Galvanic seperation inside modern ECU/FADEC (Engine Control Units) for RC model aircrafts micro turbines

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Situation

In our RC Jet model sport we see the use of micro turbines in a thrust range of 15N up to above 300N. All of these turbines have in common that they are controlled via a FADEC or ECU with a microcontroller inside.

These turbines produce thrust via hot expanding air in a typical range of 500-800°C. Big turbines in the range of 300N can have a kerosene consumption of up to 1000mL/min.

Both of these points, the hot air and the fuel flow inside a plastic tubing can create an effect so called ESD.

ESD stands for: Electro-Static-Discharge

A thunderstorm lightning strike in bad weather condition is a big Electro-Static-Discharge (ESD). Many people have experienced on a dry winter day an ESD. If you walk inside your home over the floor it can happen that the human body is electrical charged to a couple of thousand volts. A touch to a metal plate that has ground earth potential…

…yes, you felt then probably a short electrical pulse strike!

ESD is very dangerous for all electronic circuits.

It can partly or totally destroy your expensive RC electronics with in a micro second. Imagine an ESD pulse would occur during your flight. 1000, 2000 or even 5000Volts close to your RC electronic system. A very bad and dangerous situation.

Even a couple of volts above the nominal rated max. operating voltage wich is typically 3,3 or 5Volts for a semiconductor can damage the device.

The following picture was taken inside a turbine jet close to the main tank.

This picture was capured from a video that was visible at the ACT Europe webside from Mr. Westerteicher. Unfortunatly this video is no longer available on the web. You can clearly see an ESD flash from the tank tubing.

Like discussed before there are two areas were an ESD flash can occur.

1. Kerosine pumped through a plastic tank tubing.

2. High airflow hot and cold inside the RC airframe. Very critical in a fiber or carbon fiber composite airframe or fuselage.

Remember, you always generate a high electrostatic potential/voltage if two isolator grind together side by side.

Facts and practical operation

Coming from the above situation we should expect and see massive broken ECU turbine controllers. From a practical operation view this is not true. Thanks to clever engineering and a good semiconductor building design. There are two points to make an electronic ECU design robust against ESD.

1. Implementing a galvanic separation circuit, isolating the ECU against the RC receiver/servo power rail and signal bus.

2. Protecting surpressor diodes inside semiconductors, for example I/O ports at microcontrollers. Or they are attached to PCB (Printed circuit board). Unfortunatly you can`t protect all semiconductor with this type of diode or technology. Below in the table you can see some semiconductor examples in a category robust or non robust.

