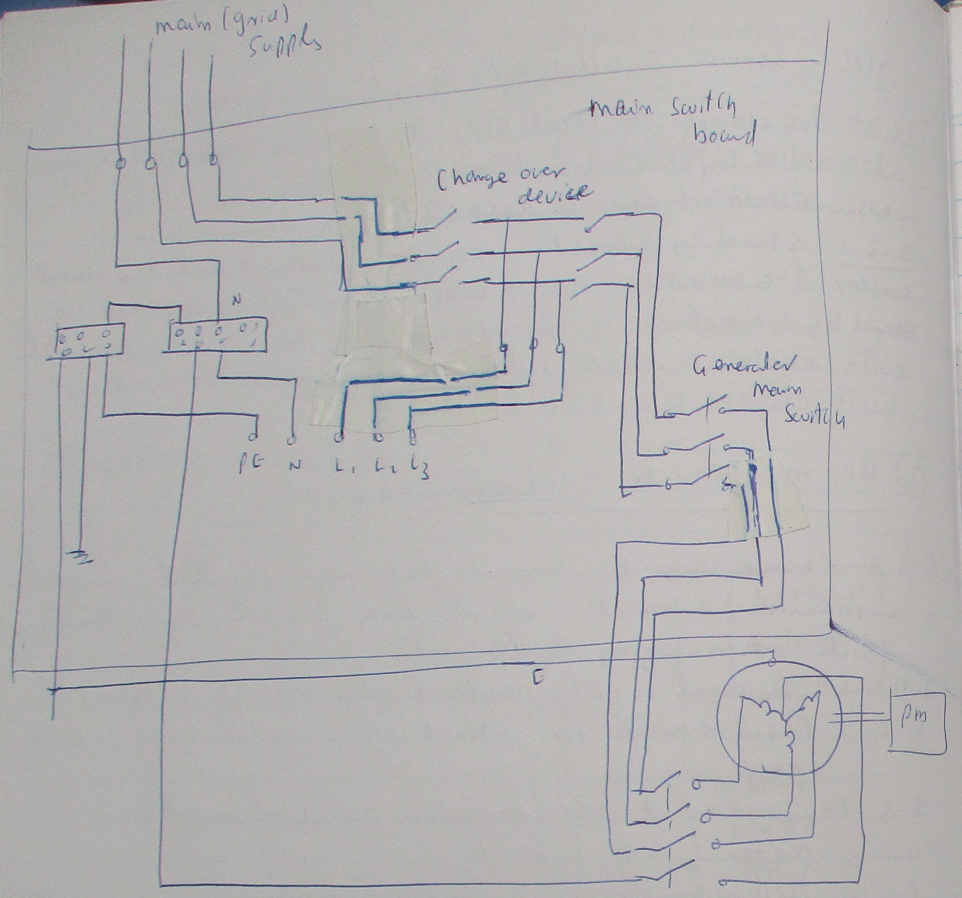


(3) Two wiring systems that would be suitable to be used as unprotected supply conductors originating at terminal of stand by generator,

wiring system with WS classification (7.2.2.2.1
when WS classification is not specified
(7.2.2.2) - The wiring system shall be of a type that is
(a) capable of maintaining supply to the equipment when exposed to ~~fire~~ either fire (or) mechanical damage (or) (b) capable of maintaining supply to the equipment when exposed to fire and protected against mechanical damage by (a) installing suitable enclosure or (ii) installation ~~at~~ in a location where the system will not be exposed to mech damage.

(4) maximum permissible unprotected cable length

2.6.13.1 — Table 2.3 max. cable length. 5.5.3.5
NSW Electrical Service Rule 4.12.5.1 — 15m
7.3.5.1 ↗

(5) use of stand by generator.

7.3.3 control 7.3.4.2 7.3.5
shall be controlled by main switch
7.3.4. Isolation, 7.3.4.2 Isolation of batteries
7.3.5 provided with overcurrent protection.

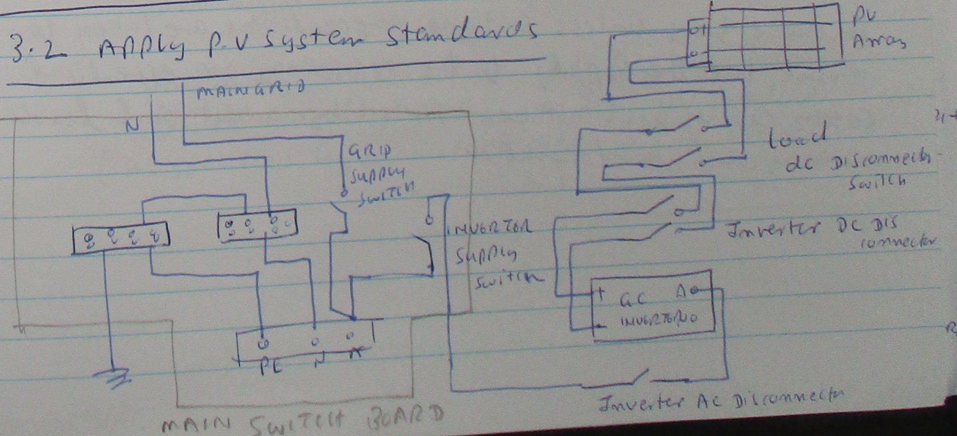
(6) ~~Two~~ AS 3010 - At least one door (3.2.3.2) — 3 months

(9) checking — (1) Exhaust system (manifold, muffler, pipe)
(2) Fuel system (supplines, return lines, filters)
(3) Ignition system (batteries, chargers)
(4) Engine (fluid level, oil pressure, coolant temperature filters, radiator hoses, belts, bearings, fitting guards)
(5) ventilation equipment
(6) control / protection settings

6–12 months

(8) <u>Testing</u>
- sample test for oils for particles and chemical composition
- functionality of change over switch (check)
- Test operation parameters under simulated emergency condition
- check functionality of alarms and indicators

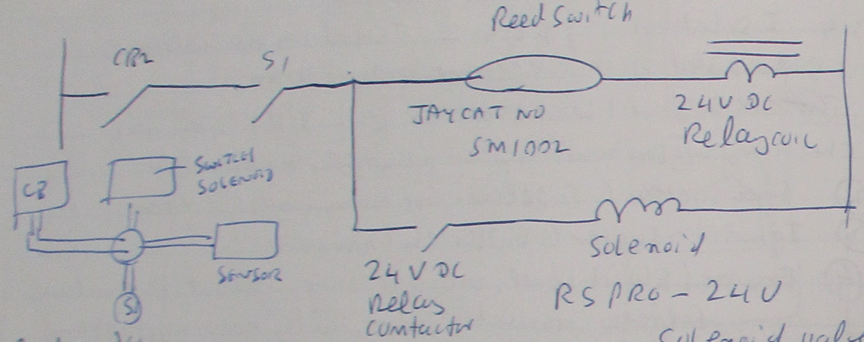
3.2 Apply P.V system standards



https://www.jaycar.com.au/components_electromechanical/switches/reed-switches/c/2CI

JAYCAR - CAT NO (SM1002) - Maniture Glass Reed Switch

RS - STOCK NO (784-002) RSPRO 24V Solenoid valve



RS PRO - 24V Solenoid valve

RS Stock no 784-0022

Reed Switch

It is closed on presence of magnetic field. It is also a sensor.

(2.2) Q5 AS3010 | 3.6.5

supply of other than emergency system (or) essential services

A single generating set shall not be used for purpose other than the supply of emergency or essential safety service described in clause 3.6.1 unless suitable precautions are taken to ensure that the supply to the emergency or essential safety services will not be affected by additional loading under any condition of operation.

(3.2) 1/ The requirement for protection of cables running between the array and inverter of a grid connected PV system.

AS5033/ 2.4.5 PV array cables of the system connected to batteries shall be protected with fault current protection devices

(2) Requirement for PV system cabling

AS 5033/ 3.5 — where PV array cabling could be confused with other wiring systems, appropriate identification shall be provided at regular intervals { Typically identification shall not be more than 3m apart }.

(3) minimum IP rating for grid connected PV system components installed outdoors.

4.2.1 PV array and PV sub array junction box exposed to the environment shall be at least IP54 compliant in accordance with AS 60529 and shall be UV resistant.

(4) maximum Array voltage for domestic grid connected PV system

AS5033 / 4.4.28 — The PV array voltage shall be considered to be equal to Voc array.

