VIVA // UGP1 // 30TH DECEMBER 2019

Development of Solar-Powered Unmanned Aerial System (UAS)

LEONG JOE YEE B17KM0011

SUPERVISED BY : DR NAZRI NASIR

UAS Defination

Unmanned Aerial (Aircraft) System

operate autonomously or to be piloted remotely

The UAV and the equipment to control it remotely

Source: Regulation (EU) 2019/945

Problem Identification

Challenge on maintain constant power supply to the load.

Power generated from PV power system must sufficient to maintain a steady flight

The harness of solar energy,

Efficiency of PV cells drops due to angle of incidence, temperature and sun intensity

Objective

Develop methodology for solar powered system design and do the set up.

Perform Parametric study & performance data collection and analysis on solar powered system

Scope

Fixed wing, plank flying wing UAV

Hand launched, low altitude solar powered UAV

UAV weight ≤1.2kg

Mono-crystalline Silicon cell arranged in series on wing.

Weight includes airframe, payload, PV cells, electronics part and Li-Po battery

History of Solar-Powered Aircraft

Abbe & Smith (2016)

Photo source: dfrc.nasa.gov
: newsweek.com
: eospso.nasa.gov
: ethz.ch

Development of PV tech (1954)

(Daryl Chapin, Calvin Fuller, Gerald Pearson)

Nimbus satellite was launched (1964)

(NASA)

the first solar- powered aircraft, Sunrise I (1974)

The first manned solar aircraft, the Gossamer Penguin (1980)

(Dr. Paul Macready)

The Solar Challenger (1981)

(Dr. Paul Macready)

Helios by *ERAST NASA* (2001)

Sky Sailor (unmanned) (2008)

(Noth)

Solar Impulse (manned) (2010)

(Bertrand Piccard & Andre Borschberg)

Configurations of UAV

Singhal, Bansod, & Mathew (2018)

1. Multi Rotor UAV
   (DJI phantom 1)

2. Fixed Wing UAV
   (QuestUAV Q-200)

3. Single Rotor UAV
   (Shenzhen Eagle Brother Model 25L)

4. Hybrid UAV (Fixed Wing /VTOL)
   (JOUAV's CW-30 hybrid VTOL/Fixed-wing)

Source: Room M. H. M. & Ahmad A. (2014).

Micro UAV
Israeli IAI Malat Mosquito


Image courtesy of Israel Aerospace Industries

Close range UAV
Optimus

SUAV
RQ-11 Raven, by US Aero Vironment

Mass Range Flight Altitude and Endurance

Medium range UAV
Israel Aeronautics Defense Dominator


Image courtesy of Aeronautics

HALE UAV
Phantom Eye


Image courtesy of Boeing Phantom Works

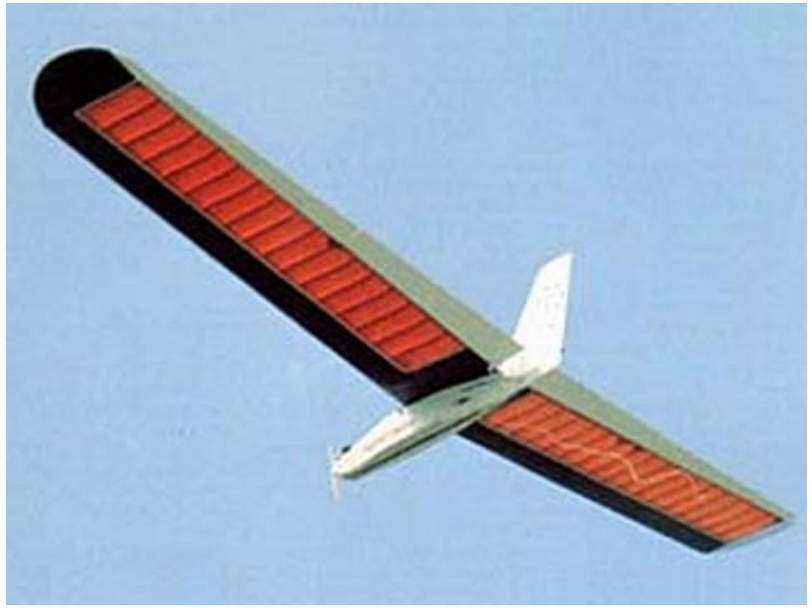
Picture Source: youtube.com (Prometreus)

