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Design and Development of Solar Drone

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Abstract: The harnessing of solar energy during operations of unmanned aerial vehicle(UAV) provides potential solution to combat energy constraints. This Thesis examines the practicality of mini solar drone and provide experimental validation in regards to energy maximization through solar energy management and flight time optimization.The simulations results are consistent with real time measurements during flight test.

This project deals with a quadcopter using solar energy as well as lithium polymer battery as power source combination to give maximum flight output. Using solar panels, it collects the energy during day time for immediate use and also store the remaining part for night as well. The objective is to identify , design and analyze such a reusable solar powered quadcopter for high altitude endurance and longer battery life.

I. INTRODUCTION

A flying item with four motors fixed with propellers and put on a fixed frame is referred to as a quadcopter (also known as a quadrotor or a quadcopter). The word "quad" in the name quadcopter denotes that this flying machine has four rotors and four propellers. Compact rotorcraft aircraft known as quadcopters have VTOL (vertical take-off and landing) capabilities. How long these drones can fly continuously is one of the limitations that prevents the widespread use of drones in general, not only quadcopters, which are powered by batteries. The idea of a limit flight time is thus born. Due to the power used by the motors, these vehicles typically only have a short flight period, though this can be increased by adding more batteries. The use of renewable energy to extend flying time, however, is a novel technique in the field of unmanned aerial vehicles.[12]

A renewable energy source is solar energy. In terms of renewable energy, it is the technology to aim for owing to its availability and abundance. Although the use of solar technology in aerial robotics is not new, the investigation of a complete and effective system for such an integration is still under investigation because it is only operating at a 21% efficiency, meaning that only 21% of the solar energy was converted into useful electrical energy.[12].

II. PROBLEM STATEMENT

Drones are now common all over the world, and they find application in various fields. There remains the underlying factor of maximum flight time. This limits the range and extent of application. Thus, the need to find a sustainable provision of energy that will go a long way in breaking the shackles of limitation in the application of energy. Bearing this in mind, coupled with the need for the preservation of the environment, there is need to develop a way of harvesting energy that will be clean and self-sustaining.

While there is a quantity of problems associated with flying drones for long times such as the risk of the drone losing connectivity with its controller – utilizing solar energy to power a drone can backing reduce the want for drones to return to their base for charging. With the right amalgamation of solar expertise and storage, a drone has the probable to run for longer remoteness. This means less time on the ground, regardless of the purpose it's serving.

III. DESIGN ANALYSIS

A. Frame

The quadcopter's frame serves as its housing, thus it must be sturdy enough to support the internal parts and withstand outside influences. It houses every part of the quadcopter. Since the quadcopter is an aeroplane, it should be lightweight, inexpensive, and sturdy for best performance.

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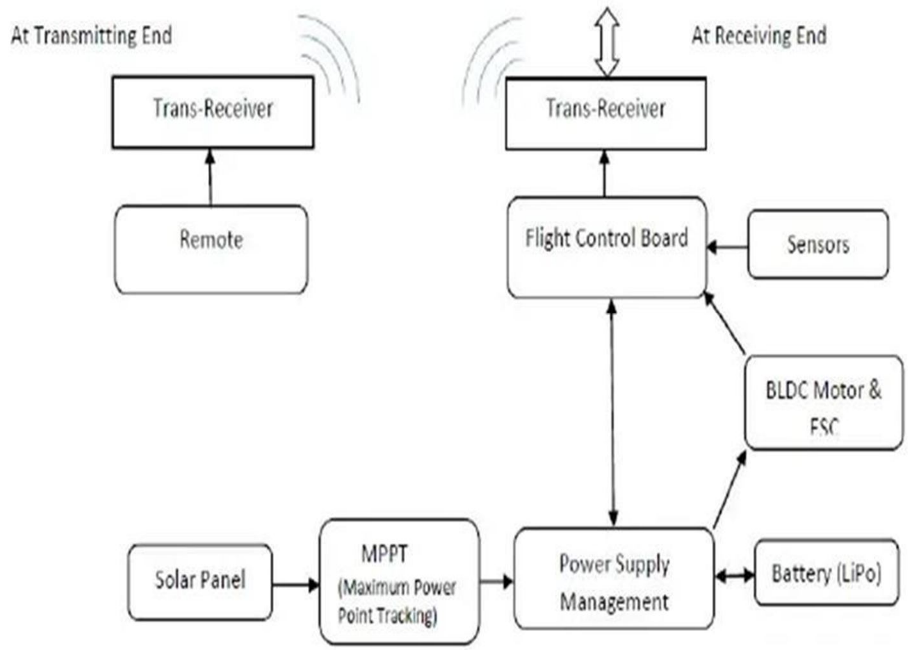
B. Working Mechanism



