POWER ELECTRONICS SYSTEMS FOR ELECTRIC VEHICLES

REPORT ON :-
THREE PHASE TWO LEVEL CONTROLLED BIDIRECTIONAL AC-DC CONVERTER WITH BIDIRECTIONAL DUAL ACTIVE BRIDGE ISOLATED CONVERTER SYSTEM

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1. Objective

To simulate a three phase two level comtrolled bidirectional ac-dc converter with bidirectional dual active bridge isolated converter system.The details of converter system amd othe rratings are given in the table below. The charging system has to be designed such that it charges from 75% of State of Charge (SOC) to 85% SOC. The charging system will charge the battery with

- 75% to 80% charging in constant current mode
- 80% to 85% charging in constant voltage mode

specifications :-

s.no	specifications	valu	unit
1	input voltage	6.6 (L-L)	KV
2	Frequency	50	Hz
3	Battery Voltage	400	V
4	Battery Energy Rating	70	kWhr
5	Battery Charging Time (20 - 80 SOC)	45	min.
6	Input Power Factor	1	–
7	Input Power Factor THD	5%	–
8	Output Voltage Ripple Of ac-dc converter	5%	–

Design considerations:-

1. AC-DC CONVERTER
2. DC-DC CONVERTER:-

The converter works in buck mode for charging the battery. On the contrary, the converter works in boost mode. Taking the buck mode as example, the control transfer function for the converter can be expressed as :-

$$G_{id(s)} = \frac{2V_{bus}(sC_O+\frac{1}{R_{load}})}{L_1C_os^2+\frac{L_1}{R_load}s+1}$$

Similarly, the control transfer function for the converter in boost mode can be expressed as :-

$$G_{id(s))} = \frac{V_{bus}(sC_O+\frac{2}{R_{load}})}{L_1C_os^2+\frac{L_1}{R_load}s+2D'^2}$$

