Avionics and Electrical Systems

Wichita State University Senior Design Project Proposal

Cooling Fan Monitor Circuit Board

1 Project Description

This project is to develop a small circuit board that will monitor the tachometer output of a brushless DC cooling fan, and then control a discrete (ground/open) output to indicate if the cooling fan is functioning as intended. The intent is for the circuit board to be small enough that it can be installed in the aircraft wire bundle with zip ties to support aftermarket and late point definition installations with minimal impact to the aircraft and/or maintenance crew.

2 Interface Requirements

2.1 Power Input

The design will be powered from a nominal 28 Vdc power bus; however, the design must operate reliably with the power input ranging from 10 Vdc to 80 Vdc.

The design must utilize only one electrical ground.

2.2 Tachometer Input

The tachometer input will be a square wave that's frequency will be proportional to the cooling fan's RPM. The tachometer signal frequency and voltage range will vary from one application to another; however, this input should be easily configurable (e.g. resistor value changes) to accept either a 0-5 Vdc square wave or a 0-28 Vdc square wave. This input should be able to accept frequencies between 0 kHz and 1 kHz.

2.3 Indication Output

This output should be a discrete output that will provide a ground whenever the cooling fan's RPM is above the defined threshold; otherwise, this output should provide an open (high impedance) output. This output should be capable of sinking 1 A continuously when it is providing a ground.

3 Functional Requirements

3.1 Indication Output Assert

The design shall set the Indication Output to ground if the tachometer input frequency is greater than the defined threshold.

3.2 Indication Output De-Assert

The design shall set the Indication Output to open if the tachometer input frequency is less than the defined threshold minus a hysteresis value; the intent of the hysteresis is to unsure the Indication

Output does not oscillate whenever the tachometer input frequency is operating at, or near, the defined threshold value.

3.3 Threshold and Hysteresis Definitions

The tachometer frequency threshold at which the Indication Output should trip currently is not a known value because testing must be completed to determine this threshold; in addition, the hysteresis value for the indication output currently isn't known because testing must be completed to define this parameter as well. Furthermore, the frequency threshold and hysteresis are values that could change from one application to another; as such these two parameters must be easily configurable on the design without the need for significant re-design. For example, one acceptable means to configure these parameters would be to change resistor values on the design. A practical starting point for the design would be to set the frequency threshold to 70 Hz and the hysteresis parameter to 5 Hz.

3.4 Tachometer Input Filtering

Filtering must be implemented on the tachometer input to ensure the design does not respond to double tachometer clock edges.

4 Packaging Requirements

The design package envelope must be less than or equal to 0.5 inches x 0.5 inches x 1.5 inches. The design's housing should be able to be zip tied to an aircraft wire bundle without risk of damaging the wire bundle…e.g. no sharp edges. The design must be able to be re-worked (e.g. change resistors, replace components) after it has been built and in service without damaging the unit.

5 Environmental Requirements

The design must operate in a temperature environment ranging from -55°C to 85°C. The design must operate at altitudes ranging from -1000ft to 55000ft. The design must be able to pass the DO-160G section 8 Vibration category S curve L test. The design must be capable of operating in a humid environment as defined by DO-160 section 6 category B. The design must be capable of passing the Indirect Effects of Lighting DO-160G section 22 test to category A3J3L3.

6 Design Constraints

The design should not contain any programmable devices (e.g. microcontrollers, FPGAs, PLDs, etc.) because this will add unnecessary complexity and cost to the certification efforts of the design since it will invoke DO-178 and/or DO-254 activities.

The design should avoid using electrical components that only have a single source of supply in order to prevent part obsolescence issues; for example if there a chip that performs a specific function and there isn't any other manufacturers that make similar components in the same footprint, then don't use that component because the Circuit Board will need to be re-designed if that component ever goes obsolete. In general, it is a better design practice to use more generic components (op amps, diodes, FETs, etc.)

than special function chips since these generic components have many alternates and equivalents within the industry.

7 Documentation

The students are expected to produce the following documentation:

- PCB Schematic Files
- PCB Layout Files
- Package Design Files
- A Report That Contains the Following Information for the Design:
    - Detailed Functional Description
    - Detailed Description of How to Set the Frequency Threshold and Hysteresis Parameters
    - Results From Any Testing that Was Accomplished to Prove Out Design

8 Design Reviews

It is recommended that the students hold design reviews with Textron Aviation throughout the design. The following are the suggested reviews; however, the students are welcome to reach out anytime they need additional direction or guidance.

- Schematic Review after proof of concept testing is complete and prior to layout of PCB
- PCB Layout Review after layout is complete and prior to ordering boards
- Packaging Review after package is designed and prior to ordering material