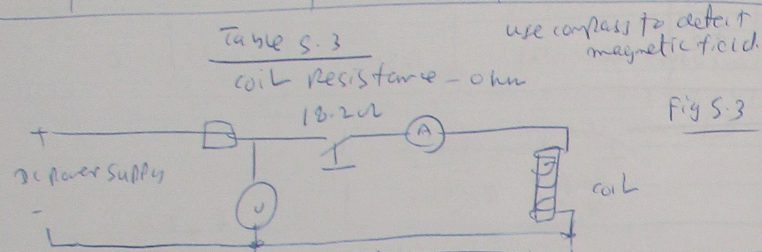


Table 5.2

Applied voltage - volt	Electrolyte observation
119V	slight
90V	more than slight
93V	medium



Applied voltage volt	circuit current - amp	coil observation
20V	0.25A	slight
18V	0.55A	slight to strong
18.75V	0.8 A	strong.

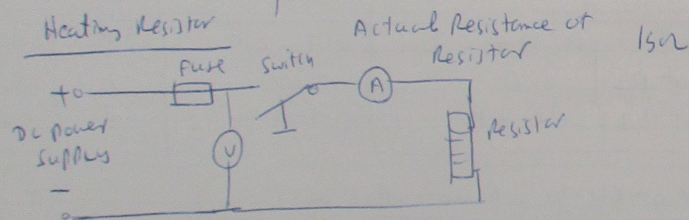
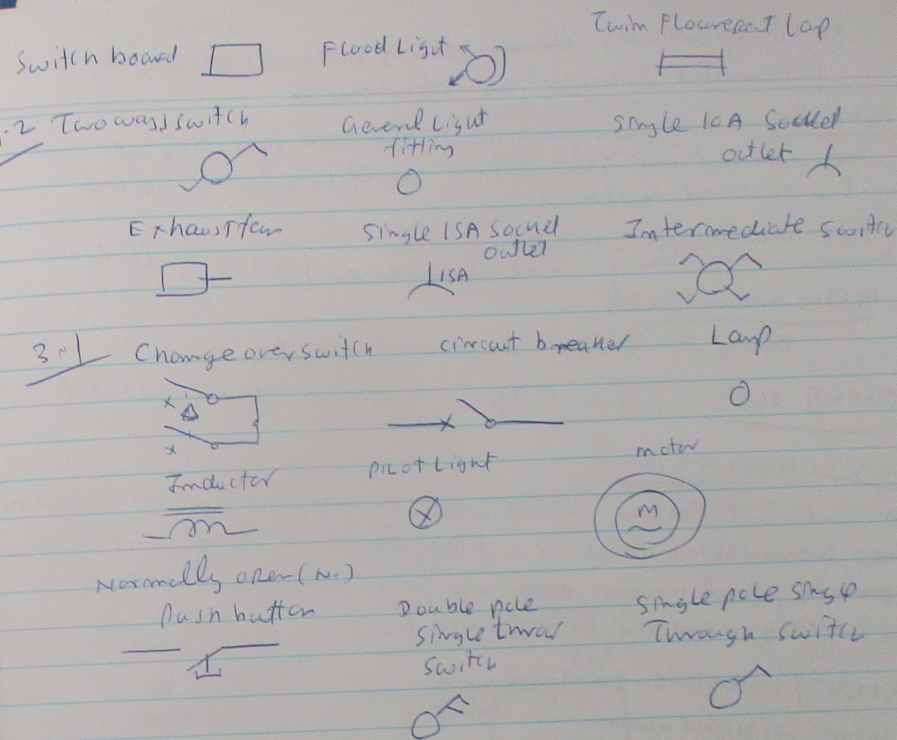


Table 5.6

Applied voltage	circuit - mA current	Resistor observation
5V	0.3A	cold
10V	0.60A	warm
15V	1A	Hot



- u E F C D 0051 3-2
- AS/NZS 3760 - 1/ Australian Chamber of Commerce and Industry
- 2/ Australian Industry Group (AIG)
- 3/ Australian Lighting Industry Association
- 4/ Standards Australia
- 5/ Standards New Zealand
- 5 other standards referenced to AS3760 (In service Safety Inspection and Testing of electrical equipment)
- 1/ AS 3000 Australian Electrical Wiring
- 2/ AS/NZS 1020:2013 The control of static electricity in non hazardous areas
- 3/ AS/NZS 1284.13:2002 Electricity metering - In service compliance Testing
- 4/ AS/NZS 2500:2010 safe use of medical Electrical Equipment in health care
- 5/ AS/NZS 2978: 1995 - Insulation Mat for Electrical purposes

Bold prints indicate, defining opening statements defining the fundamental principles and requirements

AS/NZS 3760 To ensure work places are safe by setting out recommendations in relation to testing 240V, 34 and L.V electrical equipment

3760 covered eqpt Batteries charge / laptop charger / electric drill etc

AS 3760 does not apply

Testing for design and approval of eqpt

Class II eqpt 1.4.4 Class II equipment double insulated

1.4.5 competent person

A competent person is one who the responsible person ensures, has the necessary practical and theoretical skills acquired through training, qualification, experience or a combination of these to correctly undertake the required task.

<https://infostore.saiglobal.com>

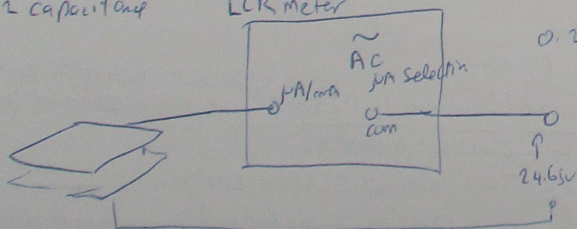
www.saiglobal.com

Electro Technology work AS 3000, AS 3760 AS 61439

UEE CP0044 Solve Problems in multi-path circuits

6.2 capacitance

LCR meter (Revisit)



0.25A f=50Hz

$$X = \frac{V}{I} = \frac{24.65}{0.25 \times 10^{-3}} = 98.6 \times 10^3 \Omega$$

$$C = \frac{1}{2\pi fC} = 123.25 \times 10^6$$

$$C = \frac{1}{123.25 \times 10^6 \times 314} = \frac{10^6}{123.25 \times 314 \times 10^6} = \frac{10^6}{38.7 \times 10^6} = 25.84 \mu F$$

CP0044

6.2 capacitance



Ext diameter of plate = 70mm

Internal dia: of plate = 10mm

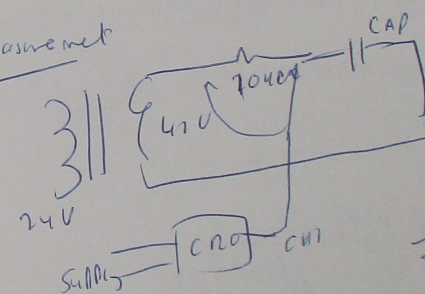
Distance between plate = 13mm

$$A = \frac{\pi}{4} (D^2 - d^2) = 0.7854 \left[\left(\frac{70}{100} \right)^2 - \left(\frac{10}{100} \right)^2 \right] = 2.35 \times 10^{-4} m^2$$

$$A_{eff} = A(2-1) = 2.35 \times 10^{-4} m^2$$

$$C = \frac{A_{eff} \times \epsilon_0 \times \epsilon_r}{d} = \frac{2.35 \times 10^{-4} \times 8.85 \times 10^{-12} \times 4}{0.013} = 0.6399 nF$$

Measurement



V = 0.1mV across

$$I = \frac{0.1 \times 10^{-3}}{10 \times 10^3} = 0.01 \times 10^{-6} A$$

$$X_C = \frac{V}{I} = \frac{42}{0.01 \times 10^{-6}} = 4200 \times 10^6 \Omega$$

$$C = \frac{1}{2\pi fC} = \frac{1}{314 \times 4200 \times 10^6} = 0.75 pF$$

- ① calculate % difference between calculated value & measured value

$$\% \text{ Difference} = \frac{0.78 - 0.6399}{0.6399} \times 100 = 17.2\%$$

Causes of difference

we know it needs to calculate area then calculate the capacitance value. difference in calculation step because is not 100% filled.

