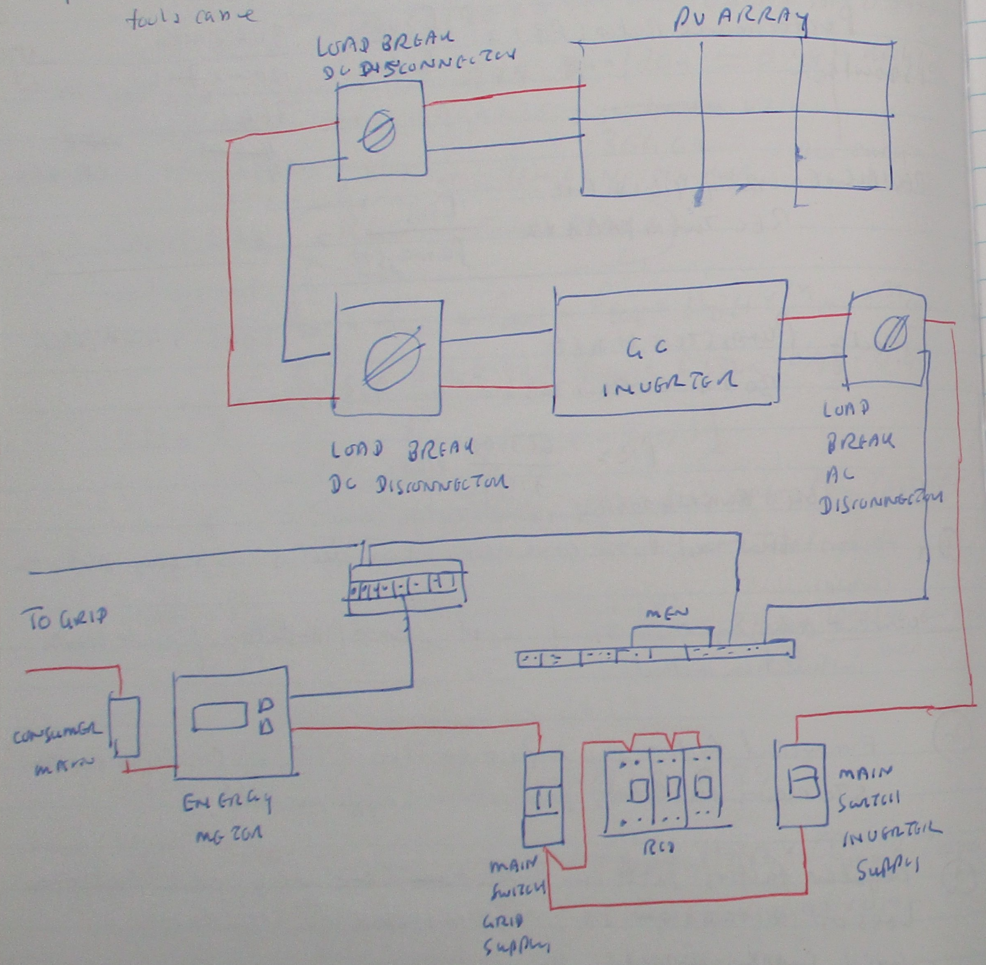
9.2 RE011 PV system isolation and routine maintenance

Hazards			
Electricity potential live cable	2	H	isolation
material on floor	3	L	House keeping
potential sharp object like tools cable	2	L	PPE gloves



Required Tools - Hand Tools, pliers, screw drivers, battery Tools

Test equipment - multimeter

General Isolation Procedure

1/ Notify and locate all isolation points
2/ Notify relevant personnel of your intent to isolate
3/ Isolate, lock and Tag all applicable isolation devices
4/ Test the test equipment on known Live source to verify functionality
5/ Test for voltage to verify de-energized
6/ Test the test equipment on a known Live source to verify functionality.

ETC PV Array - safe isolation (check list)

GC Inverter	Yes	No	Detail
Isolation point identified			
Required Tools obtained			
Required PPE obtained			
Isolation point 1 isolated			
Isolation point 1 Locked/Tagged			
Isolation point 2 isolated			
Isolation point 2 locked/tagged			
Isolation point 3 isolated			
Isolation point 3 locked/Tagged			
Voltage Tester/operation verified			
Isolation Verified at Test point 1			
Isolation Verified at Test point 2			
Isolation verified at Test point 3			
Voltage Tester operation verified			

PV Array Routine maintenance

1/ Are Any of the modules damaged Y N
2/ Are Any of the modules soiled
3/ Is the array affected by Shading?
4/ Does the array tilt angle require adjustment?
5/ Is the array mounting system damaged?
6/ Are all fixings tight and free from corrosion?
7/ Are array terminations tight and free from corrosion?
8/ Is PV wiring system damaged?
9/ Is the mpp tracking operating correctly?
10/ Is the array open circuit voltage within specified limits?
11/ Is the array short circuit within specific limit?

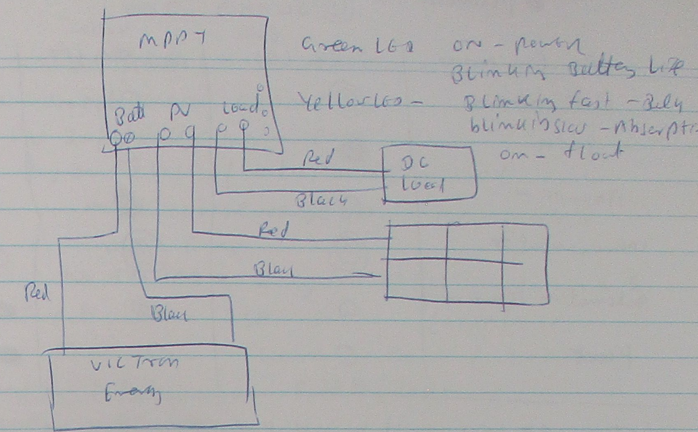
1/ Routine maintenance of PV system
3 months, 12 months, 5 years

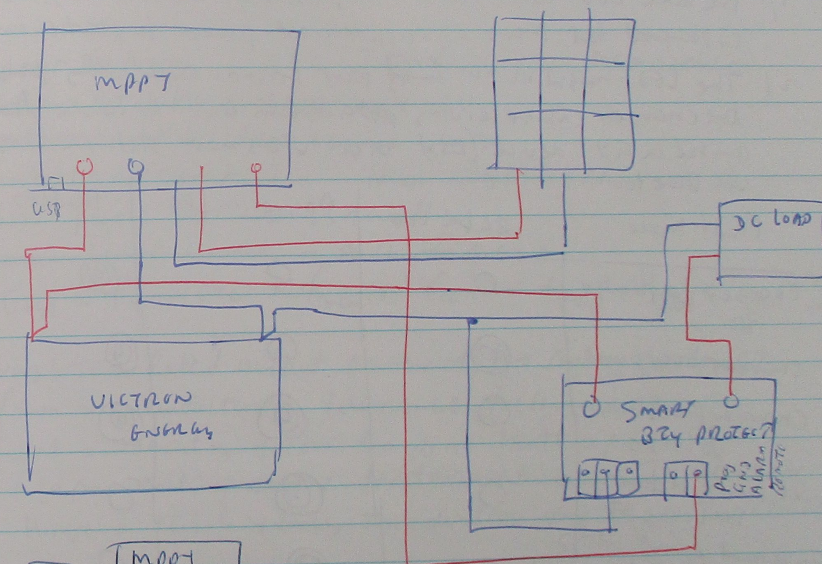
2/ who is permitted to perform routine maintenance of low voltage grid connected PV system?
Certified qualified person.

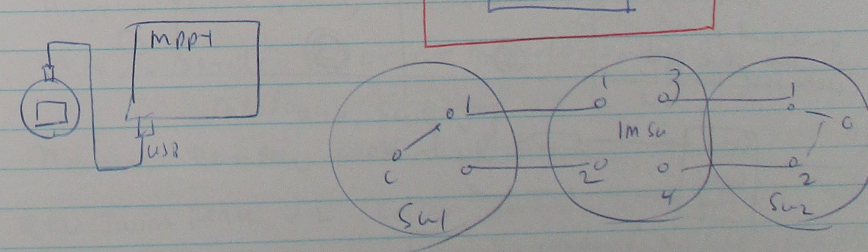
MPPT Tracker

Victron Smart solar MPPT	35A
Epever Triron Series	40A
morningstar prostar MPPT	40A
Epever XTRA Series	40A

9/







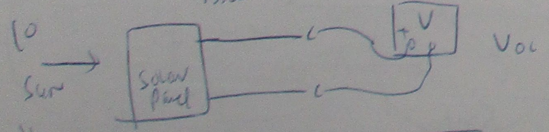
⊙ Permanent on ◎ Blinking ○ Off

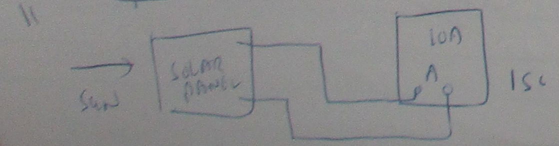
Operation mode	Bulk LED (Blue)	Absorption LED (Yellow)	Float LED (Green)
Not charging	◎	○	○
Bulk	⊙	○	○
Absorption	○	⊙	○
Manual equalisation	◎	◎	○
Automation equalisation	○	⊙	⊙
Float	○	○	⊙

1/ The bulk LED will blink every 3 seconds when the system is powered but there is insufficient power to start charging

2/ The LED might blink ~~every~~ every four seconds indicating that the charger is receiving data from another device. This can be a GX device (ESS) or a VE Smart Network link via Bluetooth

Fault mode	Bulk LED	Absorption LED	Float LED
Charger temperature too	○	○	◎
Charger overcurrent	◎	○	◎
Charger panel over voltage	○	◎	◎
VE smart networks BMS issue	○	◎	○
Internal error calibration issue setting data lost current sensor issue	◎	◎	○





SG 3K-D-N1 / SG 5K-D-N1 Inverter

PV Input power = 6700W

PV Input voltage max = 600V

PV Input Voltage / Start up voltage = 360V

mpp voltage range for rated power 260V – 490V

No of MPPT = 2, No. of PV string / MPPT = 1

max PV Input current = 25A (12.5A/12.5A)

max PV Short circuit current = 40A (20A/20A)

Rated Grid frequency = 50Hz / 60Hz

max efficiency = 97.~~4%~~

Type of PV Array – REC Twin Peak x2 mono series

open circuit voltage 38.3 → 40.2V

max power voltage 33 → 34.3V

short circuit current I_{sc} 10.01 → 10.19A

max power 300 → 330 watt

max power current – 9.11 → 9.62 A

$$E_{SYS} = P_{array\,STC} \times f_{man} \times f_{dirt} \times f_{temp} \times H_{TILT} \times \eta_{inv} \times \eta_{cable}$$

