

**МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ЧЕРНІВЕЦЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
ІМЕНІ ЮРІЯ ФЕДЬКОВИЧА**

**Навчально-науковий інститут фізико-технічних та комп'ютерних наук
кафедра електроніки і енергетики**

**Розрахунок сонячної електростанції 11 МВт
(Асуан, Єгипет)**

Кваліфікаційний проект

Рівень вищої освіти - перший (бакалаврський)

Виконав:

студент 4 курсу, 433 і групи
спеціальності 141 – Електроенергетика,
електротехніка та електромеханіка
Елбаз Ахмед Хамед Хамед Хамед

Керівник:

доктор фізико-математичних наук,
проф. **Майструк Едуард Васильович**

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YURIY FEDKOVYCH CHERNIVTSI NATIONAL UNIVERSITY**

**Educational and scientific institute of physical, technical and computer sciences
department of electronics and power engineering**

Explanatory note

For Bachelor degree project

**Theme: 11 MW solar power plant calculation
(Aswan, Egypt)**

Student

4 year, 433igroup

Programme Subject Area: 141 - Electroenergetics,
electrical engineering and electromechanics

Ahmed Hamed Hamed Hamed Elbaz

Scientific adviser:

Dr, professor **Mastruk E.**

Анотація

У кваліфікаційному проєкті представлені результати розрахунку сонячної електростанції потужністю 11 МВт, розташованої в Асуані в Єгипті. Вибираються сонячні батареї, інвертори, трансформатори, вимикачі, трансформатори струму та вимірювальні трансформатори напруги, кабелі та шини, релейний захист та вимикачі. Спроектowana однолінійна схема.

Проект написаний англійською мовою і містить: 46 сторінок, 21 рисунок, 20 таблиць, 19 посилань та 1 аркуш графічної частини формату А3.

Ключові слова: сонячна енергетика, електростанція, трансформатори, вимикачі, релейний захист, запобіжники.

Annotation

The qualification project presents the results of the calculation of a 11 MW solar power plant located on Aswan in Egypt. Solar panels, inverters, transformers, switches, current transformers and voltage measuring transformers, cables and buses, relay protection and breakers are selected. A single-line circuit is designed.

The project is written in English and contains: 46 pages, 21 figures, 20 tables, 19 references and 1 sheet of A3 graphic part.

Keywords: solar power, power plant, transformers, circuit breakers, relay protection, fuses.

Кваліфікаційний проєкт містить результати власних досліджень. Використання ідей, результатів і текстів наукових досліджень інших авторів мають посилання на відповідне джерело.

_____ Елбаз Ахмед Хамед Хамед Хамед

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INTRODUCTION

Over the past 50 years global warming has affected the world in undeniable way, the average global temperature has increased at the fastest rate recorded in history. In fact NASA experts has stated that all but one of the 16 hottest years in the recorded 134-year have accrued since 2000. Global warming occurs when *CO2* and other green house gases collected in the atmosphere absorbs sunlight and solar energy reflected from earth surface. Normally, this radiation should escape into the space , but the pollutants caused by burning fossil fuels and industrial wastes prevent the heat to escape earth's atmosphere and trap it down causing severe damage to the environment, that's known as the greenhouse effect.

As engineers, we have to play an enormous role in solving the universe Problems. We are clearly affected by the harmful impacts on the environment and

Random usage of energy source.

We must strive to expand the use of clean energysource, renewable sources, to Generate a clean and continuous source of Energy.

CHAPTER 1. THEORETICAL PART

1.1 Renewable Energy

Renewable energy is energy produced from sources like the sun and wind that are naturally replenished and do not run out. Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation. Non-renewable energy, in contrast, comes from finite sources that could get used up, such as fossil fuels like coal and oil.

The major types or sources of renewable energy are:

- [Solar energy](#) from the sun
- [Geothermal energy](#) from heat inside the earth
- [Wind energy](#)
- [Biomass](#) from plants
- [Hydropower](#) from flowing water

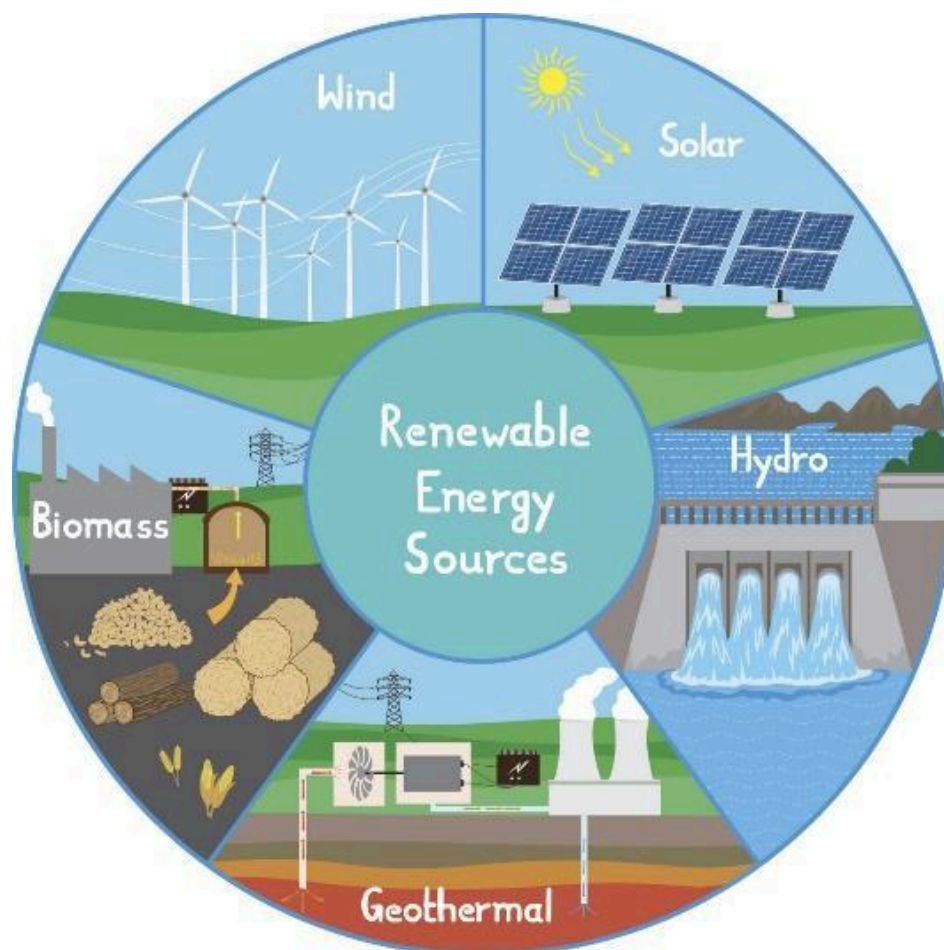


Figure.1.1 renewable energy sources



Figure.1.4 Photovoltaic solar power plant

Photovoltaic technology:

PV is the most common form used to generate electrical power from solar energy; PV Technology becomes a several billions dollar industry worldwide due to the late concerns of the rising levels of global warming, and as the fossil fuel running out crises causing its price to increase rapidly which led to regional and international conflicts.

PV system is commonly mounted on top of buildings or in unshaded sunny space where each cell converts the light of the sun into electrical energy, which can then be used to power buildings with electrical power. Solar Cell often made from semiconductors material such as silicon or germanium that produces energy via the photovoltaic effect.

1.4 Solar Thermal Energy

Known as Concentrated Solar Power (CSP).

