Available online at www.ijiere.com
International Journal of Innovative and Emerging Research in Engineering
e-ISSN: 2394 - 3343 p-ISSN: 2394 - 5494

Intelligent Alternator Controller: Prototype and Testing

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ABSTRACT:
In the world development is going on, which is continuously increasing pollution in the environment and automotive sector's contribution is in the large scale. To reduce pollution from vehicles, government sets strict norms for the emission controls of new vehicles production. Alternator is one of the vehicle components, which is contributing in vehicles emission and performance indirectly.
In conventional engine control system it is not possible to optimize the efficiency of the alternator in terms of emission and fuel consumption, due to constant voltage output and continuous loading condition. By controlling the alternators loading, it is possible to reduce fuel consumption and increase emission margin. This paper covers the approach to make alternator intelligent by implementing controller which control alternators loading and unloading in MIDC (Modified Indian Driving Cycle) on chassis dynamometer and on road conditions.

Keywords: Intelligent Alternator, INCA, MDA, MIDC

I. Introduction

In vehicle electrical power is required, which is fulfill by 12V battery but its continuous utilization make it discharge. So to charge battery we need an alternator. For more luxury and more functionality we are introducing number of devices in vehicle, so that the electrical power requirements in vehicles have been rising rapidly for many years and are expected to continue to rise. The continuous increase in power requirements is pushing the limits of conventional automotive power generation and control technology and is motivating the development of both higher-power and higher-voltage electrical systems and components.

Electrical System Used in Conventional Vehicle.
Alternator is a synchronous AC electric generator with DC diode rectification and pulse width modulation voltage control. In conventional vehicle alternator is in continuous loading condition. Conventional alternator is having efficiency of 35-45% (Bosch ~ 40-45% and TVS Lucas ~ 35-40%). A typical LCV (Light Commercial Vehicle) electrical power requirement is ~400-500 watts and to fulfill this requirement alternator consumes ~1-1.5 hp from engine. This causes more fuel consumption and more emission.

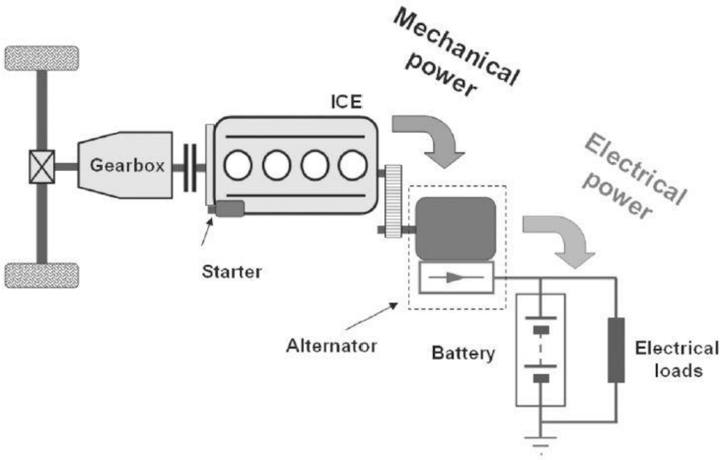

Fig. 1 Alternator working scheme

The fig.1 shows schematics of the conventional electrical system used in vehicle [2]. Where alternator takes mechanical power from engine, converted to electrical power. It is used to charge vehicle battery and parallel gives supply to vehicle electrical loads.