$P_{array\,STC}$ = Rated output power of the array under STC

f_{man} = manufacturing tolerance factor = 0.97

f_{dirt} = derating factor for dirt built up = 0.95

f_{temp} = derating factor for temperature – To calculate

H_{TILT} = Total yearly Irradiation for the site = To calculate

η_{inv} = Derating factor for inverter = 0.98

Catalogue SG 5K-D-N1

η_{cable} = Derating factor of cable = 0.97

REC Twin Peak x2 Solar array

γ = -0.37%, NOCT (Nominal module operating temperature) = 44.6C

(Tref)

$$PF = \frac{330}{40.2 \times 10} = 0.82$$

Ambient Temperature = 34.3C { 19/9/2023 1:36 PM at ~~Raves~~ Reveshby }

G = 1000 { Reference Solar Irradiance for Australia https://solcast.com

$T_{cell} = 34.3 + 1000 \frac{(44.6 - 34.6)}{800} = 47.175C$

$f_{temp} = \left[1 - \frac{r}{100}(T_{cell} - NOCT)\right] = 1 - \frac{0.37}{1000}[47.17 - 44.6]$

$= 0.99$

H_{Tilt}/day = optimal Irradiation × PSH/day

$= \frac{92}{100} \times 7.1$ (— Sydney PSH ~~Internet~~ Internet Search

= 6.532 kWh/day

$H_{Tilt}/yr = 6.532 \times 365 = 2384$ kWh/m2

$E_{sys} = P_{STC} \times f_{man} \times f_{dirt} \times f_{temp} \times H_{Tilt} \times \eta_{inv} \times \eta_{cable}$

$= 330 \times 0.97 \times 0.95 \times 0.99 \times 6.532 \times 0.98 \times 0.97$

= 1868.9 Wh/day (or) 1.868 kWh/day

Esys/yr = 1.868 × 365 = 682.14 kWh / Each module

Total module = 14

Total output power = 14 × 330 = 4620 watts

Esys/yr for 14 modules = 682.14 × 14 = 9549.96 kWh

Specific energy yield for REC TWIN PEAK V2

$= \frac{E_{sys}}{\text{power Array STC}} = \frac{682.14}{330 \times 10^{-3}} = 2067$ kWh/kW

$E_{ideal} = P_{Array STC} \times H_{Tilt} \times 365$

$= 330 \times 6.532 \times 365 \times 10^{-3} = 786.77$ kWh/kW

Eideal for 14 modules = 786.77 × 14 = 11014 kWh/yr

Performance ratio $PR = \frac{E_{sys}}{E_{ideal}} = \frac{682.14}{786.77} = 0.867$

Control protection Device selection

Type of device	Nominal current	Nominal voltage	Load breaking capacity	Installed Location
1/ CB SAA-1812-40-CR PV Switch Disconnect or 3YH32	32 A at 40C 29 A at 60C	218V dc	Yes	MSB Solar main Switch
2/ CB 1SA GO	20A	240V	Yes	MSB Solar
3/ PV Disconnector	15A	450V		Inverter

DC wiring system selection

Installation method — wiring enclosure × 90

REC TWIN PEAK ×2 solar Brochure recommends XLPE CABLE

Insulation type	~~Curr~~ Current carrying capacity min current carrying capacity	min cable size	AS/NZS 3008.1.1 2017 Table	Col.
XLPE	38 A	4mm²	5	15

How to get that data

AS3008 Air { Open Table 3(1) / Enclosed Table 3(2)

Ground { Direct Table 3(3) / Enclosed 3(4)

Installation wiring Enclosure in Air choose Table 3(2)

Item 1 — Two singlecore cable — see Table 4/5 colum 15/17

cable is copper cable — choose Table 5 col 15 force

4mm² ⟶ 32A
↑ Appropriate

CB rating 32A / 29A
Isc dc 15A

voltage drop (DC side)

$$Vd = \frac{I\ L\ Rc \times 2}{1000}$$

DC cable 4mm² cable, max temp = 110°C
the Resistance (Rc) = ?

Choose Table 34 — 110°C col 6

4mm² ⟶ 6.24 Ω/km

Idc = PV array Isc = 10.19A ⟵ use as I
Solar panel to Inverter cable length = 13m

$$\therefore Vd = \frac{I\ L\ Rc \times 2}{1000} = \frac{10.19 \times 13 \times 6.24 \times 2}{1000} = 1.7V$$

$$\%vd = \frac{vd}{Vdc\ max} \times 100 = \frac{1.7}{450} \times 100 = 0.377\%$$

↑ from datasheet

Von	Voltage drop %	minimum cable size	Table AS/NZS 2008 1.1 2017 Table	col
1.7	0.377	4mm	34	6

AC wiring system selection

~~Installation method~~ Wiring enclosure in Air
Air/enclosed — choose Table 3(2)

Two core cable — Item 7 ⟶ see Table 10/11 col 11/13

Table 10 — (solid stranded) col 11

2.5mm² — C5A ⟶ 23A
~~current~~ current carrying capacity

Insulation Type	min current carrying capacity	min cable size	AS NZS 3008.1.1 2017 Table	col
PVC	2.5mm²	23A	10	11

Voltage drop
AC multicore cable copper

Choose Table 42, operating Temp choose 75°C

75°C
2.5mm² ⟶ 15.6 mV/A-m — 3φ VC

$$1\phi\ VC = \frac{2}{\sqrt{3}} \times 3\phi VC = \frac{2}{1.7321} \times 15.6 = 18mV/A\text{-}m$$

$$Vd = \frac{VC\ L\ I}{1000} = \frac{18 \times 6.2 \times 23}{1000} = 2.566V$$

$$\% = \frac{Vd}{\text{supply voltage}} \times 100 = \frac{2.566}{240} \times 100 = 1.06\%$$

AC side total wire length — Take 6.2m

PV Array operating parameter

Total power	4020	Total module	= 16
No. of string	2	module/string	= 8
Nominal volt	54.7	Nominal current	9.0
O/C voltage	40.8	S/C current	10.11

SG5K0-MI GC INVERTER

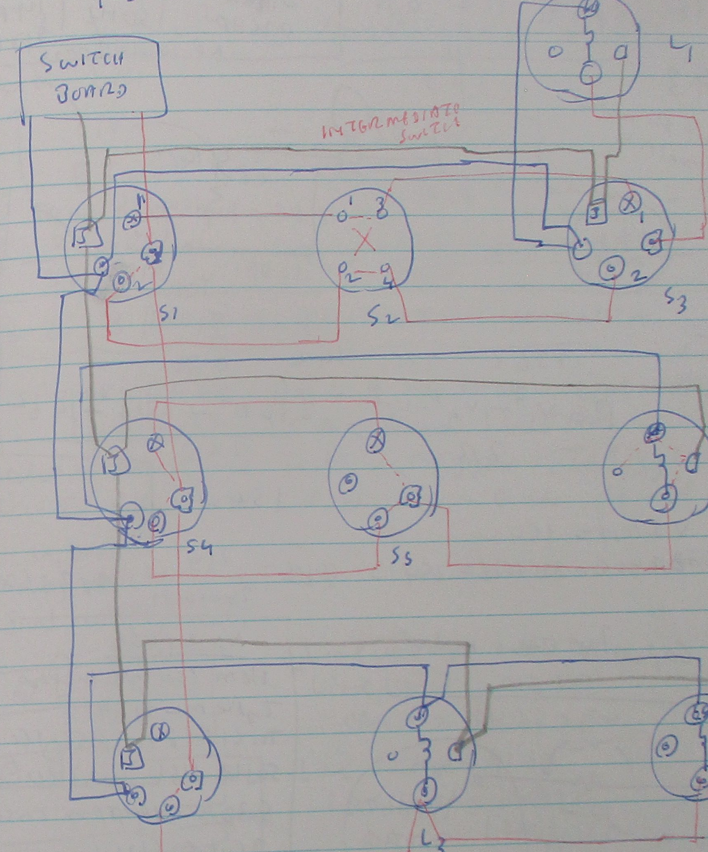
GC Inverter I/P parameter

max dc power	6700W	max dc volt	600V
mpp voltage range	90–560V	max dc current	25A (12.5A/12.5A)
No of MPPT	2	max no of string	1

GC INVERTER output parameter

volt range	180–276V	max AC power	4999VA
rated grid freq	50/60HZ	AC volt range	180/200V
max AC current	21.7A	Grid freq range	45-55/55–65 HZ

1.2.2



Pn 9607 4100

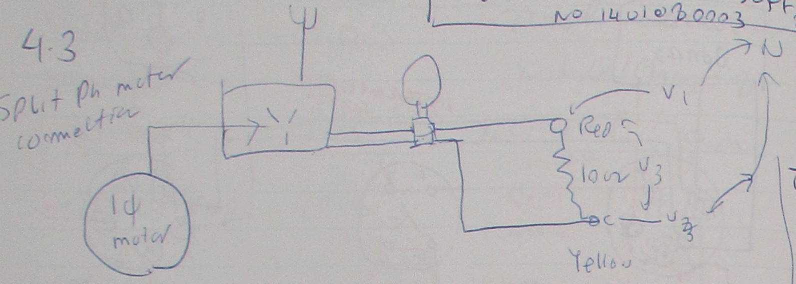
1φ induction motor

NAME PLATE
Type S224
0.18kW
0.25HP
240V
1.2A
50HZ
Insul F IP55
1370 rpm
12μF 450V
50μF 250V 240V
No 1401080003

238 , 231.7 , 11.7 0.77

4.3

Split ph motor connection



$T_{FL} = \frac{P \times 60}{2 \pi N} = \frac{180 \times 60}{2 \times 3.142 \times 1370} = 1.25N$

V_1	V_2	V_3	I
238.6	231.6	14.2	0.77

$pf = \frac{180}{240 \times 1.2} = 0.4166$

$P = \frac{V_1^2 - V_2^2 - V_3^2}{2R} = \frac{238.6^2 - 231.6^2 - 14.2^2}{2 \times 10} = 154W$

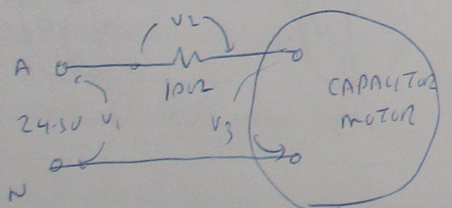
$\eta = \frac{154}{180} \times 100 = 85.5\%$

$VI\cos\phi = 154W$

~~238~~ $240 \times 0.77 \cos\phi = 154$

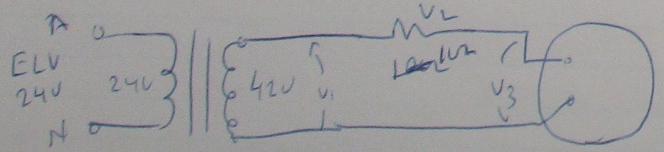
$\cos\phi = \frac{154}{240 \times 0.77} = 0.83$ lag

5.1 Capacitor start motor



Name Plate
HGM Electric motor
Type ML7124
Th Cl F(B) IP55 IEC 60034
50HZ 115V 0.37kW 0.5HP
5.38A 1400rpm cosφ 0.92
250μF (125V)
45μF (250V)

R = 2.6Ω.



