

# Experimental Investigation of Optimal Wavelength Selection for Laser Power Beaming Using Silicon Solar Cells in UAV Charging Systems

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## INTRODUCTION & AIM

### Background

- UAVs are widely used in agriculture, military, mapping, and disaster monitoring, but their main limitation is **limited flight time** due to battery constraints.
- Laser power beaming is an emerging wireless energy transfer method that enables in-flight charging of UAVs.
- The efficiency of this system strongly depends on the compatibility between **laser wavelength and photovoltaic (PV) cell spectral response**.

### This Study

- Laser sources emit monochromatic light, so this study investigates the wavelength-dependent performance of silicon solar cells to identify the optimal operating wavelength region for efficient laser-based UAV charging systems.

### Aim

- The aim of this study is to **develop a laser-based drone charging system** by utilizing experimental data on the optimal wavelength region for silicon solar cells to effectively match the laser source with the photovoltaic (PV) array for maximum power conversion efficiency.

## METHOD

### 1. Material

- 5 cm<sup>2</sup> polycrystalline silicon photovoltaic (PV) cell

### 2. Experimental Setup

- VK-SS-50 LED Solar Simulator
- VK-PP-100 PV Analyzer

### 3. Procedure

- Measured Voc, Isc, and Pmax under standard 1-sun illumination.
- Exposed the PV cell to monochromatic light across the wavelength range of 365–1030 nm.
- Maintained constant irradiance for all wavelengths to ensure accurate spectral comparison.

### 4. Measured Parameters

- Open-circuit voltage (Voc) in volts (V)
- Short-circuit current (Isc) in mill amperes (mA)
- Maximum power (Pmax) in mill watts (mW)