II. ENERGY RECUPERATION IN DRIVING CYCLE

A. Modified Indian Driving Cycle (MIDC)

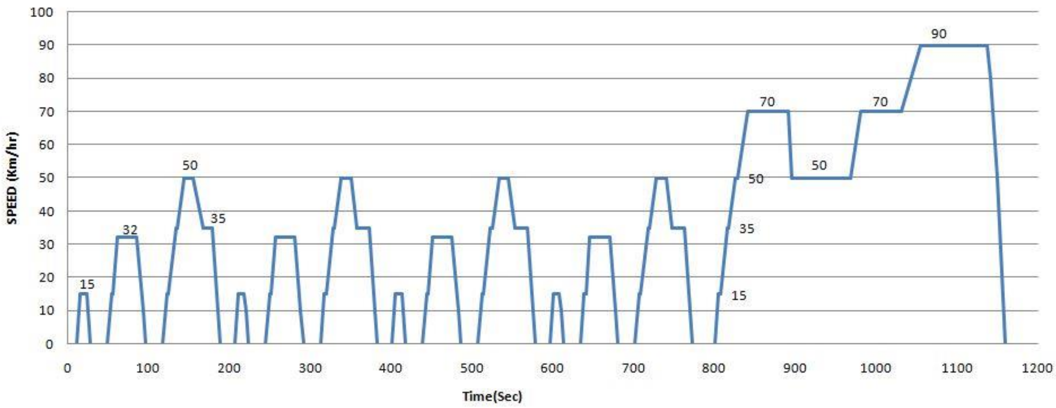

Fig. 2 MIDC driving cycle

MIDC is a typical driving cycle shown in figure 2, which design according to Indian road conditions and driving pattern. Vehicle emission is tested in ARAI, Pune running vehicle on MIDC driving cycle. Following are details of MIDC driving cycle,

Total test time	: -	1180 seconds
Total distance	: -	10.647 km
Maximum speed	: -	90 kmph
Max Acceleration	: -	0.833 m/s^2
Max Deceleration	: -	1.389 m/s^2

In MIDC driving cycle is consists of two phases Elementary Cycle of Emission (ECE) and Extra Urban Driving Cycle (EUDC). Following table explains the phases, duration of the driving cycle and travel distance [3].

TABLE I
Phases in MIDC

Phase	Start Time s	End Time s	Distance travel km
ECE 1	0	195	
ECE 2	195	390	4.053
ECE 3	390	585	
ECE 4	585	780	
EUDC	780	1180	6.594
Total	1180		10.647

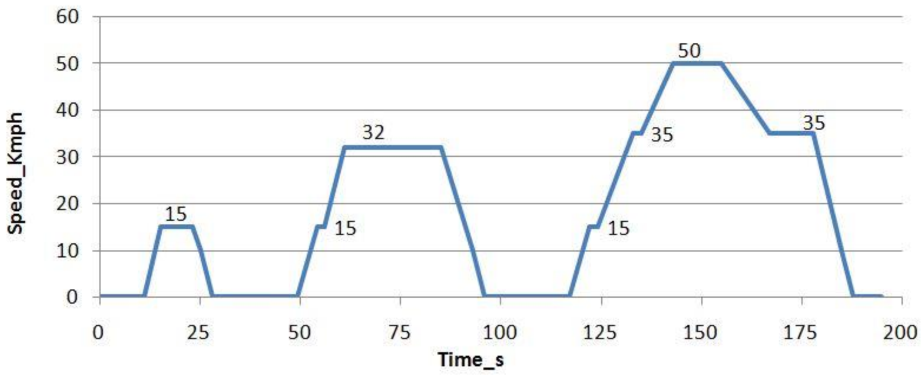

Fig. 3 ECE phase

The fig. 3 ECE phase represents the city road condition, so that we get the city driving condition and we can simulate vehicle on city road condition on chassis dynamometer.