1φ CAPACITOR START MOTOR 42V

ISOLATION TRANSFORMER

V_1	V_2	V_3	I
40.43	39.47	1.691	1.691

$P = \frac{V_1^2 - V_2^2 - V_3^2}{2R_1} = \frac{40.43^2 - 39.47^2 - 1.691^2}{2 \times 1} = 38.5W$

$EI\cos\phi = 38.5$

$40 \times 1.691 \cos\phi = 38.5$

$\cos\phi = \frac{38.5}{40 \times 1.691} = 0.569$

$\eta = \frac{37 (OP)}{38.5 (IP)} \times 100 = 96.17$

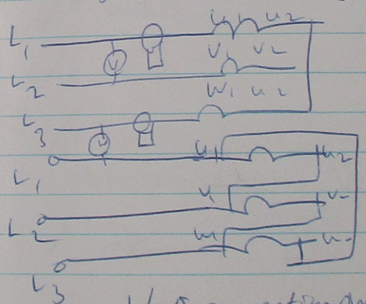
$\eta = \frac{38.5}{EI\cos\phi} \times 100 = \frac{38.5}{40 \times}$

2.2 3 Phase Induction motor connection

Power = 44W, pf = 0.84 lag, Line voltage = 41.5V
Line current 1.6A Speed 1365 rpm

Insulation Resistance Test Megger Test voltage 500V
U_1–E ∞Ω V_1E – ∞ W_1–E ∞ U_1–V_1 ∞
U_1W_1 ∞ V_1W_1 ∞

Winding resistance U_1–U_2 6.3Ω V_1–V_2 6.3Ω W_1–W_2 6.3Ω
Shaft rotate freely



Line voltage = 41.5V
Line current = 0.27A
Speed = 1425 rpm

Line voltage = 41.5V
Line current = 0.77A
RPM = 1425 rpm

1/ Δ connection draws ~~Lie~~ more line current. λ Phvoltage λ 24V, Δ phase voltage is 42V.
Line current Δ = $\sqrt{3}$ ~~ph~~ winding phase current

Δ draws more supply current

λ Power = $\sqrt{3} EI\cos\phi$ = 1.732 × 41.5 × 0.27 × 0.84 = 16.3W

Δ Power = $\sqrt{3} EI\cos\phi$ = 1.732 × 41.5 × 0.77 × 0.84
= 46.4W

~~Sta~~ main parts / stator / rotor
3φ — Stator slot / stator wdg / Sq cage rotor / Terminal / bearing / endplate

Squirrel case rotor / wound rotor

Test before service — Winding Insulation Resistance Test, Winding Resistance Test, polarity Test / No load Test.

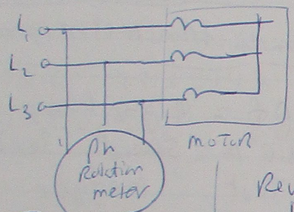
1.2 Connect, Run and Reverse a 3ϕ Induction motor

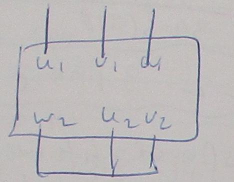
Name plate Details

Power = 440watt. Power factor 0.84 Lagging, Line voltage - 415V

Line current 1.6A Speed 1365 RPm

~~A~~ Connect 2.1.2



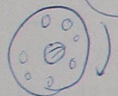


Phase sequence RST

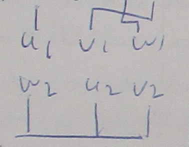
Line current 0.27A

SPEED 1485 RPm

Direction of rotation



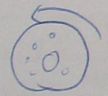
Reverse the connection



Phase sequence TSR

Line current 0.27A

Speed 1485 rpm



Direction of rotation

1| What would happen to the direction of rotation if all supply active conductors were interchanged?

It will not change the direction of rotation

2| Connection configuration — Star

3| Syn speed 400V, 50Hz 4 pole $N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500\,rpm$

4| Syn speed of 400V 50Hz 6 poles $N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000\,rpm$

5| Syn speed of 400V 50Hz, 720 rpm slip speed = 30 rpm

Syn speed = rotor speed + slip speed = 720 + 30 = 750 rpm

[pole? $N_s = \frac{120f}{P} \rightarrow P = \frac{120f}{N_s} = \frac{120 \times 50}{750} = 8$

6| Rotor speed 2856 rpm slip 4.8% 50Hz, 400V, N_s?

$N_r = (1-S) \times N_s \rightarrow 2856 = (1 - \frac{4.8}{100}) \times N_s$ | $N_s = \frac{2856}{0.952} = 3000\,rpm$

$2856 = 0.952 \times N_s$

7| Syn speed = 3000 rpm, slip speed - 126 rpm rotor speed?

Rotor speed = N_s - slip speed = 3000 - 126 = 2874 rpm

8| 400V, 50Hz, syn speed 1500 rpm slip 4% N_r = ?

$N_r = N_s(1-S) = 1500(1 - \frac{4}{100}) = 1440\,rpm$

9| Rotor speed = ? 400V ; 50Hz 4 pole slip speed 78 rpm

$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500\,rpm$, $N_r = N_s$ - slip speed

= 1500 - 78 = 1422 rpm

10| 400V, 50Hz, 8 poles, slip 4.8% N_r = ?

$N_r = N_s(1-S) = \frac{120 \times f}{P}(1-S) = \frac{120 \times 50}{8}(1 - \frac{4.8}{100})$

$= 750 \times 0.952 = 713.5\,rpm$

11| 400V, 50Hz, 4 pole, slip 4%, slip speed = ?

$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500\,rpm$ Slip speed = $N_s \times$ slip = 1500×0.04

= 60 rpm

12| Slip = ? 750 rpm | 400V, 50Hz, rotor speed = 712 rpm

∴ ~~At~~ Slip speed = $N_s - N_r$ = 750 - 712 = 38 rpm

$Slip = \frac{38}{750} = 0.0506$ or 5.06%

13| Slip = ? 400V, 50Hz, 6 poles, 920 rpm rotor speed

$N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000\,rpm$

Slip speed = $N_s - N_r$ = 1000 - 920 = 80 rpm

$Slip = \frac{slip\ speed}{N_s} = \frac{80}{1000} = 0.08$ or 8%

14| 400V, 50Hz, 2 pole, rotor speed = 2916 rpm slip = ?

$N_s = \frac{120f}{P} = \frac{120 \times 50}{2} = 3000\,rpm$, slip speed = $N_s - N_r$

= 3000 - 2916

= 84 rpm

$Slip = \frac{slip\ speed}{N_s} = \frac{84}{3000} = 0.028$ or 2.8%

15| Rotor frequency of 400V 50Hz induction motor slip = 5.4%

$f_r = S \times f_s = \frac{5.4}{100} \times 50 = 2.7\,Hz$

16| 400V, 50Hz, 4 poles motor, slip speed = 87 rpm Rotor frequency = ?

$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500\,rpm$ | ~~St~~ $f_r = S f_s$

$slip = \frac{slip\ speed}{N_s} = \frac{87}{1500} = 0.058$ | $= 0.058 \times 50 = 2.9\,Hz$

17| Rotor frequency = ? 400V, 50Hz, 6 pole, Rotor speed 900 rpm

$N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000\,rpm$ slip speed = $N_s - N_r$ = 1000 - 900 = 100 rpm

$\therefore S = \frac{slip\ speed}{N_s} = \frac{100}{1000} = 0.1$

$f_r = S f_s = 0.1 \times 50 = 5\,Hz$

2

N

Squirrel cage rotor / wound rotor

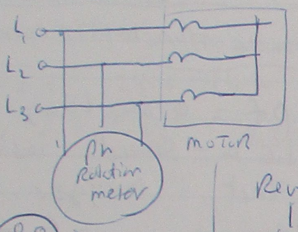
Test before service — Winding Insulation Resistance Test
Winding Resistance Test polarity Test / No load Test.

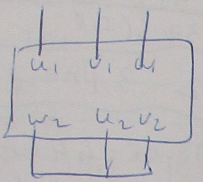
1.2 connect, Run and Reverse a 3φ Induction motor

Name Plate Details

Power = 44 watt. Power factor 0.34 Lagging, Line voltage - 415V
Line current 1.6A Speed 1365 RPM

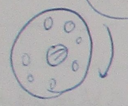
Connect 2.1.2



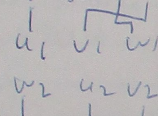


Phase sequence RST
Line current 0.27A
SPEED 1485 RPM

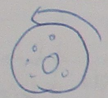
Direction of rotation



Reverse Reconnection



Phase sequence TSR
Line current 0.27A
Speed 1485 rpm



Direction of rotation

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4/ Syn speed of 400V 50Hz 6 poles $N_s = \frac{120f}{P} = \frac{120\times50}{6} = 1000$ rpm

5/ Syn speed of 400V 50Hz, 720 rpm slip speed = 30 rpm
Syn speed = rotor speed + slip speed = 720 + 30 = 750 rpm
[pole? $N_s = \frac{120f}{P} \rightarrow P = \frac{120f}{N_s} = \frac{120\times50}{750} = 8$

6/ Rotor speed 2856 rpm slip 4.8%. 50Hz, 400V, N_s?
$N_r = (1-s)\times N_s \rightarrow 2856 = (1-\frac{4.8}{100})\times N_s$
$2856 = 0.952 \times N_s$ | $N_s = \frac{2856}{0.952} = 3000$ rpm

7/ Syn speed = 3000 rpm, slip speed - 126 rpm rotor speed?
Rotor speed = N_s - slip speed = 3000 - 126 = 2874 rpm

8/ 400V, 50Hz, syn speed 1500 rpm slip 4%. N_r?
$N_r = N_s(1-s) = 1500(1-\frac{4}{100}) = 1440$ rpm

9/ Rotor speed? 400V; 50Hz 4 pole slip speed 78 rpm
$N_s = \frac{120f}{P} = \frac{120\times50}{4} = 1500$ rpm, $N_r = N_s$ - slip speed
= 1500 - 78 = 1422 rpm