3.2 Voc array shall not exceed the maximum allowed operating voltage of the PV modules (as specified by manufacturer)

4.3 Inspect Battery systems

Hazards

Battery Acid harms eye	D/H	use safety glass for eye protection
Battery acid injury on hand	D/H	use appropriate safety glove
Acide fume inhale	D/H	use battery in well ventilation

Location ETC college   Type - solar Electrical system

① Environmental condition

1.1 Area in which the battery is installed is suitably ventilated (Y)

1.2 Ambient temperature and humidity are suitable for the battery system (Y)

1.3 No external heat source are present that may cause hazardous temperature rise (Y)

1.4 Access and egress from the area is un-obstructed (Y)

② Battery system (Item)

2.1 System shut down and start up procedures documented and available (Y)

2.2 All required signs, labelling and markings are installed (as per AS/NZS 5139 section 7) (Y)

2.3 Shut down and start up procedures are consistent with diagrams and labelling (Y)

2.4 All required isolation devices are installed and are operating correctly. (Y)

2.5 All terminations are suitably tight (Y)

2.6 All required controls are installed correctly (Y)

2.7 All required protection devices and shrouds are installed correctly (Y)

2.8 All required monitoring and alarms are installed correctly (Y)

2.9 All battery system equipment is free from damage (Y)

2.10 All battery system equipment is free from excessive dust, dirt and debris (Y)

③ System parameters - Items

3.1 Battery charger settings are suitable for the equipment and desired functionality (Y)

3.2 Inverters settings are suitable for the equipment and desired functionality (Y)

Q1 Two types of batteries commonly used in backup / emergency battery banks

- Lithium Ion battery
- Lead acid battery

Q2 How many 6V, 100 Ah, VRLA batteries are required to produce a battery bank with a rated o/p 120V, 200AH

|||- — 120V — ||→ 100AH   6V 20 = 120V

|||- — 120V — ||→ 100AH   6V 20 = 120V

20 + 20 = 40

100AH + 100AH = 200 AH

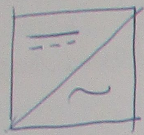
40

Q3 minimum spaced requires between 2 batteries (side by side)
600mm { AS/NZS 5139:2019   4(c)

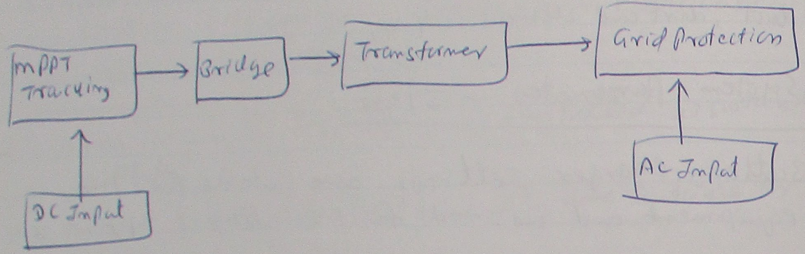
Q4 minimum vertical ~~clear~~ clearance between ~~tired~~ tiered batteries   900mm { AS/NZS 5139:2019   4(c)

5 2 Draw Inverter symbols and Diagrams

2.1 Australian Standard symbol for L.V separated Inverter



2.2 Grid connected Inverter block diagram



3 Functions of Inverter in Grid connected system

1 Central Inverter – String Inverter (connected to entire PV arrays)

2 multimode Inverter – Allow for islanding (The installation can ~~to~~ continue to operate from the alternate supply in the event of main failure) (Trigger grid protection to disconnect the alternate supply

3/ micro Inverters – (designed to use with PV arrays. consists of several small inverters each connected to individual modules within the arrays, typically mounted on to array assembly.

6.1 Alternative Supply Risk Assessment

Source 1 240V AC Grid power Location ETC workshop
Source 2 Solar Electrical system Location PV Room

Type of Hazards

High voltage	✓ worked Height	✓ Foreign bodies	Explosive gas
✓ Low voltage	Hot work	asbestos	Toxic gase
✓ Extra Low voltage	confined space	✓ dust	Explosive chemical
High current	UV radiation	✓ noise	corrosive chemical
✓ working Live	mobile plant/traffic	✓ manual handling	Toxic chemical
✓ House keeping	✓ power Tools	mechanical handling	Flora/fauna
✓ other			

Tasks

240V Grid

1. Isolate the main supply, identify the point of supply
2. switch off the isolator
3. Perform maintenance tasks
4. Inspect the insulation resistance of wiring system
5. Inspect and secure the connections

PV

6. Install/connect PV Panel
7. perform solar array wiring and connections
8. connect PV modules and arrays
9. PV module protection
10. DC/AC Isolator installation
11. Install and operate inverter

SEVERITY \ LIKELIHOOD	LIKELY	POSSIBLE	UNLIKELY
Death or permanent disability	1	1	2
Serious injury or chronic illness	1	2	3
minor injury, require first aid	2	3	4

1/ Extreme Risk
2/ High Risk
3/ medium Risk
4/ low Risk

Task	Job steps	Potential Hazard	Associated Risk	Risk Level	control measure	Responsible Person
1	240V Exposed conductor	Electrocution	Burnt out of equipment	1	Test terminal / Enclose	Supervisor
2	Faulty Isolator	Dangerous voltage present	wrong energizing	2	Test isolator without Live	Supervisor
3	untagged / unlocked main switch	Electrocution	Injury equipment damage	1	properly perform Locking Tagging	Supervisor
4	Insulation Resistance Failure	L - L fault L - N fault Live Earth	Electrocution	3	Perform ~~polarity~~ Insulation Resistance Test before energizing	Supervisor
5	reverse polarity N - E	Electrical Leakage to Earth.	Electrocution	3	Perform polarity Test	Supervisor
6	Falling from height	Injury	Equipment damage	1	use appropriate fall protection equipment	Supervisor
7	Insulation failure of connection wires	Electrical Faults	module / system Damage	2	use correct size wire protection	Supervisor
8	safety diode failure	PV module reverse charge	module over heating damage	4	use correct rating diode	Supervisor
9	Inappropriate sized isolator	Isolator Switch damaged	Electrical shock leakage	4	use appropriate size isolator	Supervisor
10	Battery Installation	Battery Terminal Faults	Battery over charge sparking	4	Properly tighten battery terminal connection	Supervisor
11	Inverter installation	Faulty Inverter	output Voltage frequency wrong.	4	Test the inverter before use	Supervisor

Shut down Procedure

1. Identify the point of supply and affected Systems
2. Identify all isolation switches
3. measure voltage, frequency before switching off
4. Isolate the supply
5. measure the affected points
6. set all equipment at off positions
7. Locking and Tagging

S.3 connect and Test an Inverter

Hazards

Falling from height D H use fall protection gear
Pre-wiring short circuit D H Test insulation resistance
out put circuit electrical short circuit D H Test insulation resistance.
Battery acid injury D H use glove eye protection
Exposed terminal D H enclose the exposed terminal.

Inverter Specification

dc input

max. input power = 670 watt
max. input voltage = 600V
MPPT voltage range 90 — 560V

max input current = 25A
max. No. of String 14

AC output

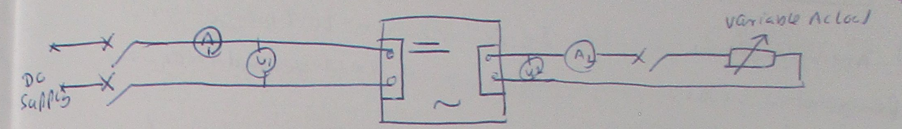
Nominal output power = 300 w
max. output power = 330 watt
Nominal ac voltage range 180/276V

max o/p current = 9.11 — 9.62A
Frequency Range 45-55/ 55-65HZ

Characteristics

maximum efficiency 85.8%
Temperature range −25 ~ +60c
power factor 0.82

connect the inverter to dc supply and variance Ac load as shown below

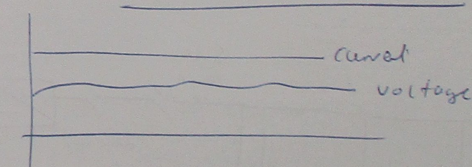


view Inverter testing video and data sheet

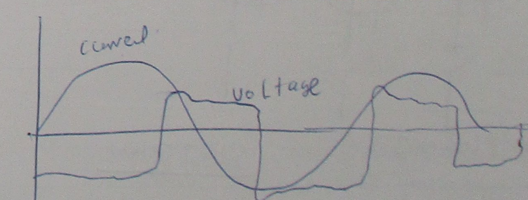
Inverter operating characteristics

LOAD	dc Input voltage V	dc Input current A	Ac output voltage V	Ac output current A	Efficiency %
No load	22V	4A	28V	0	0
Load 1	22	4	27	3	92%
Load 2	22	4	23.8	3.5	95%
Load 3	22	4	22.8	3.7	96%

Inverter Input wave form



Inverter output waveform



Grid connected Inverter Passive Protection

1. Passive Protection method monitors the voltage and frequency variations. When one or more of these parameters deviate from the permitted threshold range, an islanding event is considered to have occurred and relay circuit removes the inverter from the supply.