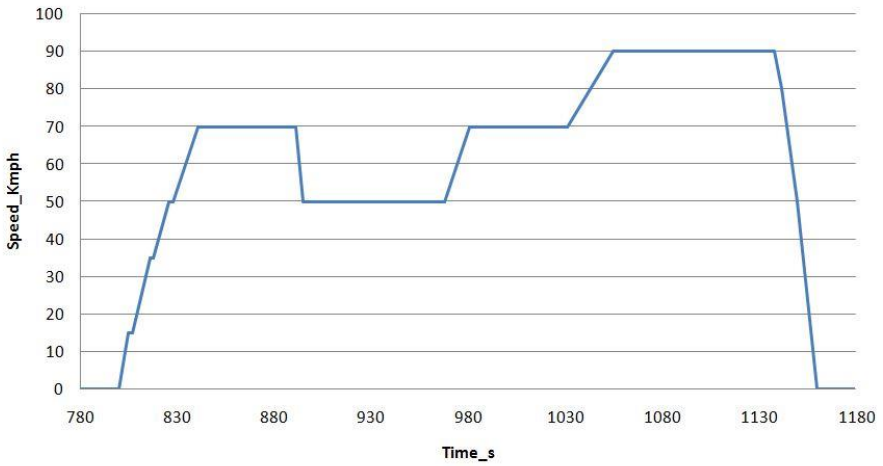

Fig. 4 EUDC phase

Fig. 4 shows EUDC phase. The EUDC segment has been added after the fourth ECE cycle to account for more aggressive, high speed driving modes. EUDC represents the highway road condition, we can simulate vehicle on highway road condition in chassis dynamometer.

In any driving cycle vehicle follow four different modes of operation. The stationary mode where fuel is burnt to keep engine running, the acceleration mode where fuel is burnt to accelerate or move the vehicle, the cruising mode where small amount of fuel is burnt to keep vehicle running, and deceleration mode where fuelling is stopped [1], [2].

Conventional alternator reacts same way in all vehicles operating mode. It continuously generates 14.4V at 25^0C ambient temperature, irrespective of driving mode or fuel burning or not. If we properly manage the vehicle fueling and loading of accessories like alternator then fuel efficiency of vehicle can be improved. It is very helpful to unload alternator in engine acceleration and idle mode. Load the alternator in deceleration, cruising mode also in braking conditions.

III.INTELLIGENT ALTERNATOR SYSTEM

Intelligent alternator systems block diagram is shown in fig. 5

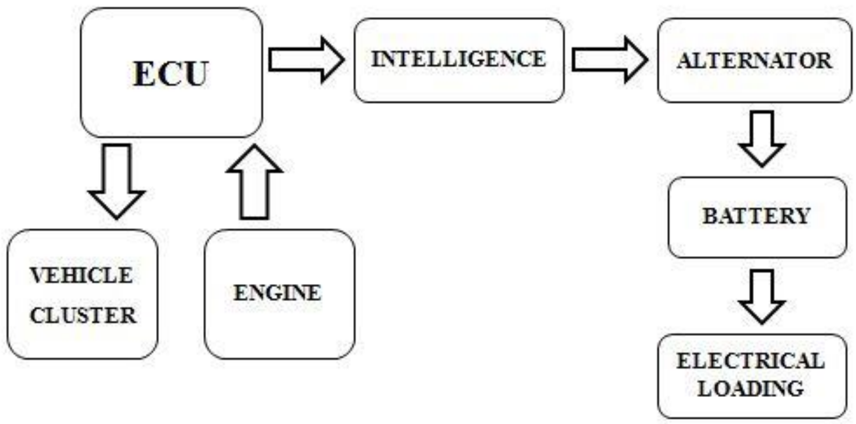

Fig. 5 (a) Block diagram of intelligent alternator system

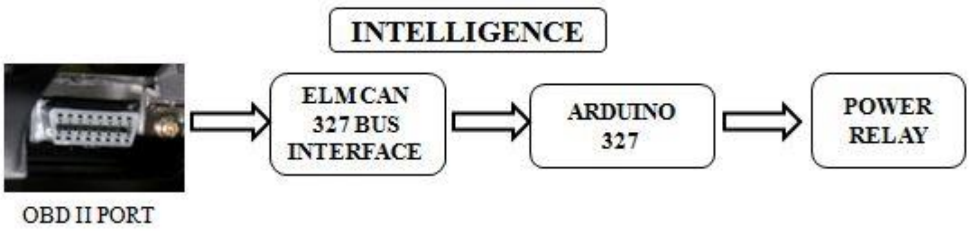

Fig. 5 (b) Block diagram of Intelligence

The fig. 5 gives idea of intelligent alternator controller. ECU is controlling engine. Through OBD II port required input parameters are logged in from ECU and are supplied to Arduino board, where vehicles operation is determined and alternators loading or unloading signal is given to power relay.