C. Energy Consumption

The energy consumption of a quadcopter depend upon the battery discharge and ampere drawn by the motor and flight controller. After which flight time of drone can be calculated.

- As per Specifications,

1.Maximum power driven by the motors,

- Current(A)= 20A, provided by ESC (70% throttle enough for lift)

Thus,

Power = Current*Voltage
= 20×11.1×0.7
= 155.4W from all 4 motors

- Solar cell Charging time:

Power Output = Total area × Solar cell efficiency × number of solar cell × Solar Irradiance
=0.0049×8×0.32×6170
=77.39watts

- As per multimeter reading solar having output voltage of 5-6V during peak sunlight,

Thus,
Charging Current=Power(watts)/output voltage
=77.39÷5
=15.47A

Now,
Assuming efficiency about 32% we get net current around 4.95A.
Charging time= (Battery Capacity) ÷ (Charging Current × Charging efficiency)

= 5200÷4.95×0.32 =3276 seconds
=54.1 minutes

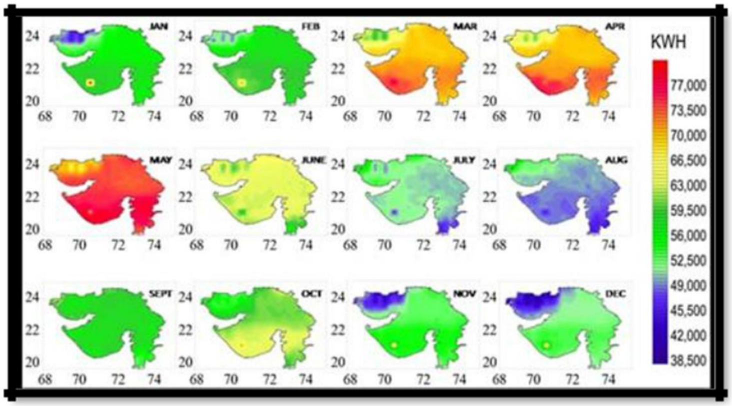


Fig Annual Solar Irradiance Gujarat

Solar Irradiance		Value in kWh/m2/day
January		6.82
February		7.08
March		6.85
April		6.17
May		5.51
June		4.48
July		3.81
August		4.16
September		5.39
October		6.58
November		6.45
December		6.46

Fig: Solar Irradiance in Ahmedabad Year 2022

IV. PRACTICAL ANALYSIS

A. Data Collection

The Data is collected during the real flight of the Quadcopter. The charging and discharging time are shown in Table 1 The Power consumption of Quadcopter with and without Solar Panel assistance is also measured and is shown in Table 8.2.

Table 1 Flight Mode with Solar

S.NO	PARTICULARS (1 cell)	CHARGING		DISCHARGING		TIME
		Volts	Amps	Volts	Amps	Hour
1	STAND STILL MODE	4.6	0.18	-	-	11 AM
2	STAND STILL MODE	4.5	0.17	-	-	12 PM
3	STAND STILL MODE	4.5	0.18	-	-	1 PM
4	STAND STILL MODE	4.3	0.16	-	-	2 PM

5	STAND STILL MODE	4.3	0.16	-	-	3 PM

S.NO	PARTICULARS	CHARGING		DISCHARGING		TIME
		Volts	Amps	Volts	Amps	Hour
1	FLIGHT MODE	12	0.20	12	2.2	11 AM
2	FLIGHT MODE	11.2	0.49	11.7	2	12 PM
3	FLIGHT MODE	29.4	3.3	11.2	1.8	1 PM
4	FLIGHT MODE	32.6	5.1	10.8	0.80	2 PM
5	FLIGHT MODE	37	6.18	10.2	1.8	3 PM