10/ 400V, 50Hz, 8 poles, slip 4.2% N_r?
$N_r = N_s(1-s) = \frac{120\times f}{P}(1-s) = \frac{120\times50}{8}(1-\frac{4.2}{100})$
$= 750 \times 0.958 = 718.5$ rpm

11/ 400V, 50Hz, 4 pole, slip 4%, slip speed?
$N_s = \frac{120f}{P} = \frac{120\times50}{4} = 1500$ rpm   Slip speed = $N_s \times$ slip = 1500 × 0.04
= 60 rpm

12/ Slip? 750 rpm | 400V, 50Hz, rotor speed = 722 rpm
∴ Slip speed = $N_s - N_r$ = 750 - 722 = 38 rpm
Slip = $\frac{38}{750}$ = 0.0506 or 5.06%

13/ Slip? 400V, 50Hz, 6 poles, 920 rpm rotor speed
$N_s = \frac{120f}{P} = \frac{120\times50}{6} = 1000$ rpm
Slip speed = $N_s - N_r$ = 1000 - 920 = 80 rpm
Slip = $\frac{\text{slip speed}}{N_s} = \frac{80}{1000} = 0.08$ or 8%

14/ 400V, 50Hz, 2 pole, rotor speed: 2916 rpm slip?
$N_s = \frac{120f}{P} = \frac{120\times50}{2} = 3000$ rpm; slip speed = $N_s - N_r$
= 3000 - 2916
= 84 rpm
Slip = $\frac{\text{slip speed}}{N_s} = \frac{84}{3000} = 0.028$ or 2.8%

15/ Rotor frequency of 400V 50Hz induction motor slip = 5.4%
$f_r = s \times f_s = \frac{5.4}{100} \times 50 = 2.7$ Hz

16/ 400V, 50Hz, 4 poles motor, slip speed = 87 rpm Rotor frequency?
$N_s = \frac{120f}{P} = \frac{120\times50}{4} = 1500$ rpm | $f_r = s f_s$
slip = $\frac{\text{slip speed}}{N_s} = \frac{87}{1500} = 0.058$ | $= 0.058 \times 50 = 2.9$ Hz

17/ Rotor frequency? 400V, 50Hz, 6 pole, Rotor speed 900 rpm
$N_s = \frac{120f}{P} = \frac{120\times50}{6} = 1000$ rpm   slip speed = $N_s - N_r$ = 1000 - 900
= 100 rpm
∴ $S = \frac{\text{slip speed}}{N_s} = \frac{100}{1000} = 0.1$
$f_r = s f_s = 0.1 \times 50 = 5$ Hz

UEEEL 0024 ~~DC~~ AC Machines 3φ

✓1 1.2 connect Run Reverse 3φ induction motor

Hazards	Supervision	Risk	Control
① Exposed conductors. Terminal	D	H	Test the eqpt before touch / cover
② Electrical Leakage to machine body	D	H	Test motor with Tester / Insulation
③ ~~out of~~ Phase out	M	G	Properly connect the machine
④ over voltage burn out of motor	D	M	use only 42 V supply

2

X3

✓4

✓5

X6

X7 2.2 motor connection / 2.3 motor construction / 3.2 motor effcy

4.3 1φ Split ph ~~co~~ motor connection 5.1 Capacitor / Shaded pole motor

5.2 Permanent Split ph motor / Shaded pole motor

✓8 5.3 1φ motor Capacitor shaded pole — Permanent / Split capacitor connection

✓9 5.3 Capacitor Start / cap. run motor 5.4 Shaded pole motor connection

✓10 6.2 universal motor 7.2.1 motor protection / 7.2.2 motor protection

8.2 3φ Synchronous Machine 9.3 Generator connection

✓11 10.3 Trouble shoot 3φ motor / control 10.4 Trouble 1φ motor control

(1.2) connect / Run / Reverse 3φ Induction motor

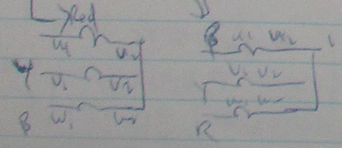
2.1.1 Nameplate

Power = 44 watts Power factor = $\frac{44}{\sqrt{3}\times 41.5\times 1.0} = 0.387$ lags

Line voltage = 41.5V Line current = 1.0A Speed = 1365 RPM

Phase sequence RST — 0.27A Line current, RPM = 1485 direction forward

TSR 0.27A RPM 1475



$T_{FL} = ?$ $P = \frac{2\pi NT}{60}$

$44 = \frac{2\times 3.1416 \times 1365\, T}{60}$

$T = \frac{44\times 60}{2\times 3.1416\times 1365} = 0.3$ N-m.

2.2 3φ Induction motor connection

Insulation Resistance $U_1 - E$ ∝, $V_1 - E$ ∝, $W_1 - E$ ∝, $U_1 - V_1$ ∝, $U_1 W_1$ ∝, $V_1 W_1$ ∝

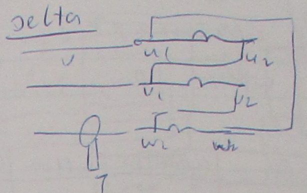
Test voltage 500V

Power = 44 watt pf = 0.387 V_L = 41.5V I_L = 1.0A

Speed 1365 rpm

winding Resistance $U_1 - U_2$ - 6.3Ω, $V_1 - V_2$ - 6.3Ω, $W_1 - W_2$ - 6.3Ω

Earth Resistance = Ohm meter 500V OL



Δ $I_L = 0.79A$

Y = $V_L = 41.5V$ $I_L = 0.27A$ Speed = 1486 rpm

2.3 3φ Induction motor Dismantling, Assembly & Testing.

(3.2) Induction motor losses & efficiency

0.41 950N 1.12A →

0.37A ~~733~~ rpm 1417

1.69A ——→ 308

ON ~~0.4A~~ 0.37A

1N 0.35 1399

0.42A 1380 rpm

2N - 1400 rpm 0.4A

0A -	0.34A	1462
0.3A	0.34	~~1400~~ 1407
0.9A	0.34	1409
1.4A	0.34	1407
2.05	0.34	1406

$P_{out} = \frac{2\times 3.1416\times 1400\times 0.2}{60} = 29.32W$

$P_{in} = \sqrt{3} EI\cos\phi = 1.7321\times 41.5\times 0.4\times 0.327 = 11.$

2A - 750 rpm, 1.85A - 1170 rpm, 1A - 1359 rpm 0.4A - 1400 rpm

2.5A — max ——→ 10N

0.4A ——— ? = $\frac{10\times 0.4}{2.5} = \frac{0.16}{1.6N}$

$1A = \frac{10\times 1}{2.5} = 4N$ | $2A = \frac{2}{2.5}\times 10 = 8N$

$\frac{2\times 3.1416\times 750\times 8}{60} = 62.8W$

effy = $P = \frac{V_1^2 - V_2^2 - V_3^2}{2R}$

$V_1 = 24.8$ $V_2 = 0.645$ $V_3 = 24.01$ $R = 1Ω$ = 13W

$I_W 3φ = 13\times 3 = 39W$

I = 0.645A

Pf 2A - 750 rpm. 0.8N

$\frac{2\times 3.14\times 750\times 0.8}{60} = 62.8W$

1.85A - 1175 rpm - $\frac{2\times 3.14\times 1175\times 0.72}{60} = 88.5W / 2 = 44.25$

$P = \frac{2\pi NT}{60}$ 1A - $\frac{2\times 3.14\times 1359\times 0.4}{60} = 56.8W = 28.4$

$NT = \frac{P60}{2\pi}$

Pf. $\frac{39}{1.7321\times 41.5\times 0.645} = 0.84$

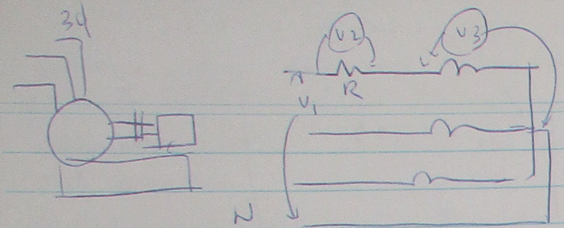
Torque full scale = $\frac{1N}{2}$

$P_{out} = 39 - 7.8 = 31.2W$ / $NT = \frac{P60}{2\pi} = 298$

Copper loss = $3I^2R = 3\times 0.645^2\times 6.3 = 7.8W$

√1 2 X3 √4 √5 X6 X7 √9 √9 √10 √11

3φ



$P_{1\phi} = 3\,\frac{V_1^2 - V_2^2 - V_3^2}{2R}$

copper loss $= 3I^2 \times 6.3\Omega$

W/F loss $= P_{IN} - 3I^2 \times 6.3\Omega$

Torque scale	V_1	V_2	V_3	P_{IN}	copper loss	W/F loss	Wout	$N_rT = \frac{W}{2\pi} \times 60$
0	24.51	0.55	24.11					
2	24.46	0.54	24.05					
	24.40	0.514	24.11					
3	24.46	0.447	24.11					
4	24.40	0.49	24.ne					
			24.09					

No load $V_1 = 24.4$, $V_2 = 0.312$, $V_0 = 24.33$

T(N)			
0.1	24.46	0.58	24.06
0.2	24.40	0.520	24.09
0.3	24.41	0.546	
0.4	24.46	0.513	24.16
0.5		0.531	
0.6			

T	V_1	V_2	V_3	P_{IN}
0.1	24.46	0.524	24.07	27.97
0.2	24.40	0.519	24.07	27.46
0.3	24.46	0.532	24.07	27.98
0.4	24.4	0.546	24.07	27.93
0.5	24.40	0.493	24.07	28.01
0.6	24.40	0.429	24.07	28.02

$P = \frac{V_1^2 - V_2^2 - V_3^2}{2R} = \frac{24.46^2 - 0.524^2 - 24.07^2}{2\times1} = \frac{12.92^2 - 0.524^2}{2} = 9.32$

3φ ×3: 27.97, 27.41, 27.98

$= \frac{12.92 - 0.519^2}{2} = 9.32$

$\frac{12.92 - 0.532^2}{2} =$

~~NrT~~ $P = \frac{2\pi N_r T}{60}$

without load

$P = \frac{24.46^2 - 0.312^2 - 24.33^2}{2\times1} = 3.12\times3$

I/P ~~W/F loss~~ $= 9.36W$

No load copper loss $= 3I^2R = 3\times0.312^2\times6.3$
$= 1.91$ ∴ W/F loss $= 9.36 - 1.91 = 7.45$

