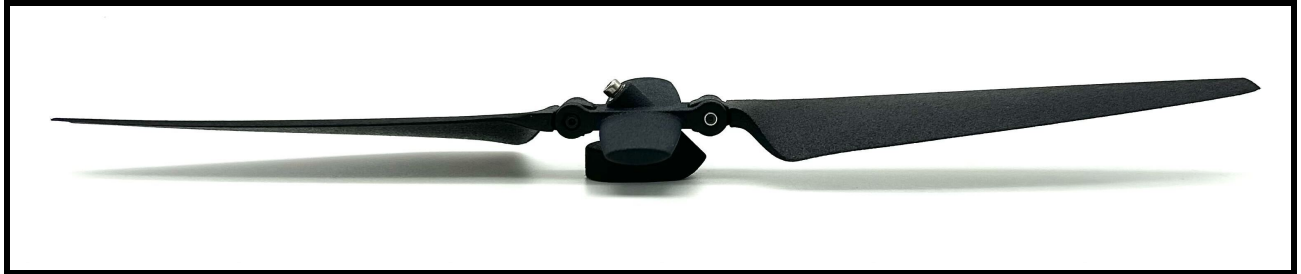


U1.0 and U2.0 | UPF-23-12 - 12" Underactuated Propeller



1 Features

- 3 degrees of freedom with one actuator
- Generate thrust & vector torque in 2 axes
- Enables new vehicle designs
- Increases hover efficiency
- Rated to 50 hours of flight

2 Applications

- Aerial Robotics
- 2 actuator UAV (6 DOF flight)
- Sliding quadrotor (6 DOF flight)

3 Description

The U1.0 and U2.0 (UPF-23-12) is a 12" flapping propeller designed to allow the control of thrust, roll torque, and pitch torque. With this propeller, a hovering UAV can be built with just two actuators. A second actuator could be an additional underactuated propeller in a coaxial, tandem, or tilt rotor configuration. A standard anti-torque rotor similar to a helicopter can also be used. In this case the performance of a fixed-pitch helicopter can be achieved without the use of a swashplate, drastically reducing complexity.

On a standard quadrotor the UPF-23-12 can be used to allow for 6 degree of freedom control by vectoring the thrust of the rotors while using standard quadrotor roll and pitch controls to maintain attitude.

The UPF-23-12 is designed to interface with the Vertiq 23 series modules. It can be controlled using the IQUART communication protocol. Fully supported in PX4 and example code is available for Ardupilot.