Table 2 Power Consumption durin

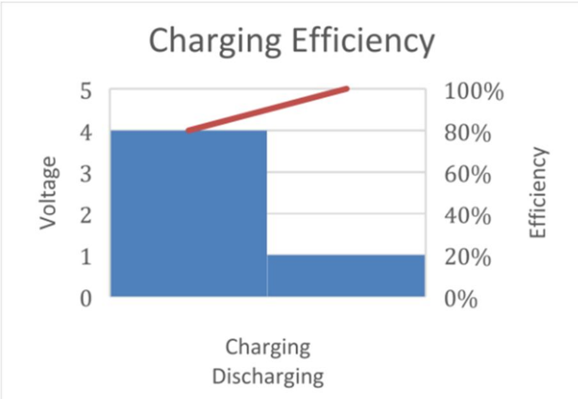
S.NO	PARTICULARS	TERMINAL VOLTAGE (V)	CURRENT I(A)	POWER P(W)
1.	WITH BATTERY	12	2.2	24.42
2.	SOLAR ASSIST	5V	0.8-0.92	4
3.	SOLAR CHARGE	5*8=40V	6.4-7.36	256W

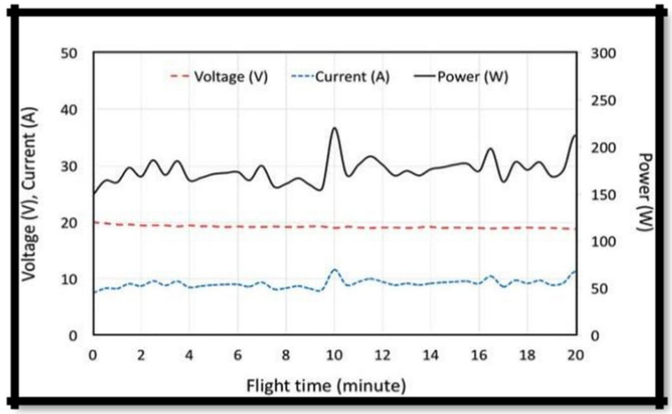
NO. Solar cell	Voltage	Amperes	Power	Time
8	38	6.3-7	239.4W	8-11 AM
8	39	6.4-7.14	237.98W	11-1 AM
8	40	6.45-7.3	292W	11-3 AM
8	40	6.3-7.22	260W	10-4 AM
8	40	6.1-7.35	244W	12-4 AM

The above table shows the real time measurements, of 8 series of solar cells at no load current during various time laps i.e peak sunlight Hours. The reading are taken from Multimeter and Ammeter respectively. The reading shows the Power generated by the solar cells.

From the Equation,

$$P = V \times I \quad [11]$$





V. CHALLENGES

1) The first challenge is obtaining enough current flow. In order for a drone to lift off, the flight controller must provide enough volts and amps through the ESC to the motors in order to generate the greatest amount of push necessary for a steady lift.
2) STRESS: Not getting enough sun. A solar-powered drone needs to be able to collect enough energy during the day to run for the extended period of time in order for it to function. The drone must use less energy than or on par with what the solar panels can provide to power its propulsion, payload, avionics, communications, and other components
3) Size and Speed (Motor): Thrust to Weight Ratio • For all multirotor designs, it's crucial to make sure that the drone's motors can generate about 50% more thrust than the drone's actual weight. The drone won't take off or respond properly to your control if all of its motors' thrust is less.

VI. CONCLUSION

In conclusion, we figured out that for a drone lift maximum thrust at minimal usage high motor with small inch propeller is the best combination. Because, we got a problem where 1800KV motor cannot lift our drone due to high propeller dimension. We also managed to get an increased flight time of more than 10 min with use of solar cell. As, we made a SPMS circuit that get us Charging efficiency ratio at 80%. The graph and data clearly showed the achieved criteria. The reading were taken at real time measurement.

