Escuela Técnica Superior de Ingeniería del Diseño

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Final year project

"Control of an electric propulsion system for a light aircraft"

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Tutor: Ramón Blasco Giménez

Valencia, July 2018

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Introduction & objectives

Problems

- Rise of fuel prices
- Increasing concern for pollution
- Industry at risk

Solutions

- Substitute by electric systems (MEA)
- Eliminate the need for fuel (AEA)

- Reducing fuel emissions
- Keeping the performance of the aircraft the same
- **Replacing the propulsion system of an already existing aircraft**

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Design of components – Batteries and motor

Motor

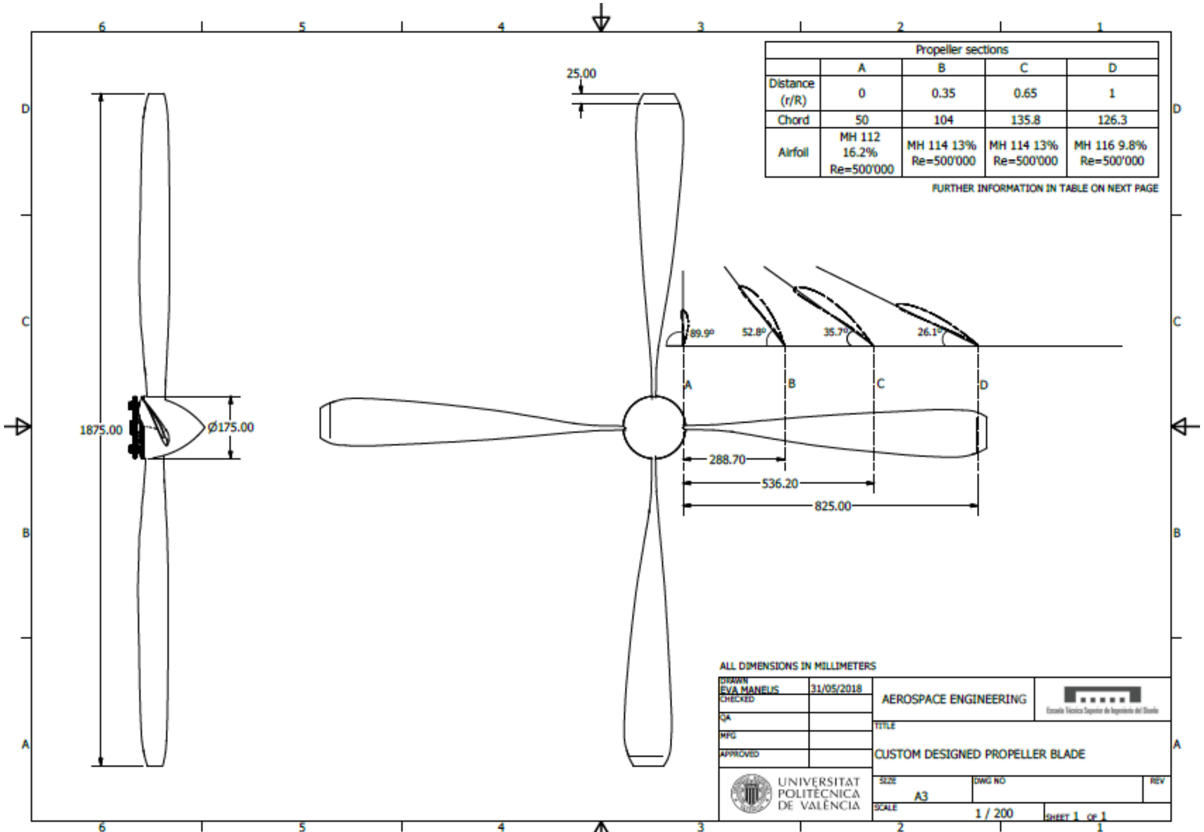
Resistance, R_s (Ω)	Inductance, L_d L_q (H)	PM magnetic flux, λ_m (Wb)	Nominal power (kW)	Max. Angular speed, ω_{max} (rad/s)
0.0112	$7.32 \cdot 10^{-5}$	1.732	180	251

Batteries

Battery energy density (Wh/kg)	Batteries weight (kg)	Batteries energy (Wh)
250	300	75000