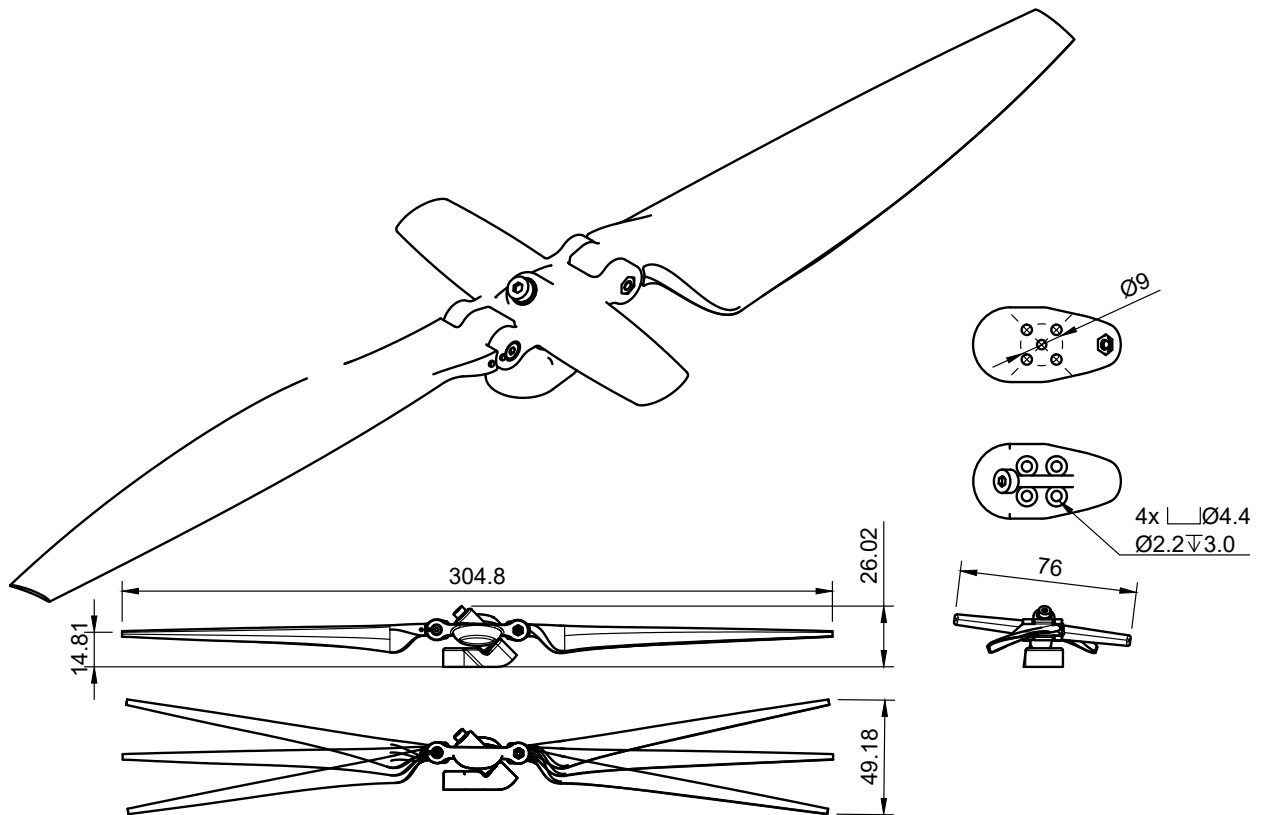
4 Technical Specifications

Table 1: Propeller Specifications

Description	Symbol	Value	Unit	Notes
Diameter	d	12	in	
Pitch	p	4	in	
Mass	m	32.6	g	
Nominal Thrust	$F_{z,nom}$	250	g	
Max Continuous Thrust	$F_{z,max}$	360	g	Thermally limited by Vertiq 23-06 continuous torque
Max Continuous Thrust	$F_{z,max}$	700	g	Thermally limited by Vertiq 23-14 continuous torque
Max Control Torque	$\tau_{xy,max}$	0.17	Nm	At nominal thrust of 250g

5 Mechanical Interface

The UPF-23-12 is composed of a motor adapter, a central hub, and two blades. The adapter interfaces directly with Vertiq 23 series modules via four M2 screws on a 9mm diameter circle. The hub is attached to the adapter via a single 2.5mm shoulder bolt. The blades are then attached with a single 2mm shoulder bolt each. A captive nut in the hub secures the blades when the bolt is tightened.



All measurements are in mm

6 Thrust Performance Data

Note: All data is collected using a Vertiq 23-06 2200Kv module.

