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Bi-directional DC-AC using BLDC motor for electric and hybrid electric vehicles applications with reduced number of switches

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ABSTRACT

Electric scooters often have a single design and are difficult to produce at a greater level than other forms of transportation. A possible cut electric scooter is built with the optimization design of the vehicle combustible wealth and the pollution characteristics in order to arrange to a correct solution by resolving each and every challenge. The engines' electrical systems are comprised of lead acid batteries. For the sake of a straightforward simulation procedure, the engine operates in two states ON and OFF while the vehicle's speed is regulated in three ranges roughly corresponding to high, medium, and low. The planetary speed ratio and the final drive speed ratio are gathered in the computation method's general outline. Utilizing simulation MATLAB, the findings of optimization strategies are resolved. This technique improves the fuel plenty and discharge quality of the possibility cut electric automobiles.

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1. INTRODUCTION

The cutting-edge element of the new technology in the development of electric scooters. Since they are less costly now, people are utilizing electric scooters more often. An obvious excellent current technology to improve vehicle emissions while putting together safe fuel discharge controls is the electric car. A mixture of two or more different energy technologies goes into making an electric car [1]. Internal combustion engines (ICE), and batteries. have characteristics that make them unique examples of a given category. The investigations are conducted by choosing state of charge (SOC) and speed ratios that are very important as indicated in Figure 1. A hybrid electric vehicle model for new European driving cycles employing optimization techniques for fuel reduction reasons under standardized conditions [2]. By alternative approach for simulating hybrid electric vehicles utilizing the cruise method before optimizing the speed ratio for power trains. By controlling the speed ratio, the fuel consumption is subsequently improved [3]. For hybrid vehicles, an optimization plug-in electric car where the driving ratio and SOC parameters were designed into the process. Finally, the transport fuel consumption is increased at [4] using the genetic algorithm approach. There are certain limitations in the sources because of non-linear loads while attempting to get maximum power [5].

In order to get around this, process optimization methods that date back to the 1930s are used [6]. Modern optimization methods are advancing quickly from earlier generations. Engineering has provided a variety of problem-solving methods that may be used both systematically and analytically [7]. Methods for addressing problems are often divided into two categories: heuristic and deterministic. In order to arrive at a clear answer, the deterministic includes the solution for problem-solving techniques [8]. As a result, the optimized switching devices vary a critical technique with minimal losing ways with certain initializing and changing in size, which may be achieved with certain optimizing methods [9]. In order to provide dependable servicing among the functional values, the voltages will be changed continuously from one range to another using the networks that are required [10]. Science breakers circuits are to be illustrated with the effective within the voltage and current ranges with lower current reduction with an active part of the current transferring to the facility AC to DC [11]–[15]. The initiator develops co-genitive brilliant power managing techniques to control the power in charge among the powered co-genitive brilliant power managing techniques to attain a low efficient fuel rates [16]–[20] in addition to the low amount mechanisms of various potential sources used in hybrid electric vehicles [21]–[27].

2. HYBRID ELECTRIC VEHICLE OPTIMIZATION TECHNIQUES FOR ROUTINE PROCESS

The control design takes into account the low-cost power systems for the specified hybrid electric vehicles (HEV). The converter and inverter sides in Figure 1suggested architecture significantly contribute to the regulation of the engine and battery powers. In this case, the driving cycle calculates the time variances between duty cycles, these are shown in Figure 1. The fuel usage is an example of a mental control using optimization methods. The procedure below demonstrates a distinct range where the plans are shown in order to initiate and terminate the process. Examples include "start 1, slow watch 1, start 2, slow watch 2, start 3, slow watch 3, slow watch k" as shown in Figure 1, which depicts the mission's start and stop procedures. Here, D displays the maximum time and distance. To complete one cycle, enter j=1, 2, 3.

