Comparison of Maximum Power Point Tracking Techniques in Electrical Power Systems of Cubesats

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small SATELLITE
AIAA/Utah State University

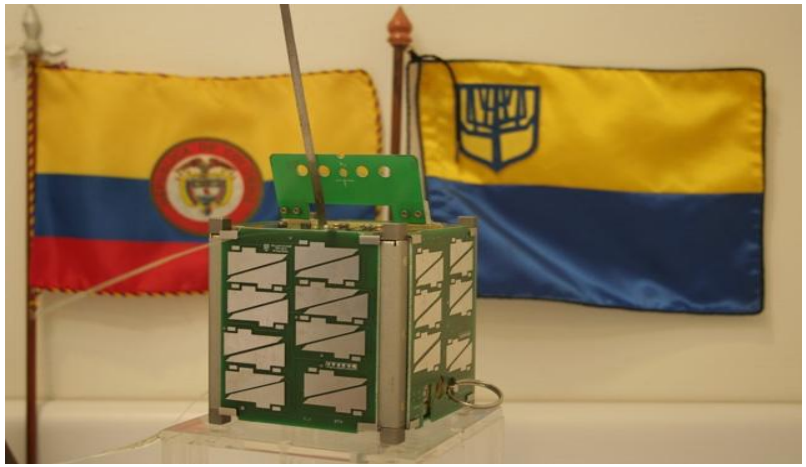
27th Annual AIAA/USU
Conference on Small Satellites

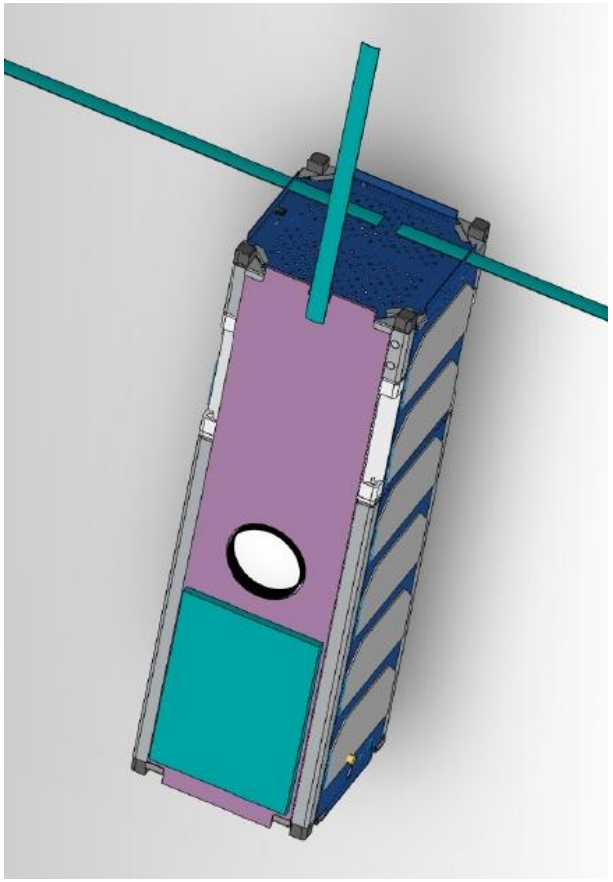
August 10 - 15, 2013

Agenda

- Introduction
  - From Libertad 1 to Libertad 2
- The problem
  - Selection of MPPT algorithm for EPS
- Method
  - Simulation over one orbit of MPPT techniques
- Results
  - Comparison of Energy for each Technique
  - Future work

Introduction





- **Classification: Nanosatellite**
- **CubeSat (Academic)**
- **Application: Earth Observation**
- **Orbit: LEO**

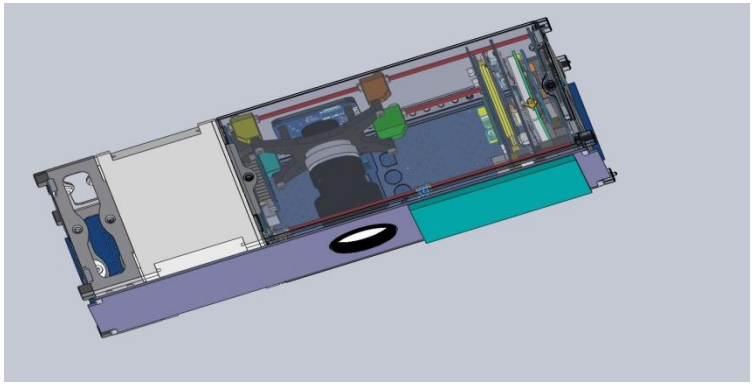
Introduction

Ground Station

Introduction

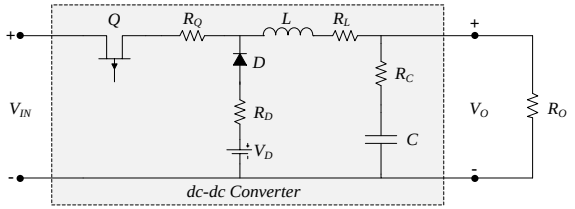
SATÉLITE LIBERTAD 2
Universidad Sergio Arboleda
Ingenierías y Ciencias