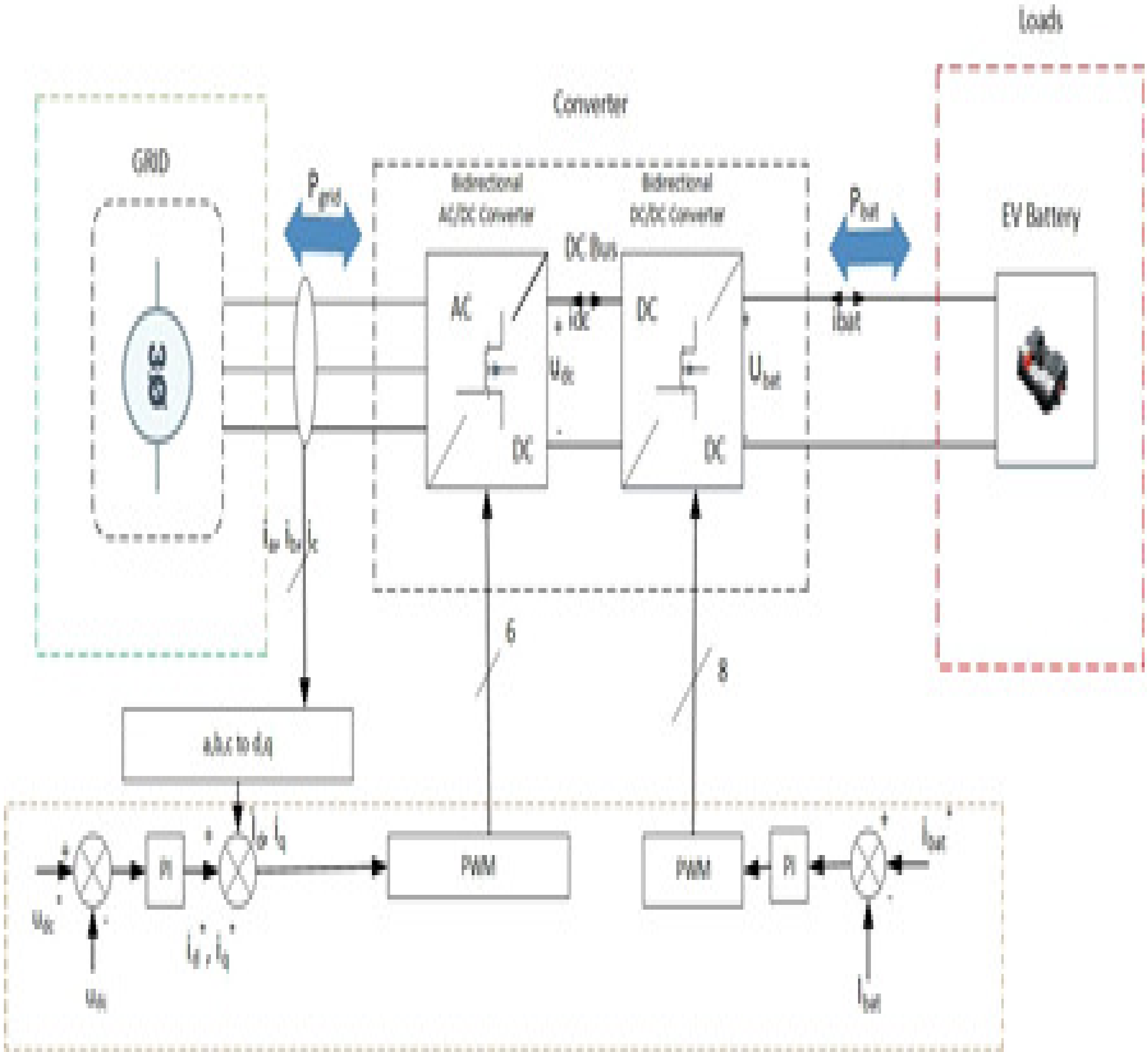
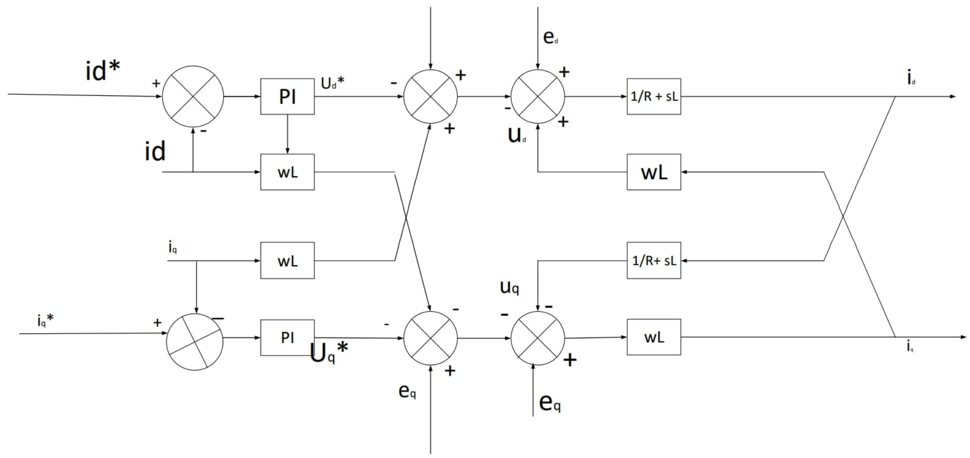


Fig. 1: Bidirectional EV Charging System

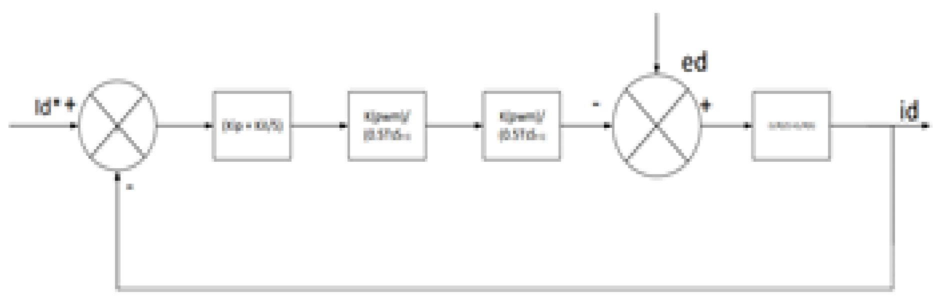
Control strategy :-

1. Current Closed-Loop Design:-

The inner current closed loop is used to keep the sinusoidal current input for system. It is obvious that the id