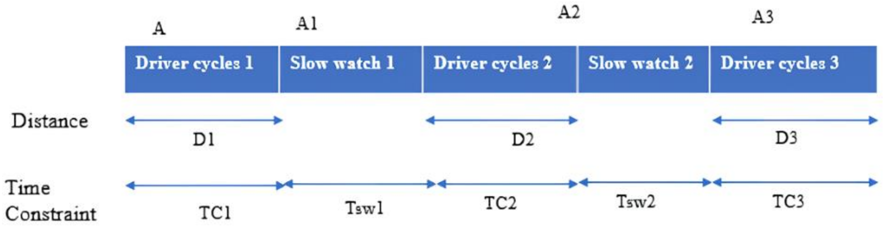


Figure 1. Driver mission plan typical plan

2.1. EV motor ratings

In the various values L_s, W_s, and H_s where the three values mean the height, length and width of the electric vehicle. While taking the mass M_s of the vehicle the velocity V_s the slope of the angles is shown in Figure 1, the total forcing in the e vehicle the propelled the addition of the forces are calculated using (1).

$$Fts = Frr(1) + Fad(1) + Fhc(1) + Fla(1) \tag{1}$$

From (1) the $Frr_{(1)}$ shows the force of the resistance while $Fad_{(1)}$ initiates the drag of aerodynamics, $Fhc_{(1)}$ initiates the climbing force on the hills, $Fla_{(1)}$ is the acceleration force. $Cr_{(1)}$ initiates the co-efficient of the resistance of rolling. The typically values of the tires are 0.015 from (2).

$$T(0) = Ft(1)\, r, and\ \omega = Vs(1)\ /r(s) \tag{2}$$

3. PROPOSED SEVEN LEVEL ASYMMETRICAL INVERTER TOPOLOGY

3.1. Circuit topologies

Figure 2 (see appendix) depicts the proposed 7-level inverter proposed topology. In this proposed topology seven level inverter are designed in order to generate the pulse at ON and OFF conditions. These conditions are shown in different modes listed below. The architecture that is suggested for each phase, which consists of two bi-directional and eight uni-directional power semiconductor switches for each phase leg. Bi-directional switches are mostly used to prevent short-circuits SC and to stop the currents flowing in opposite directions for direct current supply. The switching scheme for 7-level switching topology is shown in Table 1.

The Figure 2(a) shows the proposed topology. The switches in Figure 2(b) shows the on state for s1, s2, s5, s6, and OFF state for s3, s4, s7, and s8. The switches in Figure 2(c) will be in the ON state for s1, s2, s5, s6, and OFF for s3, s4, s7, and s8. The output voltage will be in an OFF state in Figure 2(d) the switches s1, s2, s3, s4, s5, s6, s7 and s8—are in the OFF condition. The output voltage will be in an OFF state in Figure 2(e) with the switch s1, s2 in an OFF condition, s3, s4 in a ON condition, s5 in an OFF condition, s6 in a ON condition, s7 in an OFF condition, and s8 in a ON condition. The output voltage will be in an OFF state in Figure 2(f) with the switch s1, s2 in an OFF state, s3, s4 in a ON state, s5 in an OFF state, s6 in an OFF state, s7 in a ON state, and s8 in a ON state. The switch in Figure 2(g) has the following states: s1, s2, OFF, s3, s4, ON, s5, OFF, s6, s7, s8, and OFF. The output voltage Figure 2(h) also has the following states: s8, OFF, and s1, s2.

Table 1. Switching scheme for 7-level 8-switching topology

Sl.No	S1	S2	S3	S4	S5	S6	S7	S8	Output voltage
1	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON
2	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON
3	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF
4	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
5	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF
6	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF
7	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON

4. COMPARISON BETWEEN DIFFERENT MULITLEVEL INVERTERS

These sections exhibit the comparison with several multilevel inverters in the proposed topology. According to the comparison, the suggested approaches are divided into two categories: symmetrical and asymmetrical. The charts in Figure 3 depict the varying switching count levels. The suggested topology is described in Figure 3. Power switches S1, S2, S3, S5, and S7 are in the turn-ON (i.e., conduction state) state in mode 1 while the remaining switches are in the turn-OFF state. As a result, the output voltage at the load is operational. Switches 1, 2, 5, and 6 are ON in mode 2 while switches S3, S4, S7, and S8 are OFF; as a result, the output is ON at the load. In mode 3, S1, S2, S5, S6, and S8 are in a ON state while S3, S4, and S7 are in an OFF state. As a result, the output voltages are in an OFF state. The output voltage is OFF conditions at the load in mode 4 because all switches are in the OFF condition (i.e., non-conduction state). As a result of the other switches, such as S1, S2, S5, and S7 being in the OFF state at mode 5, the output voltages at the loads are in the ON-OFF condition at this mode. In mode 6, the switches S1, S2, S5, S6 are OFF, the switches S3, S4, S7, and S8 are ON, and as a result, the output voltages at the loads are in an ON-OFF position. The output voltages at the loads are in the ON state at mode 7 because switches S3, S4, and S7 are ON while S1, S2, S5, and S6 are OFF.

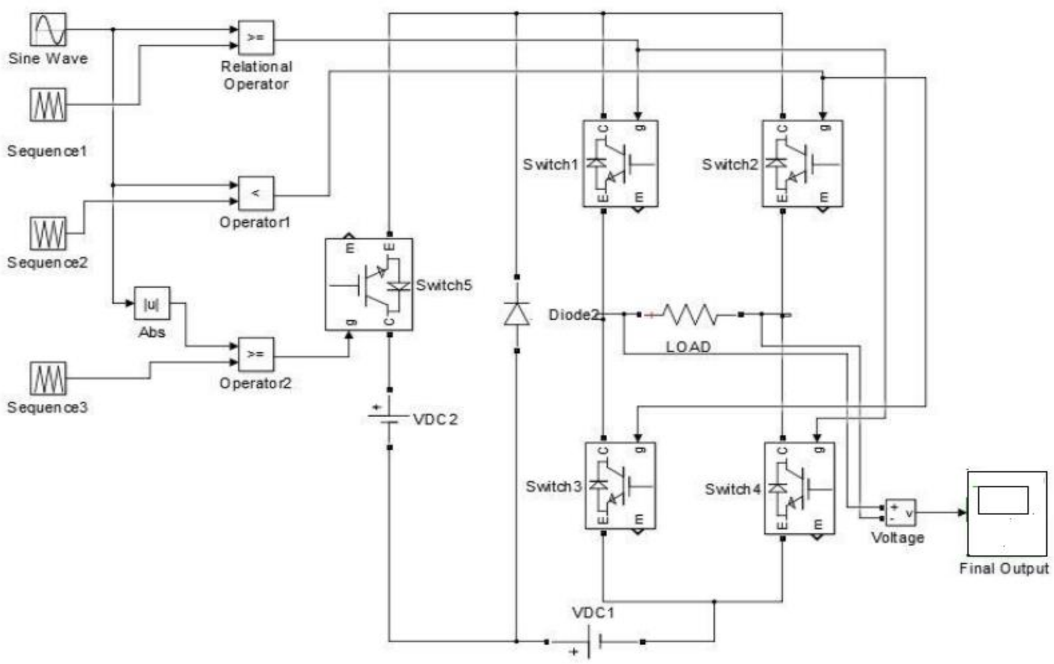


Figure 3. Implementation of proposed topology using MATLAB

4.1. Controlling process of brushless direct current motor (BLDC)

The brushless direct current motor (BLDC) motor consists of two main parts stator and rotor for all electrical part. It is easy to protect and direct current are in needed. The electronic control and current carrying conductor stator widening are flourished in certain pattern. Equations for voltage of phases a, b, c are given by (3)-(5).

$$Va = R_{a0} + i_{a1} + L(\frac{dia}{dt}) + e_{a0} \tag{3}$$

$$Vb = R_{b0} + i_{b1} + L(\frac{dib}{dt}) + e_{b0} \tag{4}$$

$$Vc = R_{c0} + i_{c1} + L(\frac{dic}{dt}) + e_{c0} \tag{5}$$

Electromagnetic torque equation is given by (6).

$$T_e = (e_{a0}i_{a1} + e_{a0}i_{b1} + e_{c0}i_{c1})/\omega \tag{6}$$

The mechanical torque is given by (7).

$$T_m = J\frac{d\omega}{dt} + B\omega + T_L \tag{7}$$

Where B: damping constant; J: rotor inertia; T_L: load torque. It is advisable to select BLDC motors when an electric vehicle or two wheels requires very little performance at extremely low range; this motor is employed in such situations. Two-wheelers are equipped with a motor of the wheel in this motor where mechanical power transfers, such as deceleration, are eliminated.