Plank Flying Wing Aircraft

Miligan (2000)

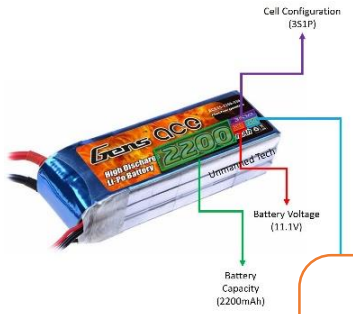
Plank Flying Wing

Unswept wing
(Make use of whole structure to locate solar panels)



tailless fixed-wing aircraft that has no definite fuselage
(Reduce Cd, weight and wing loading)

UAV Electronic Components



Energy storage device

Battery

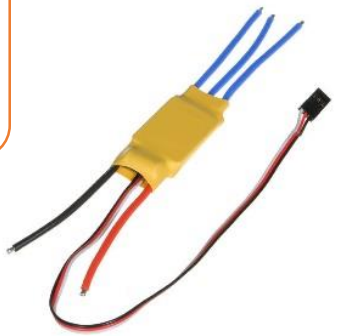
Brushless motor

Spin the propeller to generate thrust

Basic Component

Electronic Speed Controller

Control motor's speed, direction, Dynamic speed



Collect input from transmitter, pass to flight controller

Receiver

Flight Controller

Collect data from GCS, send command to ESC

Move Control Surfaces

Servo

Photovoltaic (Solar) Cells

Convert usable solar energy to electrical energy by means of photovoltaic.