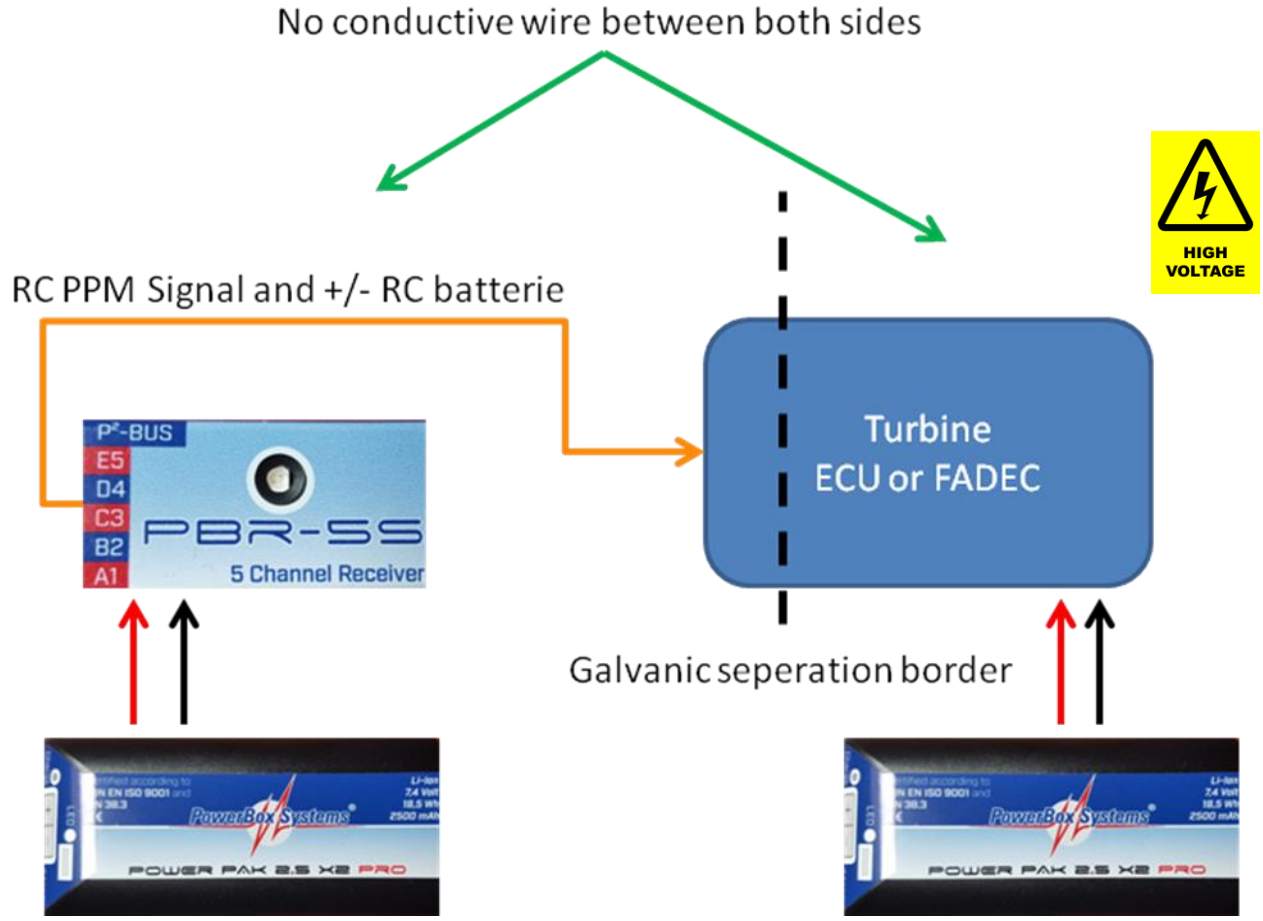
Type of semiconductor device	**Robustness against ESD**	**Used in…**
Resistor passiv	Very robust	…all electronic circuits
Capacitor	Medium robust	…all electronic circuits
Biploar Transistor	Medium robust	…all electronic circuits
MosFet Transistor	Critical not robust against ESD	…Brushless ESC motor controller
All „GaAs“ semiconductor. (WLAN 2.4GHZ chip sets)	Critical not robust against ESD	…high frequency preamplifier and mixing stage. Mainly found in the HF part of RC transmitter and receiver
Microcontroller (MCU Atmel, PIC or STM for example	Medium robust	…RC transmitter, receiver, turbine ECU´s, telemetry circuits and ESC motor controller

Under these circumstances it is a no brainer that we must protect and secure the WLAN chip sets inside our RC receiver from a possible ESD.

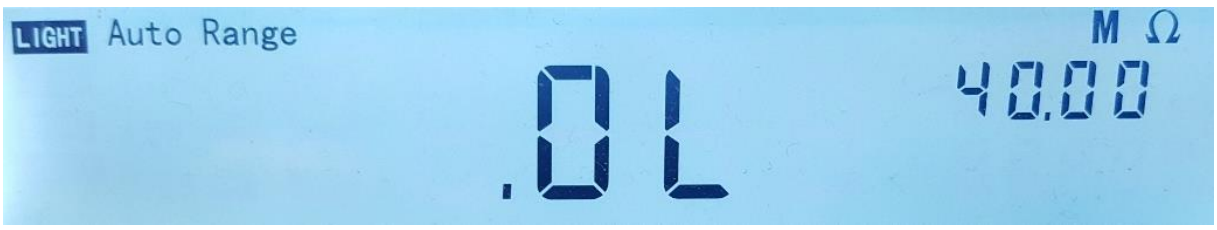
At this stage we come back to point #1 the galvanic separation of the RC / ECU power and signal wiring. How is this achieved?

