Description of Additional Supplementary Files

Supplementary Movie 1: Flapping-wing characteristics.
High-speed video recording (2000 fps) of the flapping stroke motion and passive pitching motion of the robot under 280 V and 88 Hz excitation. In a linear dual-drive configuration operating at high frequencies, significant anchorless deflection of the fuselage occurs. FVW-Fly, designed in this paper, operates in a tuning-fork vibration mode, minimizing energy dissipation caused by fuselage torsional motion and actuator coupling during flapping.

Supplementary Movie 2: Flight performance of the FVW-Fly with and without a self-stabilizing mechanism.
Video recording the flight progress of the FVW-Fly with and without a self-stabilizing mechanism.

Supplementary Movie 3: The takeoff process of the FVW-Fly ascending to a height of 20 cm under different external drive amplitudes (150–250 V).
Video recording the takeoff process of the FVW-Fly ascending to a height of 20cm under different external drive amplitudes (150V-250V).

Supplementary Movie 4: Untethered flight performance—the low-power single-flight duration exceeds 240 s.
The video records the single continuous flight duration of the untethered FVW-Fly system under low takeoff power consumption and medium-to-high takeoff power consumption. During low takeoff power consumption flights, the flight process was recorded from dual perspectives, with a single continuous flight duration exceeding 240 s.

Supplementary Movie 5: Untethered flight performance—reaching a maximum altitude exceeding 10 m.
The video records the flight process of the untethered FVW-Fly system in an open area. Following the drive input, the vehicle ascended vertically, reaching a maximum altitude exceeding 10 m.

Supplementary Movie 6: Flight performance of untethered FVW-Fly system under controlled altitude (25 cm, 50 cm, 75 cm, 100 cm).
Video recording of the fixed-altitude flight progress of the untethered FVW-Fly system at control altitudes of 25cm, 50cm, 75cm, and 100cm. A hover altitude command was set on the controller and transmitted to the untethered flight system via Bluetooth. Upon receiving the command, the robot rapidly ascended to the vicinity of the target altitude.

Supplementary Movie 7: The untethered FVW-Fly system achieved minute-scale altitude-controlled flight at a height of 50 cm.
Video recording of the stable, minute-scale altitude-controlled flight at 50 cm.

Supplementary Movie 8: Disturbance-rejection self-stabilizing flight demonstration of the untethered FVW-Fly system.
Video recording of the repeatable hit disturbance-rejection self-stabilization flight demonstration of the untethered FVW-Fly system.

Supplementary Movie 9: Three-axis torque control under external drive conditions (roll, pitch, and yaw).
Video recording the three-axis torque control of FVW-Fly under external drive conditions.

Supplementary Movie 10: Untethered lift-off speed test of the untethered FVW-Fly system (220 V and 280 V).
Video recording the takeoff process of the untethered FVW-Fly system ascending to a height of 50cm under different drive amplitudes (220V and 280V). The vehicle ascended at different speeds under the two drive signals, taking 1.04 s and 0.49 s to reach 50 cm.

Supplementary Movie 11: Altitude-controlled flight of the untethered FVW-Fly system at target altitudes of 150 and 200 cm.
Video recording the fixed-altitude flight progress of the untethered FVW-Fly system at a high controlled altitude of 150cm and 200cm. After receiving the altitude command via Bluetooth, the flight system rapidly took off to the target altitude and maintained a hover with controllable fluctuations for more than ten seconds.