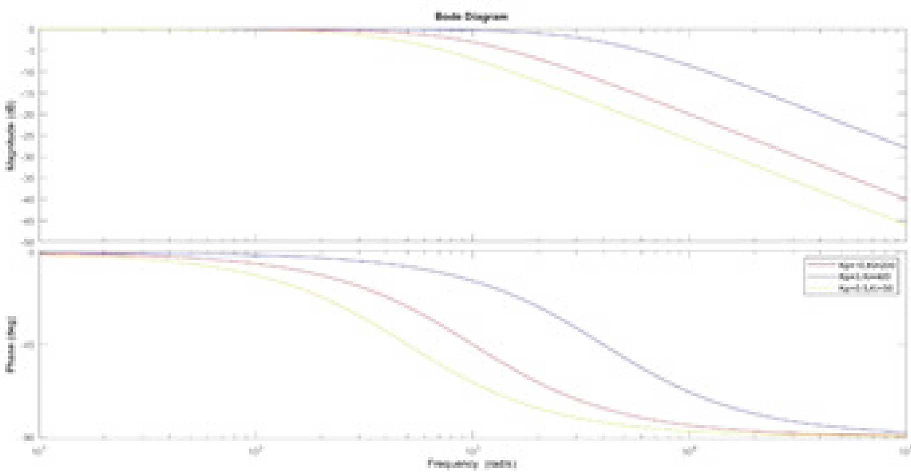
and iq current loops are similar and symmetrical. The control diagram is shown below.



T_s is the sample period of current loop; Kip and KiI are the proportional and integration coefficients of PI regulator, respectively; and K_{pwm} is the equivalent gain of the three-phase pulse width modulated converter. Now this closed loop can be simplified into the following transfer function :-

$$\frac{1}{1+\frac{R.\tau_i}{K_{ip}.Kpwm}s+\frac{1.5T_sR.\tau_is^2}{K_{ip}.Kwmp}}$$

Using the above transfer function we plotted the bode plot for various values of of K_p & K_i .



Bode diagram for different values for proportional and integration coefficients.

CALCULATIONS:-

1. FILTER CALCULATIONS:-

A. Capacitor,C calculation :-

$\frac{{V_{L-L}}^2}{3.X_c} = Q$

Q is 5% of the rated power.

$therefore, X_c = \frac{{V_{l-l}}^2}{3Q}$

Solving this we get ,

$C = \frac{3*2800}{2*\pi*50*6.6*6.6*10^6}$
therefore, C = 500 micro Farad.

B. Inductor calculations :-
$L_1 = L_2 = \frac{V_{dc}}{4*h*f_{sw}}$
here, 2h = 40% of rated current
$h = 0.4 * \frac{56000}{6600*1.732}$
h= 0.98
$putting values in the expression of L_1 and L_2, we get$

$L_1 = L_2 = 0.5mH$

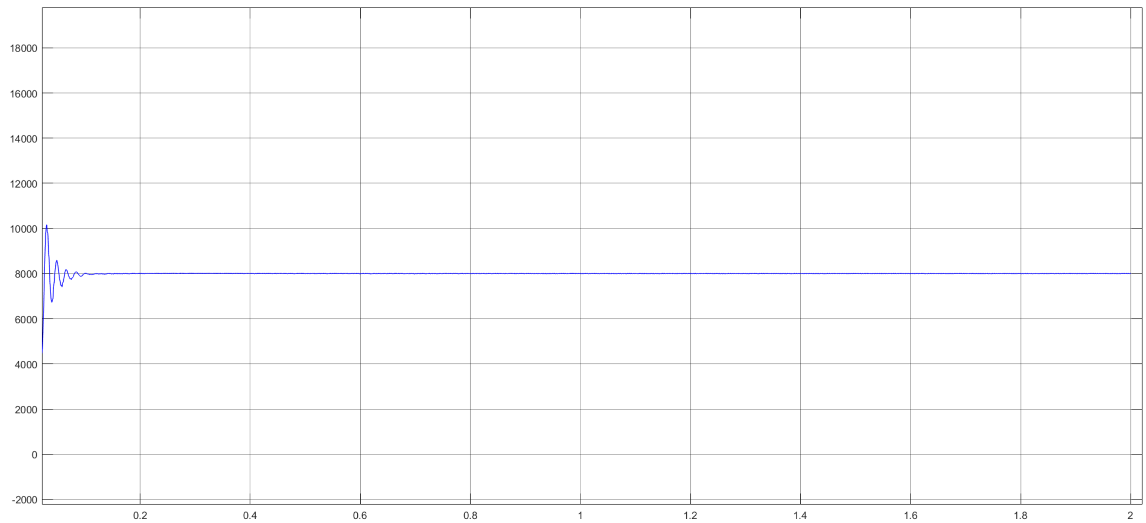
C. DAB CALCULATIONS :-
(i) inductor calculation :-