Figure 1: Thrust vs Speed

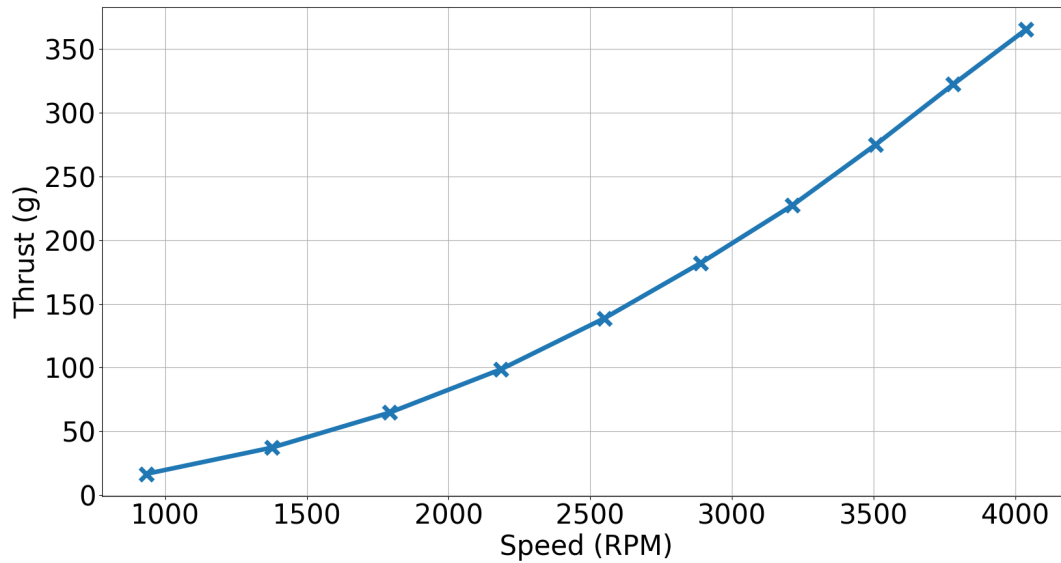


Figure 2: Torque vs Speed

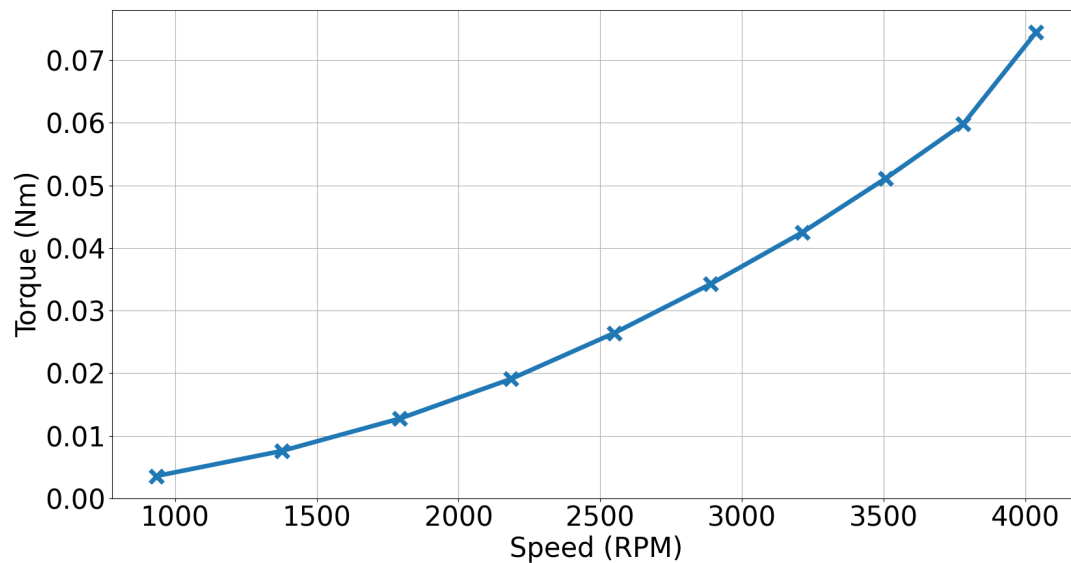
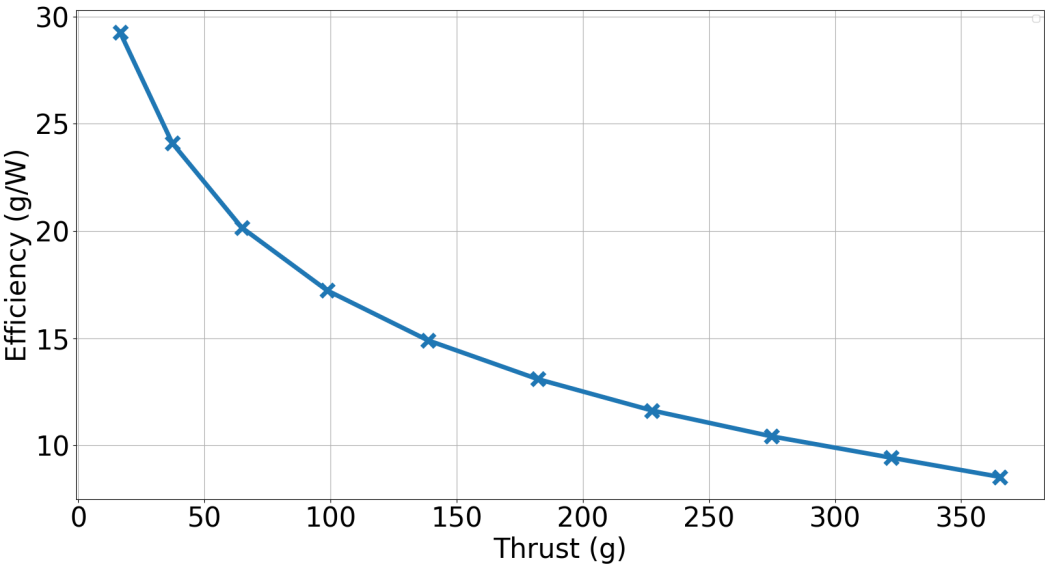


