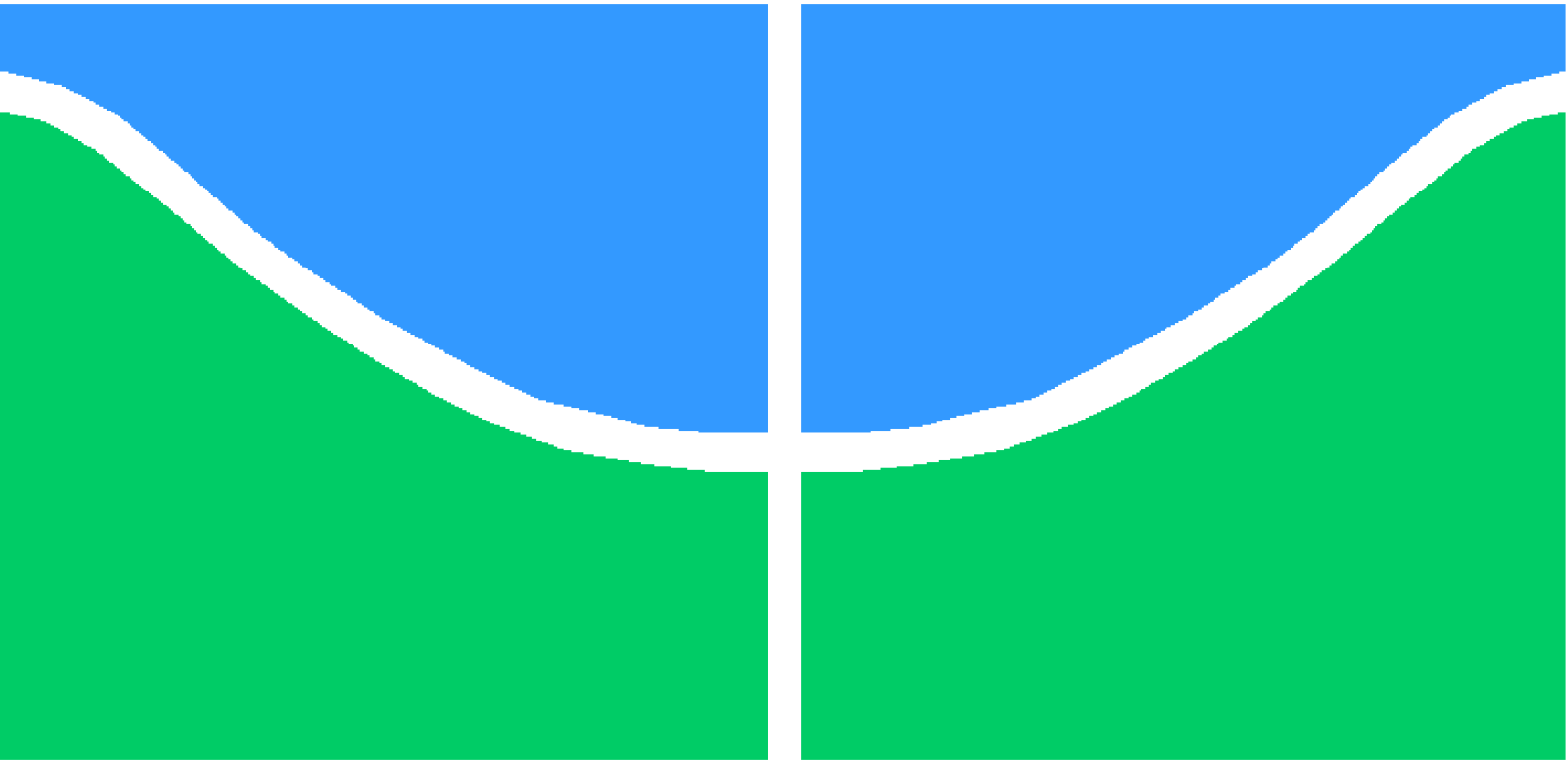

University of Brasília – UnB
Faculty UnB Gama – FGA
Nome do Curso

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Author: Nome do Autor
Advisor: Titulação Acadêmica e Nome do Orientador