Design of components - Propeller

Nº of blades	Diameter (m)	Chord	
		Tip (mm)	Root (mm)
4	1.65	50	126.3



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Implementation - Controller

$$u_d = R_s i_d + L_d \frac{di_d}{dt}$$

$$u_q = R_s i_q + L_q \frac{di_q}{dt}$$

$$T_m = \frac{2}{3} p \lambda_d i_q = \lambda_m i_q$$

→

$$I_d = \frac{1}{R_s + sL_d} U_d(s)$$

$$I_q = \frac{1}{R_s + sL_q} U_q(s)$$

2 PI Controllers

Control parameter	Response time (us)	Settling time (ms)	Overshoot (%)
Isq	740	3.7	11.5
Isd	730	201	7.86

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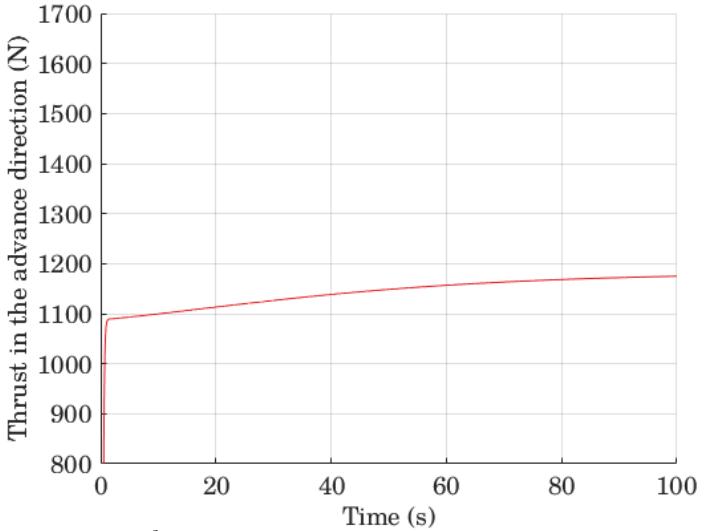
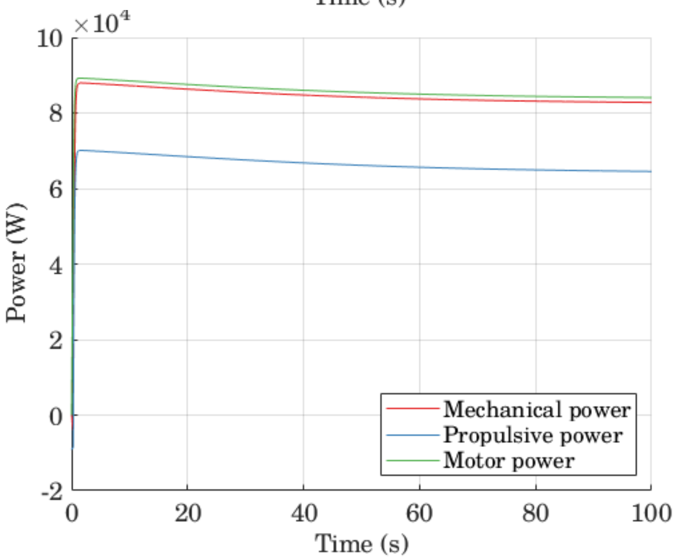
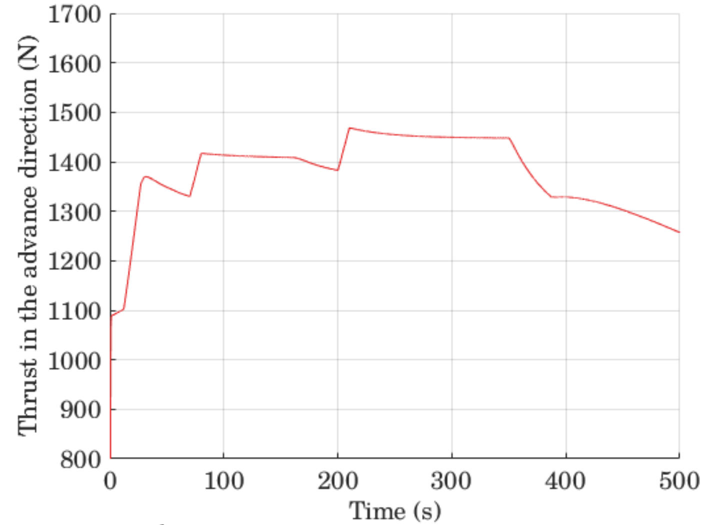
Testing - NORMAL FUNCTIONING