The 8 Solar cell series at peak time of afternoon session can generate 38-40V voltage and current of 7A respectively which can produce power of 256W which is far more than the battery consumption. Therefore, the discharge rate gets very low and charging efficiency gets increased which finally result us 10-15min extra flight endurance during peak hours. But, as the height increases it does not affect the discharge rate much due to a better voltage generation. Finally, the solar charges battery in 54 minutes as per the analysis showed.

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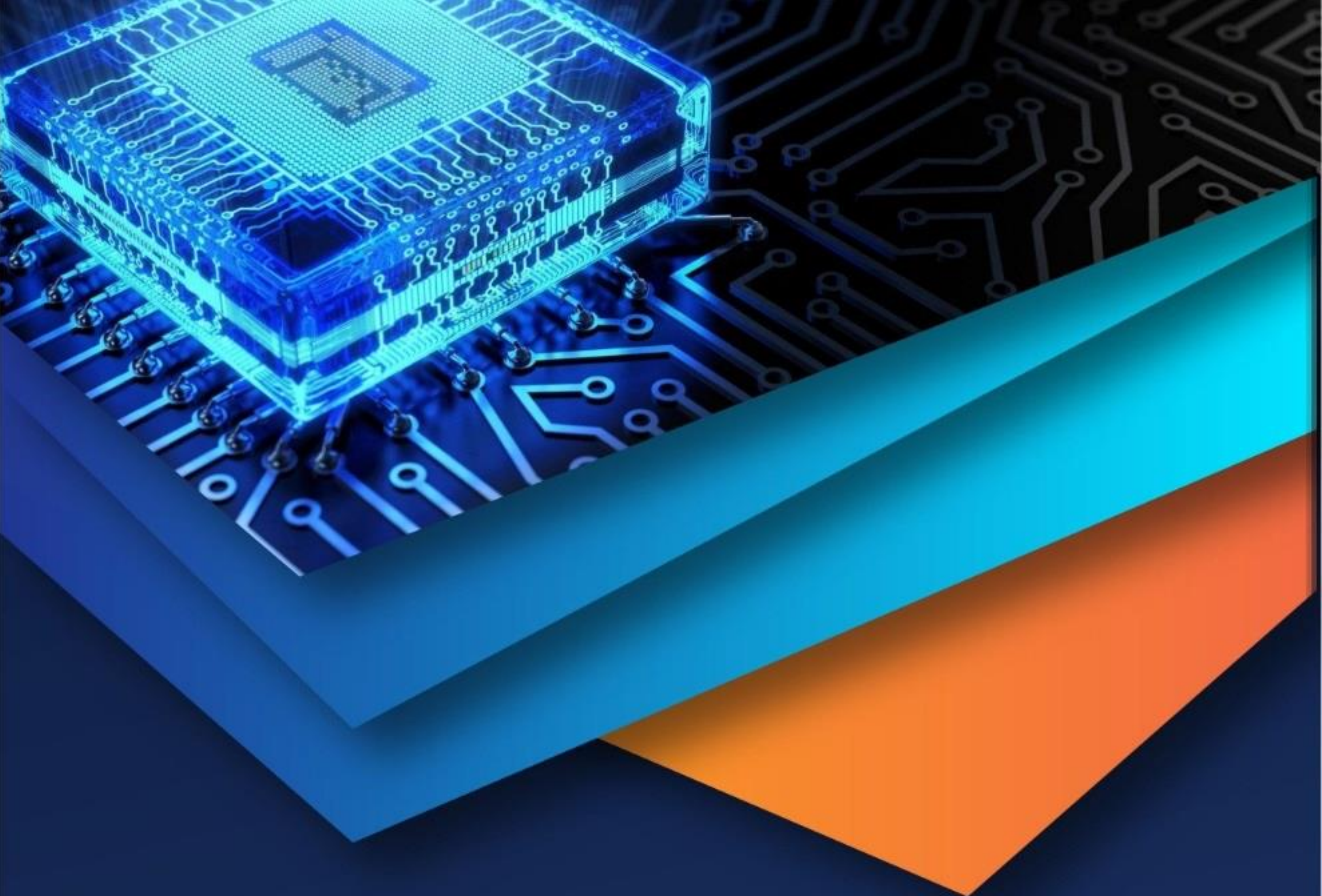

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