4.2. A comparison of machine topologies

As mentioned earlier the BLDC motors with the radial part are compared with the different topologies as mentioned in the Table 2. Brushless DC motors have friction feature like large begin torque, large efficiency around 95-98%. Brushless DC motors are suitable for large current density model approach. The BLDC motors are the most like better motors for the electric vehicle application's due to its friction features. This comparison mainly focuses on some features of electric vehicles with respect to reliable, range in speeds, loads, and efficiency.

Table 2. Comparison topologies of various motors

	Rotor-BLDC	Stator-BLDC	Hybrid-BLDC	Memory BLDC
PM material	Nd-Fe-B	Nd-Fe-B	Nd-Fe-B	Alnico
Excitations	BLDC only	BLDC only	BLDC and windings	BLDC only
Flux control	Complex	Complex	Easy	Medium
Efficiency	Very high	Very high	High	High
Power density	Very high	Very high	High	High

4.3. Battery modelling

The battery model and the designing of the Lithium ion battery are used to analyses the storage capacities of the system and the battery behaviors in different aspects. The charging and the discharging of the two methods are illustrated in (8), (9) shows the charging mode, and (10) show the dis-charging mode.

$$F(it_0, i^1) = E_{01} - K\frac{Q}{Q-it(0)}i(0) - K\frac{Q}{Q-it(0)}it(0) + Aexp(0) * (-Bit) \tag{8}$$

$$F(it_0, i^1) = E_{01} - K\frac{Q}{Q-0.it(0)}i(0) - K\frac{Q}{Q-it(0)}it(0) + Aexp(0) * (-Bit) \tag{9}$$

The battery voltages are illustrated in (10).

$$V_{ba(0)}t = f(it_0, i^1) - Ri(0)_{bat} \tag{10}$$

5. EXPERIMENTAL RESULTS

Figure 4 illustrates the degrees of specific simulated component features that will be changeable. The input and output parameters should be kept at the same value in order to sustain the model. This EV has a wheel drive, two-wheel starter, and parallel starting gearbox pathways. If a simulation component like the federal test procedure (FTP-75) is used, the driving topology is shown. These drives' fuel efficiency will be achieved by integrating composite fuel efficiency. The following methods are composed in designing the problems: i) Accelerating time 0-65 mph< =18.0 s_0; ii) Accelerating time 45-65 mph< =8 s_0; iii) Accelerating time 0_80 mph $G_0$40:2 s_0; and iv) Maximum accelerating 8 :4 m/$_{s02}$.