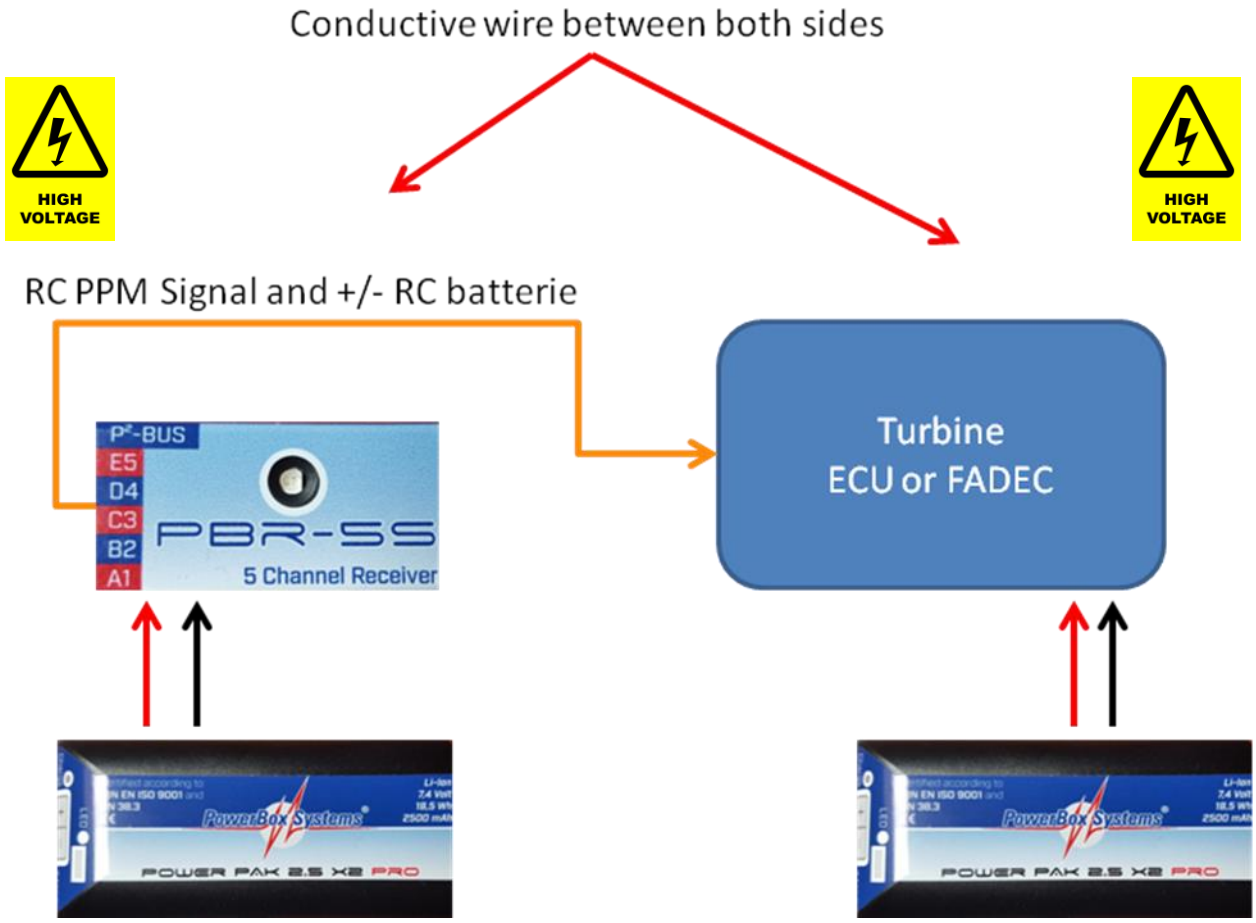
Typically the galvanic separation circuit is build in the ECU or FADEC turbine controller. Technical a type of opto coupler or magnetic separation chip is used in order to achieve this required level of security.

Unfortunately you will find ECU´s with **or** without galvanic separation in the market. The two pictures below will illustrate the situation.



If you take an ohm meter and connect one lead of the instrument to the receiver minus GND pin and the other lead to the minus of the ECU/Fadec. If you measure high resistance in the range of some mega ohm. Please see ohm meter picture below as an example. Then your ECU has a galvanic separation.





If you would make the same ohm meter measurement in the above installation with the conductive wire of the ECU that has no galvanic separation circuit, then you would get the following result.