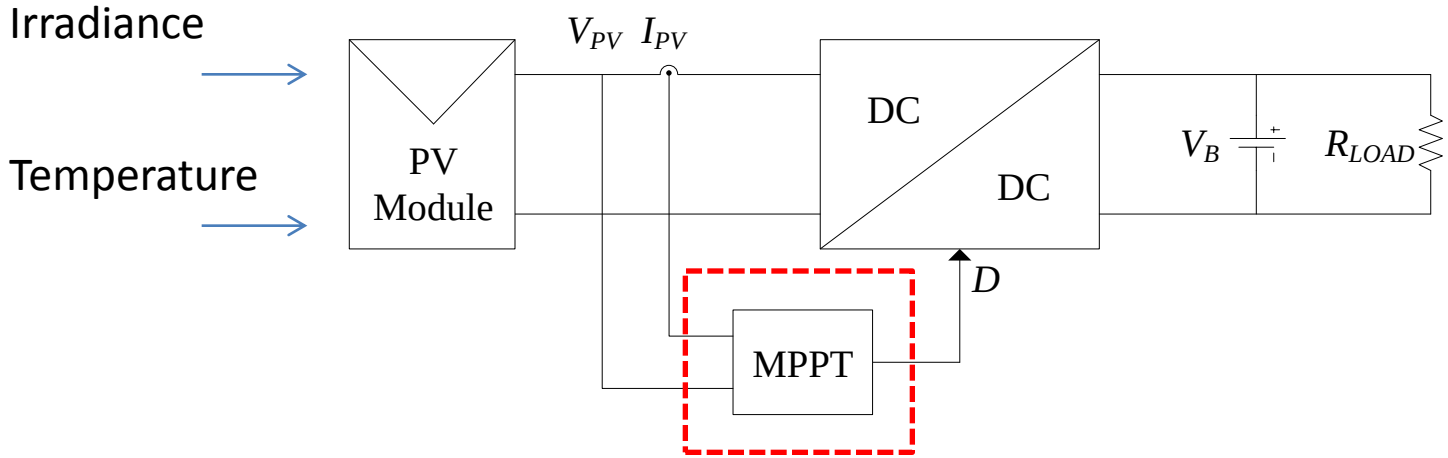
1.Development of an image acquisition system for Cubesat