Figure 3: Grams/Watt Efficiency as measured with Vertiq 23-06 2200Kv module



7 Control Performance Data

Figure 4: Maximum Control Torque vs Speed

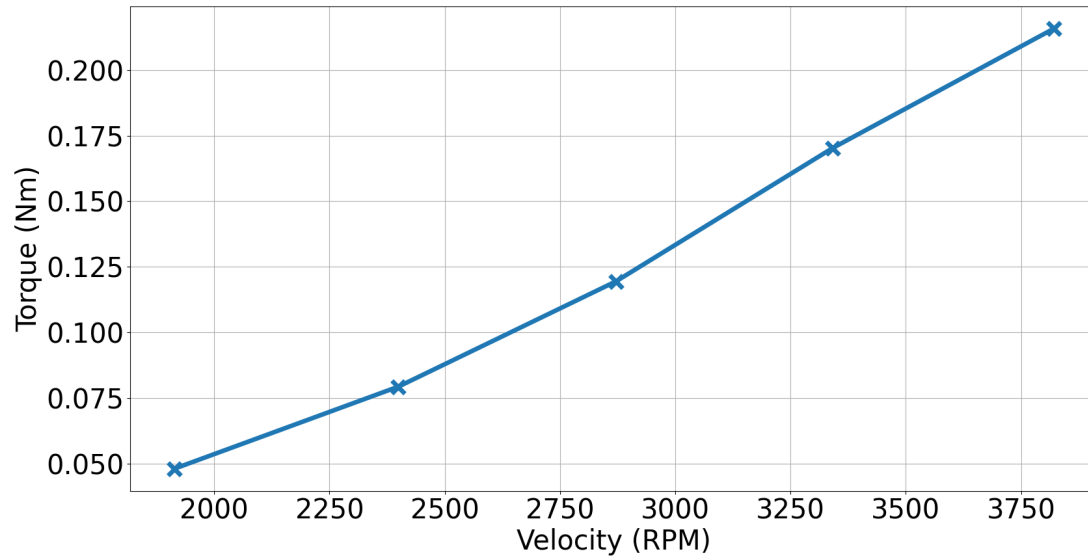
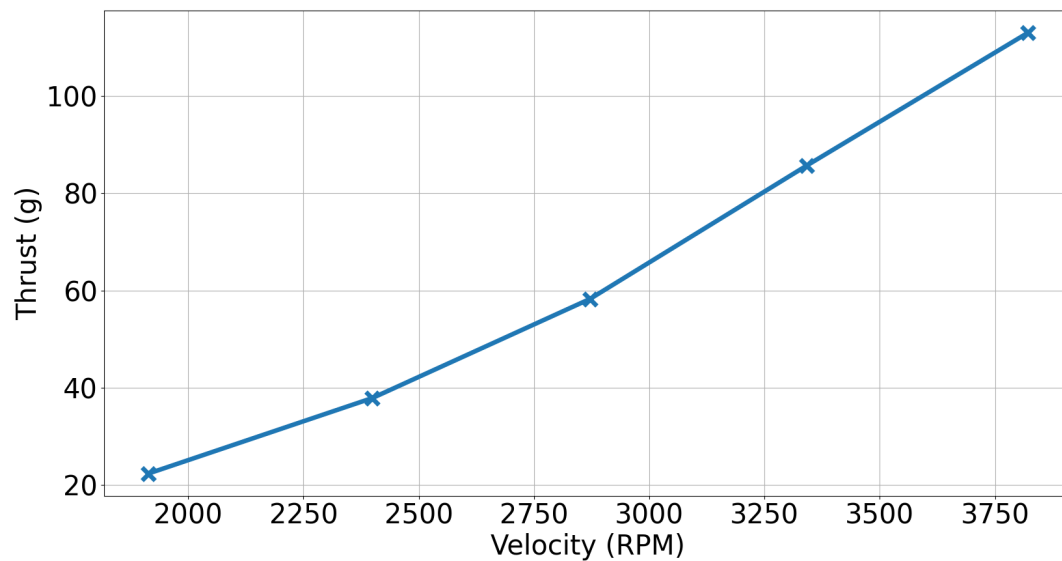


Figure 5: Maximum Control Force vs Speed



8 Torque vs Force Angle

Torque is generated both directly through the main shaft and through a force being offset from the Center of Gravity (CoG) of the aircraft. The direct torque and the torque generated by force appear at different angles approximately 81 degrees apart from each other. The torque generated by force happens forward in rotation of the propeller. Some examples of a CCW propeller are shown below at different heights above CoG.