(1.2) continue

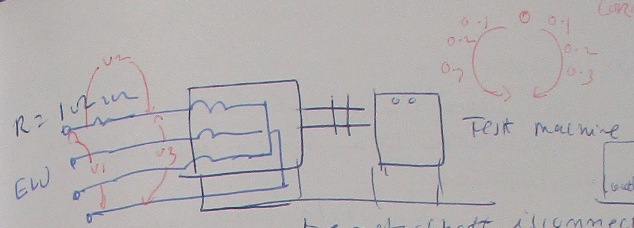
(1.3) Rotor frequency? 400V, 50Hz 6 pole induction motor rotor speed 700rpm

$N_S = \frac{120f}{P} = \frac{120\times50}{6} = 1000\,rpm$. $N_r = 700\,rpm$

slip speed $= 1000 - 700 = 300\,rpm$

slip $= \frac{\text{slip speed}}{N_S} = \frac{300}{1000} = 0.3$

$f_r = f_s \times s = 50\times0.3 = 15\,Hz$



When supply to loading m/c is applied to test 3φ motor, at ~~the~~ control [illegible] so that [illegible] at 1/10 of scale is applied

2

N

When the motor shaft is connected with testing machine, the torque is already 0.3Nm at the torque scale 0, by increasing the torque scale value, feedout and torque zone [illegible] put on motor causing slower speed of motor

~~NrT~~ I	Pcu loss ($3I^2R$ (6.3))	Pout W/F loss	Pout	$P/2\pi = N_rT$	RPM		Total loss
0.524	5.189	~~2.27~~ 7.45	~~13.48~~ 15.39	~~2 146 128.7~~ 147	~~1207~~ 1470	1365 rpm	12.63
0.519	5.09	~~9.3~~ 7.41	~~13.77~~ 14.92	~~124.27~~ 143.1	~~624~~ 715.5		12.54
0.532	5.349	~~9.3~~ 7.41	~~13.3~~ 15.21	~~127.07~~ 134.2	~~423~~ 447		12.79
0.546	5.503	~~9.3~~ 7.405	~~13~~ 14.91	~~124.2~~ 142.45	~~310~~ 356		13.08
0.493	4.59	~~9.3~~ 7.45	~~14~~ 16.03	~~131.9~~ 153.1	~~261~~ 306.2		12.04
0.429	4.52	~~9.3~~ 7.45	~~14~~ 16.11	~~135.6~~ 153.9	~~226~~ 256.5		11.97

$N_rT = \frac{P\times60}{2\pi}$, $P = \frac{2\pi N_r T}{60}$, $RPM = \frac{N_r T}{T}$

Name plate value 0.387

No load p.f. $\frac{\text{Power}}{\sqrt{3}EI} = \frac{9.36}{1.732\times42\times0.312} = 0.404$

(1.2) 19| Rotor frequency affected by rotor speed $f_r = s\times f_s$, $\frac{N_S - N_r}{N_S}$ = slip speed

~~Rotor speed~~ : The difference between rotor speed and synchronous speed causes the slip speed which ~~θ~~ is related to slip. The slip ~~de~~ reduces the supply frequency that ~~the~~ comes to rotor which is rotor frequency

20| The slip speed is related to slip. The slip reduces the supply frequency that comes to rotor which is rotor frequency

21| At what speed the rotating magnetic field produced in the stator of a 3φ induction motor?

supply frequency.

(2.3) Phase to earth = 0V

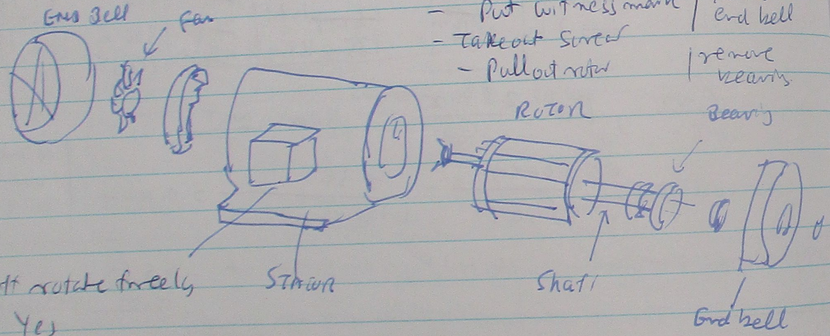
~~Nep~~ Name plate data, Power = 44W, p.f = 0.387

Line volt 41.5V Line current 1.6A Speed 1365 rpm

motor components

Components	nuts	bolts	washer
End Head (1)	4	4	4
Bearing			
Fan			
Rotor			
Stator			
Terminal box	4	4	4
End Head (2)	4	4	4
Bearing			
Protection cover band		4	4

- Put witness mark | Take out end bell
- Take out screw
- Pull out rotor | remove bearing



Shaft rotate freely

Yes

Insulation Resistance

Test voltage = 500V IR Tester

$U_1 - E - \infty$ $V_1 - E - \infty$ $W_1 - E\infty$ $U_1 - V_1 \infty$ $U_1 - W_1 \infty$ $V_1 W_1 \infty$

Winding Resistance $U_1 - U_2 = 6.3\Omega$ $V_1 - V_2 = 6.3\Omega$ $W_1 - W_2 = 6.3\Omega$

1/ minimum Insulation Resistance that should be measured between a phase winding and earth. 1MΩ

2/ ~~Yes~~ The motor was ready to be placed in a ~~the~~ active service

Earth Resistance

IR Tester 500V 0 Ω

- De energize, logout tag out,
- Remove electrical connection
- Remove fan cover
- Remove fan impeller
- Put witness mark between cover and motor body
- Check bearing,
- Remove rear shield
- Pull ~~a~~ out rotor together with front shield
- Remove the plug from terminal box
- Unscrew the bolts on the cover
- Remove the cover
- Stator winding leads are placed under it
- Check conclusion, clean, ring with multimeter
- Measure the resistance of body.

(3.2) No load $P = \frac{U_1^2 - U_2^2 - U_3^2}{2R} = \frac{24.46^2 - 0.312^2 - 24.33^2}{2 \times 1} \times 3 = 9.36$ watt

Output power = 0 NAMEPLATE 0.321

$pf = \frac{9.36}{1.7321 \times 42 \times 0.312} = 0.409$

No load efficiency Iron/fri loss $= \frac{9.36 - 7.45}{9.36} \times 100 = 20.4\%$

motor losses = 7.45 (W/F) + 1.91 (Cu) = 9.36W

(0.1) $P_{in} = \frac{24.46^2 - 0.524^2 - 24.01^2}{2 \times 1} \times 3 = 27.97W$

$27.97 - 7.45 - 3(0.524)^2 \times 6.3 = 15.39$ / O/P

$pf = \frac{27.97}{\sqrt{3} \times 42 \times 0.524} = 0.733$

$\eta = \frac{15.39}{27.97} \times 100 = 55\%$

losses = Wf loss + copper loss = 7.45 + 5.189 = 12.63W

(0.3) $P_{in} = \frac{24.46^2 - 0.532^2 - 24.07^2}{2 \times 1} \times 3 = 27.955W$

$O/P = 27.955 - 5.349 - 7.45 = 15.21W$

$pf = \frac{27.955}{1.7321 \times 42 \times 0.532} = 0.722$ | $\eta = \frac{15.21}{27.955} \times 100 = 54.4\%$

W/F loss = 7.45W copper loss = 5.34W

Total = 12.84W

(0.6) $P_{IN} = \frac{24.40^2 - 0.439^2 - 24.07^2}{2 \times 1} \times 3 = 28.02$

$P_{out} = 28.02 - 7.45 - 16.11 = 11.97W$

$pf = \frac{28.02}{1.732 \times 42 \times 0.439} = 0.727$

$\eta = \frac{16.11}{28.02} \times 100 = 57.49\%$

- The efficiency is changing depending on load
- The power factor is changing depending on load
- when the load is increased, the current is increased, varied and the speed is decreasing

output power is increasing when torque is increased the speed is decreasing

- when constant loss and variance losses are equal the motor will have maximum efficiency
- ~~The~~ Locked rotor ~~loss~~ Torque

That torque that stops the motor

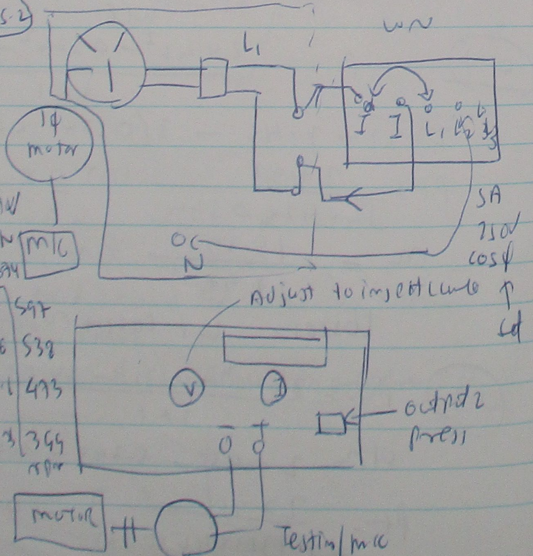
Types of losses - W F loss copper loss (~~at~~ stator wdg) rotor wdg copper loss

- motor is rotation and the rotating magnetic field will develop more circulation current in motor core causing ~~hyster~~ loss (concurrently with practical 5.2)

4.3 1ϕ 24W L1

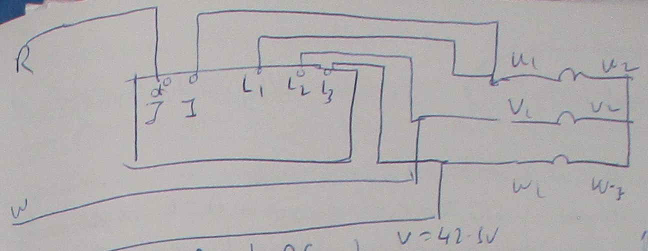
2.