2.Optimization of power systems

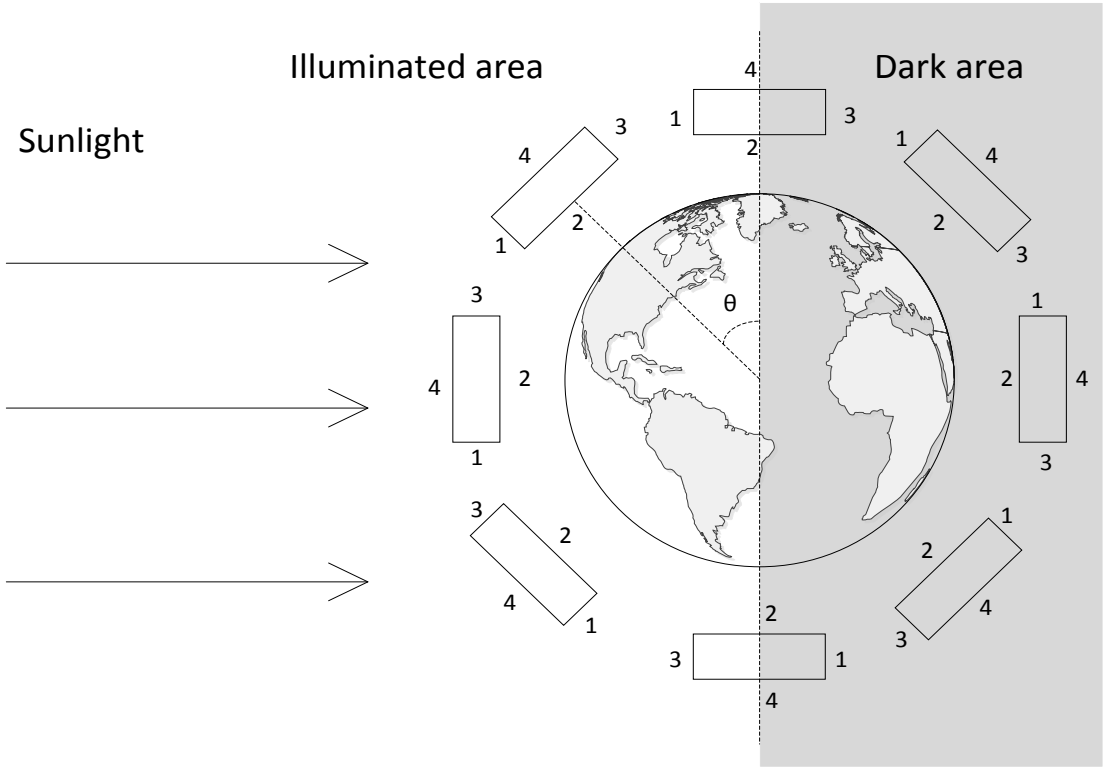
The problem



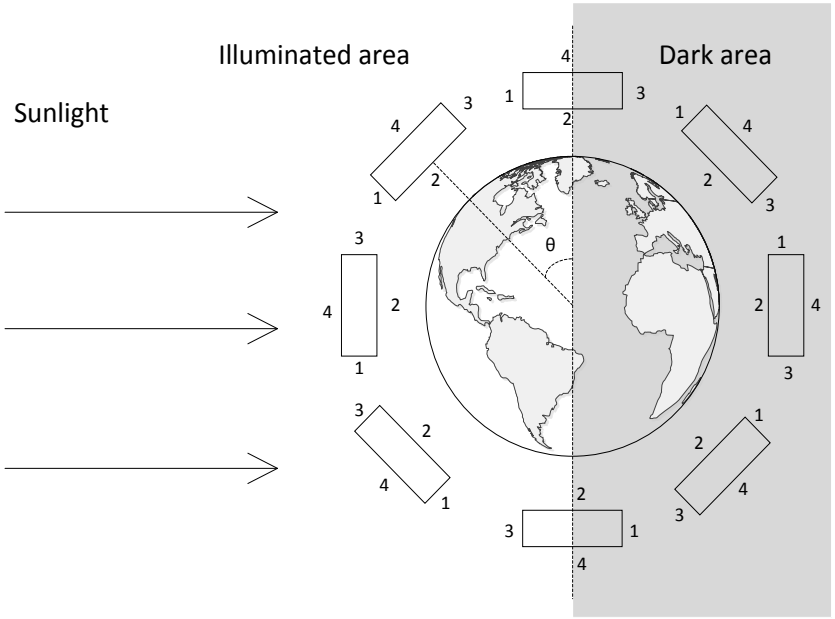


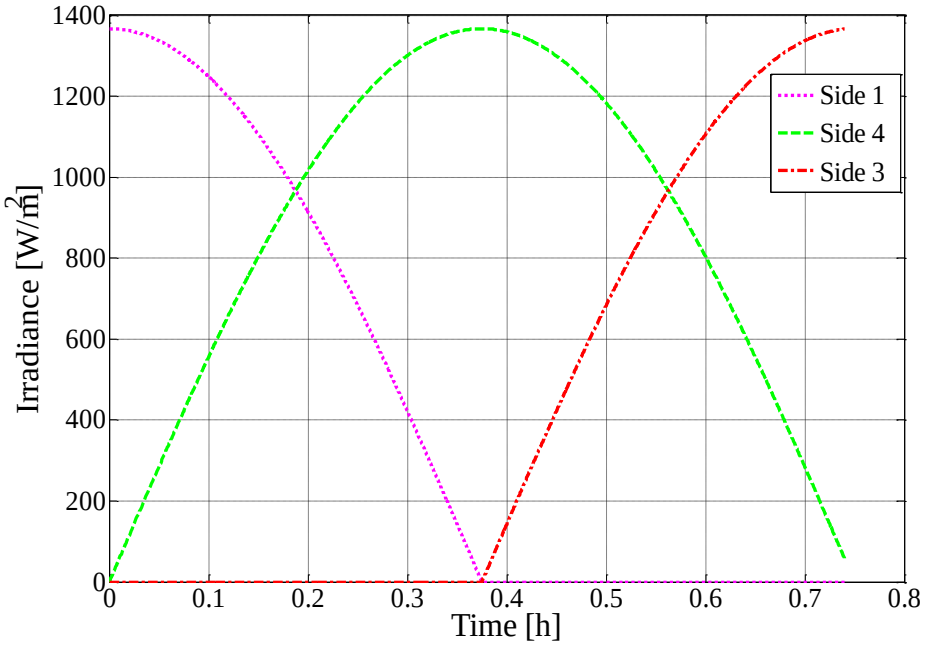
Perturb-and Observe (P&O)
Linear Reoriented Coordinates Method (LRCM)