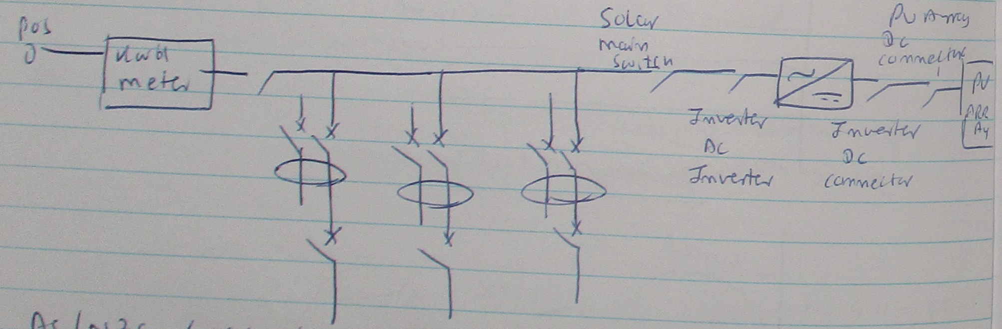
Grid connected Inverter Active protection

(2) Active methods generate the perturbation to change grid parameters such as magnitude of grid voltage and frequency in the allowable range.
Slip mode frequency shift is utilized. This varies the reactive power output of inverter. The goal of this protection method is to destabilize an islanded feeder by trying to influence the frequency.

MPPT Algorithm

(3) MPPT is the algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. It calculates the best amount of power that the panel can provide to charge the battery.

6.2 Shutdown, Isolate and Restart an Alternative supply System



AS/NZS 4836 Clause 3.2
3.2.1

SHUTDOWN

All electrical conductors and parts including neutral and earthing conductors shall be treated as energized until proven de-energized
(a) Positively identified the relevant electrical equipment and conductors, all of their energy sources and the isolation points (Clause 3.2.2)
(b) Isolated electrical equipment and conductors from all energy sources (Clause 3.2.3)
(c) Secured the isolation (clause 3.2.4)
(d) Discharged where necessary, any stored energy eg capacitors (3.9.2)
(e) Proved the de-energization of all relevant electrical equipment and capacitors (3.2.5)
(f) Identified the limits of the safe area of work (3.2.7)

SAFE RESTARTING

SECTION (4) AS/NZS 4836

(a) All relevant persons shall be notified that testing is about to commence (or) supply is about to be restored.
(b) A visual inspection shall be conducted to ensure that all tools surplus material and wastes have been removed and the worksite has been reinstated.
(c) visual inspection and tests required by AS/NZS shall be carried out.
(d) Applicable work permits shall be cancelled.
(e) Applicable personal tags and locks shall be removed.
(f) Re-energizing as required eg phase rotation are carried out.
(g) Functional testing as required eg phase rotation are carried out
(h) Confirmation that all guards and covers are reinstated ~~is~~ is obtained.

Falling from height D/H use fall protection gears.
PV Panel wiring short circuit D/H Test insulation resistance
Open circuit electrical shock D/H Test insulation resistance.
Battery Acid injury D/H use glove, eye protection
Exposed Terminals D/H Enclosed the exposed terminals
Live electrical terminals D/H ~~Test~~ Testing & Tagging

Environmental conditions — Items

1.1 Alternative supply equipment is suitably ventilated Y

1.2 Alternative supply equipment is suitably rated for ambient temperature and humidity Y

1.3 No external heat sources are present that may cause hazardous temperature rise Y

1.4 Access and egress from the area is unobstructed Y

2. Identification and labelling Item

2.1 System shutdown and startup procedures documented and available Y

2.2 All required singage, labelling and markings are installed Y

2.3 Shut down and start up procedures are consistent with diagrams and labelling Y

3. control and protection — Item

3.1 All required isolation devices are installed and are operating correctly Y

3.2 All required controls are installed correctly Y

3.3 All required protection devices ~~are~~ and shrouds are installed correctly Y

3.4 All required monitoring and alarms are installed correctly

4. System Equipment (Items)

4.1 All terminations are suitably tight Y

4.2 All system equipment is free from damage Y

4.3 All system equipment is free from excessive dust, dirt and debris

5. System parameters (Items)

5.1 charger settings are correct and suitable for the required functionality

5.2 Inverter settings are correct and suitable for the required functionality.

Alternative supply - operating voltages

Terminal	Test results (V)	volt correct
Energy source output terminal	245V	Y
Battery bank terminal	28V	Y
Battery charger terminal	28V	Y
Inverter dc terminal	28V	Y
Inverter AC terminal	240V	Y

3 General Hazards posed by PV arrays

1/ The system may remain live between panels and isolation point

2/ Risk of fire

3/ Electrical spark occurs at dc/ac isolation switches

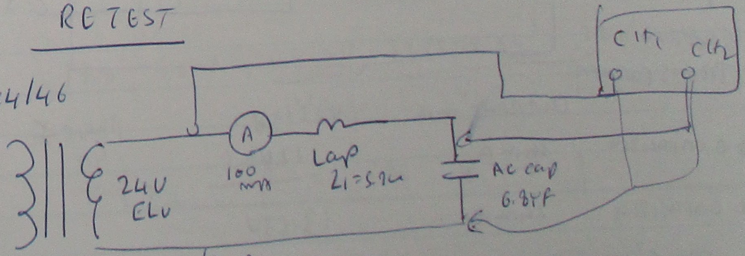
Risk posed by Automatic change over system

modern Automatic Transfer switches are packed with sensitive electronics that are susceptible to damage. It may occassionally respond to false signals.

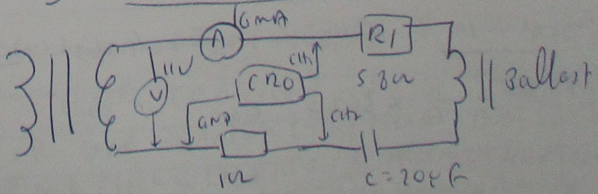
RETEST

CD 0044/46

3.3



5.2



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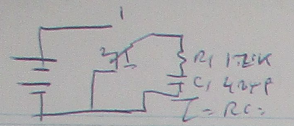


