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Printed-Circuit-Board Structural Airframe for a Lightweight Sealed Transmedium Drone in which Rigid or Semi-Rigid Boards Serve as Load-Bearing Members and Carry Power Electronics and Signal Routing

Promising · 65.7/100 | 12 claims

TECHNICAL FIELD

Airframe and electronics integration for small transmedium unmanned vehicles, specifically the use of printed circuit boards as load-bearing structural members that also carry power electronics and signal routing for a sealed air-and-water craft.

ABSTRACT

A small transmedium drone has an airframe in which one or more rigid or semi-rigid printed circuit boards (PCBs) serve simultaneously as load-bearing structural members, such as rotor arms or bulkheads, and as the carriers of power electronics, electronic speed controllers, and signal routing. Integrating structure and circuitry into shared boards reduces part count and mass relative to a separate frame and separate electronics. Because PCB material is load-limited, the disclosed airframe is scoped to a small craft and the structural boards are reinforced at high-stress regions and supported by a small number of non-PCB stiffeners where needed. For the transmedium and marine environment the structural boards carry a conformal coating and the airframe includes a sealing arrangement that protects the conductors and components against water ingress while the board still bears load. The result is a lighter, lower-part-count sealed airframe for a small air-and-water drone. Known PCB-frame micro-drones and structural-electronics concepts exist; the disclosed advance is the specific load-bearing PCB airframe sealed and conformal-coated for transmedium operation, with reinforcement honestly bounded to a small load-limited craft.

BACKGROUND

Small drones benefit from low mass and low part count. A conventional drone carries a separate mechanical frame and separate electronics boards, so mass and assembly labour are duplicated. The idea of using a printed circuit board as a structural element is known: hobby and research micro-drones have used a single PCB as a combined frame and controller board, and the broader field of structural electronics integrates circuitry into load-bearing parts. However, PCB laminate is a load-limited material; it is stiff in plane but has modest strength, is prone to delamination at concentrated loads, and is degraded by water and salt. For an ordinary dry micro-drone these limits are tolerable, but a transmedium drone that is submerged in water faces water ingress, corrosion of conductors, and pressure loading, and a naive PCB frame would fail in that environment. Prior PCB-frame drones are neither sealed for submersion nor reinforced and conformal-coated for the marine environment, and structural-electronics teaching does not address a sealed transmedium airframe. There remains a need for a load-bearing PCB airframe that honestly accepts the load limits of the laminate by reinforcing high-stress regions and bounding the design to a small craft, while adding the conformal coating and sealing arrangement needed for a drone that crosses the air-water interface and operates submerged.

SUMMARY OF THE INVENTION

The invention provides a transmedium drone airframe in which one or more rigid or semi-rigid printed circuit boards act as load-bearing members and also carry power electronics, electronic speed controllers, and signal routing, reducing part count and mass. The structural boards include rotor arms, bulkheads, or a chassis plate, and conductors and components are routed on or within the same boards. Recognising that PCB laminate is load-limited, the design reinforces high-stress regions, for example at rotor-arm roots and mounting points, and supports the boards with a small number of non-PCB stiffeners where required, and the design is bounded to a small craft within

the strength capacity of the laminate. For the transmedium and marine environment the structural boards carry a conformal coating and the airframe includes a sealing arrangement, such as a sealed enclosure or potting around exposed conductors and connectors, that protects against water ingress while the board continues to bear load. The disclosure acknowledges the stiffness and strength tradeoff and scopes the claims to the sealed, conformal-coated, reinforced load-bearing PCB airframe for a small transmedium craft.

DETAILED DESCRIPTION

FIG. 1 is a perspective view of a small transmedium drone with an airframe formed of structural printed circuit boards including rotor arms (200) and a central chassis board (202). FIG. 2 is a plan view of one structural rotor-arm board (200) showing copper signal routing (204), an electronic speed controller (206) mounted on the board, and a reinforced root region (208). FIG. 3 is a section view showing a structural bulkhead board (210) bearing a power-electronics region (212). FIG. 4 is a detail of a reinforcement at a high-stress region, comprising added laminate plies and a non-PCB stiffener (214). FIG. 5 is a section view of the sealing arrangement (216), showing a conformal coating (218) on the board and potting (220) around an exposed connector. FIG. 6 is a block diagram of the power and signal architecture carried on the structural boards. FIG. 7 is an exploded view showing the reduced part count relative to a separate frame and separate electronics. Referring to FIG. 1 and FIG. 2, the rotor-arm boards (200) are rigid or semi-rigid printed circuit boards that extend from the central chassis board (202) and carry a rotor motor at their tips. The same boards carry the copper signal routing (204) and the electronic speed controllers (206) for the motors, so the structure and the drive electronics are one part rather than two. The boards are dimensioned so that in-plane bending and torsion loads from the rotors are carried by the laminate. Referring to FIG. 3 and FIG. 4, because PCB laminate is load-limited, the high-stress regions, in particular the rotor-arm root (208) and component mounting points, are reinforced by added laminate plies, local thickening, or a bonded non-PCB stiffener (214) such as a light metal or composite insert. The airframe is bounded to a small craft whose rotor and payload loads remain within the strength capacity of the reinforced laminate; the disclosure acknowledges the stiffness and strength tradeoff against a dedicated structural frame. Referring to FIG. 5, for transmedium and marine use the structural boards carry a conformal coating (218) over the conductors and components, and the airframe includes a sealing arrangement (216) such as a sealed enclosure, gasketed cover, or potting (220) around exposed connectors so that water and salt are excluded while the board continues to bear load when the drone is submerged. Referring to FIG. 6 and FIG. 7, the power bus, signal routing, and speed controllers are laid out on the structural boards so that wiring harnesses are largely eliminated, reducing part count and mass. In an embodiment the chassis board (202) also forms a sealed lid of an electronics compartment, combining a structural, electrical, and sealing function in one part.