The problem

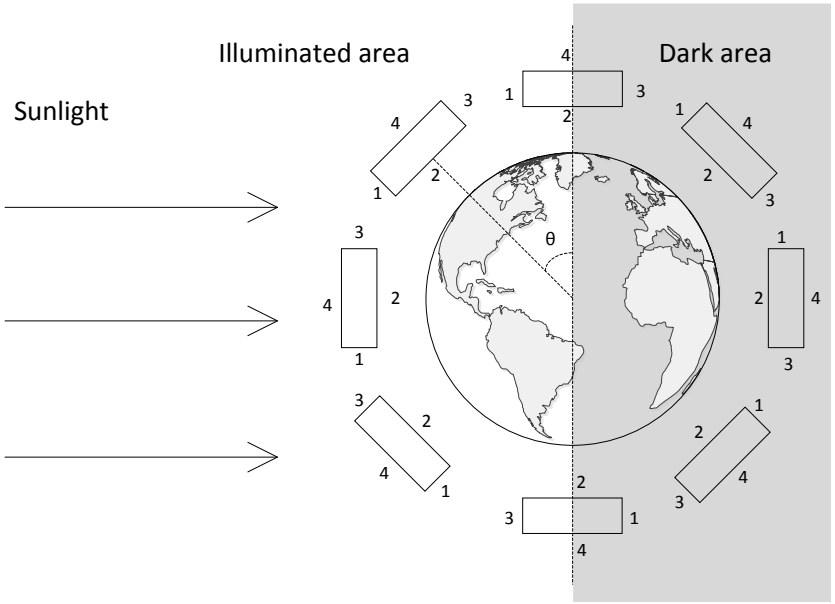


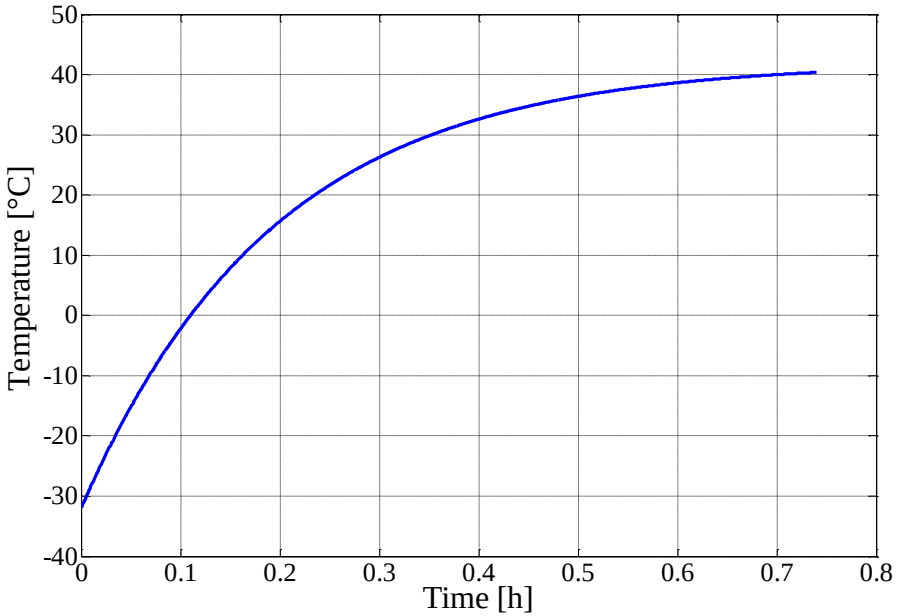
Environment conditions



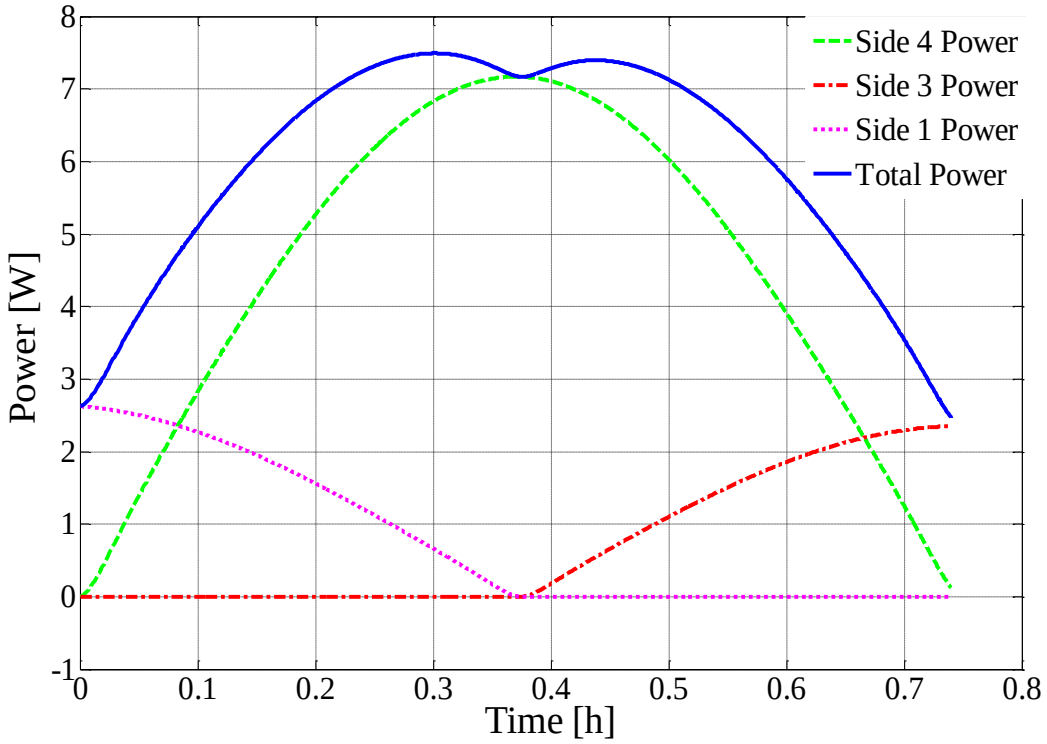


Environment conditions