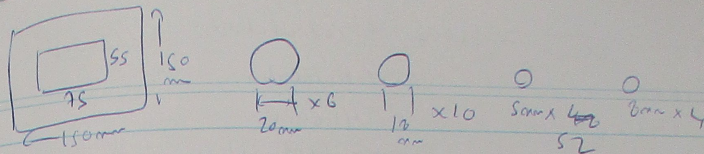
- ② The model capacitor used for this practical is large & only has a few capacitors. Discuss how a non-compact capacitor could be constructed
 By using flexible dielectric sheet like oiled paper sandwiched between sheets of metal foil. non-compact capacitor can be produced.

- ③ 3 ways to adjust capacitance value
 - Adjusting the effective plate area, adjusting the thickness of dielectric, adjusting the relative permittivity of dielectric.

- ④ $C = 0.01 \mu F$ 30mm x 20mm plate, 0.08mm thick
 $\epsilon_r = 7$
 $C = \frac{A \epsilon_r \epsilon_0}{d}$ $\rightarrow A_{eff} = \frac{Cd}{\epsilon_r \epsilon_0} = \frac{0.01 \times 10^{-6} \times 0.002 \times 10^{-3}}{7 \times 8.85 \times 10^{-12}} = 0.0129$
 $A_{eff} = A(N-1)$ $N = \frac{A_{eff}}{A} + 1 = \frac{0.0129}{30 \times 10^{-3} \times 20 \times 10^{-3}} + 1 = 22 + 1 = 23$

- ⑤ 6 dielectric materials commonly used for capacitors
 Ceramics, plastic film, oxide layer on metal (Aluminium, titanium, niobium, molybdenum), porcelain, polystyrene

- ⑥ Construction of electrolytic capacitor
 An Aluminium electrolytic capacitor consists of aluminium plates and paper dielectric. The plates & dielectric are rolled and encased in a protective coating.



$$A = 150 \times 150 - [75 \times 75 + 6 \times 0.7854 \times 20^2 + 10 \times 0.7854 \times 12^2 + 4 \times 0.7854 \times 5^2 + 4 \times 0.7854 \times 20^2]$$

$$= 22500 - [4125 + 1824.96 + 2844.66 + 1021 + 201.06]$$

$$= 22500 - [9796.68] = 12703.32 \text{ mm}^2 = \frac{12703}{10^6} = 0.0127 \text{ m}^2$$

$$C = A_{eff} \times \frac{\epsilon_0 \epsilon_r}{d} = 0.012(2-1) = 0.012 \text{ m}^2$$

$$C = \frac{A_{eff} \times \epsilon_0 \epsilon_r}{d} = \frac{0.012 \times 8.85 \times 10^{-12} \times 7}{0.0008} = 9.44 \text{ pF} \approx 10 \text{ pF}$$

measured value = 25.82 pF
 calculated value = 20 pF

SERIES PARALLEL CIRCUIT C D0044

2.2.1 $R_1 = 5.6k$ $R_2 = 12k$ $R_3 = 4.7k$ $R_4 = 100k$

V _T	TOTAL VALUE		BRANCH CURRENTS (mA)				VOLTAGE DROP (V)			
	R _T	I _T	I ₁	I ₂	I ₃	I ₄	V _{R1}	V _{R2}	V _{R3}	V _{R4}
3V dc	118.6 Ω	0.0152 AMP	0.0152	0.0152	0.0152	0.0152	0.146	0.338	0.338	2.52V

Turn on Supply, measured value

V _T	TOTAL VALUE		BRANCH CURRENTS (mA)				VOLTAGE DROP (V)			
	R _T	I _T	I ₁	I ₂	I ₃	I ₄	V _{R1}	V _{R2}	V _{R3}	V _{R4}
3V dc	120	25 mA	25mA	18 mA	4 mA	25 mA	143 mV	0.338 mV	0.338 mV	2.54 V

$$R_T = \frac{V_T}{I_T} = \frac{3}{25 \times 10^{-3}} = 120 \Omega \quad \text{calculated } R_T = 118.6 \Omega$$

①

V_{R1} (measured)

143 mV

V_{R23} (measured)

339 mV

V_{R4} (measured)

2.54 V

measured value

$$I_2 + I_3 = 18 + 4 = 22 \text{ mA}$$

②

$$\text{Calculated value} \rightarrow I_2 = 0.0186, I_3 = 0.0072 \text{ A}$$

$$I_2 + I_3 = 0.0186 + 0.0072 = 0.026 \text{ A} \rightarrow 26 \text{ mA}$$

③

When R_3 is shortcircuited $\rightarrow R_{23} = 0$

$$R_T = R_1 + R_{23} + R_4 = 5.6 + 0 + 100 = 105.6 \Omega$$

③

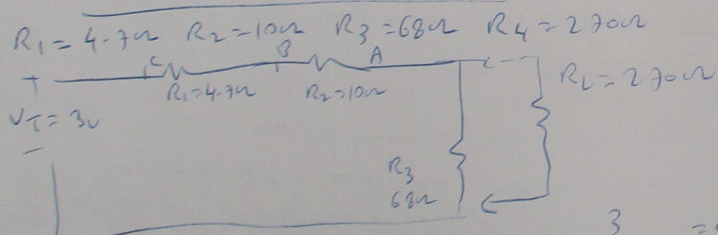
$$I_T = \frac{3}{105.6} = 0.0284 \text{ A (or) } 28.4 \text{ mA}$$

The current will increase

open circuit $R_4 \rightarrow R_4 = \infty$ No current will flow into circuit.

④

2.2.2 voltage divider circuit



⑤

$$R_T = 4.7 + 10 + 68 = 82.7 \text{ k}\Omega, I_T = \frac{3}{82.7} = 0.0362 \text{ A}$$

⑥

$$V_C = 3 \text{ V}, V_B = 3 - 0.0362 \times 4.7 = 2.829 \text{ V}$$

$$V_A = 3 - 0.0362 \times 14.7 = 2.467 \text{ V}$$

$$R_3 || R_L = \frac{68 \times 270}{68 + 270} = 54.3 \Omega, R_T = 4.7 + 10 + 54.3 = 69 \Omega$$

$$I_T = \frac{3}{69} = 0.0434 \text{ A}, V_C = 3 \text{ V}, V_B = 3 - 0.0434 \times 4.7 = 2.796 \text{ V}$$

$$V_A = 3 - 14.7 \times 0.0434 = 2.362 \text{ V}$$

calculated value,

unloaded condition

loaded condition

V_A	V_B	V_C	V_A	V_B	V_C
2.4 V	2.75 V	3 V	2.2 V	2.6 V	3 V

measured value

unloaded condition (V)

loaded condition (V)

V_A	V_B	V_C	V_A	V_B	V_C
2.39	2.83	3.00	2.39	2.83	3.00

$$V_1 = \frac{R_1}{R_1 + R_2} V_T, V_2 = \frac{R_2}{R_1 + R_2} V_T$$

The voltage drop is proportional to Resistance value when the current does not change.