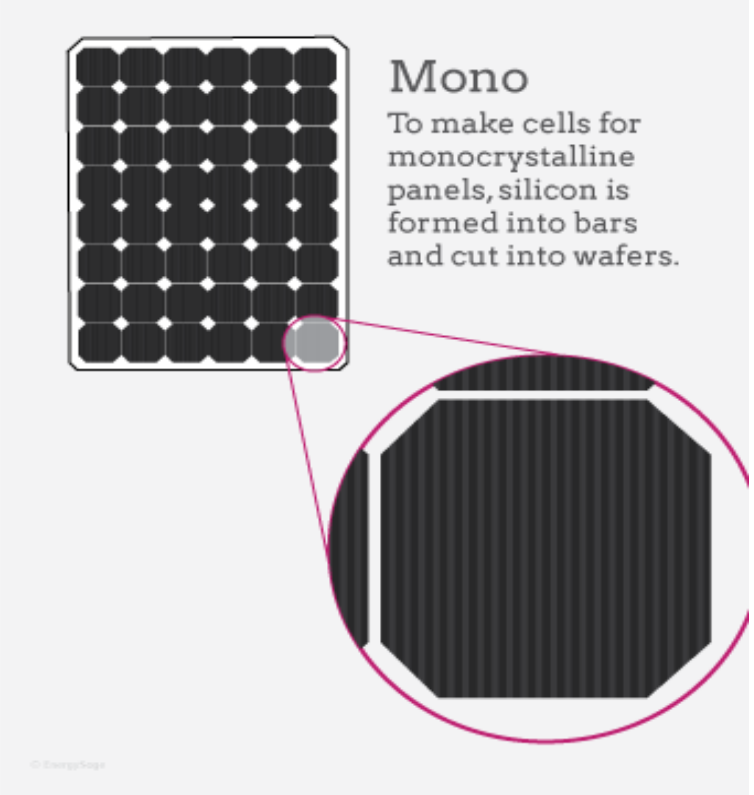


Photo source:
goodenergy.co.uk

Solar cell efficiency (Maximum):-

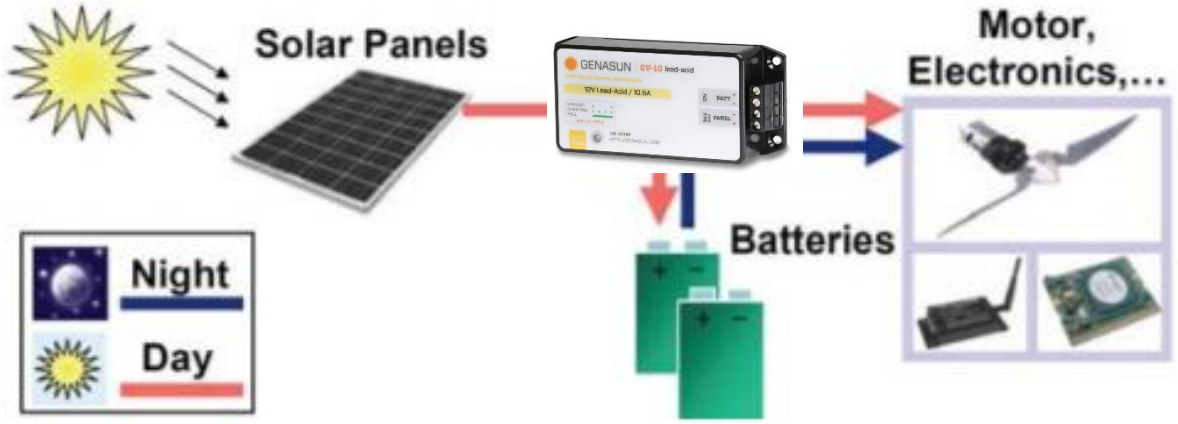
$$\eta_{max} = \frac{P_{max}}{E \times A_C} \times 100\%$$

P_{max}= Maximum Power Output (W)
E= Incident Radiation flux (W/m^2)
A_C= Area of collector (m^2)

Source:
Adejuyigbe et al. (2013).
Swami R. (2012).

Maximum Powet Point Tracker (MPPT)

Diehl, (2015)



MPPT: DC-DC buck converter

Function: Efficiently adjust the maximum power point to extract the maximum power according to the surrounding.

Selection of MPPT:

$$P_{PV} = IV_{bat}$$
$$52.8W = I \times 7.4V$$
$$I = 7.135 + 25\% = 8.92A$$

Therefore, Genasun 10.5A MPPT is chosen.

Weight Estimation

Objective: To show the distribution of weight on avionics, airframe and payload.

Components	Weight
2S 7.4V LiPo cell	81g
30A Skywalker ESC	37g
Sunpower C60 PV cell	9g x 16= 144g
Brushless motor	102g
Propeller	15g
Flight controller	58g
Receiver	16.8g
MPPT	185g
Telematry and GPS	50g
Wiring System	60g
Airframe Structure	400g
Total	1155g

Performance Analysis

Objective: To predict the power available and power required for the UAV to achieve stable and longer endurance flight.

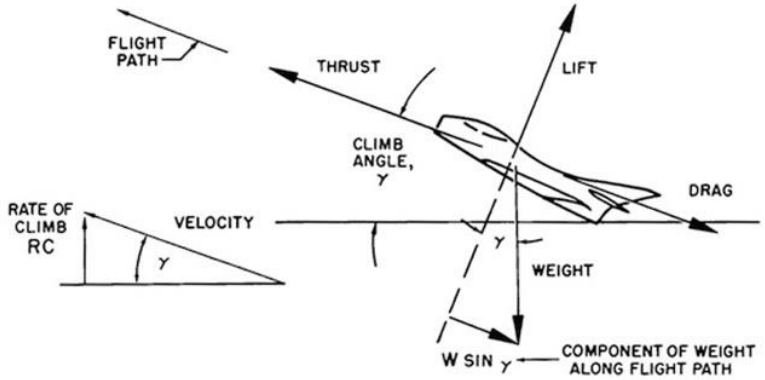
Power Generated

$$P_{PV} = \eta_{PV} \times \eta_{MPPT} \times S_{PV} \times G$$

average irradiance, G in Kuala Lumpur from ECOTECT 5.2v-weather is $604.353 W/m^2$