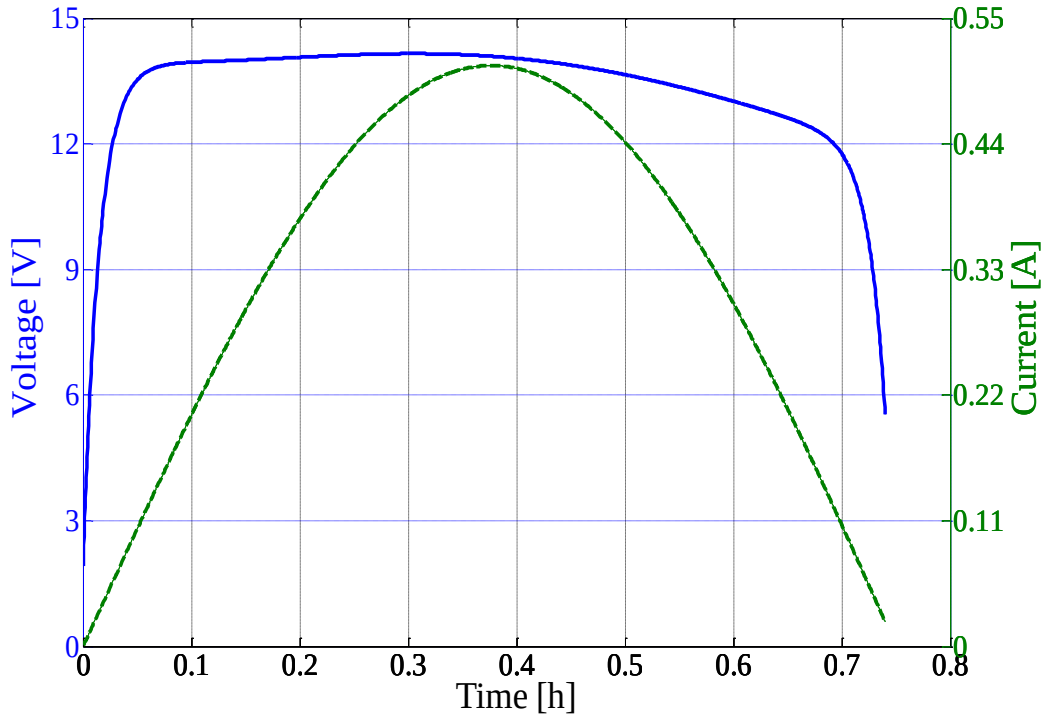




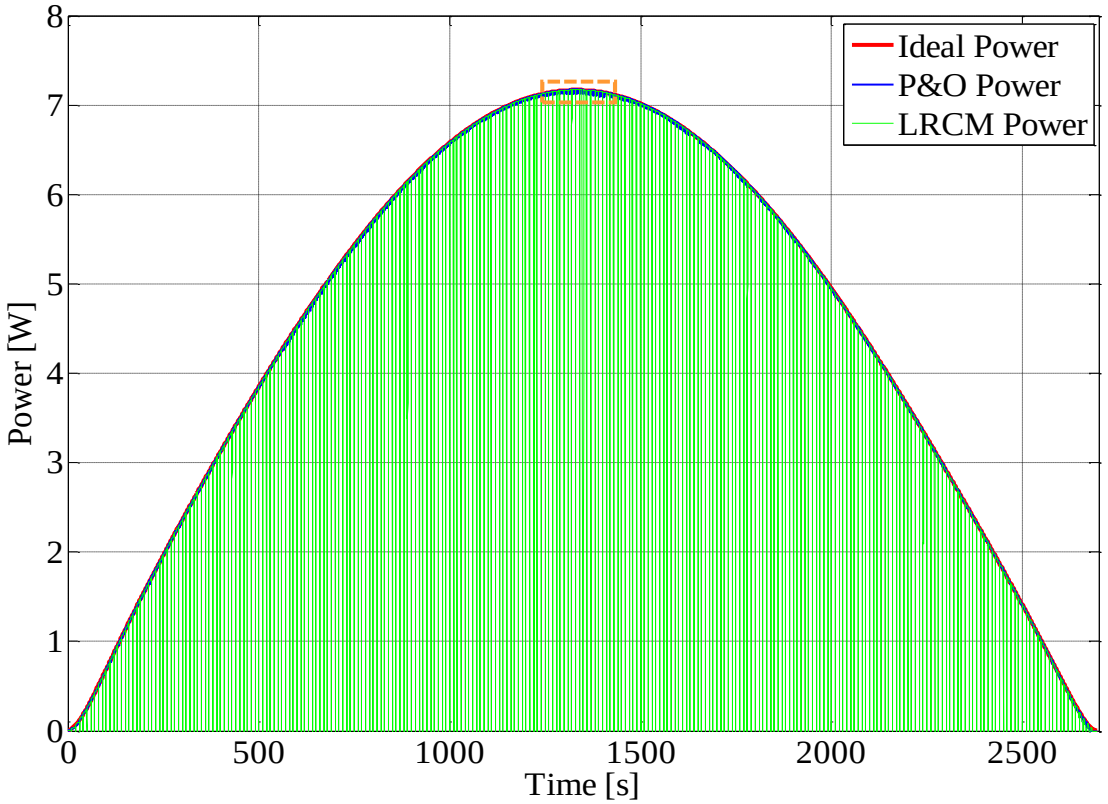
Results


Side 4 Power
Side 3 Power
Side 1 Power
Total Power
Power [W]
Time [h]
8
7
6
5
4
3
2
1
0
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