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Nome do Autor

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University of Brasília – UnB

Faculty UnB Gama – FGA

Advisor: Titulação Acadêmica e Nome do Orientador

Co-Advisor: quando houver, Titulação Acadêmica e Nome do Orientador

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1 Introduction

With the advancement of technology cars are leaving the factory each time with more power for more affordable prices. In 1995 the best-selling car in Brazil (HERNANDES, 2017) *(Volkswagen Gol Plus 1.0)* had 49.8hp of maximum power and brand-new would accelerate from nought to 100kph in 22.4 seconds (CNW, 2017b) while sales champion of 2015 *Volkswagen Gol 1.0* had 76hp of maximum power and could do the same challenge in 13.3 seconds (CNW, 2017a), almost half the time from the previous. Interisting fact is even though the latter is 20 years younger, both cars have similar brake systems, disk brakes in the front and drum ones in the back. To make things worse, the younger one does not have ABS *Anti-lock Braking System*, which only became mandatory for cars manufactured from 2014 and beyond according to brazilian regulations.

Although this is short analysis has only two subjects it brings up that maybe manufactures and customer are too focused in performance rather than safety. Of course for a standard customer it is obviously hard too evaluate the breaking performance of a vehicle upon buying it. Governament and legal authorities have been creating strict regulations for manufactures too follow in order to ensure that cars have a higher standard of safety.

Brake systems are extremely important in terms of safety because even though cars nowadays are required to have a higher perfomances in crash tests it is always favored too avoid collisions.

Brake tests with full scale vehicles are expensive and this somehow makes extensive testing unfeasible. Also the time required for each test might be a constrain. It is a possibility that maybe using small scale tests it would still be possible to provide relevant information about quality and performance of brake systems with lower costs and reduced time. Small scale tests do not have the purpose of fully replacing full scale ones, but the savings in costs and time that they can provide could be used for mass testing, and this can already show their utility and relevance (GARDINALLI, 2005).

Judging the brake efficience of a vehicle as a whole involves a lot of factors, a small scale test will not provide results that could be used directly to address the quality of a car break system but it is possible to focus the results in the performance of individual componentes of the system such as pads, disks and calipers (HALDERMAN; MITCHELL, 2016), and evaluating the performance of this components is a good start for judge the brake capacity of a brake system.

Braking tests have been carried out for years and have been regulated for some time. A international standard for brake testing has been the regulation *SAE J2522* (SAE,

2016), it gives a the description of how break tests should be conducted for evaluating low weight passengers cars.

1.1 Purpose of the project

The purpose of this work is too develop, implement and test a microcontrolled electronic instrument system for monitoring and controlling a small scale brake-testbench based on the information from the internationl regulation *SAE J2522* (SAE, 2016). The system will comprehend both software and hardware layers and should be able to perform brake tests and acquire physical data through sensors in order to judge brake systems components level of performance.

1.2 Text Structure

Chapter 2: Chapter 3: Chapter 4: Chapter 5:

2 Literature Review

2.1 The need for performing brake tests

The brake system is a critical part of an automobile, thanks to this system it is possible to use the latter under safe conditions both in urban and rural areas. There are some ideal requirements that a brake system should be able to attend (KAWAGUCHI, 2005) :

- Reduce the speed of a moving vehicle, increasing the deceleration of the same.
- Stop the vehicle completely.
- Maintain the vehicle speed, preventing unwanted acceleration in downhill paths.
- Keep the vehicle motionless while it is parked.

It is important to emphasize that this conditions are ideal, considering that in extremely hazardous or stressful situations the system might not operate properly and will not attend thoose previous requirementes. Considering the importance of brake system the same need to have minimal breaking capacity so vehicles can be decelerated with greater efficience.

In contrast, more effective brake systems means more cost to manufactures and consenquently to customers. Theoretically this would meant that manufactures need to choose a trade-off between quality and cost. However, the point in which this trade-off is setted is determined by governament regulations. Moreover if there was no general regulations each car manufecturer would have a standard that they judge is sufficient. In Brazil the governament partitions that define this regulations are the *National Traffic Council* and the *National Institute of Meteorology, Quality and Technology*, most of those regulations are based in the european regulation ECE-13/05 (INMETRO, 2013) .