$\tau = RC = 1.2 \times 48 = 57.6$ Time to charge fully

~~τ~~ = 5RC $t = 5RC = 57.6 \times 5 = 288$

Edit 9/10/2023 EL008 4.1, 1.2, 4.2.1, 4.2.2, 3.3.2 / 2.3 / 1.3 / 3.3.1 | NICHOLAS HIENTZOS

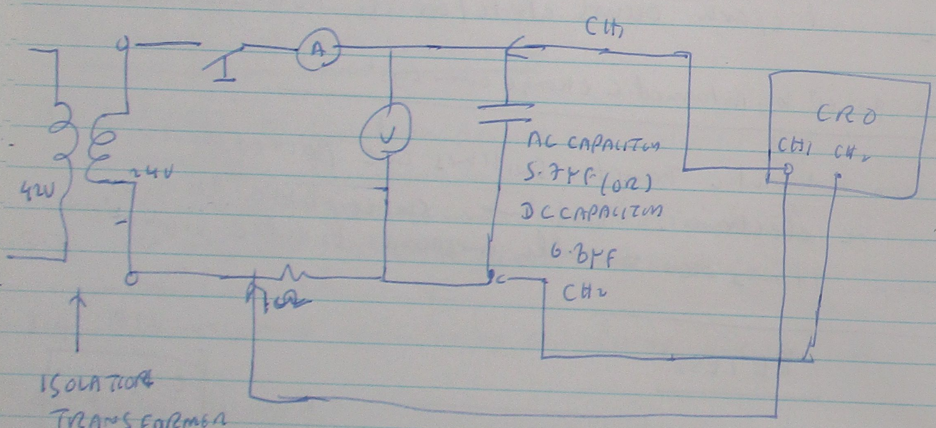
9/10/2023 EL0010 1.2, 2.3, 3.2

10/10/22 11/10/2022 ~~1.2.1~~ EL009 – 1.2.1, 1.2.2, 2.1, 2.2, 4.3, 5.2, 6.1, 6.2, 3.2, 7.2

EL0020

RETEST WITH AC CAPACITOR
3.3, 5.2, 6.5

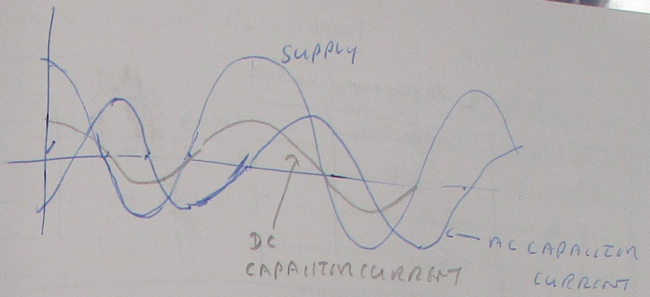
3.3 CAPACITANCE IN AC CIRCUIT



	CURRENT mA	voltage	phase ∢
DC CAPACITOR	34mA	12V	90
AC CAPACITOR	24mA	13.53V	

CRO READING d = 1 division T = 4 division

$\phi = d/T \times 360 = \frac{1}{4} \times 360 = 90$



DC CAPACITOR $X_C = \frac{V}{I} = \frac{12}{34 \times 10^{-3}} = 352.9\Omega$

AC CAPACITOR $X_C = \frac{V}{I} = \frac{13.51}{24 \times 10^{-3}} = 562.91\Omega$

$X_C = \frac{1}{2\pi f c}$

DC CAPACITOR $X_C = \frac{1}{2 \times 3.1416 \times 50 \times 6.8 \times 10^{-6}} = 468\Omega$

AC CAPACITOR $X_C = \frac{1}{2 \times 3.1416 \times 50 \times 5.7 \times 10^{-6}} = 558\Omega$

AC CAPACITOR GIVE MORE ACCURATE RESULT.

5.2 RLC Series circuit

$X_C = \frac{1}{2\pi f c} = \frac{1}{2 \times 3.1416 \times 50 \times 55 \times 10^{-6}} = 57.9\Omega$

$Z = \sqrt{1^2 + (343 - 57.9)^2} = \sqrt{1^2 + 285.1^2} = 285\Omega$

13.8, 38mA, 0.038V (V_R), $38 \times 57.9 \times 10^{-3} = 22V$ (V_C) $V_L = 13V$

$\tan\phi = \frac{285}{1} = 285$ $\phi = 89.7°$

Hazard, overvoltage in supply P M use only 42/240V supply, CRO Ground and circuit ~~ground~~ ground conflict M, P use isolation transformer, overvoltage damage circuit M P check voltage need to rating at all across series circuit M P check voltage rating of all components.
Electrolytic Cap: can be damaged by wrong polarity in supply M P check capacitor type with ~~the~~

Table 1 Measured value

~~D~~ CAPACITOR TYPE	RESISTOR Ω	CAPACITOR µF	INDUCTOR Ω	H
DC	5.8	20	9	1.1
AC	1	55	9	1.1
				1.1

Table 2 calculated Reactance & Impedance

CAPACITOR TYPE	Inductor X_L	Z_L	ϕ_L	CAPACITOR X_C	CIRCUIT Z	ϕ
DC	342.86	343	88.4	159	159	90
AC	342.83	343	88.4	57.9	285	89.7

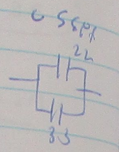


Table 3 calculated voltage & current

CAPACITOR TYPE	supply voltage	current	resistor voltage	capacitor voltage	Inductor voltage
DC	12	65.2 mA	0.554V	10.3	5.49
AC	13.8	38mA	0.038V	22	13

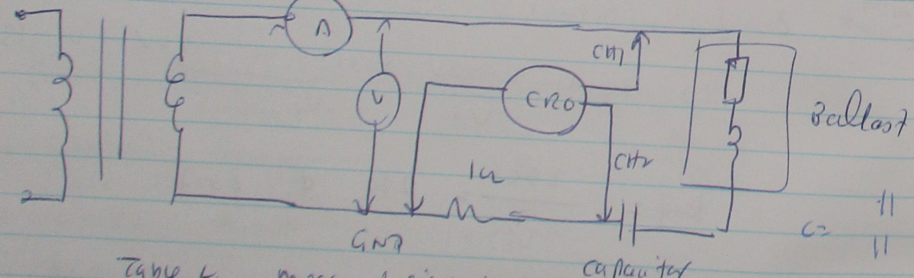
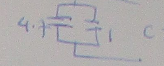
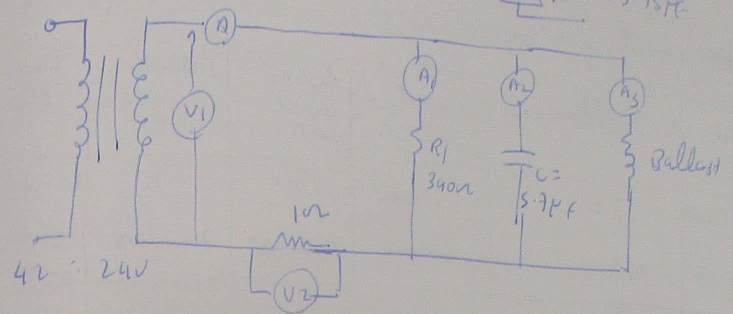


Table 4 measured circuit parameters

	supply voltage	current	resistor voltage	capacitor voltage	Inductor voltage	phase ∢
DC capacitor	12	16mA	~~[illegible]~~ 0.32	10.92	5.54	88.15
AC capacitor	13.21	38mA	0.038	4.27	17.74	89.4

6.5 parallel RLC circuit





2.1.1 circuit component

CAPACITOR TYPE ~~DC capacitor~~	RESISTOR (R)	CAPACITANCE	INDUCTOR - Ballast R	L
DC capacitor	5.8Ω	20µF	9Ω	1.09H
AC capacitor	390Ω	5.7 ~~55~~ µF	9Ω	1.09H

2.1.2

~~DC~~ capacitor TYPE	INDUCTOR X_L	Z_L	ϕ_L	CAPACITOR X_C	CIRCUIT Z	ϕ
DC cap.	479.9	480	88.9	159.23	5	1.31
AC cap	479.9	480	88.9	~~57.9~~ 558	339	6.46

AC capacitor

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\times 3.1416\times 50\times \cancel{55}\,5.7\times 10^{-6}} = \cancel{57.9\Omega}\ 558$$

$$\frac{1}{Z_t} = \frac{1}{R} + \frac{1}{(X_L - X_C)} = \frac{1}{390} + \frac{1}{}$$

$$\frac{1}{Z_t} = \frac{1}{R} + \frac{1}{jX_L} + \frac{1}{-jX_C} = \frac{1}{340} + \frac{1}{+j479.9} - \frac{1}{-j\,\cancel{57.9}\,558}$$

$$= 2.56\times10^{-3} + (-j2.08\times10^{-3}) + j\,1.79\times10^{-3}$$

$$\frac{1}{Z}\ \cancel{256} = 2.56\times10^{-3} + j\,0.29\times10^{-3}$$

$$\frac{1}{Z_t} = \frac{2.56\times10^{-3}}{\cancel{2.56\times10^{-3}+5.1}}$$

$$= \sqrt{(2.56)^2 + (2.08 - (1.79))^2}$$

$$= \sqrt{2.56^2 + 0.29^2}\times10^{-3}$$

$$\tan^{-1}\frac{0.29}{2.56} = 6.46 \qquad Z_t = \frac{1000}{\cancel{2.56}} = \frac{\cancel{3}\,11}{340\Omega}$$

$$\frac{1}{Z_t} \qquad \frac{1}{Z_t} = \frac{1}{2.56\times10^{-3}} \quad Z_t = \frac{10^3}{\cancel{1.10}}$$

use supply voltage calculate

Type of Capacitor	Supply voltage	Total Current mA	Resistor current mA	Capacitor current mA	Inductor current
DC capacitor	12	2 mA	2.06	0.075	0.025
AC capacitor	13.9	36mA	35mA	24.9mA	29mA

