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Characterization and Validation of Telemetric Digital Tachometer based on Hall Effect Sensor

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INTRODUCTION

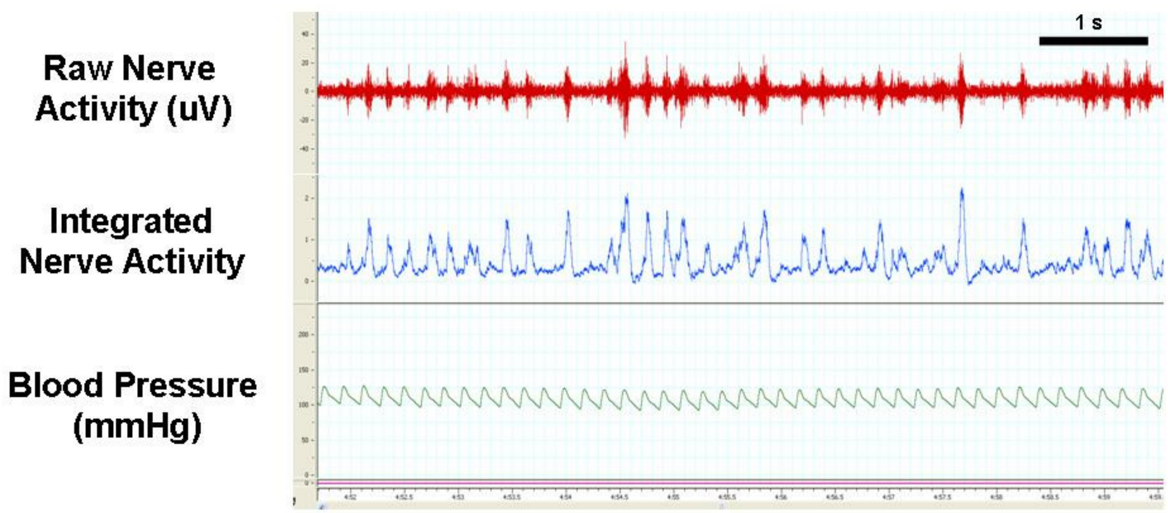
Telemetry

A telemeter is a device used to remotely measure any quantity. The term telemetry commonly refers to wireless data transfer mechanisms, nevertheless, it also encompasses data transfer over other media such as telephone or computer networks.

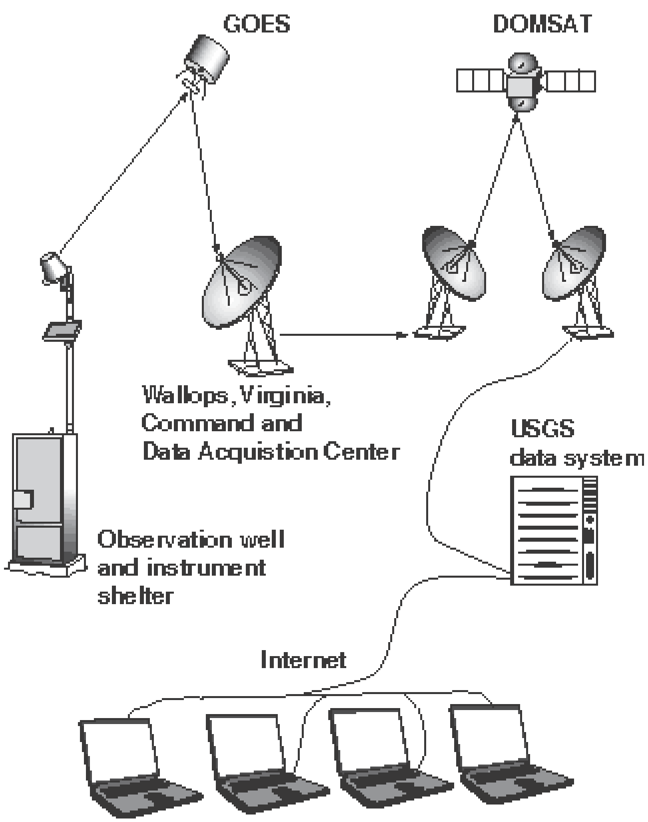
This work is focused on transferring data from a remote motor over the IEEE 802.15.4 standard, commonly referred as Zigbee protocol.