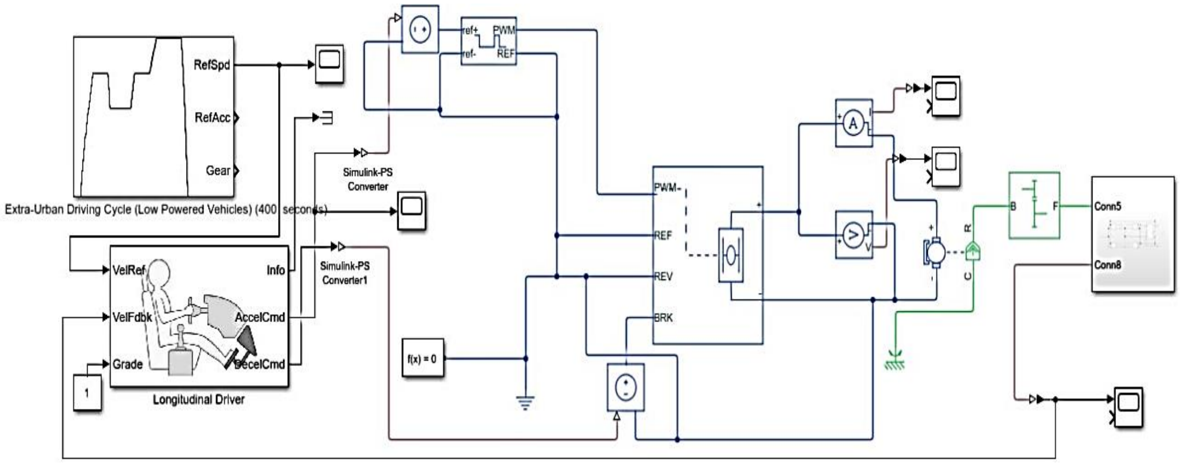


Figure 4. Electric vehicle model using MATLAB

The circuit in Figure 5(a) (see Appendix) shows the drive cycle waveform where the signals at the second starts to increase. At the Figure 5(b) (see Appendix) depicts the waveforms of drive cycle FTP-75 of the vehicle speed. Figure 5(c) depicts the solar PV system for EV charging that was examined. At Figure 5(d) (see Appendix). Shows the waveform for the vehicle speeds of BLDC motor. The Figure 5(e) (see Appendix) shows the voltage range of the battery where it increases to a certain level. At the Figure 5(f) (see Appendix) shows the battery charging waveform. The use of MATLAB software (Simulink) for the simulation part's operations is absolutely necessary. As a result, In the Figure 5(g) (see Appendix) shows the stator output where the speed starts to increase. In the Figure 5(h) (see Appendix) shows the rotor output, in the Figure 5(i) (see Appendix) shows the electromagnetic torque and whereas in the Figure 5(j) (see Appendix) shows the DC bus voltage output. As a result, it may be possible to create EV charging stations that use solar energy realistically and optimistically. The specialized batteries rated to levels with higher topologies that execute the energy transfer from one component to another while charging EV batteries.

6. CONCLUSION

The modelling and control of a permanent magnet brushless DC motor (PMSM BLDC) for an electric vehicle have been shown in this study. The research for the design, model, and simulation of EV components using solar energy as the input source is shown in the suggested topology. Less optimization is used in the current procedure. The harmonic reduction is 9.03, yet in this suggested topology, the harmonic reduction is just 3.64%. The many components for the methodologies and techniques used, as well as signal processing, are relevant to the suggested solutions for electric vehicle or EV charging that have been described. In this article, an EV with a battery charge design that maintains a power factor value of 0.95 or such is discussed. The PWM three level-boost rectifier are employed in this architecture as a result. As a result, one of the key debates surrounding EV technology is the EV charging schemes. Therefore, it is recommended that renewable and clean processes employ zero-emission batteries in order to accomplish this procedure. Therefore, it is evident from the simulation results that the BLDC motor is appropriate for EVs to drive the car efficiently.