Figure 6: Torque Contribution and Force at 0.0mm Height

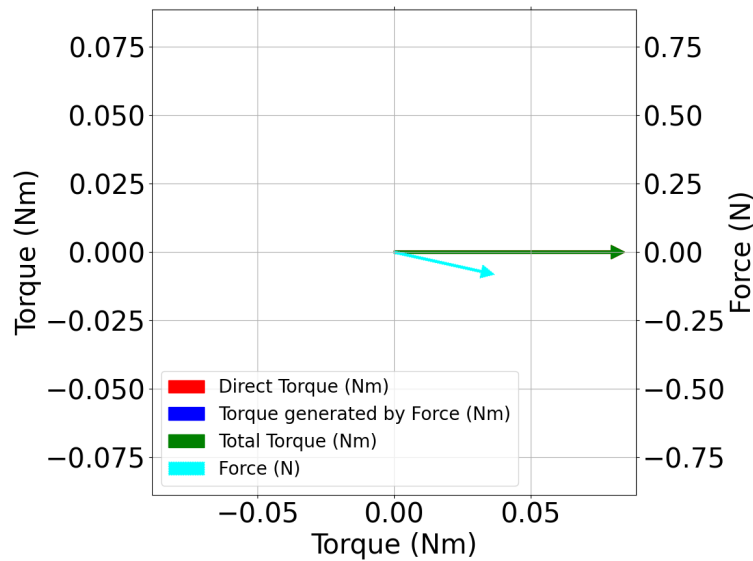


Figure 7: Torque Contribution and Force at 50.0mm Height

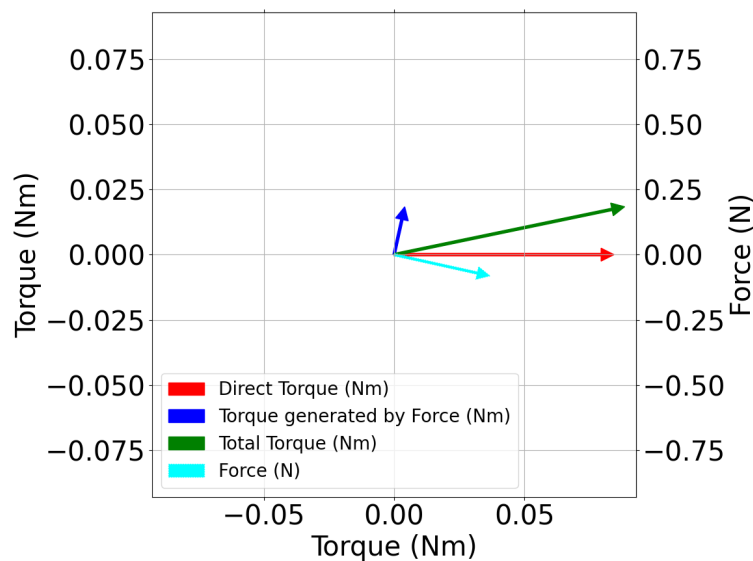
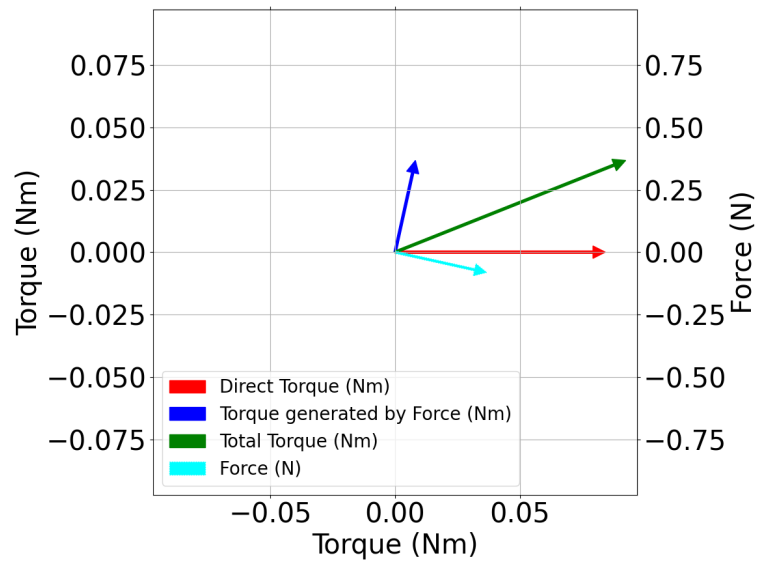


Figure 8: Torque Contribution and Force at 100.0mm Height



9 Additional Documentation

- [Product Page](#)
- [Thrust data](#)
- [Manual, Tutorials, and API Documentation](#)
- [API Libraries](#)

10 Revision History

Table 2: Revision History

Version	Date	Changes
1.0	2024-11-14	Initial Version
1.1	2024-11-14	Changed colloquial name from UP12 to UPF-23-12