Biomedical Instrumentation

Telemetry applications:

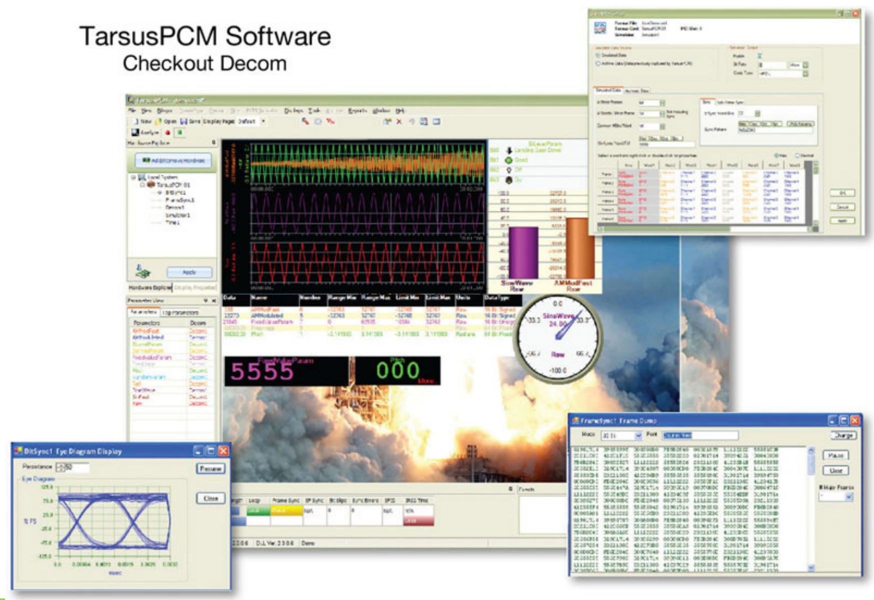


Military Industry



Several researches have been presented in the medical, military and automotive industries.

Everyday we are more an more involved with telemetry systems. Our cars they now have GPS systems which guide us to our destinies, and even can provide us information of positioning, routes or fuel spend.



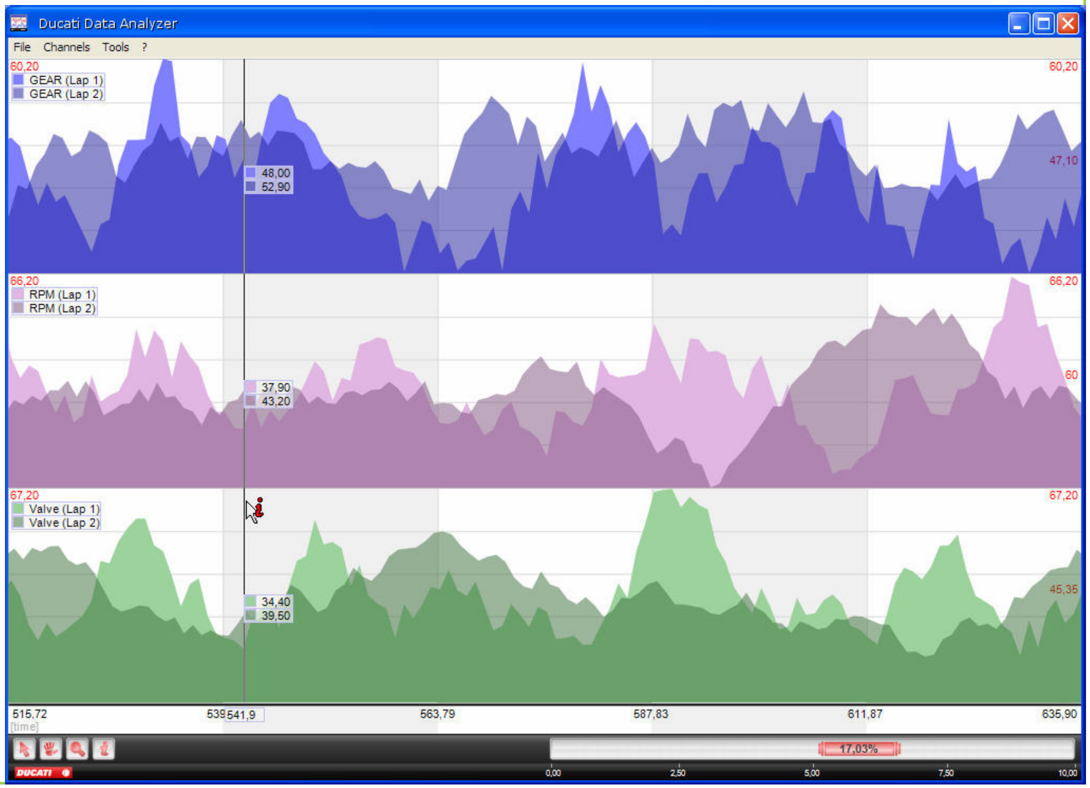
Having an accurate information about shaft's speed is possible to take better decesions during dynamic events like acceleration and endurance of Formula SAE competition.