APPENDIX

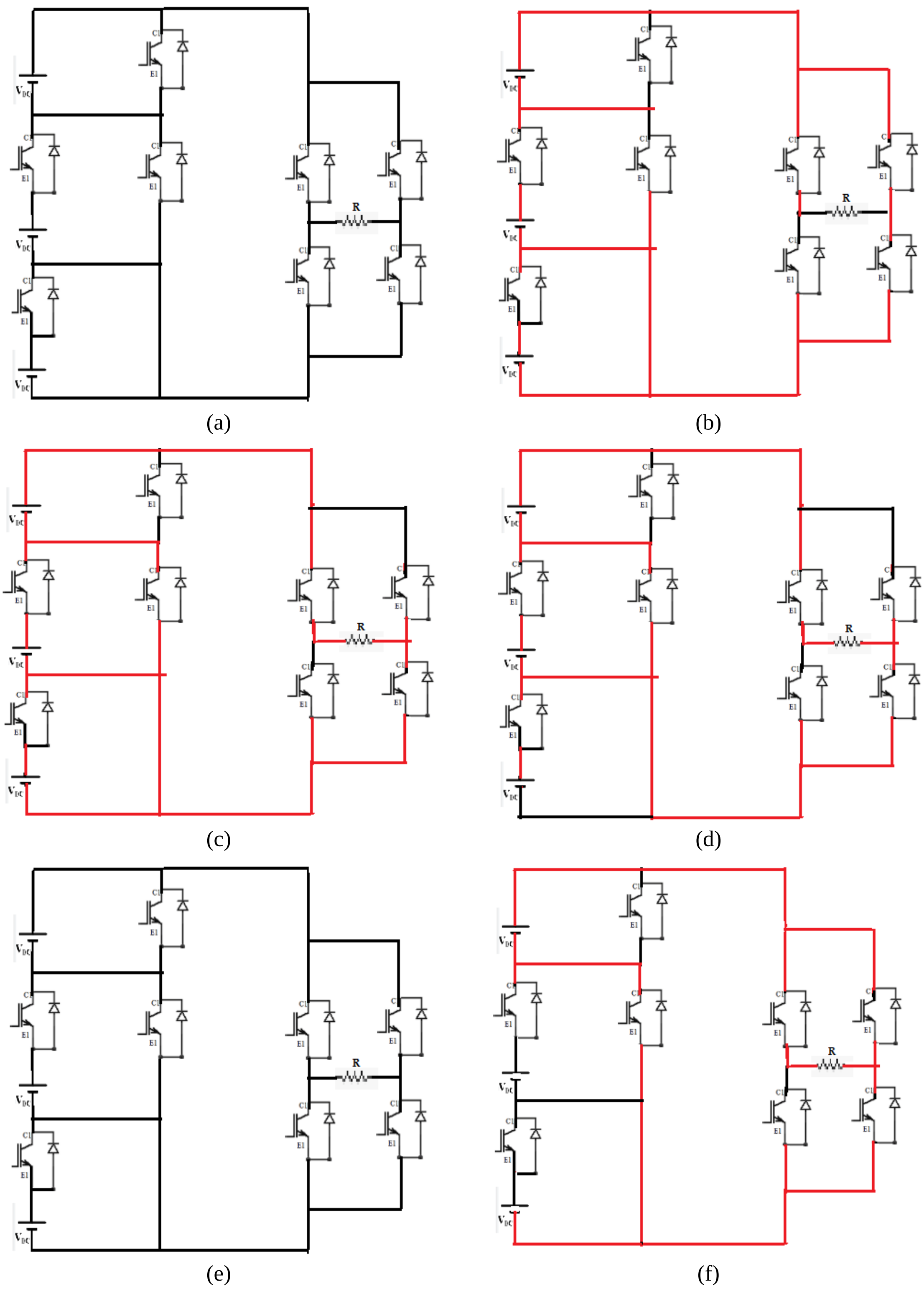
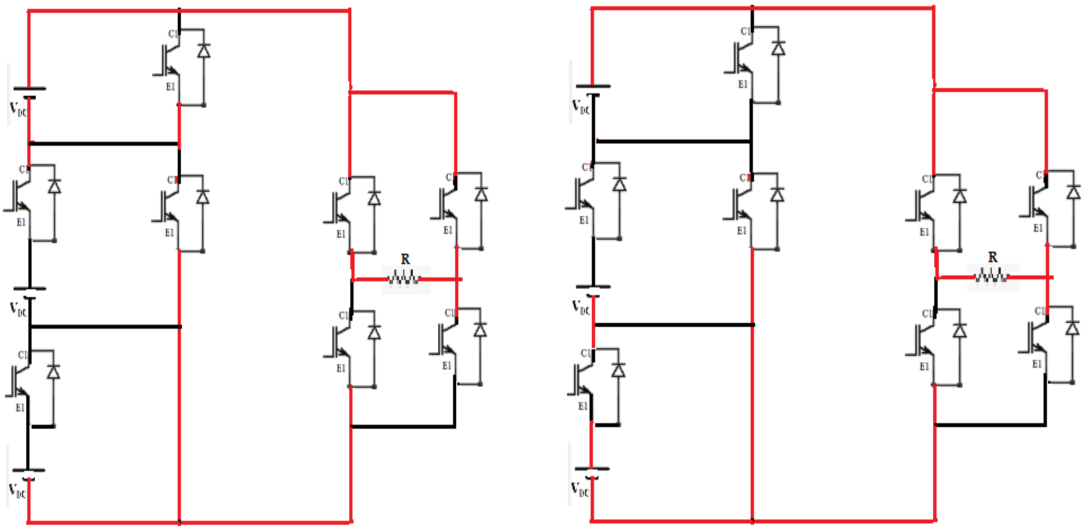
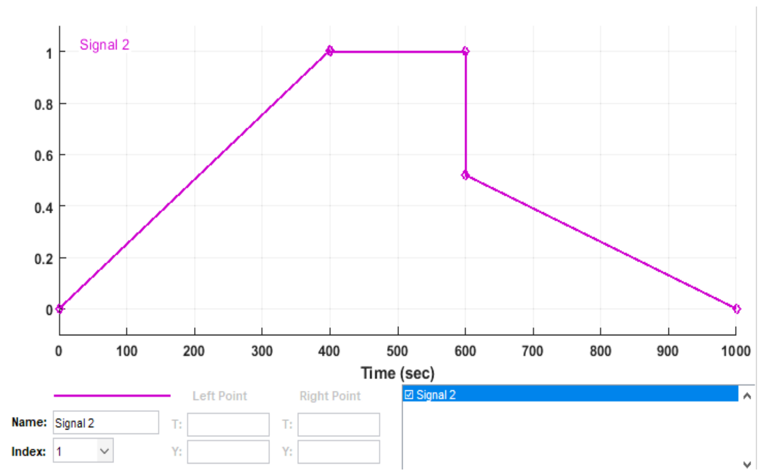