B. VEHICLE DYNAMIC STUDY

TABLE II. Vehicle and engine specification

Vehicle type	Light Commercial Vehicle
Engine	Single cylinder 600cc, Naturally aspirated
Fuel	Diesel
Cooling system	Water cooled
Rated Power	12HP @ 3000 rpm
Max. Torque	35 Nm @ 16000 rpm
EGR	Proportional
Auxiliary systems	EGR cooler, Oil mist separator

Vehicle dynamic behavior is studied through data logging device and INCA data acquisition software. Recorded data is analyzed in MDA [7], [8].

For data logging from vehicle Arduino electronics hardware is prepared which is connected to OBD communication port and this device logged real time data which is stored in memory card. This is very useful device for monitoring the vehicle dynamic on road conditions. The fig. 6 shows the real time data logging device.

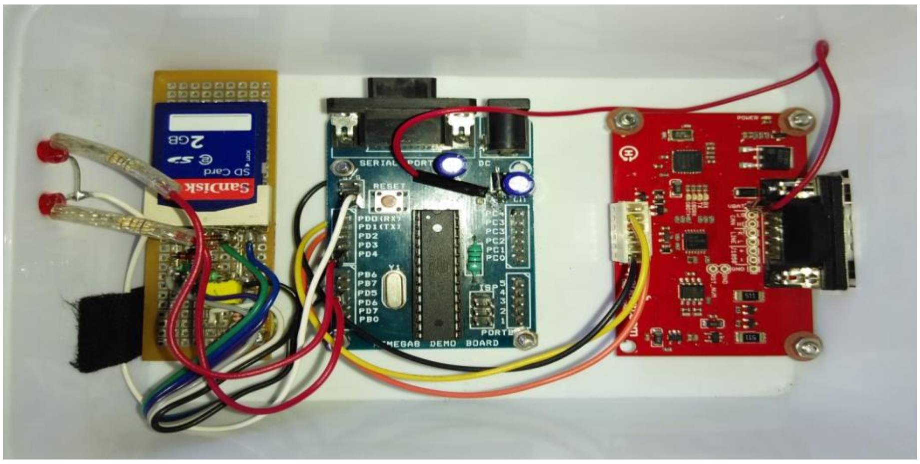

Fig. 6 Real time Data logging device

Table III shows the sample of real time data logged in memory card.

TABLE III. Real Time data logged

clntTemp(DegC)	engRPM	VehSpd(Kmph)	engRunTim(Sec)	engLoad(%)	AccPosD(%)
22	0	0	0	0	14
22	0	0	0	0	15
22	80	0	0	0	14
22	185	0	0	100	14
22	315	0	0	43	14
22	1211	0	0	43	14
22	1167	0	1	45	14
22	1045	0	2	46	14
22	1176	0	3	49	14

It is possible to log all data which are available to read through OBD II communication port. Table III shows sample of required data for analysis.