· Look similar to photovoltaic PV cells; but they work differently.

CSP cells draw in a concentrated beam of sunlight, reflecting it through a system of mirrors causing heat generation that in turn heats water causing steam that activates a turbine to produce electricity through a conventional generator. Where PV produces energy from light, CSP produces energy from heat.



Figure.1.5 Concentrated Solar Power plant

1.5 Solar power in Egypt

Egypt is geographically located between latitudes 22 and 31.5 North, and thus Egypt is considered in the heart of the global solar belt, and thus it is considered one of the richest countries in the world with solar energy.

In Egypt, there is one of the largest solar power stations in the world (Benban solar park) is located in the city of Aswan and it consists of 32 power stations.

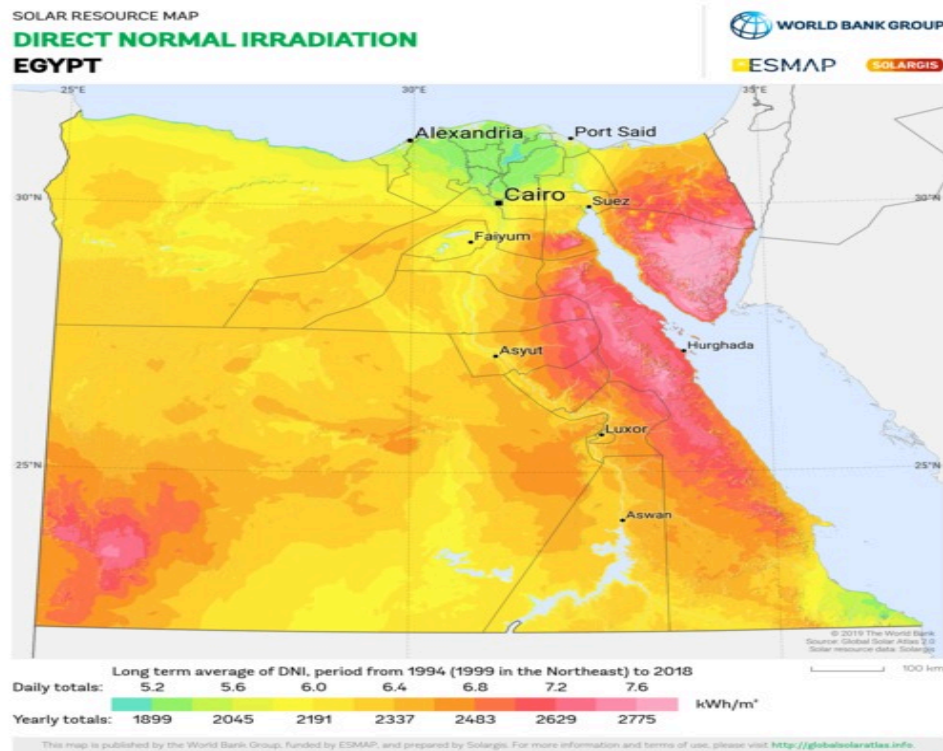


Figure.1.6 illustrative map of DNI in Egypt

· Copper indium gallium selenide (CIGS)

Solar Panel Types by Efficiency

Monocrystalline panels have an efficiency rating over 20%.

PERC panels add an extra 5% efficiency thanks to their passivation layer.

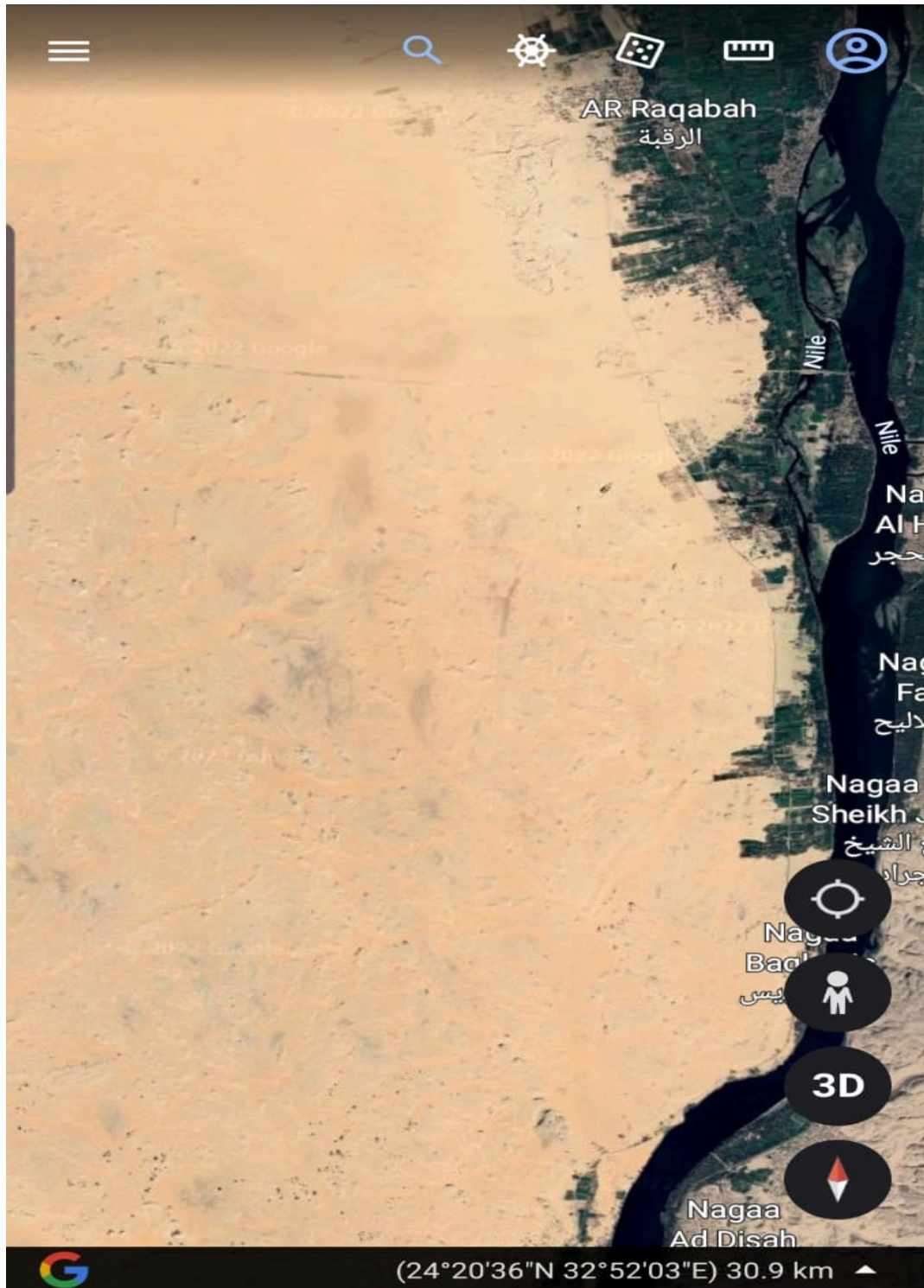
Polycrystalline panels hover somewhere between 15-17%.

CHAPTER 2. CALCULATION AND CHOICE EQUIPMENT

2.1 Determination place and it's characteristic

We decided to build our solar power station 28 km north of Aswan city.

This place is perfect to make a solar station on it due to the big amount of solar radiation that falls on the ground there, and that According to methodological data form GLOBAL SOLAR ATLAS.