FORMULA SAE

F1 cars are some of the most heavily instrumented objects in the world. Indeed, you can view the cars as rolling sensor networks.

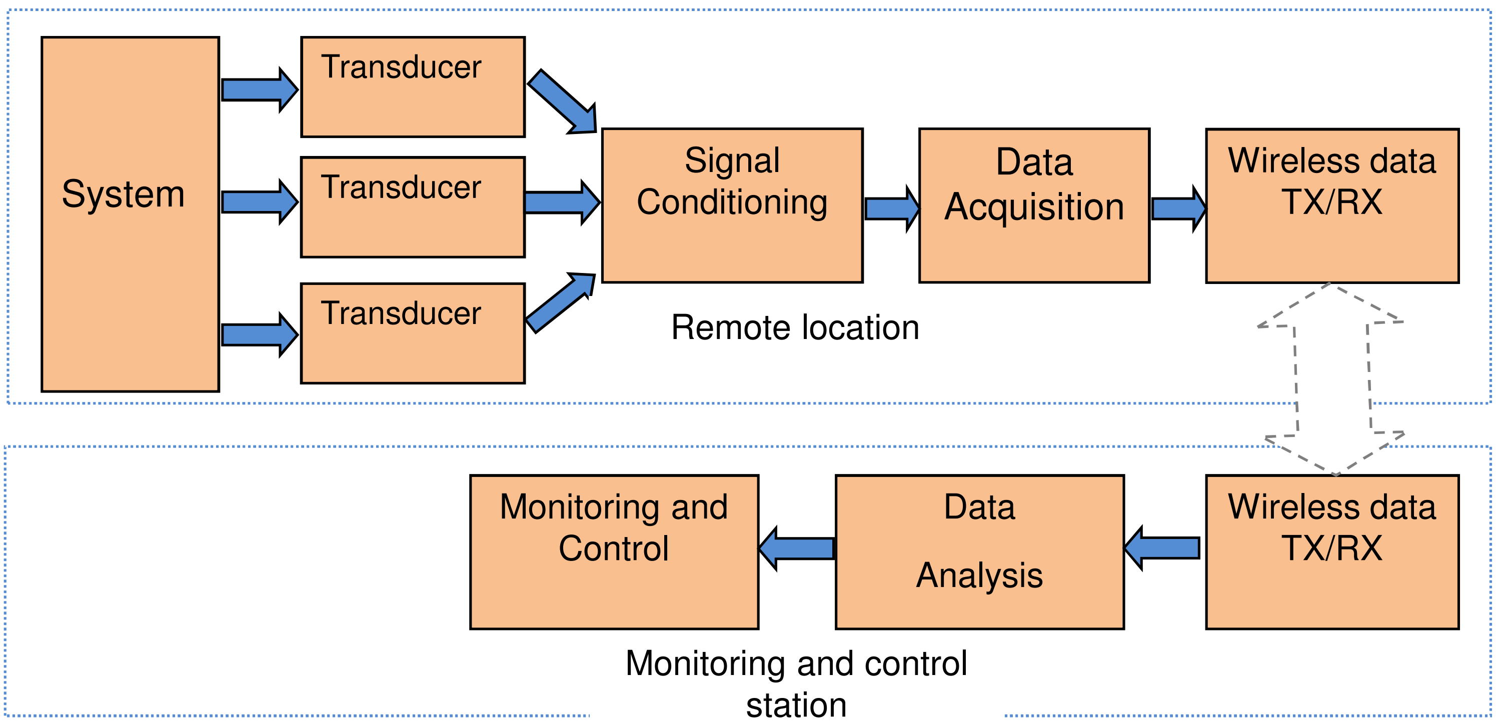
- J. Waldo

Automotive Industry



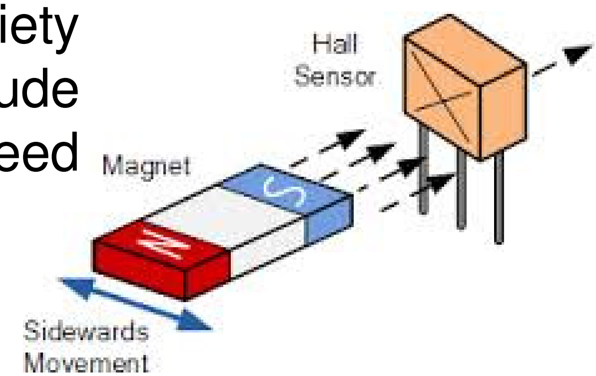
TELEMETRY SYSTEM

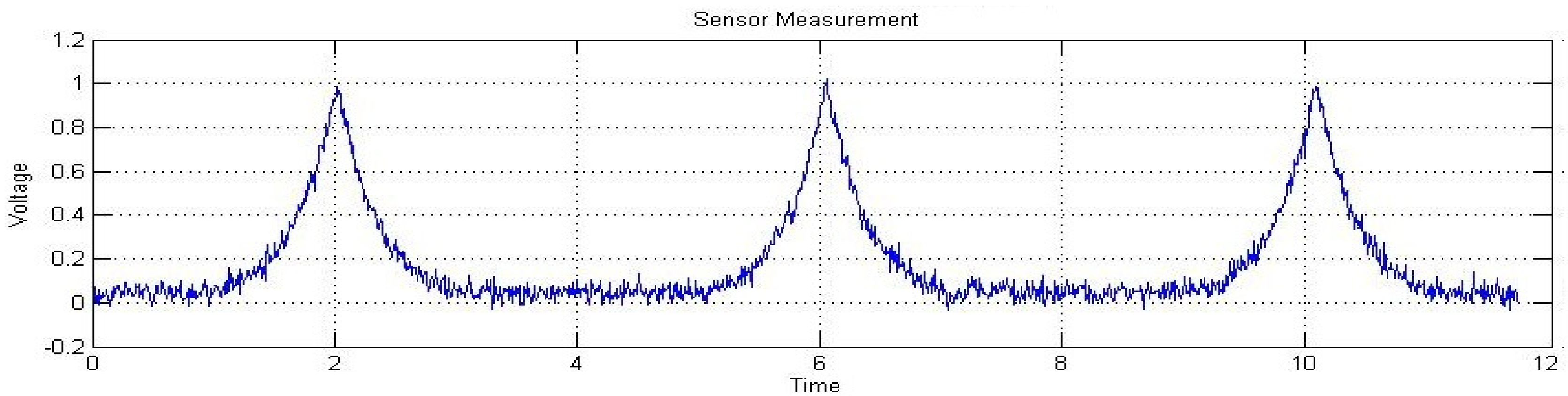