$$P_{PV} = 0.225 \times 0.96 \times (0.125 \times 0.125 \times 16 cells) \times 604.353$$

$$P_{PV} = 32.635 W$$



Power Required

We calculated and predicted the power required for a steady, unaccelerated climb

$$TV = DV + WV sin\,\gamma$$

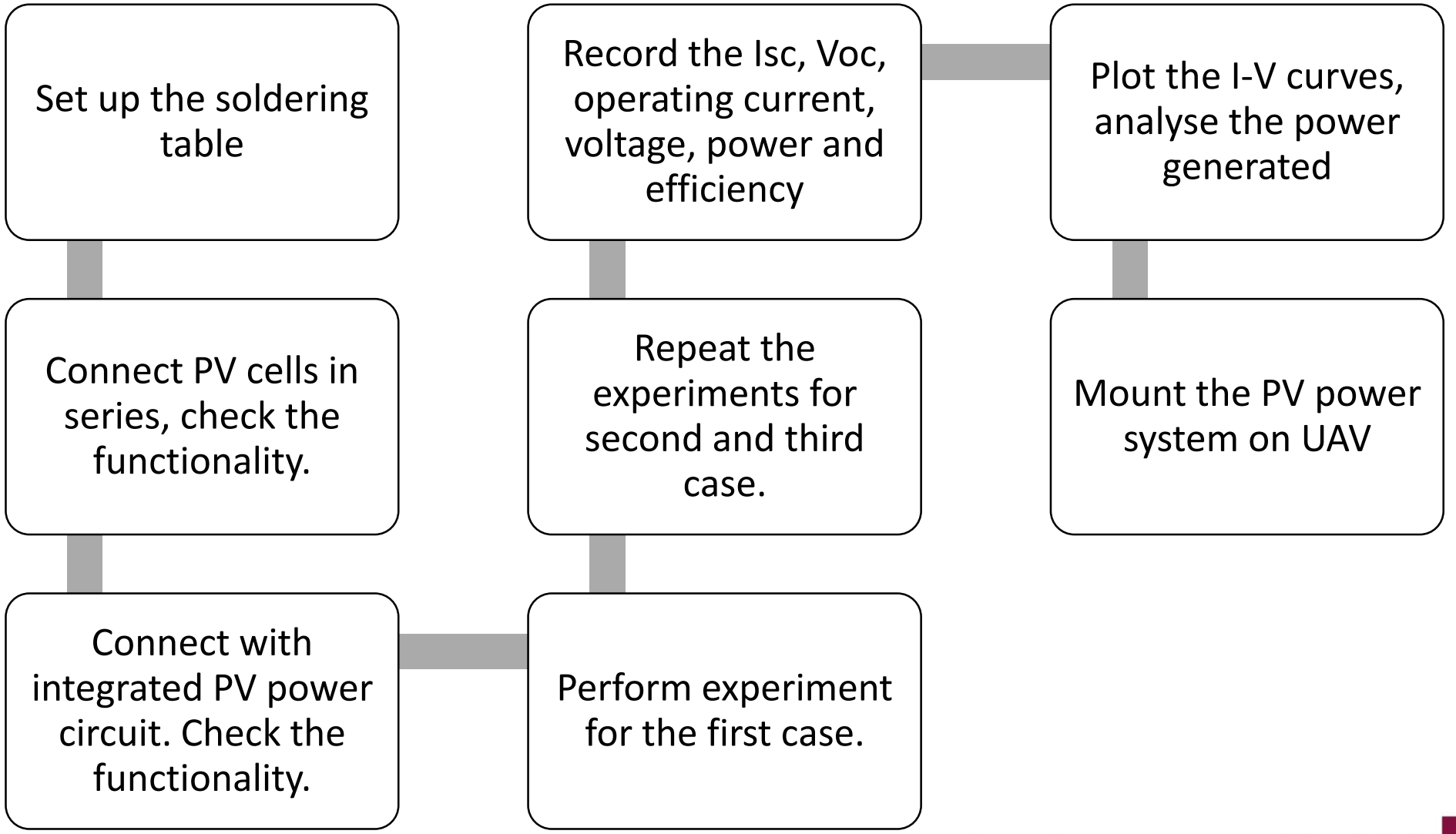
$$TV = (1.044)(10) + (1.2)(9.81)(10)\sin 5° = 20.7N$$