Monthly averages

Direct normal irradiation

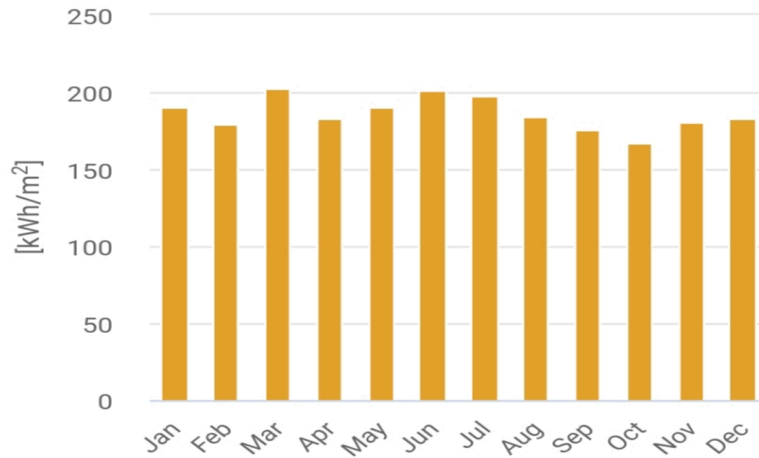


Figure.2.1 scheme of monthly DNI in Aswan

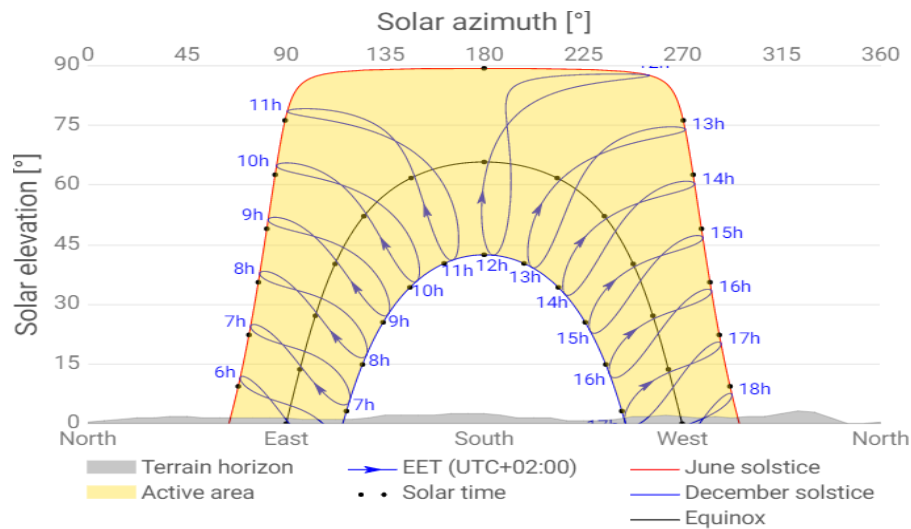


Figure.2.1 scheme of solar azimuth in Aswan

2.2 Monocrystalline panel

For this project , we chose a Monocrystalline panels with high efficiency because we have specific area.

Single-crystal panel, Cortex P3 series Bifacial 560 W

Table 2.1

Characteristic	The value of the characteristic
Model type	Monocrystalline
Maximum Power (Pmax):	560 Wp
Voltage at Maximum Power (Vmpp).In	42 V
Current at Maximum Power (Impp).In	13.35 A
Open Circuit Voltage (Voc):	50.2 V

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Short Circuit Current (Isc):	14.12 A
Panel Efficiency:	21.73 %
Panel Dimension (H/W/D) :	2274x1133x35 mm
Weight :	30.2 kg
Cell Number :	120
junction Box Protection Class :	IP 68

Next we need to determine the Number of panels that used for the plant.

Our design is 11MW on grid and to calculate number of panels we use this formula

$$\text{Number of panels} = \frac{p_t}{P_{\text{max of single panle}}} = \frac{11\text{MW}}{0.560\text{KW}} = 19642 \quad (1)$$

The installation of panels is towards the south at an angle 30°, which provides the greatest amount of solar radiation on the solar cells .

2.3 Selection and calculation of the number of inverters and their load

We use in this solar power plant a 3 phase inverter type ATO-OGI-200kW. Has such characteristics:

Table 2.2

characteristics	The value of the characteristic
Rated output power:	200kW
Rated voltage:	480V
Rated current:	417A
Frequency:	50Hz
Efficiency:	93%
Size (D*W*H)	1000*1200*1800mm



Fig.2.3 Appearance of the inverter

For inverter:

$V_{in} = 480 \text{ V}, I_{in} = 417 \text{ A}$

For panel:

$V_p = 42 \text{ V}, I_p = 13.35 \text{ A}$

Parameter list and protection for inverter.

Table2.3

Parameter List

Model		ATO-OGI-200kW
Size (D*W*H)		1000*1200*1800mm
Weight		1350kg
Certificate		CE, UL, SA, SAA, VDE
Warranty period		24 months
AC Input	Rated voltage	AC input voltage is the same value as the AC output
DC Input	Rated voltage	240V/ 300V/ 360V/ 480V/ 600V DC (can be customized)
	Rated current	417A @480V DC
AC Output	Rated output power	200kW
	Output waveform	Pure sine wave
	Rated voltage	208V/ 220V/ 230V/ 240V/ 380V/ 400V/ 415V/ 460V/ 480V (optional)
	Phase	3 phase 4 wire+PE wire (single phase/ split phase can be customized, please contact us by email)
	Rated phase current	303A @380V AC
	Frequency	50Hz or 60Hz
	Power factor	>0.99
	Overload ability	150%, 5 seconds
	Efficiency	>93%
	Waveform distortion rate	THD<3%
	Dynamic response (0 to 100% load)	5%, ≤50ms
	Display	LCD
	Running mode	Working continuously
	Electrical insulation properties	2000Vac, 1min
Communication interface	RS485 (optional), it can remote control the start/stop of the inverter and convey the data as below: 1. Input DC current 2. Input DC voltage 3. Output AC current 4. Output AC voltage 5. Power consumption (kWh) 6. Some fault information	
Protection Function	Protection	Input reverse polarity, under voltage, over-voltage, output over-current, short circuit, overheating
	Colling method	Fan-cooled
	Short-circuit protection	No automatic recovery, need to restart the machine
Working Environment	Noise (1 meter)	≤50dB
	Degree of protection	IP20 (indoor)
	Working altitude	≤2000m
	Working temperature	-25~+55°C
	Relative humidity	0~90%, non-condensing
Note	The above parameters are for reference only, can be customized according to customer's requirement!	

To determine number of panels that used in a one module, must calculate how many panels could connected in series & parallel with one inverter.

$$N_p (\text{series}) = \frac{480}{42} \approx 11$$

$$N_p (\text{parallel}) = \frac{417}{13.35} \approx 31$$

$$\text{Number of panel} = 11 \times 31 = 341$$

And to determine the power of module, must calculate voltage & current of the module.

$$V_{mod} = 11 \times 42 = 462 \text{ V}$$

$$I_{mod} = 31 \times 13.35 = 413.85 \text{ A}$$

Next we find power of the module According to the formula:

$$P = I \times V \tag{2}$$

$$P_{inv} = 462 \times 413.85 = 191.2 \text{ KW}$$

$$\text{Number of modules} = \frac{19642}{341} = 57 \text{ modules}$$

But we will use 56 modules to make this scheme have better stability and will be more uniticated.

Drawing of one module, consists of 31 lines connected in parallel and 11 panels in each line connected in series.