When load is connected, R_3 value is reduced because of parallel effect. Total resistance value of the circuit is reduced. Total current increased. More voltage drop occurs at the points before R_3 and voltage at R_3 value is reduced.

Application of voltage divider circuit

- Adjusting the level of signal
- Bias of active devices in amplifiers
- Voltage measurement by wheatstone bridge.

UGEC00044 | Practical 7.2

$$C \text{ series} \rightarrow C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} \quad Q = V_C$$

$$C \text{ parallel} = C_T = C_1 + C_2 + C_3$$

Dc power supply, digital multimeter $C_1 = 4.7 \mu\text{F}, C_2 = 22 \mu\text{F}$

$C_3 = 47 \mu\text{F}$

Measure capacitors by LCR meter use 190 m F gres

Capacitor	Specified value μF	measured value μF
C_1	4.7	4.62
C_2	22	22.9
C_3	47	48.6

$$R_T = \frac{V_T}{I_T} = \frac{3}{25 \times 10^{-3}} = 120\Omega \quad \text{calculated } R_T = 118.6\Omega$$

V_{R1} (measured)	V_{R1} (calculated)
1.43mV	0.1416mV
V_{R23} (measured)	V_{R23} (calculated)
339mV	338mV
V_{R4} (measured)	V_{R4} (calculated)
2.54V	2.52V

measured value

$$I_2 + I_3 = 18 + 4 = 22 \text{ mA}$$

$$\text{Calculated value} \rightarrow I_2 = 0.0188, I_3 = 0.0072 \text{ A}$$

$$I_2 + I_3 = 0.0188 + 0.0072 = 0.026 \text{ A} \rightarrow 26 \text{ mA}$$

When R_3 is shortcircuited $\rightarrow R_{23} = 0$

$$R_T = R_1 + R_{23} + R_4 = 5.6 + 0 + 100 = 105.6 \Omega$$

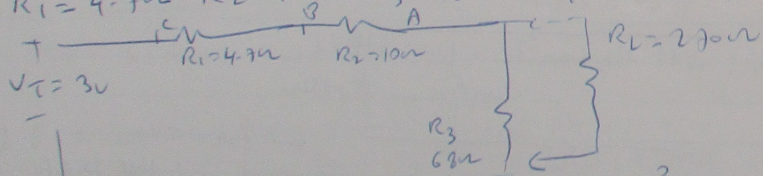
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The current will increase

open circuit $R_4 \rightarrow R_4 = \infty$ no current will flow into circuit.

2-2-2 voltage divider circuit

$$R_1 = 4.7\Omega, R_2 = 10\Omega, R_3 = 68\Omega, R_4 = 270\Omega$$



$$R_T = 4.7 + 10 + 68 = 82.7\Omega, I_T = \frac{3}{82.7} = 0.0362 \text{ A}$$

$$V_C = 3V, V_B = 3 - 0.0362 \times 4.7 = 2.829V$$

$$V_A = 3 - 0.0362 \times 14.7 = 2.467V$$

$$R_3 || R_4 = \frac{68 \times 270}{68 + 270} = 54.3\Omega, R_T = 4.7 + 10 + 54.3 = 69\Omega$$

$$I_T = \frac{3}{69} = 0.0434 \text{ A}, V_C = 3V, V_B = 3 - 0.0434 \times 4.7 = 2.796V$$

$$V_A = 3 - 14.7 \times 0.0434 = 2.361V$$

calculated values

unloaded condition			loaded condition		
V_A	V_B	V_C	V_A	V_B	V_C
2.4V	2.75V	3V	2.2V	2.6V	3V

measured value

unloaded condition (V)			loaded condition (V)		
V_A	V_B	V_C	V_A	V_B	V_C
2.39	2.83	3.00	2.39	2.83	3.00

$$V_1 = \frac{R_1}{R_1 + R_2} V_T, \quad V_2 = \frac{R_2}{R_1 + R_2} V_T$$

The voltage drop is proportional to resistance value when the current does not change.

when load is connected, R_3 value is reduced because of parallel effect. Total resistance value of the circuit is reduced. Total current increased. More voltage drop occurs at the points before R_3 and voltage at R_3 (avg) value is reduced.

Application of voltage divider circuit

- Adjusting the level of signal
- Bias of active devices in amplifiers
- Voltage measurement by wheat stone bridge.

UGFC00044 | Practical 7-2

$$C \text{ series} \rightarrow C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} \quad @ = V_C$$

$$C \text{ parallel} = C_T = C_1 + C_2 + C_3$$

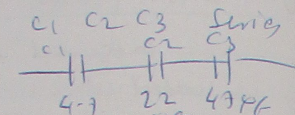
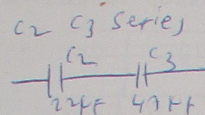
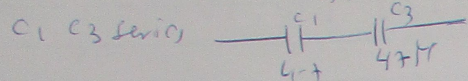
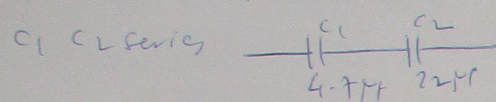
DC power supply, digital multimeter $C_1 = 4.7\mu F, C_2 = 22\mu F$

$C_3 = 47\mu F$

measure capacitors by LCR meter use 190m F range

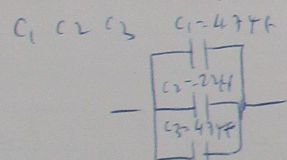
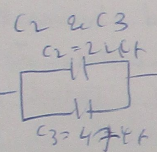
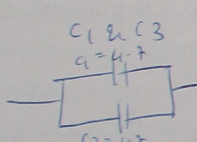
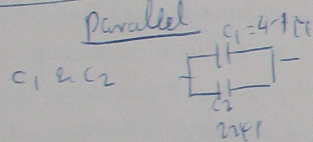
Capacitor	Specified value μF	measured value μF
C_1	4.7	4.62
C_2	22	22.9
C_3	47	46.6

Connect C_1, C_2, C_3 in series



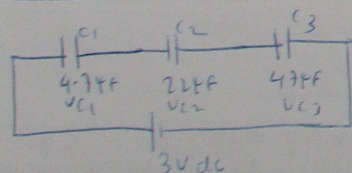
C_1, C_2 Series	measured μF	calculated μF
C_1, C_2 Series	3.65	$4.7 // 22 \approx 3.83$
C_1, C_3 Series	4.2	$4.7 // 47 \approx 4.21$
C_2, C_3 Series	15.5	$22 // 47 \approx 15$
C_1, C_2, C_3 Series	3.56	$4.7 // 22 // 47 \approx 3.58$