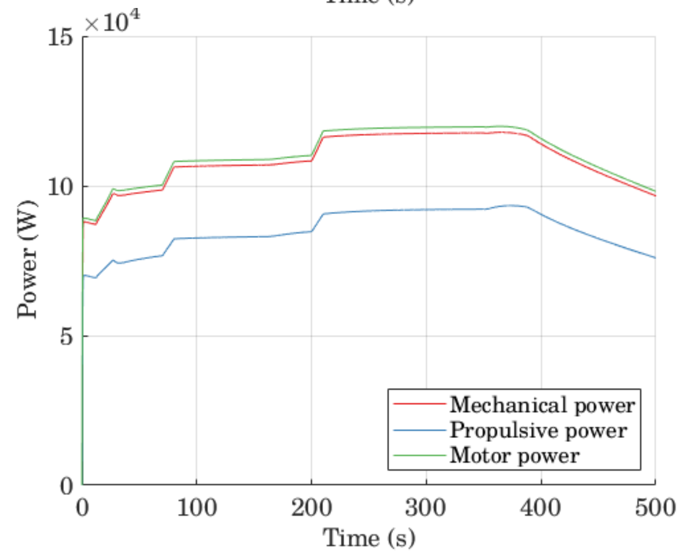
Levelled flight





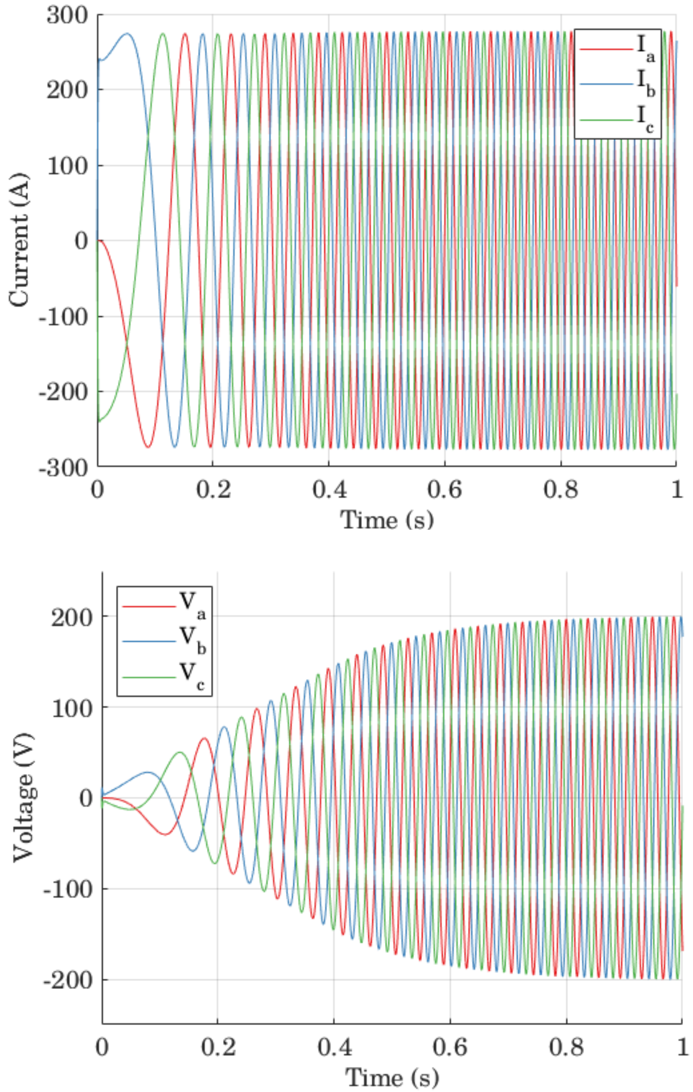
Flight with climbs and descents



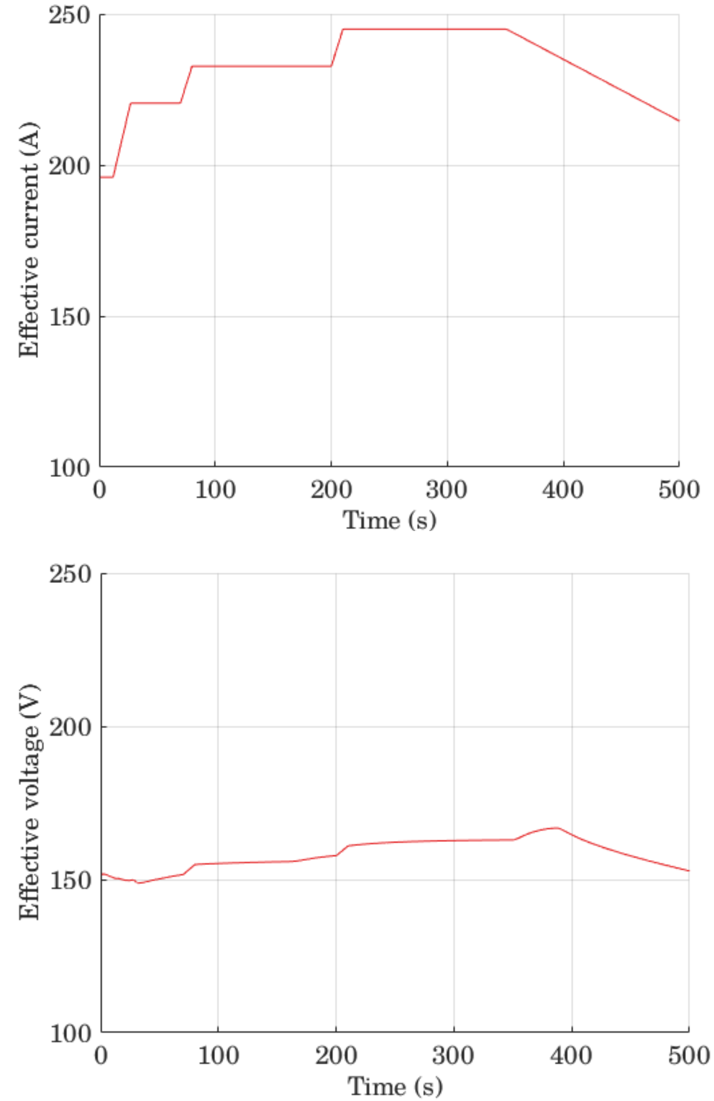


Testing - NORMAL FUNCTIONING

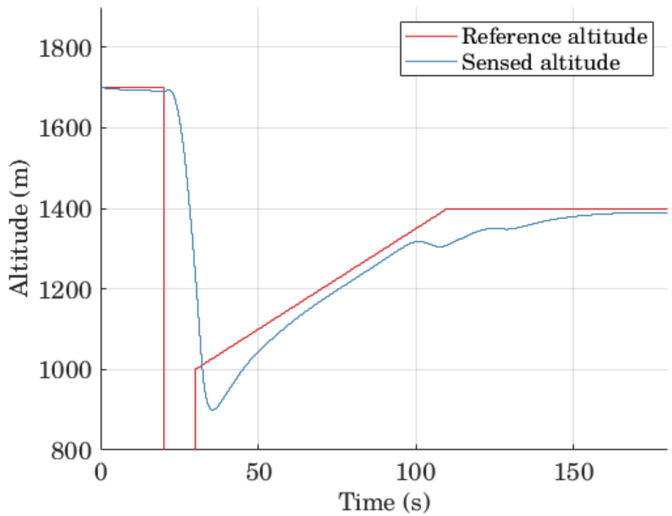
Levelled flight

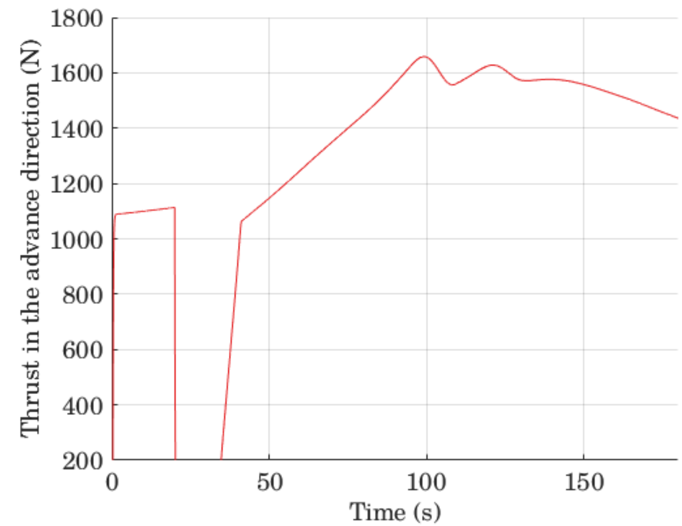


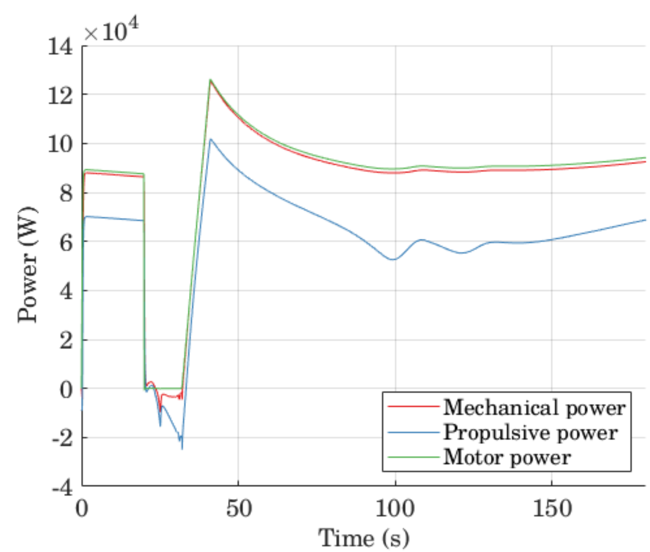
Flight with climbs and descents



Testing - MOTOR FAILURE RECOVERY



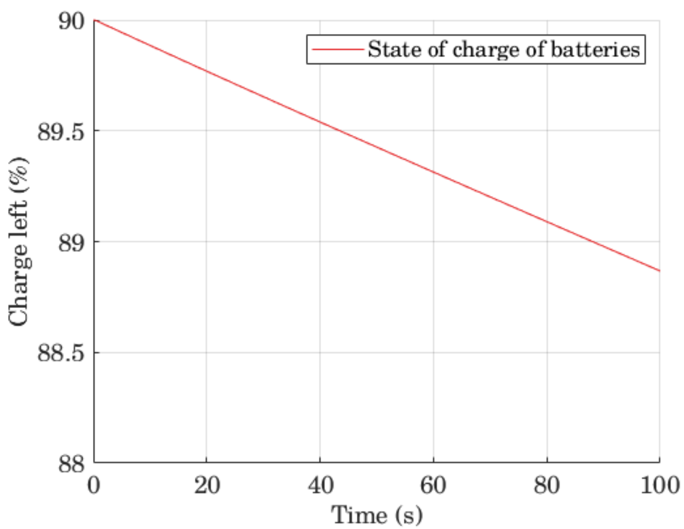