According to the Telemetry Applications Handbook, a telemetry system can be divided into two big funcional blocks. Transmission subsystem and reception subsystem, as shown as follows:



SENSING AND SIGNAL CONDITIONING

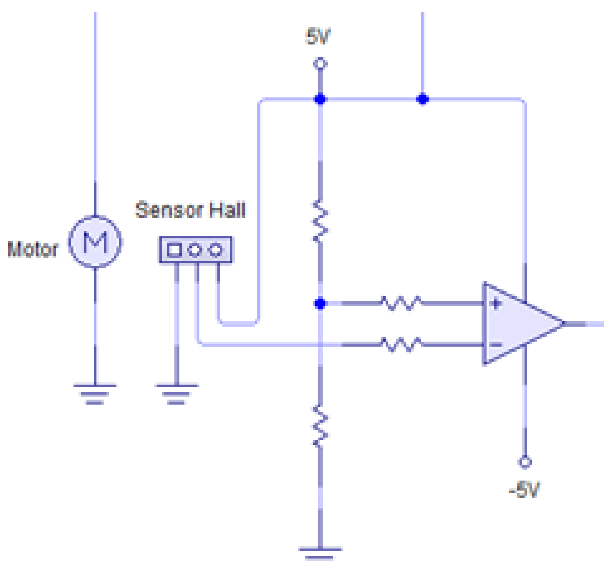
Hall effect sensors have been used in a wide variety of applications for years. These applications include them as proximity switching, positioning and speed detection