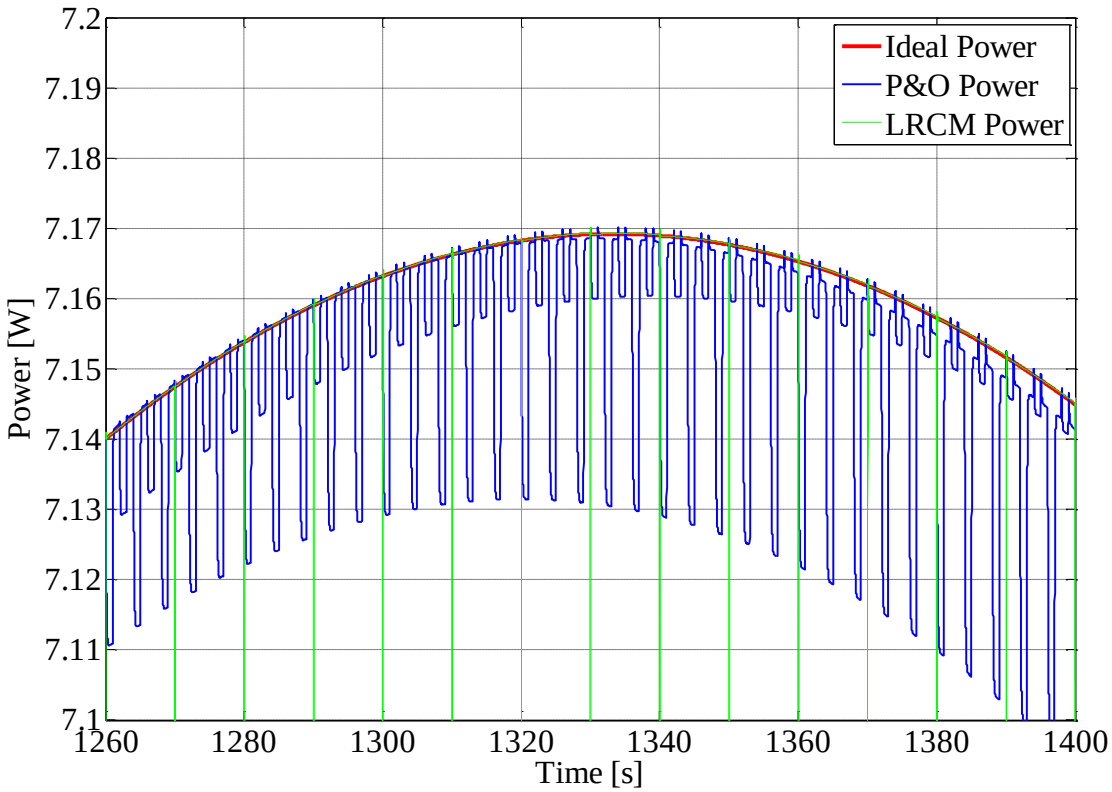
Results


15
12
9
6
3
0
Voltage [V]
0.55
0.44
0.33
0.22
0.11
0
Current [A]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Time [h]

