Transponders for an Identification Friend-or-Foe (IFF) System

Introduction

Identification Friend-of-Foe (IFF) is an identification system currently used in the military for the command and control of military vehicles and fighter aircrafts. An IFF transponder system is capable of receiving a RF signal and transmitting a RF signal of its own. It "enables the military and civilian air traffic control interrogation systems to identify aircraft, vehicles or forces as friendly and to determine their bearing and range from the interrogator [1]." IFF systems are widely used in military for the identification of a friend or a foe in unmanned areal vehicles (UAVs) and aircrafts. This technical review briefly summarizes some commercially available transponders for IFF systems, explains the advances in IFF technology, and provides a set of guidelines for ideal operation.

Commercial Applications of Transponder Systems

Commercial transponder systems are used in sporting events where timing is essential for determining the placement of the participants. A transponder utilizing RFID technology is attached a runner, for example, which transmits a unique identification signal used by the radio receiver to determine the geolocation of the runner. Large sporting events such as marathons, triathlons, swimming events, NASCAR races, and drone racing utilize transponder systems to determine the amount of time each participant takes to finish the race.

Due to the timing constraints of marathon events, a very specific type of transponder system is needed. A compact transponder system that can mount on the chest or the foot of a participant is currently the most popular solution. Transponder systems mounted on the foot of a runner are active transponder systems with a typical accuracy of up to 0.003 seconds [2]. Transponder systems mounted on the chest of a runner are passive disposable transponder systems. Such disposable transponder systems must be within three feet of the receiver for ideal functioning capabilities [3].

Passive transponder systems cost $1 on average which is 1.6% the price of an active transponder systems which cost more than $60 on average. A passive transponder system is thinner and flexible

whereas an active transponder system is rugged. Moreover, passive transponder systems can last a lifetime without a battery source, while an active transponder system requires frequent battery replacements. Passive transponder's 0.865 – 134 KHz range provides a larger operating frequency than an active transponder's 433 – 915 MHz [4]. OmniID is the world leader in manufacturing and supplying of RFID tags used in passive and active transponder systems [5].

Technology of Transponder systems

Functionality

The body of an active transponder typically holds an amplifier circuit that generates the outgoing radio signal. Amplifier circuits, which are built using operational amplifiers, are used in RF system design. The two fundamental types of amplifiers used in RF systems are power amplifiers and low-noise amplifiers. The power amplifier is "used to increase the power level of the signal before it is sent to the antenna [6]." Increasing the power level of the signal allows for the transponder to have a longer range. An active transponder, which has a battery built in, can increase the power level of the signal unlike a passive transponder that doesn't have a battery. Thus, an active transponder can send signals over long distances whereas a passive transponder must be in close proximity to the receiver for ideal performance. Additionally, low-noise amplifiers are used on the receiver side of a transponder system to amplify the received signal while causing minimal degradation to the original signal [6].

Improvements

Although the original concept for developing a RFID-based transponder system was released in 1950s, the underlying RF circuit design has remained largely unchanged since its initial inception in the industry [7]. However, some improvements have been made as evident in the newer active transponder system compared to the older passive transponder systems. Longer operating ranges, higher reliability, in addition to better accuracy, have been revealed in the active transponder systems, but at a cost of additional weight and a higher price tag [4].

Implementation of Transponder Systems

Implementation of active transponder systems in an IFF scenario is inherently more complicated than implementing a transponder system in sporting events. During 2003, "the US PATRIOT Phased Array Tracking Radar intercepted and shot down a British Tornado aircraft because of the misclassification. [9]" Some improvements, however, have been made as shown by [9] that "confirmed that the IFF rate can be significantly improved by applying some improvement plans of passive ID factors.[9]" Sensors in military vehicles and aircrafts without IFF capability are susceptible to being spoofed by adversaries, thus compromising their surveillance and air-defense network [8]. The combination of IFF's military application and its ability to withstand adversary spoof attacks, transponder systems utilized in the military can cost $42.8 million [8]. On a battle front, however, IFF systems allowing the infantry to identify other soldiers as a friend or foe are currently under development.

References

[1] "Raytheon: Identification Friend or Foe (IFF)," *Raytheon: Customer Success Is Our Mission*, 05-Mar-2019. [Online]. Available: https://www.raytheon.com/capabilities/products/iff. [Accessed: 06-Mar-2019].

[2] "ProChip FLEX | MYLAPS Sports Timing," *MYLAPS*, 05-Mar-2019. [Online]. Available: https://www.mylaps.com/prochip-system/prochip-flex/. [Accessed: 06-Mar-2019].

[3] R. F. I. D. Journal, "How Accurate Can RFID Tracking Be?," *RFID Journal*, 06-Aug-2015. [Online]. Available: https://www.rfidjournal.com/blogs/experts/entry?11454. [Accessed: 06-Mar-2019].

[4] S. Smiley, "Active RFID vs. Passive RFID: What's the Difference?," *RFID Insider*, 27-Mar-2018. [Online]. Available: https://blog.atlasrfidstore.com/active-rfid-vs-passive-rfid. [Accessed: 06-Mar-2019].

[5] "Active RFID Tags," *Omni-ID*. [Online]. Available: https://www.omni-id.com/active-rfid-tags. [Accessed: 06-Mar-2019].

[6] "Active Components in RF Circuits," *All About Circuits*. [Online]. Available: https://www.allaboutcircuits.com/textbook/radio-frequency-analysis-design/rf-principles-components/active-components-in-rf-circuits/. [Accessed: 06-Mar-2019].

[7] "Aircraft Transponders History," *EAI*. [Online]. Available: https://www.experimentalaircraft.info/homebuilt-aircraft/avionics-transponder-2.php. [Accessed: 06-Mar-2019].

[8] "Air Force orders secure IFF avionics from Raytheon to help safeguard U.S. military aircraft," *Military & Aerospace Electronics - Military technology, weapons, equipment & systems for the military industrial complex.*, 12-Jun-2017. [Online]. Available:

https://www.militaryaerospace.com/articles/2017/06/secure-iff-avionics.html. [Accessed: 06-Mar-2019].

[9] Majung and Kim Byung-pyo, “A Study on the Improvement of the Identification Friend or Foe Rate of Patriot Using DMAIC,” *Article*, Oct-2017. [Online]. Available: https://www.researchgate.net/publication/325175367_A_Study_on_the_Improvement_of_the_Identification_Friend_or_Foe_Rate_of_Patriot_Using_DMAIC/citations. [Accessed: 06-Mar-2019].