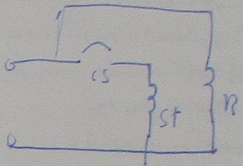
	48W - 0.29A		cosϕ		
	0 - 0.93A		0.72		
12V	0.4W	0.92	0.8	21.7W 136.64	1N
15V	0.2W	0.93	0.82	123	1394
17.43	0.3W	0.93	0.24	127.5	597
19.39	0.34	0.94	0.25	191.96	538
20.8	~~0.46~~ 0.4	0.46	0.26	198.1	493
23.41	0.5W	0.98	0.29	209.3	349 rpm



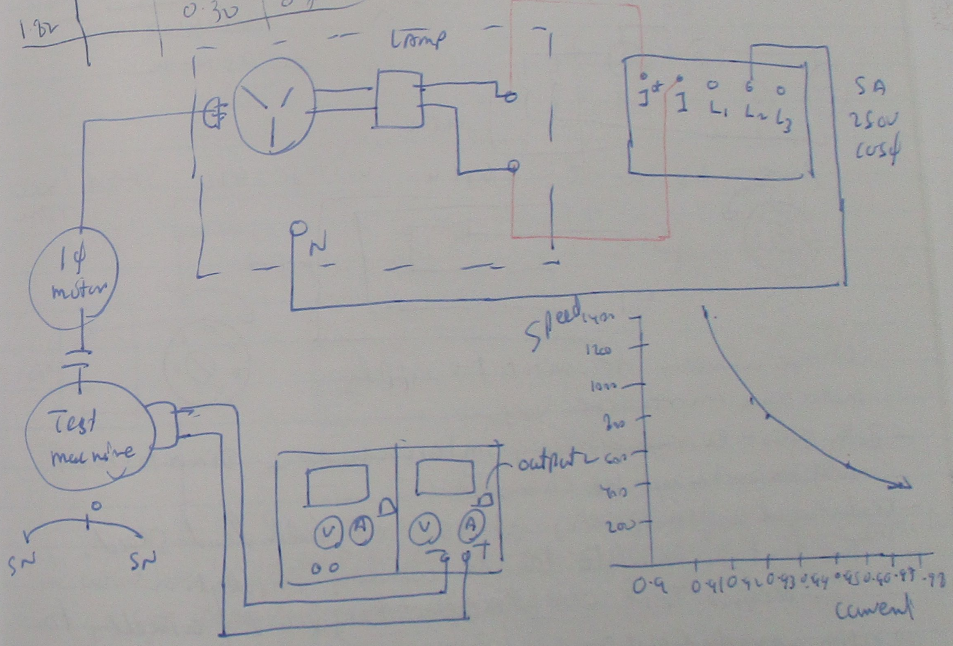
T = P = 2πNT / 60

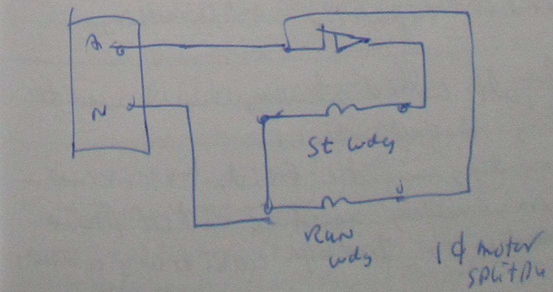
N = P×60 / 2π×T





V	T	A	PF
		0.41	0.76
10V	1	0.41	
0.53V	9	0.39	0.72
0.71		0.32	0.7
1.82		0.30	0.7





S.1 capacitor start motor

Concurrently with practical S.3

√1 Earth resistance IR tester 500V on

2 Insulation resistance IR tester 500V A-E ∞Ω N-E ∞Ω

X3 winding resistance – multimeter, ohm range | start wdg / Run wdg } 2.6Ω

Shaft rotate freely – yes

name plate

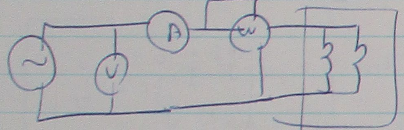
√4 power = 0.037kW PF 0.92 Voltage 420 / 115V

current = 5.33A Efficiency – pole = 4 Speed 1400 rpm

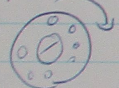
√5

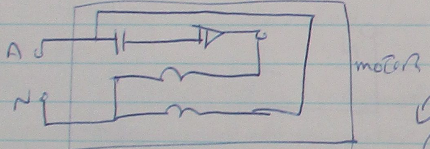
X6 $P_{out} = \frac{2\pi n T}{60}$, $T = \frac{P_{out} \times 60}{2\pi n} = \frac{37 \times 60}{2 \times 3.1416 \times 1400}$

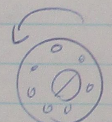
$= 0.25 N\text{-}m$

X7 

Power = 38.5W I = 1.691 A Voltage = 420 Speed 1400 rpm

√ 



√ 

√10 Change winding, reconnect the supply

√ motor run in reverse yes.

- Both start & run winding interchanged – Direction of rotation will not be changed.
- Centrifugal switch operates at 75% of full load speed.
- The test to indicate damaged winding insulation
  - megger test on winding to ground / winding to winding.

Rotating magnetic field produced in capacitor start motor

- The auxiliary ~~w~~ coil, also called starting coil is used to create an initial rotating magnetic field

In order to create a rotating magnetic field, the current flowing through the main winding must be out of phase in respect to the current flowing through auxiliary winding

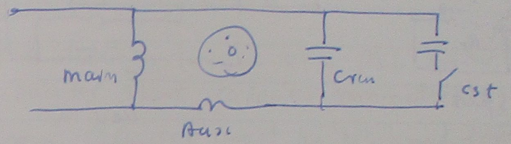
The capacitor effect produces 90° out of phase current,

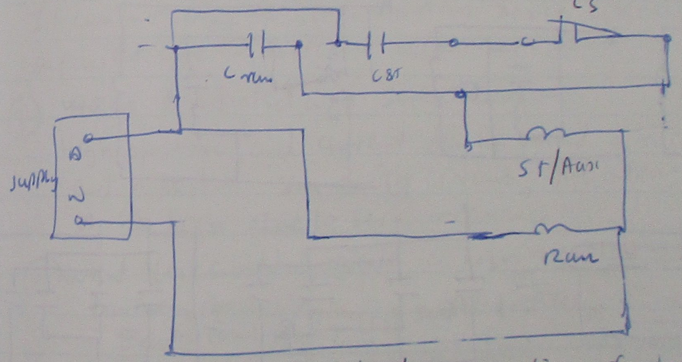
- 3 Applications of a capacitor start motor
- Refrigerator compressor / pump / conveyer,

Distinguish a capacitor start motor from a split phase motor by looking at it. 2

- The auxiliary winding of a permanent split phase motor has a capacitor in series with it during starting and running. A capacitor start induction motor only has a capacitor in series with the auxiliary winding during starting. N

S.3 capacitor start / capacitor run motor



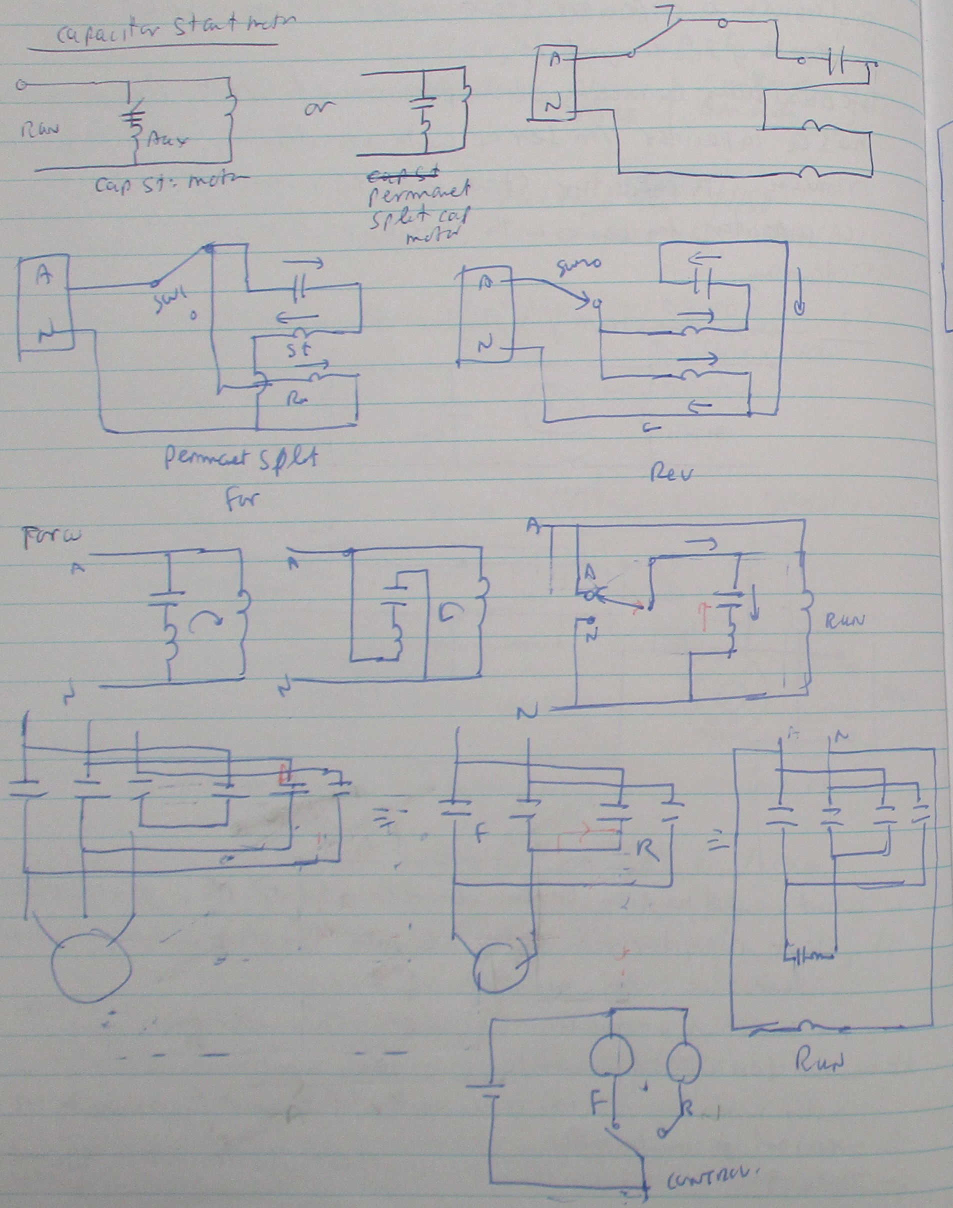


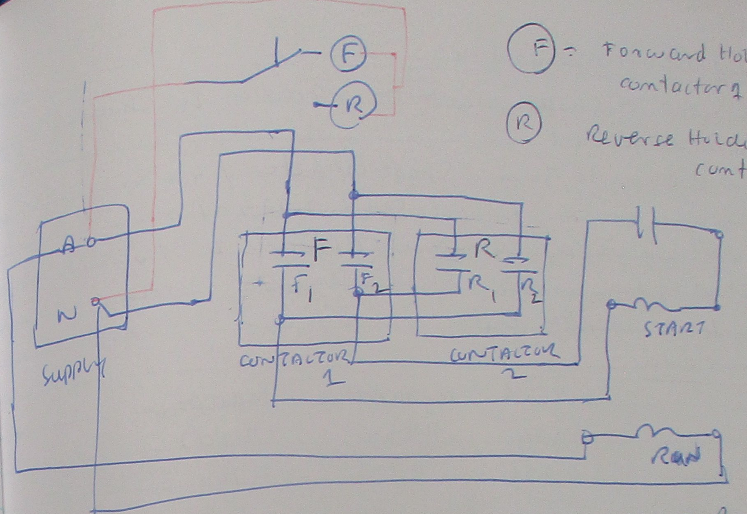
- What would happen to the direction of rotation for a capacitor start, capacitor run motor if both the start and run winding leads are interchanged?
  - Direction of rotation will not be changed
- What test would indicate a broken winding conductor?

  motor winding resistance is infinity by measuring with IR tester or multimeter
- Type of motor used in capacitor start / capacitor run motor – Squirrel cage
- 3 applications of capacitor start / capacitor run motor
- Refrigerator compressor / pump / conveyer.