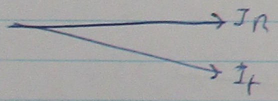
measured value

Type of capacitor	Supply voltage	Supply current mA	Branch current mA: Resistor I_R	Capacitor I_C	Inductor I_L	Phase angle
DC capacitor	12	1.5A	8.5	36mA	50mA	10
AC capacitor	13.9	$\frac{0.041}{1}$ = 41mA	34 mA	28mA	30mA	3.36

AC capacitor gives more accurate results between measured value and calculated value

$\theta = \tan^{-1} \frac{30-28}{34}$

$= 3.36$



Type of activity	Supply voltage volt	Current mA	Branch current mA: Resistor I_R	Capacitor I_C	Inductor I_L	Phase Angle
Calculation	13.9	36mA	35mA	24.9mA	29mA	6.46
measuring	13.9	41mA	34mA	28mA	30mA	3.36

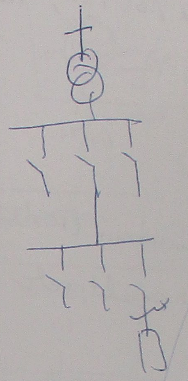
$V_d = \frac{V_C L I}{1000} =$ $0.336 = \frac{V_C\ 300\ 12}{1000}$ $V_C = \frac{0.336 \times 1000}{300 \times 12}$

~~$V_d = $ $V_d = 0.336 \times 400$~~

$V_d\% = \frac{V_d \times 100}{400}$ | $V_d = \frac{V_d\% \times 400}{100} = \frac{0.336 \times 400}{100} = 1.44$

$50mm^2$ $V_d = \frac{0.92 \times 35 \times 160}{1000} = 5.152$ $V_C = \frac{V_d \times 1000}{300 \times 12} = \frac{1.44 \times 1000}{300 \times 12} = 0.333$

$\%V_d = \frac{5.152}{400} \times 100 = 1.22$



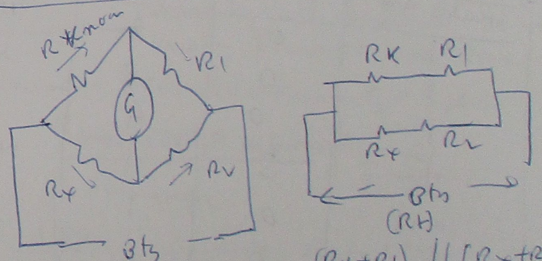
$\frac{(R_1+R_x)^2}{2(R_1+R_x)} = \frac{R_1+R_x}{2}$

$R_t = \frac{R_1+R_x}{2}$ when Bridge is balanced. The value is max.

(or)

$R_t = \frac{R_2+R_x}{2}$ $\frac{R_1}{R_2} = 1 \rightarrow R_1 = R_2$

$R_t = R_x$ when ~~ratio~~ $\frac{\text{ratio}}{\text{arm}} = 1$



$(R_u+R_1) \parallel (R_x+R_2)$

$R_t = \frac{(R_u+R_1)(R_x+R_2)}{R_u+R_1+R_x+R_2}$

$= \frac{(R_u+R_1)(R_x+R_1)}{R_u+R_1+R_x+R_1} = \frac{R_uR_x+R_1R_x+R_uR_1+R_1^2}{R_u+R_x+2R_1}$

$R_t = \frac{R_uR_x+R_1R_x+R_uR_1+R_1^2}{R_u+R_x+2R_1}$

When $R_u = R_x \rightarrow$ $R_t = \frac{R_x^2+R_1R_x+R_xR_1+R_1^2}{2R_x+2R_1} = \frac{R_x^2+2R_1R_x+R_1^2}{2(R_1+R_x)}$

Practical – wheat stone Bridge Trainer

Step 1 – setup the equipment
Step 2 – Set decade resistance value 1kΩ
Step 3 – Then vary the ratio arm value 1
Step 4 – Press X_1 and X_2 together and see the pointer position of galvanometer

If galvanometer indicates zero (middle) position, then calculate R_x as follows

$$\frac{R_{unknown}\text{ (Decade resistance box value)}}{R_{unknown}} = \frac{R_1}{R_2}$$

$$\frac{1k\Omega}{R_x} = 1$$ Thus Runknown (R_x) = 1 kΩ

Take out Runknown and measure it with multimeter = 994Ω

Table 5.4

Ratio Arm	x100	x1000	Position of Galvanometer
1	0	2	Not at zero
1	0	3	Not at zero
1	0	4	
1	3	1	not at zero
1	0	1	Not at zero
0.01	0	1	
10	0	1	Not at zero
1	0	1	At zero

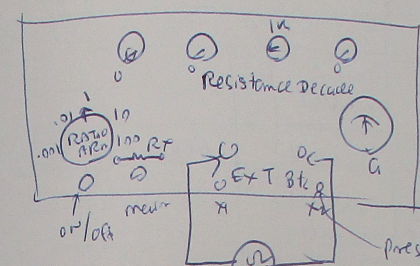
Only at the balanced position, the galvanometer pointer indicates zero position and then the formula

$$\frac{R_{unknown}\text{ (Decade Resistance box Value)}}{R_{unknown}} = \frac{R_1}{R_2}$$

can be utilized to calculate the unknown Resistance R_x

5.2.1 Resistance measurement

Wheat Stone Bridge Trainer



R_x = unknown Resister (1kΩ)

no needs supply

1. Setup equipment
2. Set decade resistance value 1kΩ
3. Vary the ratio arm value, 0.001, 0.01, 1, 10, 100, 1000 and then read the resistance shown on digital multimeter scale

Ratio Arm	Measured Resistance Value
0.001	327
0.01	330
1	411
10	393
100	386.6

At ratio arm value 1, the valued resistance is maximum, it means the current flow will be minimum. At balanced condition, the amount of current flow in to galvanometer is minimum - for accurate measurement, it is zero

The formula is
$$\frac{R_{unknown}\text{ (decade Resistor box)}}{R_{unknown}} = \frac{R_1}{R_2}$$

$$\frac{1k\Omega}{R_x} = 1 \longrightarrow R_x = 1k\Omega$$

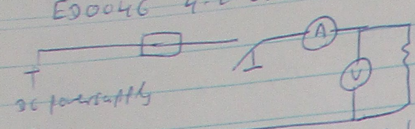
Take out R_x, measure with multimeter = 994Ω
It is not actual wheatstone bridge, It is just a simulator to assist to understand the wheatstone bridge function.

It doesn't need supply.

Ratio Arm – 1
Set X1000 – 1
Press X_1, X_2
See galvanometer

Then alter X100 1 → 10
See what happen
Alter X1000 1 → 10
what happen
R_x = 1kΩ
at $\frac{1k\Omega}{R_x} = 1$ Galv show 0

E00046 4-2 Electrical power



4·1

Setting	cct voltage	cct current mA	Power $V = I \times I$
Setting 1	10	95–100mA	1 watt
—— 2	20	195–200mA	4 watt
—— 3	30	295—300mA	9 watt

Replace R_1 with $R_2 R_3$

Test

4.2 Resistor	cct voltage	cct current mA	power $P = UI$ watt
$R_1 = 100Ω, 10W$	15V	140 – 160	1·46 — 2·56
$R_2 = 230Ω$ 10W	15V	50 – 60	0·675 — 0·942
$R_3 = 330Ω$ 5W	15V	30 — 45	0·351 — 0·75

Give voltage 3·3V

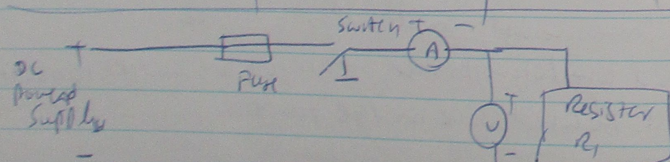
4.3 Resistor	current (mA)	Volt (V)	observation
$R_4 = 15Ω$, 10W	0·2 – 0·23mA	3·3V	Hot
$R_5 = 15, 0.5W$	0·2 — 0·23mA	3·3V	cold

measured

R_1 - specified = 100Ω, R_1 measured 95–105Ω

Supply voltage 15V dc, record in Table 4.4

4.4 Voltage V	current (mA)	Calcu. Power $P = VI$	I^2R	U^2/R
15	140mA	1-9-2·2	1-9-2·2	1-9-2·2



Current Amp	Voltage (V)	watt = VI	meter	Actual
2	50	2×50 = 100W	40%	40W
230mA	24	0·23×24 = 5·52	55%	3·0W

Supply voltage doubled → The power will increase 4 times

doubled the value of capacitor – The power will decrease in half

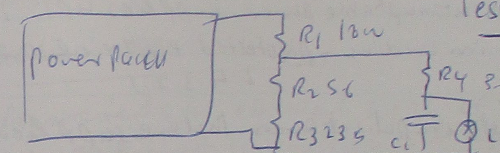
Why resistors have a power rating

Resistors in an electric circuit have a limit to the amount of heat they can dissipate. This ~~l~~ level of heat is express as power (in watts) and if this rating is exceed the component will fail.