0.5Ohm, close to zero! This is more or less the conductive wire between ECU and receiver that you measure. By the way, everything less than 100K ohm is rated as conductive. This ECU has no galvanic separation. In case that an ESD would occur, this voltage pulse then can easily damage or destroy the sensitive 2.4Ghz chip set at the receiver side. In the installation with the galvanic separation this **can`t** happen.

If you have followed and read this “White Paper” until here, I´m pretty sure you will ask yourself the question what type of ECU/Fadec has the high security level of a galvanic separation and what type not.

If have to apologize, as the author of this document I will not start an ECU bashing at this point. Build your own opinion, use the above ohm meter method in order to identify a ECU with or without galvanic separation. I know 7 different ECU types in detail. 4 ECU units have a galvanic separation, 3 not.

One step further and conclusion

Even if you have identified that your ECU has the good galvanic separation, make sure that no additional circuits or wiring will by-pass it.

Candidates for a bad galvanic separation by-pass are:

- Use of a common battery for RC receiver and ECU
- Telemetry ECU data converter with no galvanic separation
- Telemetry ECU kero pump current measurement with no galvanic separation
- Ideas of connecting all electric circuits inside a turbine jet to a common ground

If you have identified that your ECU has no galvanic separation, don`t worry there are solutions in the market that can establish a separate galvanic separation outside the ECU.

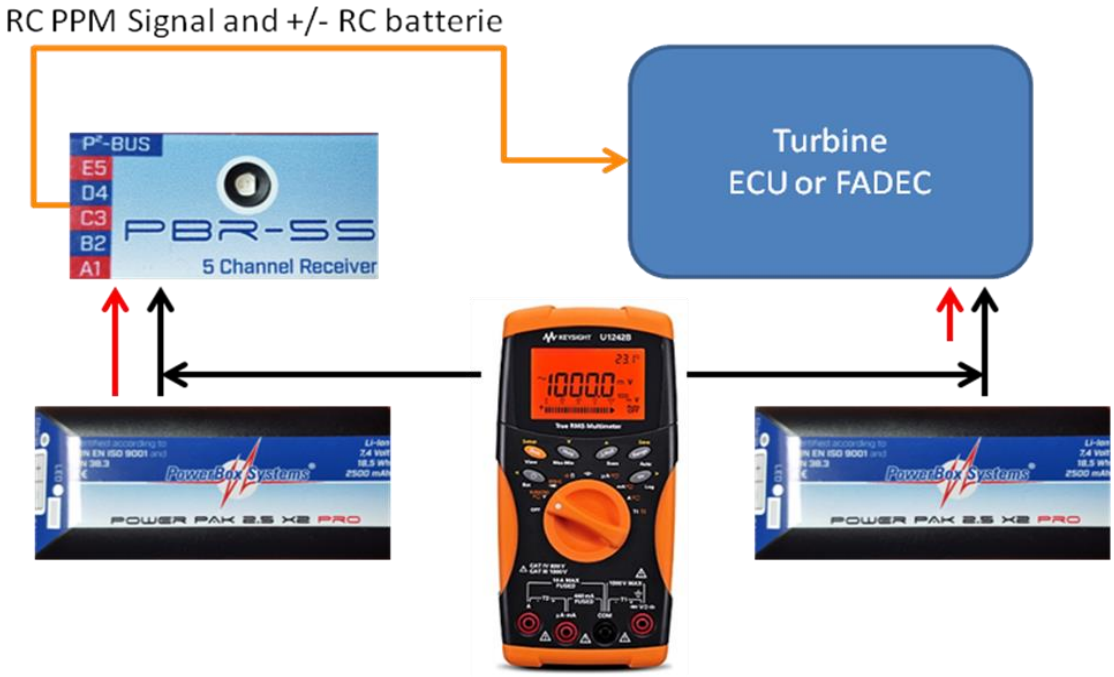
In order to summarize the situation:

1. Never operate and fly your micro turbine jet without a galvanic separated ECU
2. Check from time to time your galvanic separated ECU with the ohm meter test
3. Check your electrical RC and ECU turbine installation on a regular basis, i.e range test

If you have further question don`t hesitate to contact the author under the following e-mail: d.bubley@t-online.de

Appendix: Ohm meter test

Ohm meter test for galvanic separation



...or

Ohm meter test for galvanic separation with telemetry