$\Delta I_l = \frac{V_o(1-D)}{L.f_s}$
$2\% = \frac{0.02*140*10000}{400*0.5}$
$therefore; L = 2mH.$

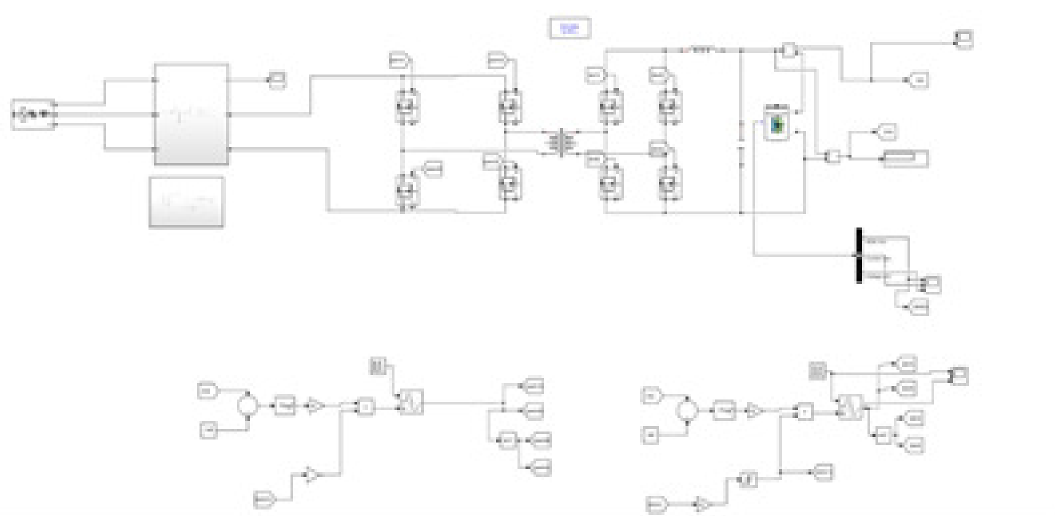
(ii) Capacitor Calculation :-
$\Delta = \frac{V_o(1-D)}{8.L.C.f^2}4$
$0.025 * 400 = \frac{400*0.5}{8*0.001*2*C*10000L}$
$C = 190\mu F.$

Simulation and experiment results

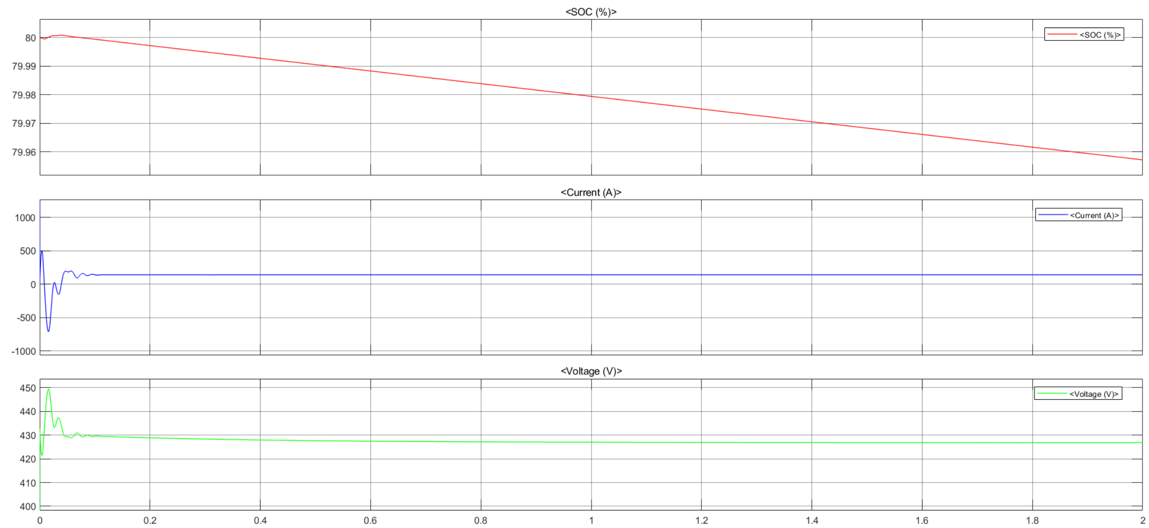
1. Simulation results : - Simulation is established in

