Electrocharger: Electric Supercharger
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Senior Project Proposal

Summary
This proposed project is an electric supercharger modification for all CAN protocol OBD-II equipped vehicles. Using OBD-II engine RPM messages, the product will control an electric motor connected to a compressor wheel to in order to produce forced induction. This product will be mostly plug and play, with some assembly required, and a competitive price point.

Background
Forced induction systems on cars are limited to superchargers and turbochargers. A supercharger is a system that has a compressor that is run mechanically, for example, by a belt. A turbocharger is a system that has a compressor that is run by a turbine, which spins from a fluid like air or water. Currently, car manufacturers are undergoing a revolution of forced induction. The majority of car companies, small and large, are moving to smaller displacement engines amid strict gas mileage regulations. Companies are adding turbochargers in order to keep the fuel economy up while retaining a useable amount of power.

Turbochargers have been a revolution of their own, but even they have their own drawbacks. Turbochargers only work because they run on spent exhaust fumes (Fig. 1). These exhaust fumes are routed straight out of the engine and into the turbine housing of the turbocharger. The force of the exhaust fumes will spin the turbine wheel which is connected to the compressor wheel on the other half of the turbocharger. The compressor wheel spinning will then draw air through the intake of the engine and “force” more air in. The amount of air being fed in is greater than if the engine was drawing air by itself, hence “forced induction”.

The engine drawing air by itself can only draw at atmosphere pressure, or 0 pounds-per-square-inch (PSI) of absolute pressure. A low-pressure turbocharger can increase that amount to somewhere between 3 and 7 PSI of absolute pressure, while high-pressure turbochargers can do up to 40 PSI. That is a significant increase in the amount of airflow to the engine, which will greatly increase the power output of the engine. With the correct tuning, the addition of a turbocharger can increase horsepower and torque but can keep the gas mileage the same, or even improve it. But this still is not the most efficient this system can be. The inherent problem with this system is that the exhaust fumes running the turbine side of the turbo will cause parasitic losses on the engine. The act of spinning the turbine wheel causes a backpressure on the engine which will decrease the power gain, because the engine has to work harder just to push those exhaust fumes out. The addition of the turbo increases the overall efficiency of the engine but this backpressure is the limiting factor in this type of setup.
The other common form of forced induction is belt driven supercharging. The supercharger works very similarly to a turbocharger, in that it uses engine energy to compress more air than the engine can draw itself. Compared to figure 1, a supercharger is the same minus the red section of the diagram, since superchargers are driven via a belt connected to the crankshaft. Belt driven superchargers means that the engine is directly using energy to drive the supercharger. This causes some parasitic loss in this setup. The act of driving the supercharger with the engine can cause noticeable drops in power, compared to a turbocharger setup, which itself has parasitic losses. These two setups are can both be more efficient than a naturally aspirated engine, but as I have shown, have their own inherent drawbacks.

This brings us to the electric supercharger. These have been in testing by OEM car manufacturers for a few years [1]. There are also add-on kits already available for sale today. Some kits cost under $100 [2] and some cost over $1000 [3]. These kits vary in ease-of-installation and in actual performance increase. Most of these kits seem to provide no real performance increase, especially the ones on the cheaper side. The best add-on kit seems to be the Phantom Supercharger, which retails for around $1700. It has been independently tested and reviewed, and consistently shows considerable power gains over natural aspiration [4].

Fig. 1 General diagram of turbocharger setup [5]

**Description**

This product will be the compressor side of a turbocharger (see Figure 1) connected to a motor that is being controlled by an MCU. The MCU will process the OBD-II messages for RPM to control the electric motor speed. The OBD-II messages will come from the OBD-II diagnostic port located under the dash of many vehicles. The MCU will also be a PID controller for the motor in order for it to be as accurate as possible. The motor will need power circuitry to convert the car battery power to be useful for the motor and microcontroller. There will be a user interface for changing configurable settings, such as variable boost pressure. The intended consumer is someone looking to modify their existing car to have more power than it has stock.
This product should be easy to install and essentially, a plug and play system with some assembly required. This product will only be compatible with CAN based OBD-II cars, so any 2008+ cars and select earlier cars.

Prioritized List
1. OBD-II communications
2. Motor Controller/Power Circuitry
3. User Interface for configurable settings
4. “Boost by gear”/Variable boost pressure

Constraints
This product will follow the SAE J1979 standard as well as ISO 15765 CAN protocol. I will use the SAE J1979 standard PID for RPM, which is Mode 1 PID 0x0C [6]. I will use the ISO 15765 CAN protocol for baud rate, CAN message header length, voltage levels, and OBD-II port pin out [7].

Size constraints are unspecific as this product will be compatible with a wide variety of cars, therefore there are a wide variety of size constraints. To solve this issue, the product should be fairly small so that it will fit into most engine bays in a reasonable manner. The size of all electric components should be able to fit into an 8x8x2 inch box. This size should be small enough that there will a space in most engine bays that are big enough to accommodate it.

The cost of this product should be cheaper than the Phantom Supercharger or the other well performing products on the market. Since real performance increasing electric superchargers cost $1000+, my price point will be under $500. This way it will be affordable compared to all other real, performance increasing, electric forced induction add-ons on the market. The cost and size constraints should make this product very competitive to other similar, marketable products.

Since this product will be working in an automotive environment, safety and reliability are of paramount concern. I will use MISRA as a guideline for best coding practices in terms of working reliably and safely in an automotive environment.

Preliminary Development Plan
This product will use a microcontroller as the main source of control. The MCU will control the motor as well as processing OBD-II messages. See figure 2 for a high level diagram of how the MCU will operate in the system. An automotive ECU simulator to spoof OBD-II messages will be used for testing and demonstration purposes, if a real car is not available.
Fig. 2, preliminary flow diagram

Fig. 3 Preliminary picture of product [8]
Bibliography


[2] https://www.wish.com/c/54c2f941429a6a115370e48f?hide_login_modal=true&from_ad=pla1&gclid=CPX2mPun-c8CFdKFGodCe0D1w


