Fuel Cell UAV

Power Regulation and Temperature Control System

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Contents:

Functionality:

Fuel cell voltage regulation, temperature control, and air feed, along with the main motor on/off control are provided by the electronics described in this document. The 16-36 volt (V) output of the fuel cell is regulated to 12V at a maximum of 1.67 amps (A), and 24V at a maximum of 6.25A.

The fuel cell temperature is regulated by means of fans on the fuel cell itself, thermistor controlled fans on a remote radiator, and a water pump for the radiator. All of these may be turned on/off on these circuit boards, and the hysteresis and temperature set point of the radiator fan control circuit are set on these boards.

Air is provided to the fuel cell by means of a compressor powered and controlled from these boards. In the current implementation, the compressor may only be turned on and off. In a future revision, the compressor will be controlled via a current sensor on the fuel cell power output.

The main motor is enabled/disabled by means of a switch on these boards. This functionality is provided so that the motor can be easily disconnected for testing and maintenance of the fuel cell.

Power Regulation Specifications:

Voltage	**Current Capacity**	**Power Capacity**
Input: 16-36V	4.72-10.6 A	170 Watts (W)
Battery Input: 12V	14.2 A	170 Watts
12 V	1.67 A	20.0 W
24 V	6.25 A	150 W

Implementation:

This system is split into two circuit boards: one holds the 12V voltage regulator, the other holds the 24V voltage regulator.

The 12V board also holds the thermistor control circuit for the fuel cell radiator fans, the relay for the fuel cell fans, the relay for the water pump, and a set of switches to turn the fans, pump, and main motor on and off.

This board has three connectors. The MAIN connector takes in power for the board from the fuel cell and has an output for 12V regulated power. It also connects the thermistor to the board and provides power to the radiator and fuel cell fans. Its pinout is as follows:

MAIN Connector Pinout	
1	12V power for radiator fans
2	Ground for radiator fans
3	Thermistor sensor in
4	Thermistor ground
5	12V power for fuel cell fan
6	Ground for fuel cell fan
7	Motor Controller 1
8	Motor Controller 2
9	12V Regulated Out
10	Ground
11	12V unregulated In
12	16-36V unregulated In

The DAQ connector is intended to be connected to a Data Acquisition System. It has pins for thermistor output, fuel cell output voltage, 12V regulator voltage, and ground. All of these are intended to be connected to high-impedance inputs on a data acquisition system, and should not be loaded heavily. The thermistor output is simply a direct connection to the thermistor input bridge. It is particularly sensitive to loading, and should not be externally tied high or low. It should be directly connected to a high impedance input on the data acquisition system.

DAQ Connector Pinout	
1	Thermistor output
2	Fuel cell output voltage
3	12V regulator output voltage
4	Ground

The third connector is the BACK connector. This is on the rear of the board, and connects to the 24V board. It provides power to the water pump and to the compressor control circuit.

BACK Connector Pinout	
1	12V power to compressor circuit
2	Ground for compressor circuit
3	12V power to water pump
4	Ground for water pump
5	Not connected
6	Not connected

The DIP switch on this board is connected as follows:

DIP Switch Controls	
1	Not connected
2	Radiator Fan enable
3	Main Motor enable
4	12VDC regulation enable
5	Compressor circuit enable
6	Water pump enable
7	Fuel Cell Fan enable
8	Not connected

The switches for the radiator fan, compressor circuit, water pump, and fuel cell fan switch 12V power to the relays for each of these circuits. When the switch is turned off, no power is provided to the relays and the circuit is disabled. The main motor enable switch shorts pins 7 and 8 of the MAIN connector, turning on the motor controller. The 12VDC regulation enable

switch ties the ON/OFF pin of the voltage regulator to the 18-36V fuel cell input, enabling regulation.

The thermistor temperature control circuit for the radiator fans consists of a thermistor-bridge and a reference bridge connected to a comparator. The voltage of the reference bridge (and consequently the temperature setpoint of the temperature control circuit) is adjusted with the TEMPSET potentiometer. The hysteresis of the temperature control circuit is set with the HYSTERESIS potentiometer. This potentiometer is connected so that it sets the sensitivity of the comparator and the sensitivity of the temperature control circuit to changes in temperature.

Finally, there is a slide switch on the 12V board to select the power source for the 12V regulator. The switch selects between a 16-36V supply from the fuel cell and a 12V supply from an off-board preflight unit.