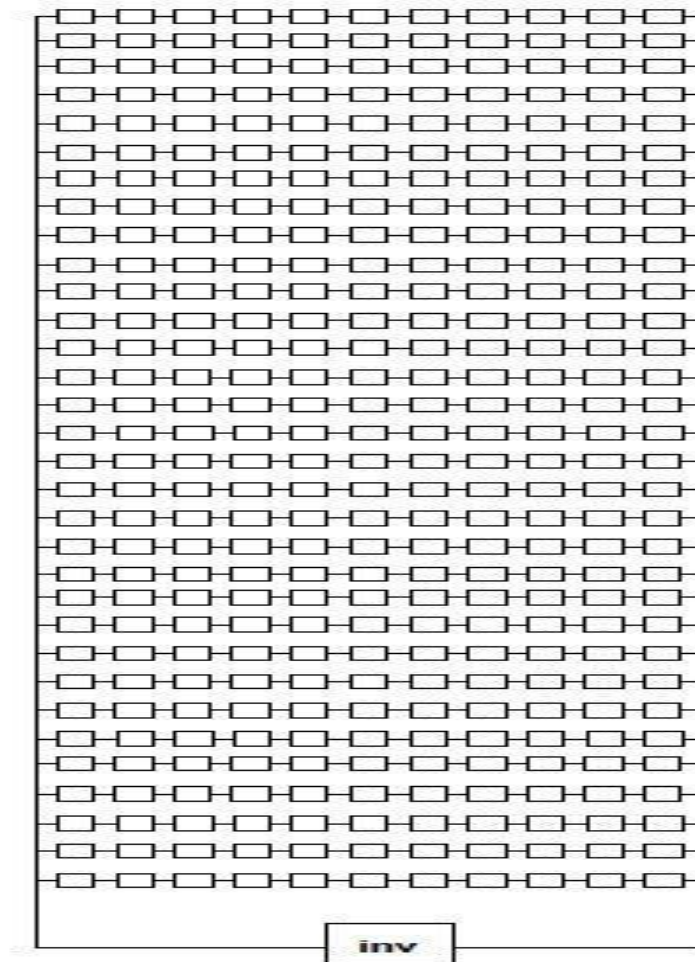


Fig.2.4 illustrative drawing of module

2.4 Selection and calculation of transformers (11/0.4)

Table 2.4

model	Rated capacity(KVA)	Connection symbol	High-voltage	Trapping range	Low-voltage	No-load loss	Load loss	No-load current	

SC10-800	800	Yyn0 or Dyn11	15 20 22	5%	0.4	1775	7910	1.2	
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Fig.2.5 SC10-800 transformer

We will connect 4 inverter (module) with one transformer and determine transformers we need

$$\text{Number of transformer} = \frac{56}{4} = 14 \text{ transformers}$$

2.5 Selection and calculation of transformer (66/11)

8 MVA 8000 KVA 66 KV oil immersed power transformer:

Table2.5

Rated Power (KVA)	High Voltage (KV)	H.V.Tap range	Low Voltage (KV)	Connection symbol	Short Circuit Impedance (%)	No-load loss(KW)	On-load loss(KW)
8000	63 66 69	±8x1.25%	6.3 6.6 10.5 11	YNd11	9	11.2	40.4



Fig.2.6 8000 KVA 66 KV power transformer

We will connect a seven transformer 11/0.4 with one big transformer 66/11, so we will need to use two transformer (66/11) at the power station we make.

2.6 Selection and calculation of cables

Cable sizing is the process of selecting appropriate sizes for electrical power cable

Conductors. Cable sizes are typically described in terms of cross-sectional area.

The proper sizing of cables is important to ensure that the cable can:

- Operate continuously under full load without being damaged
- Provide the load with a suitable voltage (and avoid excessive voltage drops)
- Withstand the worst short circuits currents flowing through the cable

To determine types of cables we need, we must calculate the flowing current between any connection in the system.

According to connection Y/Y

$$S = \sqrt{3} \times U_{LL} \times I \quad (3)$$

$I_1 = 13.35$ A, when I_1 is a flowing current in the module between panels

Selection cable:

Rated Current: 20 Amp Black Two Core Round Electric Wire 220V, Wire Size: 1.5 Mm Dia

Table2.6

Wire Size	1.5 mm Dia
Rated Current	20 Amp
Number Of Core	2
Usage/Application	Electrical Fitting
Voltage	220 v
Color	Black
Conductor Material	Copper



Fig.2.7 Black Two Core Round Electric Wire

$I_2 = 13.35 \times 31 = 413.85$ A, when I_2 is a flowing current between panels and inverter

Selection cable:

$$F_e = I / j_{ec} \text{ economically size of cabel} \quad (4)$$

$j_{ea} = 1.4$ for aluminum

$j_{ec} = 2.5$ for cupper

$$F_e = 413.85 / 2.5 = 165.54 \text{ mm}^2$$

Table2.7. RECTANGULAR SHAPED BARE COPPER BUSBARS

Size	a (mm)	b (mm)	X-Section (mm ²)*	Unit Weight (kg/m)
25x3	3	25	74	0,66
30x3	3	30	89	0,80

25x4	4	25	99	0,88
30x4	4	30	119	1,06
20x5	5	20	99	0,88
25x5	5	25	124	1,10
30x5	5	30	149	1,33
30x10	10	30	299	2,65
32x10	10	32	319	2,83
40x5	5	40	199	1,77
40x10	10	40	399	3,54
50x5	5	50	249	2,22
50x10	10	50	499	4,43
50x15	15	50	749	6,65
60x5	5	60	299	2,66
60x10	10	60	599	5,32
60x12	12	60	719	6,39
60x15	15	60	899	7,98
75x6	6	75	449	3,99
80x5	5	80	399	3,55
80x10	10	80	799	7,10
80x15	15	80	1199	10,65
80x20	20	80	1599	14,20
90x10	10	90	899	7,99
92x5	5	92	459	4,08
100x5	5	100	499	4,44
100x8	8	100	799	7,10
100x10	10	100	999	8,88
100x12	12	100	1199	10,66
100x15	15	100	1499	13,32
100x20	20	100	1999	17,76
100x30	30	100	2999	26,64
110x6	6	110	659	5,86
120x5	5	120	599	5,33

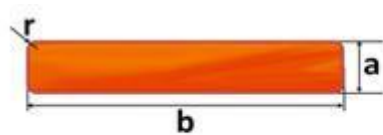
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120x10	10	120	1199	10,66
120x12	12	120	1439	12,79
120x15	15	120	1799	15,99
120x20	20	120	2399	21,32
125x10	10	125	1249	11,11
128x5	5	128	639	5,69
130x7	7	130	909	8,09
140x10	10	140	1399	12,44

ROUNDED SHAPE COPPER BARS

Delivered in diameters of Ø 8-10-12-14-15-16-18-20-22-24-26-28-30-32-34-35-36 mm and in lengths 2 - 6 m.