$$P_{required} = 20.7N$$

Solar Panel Setup and Analysis

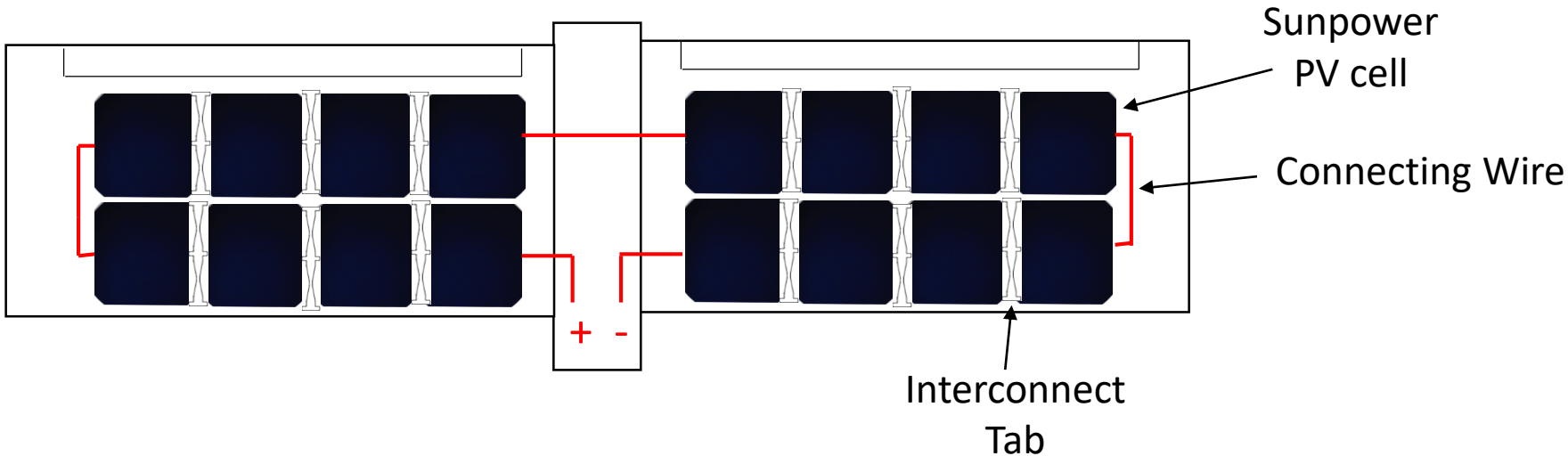
Objective:

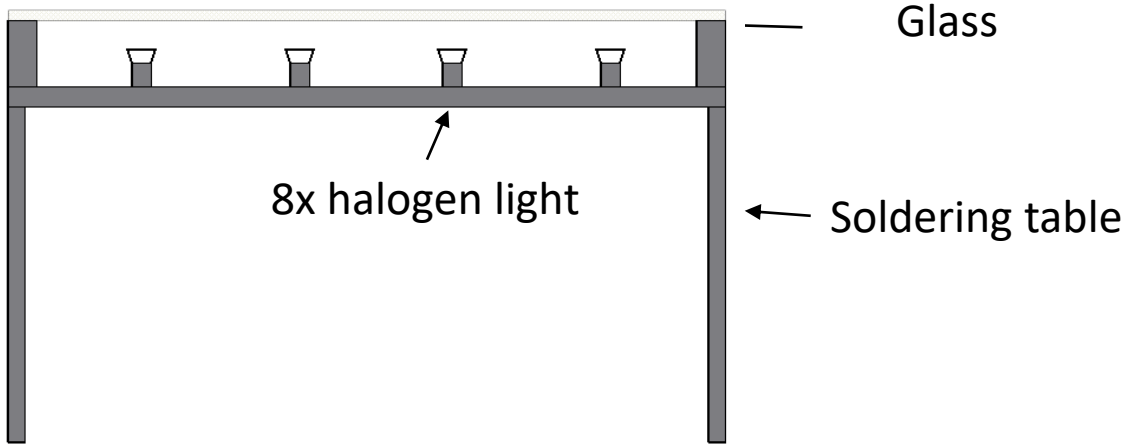
Perform soldering , testing on PV cells, study on the factors that influence the characteristics of the PV cells through performance and I-V curve.