Considering the importance of regulatory standards, the need for brake tests becomes even more evident as it is mandatory to ensure that brake-systems will attend to regulations requirementes. Only with extensive testing it is possible to ensure that a particular system will attend to all standards regarding it's category of operation.

Making all theese considerations, a *Break-System-Testbench* may be considered a useful device for the automotive industry. Considering that it would be able to simulate a close enough replica of real evironments and situations that a brake system is submitted, this testbench could allow car manufactures and break system parts manufactures to avoid

expenses in tests as they would be able to test different parts of the system in a assisted and controlled evironment.

2.2 Working principles of disk brake systems

This section will give a short explanation of how disk breaks works as the vast majority of cars and motorcycles nowadays are equiped with this technology instead of the outdated drum scheme.

In general terms we can make an analogy of how disk brake works with how bicycles brakes works. In a bicycle the brake calipers squeeze the wheels in order to promove deceleration to the wheel and reduce the bike speed. In disk breaks the calipers apply pressure to the rotor *disk*, the rotor is directly connected to the wheel spinning at the same speed, this way the system decelerates the rotor and the wheel trying to reduce the vehicle speed. In car disk breaks there is a component called pad, as seen on Figure 1 pads are located between the calipers and the rotor. Pads have the functionality to reduce the wear generated by friction in the rotor. In normal conditions during proper maintenance calipers are hardly-ever replaced, pads are replaced every once in a while and disks are replaced also every once in a while but less frequently than pads.

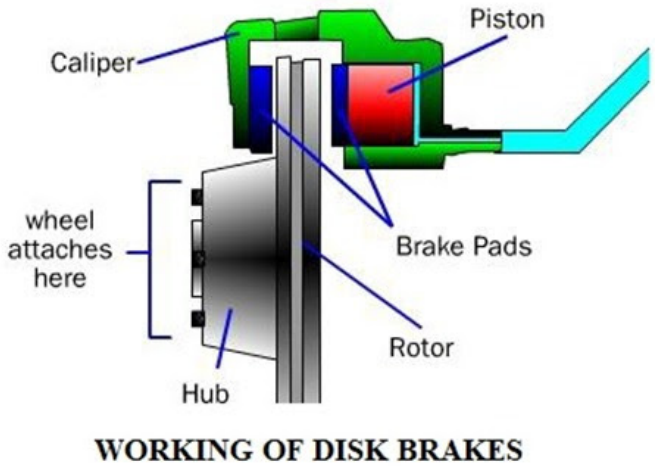

Figura 1 – Schematic for disk brake systems (UNKNOWN, 2017)

2.3 Monitored parameters

As metioned before this paper will be based in the *SAE J2522* regulations, this regulation says that to evaluate the efficiency of a brake system it is mandatory to monitor temperature on the brake pads, the pressure applied on the disk and the speed of the

rotor throughout all the process. Monitoring the vibration is not mandatory but has some advantages.

- *Temperature of brake pads:* During all test it is mandatory to have full knowledge of the temperature of the break pads, firtly because of security reasons (there is upper limit for temperatura in any system) and also because of the wear of parts that is related to temperature.
- *Pressure applied on the disks:* Knowing the magnitude of this force means being able to relate the pressure applied and the deceleration, knowing how the pressure applied increases the temperature of the pads and evaluate how this promotes wear of the parts.
- *Rotation speed:* Without knowing how the speed of the rotor varies over time it would be impossible to determine the acceleration and deceleration rates among many other issues.
- *Vibration:* As mentioned before this is not mandatory but rather interesting, measuring vibration makes it possible to determine how the extensive use can wear out the parts and reduce stiffness among other properties. Also it is natural that the system will vibrate during braking, minimal vibration or too much vibration can indicate a fault that on the future could damage the system.

3 Methodology

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Appendix

APPENDIX A – First Appendix

Texto do primeiro apêndice.

APPENDIX B – Second Appendix

Texto do segundo apêndice.

Annex

ANNEX A – First Annex

Texto do primeiro anexo.

ANNEX B – Second Annex

Texto do segundo anexo.