DRAWINGS

FIG. 1 is a perspective view of a small transmedium drone with an airframe formed of structural printed circuit boards including rotor arms and a central chassis board; FIG. 2 is a plan view of one structural rotor-arm board showing copper signal routing, a board-mounted electronic speed controller, and a reinforced root region; FIG. 3 is a section view of a structural bulkhead board bearing a power-electronics region; FIG. 4 is a detail of a reinforcement at a high-stress region with added plies and a non-PCB stiffener; FIG. 5 is a section view of the sealing arrangement showing a conformal coating and potting around an exposed connector; FIG. 6 is a block diagram of the power and signal architecture carried on the structural boards; FIG. 7 is an exploded view showing the reduced part count relative to a separate frame and electronics.

CLAIMS

1. A method of constructing a transmedium unmanned vehicle, the method comprising: forming at least one structural member of an airframe of the vehicle from a rigid or semi-rigid printed circuit board, the structural member being arranged to bear a flight or submersion load of the vehicle; routing power electronics, an electronic speed controller, and signal conductors on or within the same printed circuit board so that the structural member also carries drive and signal circuitry; reinforcing a high-stress region of the printed circuit board, the airframe being bounded to a load-limited small craft; and applying a conformal coating to the printed circuit board and providing a sealing arrangement that excludes water ingress from the conductors and components while the printed circuit board continues to bear the load when the vehicle is submerged.

2. A transmedium unmanned vehicle comprising: an airframe having at least one structural member formed of a rigid or semi-rigid printed circuit board arranged to bear a flight or submersion load; power electronics, an electronic speed controller, and signal conductors carried on or within the same printed circuit board; a reinforcement at a high-stress region of the printed circuit board; a conformal coating on the printed circuit board; and a sealing arrangement arranged to exclude water ingress from the conductors and components while the printed circuit board bears the load during submersion, the airframe being bounded to a load-limited small craft.

3. The method of claim 1, wherein the structural member comprises one of a rotor arm, a bulkhead, and a chassis plate of the airframe, and a rotor motor is mounted to a tip of the structural member.

4. The method of claim 1, wherein reinforcing the high-stress region comprises one of adding laminate plies, locally thickening the board, and bonding a non-PCB stiffener of light metal or composite at a rotor-arm root or a mounting point.

5. The method of claim 1, wherein providing the sealing arrangement comprises potting an exposed connector and sealing an electronics compartment of the airframe against water ingress during submersion.

6. The method of claim 1, further comprising forming a chassis printed circuit board that simultaneously provides a structural function, a power and signal routing function, and a sealed lid of an electronics compartment.

7. The method of claim 1, wherein routing the signal conductors on the printed circuit board eliminates a wiring harness between the electronic speed controller and a rotor motor, thereby reducing a part count and a mass of the vehicle.

8. The method of claim 1, wherein the airframe is bounded to a small craft whose rotor and payload loads remain within a strength capacity of the reinforced printed circuit board, the bounding accepting a stiffness and strength tradeoff against a dedicated structural frame.

9. The system of claim 2, wherein the structural member is a rotor arm extending from a central chassis board and carrying the electronic speed controller for a rotor motor mounted at a tip of the rotor arm.

10. The system of claim 2, wherein the reinforcement comprises a bonded non-PCB stiffener at a rotor-arm root of the printed circuit board.

11. The system of claim 2, wherein the sealing arrangement comprises at least one of a sealed enclosure, a gasketed cover, and potting around an exposed connector, and the conformal coating extends over conductors and components of the printed circuit board.

12. The system of claim 2, wherein a chassis printed circuit board of the airframe simultaneously bears a structural load, carries a power bus and signal routing, and forms a sealed lid of an electronics compartment of the vehicle.

PATENTABILITY SELF-ASSESSMENT (30-FACTOR)

Patentability	78.0%
Prior-art position	52.0%
Technical merit	60.0%
Commercial	64.0%
Composite genius score	**65.7/100 (Promising)**

FILING ROUTES

United Kingdom (UK IPO)
GB national application at UK IPO with combined search and examination; narrow the independent claims around the sealed, conformal-coated, reinforced load-bearing PCB airframe for a transmedium craft to distinguish over dry PCB-frame micro-drones and general structural-electronics art.

Ireland (IPOI / Irish PATO)
IE 10-year short-term patent suits the incremental subject matter; consider EPO or PCT only if the sealed transmedium integration feature distinguishes cleanly on search.

PRIOR-ART VERIFICATION (LIVE SEARCHES)

UK IPO patent search (Ipsum)
UK national register and file inspection
https://www.search-for-intellectual-property.service.gov.uk/SearchByNumber

Espacenet (EPO)
European/worldwide prior-art search
https://worldwide.espacenet.com/patent/search?q=pcb%20structural%20airframe%20transmedium%

Google Patents
Full-text + family view

IPOI (Irish Patents Office)
Irish national filing route (short-term + full-term)
https://www.ipoi.gov.ie/en/types-of-ip/patents/

https://patents.google.com/?q=(pcb%20structural%20airframe%20transmedium%20drone%20UAV%20transmedium)&type=PATENT

EPO CPC B64U (UAS)
Unmanned-aircraft classification
https://worldwide.espacenet.com/patent/search?q=cpc%3DB64U

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