Results


Ideal Power
P&O Power
LRCM Power
Power [W]
Time [s]
0
1
2
3
4
5
6
7
8
0
500
1000
1500
2000
2500

Results


Ideal Power
P&O Power
LRCM Power
Power [W]
Time [s]
7.2
7.19
7.18
7.17
7.16
7.15
7.14
7.13
7.12
7.11
7.1
1260
1280
1300
1320
1340
1360
1380
1400

Conclusions

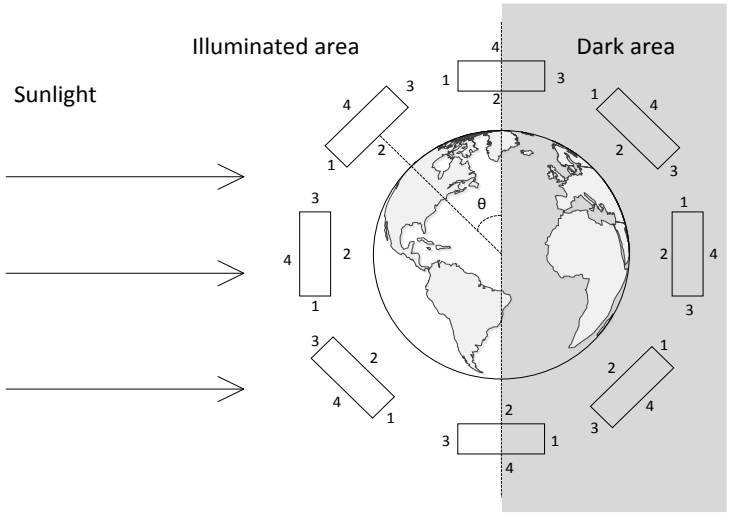
- The ideal operating point of the PV cells was estimated during the orbit sunlight period to be used as a benchmark for the MPPT comparisons
- Both MPPT methods presented a similar performance over an entire sunlight period

Conclusions

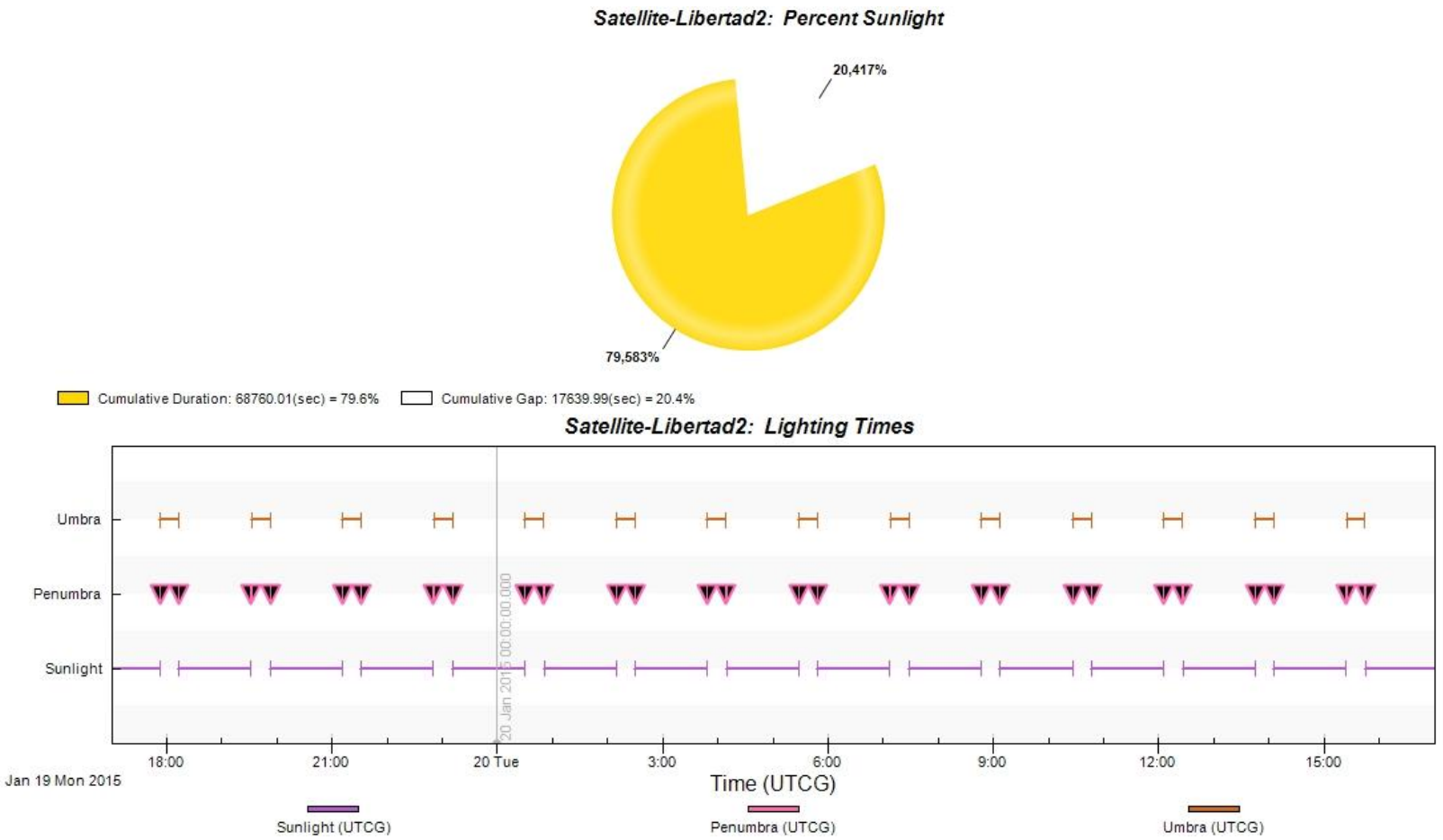
- An effective operation of LRCM requires precision in the mathematical model of the PV panel.
- LRCM could be implemented without the disconnection of the PV panel
- In the case of P&O method, a careful selection of the sampling time and the step size must be done for its correct operation.

