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Efficient Utilization of Negative Half Wave of Regulator Rectifier Output to Drive Class D LED Headlamp

Authors : Lalit Ahuja, Nancy Das, Yashas Shetty

Abstract : LED lighting has been increasingly adopted for vehicles in both domestic and foreign automotive markets. Although this miniaturized technology gives the best light output, low energy consumption, and cost-efficient solutions for driving, the same is the need of the hour. In this paper, we present a methodology for driving the highest class two-wheeler headlamp with regulator and rectifier (RR) output. Unlike usual LED headlamps, which are driven by a battery, regulator, and rectifier (RR) driven, a low-cost and highly efficient LED Driver Module (LDM) is proposed. The positive half of magneto output is regulated and used to charge batteries used for various peripherals. While conventionally, the negative half was used for operating bulb-based exterior lamps. But with advancements in LED-based headlamps, which are driven by a battery, this negative half pulse remained unused in most of the vehicles. Our system uses negative half-wave rectified DC output from RR to provide constant light output at all RPMs of the vehicle. With the negative rectified DC output of RR, we have the advantage of pulsating DC input which periodically goes to zero, thus helping us to generate a constant DC output equivalent to the required LED load, and with a change in RPM, additional active thermal bypass circuit help us to maintain the efficiency and thermal rise. The methodology uses the negative half wave output of the RR along with a linear constant current driver with significantly higher efficiency. Although RR output has varied frequency and duty cycles at different engine RPMs, the driver is designed such that it provides constant current to LEDs with minimal ripple. In LED Headlamps, a DC-DC switching regulator is usually used, which is usually bulky. But with linear regulators, we're eliminating bulky components and improving the form factor. Hence, this is both cost-efficient and compact. Presently, output ripple-free amplitude drivers with fewer components and less complexity are limited to lower-power LED Lamps. The focus of current high-efficiency research is often on high LED power applications. This paper presents a method of driving LED load at both High Beam and Low Beam using the negative half wave rectified pulsating DC from RR with minimum components, maintaining high efficiency within the thermal limitations. Linear regulators are significantly inefficient, with efficiencies typically about 40% and reaching as low as 14%. This leads to poor thermal performance. Although they don't require complex and bulky circuitry, powering high-power devices is difficult to realise with the same. But with the input being negative half wave rectified pulsating DC, this efficiency can be improved as this helps us to generate constant DC output equivalent to LED load minimising the voltage drop on the linear regulator. Hence, losses are significantly reduced, and efficiency as high as 75% is achieved. With a change in RPM, DC voltage increases, which can be managed by active thermal bypass circuitry, thus resulting in better thermal performance. Hence, the use of bulky and expensive heat sinks can be avoided. Hence, the methodology to utilize the unused negative pulsating DC output of RR to optimize the utilization of RR output power and provide a cost-efficient solution as compared to costly DC-DC drivers.

Keywords : class D LED headlamp, regulator and rectifier, pulsating DC, low cost and highly efficient, LED driver module
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