5.2 Permanently split capacitor (PSC) motor connection
concurrently do with practical 4.3

Capacitor start motor





(F) = Forward Holding coil contactor 1 F1 F2

(R) Reverse Holding coil contactor 2 R1 R2

F - Forward

R - Reverse

① why the starting torque of a PSC motor is less than that of capacitor start capacitor run motor

In PSC The run capacitor must be designed for continuous use. It cannot provide the starting boost like as starting capacitor due to different capacitance value.

② Risks associated with series resonance.
High voltage and current can be found across inductor and capacitor. In motor circuit, the motor terminal voltage can be high due to series resonance.

③ What test would indicate a high resistence on protective earthing conductor.)
Earth continuity test with IR Tester

④ Two applications of PSC motor
– Fans, blowers, heaters, Airconditioner.

⑤ main difference between a capacitor start motor & PSC motor
Both motors have 2 windings but PSC motor has a single capacitor permanently connected.
capacitor start motor has the capacitor during the starting time that is switched off around 75% of speed by centrifugal switch.

5.4 Shaded pole motor connection

view video of shaded pole motor operation & shaded pole motor data sheet

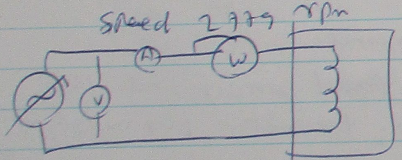
Dimension ϕ 45.0 70.3mm Shaft diameter ϕ 4.0mm
voltage 230V ac 50Hz No load speed 2779 rpm
No load current = 0.096A, Nominal o/p power = 2.33W
~~Sta~~ Starting torque = 5.87 mN·m Life 3000hr
weight 400g operating Temp = −10 to 50°C

performance data

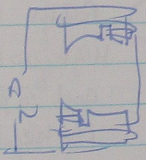
	no load	max eff	max pow
~~Speed~~ Speed	2779	2339	2107
current A	0.096	0.105	0.109
Torque (mN·m)		9.11	10.79
Effcy		17.4	14.50
power (w)		2.23	2.33

Name plate Detail 2.33W (power) pf = 0.1
voltage = 230V current 0.096A , effcy 17.4 No of pole 2
speed 2779 rpm

Load characteristics



motor power = 2.23W
current = 0.105A
voltage = 230V
speed = 2339 rpm



Shaded pole motor

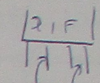
Starting torque production

A shaded pole motor is a single phase induction motor provided with an auxiliary short circuited winding displaced in magnetic position from the main winding. ~~The au~~ This auxiliary winding (called shading coil) produced the magnetic field which consists of two phase displaced fields which turn the motor shaft to rotate.

Disadvantage — very small starting torque, low efficiency
Advantage — Suitable for small devices which require low starting torque
Applications — ~~Rel~~ Relays, Hair dryers, Table fan

6.2 Universal motor connection

Loon milwaukee fuel Hand held grinder
✓ M18 FAG 125XPD code 4626 92011 8890202,
18V n = 8500 min of max 125mm , Find data sheet of milwaukee grinder
DISC size = 125mm
Spindle Ø3/8 M18 R = 10.2kΩ



Grinders = 1020W
9–12 min run time 1300 watt on 12Amp
Online Research.
view milwaukee m18 cord wattage testing video
drill 850W | O/P 132.2W
blower 422W drill 380W
Saw = 794W cutter – 420W

Angle Grinder power = 153W
voltage = 18V
current = 8.5A

Angle ~~Gri~~ cutter / grinder 153W ✓

$I = \frac{153}{18V} = 8.5A$

$R = \frac{18}{8.5} = 2.11\Omega$

— MILWAUKEE FUEL Hand held Grinder simulation video + Data sheet + Tools in workshop (name plate)

Earth Resistance
IR tester 500V 0 ~~∞~~ Ω

Insulation Resistance A-E N-E
IR Tester 500V ∞Ω ∞Ω

Winding Resistance
calculation from Data

voltage = 18V
current = 8.5A

power = 153W
$current = \frac{power}{voltage} = \frac{153}{18} = 8.5A$

Shaft freely – Yes

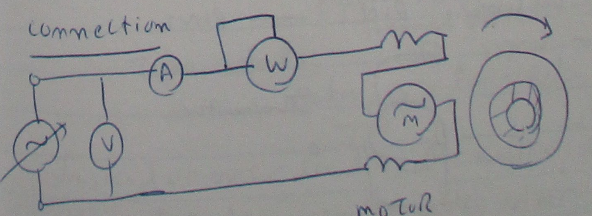
$Resistance = \frac{voltage}{current} = \frac{18}{8.5} = 2.11\Omega$

Name Plate Details

power = 153W. Power factor — , voltage = 18V dc , current = 8.5A
Efficiency = — No of poles = 2 speed = 8500 rpm

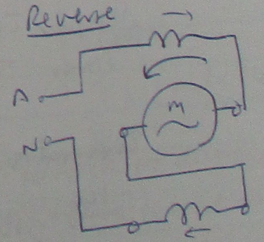
$P_{out} = \frac{2\pi nT}{60} \longrightarrow T = \frac{P_{out} \times 60}{2\pi n} = \frac{153 \times 60}{2 \times 3.1416 \times 8500} = 0.123$ N·m

Connection



power = 153W
current = 8.5A
voltage = 18Vdc
speed = 8500 rpm

Reverse



① List the main components that make up a universal motor
frame and stator.
- A universal motor consists of a stator on which the field poles are mounted. Field coils are wound around the field poles. The rotary armature has straight or skewed slots and a commutator with brushes resting on it.

② What is the purpose of the commutator in universal motor
The commutator is used to reverse the direction of the current flow in the armature windings as the rotor rotates.

③ What is the purpose of the brushes in a universal motor?
The brush conducts electrical current between the stationary wires (stator) and the rotating wire (rotor) of motor.

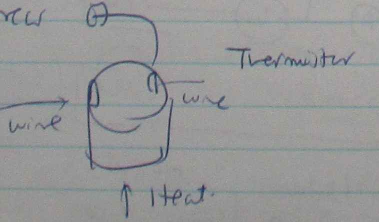
④ What is the purpose of the bearings in a universal motor?
To support and locate the rotor, to keep the air gap small and consistent and transfer the loads from the shaft to the motor.

⑤ Applications: Table fans, Hair dryers, Grinder, portable drill machines.

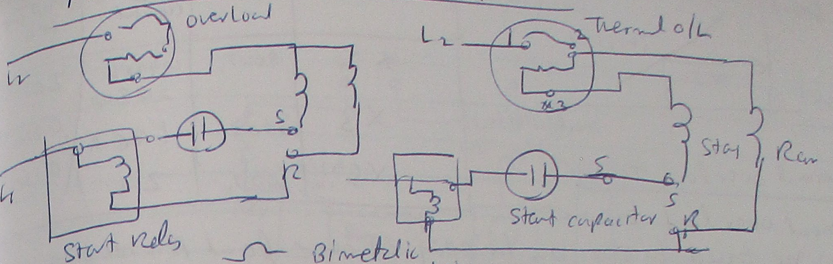
⑥ Torque production in universal motor.
The windings are connected in series ~~with the~~ in universal motors and the DC (or) AC is supplied, As a result, magnetic fields develop around the armature and field winding. The reaction between series magnetic and armature fields forcefully forms unidirectional torque and causes the shaft to rotate.

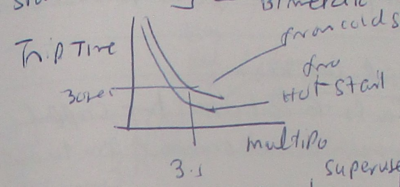
Higher Temp - un screw PIN 1 —— PIN 2
lower Temp - Screw

Temp rating
146



7.2.1 Motor Thermal overload Protection

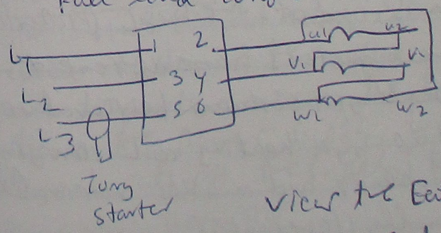




multiple = 3.5
Trip time 30sec

	Supervise	Risk	Control
Exposed Terminals	D	H	Test terminals before touching, cover terminals
Wrong voltage applied to starter	A	m	only 42V 3Ø is applied
Electrical current leak to body	B	m	Test motor insulation resistance
Wrong connection / Phase out Line to Line fault	A	m	correctly do the connection

Name plate Detail
Power 44W, Power factor 0.387, Line voltage = 415V
Line current 1.6A, speed 1365 rpm, Insulation class F
Full load Torque 0.3 N-m.



use Y Δ starter fault mode to simulate DOL starter

Note motor current 0.42A

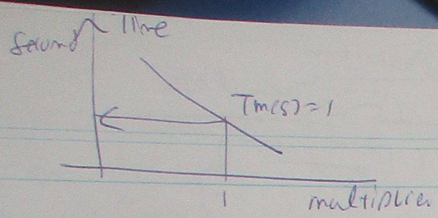
View the Eaton Thermal load setting video

Follow Red Arrow
Thermal overload ZCC

Type details
Eaton over load Relay

Setting
3.5 (multiple
30 second)

Instead of over loading the motor, due to risk of damage view the demonstration video view Eaton time current curve Page 24



t = multiplier	LOAD	Line current	Trip Time sec
X 2	200%	0.42x2 = 0.84A	2 sec
X3	300%	1.26 A	0.3sec
X5	500%	2.1	0.1sec

Thermal overload toolar

- without overload the motor will be forced to stop by trippin of overload protection device at normal curret.
- Thermal overload device is set too high
  The overload protection device fails to cut off the supply causing continuous flowing of overload current in to motor and motor will be burnt out.