Rounded corner



Rounded edge

MATERIAL	Cu-OF / Cu-ETP
Cu CONTENT	min. %99.90
STANDARD	TS 435, EN 13601
CONDUCTIVITY	57 – 58 μS
TYPE	Rounded corner, rounded edge
TEMPER	Semi-hard
DELIVERY	Cut in 2 – 6 m (6.5-19 ft) lengths, on wooden pallets and PE covered acc. to customer requirements.

$$I_{3,1} = \frac{200}{0.4 \times \sqrt{3}} = 288 \text{ A}$$

Selection cable:

Hi-Flex 300 Amp 40mm² Battery / Starter / Inverter / Welding PVC Cable Wire

Single insulated battery / starter cable

Resistant to petrol, lubrication oils and diluted acids

40mm² Cable

300 Amps

12.7mm Overall Diameter of Cable



Fig.2.8 Hi-Flex 300 Amp 40mm² wire

$$I_{3,2} = \frac{800}{0.4 \times \sqrt{3}} = 1154.7 \text{ A}$$

$F_e = I/j_{ec}$ economically size of cabel

$$F_e = 1154.7 / 2.5 = 461.88 \text{ mm}^2$$

Section of cable $I_{3,2}$ determined from Tabl2.7. RECTANGULAR SHAPED BARE COPPER BUSBARS.

$$I_{4,1} = \frac{800}{11 \times \sqrt{3}} = 41.98 \text{ A}, \quad I_{4,2} = \frac{7 \times 800}{11 \times \sqrt{3}} = 293 \text{ A}$$

Selection cable:

$F_e = I/j_{ec}$ economically size of cabel

$$F_e = 41.98 / 2.5 = 16.79 \text{ mm}^2, \quad F_e = 293 / 2.5 = 117.2 \text{ mm}^2$$

6.35/11kV CU/XLPE/CTS/PVC 3C POWER CABLE

Table2.8

nominal area of conductor	maximum conductor resistance at 20 °C	thickness of xlpe insulation	thickness of copper tape	appro. overall diameter	appro. cable weight	standard packing length	drum size	appro. gross weight
Sqmm	Ohm/Km	mm	mm	mm	kg/km	Metre ±10%		KG
35	0.524	3.4	0.06	41.74	2137	500	D-16	1169
50	0.387	3.4	0.06	44.31	2582	500	D-17	1391

70	0.268	3.4	0.06	48.18	3320	500	D-22	1760
95	0.193	3.4	0.06	52.26	4206	500	D-23	2203
120	0.153	3.4	0.06	56.54	5123	500	D-24	2662
150	0.124	3.4	0.06	58.9	5940	500	D-25	3070

$$I_s = \frac{8000 \times 2}{66 \times \sqrt{3}} = 139.96 \text{ A}$$

Selection cable:

66kv High Voltage Power Cable 630mm² 500mm² 400mm²

Application:

Construction, Underground, Industrial, Power Station

Voltage:

Super-high Voltage Cable

Current:

DC Cable

Insulation Material:

XLPE

Sheath Material:

PVC

Material Shape:

Round Wire

Wire Core Material:

Bare Copper Wire

Voltage Degree:

48/66kv to 127/220kv

Section	Insulation Thickness	Metallic Sheath Thickness	Sheath Thickness	Overall Diameter	Cable Weight	Electrical Resistance
						DC.20°C
No.xmm ²	mm	mm	mm	mm	kg/km	Ω/km
48/66 kV						

1×185	14.5	2.0	4.0	68.3	5250	0.0991
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2.7 Calculate Resistivity of transformers & lines

To calculate the Resistivity of our small and big (high voltage) transformers we will use this formula:

$$X_T = \frac{U_K(\%) \cdot U_{BH}^2}{100 \cdot S_{THOM}} \quad (5)$$

$$X_{Ts} = \frac{5 \times 11000^2}{100 \times 800000} = 7.56 \text{ Ohm, this is the value Resistivity of transformers (11/0.4)}$$

$$X_{Th} = \frac{9 \times 66000^2}{100 \times 8000000} = 49 \text{ Ohm, and this is the value Resistivity of transformers(66/11)}$$

To calculate the Resistivity of lines, we should determine the length of cables and work according to formula:

$$R = \rho \frac{l}{F}, \quad r_o = \frac{\rho}{F} \quad (6)$$

When P is a constant Resistivity of cable material, and L is the length of cable and F is the cable diameter

P for copper is =0.018 Ohm

$L_1 = 300 \text{ m}, L_2 = 320 \text{ m}$

$L_{3,1} = 50 \text{ m}$

$$R_{3,1} = 0.018 \times \frac{50}{40} = 0.0225 \text{ Ohm}$$

$L_{3,2} = 485 \text{ m}$

$$R_{3,2} = 0.018 \times \frac{485}{499} = 0.0175 \text{ Ohm}$$

$L_{4,1} = 40 \text{ m}$

$$R_{4,1} = 0.018 \times \frac{40}{35} = 0.02057 \text{ Ohm}$$

$L_{4,2} = 3000 \text{ m}$

$$R_{4,2} = 0.018 \times \frac{3000}{120} = 0.45 \text{ Ohm}$$

$$L_5 = 60 \text{ km}$$

$$R_5 = 0.018 \times \frac{60000}{185} = 5.8378 \text{ Ohm}$$

2.8 Calculate of short current

We will calculate short current to help to determine the parameters of current transformer by this formula:

$$I_K^{(3)} = U_{c.H.} / \sqrt{3} \cdot z = U_{c.H.} / \sqrt{3} \cdot \sqrt{(\sum R)^2 + (\sum X)^2} \quad (7)$$

$$I_{k1} = \frac{11000}{\sqrt{3} \times (R_{4,1} + R_{4,2})} = 13496 \text{ A}$$

$$I_{k2} = \frac{66000}{\sqrt{3} \times \sqrt{(R_{4,2}^2 + X_{Th}^2)}} = 777.6 \text{ A}$$

$$I_{k3} = \frac{66000}{\sqrt{3} \times R_5} = 6527.3 \text{ A}$$

Then we will calculate I_y to help in determining the fuses by the formula:

$$I_y = I_K^{(3)} \cdot \sqrt{1 + 2(k_y - 1)^2} \quad k_y = 1, 2, \dots, 1, 3 \quad (8)$$

$$K_y = 1.25, \sqrt{1 + (2 \times 0.25^2)} = 1.06$$

$$I_y = I_k \times 1.06$$

$$I_{y1} = I_{k1} \times 1.06 = 13496 \times 1.06 = 14305.7 \text{ A}$$

$$I_{y2} = I_{k2} \times 1.06 = 777.6 \times 1.06 = 824 \text{ A}$$

$$I_{y3} = I_{k3} \times 1.06 = 6527.3 \times 1.06 = 6918.9 \text{ A}$$

2.9 Selection of current transformers

We use Current transformers to measure the current of another circuit, current transformers have a Turns Ratio which mean for example 1000 : 5, the flowing electrical current is transferred from the primary coil which is 1000 A to 5 A in the secondary coil, and that is why the current transformer is used for :

- Operate the measuring devices
- Monitor the high voltage lines
- Operate electrical protection devices

According to the parameters of I_k we have we will determine the current transformers

Bus current transformers TSHL-20

Table 2.9

Rated voltage / kV	20
Maximum operating voltage/ kV	24
Rated primary current/ A	3000, 4000, 5000, 6000, 8000, 10000, 12000 14000, 15000, 16000, 18000
Rated frequency of alternating current/ Hz	50 or 60
Number of secondary windings	2 or 3
Rated secondary current/ A	1; 5
Accuracy class: - secondary winding for measurements - secondary winding for protection	0,2; 0,2S; 0,5; 0,5S; 5P; 10P 5P; 10P
Rated secondary load at power factor $\cos = 0.8$, V • A: - secondary winding for measurements - secondary windings to protect the accuracy class 5P - secondary windings to protect the accuracy class 10P	30* 30
Nominal limiting multiplicity of secondary windings for protection, not less than: - for accuracy class 10P at rated primary currents, A: 3000 4000 5000; 6000 8000 10000; 12000; 14000; 15000; 16000; 18000 - for accuracy class 5P at rated primary currents, A: 6000; 8000; 10000 12000; 14000; 15000; 16000; 18000	13 15 16 14 12 20
Test voltage, kV:- full storm impulse - one minute industrial frequency	125 65

SDH-60 2000/5A ct current transformer High accuracy SDH Class 0.5 window type current transformer CT1

Application:

1. Current measurement, monitoring and protection for electrical wiring and equipment.

2. Current and power measurement for electric motors, lighting, air compressor, heating
3. Current, power and energy monitoring device.
4. Relay protection device.