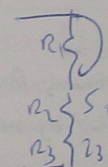
Does the practical give full proof of power equation $P = I^2R$ and $P = U^2/R$

Yes, measured values are consistent with the equation $P = I^2$ and $\frac{U^2}{R}$

Test Answer



(1)



R_1 Short

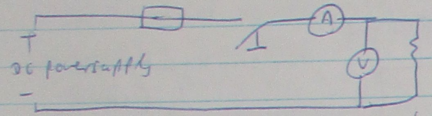
$R_T = 5·6 + 23·9 = 29·5Ω$

(2) R_1 open R_T ∝ ∞Ω

(3) capacitor failure – Shorting by insulation defect
open terminal due to overheat

(4) Time delay $\tau = RC$ = Change R twice or change C twice

E00046 4-2 Electrical power



4.1

Setting	ckt voltage	ckt current mA	Power $V = I \times I$
Setting 1	10	95-100mA	1 watt
—— 2	20	185-200mA	4 watt
—— 3	30	295—300mA	9 watt

Replace R_1 with $R_2 R_3$

Test

4.2 Resistor	ckt voltage	ckt current mA	power $P = VI$ watt
$R_1 = 100\Omega$, 10 W	15V	140 — 160	1.46 — 2.56
$R_2 - 230\Omega$ 10w	15V	50 — 60	0.675 — 0.942
$R_3 - 390\Omega$ 5w	15V	30 — 45	0.351 — 0.75

Give voltage 3.3V

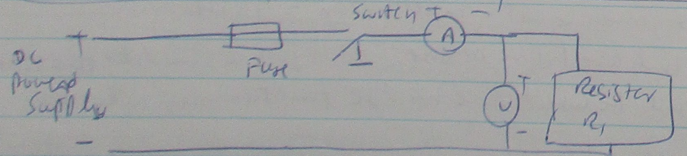
4.3 Resistor	Current (mA)	Volt (V)	observation
$R_4 = 15\Omega$, 10W	0.2 — 0.23mA	3.3V	Hot
$R_5 = 15$, 0.5W	0.2 — 0.23mA	3.3V	Cold

Measure R_1

R_1 - Specified = 100Ω, R_1 measured 95-105Ω

Supply voltage 15V dc, record in Table 4.4

4.4 Voltage V	Current (mA)	Calc. Power $P = VI$	I^2R	U^2/R
15	140mA	1.9-2.2	1.9-2.2	1.9-2.4



Current Amp	Voltage (V)	watt = VI	meter	Actual
2	50	2×50 = 100W	40%	40W
230mA	24	0.23×24 = 5.52	55%	3.07 W

Supply voltage doubled → The power will increase 4 Times

Doubled the value of capacitor — The power will decrease in half

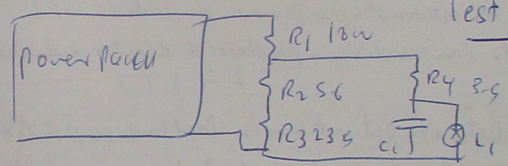
Why resistors have a power rating

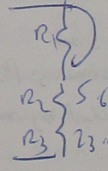
Resistors in an electric circuit have a limit to the amount of heat they can dissipate. This level of heat is express as power (in watts) and if this rating is exceed the component will fail.

Does the practical give full proof of power equation $P = I^2 R$ and $P = U^2/R$

Yes, measured values are consistent with the equation $P = I^2$ and $\frac{U^2}{R}$

Test Answer



1. 

R_1 Short

$R_T = 5.6 + 23.9 = 29.5\Omega$

2. R_1 open R_T ∝ ∞Ω

3. capacitor failure - Shorting by insulation defect, open terminal due to overheat

4. Time delay $T = RC$ = Change R twice or change C twice

BL0012

3.1 Using Standards - Medical Treatment Areas

- Classification of body protected Electrical Area 2 (2.4.1.1)
  Earthing in body protected Electrical Area 3 (3.2)
  medical installation in residential homes 5
  commissioning electrical installations in patient areas - 6
  Requirement of RCDs in patient areas - 8
  Requirement for signage in a body - protected electrical area - 3
- Routine inspection & testing of protective earthing conductors in body protected area - 4.4.2.3
  Requirement for protection of L.V AC wiring systems against mechanical damage in patient areas 6.3.2
  LPS protection of L.V uninterruptable power supplies UPS 2.9.1
  Earthing of socket - outlets in cardiac - protected electrical area 2.4.3.7.1

Identification of socket outlets in patient areas that are supplied from an isolation transformer - 2.7.4.3.1

(1) 3 Australian standard - medical - 3000/3003/2500
(2) patient area - 2.2.1 AS3003 Documentation outlining patient area locations and classification shall be provided by responsible organization / entity.
(3) 6 Examples - body protected electrical area
- Anaesthetic bays, Audiometry, Blood collection, Chiropratic, Dental surgeries, Physiotherapy.

< Body protected electrical space is a patient care location that needs to undergo yearly routine inspection & testing.
every power point is protected by a safety switch. (imperative in any area where patients are being treated)

Cardiac protected electrical Area

Areas where microshock is likely - (1 Patient's intravascular device, 2/ ECG monitoring.

1/ Cardiac catheter laboratories 2/ Cardiac intensive care unit
3/ coronary care unit 4/ operating theatres used for cardiac surgery

EL0012

3.2 Using standards - Construction and demolition sites

AS3000 - Applicable to specific electrical installation - Section '7'

AS3000:2018 Additional Requirement for electrical installation
7.8.2.1 - Electrical installations for construction and demolition sites shall comply with AS/NZS 3012.
AS 3012:2019 - Sections applicable to the items on construction & demolition sites,

	AS 3012 section
Installation of temporary switchboards -	2
Installation of temporary construction wiring -	2
Inspection and Testing of temporary construction wiring -	3
control and protection of construction wiring and equipment -	2
verification of RCDs -	3
Inspection & testing of generator sets -	3

AS 3012 Specific clause

Requirements for electrical supply of luminaires 2.1.2
Identification of construction wiring - 2.5.4
Requirements for transportable structures - 2.9
Requirement for documentation of periodic verification 3.2
minimum IP rating of portable luminaires 2.7.1
Definition of RCD P Inverter - 3.9

1/ Three Australian standards containing requirement for selection & installation of electrical wiring equipment
AS3000 / 3012 / 3190

2/ Auxiliary socket outlet panel
AS3012 1.4.7 A socket outlet assembly supplied by a fixed wire - dedicated final sub circuit of construction wiring

3/ 3 types of construction / demolition sites covered by AS/NZS 3012:2019
(1) Building work
(2) The laying, lining (or) maintenance of pipes (or) cables
(3) site offices.

EL0012

3.3 Using standards – Relocable Installation

AS3000 – Specific Electrical Installation – Section 7

AS3000:2018 clause relating to additional requirement for electrical installations in caravans.

7.2.2.3 Electrical installations in transportable structures and vehicles including their site supplying shall comply with AS/NZS 3001.

	AS3001 Section
1 Protection of permanent wiring in caravans	3
2 permanently connected appliances in caravans	4
3 Earthing of caravans	3
4 Inspection and Testing of electrical installation in caravans	2
5 connection of caravan to a site supply using a supply lead	5

AS3001 clause,

1/ overcurrent protection of final sub circuit in caravans 2.2.7.4 3.3.1.1
2/ minimum size of cables used in caravan wiring system 3.4.1
3/ parts of a caravan that are required to be earthed 3.5.1.2
4/ conductors permitted for use as equipotential bonding conductors 3.5.1
5/ required IP rating of socket outlets installed on exterior of caravan 3.6.3.4
6/ Requirements for the control of a permanently connected electric cooktop in a caravan 3.7.1

AS standards – Selection/wiring in caravan – AS3001, 3002, 3012

Caravan AS3001 1.4.5 – A trailer designed to be towed by a road vehicle and often used for living and accommodation or a self propelled vehicle (motor home) providing similar features to those caravan.