Parallel



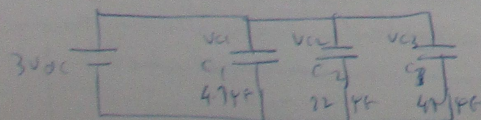
Combination	measured cap μF	Total cap μF
C_1, C_2	27.6	$4.7 + 22 = 26.7$
C_1, C_3	53.1	$4.7 + 47 = 51.7$
C_2, C_3	71.4	$22 + 47 = 69$
C_1, C_2, C_3	76.1	$4.7 + 22 + 47 = 73.7$

C_1, C_2, C_3 Series



Supply Voltage	V_{C1}	V_{C2}	V_{C3}	Total Voltage
3V	1.25	0.72	0.5	3.1V

C_1, C_2, C_3 parallel



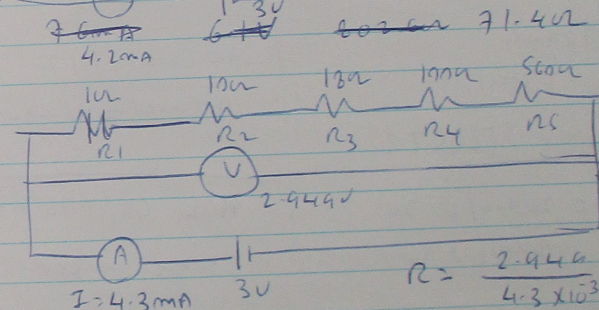
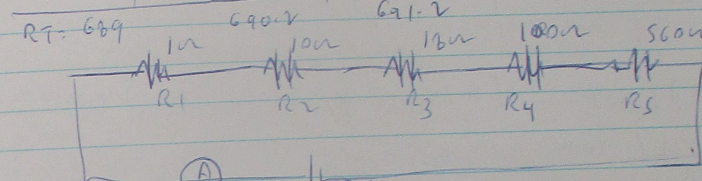
Supply voltage	V_{C1}	V_{C2}	V_{C3}
3V	3.1V	3.1V	3.1V

S.2.1 measure Resistance

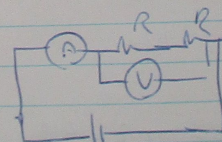
$R_1 = 10\Omega$ $R_2 = 100\Omega$ $R_3 = 1k\Omega$ $R_4 = 10k\Omega$ $R_5 = 500\Omega$

Table S.1

R	Analog	Digital
$R_1 10\Omega$	1.20	1.50
$R_2 100\Omega$	100	10.30
$R_3 1k\Omega$	1.00	1.420
$R_4 10k\Omega$	1100	101.20
$R_5 500\Omega$	550	559

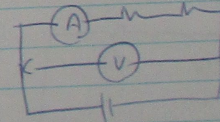


$$R = \frac{2.946}{4.3 \times 10^{-3}} = 685.8\Omega$$



Short Shunt for Low Resistance

The voltage drop in series resistor can not be too much different from the voltage drop across resistors.



Long Shunt for High resistance measurement

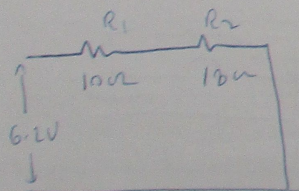
Total current value is small. The current flowing into parallel voltmeter and the current flow into resistor will not be different.

S.2.2 Impedance Resistance measurement

10K - Digital meter	measured	meter
$R_1 \approx 10K$	9.21K	multi meter
Resistor Board - $R_2 = 100K$	$0.1M = 100K$	IR Tester 500V
Standard $R_3 = 1M$	1.2M	IR Tester 500V
$R_3 = 10M$	12M	IR Tester 500V

Resistor Board				
1/220K	2/10K	3/680K	4/12K	5/500K
6/100K	7/2K	8/47K	9/330K	10/100K
11/100K	12/10M			

CD0041
4.3 Loading Effect of meters
Analog multimeter ST306TR
Input impedance 20K/V DC
8K/V AC
max 10A.



10K

Q1/ $R_T = R_1 + R_2 = 10 + 10 = 20K$
 $V = 6.2V$
 $I = \frac{V}{R_T} = \frac{6.2}{20} = 0.2214A$

$V_{R1} = I R_1 = 0.2214 \times 10 = 2.214V$
 $V_{R2} = I R_2 = 0.2214 \times 10 = 3.92V$

Q2/	$V_{R2} = 3.92V$	calculated
	$V_{R2} = 4V$	(Analog) Error = +0.02V (3.92-4)
	$V_{R2} = 3.8$	(Analog multi) = -0.01V (3.92-3.8)
	$V_{R2} = 4.04V$	(Digital) Error = +0.06V (4.04-3.92)

Q3 $R_T = 100K + 1M = 1.1M = 1.1 \times 10^6 \Omega$
 $V = 6.2V$, $I = \frac{6.2}{1.1 \times 10^6} = 5.636 \times 10^{-6}A$
 $V_{R4} = 1 \times 10^6 \times 5.636 \times 10^{-6} = 5.636V$

$V_{Analog} = 0.4V$ Error 0.2V
 $V_{Digital} = 5.63V$
 Error = -0.006V

Table 4.1		
voltage sensitivity	Analog meter	digital multimeter
	30V	1000V
		600V

Table 4.2 measured voltage

	$V_{Supply} = 6.2V$		
	V_{Analog}	$V_{Analog Multi}$	$V_{Digital}$
V_{Supply}	5.8	6.1	6.26V
V_{R1}	2.5	2.2	2.21V
V_{R2}	4	3.8	4.04V

	$V_{Supply} = 6.2V$		
	V_{Analog}	$V_{Analog Multi}$	$V_{Digital}$
V_{Supply}	6V	6.1V	6.25V
V_{R3}	No indication	0.4V	0.567V
V_{R4}	0.4V	3.8V	5.63V

UEERE0022 ~~Bas~~ Solve Basic Problems in
Photovoltaic energy apparatus & systems
Pyranometer APP | Scan the scan app

Solar Tester

1.1 solar Irradiance

Latitude 31.429 302 S 21371376
Longitude 154.9180 7006299499

SKILL PRACTICE 1-1
SOLAR RADIATION

2.1.2 www.bom.gov.au

Climate Past weather / ~~maps~~ / maps - Average / Sunshine radiation cloud
Sunshine duration Sydney - 5-6 hr
Jan - 6 / Feb - 6 / Mar - 7 / May - 6 / June - 6 / Jul - 7
Aug - 8 / Sept - 6 / Oct - 6 / Nov - 8 / Dec - 8