Two scenarios ~~are~~ can result in a motor becoming overload
- mechanical overload. – motor shaft is carrying too much mechanical load beyond its capacity
- Electrical overload – fluctuation voltage, under voltage causing motor to draw more current to carry the load

Risks to a motor during an extended overload condition
- Failure of motor insulation
- Turn to turn short / phase to phase short circuits
- Burning out of supply wires to motor.

operating principle of Thermal overload

The coefficient of expansion is one of the basic properties of any material. Two different metals have different linear expansion causing bending at certain temperature. When a bimetallic strip is heated up by a heating coil carrying over current of the system, it bends and makes normally open contacts /or/ open normally close contact.

AS3000/2018

motors are protected against over load and over temperature AS3000 clause 4.13.2 and 4.13.3

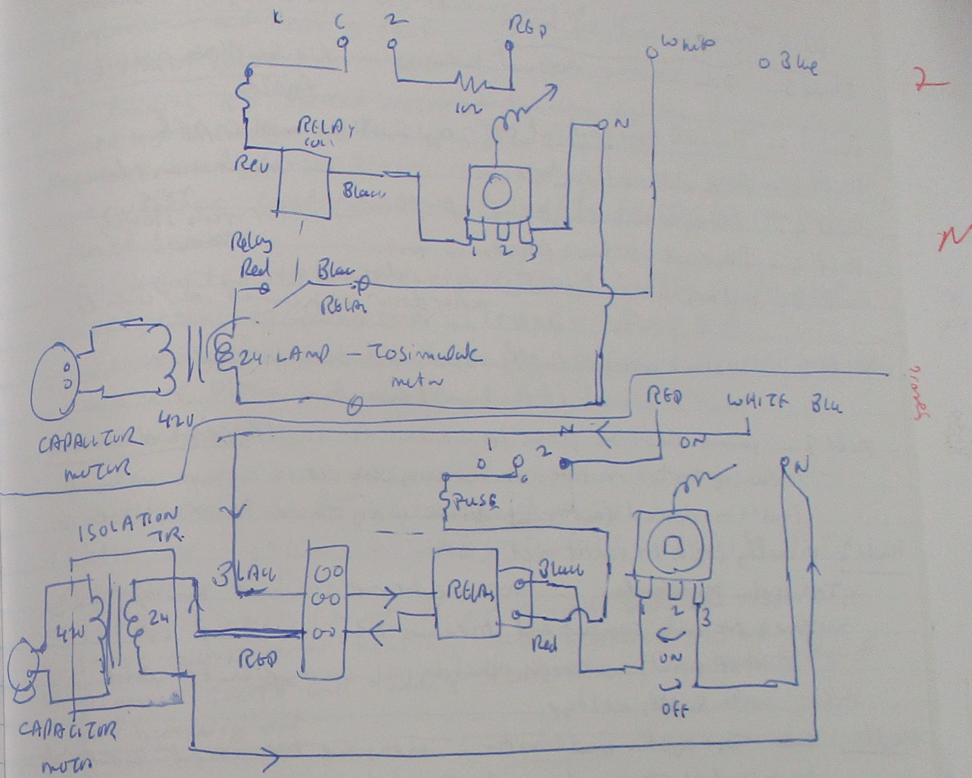
XX Exposed terminal 2 H Test terminal before touching cover terminal

wrong voltage applied to starter 4 m only 42V 3φ is applied

Electrical current leak to body 3 m Test motor insulation resistance

wrong connection phase out L-L fault 4 m correctly do the connection

7.2.2 motor Thermister Protection



- Energize the motor
  motor control circuit relay is energized when temperature is not the value of setting of thermostat. motor runs
  when temperature reaches the thermistor setting value, thermostat cuts off the power supply to control ~~the~~ circuit relay coil.
  relay coil cuts off the supply to motor. motor stops

open circuit Thermister

Relay circuit is cuts off. Relay coil de-energized. motor stop.

Thermister relay vs bimetallic type thermal overload

Thermister relays can accurately control the motor energizing ~~circuit~~ control circuit without needing ~~to~~ motor overload.

Disadvantage of using Thermister relays

when power supply to energizing circuit is unavailable (or) failure of energizing circuit, motor operation can also ~~be~~ disturbed.

PTC rather than NTC when temp rises, PTC cuts off the supply which is more relevant to motor operation as motor is overloaded, temp rises.

44 watt, 41.5V, 1365 rpm
42V control circuit, motor starter

10.3 Troubleshoot 3ϕ motor

/1 Fault 1 - DOL Starter does not energise - No Switching on of supply

Fault 2 - Thermal overload cut off - No switch on of supply

2 Fault 3 - Phase out of one phase - motor runs slowly noise

X 3 Fault 4 - reverse polarity of one ~~ϕ~~ phase - motor runs slowly noise

Fault 5 - Phase out of two phases - motor doesnot run

/4 Fault 6 - motor shaft is locked and jamed - motor draw high current, do overload

✓5 Fault 7. Neutral wire of supply is out and over voltage in phase occurs - it can burn the motor

X6 Fault 8 - ~~Revd~~ Reverse phase sequence in supply connection causing motor rotates in wrong direction.

X7 Fault 9 - Ground fault - measure windg to earth resistance.

Fault 1 visually check the operation of starter.

✓ - Test eqpt - multimeter, - measure the resistance ~~of~~ energising at press ~~the cont~~ contact and measure the resistance of contact points. , check holding coil voltage & compare

✓ - ch with supply voltage.

✓1 Fault 2 ~~mea~~ Test eqpt - multimeter - measure the input & output terminal of Thermal overload connection

✓1 Fault 4 - disengage motor shaft from load - Alternatively reverse the connection of phases & see the direction of rotation of motor. repeat the step until motor runs smoothly & in the right direction

/ Fault 5 measure motor ~~ter term~~ phase to N voltage at motor terminal. Reconnect the missing phase

Fault 6 check the load of motor. Rotate motor shaft by hand

Fault 7 measure supply voltage. check Neutral connection at the switchboard / Circuit meter

Fault 8 Sequence meter - check the supply phase sequence. use megger to measure motor insulation resistance.

Fault 3 Phase out of one phase in 3ϕ motor, supply fuse blown out motor draws higher current, slowly running

measure supply voltage at each phase | Inspect the fuse fuse blown out / replace.

Different types of faults in 3ϕ motor & control

- overcurrent, over voltage, undercurrent, under voltage, temperature and bearing fault.

- Location of fault

over loading and locked rotor at loading system ground fault caused by insulation failure of motor winding phase reversal, single phasing caused ~~at~~ at supply terminal over voltage, under voltage at supply system to control panel to motor

- It is important to check the condition of supply voltage at supply side regarding over vol~~tage~~ tage or phase out.

- Load side of circuit components need to be checked ~~regarding~~ loose or blown out ~~fault~~ fuse at the load side.

mechanical faults

- Broken rotor bar or cracked rotor end ring causing vibration and malfunctioning of motor

- Static or dynamic airgap irregularities causing unstable operation of motor

- Bent shaft which can result in a rub between rotor and stator causing over heating and burning out of motor

- Jammed shaft and heavy load causing motor overload and burning out.

10.4 Troubleshoot 1ϕ motor

Split phase motor faulty scenario 1

0.18kW 240V, 4 poles, 1400 rpm S.32Ω

control - C3. On/off switch

- View video provided by trainer. "centrifugal switch not working"

Take out end plate (Hand Tool),

check centrifugal switch (commutator) | check contact.

centrifugal switch does not open properly causing start winding over heating (location - at centrifugal switch | Adjust centrifugal switch contact

Split phase motor faulty scenario 2

0.18kW 240V, 4 poles, 1400 rpm

circuit breaker, on/off switch.

View video provided by trainer.

motor winding ground fault.

Test insulation resistence between motor winding and enclosure body. | Megger 500V | low insulation resistence indicates ground fault.

Test insulation resistence between motor winding and enclosure/body Megger 500V, low insulation resistence indicates ground fault.
- motor insulation broken causing electrical leakage
  Location - motor winding. Repair the winding.

Capacitor start motor Faulty Scenario 1

0.37kw, 42V, 1400rpm | control - circuit breaker
view the video. Faulty capacitor.
- Disconnect the supply (Hand Tool), Disengage the motor from load | open the cover (Hand Tools), Take out capacitor / measure capacitance value (capacitance meter) - correct capacitance value.
- measure motor winding resistence | ohmmeter / low resistence
- capacitor faults. motor terminal box.
  Replace with the same type of capacitor with equivalent capacitance value.

Capacitor start motor Faulty Scenario 2

~~0.37kw~~, 42V, 1400rpm
circuit breaker, view the video
centrifugal switch doesnot open properly causing start winding over heat, Location centrifugal switch.
Adjust centrifugal switch contacts.

~~0.37kw~~, Permanently split capacitor motor - Faulty scenario 1

0.37kw, 42V, 1400rpm, circuit breaker video
capacitor value is too small
- Disconnect the supply (Hand Tool), Disengage the motor from load (Hand Tool), open the cover (Hand Tool), Take out the capacitor (measure the capacitance value) (capacitance meter, capacitance value is ~~too~~ too small.
- small capacitance value causing no enough torque.
Location - capacitor.
Replace the capacitor with correct value as described on its name plate.

Permanently split capacitor motor - Faulty scenario 2

0.37kw, 42V, 1400rpm
circuit breaker, view the video, Testing & rewinding.
one winding of motor is burnt out.
- Disconnect the supply (Hand Tool)
- Disengage the motor from load (Hand Tool)
- open the ~~cot~~ cover (Hand Tool), measure winding resistence (ohmmeter) winding resistence must be the value expressed in manual.
- Inspect the motor winding (visual)
- one winding of motor is burnt out | In motor winding / Test, inspect, confirm and hand it to motor winder.

Capacitor start / capacitor Run motor / Faulty scenario 1

0.37kw, 42V, 1400rpm circuit breaker.
- previous video of capacitor start motor faulty scenario 1
* Faulty start capacitor
- Disconnect the supply (Hand Tool), Disengage motor from load (Hand Tool), Take out capacitor (Hand Tool)
- measure capacitance value | capacitance meter | capacitor in terminal box of motor. Replace the capacitor.

Capacitor start, capacitor run motor - Faulty scenario 2

5.5hp, 230V | control circuit breaker
view the video.
Description - old and torn components.
- Dismantle the motor (Hand Tool), Test and check the components (visual / ohmmeter), Bring the replacement component (Hand Tool)
Assemble the motor (Hand Tool).
Test run the motor (voltmeter / Ammeter) (voltage and current value)
- overall check, ~~or~~ find the damage, torn components.
The whole motor | Replace the torn components.

Universal motor - (Faulty scenario 1)

153W, 12V, 8500rpm
Hand button, view universal motor repair video 2
Wornout bearing