

## 6 SUMMARY

After testing three types of suspension systems in different road conditions, it is clear that, controlling the vehicle vibrations using the active suspension system showed great results. These results are clear by taking a look at the amplitude of vibrations in all wheels after being reduced by almost 50% when being excited by a step input. Moreover, the control method with active suspensions can still reduce the vibrations of the vehicle more than 50%, thanks to the PID controller, which allowed engineers to minimize vibrations to a minimal level. Yet, active suspension systems are still implemented only in race cars as it is needed in providing riders with high stability and acceleration to reach the maximum performance during the race. While in conventional cars, utilizing active suspension systems is still very difficult due to its complexity, heavy weight, costly maintenance and high energy consumption. On the other hand the semi-active electromagnetic suspension system appeared to be efficient and effective as it reduced the vibrations in the car which was passing over a bump of 0.01 m amplitude with speed of 13,8 m/sec by almost 70%. This was achievable by using an electromagnetic damper, which its only drawback was its slightly heavy weight and average controllability. However, it is still cheaper and lighter than fully active suspensions with electromagnetic motors. As a result, electromagnetic semi-active suspension systems are used by many manufacturers.

Overall, this study showed the power of PID controller in controlling the vibration in vehicles. As it was mentioned, the PID controller can only work in active suspension systems, therefore, further research work must be done to start using active suspension systems in conventional vehicles which will provide the passengers with a totally different experience in stability, comfort and ride quality. This won't happen unless a way is figured out to reduce the weight of the system as its heavy weight might affect the performance of the conventional cars. This is because conventional cars usually have less motor power than race cars. This could be done through using for instance lighter materials for the motor and devices. Also, it is important to start a research work on ways to reduce the price of the active suspension as it is an expensive system with sensors, electrical and hydraulic components. This could be done through using for instance cheaper materials, which will allow the passengers to fix or replace the system in case of deficiency without spending huge amount of money.