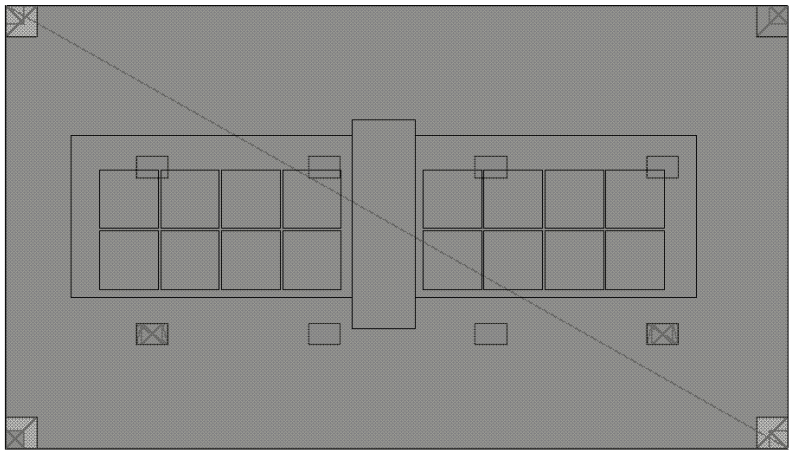
Soldering of PV Cells

η_{PV}	22.5%
P_{MPP}	55.22 W
V_{MPP}	9.312 V
I_{MPP}	5.93 A



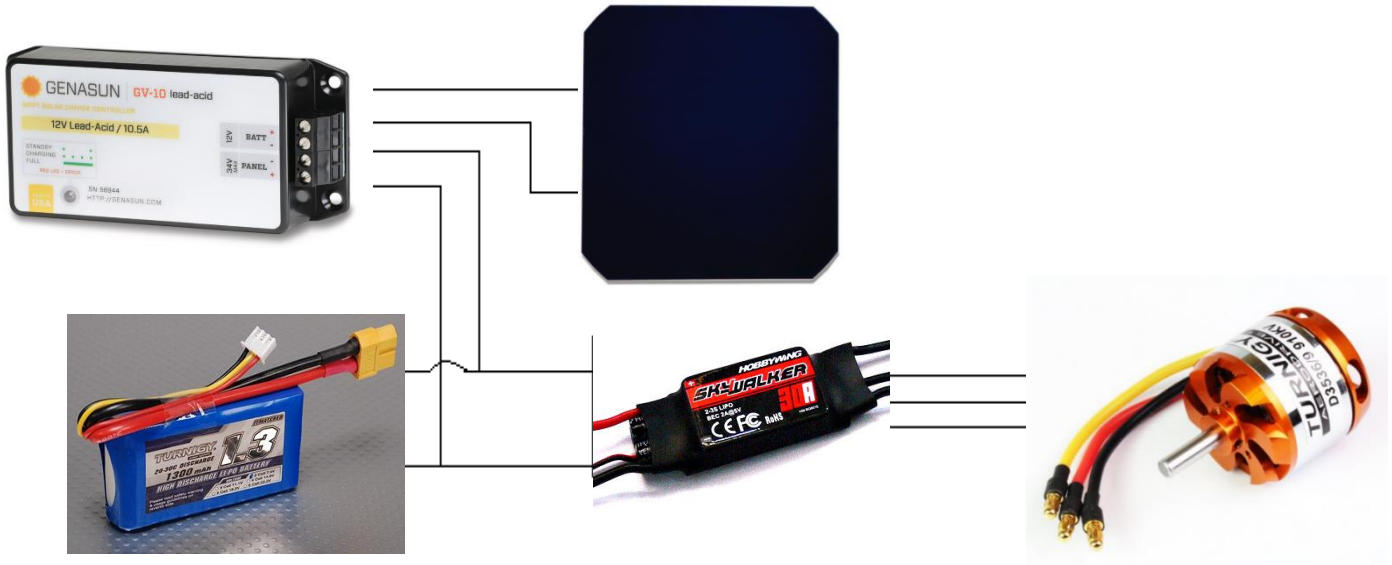


Front view of soldering table



Top view of soldering table

Integrated PV Power System Circuit



UAV Power System Components:

1. 2S 7.4V LiPo cell
2. Sunpower C60 PV cell
3. 30A ESC
4. 910KV Brushless Outrunner Motor
5. Genasun 10.5A MPPT

Control System:

1. PX4 2.4.6 Pixhawk + Telematry

Ground Control Station:

1. Ardupilot Mision Planner

Experiment Setup

Factors Influencing the characteristics of PV cell

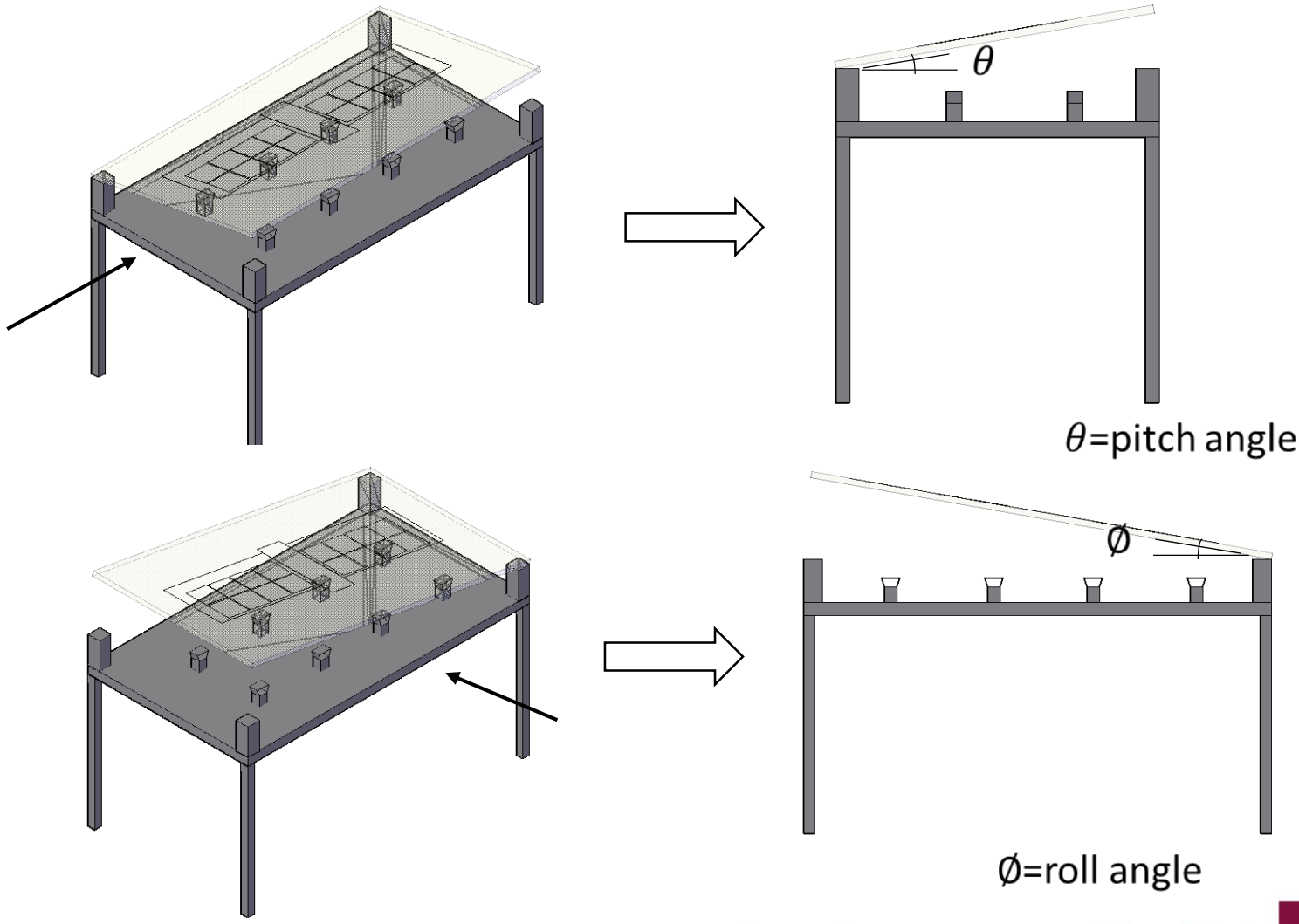
- **Sun Angle of Incidence**

To investigate on the pitch & roll angle effect the PV cells efficiency.

Place the PV cells on glass surface. Secure with tape.

Tilt the surface with the required pitch/roll angle. Observe the result.

Repeat the test with different pitch/roll angle. Observe the result.



Experiment Setup

- **Sun Intensity**

To understand the influence of the transparent on PV cell efficiency.

Put on a layer of transparent film below the PV cells.

↓

Switch on the halogen light and observe the result.

↓

Repeat the test without transparent film

Factors Influencing the characteristics of PV cell

- **Operating Temperature**

To understand the influence of temperature on PV cells efficiency.

Switch on the halogen light and observe the result at ambient temperature.

↓

Adjust the surrounding temperature using air-cond, repeat and observe the results.

Literature review

Study	Researchers
History of Solar Powered Aircraft	Abbe & H.Smith, 2016 Zhu, ZhengGuo, & Hou, 2014
Photovoltaic power system	Patel, 1999 Noth & Siegwart, 2006 *Swami R., 2012* *Adejuyigbe S. B. , Bolaji B. O., Olanipekun M. U., and Adu M. R., 2013*
UAV	Regulation (EU) 2019/945 *Room M. H. M. & Ahmad A., 2014* Boukoberinea, Zhoub, & Benbouzid, 2019 Philipp, et al., 2017 Morton, D'Sa, & Papanikolopoulos, 2015
Performance of UAV	Anderson, 2016
Intergrated power circuit, MPPT	Patel, 1999 Noth & Siegwart, 2006

Gantt Chart UGP 1

TASK/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
First Meeting with Supervisor																				
Discuss and decide objective & scope of project																				
Participate in briefing, talk and flight test																				
Literature Review																				
Report Writing																				
Presentation to Supervisor																				
Propose solar panel electronic components																				
Develop design methodology																				
Performance characteristics analysis of UAV																				

Gantt Chart UGP 1

TASK/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Design solar panel arrangement on UAV																				
Propose Experiment set up																				
Finalise Methodology																				
Final Preparation for Seminar Presentation																				
Seminar Presentation (VIVA)																				
Report Submission to Supervisor																				
Repairing Report																				
Report and Logbook Submission to Faculty																				

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

univteknologimalaysia utm_my utmofficial

Thank You

www.utm.my

innovative • entrepreneurial • global