Figure 2. Topology of seven level inverter: (a) proposed topology; (b) mode 1 on state for S1, S2, S5, S6, and OFF state for S3, S4, S7, and S8 output voltage +V_{dc}; (c) mode 2 ON state for S1, S2, S5, S6, and OFF state for S3, S4, S7, and S8 output voltage +2V_{dc}; (d) mode 3 switches on state S1, S2, S3, S5, S6, and S8 OFF state S3, S4, S7 output voltage +3V_{dc}; (e) mode 4 S1, S2, S3, S4, S5, S6, S7, S8 output voltage 0; (f) mode 5, on state S3, S4, S6, S8, OFF state S1, S2, S5 output voltage -V_{dc},

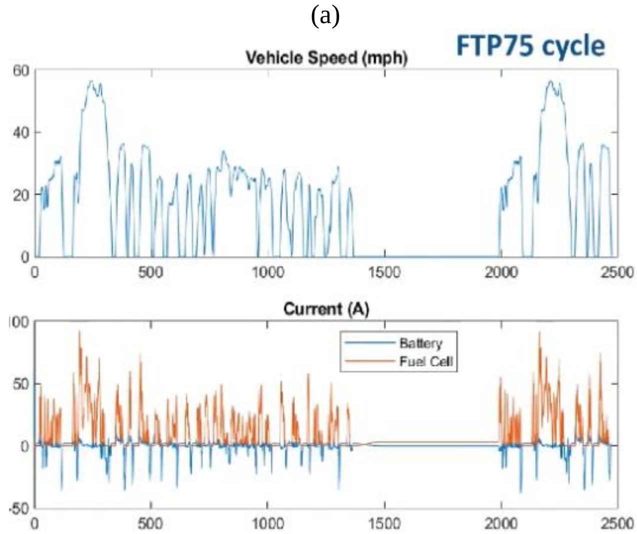


(g) (h)

Figure 2. Topology of seven level inverter: (g) mode 6, on state s3, s4, s7, s8, and s1, s2, s5, s6 OFF state output voltage -2 V_{dc}; and (h) Mode 7 s3, s4, s7 ON state and S1, S2, S5, S6, and S8 OFF state output voltage -3 V_{dc} (continued)