Transportable structures

1/ Relocable home
2/ site office
3/ Display units not intended for accommodation.
4/ Vending vans and Trailers

EL0012

3.4 Using standards – Caravan parks

→ ALSO

AS/NZS 3001 section

1/ Caravan supply arrangements from socket outlet in caravan parks – 4
2/ calculation of maximum demand for caravan park installation APPENDIX 'A'
3/ generator supply for caravan parks – 2
4/ Inspection and Testing of electrical installations in caravan parks – 3
5/ Provision of instructions for connection of caravans to caravan park supplies – 5

AS/NZS 3001

1/ Requirement of earthing of site supplies – 3.5
2/ Requirements for weather proofing of services pillars in caravan parks – 2.2.6.1 / 2.2.8.3
3/ minimum depth of cover for underground wiring system – 2.2.2
4/ Inspection and Testing of electrical installations in caravan parks – 3
5/ Provision of instructions for connection of caravans to caravan park supplies – 5
4/ Definition of Amenities – 1.4.1
5/ minimum rating for a socket outlet intended to supply a caravan 2.2.8.3

Aust. Std: Selection and installation of electrical wiring – caravan AS3001, 3002, 3012

Service pillar 1.4.9 – A specialized switchboard together with its supporting structure. The switchboard contains one or more socket-outlets for the purpose of supplying power to transportable structures

Two camping Areas not covered by AS 3001

– Transportable structures such as homes
– Vehicles that rendered immobile

ELO012

3.5 Using standards marinas & Boats

~~Definition~~ Installation marina AS3000 Section 7

7.8.2.4 – Electrical installations in marinas and recreational boats shall comply with AS/NZS 3004.

1 definition – 1 (AS3004 section) (AS 3004:1:2014)
2 low voltage switch boards for the supply of boats (2)
3 use of isolation transformers in marinas – (2)
4 methods of connections for boats – 3
5 minimization of galvanic corrosion 1

3004:1:2014 Clause

1/ maximum number of socket-outlets permitted on a single service pillar – 2.8
2/ Requirements for bonding of metallic pipework in marinas 3.6
3/ Types of supply leads permitted for the connection of recreational boats to the marina electrical installation 4.2
4/ Requirements for periodic testing of RCDs 2.6
5/ wiring systems permitted for use in marina installations 2.1

3004:2:2014 section

1/ definition 1
2/ selection of cables for marine environment – 6
3/ cable support and protection on boats – 7
4/ requirements for basic protection in low voltage ac installation on boats 4
5/ shore connection arrangements – 3

3004:2:2014 Clause

1/ definition of boat earth 6.3
2/ Requirement for dc switch boards on boats 3.1 / 3.6
3/ Protection by the use of class II equipment 4.5
4/ minimum insulation resistance for lighting & power circuit on boats 8.3
5/ Additional Lithium battery installations on boats 2.9+2.10

AS 3004 + AS3962 + AS 3022 (Safety criteria for elect: equipt design)

Safety voltage Sourceless 1-4-128
Essential services on ~~board~~ boats
1/ Engine drive system & Accessories
2/ Electrical system
3/ ventilation + Air-cond
4/ Navigational equipments

ELO012

3.6 Using standards – Shows and Carnivals

Show/carnival AS3000 Section 7

7.8.2.5 Electrical installations in shows and carnivals shall comply with AS/NZS 3002.

AS 3002/Section

1/ definitions – 1
2/ Permanent L.V switch boards on shows and carnival sites – 2
3/ Supplying shows and carnivals from an inverter system 3
4/ carnival festoon lighting – 4
5/ carnival rides – 4
6/ cables used for temporary wiring of electrical equipment – 4

AS3002 Clauses

1/ minimum depth of cover for underground wiring systems 2.1
2/ Selection of cables for temporary distribution systems 4.2
3/ Types of inverters permitted for use on shows and carnivals sites 3.3
4/ Identification of switch boards 2.4
5/ Testing RCD 3.4
6/ overcurrent protection of connection facilities – 2.4

Australian standards for shows and carnival wiring

AS3000, AS3002, AS3005 (Tents)

Definition of site

AS 3002, 1.1

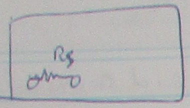
The supply of electricity at low voltage by wiring systems to power consuming devices used for accomodation, entertainment or display purpose within concessions, tents, living quarters and other structures.

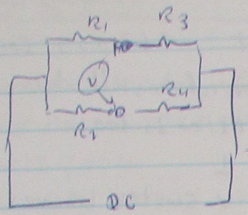
max: duration of event covered by AS3002

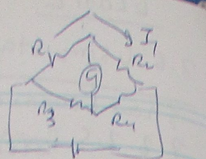
4 weeks.

3 real world examples of events covered by AS/NZS 3002:2008

Shows
carnivals
Exhibitions.

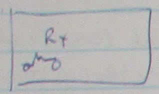






$I_1 R_1$

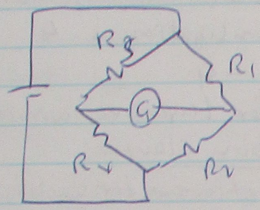
$$\frac{I_1 R_1}{I_2 R_3} = \frac{I_1 R_2}{I_2}$$



Ratio Arm

$$\frac{R_S}{R_X} = \frac{1}{10}$$

$$\frac{1K}{R_X = 1K} = 1$$

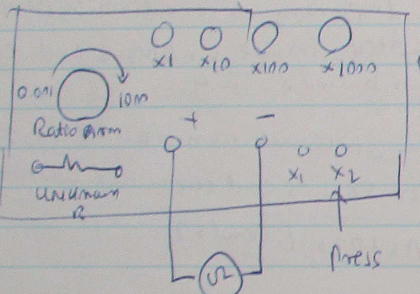


Decade R. Ratio Arm

$$\frac{R_S}{R_X} = \frac{R_1}{R_2}$$

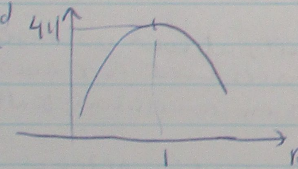
$$\frac{1K}{R_X} = \frac{10}{10}$$

Set $R_S = 1K\Omega$



Ratio Arm =	Ω
1000 / ~~0.001~~	386
100	389.7
10	393
1	411
0.1	394
0.01	388
0.001	387

set Ratio Arm = 1
Set x1000 → 1
Press X1 X2
See galvanometer
Then Alter x100 - 1 → 10
see what happens to meter.



max R = min current
Balance

$$\therefore \frac{R_S}{R_X} = \text{Ratio Arm} \; \frac{R_1}{R_2}$$

$$\frac{1K\Omega}{R_X} = 1 \qquad \therefore R_X = 1K$$

measure unknown Resistor = 0.999KΩ = 1KΩ

You had to adjust Decade Resistance

This is not actual wheatstone bridge just trainer but you can ~~know~~ he demonstrated wheatstone bridge

Q5 | NCC Requirements affecting electrical installation - Fire resistance, Emergency lights & exit signage, lighting and ventilation - Energy efficiency.

EL0012 Apply Building codes and Heritage Requirements

1.1 Apply Building Code Requirements

Debris injuries D/H House keeping | cut by sharpedge D/H use safety gear, Eye injury D/H use safety gear.

~~wal~~ socket outlet installation on fire rated wall

2.1.3 Wall base material - concrete, concrete block, reinforce concrete with 2 to 4 hours of fire rating

method of installation - Fire barrier sealing with specified clearance

wiring Rules | NCC Ref - AS/NZS 3000:2018 Clause 4.2.2.6 + 3.9.4.3
https://ncc.abcb.gov.au Section C Fire resistance C.3.15

2.2.3 Install wiring in Building Structure

wiring system - wiring system shall be of a type that is capable of maintaining supply to equipment when exposed to fire or mechanical damage.

method of installation Install cables in steel conduit. AS/NZS3013
Flame retardant cable AS 2122, WS 52 (↑ 2 hr ↑ moderate)
Fire resistant conduit (PMA), cable support system Burndy.