Technical data:

Table2.10

Electrical Parameter		Mechanical Parameter	
Frequency	50/60Hz	Case	PC/UL94-V0
Rated Input	1A-5000A	Bobbin	PBT
Measuring range	5%In-120%In	Core	Silicon steel
Rated Output	1A,5A	Construction	Screw
Ratio Voltage	0.72KV (AC)	Operating Temp	-25°C~+75°C
Dielectric strength	3.0KV/1mA/1min	Operating Humidity	≤85%
Insulation Resistance	DC500V/100MΩ min	Output Connection	Terminal



SDH-60

Fig.2.9 SDH-60 2000/5A current transformer

5kV Thru 69kV Current Transformers (Outdoor)

Models JCK-3 /JCK-4

5kV to 8.7kV, 60kV to 75kV BIL 5A to 800A

DIMENSIONS

Height: 13.63”

Width: 7.88”

Length: 11.00

FREQUENCY

50-60 Hz

According to the parameter of this current transformer (single phase) we will need to use 3 of it

Table2.11

JCK-3/ JCK-4/ DATA TABLE							
Current Ratio (Amps) Pri : Sec	IEEE Accuracy Class 60 Hz Burden		Continuous Thermal Current Rating Factor	Mechanical Limit, Amps	One Second Thermal Limit, Amps	Catalog Number	
	Meter Class					JCK-3 5,000 V BIL 60 kV	JCK-4 8,700 V BIL 75 kV
	B0.1 B0.2	B0.5	@ 30°C Amb.				
Single Ratio							
5:5	0.3	0.3 ¹	3.0	3400	1900	753X051001	754X051001
10:5	0.3	0.3	3.0	3400	1900	753X051002	754X051002
15:5	0.3	0.3	3.0	5100	2850	753X051003	754X051003
20:5	0.3	0.3	3.0	6800	3825	753X051004	754X051004
25:5	0.3	0.3	3.0	8500	4775	753X051005	754X051005
30:5	0.3	0.3	3.0	10200	5725	753X051006	754X051006
40:5	0.3	0.3	3.0	13600	7650	753X051007	754X051007
50:5	0.3	0.3	3.0	17000	9550	753X051008	754X051008
75:5	0.3	0.3	3.0	21250	11775	753X051009	754X051009
100:5	0.3	0.3	3.0	34000	19125	753X051010	754X051010
150:5	0.3	0.3	3.0	42500	23575	753X051011	754X051011
200:5	0.3	0.3	3.0	56100	38250	753X051012	754X051012
300:5	0.3	0.3	3.0	85000	46750	753X051013	754X051013
400:5	0.3	2.5	2.5	85000	47600	753X051014	754X051014
600:5	0.3	2.0	2.0	85000	51000	753X051015	754X051015
800:5	0.3	1.5	1.5	85000	51000	753X051016	754X051016

Current transformer COF (25 - 170 kV)

Reliable oil-insulated top-core design current transformer for outdoor use

Applications:

- Revenue metering
- Protective relaying
- System control and indication of power flow

Table2.12

Installation	Outdoor
Design	Top coretype
Insulation	Oil-paper
Highest voltage for equipment	25 - 170 kV
Max. primary current	Up to 3,400 A
Short-circuit current	Up to 120 kA/1 sec
Insulators	Porcelain (silicon rubber optional)
Creepage distance	≥ 25 mm/kV (longer on request)
Service condition	
<ul style="list-style-type: none"> • Ambient temperature 	-40 °C to +40 °C (standard)
<ul style="list-style-type: none"> • Design altitude 	Maximum 1000 m (standard)
	*Other temperatures and altitudes are possible
Accuracy	Meets all IEEE metering and protection classes (0.3%, 0.15%, C100, C200, C400 and C800) IEC also available on request

2.10 Determining of single breakers & fuses

We use breakers to protect our system from damage caused by Overload or Overcurrent, and it is like an automatic switcher and it have parameters.

Single breaker (SB)

Module:

Miniature Circuit Breakers (MCB)

These breakers have the breaking capacity (Icu) complying with the Standard IEC 60947-2 and the energy selectivity limits refer to this Standard.

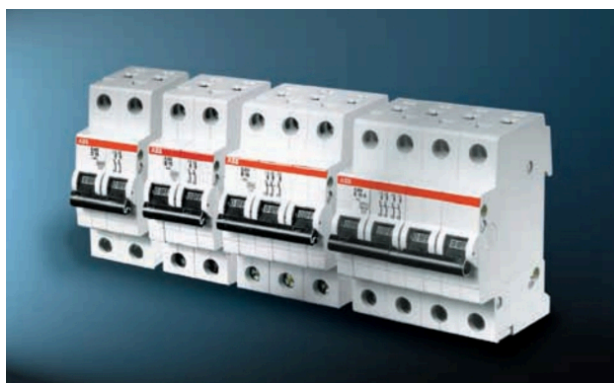


Figure.210 miniature circuit breaker(MCB)

11KV and 630A OUTDOOR 11KV Vacuum Circuit Breaker (SB1)

Table2.13

Power	11KV , 630A,20/25KA
Rated Current	630/800/1250A
No. of breaks / pole	1
Brand	BUSH ELECTROMECH,ABB VD4/VIND
Rated making current (kApeak)	65.75
Rated short time withstand current	26.3
First pole to clear factor	1.5
Opening time (MS)	40 +- 10
Closing time (MS)	60 +- 15
Reclosing time (MS)	300
Contact stroke (mm)	20
Weight (approx.) (Kg)	850
Power Freq. withstand voltage (kV RMS)	28
Impulse withstand voltage (kVpeak)	75
Rated frequency (Hz)	50
Creepage distance to earth (mm)	450
Rated normal current (A)	1250
Rated breaking current (kA)	26.3

OUTDOOR HIGH VOLTAGE VACUUM CIRCUIT BREAKER ZW32-12 (SB2)

Table2.14

Specifications

No.	Item	Unit	Data
1	Rated voltage	kV	12
2	Rated frequency	Hz	50
3	Rated current	A	630
4	Rated short-circuit opening current	kA	20
5	Rated peak withstand current(peak)	kA	50
6	Rated short-time withstand current	kA	20
7	Rated short-circuit closing current(peak)	kA	50
8	Mechanical life endurance	time	10000
9	Rated short -circuit current opening frequency	time	30
10	Power frequency withstand voltage(1 min):among phases,to ground/fracture	kV	34/42/48
11	Lighting impluse withstand voltage(peak):among phases,to ground/fracture	kV	75/85
12	Secondary loop 1 min power frequency withstand voltage	kV	2