UV Sun Protection | 23 September

1.2 Sydney location 30° 30' S

2.1 Internet

Current location Verecks - NSW
www.latlong.net
9 main street Sydney
Latitude - 33.936668
Longitude 151.019136

www.bom.gov.au - climate & past weather
maps - history to now
Solar exposure

11 September 2023 18 MJ/m²

$$k_w / m = \frac{MJ/m^2}{3.6} = \frac{18}{3.6} = 5 \text{ kW/m}$$

www.bom.gov.au - climate & past weather

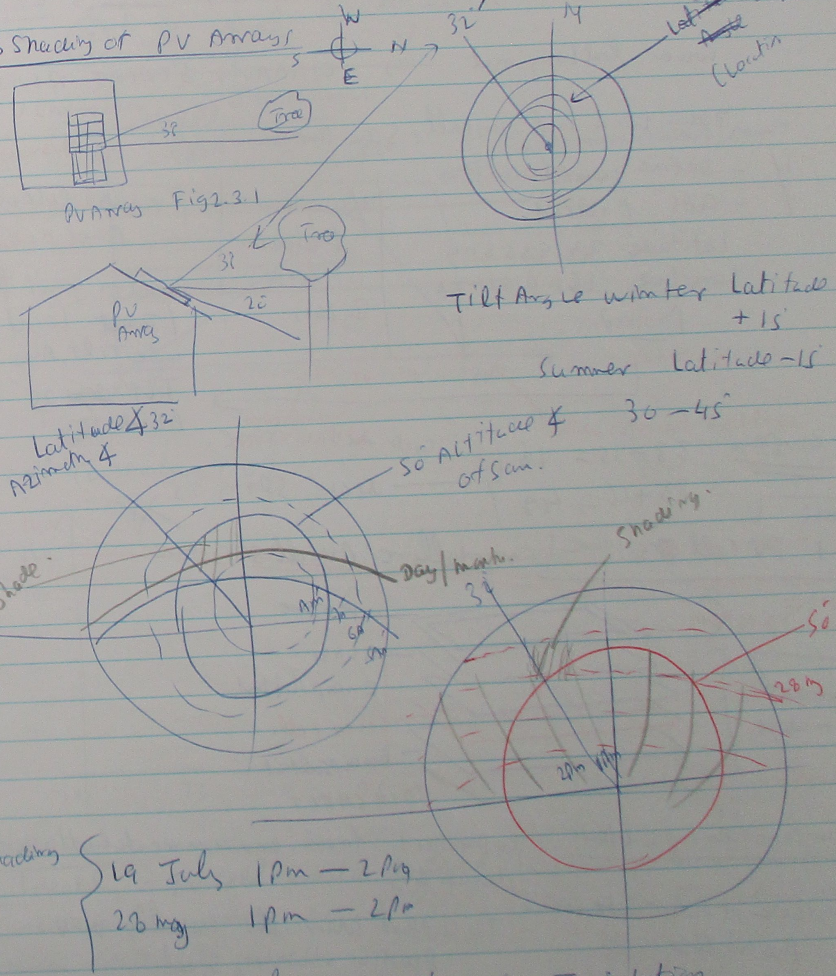
maps - average
Sunshine - radiation cloud
Sunshine duration
Jan → 21
7.08 w/m
1066 lux

nsrdb.nrel.gov
orja solar meter
radiation meter
Solar radiation meter
orja
Google Maps

12/9/2023 1:22 PM 6.79 w/m²
969 Lux

Solar spotter / PV calculator

2.3 Shading of PV Arrays



Factors causes Daily & variation of Irradiation
Seasonal change, Shading & soil loss, cloud cover, Time of day

- 1-2 Determine Suitable Location & tilt angles for PV arrays.
- Approx formulae to calculate Tilt Angle
- Tilt Angle = Latitude Angle + 15° (winter)
- Latitude Angle - 15° (summer)

For 33° → winter = 33 + 15 = 48°
 summer = 33 - 15 = 18°

$$\text{Avg} = \frac{48 + 18}{2} = \frac{66}{2}$$

www.latlong.net → QMAVIS STREET RECOVERY

Room load and install Scan the Sun app

- 1/ Define your location
 - GPS - Proceed
 Latitude 33.9368114
 Longitude 151.0191978
 Proceed

- 2/ contour the location shape
 By (1)

- 3/ Adjust solar panel
 position your phone
 Target level 100%
 note Tilt Angle
 Tilt 25°
 Azimuth 350°

within this range.

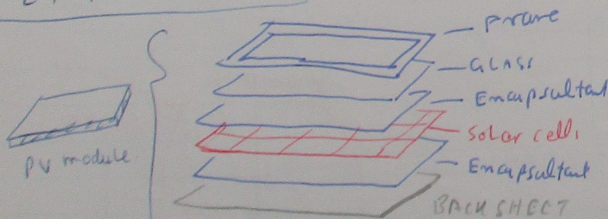
compare 33 - 15 = 18°
 33 + 15 = 48°

Now spring 25°

Skills

2.1 PV cell structure

Crystalline PV cell structure



Purpose of Encapsulant

To protect from environmental attack and durability

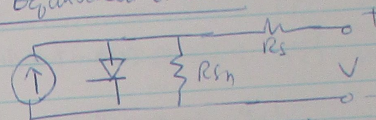
Purpose of substrate in PV module

- To support solar cells usually glass plastic stainless steel.

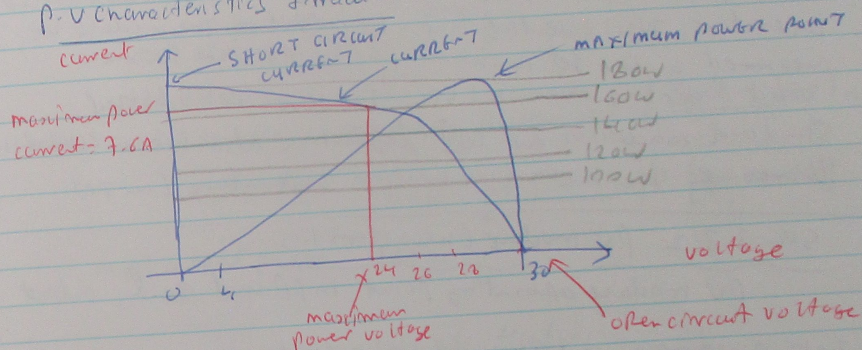
Nu So E 3E - mono crystalline silicon
 photovoltaic module 180W max power

3.1 PV cell Equivalent circuit and operating characteristics

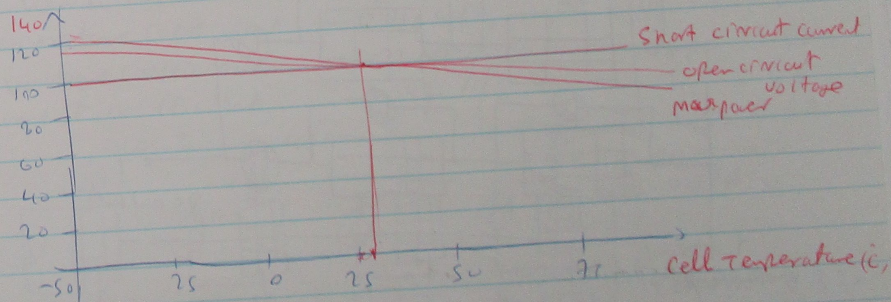
PV cell Equivalent circuit



P-V characteristics Irradiance



cell Temperature (°C)



Fill Factor

Ideally a PV cell would deliver its short circuit current up to a voltage equal to its open circuit voltage at an ideal fill factor

Irradiance and module output power
 Higher the irradiance, the higher the output power becomes.