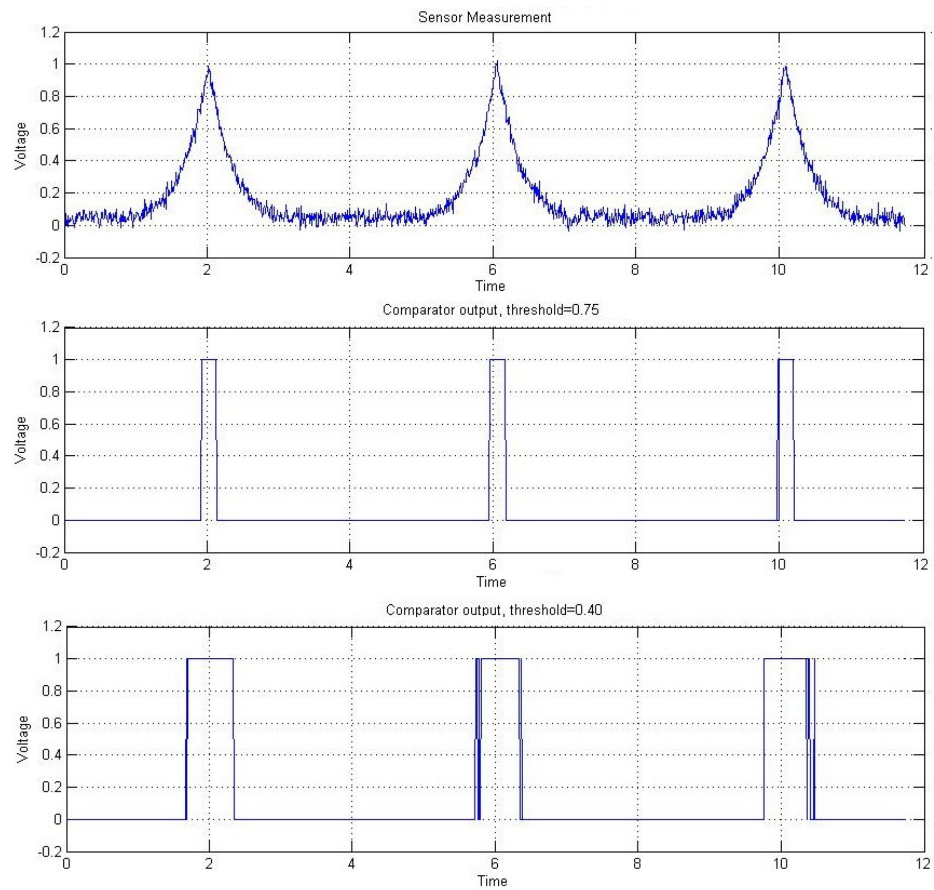


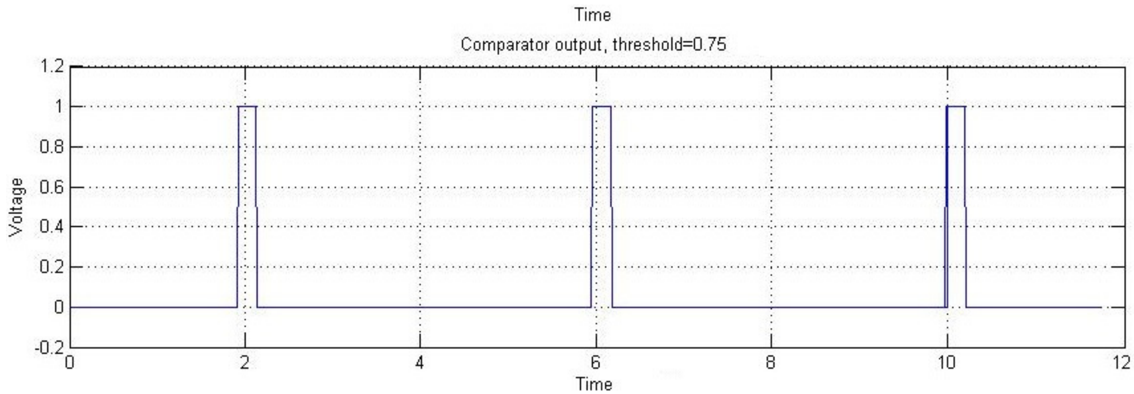


In order to detect the speed of the motors' shaft, there are placed three permanent magnets equally spaced at 120°, whose magnetic fields can be detected by a fixed Hall effect sensor