Outdoor Sf6 Gas Circuit Breaker 66kV/132kV (SB3&SB4)

table2.15

No.	Item	Unit	Data
1	Rated voltage	KV	145
2	Rated frequency	Hz	50/60
3	Rated current	A	3150
4	1min power frequency withstand voltage	KV	265
5	Lingthning impluse withstand voltage(peak value	KV	650
6	5 min power frequency voltage at zero gas pressure	KV	109
7	Rated short circuit breaking current	KA	80...100
8	Rated out-of-phase breaking current	KA	10
9	Rated cable(line) charging breaking current(peak)	A	50
10	Rated gas pressure	MPa	0.5
11	Main loop resistance	uΩ	≤45
12	Operation sequence		O-0.3s-CO-180s-CO
13	SF6 gas leakage rate(per year)	%	≤1
14	Moisture content(V/V)	ppm	≤150
15	Across the open contacts	mm	≥3950
	Creepage distance		
	TO earth		≥3950
16	Mechanical life	times	10,000

11KV Drop out Fuse (F1)**Table2.16**

Voltage	11/22/33KV
Usage/Application	Substation and Overhead
Current Rating	200/400/600/800 amp
Fuse Type	Resettable Fuse
Color	Gray and Brown
Brand	NATIONAL
Material	Polymeric and Porcelain
Poles Description	3 Pole
Power Source	Electric
Minimum Order Quantity	01 Set

SMDPower Fuses - Outdoor Transmission (F2)

Rated nominal voltage 69 KV, Maximum current 100 A and Interrupting 50 or 60 Hz



Figure2.12 SMDPower Fuses – Outdoor

2.11 Determining of measuring voltage transformer

11KV Power Measurement Oil Type Combined Transformer

Table 2.17

Product name	Oil type combined transformer
Material	Copper + stainless steel
Color	brown
Rated voltage	3.6-12KV
Current ratio	5/5-300/5
Voltage transformation ratio	10/0.1
Accuracy Class	0.2S/0.5

Feature	Three phase three wire
---------	------------------------



Figure.2.11 Measurement Oil Type Combined Transformer

Three Epoxy Cast Resin High Voltage Potential Transformer.

Potential Transformer: 66kV

Table 2.18

Material	Epoxy Cast Resin
Phase	Three
Frequency	50 Hz
Usage/Application	Industrial
Country of Origin	Made in India
Maximum System Voltage	245 kV
Ambient Temperature	-30 To 50 Degree Celsius
Primary Rated Current	5000 A
Secondary Rated Current	10 A
Minimum Order Quantity	1

Design & Structure

- Optimized Design for Measuring
- Lean manufacturing concept applied to the whole supply chain

- External insulation with procelain or composite insulator



Figure.2.13 Epoxy Cast Resin Potential Transformer

2.12 Determining of relay protection

AM5 protection relay with overcurrent IDMT earth fault overload RS485. **Table2.19**

Auxiliary power supply	Rated input	AC/DC 220V 110V,DC48V
	Range	rated voltage*(1±20%)
	Power consumption	≤10W(DC)
Rated voltage	Rated input	AC 100V/100/(3 ^{1/2})V
	Range	1~120V
	Accuracy	±0.5%
	Power consumption	≤0.5VA(single phase)
Rated current	Rated voltage	AC 5A/1A
	Range	0.04In~15In
	Accuracy	±0.5%
	Power consumption	≤0.5VA(single phase)

