First Hardware Platform for Wireless Avionics Intra-communications (WAIC)

C. Hennemann, D. Piguet, P. Dallemagne

Today, wired sensors are used for monitoring the condition of aircraft engines, airframes, structures, gearboxes, etc. Wireless Sensor Networks promise unprecedented operational benefits, such as reduced airplane sensor wiring costs and weight. To this end, the aeronautic industry proposes the Wireless Avionics Intra-Communications (WAIC), a new radiocommunication standard between avionics components. CSEM designed and implemented one of the first WAIC band transceiver demonstrators, which will connect wireless sensors to a Wireless Data Concentrator.

An Airbus A380-800 contains around 100'000 wires for a total length of 470 km and a mass of 5700 kg. 30% of these electrical wires could be replaced by wireless communication, more given redundancy (as the wiring is usually doubled or even tripled), bringing advantages in terms of added diversity and lower weight.

The frequency band 4200 to 4400 MHz was recently allocated to the aeronautical WAIC standard. The technical conditions for the use of WAIC systems operating in the aeronautical mobile are described by the ITU [1] (ongoing process).

CSEM has been active in the domain of wireless aeronautic application for years and has delivered numerous demonstrators and prototypes of innovative wireless solutions for aircraft monitoring and control. Recently, CSEM developed and tested a first WAIC proof of concept platform, addressing a transceiver front-end system architecture operating in the target WAIC frequency band (4.2 to 4.4 GHz).

The up/down frequency conversion requires the distinction between the transmission (Tx) and the reception (Rx) channels in order to run the TDMA protocol. Only the 2.4 GHz transceiver (TRX) knows the operating mode (Tx, Rx, sleep, idle...) and can externally provide this information to correctly drive the frequency converter (Tx or Rx mode). Figure 1 depicts the architecture using two switches.

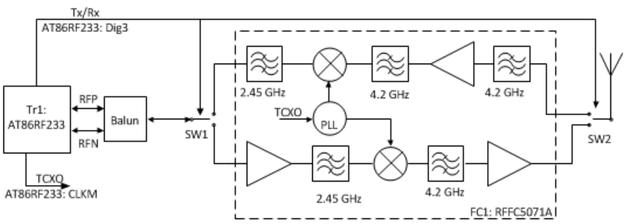

Figure 1: WAIC architecture using two switches.

Alternatively, we can use an RF circulator, which allows for separation of the TX and RX paths. With this architecture, there is no need for a control signal (TX / RX), as shown in Figure 2.

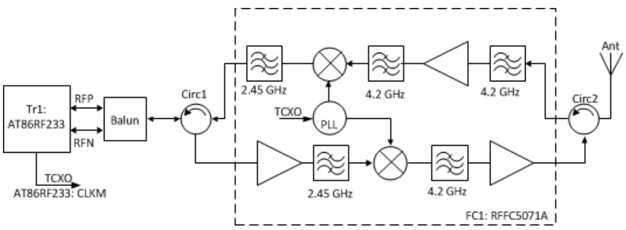

Figure 2: WAIC architecture using two circulators.

Figure 3 illustrates the implementation based on the latter architecture employing an RF circulator.

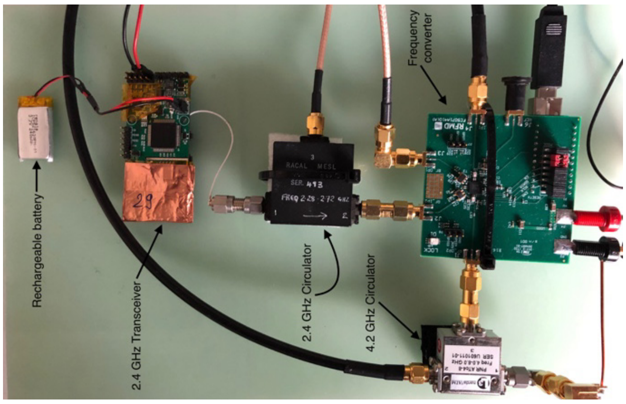

Figure 3: Implemented platform.

The Packet Success Rate (PSR) was measured with and without the up/down converter (4.4 and 2.4 GHz) to evaluate the frequency conversion implementation. The PSR is defined as the ratio of the number of correctly Rx packets divided by the number of Tx packets. The table below summarizes the results.

Frequency	Rx Packets	Tx Packets	PSR [%]
2.4 GHz	346'500	382'845	90.5%
4.4 GHz	385'842	406'493	94.9%

The 4.4 GHz system was found to perform better, despite the conversion electronics, as it avoided interference in the crowded 2.4 GHz ISM band due to, *e.g.*, WiFi and Bluetooth, which creates collisions, degrading the performance of the TDMA system. The addition of a frequency converter does not modify or degrade the performance of the original 2.4 GHz TRX. Further tests will be performed in a representative environment and protocol research will focus on solving the radio altimeter coexistence issue.

Additional characterization will be performed in a real environment consisting of sensor nodes and one Wireless Data Concentrator (WDC) organized in star topology. Ultimately, the sensor node will be energy-autonomous and will measure physical quantities such as strain, acceleration or electrical current, which are transmitted in real-time to the WDC, via the TDMA protocol developed by CSEM for aerospace applications. This protocol requires a half-duplex TRX, among other requirements, which are met by the experimental WAIC platform. In addition, WAIC is partly shared with the radio altimeter band, which brings challenging coexistence issues that CSEM ambitions to solve in the near future.

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[1] ITU-R M.2085 and ITU-R M.2319 recommendations (in progress).