Because of the magnetic field can be detected from a certain distance before the magnet crosses in front of the sensor, and after it crosses it, it is necessary a signal conditioning stage to transform this variable voltage output to a pulse train, which can be processed by a micro controller. This conditioning task is performed by a single operational amplifier comparator with a reference signal used as threshold.



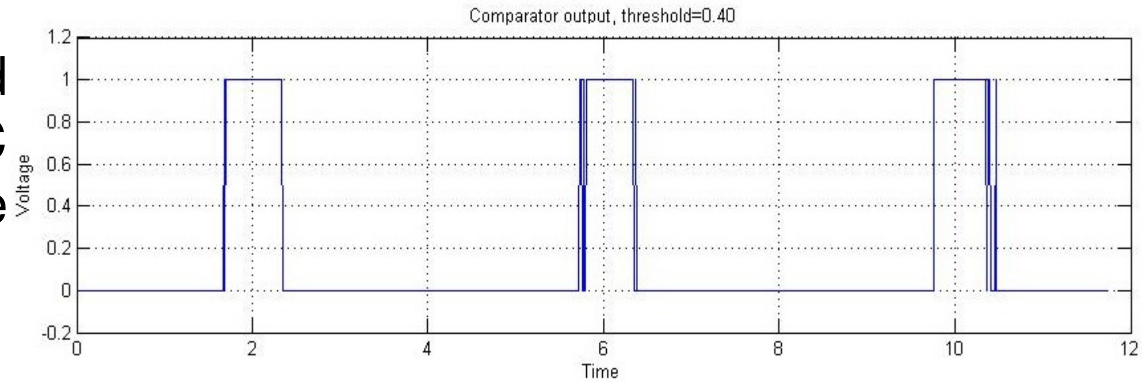




Threshold = 0.75

By changing the threshold parameter in the comparator, the pulse width is modified. Greater thresholds carry thinner pulses, while lower thresholds implies wider pulse trains.

Threshold = 0.40



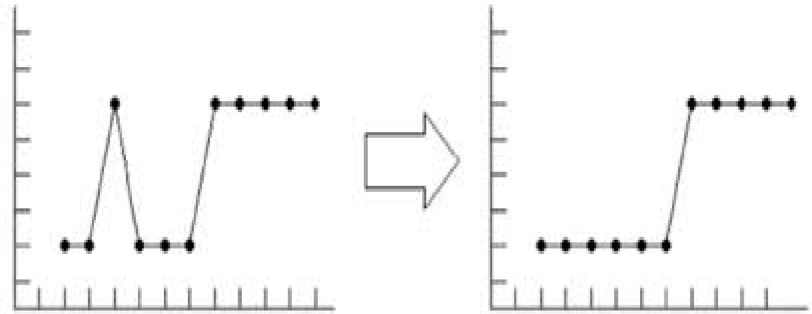
This pulse trains are counted by a micro controller PIC 16F887 in order to compute the corresponding speed.

WIRELESS TRANSMISSION AND RECEPTION

Wireless transmission and reception is done by two Xbee RF modules working in transparent mode, this implies that, all UART data received in the transmission module is queued for RF transmission. When RF data is received by the reception module, it is transmitted to the data analysis block to later be displayed