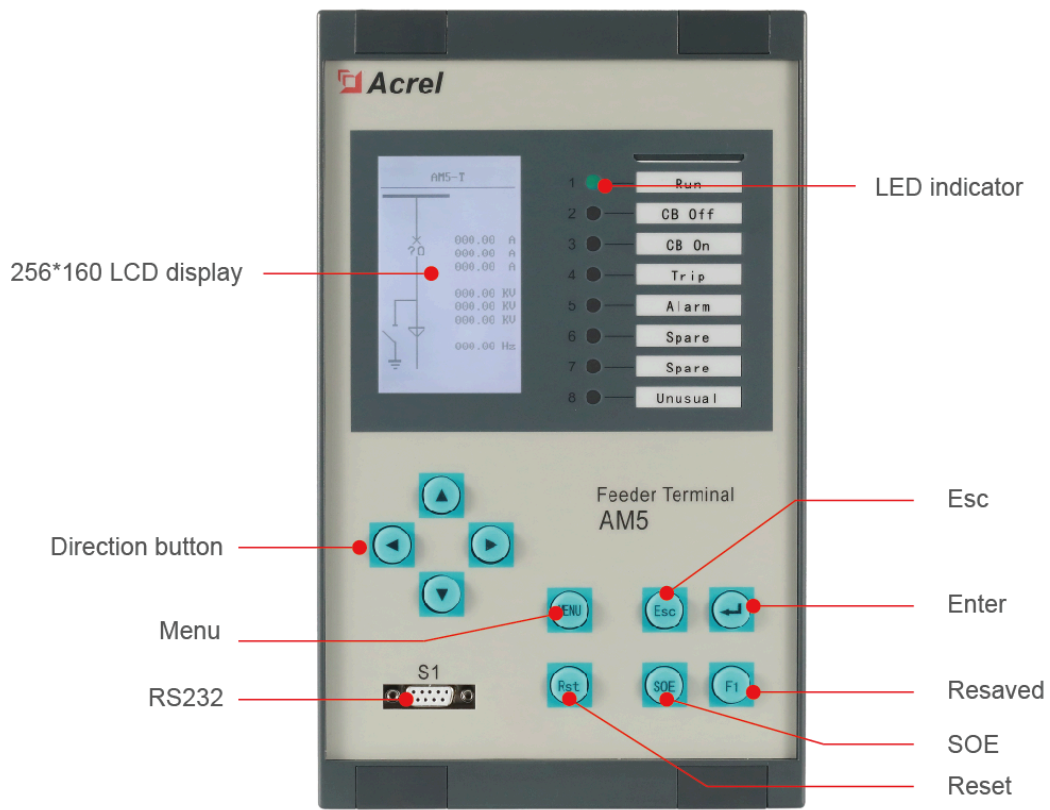


Fig.2.14 AM5 protection relay with overcurrent IDMT

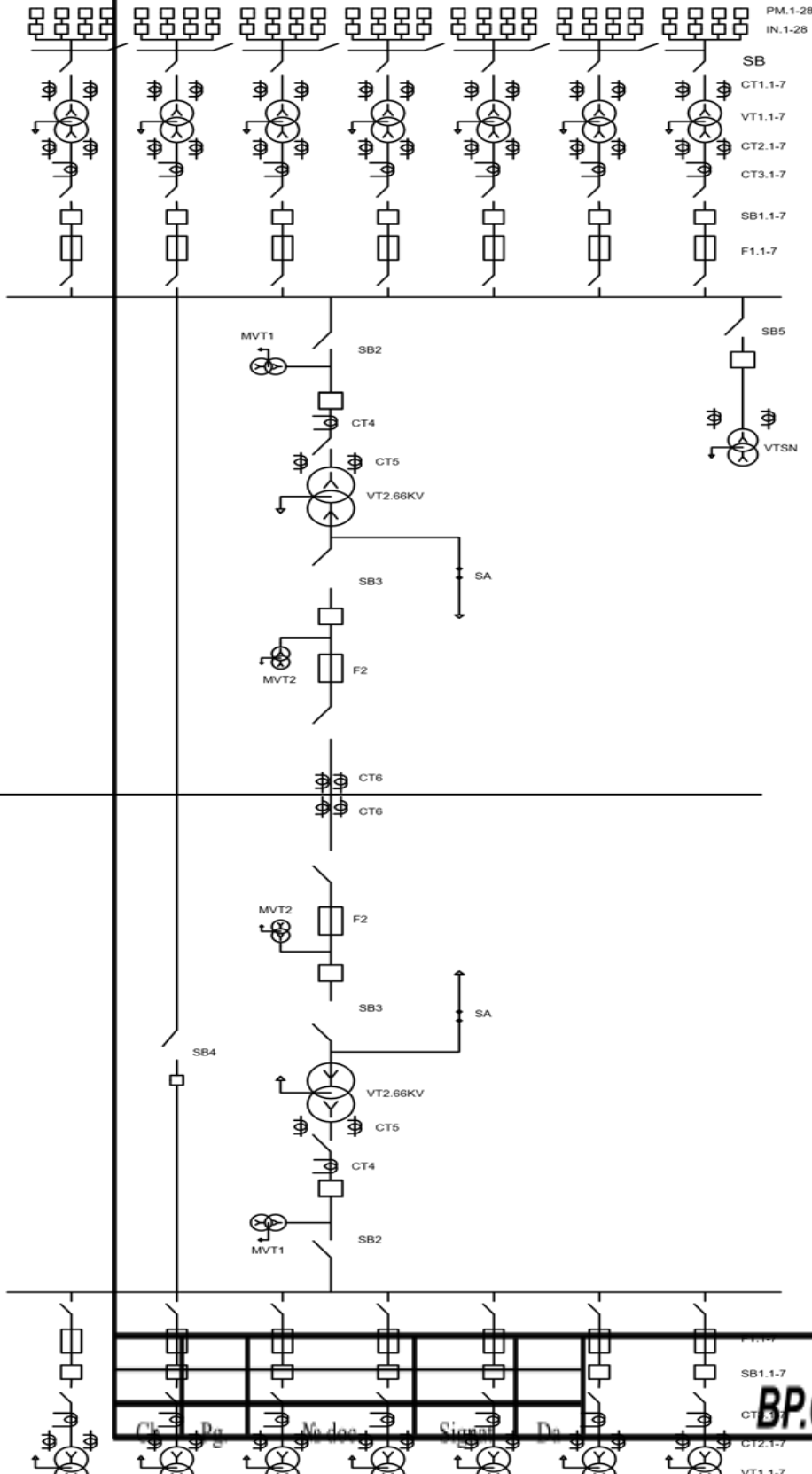
Figure 2.15. oneline scheme

CHAPTER 3. TECHNICAL ECONOMIC CALCULATION

The cost of a solar plant includes the cost of devises from panels, inverters, transformer, cables, breakers ... etc.

Table3.1

N	Name of device	Number	Price	Total cost
1	Single crystal panel 560 w	19642	235\$	4 615 870 \$



2	3 phase inverter type ATO-OGI-200kW	56	65 916 \$	3 691 296 \$
3	SC10-800 transformer	14	3400 \$	47 600 \$
4	8 MVA 66 KV transformer	2	200000 \$	400000 \$
5	Cable 1.5 Mm Dia Roll 90 m	190 Roll	7.15 \$ per Roll	1358.5 \$
6	RECTANGULAR BARE COPPER BUSBARS40x5 X-199	17920 m	35 \$ per meter	627200 \$
7	Cable Hi-Flex 300 Amp 40mm ²	700 m	1.5\$ per meter	1050 \$
8	RECTANGULAR BARE COPPER BUSBARS50x10 X-499	13580 m	70 \$ per meter	950600 \$
9	11kV CU/XLPE/CTS/PVC 3C POWER CABLE35mm	560 m	20 \$ per meter	11200 \$
10	11kV CU/XLPE/CTS/PVC 3C POWER CABLE120mm	12000 m	70 \$ per meter	840000 \$
11	66kv High Voltage Power Cable	60 Km	3.5 per meter	210000 \$
12	<u>Bus current transformers TSHL-20</u>	2+2	512 \$	2048 \$
13	5kV Thru 69kV Current Transformers (Outdoor)	2*3	110 \$	660 \$
14	<u>Current transformer COF (25 - 170 kV)</u>	15+14	420 \$	12180 \$
15	<u>circuit breaker (SB)</u>	14	190 \$	2660 \$
16	OUTDOOR 11KV Vacuum Circuit Breaker (SB1)	15	31200	468000 \$
17	VACUUM CIRCUIT BREAKER ZW32-12 (SB2)	2	7000 \$	14000 \$
18	Circuit Breaker 66kV/132kV	3	20000 \$	60000 \$
19	<u>Switch XPA</u>	12	190 \$	2280 \$
20	11KV Drop out Fuse (F1)	14	104 \$	1456 \$
21	<u>SMD Power Fuses - Outdoor Transmission (F2)</u>	2	150 \$	300 \$
22	<u>2000/5A current transformer</u>	14	12 \$	168 \$
23	Voltage transformer self need	1	3400 \$	3400 \$
24	Measuring voltage transformer MV1 11KV	2	560 \$	1120 \$
25	Measuring voltage transformer MV266KV	2	650 \$	1300 \$
26	Relay protectionovercurrent IDMT	49	777 \$	38073 \$
The total cost				12003819.5 \$

CONCLUSIONS

- In this qualifying work was considered the design of solar power plant with a nominal capacity of 11 MW which is located in Aswan (Egypt)
- Chosen 19642 monocrystalline solar panels
- Chosen devices and equipment such inverter, transformer, cables, fuses, breakers.....etc.
- Drawing illustrative scheme of plant
- Calculate technical economic cost of the plant 12003819.5\$

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vehicles, or trees. Don't use a dry stick or piece of rope or hose as they will not offer any protection. Don't enter an area that might be

5. **Call the owner of the power system and 911 (or other local emergency number)** A crew with proper training and equipment will arrive as soon as possible.

6. Accept confirmation that the system has been de-energized and is safe only from a representative of the power system who is on site.

General limits of approach

The key to safety is to keep a safe distance from overhead and underground power lines. Part 19 of the Regulation lists the distances that workers must keep away from exposed energized conductors.

Table -1A in the Regulation gives the general limits of approach. This is the minimum distance from overhead energized high-voltage lines that non-qualified workers and their materials, equipment, and machinery must maintain.

The limits of approach vary with the voltage. The tools and equipment that you hold or operate are an extension of your reach. You must ensure that you have enough room for movement with your tools without violating these limits.

Table 1A: Minimum approach distance for working close to exposed electrical equipment and conductors

Voltage, phase to phase	Minimum distance	
	Meters	Feet
Over 750 V to 75 kV	3	10
Over 75 kV to 250 kV	4.5	15
Over 250 kV to 550 kV	6	20

Table 1B: Minimum clearance distance for passing under exposed electrical equipment and conductors

Voltage, phase to phase	Minimum distance	
	Meters	Feet
Over 750 V to 75 kV	2	6.5
Over 75 kV to 250 kV	3	10
Over 250 kV to 550 kV	4	13

Where any portion of a machine or equipment may come closer than the minimum distance prescribed, form 30M33 must be completed before work begins. This allows the owner of the power system to provide some form of protection.

On the ground stay at least 10 m (33 ft.) away from operating equipment because if it contacts an energized line the electricity will go to ground. The operator should be on the vehicle with everyone else clear of the vehicle when the boom is in motion. If you must approach, ensure the equipment is not operating.

3. Stay back, and call for help.

Stay back at least 10 m (33 ft.) from a fallen power line, exposed underground power line, or any object in contact with the line. If the machinery you are operating contacts an energized line, move it away from the line to break contact. If you can't do this, stay put in the machine until help arrives.