1. If the irradiance on the module is increased then the current from the module will increase proportionately.

3. Cell operating temperature is mpp
High cell temperature decreases cell mpp

4. Five factors that decrease the performance of a PV cell
cell temperature, mechanical, Electrical, Thermal
Environmental stresses,

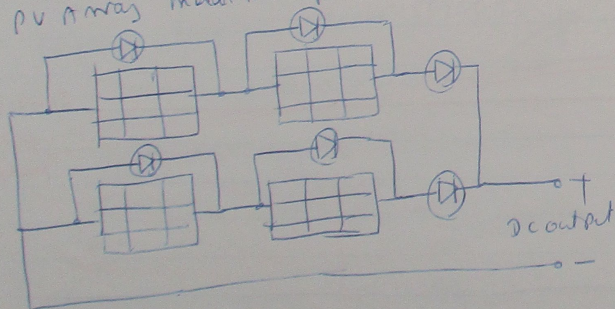
5. Standard Test conditions (STC) used to test the performance of PV module,

Because of the variation of the module output and irradiance and temperature it is essential that the output of the module be measured under set condition (not be possible to make valid comparisons otherwise) etc therefore established standard conditions for cell temperature also been established to measure the normal operation temperature (NOCT)

SL 3.3-2 PV module characteristics

PV module operating point mpp and daily output

2.1 PV Array maximum power output



Module specifications

Number and type of cell 48x monocrystalline

Temperature coefficient -0.427 W/°C

Voltage coefficient -0.112 V/°C

Current coefficient 0.047 %/°C

NOCT 46°C

mp = 120W

Voc = 30.1V

Vmp = 23.8V

Isc = 8.4A

Imp = 7.5A

Ambient Temperature 29°C Irradiation 900W/m²

$$T_{cell} = T_{amb} + \frac{G (NOCT - 20)}{800}$$

T_{cell} = cell temperature in degree celsius (°C)

T_{amb} = Ambient temperature in degree celsius (°C)

G = Irradiance in W/m² (W/m²)

$NOCT$ = Normal operating cell temperature (°C)

$$T_{cell} = T_{amb} + \frac{G (NOCT - 20)}{800}$$

$$= 29 + \frac{900 (46 - 20)}{800} = 58.3^\circ C$$

$$\text{max. output power} = \text{maximum power} + \frac{[T_{cell} - T_{amb}] \times T_{mp}}{T_{mp}}$$

$$= 120 + \frac{[58.3 - 29] \times [7.5]}{7.5} \text{ W}$$

$$\text{mpp output power} = 166 \text{ W}$$

PV Array diagram & module specification

Number & type of cells 32x monocrystalline

Temperature coefficient -0.46 W/°C

Voltage coefficient -0.31 V/°C

Current coefficient 0.047 %/°C

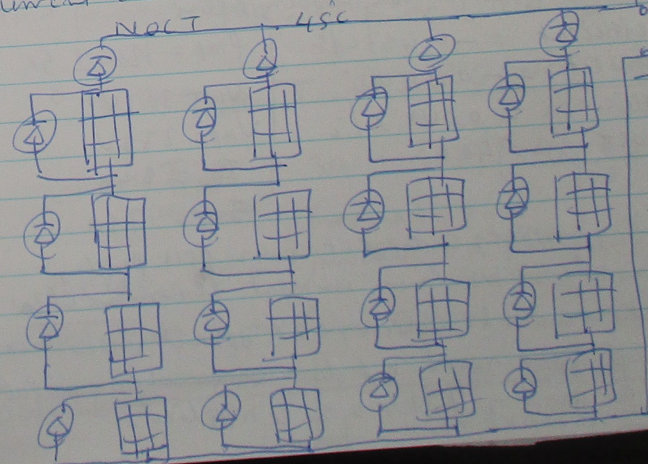
mp = 76W

Voc = 20.2V

Vmp = 15.9V

Isc = 5.2A

Imp = 4.8A



Ambient Temperature 32°C

Irradiation 1100W/m²

$$T_{cell} = T_{amb} + \frac{G (NOCT - 20)}{800}$$

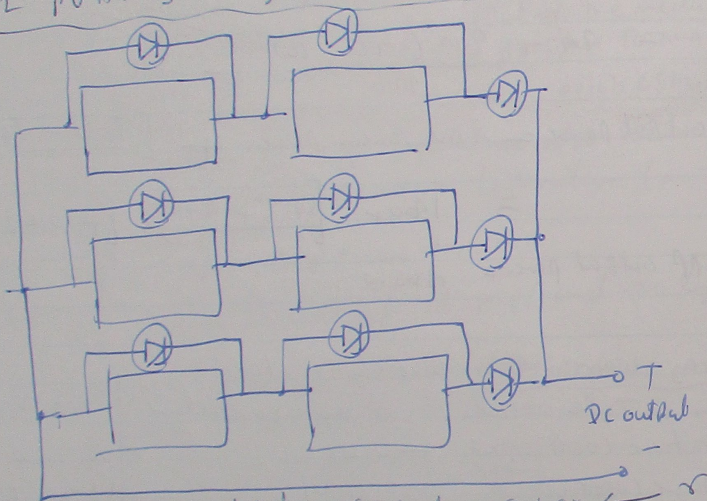
$$= 32 + \frac{1100 (45 - 20)}{800} = 66.4$$

mpp output power = $P_{mp} + [T_{cell} - T_{amb}] \times \text{Temperature coefficient w/c}$

$$= 76 + [66.4 - 32] \times [-0.46]$$

$$= 57.2 \text{ W}$$

2.2 PV Array Daily Energy output



power output coefficient = 0.45% ← γ

Number and type of cell = 40x monocrystalline

Temperature coefficient = $-0.407 \text{ W/}^\circ\text{C}$
 voltage coefficient = $-0.112 \text{ V/}^\circ\text{C}$
 current coefficient = $0.04 \text{ A/}^\circ\text{C}$
 NOCT = 46°C

$P_{mp} = 120 \text{ W} \pm 5\%$
 $V_{oc} = 30.1 \text{ V}$
 $V_{mp} = 23.2 \text{ V}$
 $I_{sc} = 6.4 \text{ A}$
 $I_{mp} = 7.5 \text{ A}$

The array location receives average of 5.92 psh per day
 operates in an average maximum ambient temperature of 30°C

The array orientation and tilt achieves 92% optimal irradiation
 operates unshaded year round. but dust accumulation requires that a derating factor 0.95 be applied.

A loss of 2% must be factored into account for voltage losses and the GC Inverter used with the PV array is 99% efficient.

Array energy output calculation

$$P_{STC} \times \left[1 - \gamma (T_{cell} - T_{ref}) \right] \times f_{man} \times f_{aint} \times H_{tillt}$$

E_{module} = The daily energy output of module (Wh)

P_{STC} = The module power output rating under Standard Test Conditions (W)

f_{temp} = Temperature derating factor, dimensionless
 f_{man} = derating factor for manufacturing tolerance, dimensionless

f_{aint} = derating factor for dirt, dimensionless

T_{ref} = cell temperature at STC ($^\circ\text{C}$)

$T_{cell, eff}$ = effective average daily cell temperature ($^\circ\text{C}$)