DATA ANALYSIS AND DISPLAY

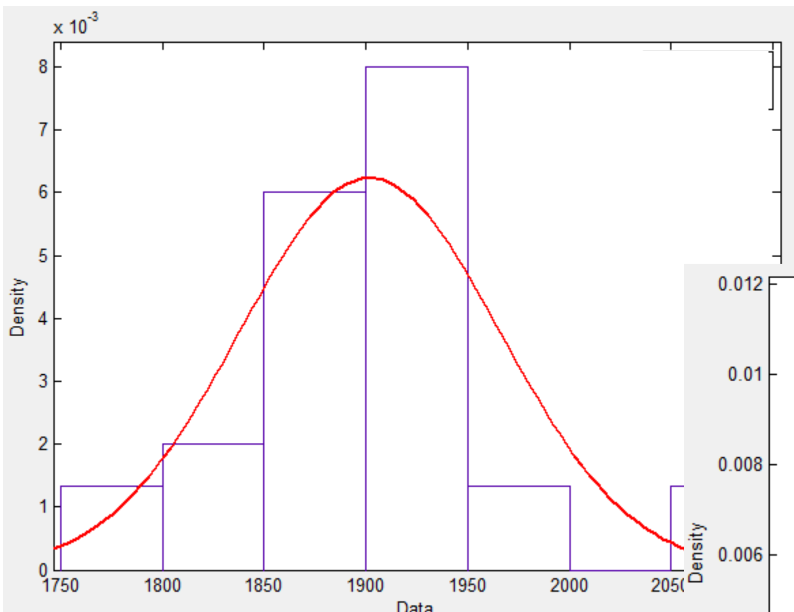
Before data is display, it is processed by a median filter, in order to eliminate zeros from the raw data. These zeros are obtained principally by errors in the data transfer process.

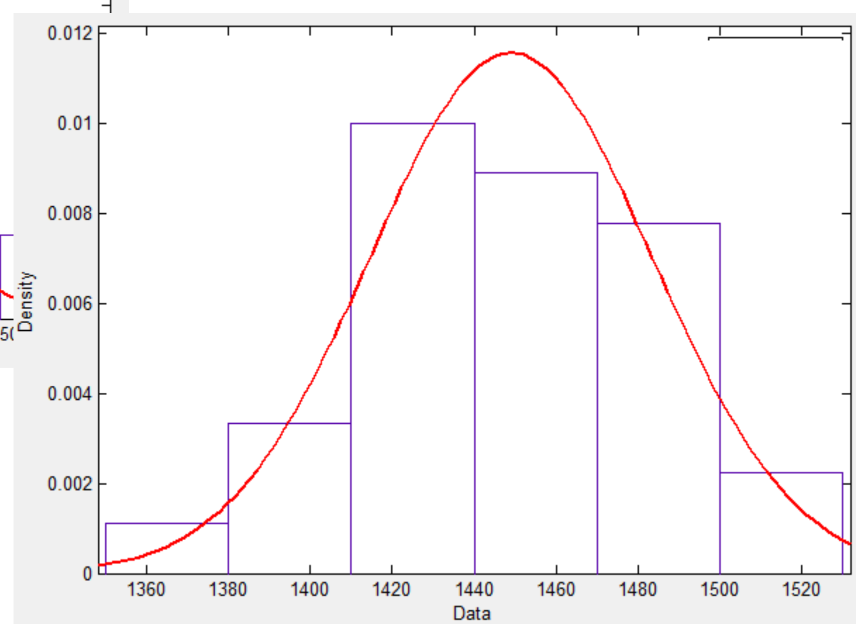


monitoring interface developed in the graphical LabView software gives the user the possibility to observe the instant speed through a sliding gauge, the historical speeds displayed in a waveform chart as well as the channel to properly establish communication between the computer and the RF reception module.