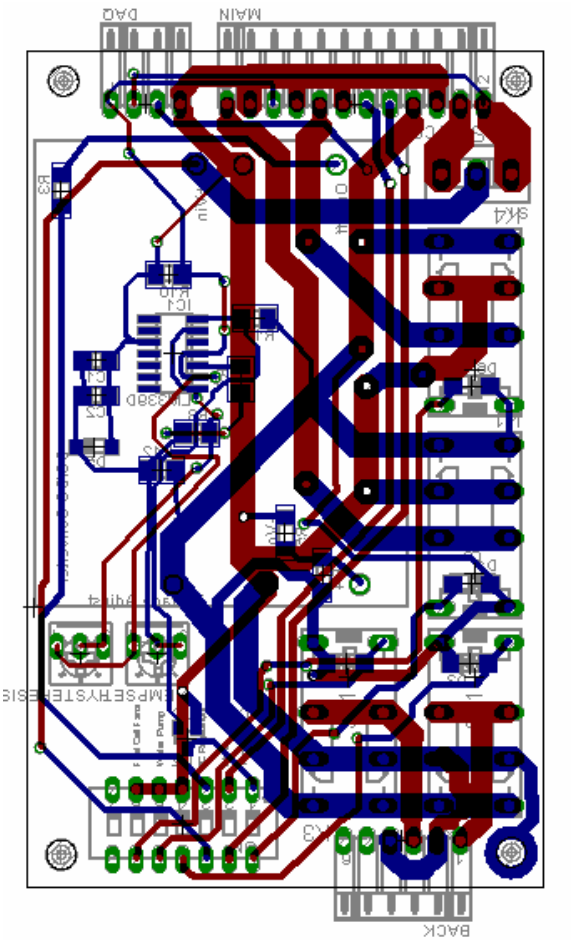

Figure 1: 12-Volt Board Layout

The 24V board, in addition to the 24V voltage regulator, holds the compressor control circuit. In the current implementation, this circuit consists of a relay to switch power to the compressor when the circuit is enabled. This board likewise has three connectors. The 24MAIN connector has an input for fuel cell power, and an output for regulated 24V power.

24MAIN Connector Pinout	
1	24V regulated power output
2	Ground
3	Ground
4	16-36V unregulated in

The BACKIN and BACKOUT connectors replicate the BACK connector on the 12V board. They each have connectors for the compressor and water pump. The BACKIN connector is intended to be connected to the BACK connector on the main board, while the BACKOUT connector is an output to the compressor and water pump.

BACKIN Connector Pinout	
1	12V power to compressor circuit
2	Ground for compressor circuit
3	12V power for water pump
4	Ground for water pump
5	Not connected
6	Not connected

BACKOUT Connector Pinout	
1	12V power to compressor
2	Ground for compressor
3	12V power to water pump
4	Ground for water pump
5	Not connected
6	Not connected

The 24V regulator is connected so that it will always regulate when it is connected to a 9-36V input. The compressor relay's coil is connected through the BACKIN connector to the DIP switch on the 12V board.

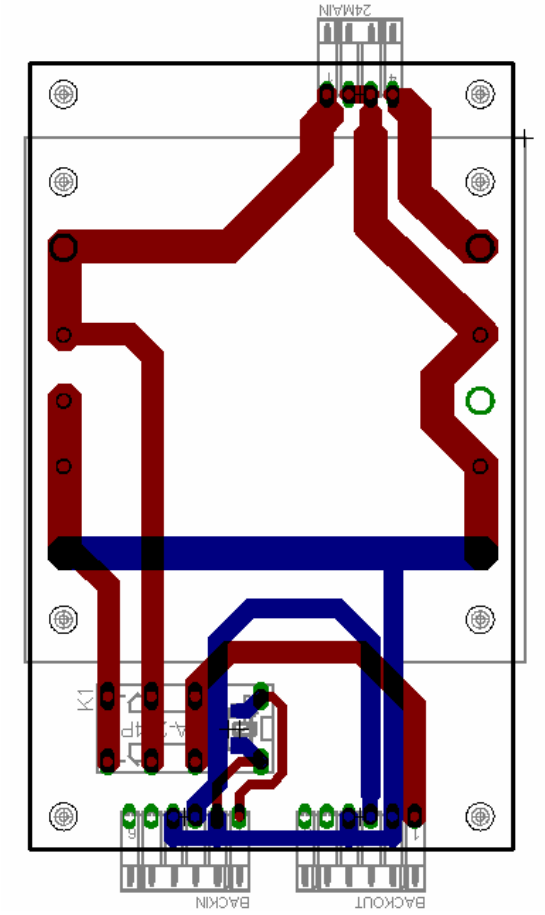

Figure 2: 24-Volt Board Layout

Operation:

The fuel cell power regulation and temperature control system has three operational states. **Off mode** has all the fans, the water pump, and the compressor turned off, and regulation disabled. In Off mode, all the dip-switches on the 12V board should be in the off position. This system should be put in Off mode whenever no power is required for any UAV systems.

In **Preflight** mode, the radiator fans are controlled by the thermistor control circuit, the radiator water pump is turned on, and the compressor and fuel cell fans are both disabled. To engage Preflight mode, switches 2, 4, and 6 of the DIP switch should be turned on, and the slide switch should be in the preflight 12V position. Switches 3, 5, and 7 should be in the off position. Preflight mode is intended to be engaged when the aircraft is being readied for flight, and the fuel cell is being pre-heated. The fans and pump are powered from the off-board battery, and the fuel cell output is disconnected from the 12V regulator.

The third mode is **Flight** mode. This mode is engaged by flipping DIP switches 2, 3, 4, 5, 6, and 7 to the on position, and then sliding the power source select switch to the fuel cell. It is important to configure the DIP switch before sliding the source select to fuel cell, as cooling and air supply should be enabled for the fuel cell before any major load is placed on it. Flight mode is used when the aircraft is ready for flight, and the fuel cell is producing power. All cooling and air supply functions are enabled, as they should be during flight.

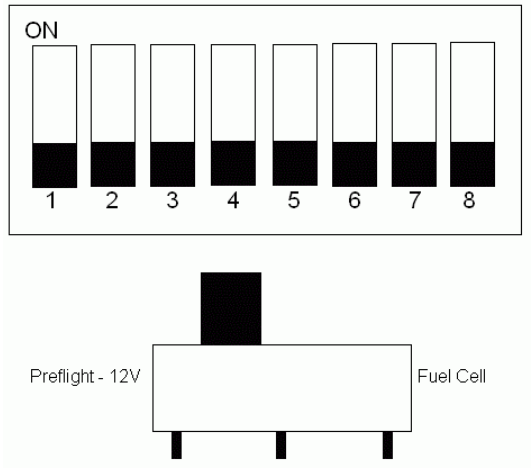

Figure 3: Switch positions for Off mode

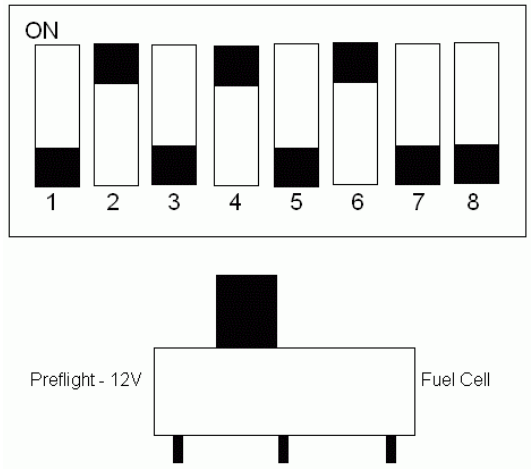

Figure 4: Switch positions for Preflight mode

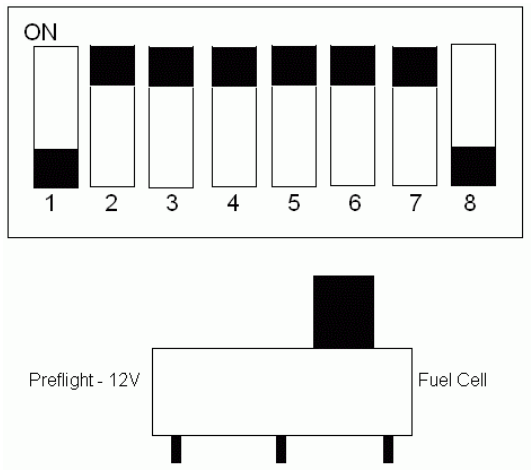

Figure 5: Switch positions for Flight mode