γ = power output coefficient ($^\circ\text{C}^{-1}$)

$$P_{STC} = P_{mp} \times \text{GC Inverter efficiency} \times \text{voltage loss}$$

$$= 120 \times \left(\frac{100 - 2}{100} \right) \times (0.96)$$

$$= 120 \times 0.98 \times 0.96 = 114.24 \text{ W}$$

$$\text{output power} = P_{STC} \times \left[1 - \gamma (T_{cell} - T_{ref}) \right] \times f_{man} \times f_{aint} \times H_{tillt}$$

$$\gamma = 0.45 \quad T_{cell} = T_{amb} + \frac{G (NOCT - 20)}{800}$$

$$T_{cell} = 30 + \frac{800 (46 - 20)}{800} = 56^\circ\text{C}$$

$T_{ref} = NOCT = 46^\circ\text{C}$

$$H_{tillt} = \text{optimal irradiation} \times \text{PSH/day} = \frac{92}{100} \times 5.92$$

$$= 5.45 \text{ kWh/m}^2 \text{ day}$$

Dirt derating factor $f_{dirt} = 0.95$

$$\text{output power} = 114.24 \times \left[1 - \frac{0.45}{100} (56 - 46) \right] \times 1 \times 0.95 \times 5.45$$

$$= 114.24 \times 0.95 \times 5.45 = 581.5 \text{ Wh}$$

$$\begin{aligned} \text{Output Power} &= P_{STC} \times \left[1 - \alpha (T_{cell} - T_{ref}) \right] \times f_{man} \times f_{aht} \times \frac{1}{1.1} \\ \text{Energy/module} &= 169.3 \left[1 - \frac{0.45}{100} \times (56 - 46) \right] \times 1 \times \frac{95}{100} \times 5.45 \\ &= 169.3 \left[1 - \frac{0.45 \times 10}{100} \right] \times 0.95 \times 5.45 \\ &= 169.3 \times 0.955 \times 0.95 \times 5.45 \end{aligned}$$

$$f_{temp} = \left[\frac{1 - \alpha (T_{cell} - T_{ref})}{1 - \alpha (56 - 46)} \right] = \frac{1 - 0.45(56 - 46)}{1 - 0.45 \times 10} = 3.5\%$$

$$\therefore 100 - 3.5\% = 96.5\% = 0.965$$

$$E_{module} = 169.3 \times 0.965 \times 0.95 \times 5.45 = 845 \text{ Wh} \times 6 =$$

$$P_{avg} = \frac{E_{design}}{P_{STC} \times \eta_{eff} \times f_{derate}}$$

Peak
Sun hr

for 6 module

$$= 845 \times 6 = 5070 \text{ Wh}$$

$$E_{design} = P_{avg} \times P_{SH} \times$$

$$E_{module} = P_{STC} \times f_{temp} \times f_{man} \times f_{aht} \times \frac{1}{1.1}$$

$$E = \text{No. of module} \times E_{module}$$

$$E_{module} = \text{Energy output Wh/module}$$

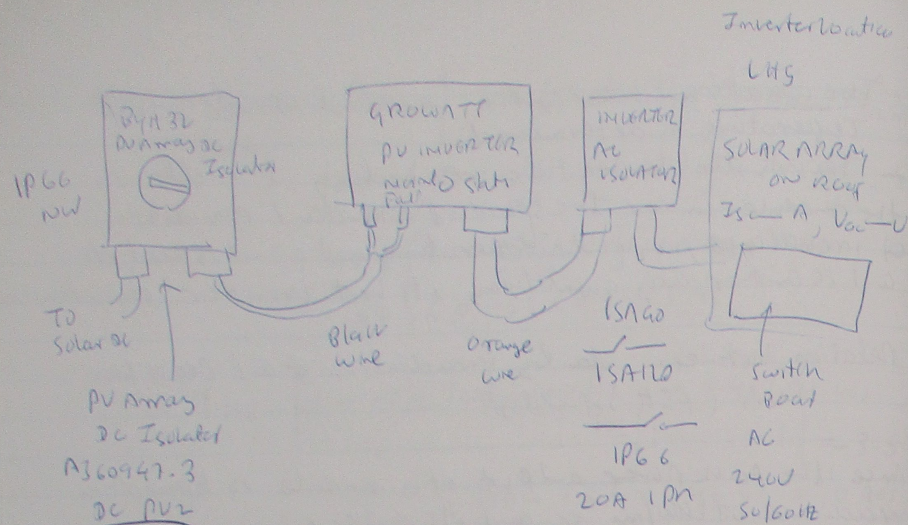
1/ The correction under nominal operating cell temperature is determined
This is the temperature reached by the cells in the module under the specified standard conditions of irradiance, ambient temperature and wind speed etc and is another way quantifying its best transfer characteristics ✓

2/ Relation between daily irradiation & peak sun hours (PSH) per day.

Since the peak power output of a module is based on irradiance of 1000 W/m^2 and its output varies in direct proportion to the irradiance multiplying by module power in watts by peak sun hours will give the total module output in kWh

UCCRE0011 Design Grid connected Photovoltaic Power supply system
+ UCCRE0016 Install, commission and commission
LV Grid connected Photovoltaic Power system

GROWATT PV INVERTER | model Sungold 1500 made in China
M2B06, model name Sungold 1500
certificate Number SAA 100919
U_{ac} max 450V, I_{ac} max = 8A U_{ac} range 100V - 450V
U_{ac} norm 230V f_{ac} norm 50Hz
P_{ac} norm = 1650W I_{ac} norm 7.2A PF = 1.0
Protection Degree IP65
operating Ambient Temperature -25 ~ +60°C
AS 4777 AS 3100



Inverter Location
LHG

RE0016
6.3

GROWATT PV INVERTER

model Sungold 1500

certificate number SAA100919

AC INVERTER INPUT PARAMETERS

max. dc power 1200 watts

max. dc voltage range 120V - 450V

no. of MPPT (Tracker) 1

max. no. of strings 1

AC INVERTER OUTPUT PARAMETERS

AC voltage range 200 ~ 250V

max. AC power 1650 watts

Rated grid frequency 50 Hz

AC voltage range 200V AC - 250V AC

max. current 8A

Grid frequency range 40.1 Hz - 50.9 Hz

PV Array operating parameter

NU S0 E3G - o/c voltage 30V, max. power voltage 23.7V

max. power 120W

$I_{sc} = 2.37A$

max. power current 7.6A

REC TWINK PEAR 2 o/c voltage 38.3 → 40.8V, max. power voltage 33 → 34.3V

max. power 300 - 310W, max. power current 9.11 → 9.62A

PV Array operating parameters

Total power = 4620 watt

Total modules = 14

no. of strings = 2

modules per string = 8

Nominal voltage 54V

Nominal current = 9.6A

O/C voltage 40.8

S/C current = 10.19A

control protection device selection

Type of device	Nominal current	Nominal voltage	Watt Break capacity	INSTALLATION LOCATION
1/ circuit breaker	32A at 400V	212V dc	Yes	MSB Solar main switch
SA-121240-CA	24A at 600V			
PV switch disconnecter				
BYA 32				
2/ circuit breaker	20A	240V	Yes	MSB Solar
ISA 60				
3/ PV Disconnecter	15A	450V		Inverter

DC wiring system selection

Installation method - wiring enclosure / solar

Insulation Type	Minimum current carrying capacity	Minimum cable size	Table	Column
XLPE	38A	4mm ²	S	IS
REG TWINK PEAR 2mm				
Installation method				
Installation - wiring enclosure in air				
3/77 enclosure				
Item 1	Two single core cable - See Table 4/5			
	col 15 → 17			

CR ratio 32A/20A

I_{sc} 15A

dc

Voltage drop.

