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PhD THESIS

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**Study of the magnetic behavior of rectangular coils for  
the information transmission of short range in  
intelligent transport systems**

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## Abstract

## **Study of the magnetic behavior of rectangular coils for the information transmission of short range in intelligent transport systems**

The set of applications and technological systems created to improve safety and efficiency in land transport (road and rail), that facilitate the control, management and monitoring are known as Intelligent Transport Systems (ITS). ITS have become a necessity due to the growth in vehicle traffic that requires developing strategies to increase levels of security in people who move in any land transport system.

ITS systems incorporate the new technologies for traffic control and management, which integrate information and communication systems between users and infrastructure, vehicles and others (pedestrians, authorities, concessionaire's service ...). These systems help to share information between all the elements involved in the transport systems, getting greater road safety, improving travel times and reducing the environmental impact.

To move efficiently through any mode of land communication one needs an integrated system. This system requires to identify the type of vehicles which are on the road and to share information between these vehicles and infrastructure.

To establish communication between vehicles and infrastructure, wireless communication is required. But incorporating a mobile communication system is expensive. Another possibility is using a dedicated short-range communication system, which is exempted from service payment but requires a high initial investment for the installation.

This thesis presents a communication system between infrastructure and vehicles, using magnetic coils as antennas. Magnetic coils are world-wide used devices for vehicles detection due to its low maintenance and high durability.

In the first part of this work the study of the magnetic field generated by rectangular coils and their validation with experimental data is proposed. For this analysis a simulating software was developed. It allows to know the distribution of the magnetic field generated by a magnetic loop.

The second part consists in analyzing and proposing a model to calculate the voltage level that could be transmitted between two coils; the first coil is a transmitter and the other coil is a receiver. The simulation results were compared with experimental values.

The mentioned results are used for the design of coils. This tool allows handling variables such as size, number of turns, supply current, separation distance between coils and signal frequency. This tool also helps to predict the level of the sensed signal and to build the receiver circuit design.

In the third stage and based on the simulation results, a system of short-range communication was designed. For this purpose, magnetic induction, as a medium for transferring information between two magnetic loops was used. By this means it was noticed that the short-range communication, in a restricted area and without emitting radio signals that could interfere with other systems, is possible.

Magnetic loops are devices that are installed on many highways, so a short-range communication using these devices do not require further investment in its installation, except the communication circuit, which is currently added in magnetic loops controllers. In this thesis, the use of magnetic coils made of flat cable is also discussed, which opens the possibility of using mobile coils.

Short-range communication using magnetic loops proposes a low-cost solution for communication between vehicles and infrastructure. This feature is easy to implement in a greater number of points. Also, because the communication is achieved by means of magnetic fields coupling, the weather conditions would not have a significant effect on the transmission.

The results of this research have been published and presented in the following works:

- Data transmission between magnetic loops. (ITACA-WIICT 2015). España. ISBN 978-84-608-4139-5.
- Levels of induced voltage between rectangular magnetic loops. (ITACA-WIICT 2014). España. ISBN: 9788469711668.
- Voltaje inducido entre espiras magnéticas rectangulares. (7° Encuentro de Investigación Congreso Internacional de Ciencia, Innovación y Tecnología). 2014. México.
- Comunicación Inalámbrica de corto alcance. (5° Encuentro de Investigación). 2012. México. ISBN: 978-607-95742.
- Campo magnético generado por líneas conductoras de corriente eléctrica. (4° Encuentro nacional de investigación). 2011. ISBN: 978-607-95742-0-8.
- Communication Between Magnetic Loops. (16th World Road Meeting). 2010. Portugal. Proceedings.
- Estudio Teórico del Campo Magnético y Perfil Magnético Real de Sensores de Espira Magnética en Sistemas de Control de Tráfico. (SAAEI 08). España ISBN: 978-84-96997-05-9
- Estudio Teórico y Práctico del Comportamiento de Sensores de Espira Magnética en Sistemas de Control de Tráfico. (Ciencia y Tecnología en la Frontera). 2008. México. ISBN: 1665-9775.
- Aplicación del RFID para la identificación de vehículos. (Jornada CRIA: TICs Y LOGÍSTICA EN EL SECTOR DEL AUTOMÓVIL). 2008. España.
- Sistemas Sensores Empleados en ITS. (VII Congreso Español Sistemas Inteligentes de Transporte). 2007. España.
- Los Sistemas RFID y WAVE para Comunicaciones en Entornos ITS. (VII Congreso Español Sistemas Inteligentes de Transporte). 2007. España.