Wiring Rules AS3000:2018 Clause 7.2.7.2.1 (a)

2.3 maintain Fire barrier

| Fire barrier must be ~~...~~ re instated by using fire pillow, Fire rated mastic in accordance with NCC.

method of reinstating fire rating - | Utilize intumescent coating paints to achieve 2 hr rating | FRL - Fire Resistance Level (7.2.1.2, 7.2.4)

Wiring Rules | NCC Ref - NCC Specification C1.1 & Section C Fire Resistant.

Q1 NCC - Electrical installation in a residential house → NCC vol ~~1~~ 2

Q2 Electrical Installation in shopping centre Class 5/6/7 - NCC vol 1
NCC vol 2 - Class 1 + 10a/b | NCC vol 1 - (2 → 9) NCC vol 3 - Drainage/plumbing

Q3 maintenance of Fire barrier 3.9.4.3
AS3000 2008 (3.9.4.3) The risk of spread of fire shall be minimized by selection of appropriate material & installation. wiring system shall be installed so that general building structure performance of fire safety are not reduced.

Q4 3.9.4.3 (AS 3000) - The opening shall be close fitting to the wiring system ~~ai~~ and at least 50mm from any service opening & the CSA of opening shall not be greater than 500mm².

EL0012

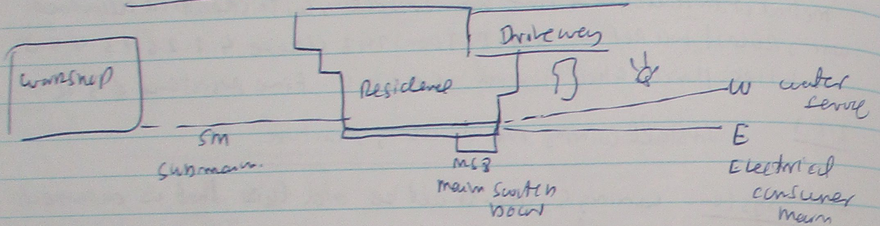
3.1 using Standards – Medical treatment Areas

AS/NZS 3000:2018 Section 7

AS/NZS3000 Clause 7.8.2.2

Requirement – Electrical installation in electromedical treatment area shall comply with AS/NZS3003

Cluster Skills Test Phase(2)



Residence

Qty	Type
✓22	Lighting points
✓2	40W 230V Exh. fan
✓27	10A 230V double socket outlet
✓5	10A, 230A single socket outlet
1	15A, 230A single socket outlet
1	11kW 230V upright stove
1	12.5kW, 400V 3φ Instantaneous water heater
1	230V reverse cycle Aircon (12.4A max)

Workshop

Qty	Type
✓8	Lighting points
✓1	30W, 230V Exh. fan
✓7	10A 230V double socket outlet
✓4	10A 230V single socket outlet
1	15A 230V single outlet
1	3.5kW 400V wood lathe
1	2.4kW 230V Air compressor

Residence + workshop

Load	Load group	Calculation	A R	B W	C 3
~~20~~ Residence 22 Lighting point 40W	(C1) A(i)	20pt – 3A, Add 20pt = 2A, 5A		~~5A~~ 5A	~~5A~~
2 x 40W 230V Exh. fan	30pt A(i) (C1)				
27 10A double socket	B(i)	27 x 2 = 54			
5 x 10A single socket	B(i)	5 x 1 = 5, 59			
		10 x (10A double socket outlet 2x10 = 20 (10A for 1–20M)	~~10A~~		10
		10 (10A double socket outlet 2x10 = 20		10	
		7 (10A double socket outlet) + 5 x 10A single outlet 7x2+5 = 19			10
1 x 15A 230V single socket outlet	B(ii)	10A	~~15A~~	~~10~~	10
1 x 11kW 230V upright stove	(c)	50% connected load $\frac{11 \times 1000}{230} \times 0.5 = 23.9$	~~23.9~~		
1 x 12.5kW 400V 3φ Inst. water heater	(e)	33.3% $\frac{12.5 \times 10^3}{1.7321 \times 400} \times 0.333 =$	6	6	6
1 230V Reverse cycle Aircon	(d)	75% 18.4A x 0.75 = 13.8		13.8	
			~~42~~ 29.9	~~28~~ 34.0	~~32~~ 36

maximum demand = 36A. for Residence.

Load	~~Workshop~~ Load Group	Calculation	A	B	C
RES			29.9	34.8	36
8 Lighting pt. / 80W 230V Exh fan	Workshop A(i) 8 light + 1 Exh fan = 9 pt	8 light + 1 Exh → 9pt ⇒	3A		
7x 10A 230V double socket outlet + 4x10A 230 single socket	B(i)	7x2 = 14pt + 4 = 18 → 10A	10 (42.1)	(34.8)	(36)
15A 230V single socket	B(ii)	10A		10A (44.8)	(36)
1x 3.5kW 400V load lathe	C2 (d)	$\frac{3.5\times10^3}{1.732\times400}$ = 5.05	5	5	5A
2.4kW 230V Air comp.		$\frac{2.4\times10^3}{230}$ = 10A			10.4
		TOTAL SM	18	15	15
		TOTAL	47.9	49.8	51.4

Current carrying capacity of consumer mains

3core cable Enclosed UG. Installation condition UG conduit, use X90

maximum demand = 51.4 for Residence + workshop

maximum demand = 18 for workshop

maximum demand 36 for Residence.

Table 3(4) UG wiring Enclosure One 3core cable

Element 4, → Table 13/14/ col 25–27

use V90 → Table 14 col 25 15 col 15 Derat 22/col 4

51.4A — (63A) → $10mm^2$ 1 cct = 1

Vd ~~Trefoil~~ Table 42 — multicore col 8

V90 → $10mm^2$ → 4.05 (90°C)

Length — ~~10mm~~ 20m 8

$Vd = \frac{VcLI}{1000} = \frac{4.05\times51.4\times8}{1000}$ = ~~4.16~~ 1.66

Vd % = ~~$\frac{4.16}{415}$ max~~ $\frac{1.66}{415}$ max 0.32% ✓

Submain ⇒ 18A max. demand Table 3(4) X90 Table 14 col 15

Vd = Table 42 multicore 2.5mm²

2.5mm² → 16.4

$Vd = \frac{VcLI}{1000} = \frac{16.4\times55\times18}{1000}$ = 16.25 V $\frac{16.25}{415}\times100$ = 3.9%

4mm² $Vd = \frac{10.2\times55\times18}{1000}$ = 10.09 — $\frac{10.09}{415}\times100$ 2.43%

6mm² $Vd = \frac{6.2\times55\times18}{1000}$ = 6.72 — $\frac{6.72\times100}{415}$ = 1.6%

(10mm²) $Vd = \frac{4.05\times55\times18}{1000}$ = 4.0096 $\frac{4.0095\times100}{415}$ = 0.961

Choose 10mm² X90 cable.

Consumer mains

Min. cable size	Current carrying capacity Table	Column	Rating/Derating Table	Col
10mm²	14	25	22	4

Voltage drop

Cable size	Cct load	Route length	Volt. drop Vmt	%	AS/NZS3000 Table	Col
10mm²	51.4	8	1.66	0.38	42	8

Submain

Min cable size	Current carrying capacity Table	Col	Rating Table	Col
~~2.5mm~~ 10mm²	14	25	22	4

Voltage drop cable size	Cct load	Route length	Volt. drop	%	AS3000 Table	Col
10mm²	18	55	4.0096	0.96	42	8

Final subcircuit V90 circular 4 core TPS V90 15m clipped to timber ceiling joist, installed.

12.5kW, 400V 3ϕ Instantaneous water heater V90 15m

$I = \frac{12.5\times10^3}{\sqrt{3}\times400}$ = 18.04A ~~max demand = 33.3% = 6A~~ Table C9. — connected load

Earth fault loop impedance ? Total length = 55 + 8 = 63m.

Cables = Active = 10mm² (55 + 8) = AC Resistance Table 35 3000

10mm² → 2.33Ω/km (90°C) → $\frac{2.33\times63}{1000}$ = 0.1449

Active	Earth
10mm²	4mm² → Table 35/3000 5.82Ω/km

$5.82\times63/1000$ = 0.37

Earth cable size = 3000 → Table 5-1

Total Route fault loop = 0.1449 + 0.37 = 0.515Ω