Future work

- Different situations without attitude control are being analyzed to know the performance of the MPPT

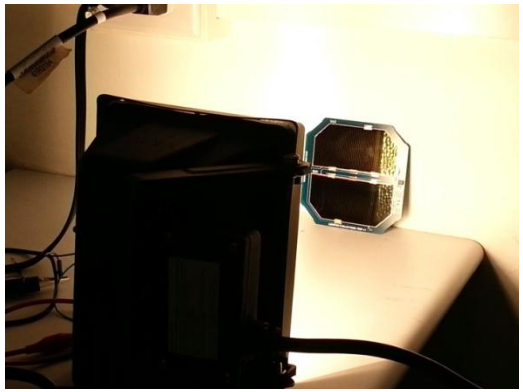


Future work


Satellite-Libertad2: Percent Sunlight
20,417%
79,583%
Cumulative Duration: 68760.01(sec) = 79.6%
Cumulative Gap: 17639.99(sec) = 20.4%
Satellite-Libertad2: Lighting Times
Umbra
Penumbra
Sunlight
20 Jan 2015 00:00:00.000
18:00
21:00
20 Tue
3:00
6:00
9:00
12:00
15:00
Jan 19 Mon 2015
Time (UTCG)
Sunlight (UTCG)
Penumbra (UTCG)
Umbra (UTCG)

Future work

1.Experimental validation



2.Experimental validation

Thank you!

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Questions?

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SATÉLITE LIBERTAD 2 Universidad Sergio Arboleda Ingenierías y Ciencias

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Lighting

Satellite-Libertad2: Lighting

Sunlight Times

Global Statistics

Min Duration	19 Jan 2015 17:00:00.000	19 Jan 2015 17:52:28.764	3148.764
Max Duration	26 Jan 2015 14:08:18.598	26 Jan 2015 15:27:20.599	4742.002
Mean Duration			4699.866
Total Duration			479386.290

Penumbra Times

Global Statistics

Min Duration	19 Jan 2015 17:52:28.764	19 Jan 2015 17:52:53.133	24.369
Max Duration	26 Jan 2015 15:47:13.405	26 Jan 2015 15:47:38.998	25.593
Mean Duration			24.947
Total Duration			5039.383

Umbra Times

Global Statistics

Min Duration	26 Jan 2015 15:27:45.967	26 Jan 2015 15:47:13.405	1167.437
Max Duration	19 Jan 2015 17:52:53.133	19 Jan 2015 18:13:06.544	1213.411
Mean Duration			1191.825
Total Duration			120374.327

Lighting

- Semieje mayor=7100 (700 km sobre la superficie terrestre)
- Eccentricidad=0.009
- Inclinación=98 grados
- Longitud de nodo ascendente=191 grados
- Argumento del perigeo=189 grados
- Anomalía verdadera=0 grados