 I_{dc}

DC
cancel

$$\therefore R_C = 0.2 / u_{om} =$$

$$V_d = \frac{10.19 \times L \times 6.24 \times 2}{1000}$$

$$1.7 = \frac{10.19 \times L \times 6.24 \times 2}{1000} \rightarrow \frac{17 \times 1000}{10.19 \times 6.24 \times 2} = 13.36 \text{ m}$$

A criteria for system selection

Installation method - ~~with~~ ^{using} Wrapping Enclosure.

current carrying capacity

$$\begin{aligned} \%V_d &= \frac{1.7V}{V_{dmax}} \times 100 \\ &= \frac{1.7}{450} \times 100 \\ &= 0.37\% \end{aligned}$$

AC wiring system Enclosed Table 3(2)

Two cone on NCB

Item 7 $\longrightarrow$ Table 10/11 col 11-13

Table 10

2 Samen² → cu
cu II Enzyme im AN
solid stranded
23p

вольтметр

AC - multicore and copper so Table 42
multicore with special or copper conductor.

AC temperature 75°C

$2.5 \text{ mm}^2 \longrightarrow 15.6 \text{ cm V/A-cm}$

$$\therefore \text{pf voltage} = \frac{2}{\sqrt{3}} \times 15.6 = 18 \text{ mV/A} \sim$$

$$V_d = \frac{V_c L I}{1000} = \left| 2.6 = \frac{18 \times L \times 23}{1000} \right| \quad \left| L = \frac{2.6 \times 1000}{18 \times 23} \right|$$

$$= 6.2 \text{ m.}$$

Total ac wiring length = 6 cm.

mass current (Ar) = 23

$\therefore V_d = \frac{V_c L I}{1000} = \frac{18 \times 6 \times 23}{1000} = 2.496$

$\therefore \frac{2.496}{240} \times 100 = 1.04\%$

$$E_{sys} = P_{avg, sys} \times f_{man} \times f_{dist} \times f_{top} \times H_{net} \times \overset{m \times m}{\underset{\substack{\uparrow \\ \text{Amount} \\ 987, \\ \text{Taken } 0.91}}}{inv\ carb}$$

Each Array

Sharp bow

$$= 120 \times 0.97 \times 0.82 \times 6.832$$

R

$$f_{\text{top}} = \text{Power}/\bar{P}_{\text{Top}} \text{ coefficient} = -0.485\%$$

$$N_{OCT} = 47.6^\circ \text{ (operating temperature module Temp } 25^\circ\text{C)}$$

from Internet search

$$T_{ref} = 293.15 \text{ K}$$

optimal Irradiation $\times \text{PSD} / \text{deg}$
 $= \frac{92\%}{\ln 2} \times 7.1$

$\frac{100}{6.532} \text{ h}$

19/9/2023
1:36 PM

$$T_{cell} = T_{ambient} + \frac{G(NOC7 - T_{amb})}{h_{ood}}$$

$$T_{cell} = 34.3 + \frac{1000(49.5 - 34.3)}{900} = 50.8 \quad 1900$$

From Brochure 2384
Solar Tomadine /m²

for Australia

<https://solcast.com>

$f_{temp} = ?$

$$f_{temp} = [1 - \alpha (T_{cell} - T_{ref})] = [1 - \frac{0.485}{100} (50.2 - 25)]$$

$$= 1 - \frac{0.485}{100} \times 25.2 = 1 - 0.0123 = 0.9877$$

$$E_{sys}/day = P_{STC} \times f_{max} \times f_{air} \times f_{temp} \times H_{Tilt} \times M_{inv} \times M_{cable}$$

$$E_{sys}/day = 180 \times 0.9877 \times 0.95 \times 0.9877 \times 6.532 \times 0.97 \times 0.97$$

$$= 999 \text{ kWh/day} = 0.999 \text{ kWh/day}$$

$$\text{for 365 days/yr} = 0.999 \times 365 = 364.6 \text{ kWh}$$

$$\text{kWh/day} = 0.999 \times \text{No. of modules} \quad \text{kWh/yr} = 364.6 \times \text{No. of modules}$$

Each module REC $\times$ $\text{2000 PPA} \times$

$$E_{sys} = P_{STC} \times f_{max} \times f_{air} \times f_{temp} \times H_{Tilt} \times M_{inv} \times M_{cable}$$

$$= 300 \times 0.97 \times 0.95 \times f_{temp} \times 6.532 \times 0.97 \times 0.97$$

$$f_{temp} = ? \quad f_{temp} = [1 - \alpha (T_{cell} - T_{ref})]$$

$$\alpha = -0.37, \quad \text{Nominal module operating Temp} = 44.6^\circ\text{C} - T_{ref}$$

$$T_{cell} = T_{ambient} + \frac{G (NOCT - T_{ambient})}{800} = 34.3 + \frac{1000 (44.6 - 34.3)}{800}$$

$$= 34.3 + \frac{1000 \times 10.3}{800} = 47.175^\circ\text{C}$$

$$f_{temp} = [1 - \frac{0.37}{100} \times (47.17 - 44.6)] = 0.99$$

$$E_{sys} = P_{STC} \times f_{max} \times f_{air} \times f_{temp} \times H_{Tilt} \times M_{inv} \times M_{cable}$$

$$= 300 \times 0.97 \times 0.95 \times 0.99 \times 6.532 \times 0.97 \times 0.97$$

$$= 1682 \text{ kWh/day or } 1.682 \text{ kWh/day}$$

$$\text{for 365 days/yr} = 1.682 \times 365 = 613.95 \text{ kWh per each module}$$

$$\text{Total Energy/day} = 1.682 \times \text{No. of modules}$$

$$\text{Total Energy/yr} = 1.682 \times 365 \times \text{No. of modules}$$

$$E_{ideal} = P_{avgSTC} \times H_{Tilt}$$

$$\text{Specific Energy Yield} = \frac{E_{sys}}{P_{avgSTC}} = \frac{999 \text{ kWh}}{180}$$

$$\text{for Snapshot} = \frac{364.6 \text{ kWh/yr}}{180 \times 10^{-3}} = 2025 \text{ kWh/kW}$$

$$E_{ideal} = 180 \times 6.532 \times 365 \times 10^{-3}$$

$$\text{Performance Ratio (PR)} = \frac{E_{sys}}{E_{ideal}} = \frac{364.6 \text{ kWh}}{180 \times 6.532 \times 365 \times 10^{-3}}$$

1360W/m²

$$= \frac{364.6}{449.1} \times 100 = 81.2\%$$

SPECIFIC ENERGY YIELD FOR REC TWO MPAA x 2

$$\frac{E_{sys}}{P_{avgSTC}} = \frac{613.95 \text{ kWh/yr}}{300 \times 10^{-3} \text{ kW}}$$

$$= 2046.5 \text{ kWh/kW}$$

$$E_{ideal} = P_{avgSTC} \times H_{Tilt}$$

$$= 300 \times 6.532 \times 365 \times 10^{-3} = 715.25 \text{ kWh/yr}$$

$$\therefore PR = \frac{613.95}{715.25} \times 100 = 85.8\%$$

$$E_{sys} = 364.6 \text{ kWh} \times 14 = 5104.4 \text{ kWh}$$

TOTAL POWER

① 4 factors that need to be considered when selecting a sizing PV system:

cables, current carrying capacity, voltage drop, impedance, route length, installation method

② Financial factors can impact on the design of PV power system. STC claims on energy production less power bills

③ Regular factors that can impact on the design of a PV system: Loss of accreditation i.e., not installed to standards and supply impact.