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The evolution of automotive electrical system architecture in commercial and military applications is discussed in this paper. The present voltage levels of 14 volt in commercial and generally 28 volt in military vehicles are unable to sustain the growing demands of electrical loads, created largely due to the advent of power electronics. In this paper the issue of transitioning to 42 volt system is discussed. Presently 42 volt system is finding its headway in the commercial automotive industry. A large number of papers have discussed the pros and cons of 42 volts systems for commercial vehicles. However, there still remain some significant issues which need to be examined very carefully in order to have 42 volt systems transitioned to military vehicles. In military applications, 42 volt system issues have ramifications towards cost and technical advantages. The paper discusses these issues, with the commercial manufacturing infra-structure in perspective. In addition, other electrical system architectures besides the 42 volt system are introduced as a prelude to their possible introduction in future military vehicles.

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## 42 Volt Electrical Power System for Military Vehicles --- Comparison With Commercial Automotive Systems

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### **Short Abstract:**

The evolution of automotive electrical system architecture in commercial and military applications is discussed in this paper. The present voltage levels of 14 volt in commercial and generally 28 volt in military vehicles are unable to sustain the growing demands of electrical loads, created largely due to the advent of power electronics. In this paper the issue of transitioning to 42 volt system is discussed. Presently 42 volt system is finding its headway in the commercial automotive industry. A large number of papers have discussed the pros and cons of 42 volts systems for commercial vehicles. However, there still remain some significant issues which need to be examined very carefully in order to have 42 volt systems transitioned to military vehicles. In military applications, 42 volt system issues have ramifications towards cost and technical advantages. The paper discusses these issues, with the commercial manufacturing infra-structure in perspective. In addition, other electrical system architectures besides the 42 volt system are introduced as a prelude to their possible introduction in future military vehicles.

**Keywords:** 42 volt system, automotive electronics, vehicular power system, power electronics, vehicular electrical system architecture, more electric vehicle (MEV), LAV, HMMWV, wiring harness, alternator.

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### **Extended Abstract:**

The evolution of electrical system voltage and power in automobile has followed a rising trend during the past few decades. It started initially with a 6 volts system. In the mid 1950's the automobile industry changed the voltage level standards to 12 volts due to the increase in electrical loads. This led to reduced current requirements in the wirings and consequent reduction in the copper weight. In the past two decades, the use of computers, electronics, cellular phones, and the multimedia in the vehicles, and more importantly the application of power electronics based electrical actuators allowing the replacement of the existing hydraulic or pneumatic, or other mechanical systems with electrical systems, all have shown a growing trend. This is continuing, and in the near future an almost exponential increase in the electrical loads is likely to take place in the automobile. Present full load power demand in the commercial passenger automobile is somewhere around 1500-2000 watts. It is anticipated that the power need could very well rise to around 3 Kw or 3.5 Kw (with an anticipated 5 Kw later on) in automobiles in the near future.

The needs in the military vehicles, though somewhat different, will follow a similar trend. As a matter of fact, the power need may be relatively higher, depending on the vehicle in question, such as tank, LAV (Light Armored Vehicle), and HMMWV (High Mobility Multi-purpose Wheeled Vehicle). In order to address the increasing electrical load demands in automobiles, the automotive industry is currently trying to implement a 42 volt dc architecture in vehicles. This will lead to size and weight reduction, particularly in wiring harness, for a given amount of power transfer. The military vehicles presently use mostly 28 volts architecture. Switching to 42 volts dc will reduce the wiring harness size and weight in the military vehicles. The application of 42 volts dc brings a number of issues and challenges such as arcing, load dump spikes, ignition system design (applicable to gasoline IC engine vehicles only), battery, and alternator, all of which need to be addressed. The military enjoys certain opportunities and advantages over the commercial industry in applying new technologies, such as higher voltage systems, battery, and flywheel, as regards cost and supplier infra-structure. The purpose of this presentation is to compare the commercial and military trends in terms of loads, the requirements and operation style, design considerations, cost benefits of transition to 42 volt system in military, and other advantages. We will discuss the current state of the art on this issue and the research work warranted to advance the technology.

Currently a reasonably mature technology exists in power electronics, which is applicable to military applications as well and is essential for the 42 volts dc system architecture [1-5]. Power electronics will be needed for the conversion of the variable speed generator voltage to provide a constant voltage. In addition, the existing technology of the 42 volt alternator designs can be readily used.

One of the advantages of 42 volts with respect to both the commercial market and the military applications is the use of intermittent (when needed) electrical components instead of mechanical components that run continuously. The mechanical devices are parasitic much of the time. This also leads to fuel savings of about 10%. Also, applications that were not easily implementable at lower voltages would be available, such as electrical valve control for engines.

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In general the use of high speed alternator leads to reduction in size of the machine. Additional research in this area is needed to achieve a mature high speed alternator design technology. Military applications of 42 volts dc architecture in tanks, LAV's and HMMWV's etc. can very well complement the technology already introduced by the commercial automobile industry. In that case the technology which cannot be implemented in commercial vehicles due to regulations, and cost restrictions, can be borrowed and expeditiously implemented in the military vehicles and later improved and exported back to the automobile industry.

Apart from the reduction in cost and weight of the wiring harnesses, 42 volt system will lead to certain advantages, such as dual-usable (with commercial automotive industry) components (batteries, alternators, actuators) leading to cost benefits. The disadvantages of the 42 volt system are the life of the incandescent bulbs used in the vehicle, because filaments with higher voltage and same power have to be thinner. This leads the filament to be fragile and of shorter life. This can be addressed, however, by introducing different kinds of gas discharge lamps. Other disadvantages relate to load dump issues and high voltage transient spikes. Some companies are working on voltage choppers to reduce the voltage so that incandescent 12 volt lights work.

This paper suggests that it is beneficial for the military to phase in to a complete 42 volts electrical system architecture, initially starting with a dual 28 volt and 42 volt system existing together. Military does not necessarily need to follow the exactly same path as the automobile industry due to reasons cited earlier. This means, it can try to replace more of its vehicular devices to operate electrically, compared to the automotive industry. Opportunities exist in the military to further improve a new technology, which is initially prohibitive in the automotive industry, and then export these back to the industry. Advantages of switching to 42 volt initially will be in terms of cost and weight savings due to the wiring harness and certain components. Any fuel saving which is achieved by introducing the 42 volt system will be a welcome selling point in military systems because military has to transport its own fuel to the site of operation. 42 volt system allows component applications that are not easily available with the lower voltage systems. In future nothing should preclude the military to switch to other higher voltages, namely 120 volt ac system or something else. Using 42 volts dc in synch with automotive industry will lead to commonality of components leading to dual-usage applications. Using 120 volts ac will also lead to the commonality with the whole utility power industry. Only pursuing the research and development and then working towards implementation in the military, will lead to the true answer about which architecture is best for it.

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