RESULTS AND DISCUSSION

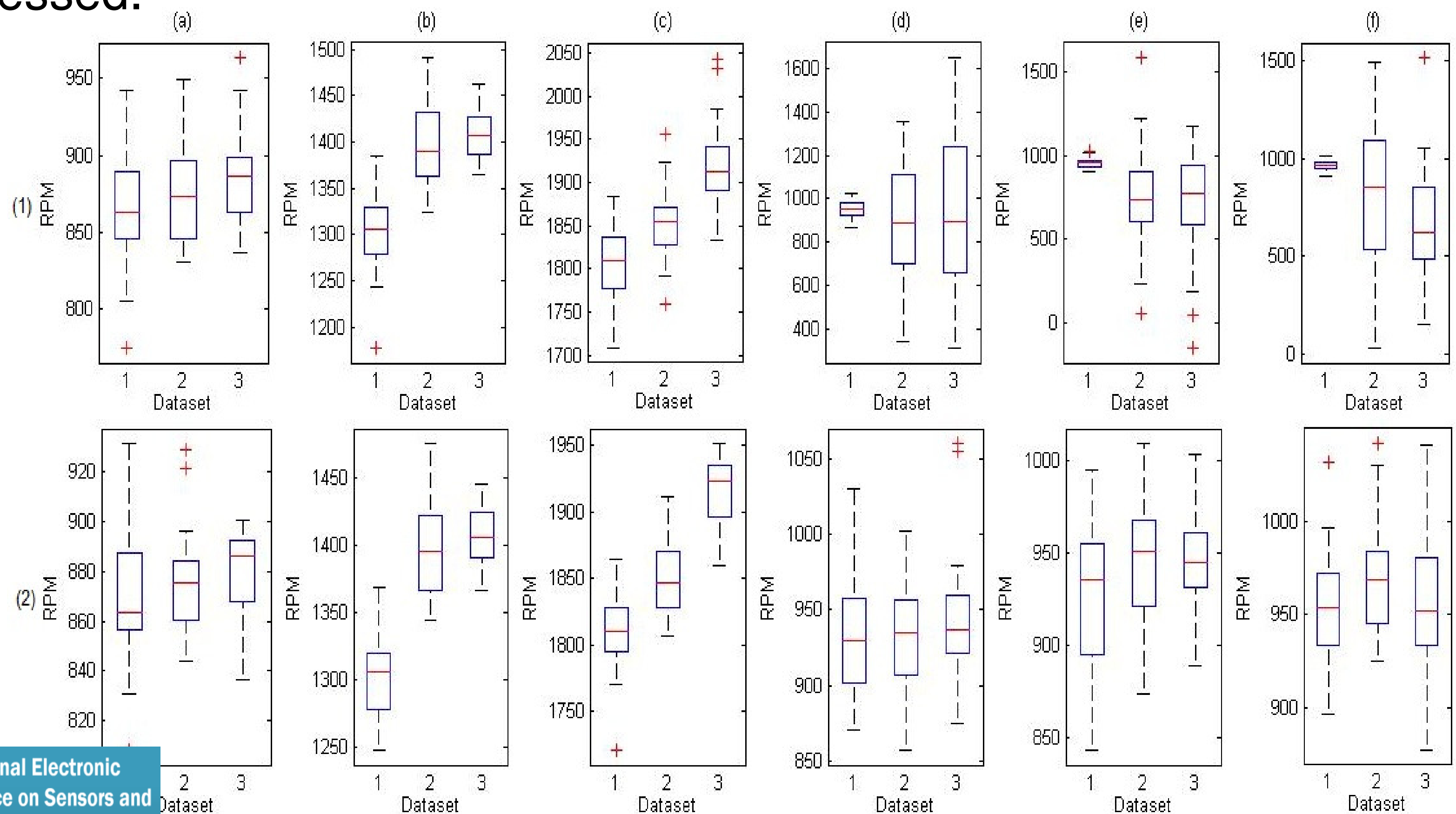
To validate the presented work, various measurements were performed, varying principally three variables: Speed given in revolutions per minute (*n*), distance of transmission (*d*), and sample time (*T*). In order to have statistical validity, there were taken 30 samples of every variable combination, then, this data was fitted into a normal distribution to obtain the mean and standard deviation of the dataset.





Normal distribution fitting

Next figure shows de box plots for diverse datasets obtained varying speeds, sample times and measurement distances. First row shows data before median filtering. Second row show data after median filtering. Data spreading is caused by missed information in the data transfer processed.



CONCLUSSIONS AND FURTHER WORK

In this study, a low cost digital tachometer has been characterized. Important achievements have been reached to implement this methodology in the research of other physical variables oriented to monitor and control diverse variables in a Formula SAE automobile. Has been validated the reliability and repeatability of the whole system, including sensing, signal conditioning, wireless transmission-reception, data analysis and data display functional blocks.

Diverse experiments were performed, documenting the consequences of changing speeds, distances and sample times.

By increasing the sample time, the mean value approaches the real speed, but the system response is slower. In the other hand, by decreasing the sample time the response is faster, but the mean value departs from the real value, according to the measurements taken by a commercial optical tachometer model DT-2234C.

Getting an error correspondence between the real speeds and computed speeds in a given sample time it is possible to obtain a correction function to compensate this difference, while preserving useful time response.

As further work is still pending the research of other wireless technologies and/or communication protocols that can be useful in greater distances and adverse conditions. It is important to note that until this point all experiments were done in a laboratory with controlled conditions and may vary when applied to an automobile.

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