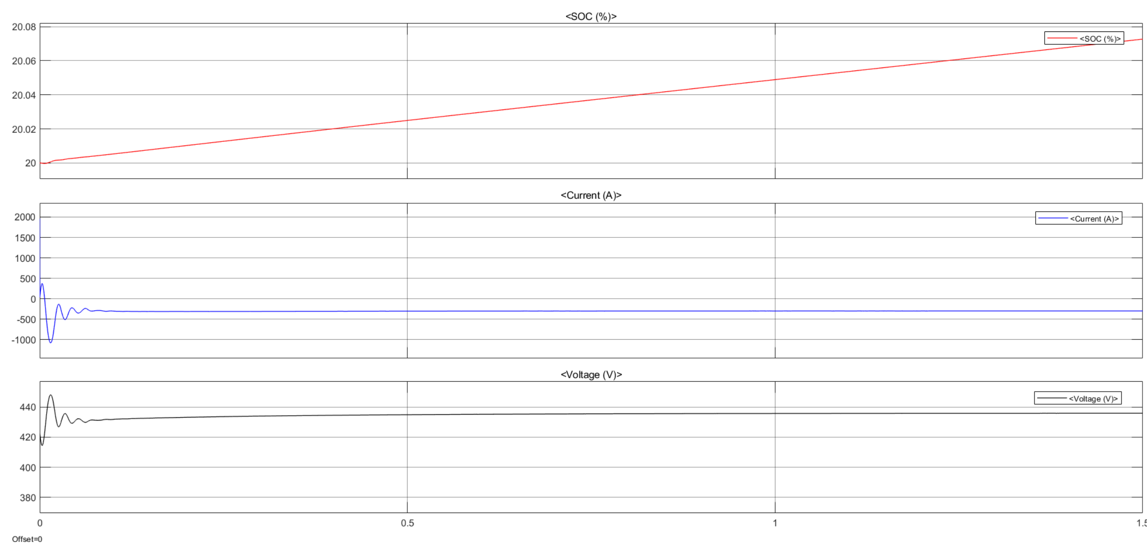


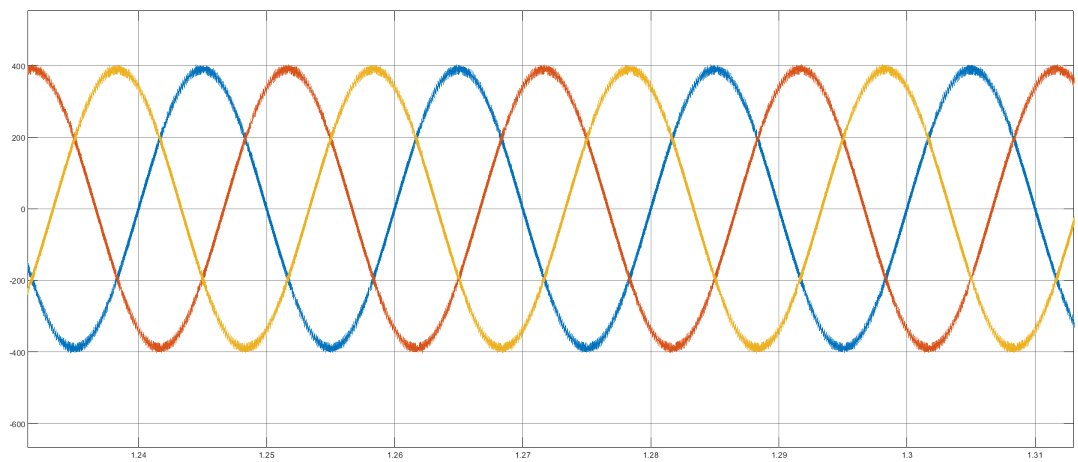
MATLAB.
System configuration is shown in figure 1, and detailed parameters are in table.



Discharging output


<SOC (%)>
<Current (A)>
<Voltage (V)>


<SOC (%)>
<Current (A)>
<Voltage (V)>
Offset=0


400
200
0
-200
-400
-600
1.24
1.25
1.26
1.27
1.28
1.29
1.3
1.31