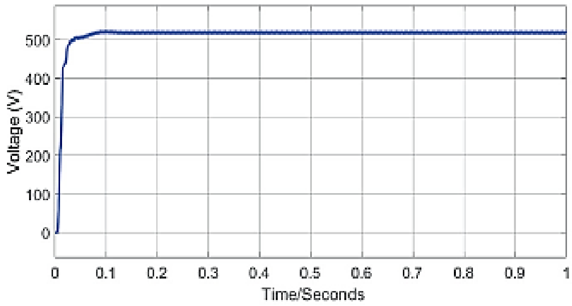


(a)

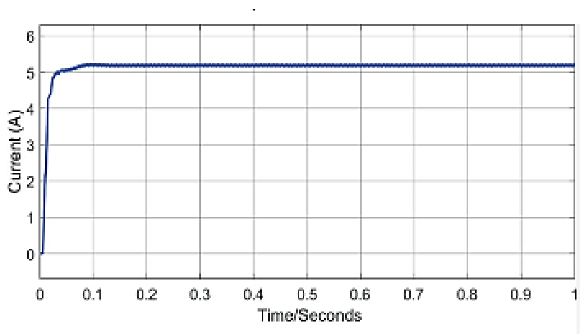


(b)

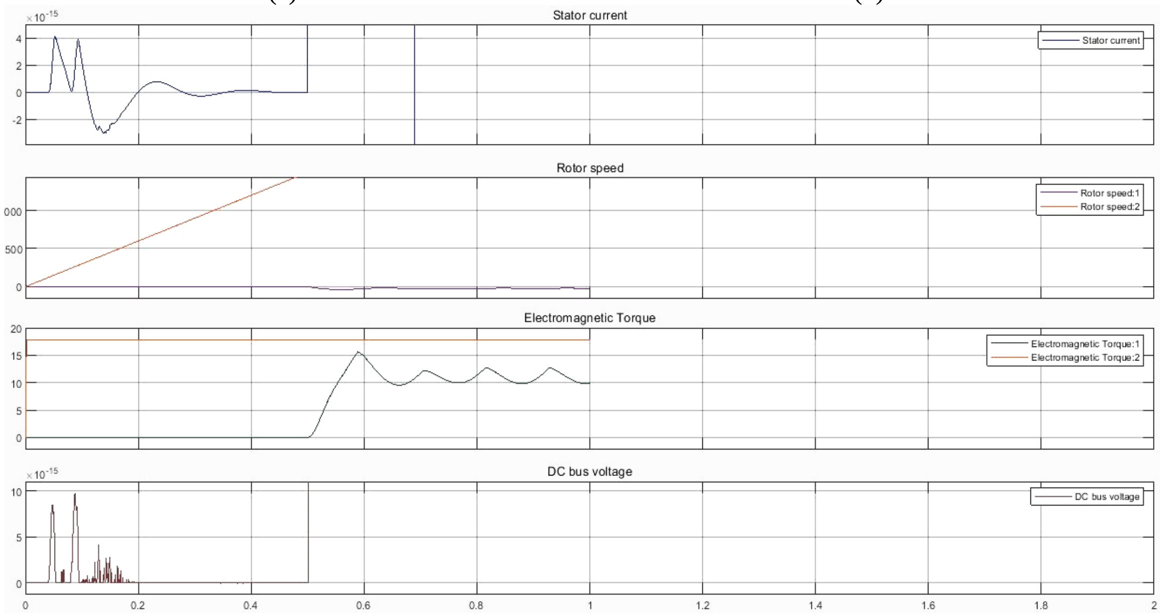
Figure 5. Drive cycle FTP-75: (a) Waveform at signal 2 and (b) vehicle speed



(c)



(d)



(Time seconds)

(e)

Figure 5. Drive cycle FTP-75: (c) battery speed value changing curve, (d) voltage range in battery, and (e) BLDC motor stator output, rotor output, electromagnetic torque, DC bus voltage (continued)

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