- 20 seconds with motor off and free-fall
- Still does not reach maximum power
- Can recover

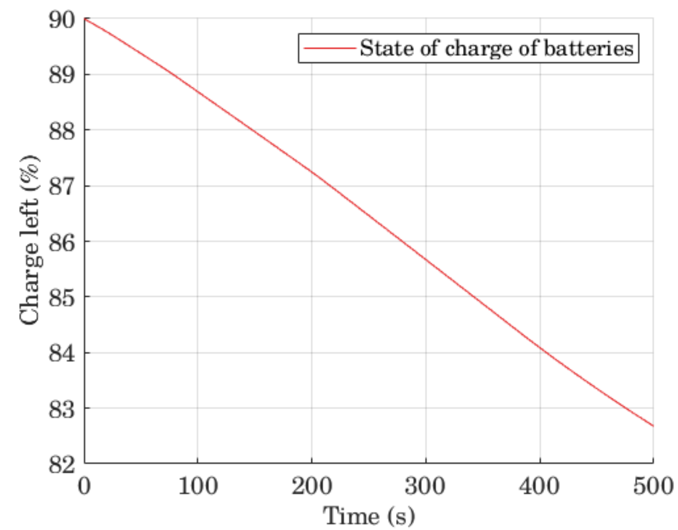
Testing - ESTIMATED AUTONOMY

Levelled flight



- Linear discharge
- Estimated: 106 minutes

Flight with climbs and descents



- Approximately linear
- Estimated: 80 minutes

- **Lower autonomy than fuel counterparts**

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Conclusions

- Lower autonomy
- Lower cost per hour of flight
- Plausible for certain functions and missions. E.g.:
  - Pilot training
  - Airport surveillance

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Budget

Concept	Amount (€)
Group 1	6658.90
Group 2	292.50
TOTAL	**6951.40**
General expenses (15%)	1042.71
Industrial profit (6%)	417.08
TOTAL	**8411.19**
VAT (21%)	1766.35
TOTAL	**10177.54**

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Thank you for your attention