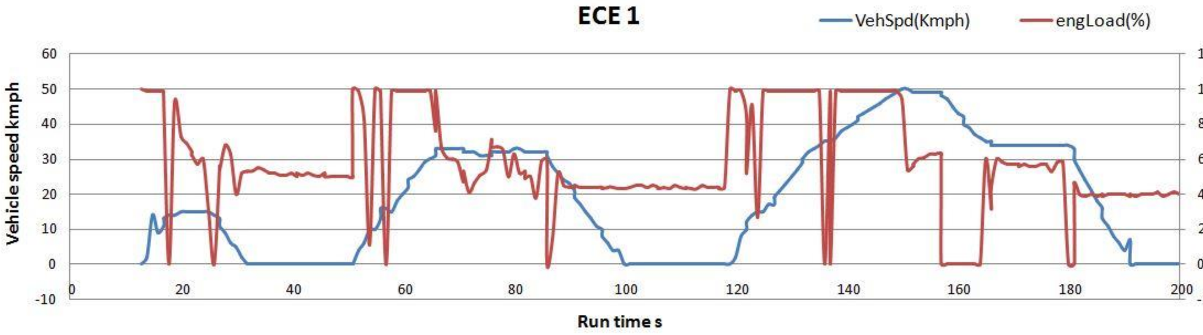

Fig. 7 (a) ECE1

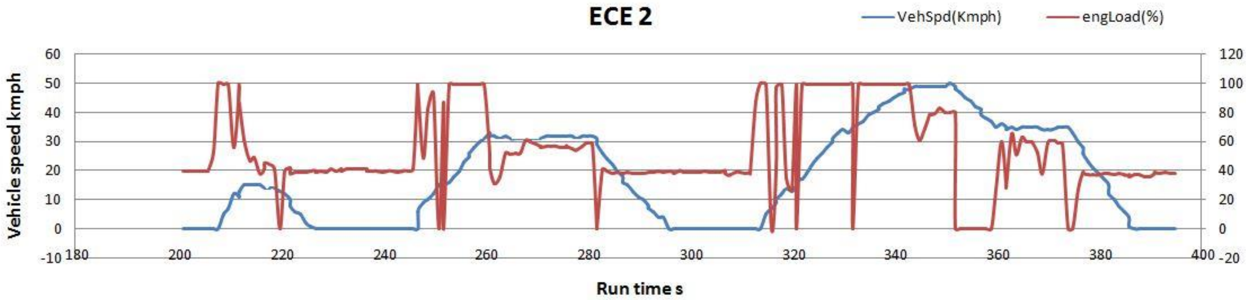

Fig. 7 (b) ECE2

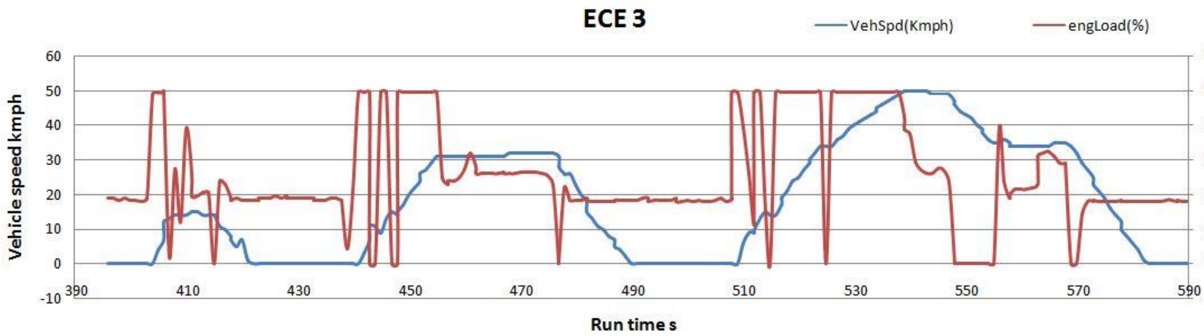

Fig. 7 (c) ECE3

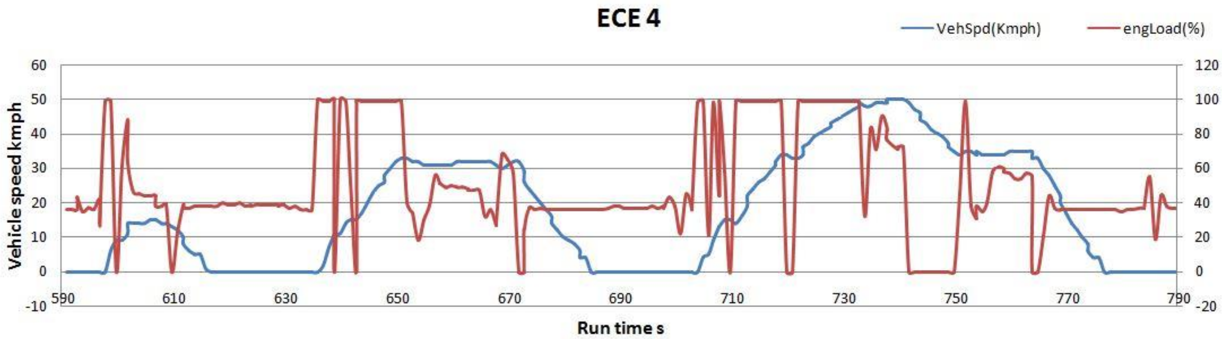

Fig. 7(d) ECE 4

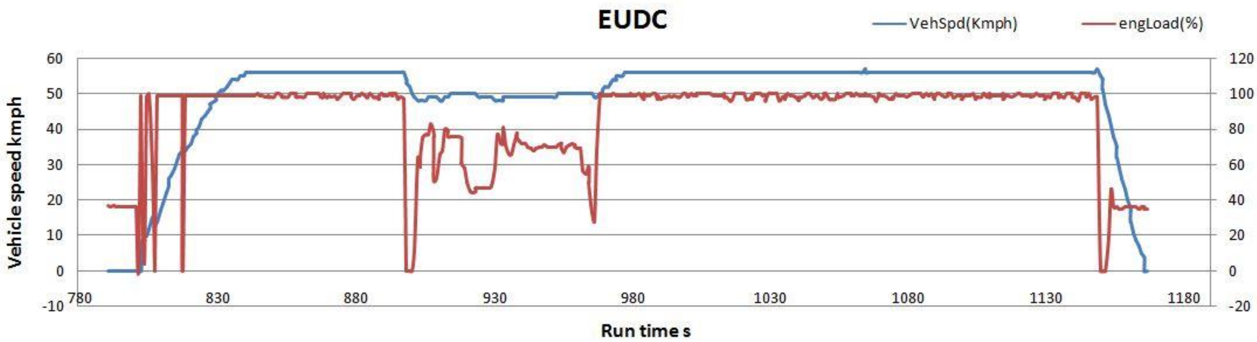

Fig. 7 (e) EUDC

Fig. 7(a) to (e) represents real time data recorded in data logger. Referring Fig. 7 (a) to (d) it is clear that in first ECE all systems, fuel, engine temperature are stable so initial fuelling requirement is more compare to remaining ECE. Here load percentage gives the respective fuelling.

On chassis dynamometer vehicle is tested and real time data is recorded in INCA that recorded data is analyzed in MDA The fig. 8 shows the variables from MDA window.

Fig. 8 MDA window

INCA measures data during MIDC and in MDA same data is analyzed. Individual variables are analyzed and alternator loading and unloading points are determined.

IV. CONCLUSION

Reference [1], [2] shows that fuel efficiency can be improved by ~4 - 7% and ~3 - 3.5 g/km CO2 benefit is possible by using smart alternator.

Vehicle emission test is successfully conducted on chassis dynamometer and vehicle behavior on on-road, both results are analyzed and energy recuperation points are determined for alternator loading and unloading. Programming of controller is under process, after completion of program. Vehicle trials will be conducted, so fuel efficiency and emission effect due to controller will be analyzed.

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ABBREVATIONS

MIDC	-	Modified Indian Driving Cycle
INCA	-	INtegrated Calibration and Acquisition
MDA	-	Measured Data Analyzer
LCV	-	Light Commercial Vehicle
ECE	-	Elementary Cycle of Emission
EUDC	-	Extra Urban Driving Cycle
EGR	-	Exhaust Gas Recirculation