## RESULTS & DISCUSSION

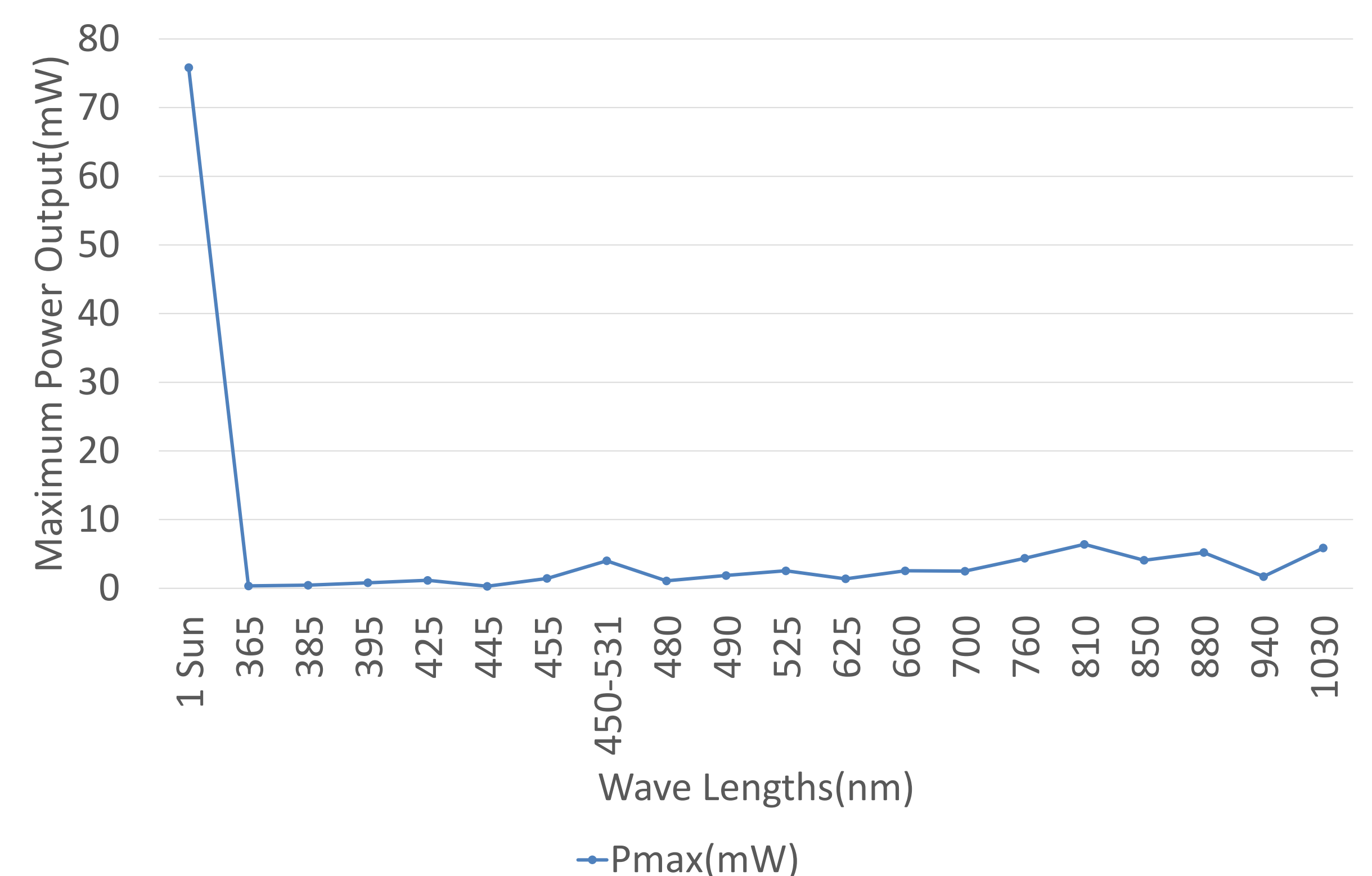
### Key Findings

- The output power of the silicon solar cell varies significantly with the wavelength of the incident monochromatic light.
- Under standard 1-sun illumination, the maximum power output achieved was 75.84 mW. Under monochromatic testing, the minimum power output was 0.29 mW at 445 nm, indicating low spectral response in the blue region.
- The maximum monochromatic power output was 6.4 mW at 810 nm, showing strong response in the near-infrared region.
- The optimum wavelength region for laser power beaming is identified as 810–880 nm for silicon PV cells. The near-infrared (NIR) region is suitable for UAV charging due to reduced atmospheric losses and better transmission efficiency.

### Discussion

- The solar cell shows strong wavelength dependence, with better performance in the near-infrared region compared to visible wavelengths due to improved absorption and carrier generation in silicon.
- Lower output at shorter wavelengths (e.g., 445 nm) is mainly caused by higher surface recombination losses and reduced effective carrier collection.
- The optimum wavelength range (810–880 nm) is well matched with silicon's spectral response and is suitable for efficient laser power beaming applications with reduced atmospheric losses.
- Using **multiple laser wavelengths instead of a single source** can enhance spectral utilization and improve the overall efficiency of photovoltaic-based UAV charging systems.

Wave Length Vs Maximum Output Power



## CONCLUSION

- This study successfully demonstrated the wavelength-dependent performance of silicon solar cells for laser-based UAV charging applications.
- The results confirmed that the solar cell achieves its highest response in the near-infrared region, with the optimum wavelength range identified as 810–880 nm.
- The findings highlight that proper laser wavelength selection is critical for maximizing power conversion efficiency in laser power beaming systems.
- Overall, the study provides a clear guideline for designing efficient wireless UAV charging systems and suggests that multi-wavelength laser integration can further improve system performance.

## FUTURE WORK

- Extend the study to include other photovoltaic materials (e.g., monocrystalline silicon, GaAs) for improved laser power conversion efficiency.
- Investigate higher power laser sources and real UAV flight conditions to validate system performance in practical environments.
- Develop an adaptive multi-wavelength laser system to optimize energy harvesting across a broader spectral range.

## REFERENCES

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