Impedance Matching Using Cascaded Boost-Buck Converter For High Efficiency in WPT

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CONTENTS

INTRODUCTION

- Wireless power transmission is one of the most promising technology for the future
- We have various wireless power transfer technologies like inductive coupling , magnetic resonance coupling , microwave etc.
- One of the main challenge of WPT is the design of the system to transfer power efficiently
- Here we introduce a best converter topology for impedance matching for efficient wireless power transfer

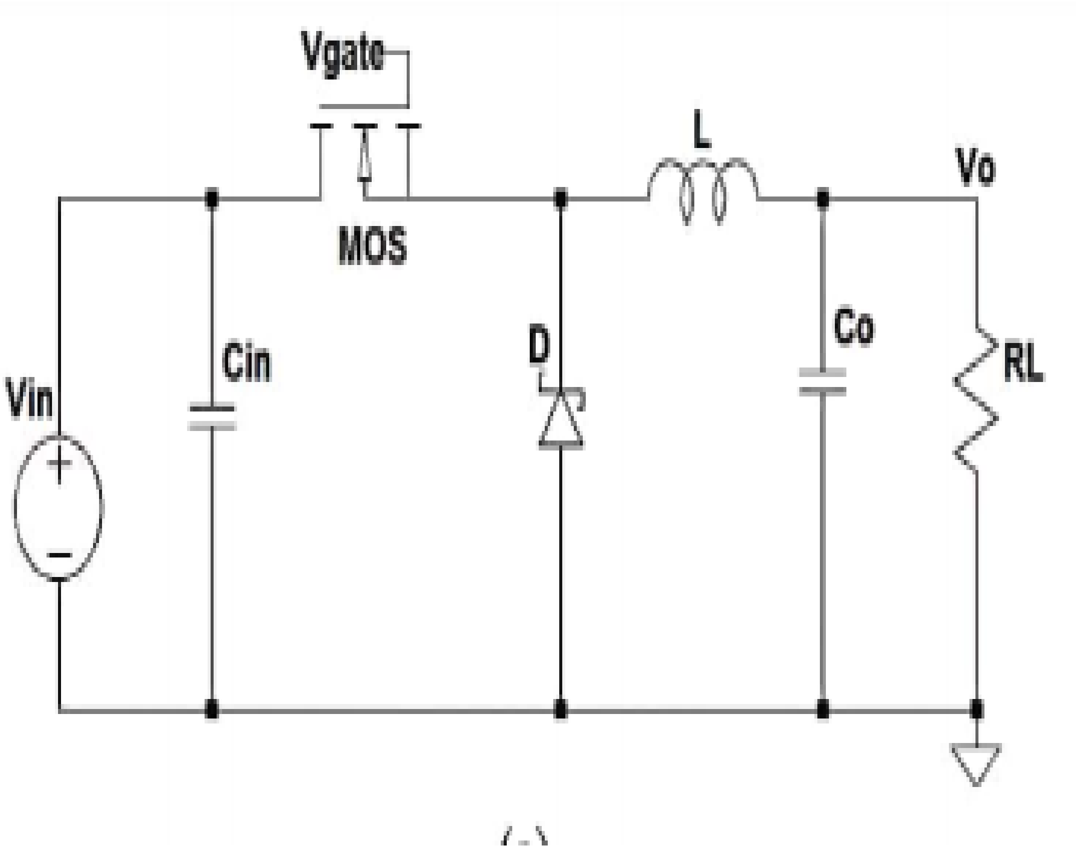
TOPOLOGIES OF DIFFERENT CONVERTERS

<u>Buck converter (DCM)</u>

- Output current $I_0 = \frac{1}{2}(D+\delta)I_{Lp}$.

- $R_{in} = (2Lf_{sw}/D^2)\ \dfrac{1}{1-V_0/V_{in}}$

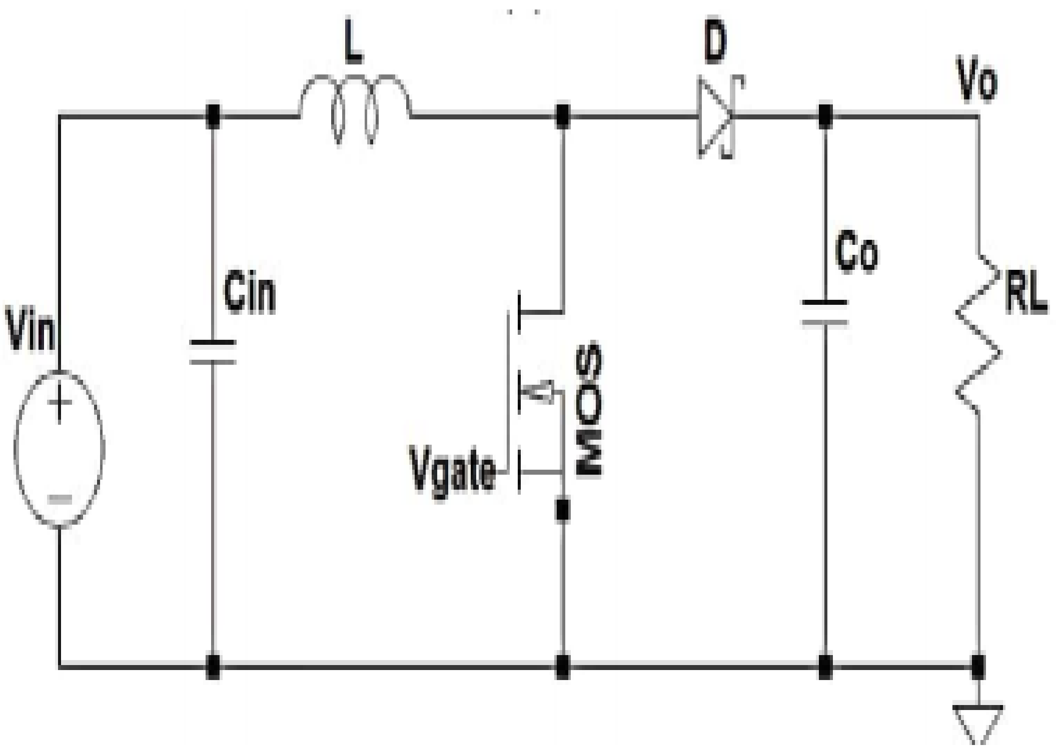
- Output voltage $V_0 = \dfrac{V_{in}^2}{\dfrac{2LI_0}{D^2} + V_{in}}$



TOPOLOGIES OF DIFFERENT CONVERTERS (cont..)

<u>Boost converter (CCM)</u>

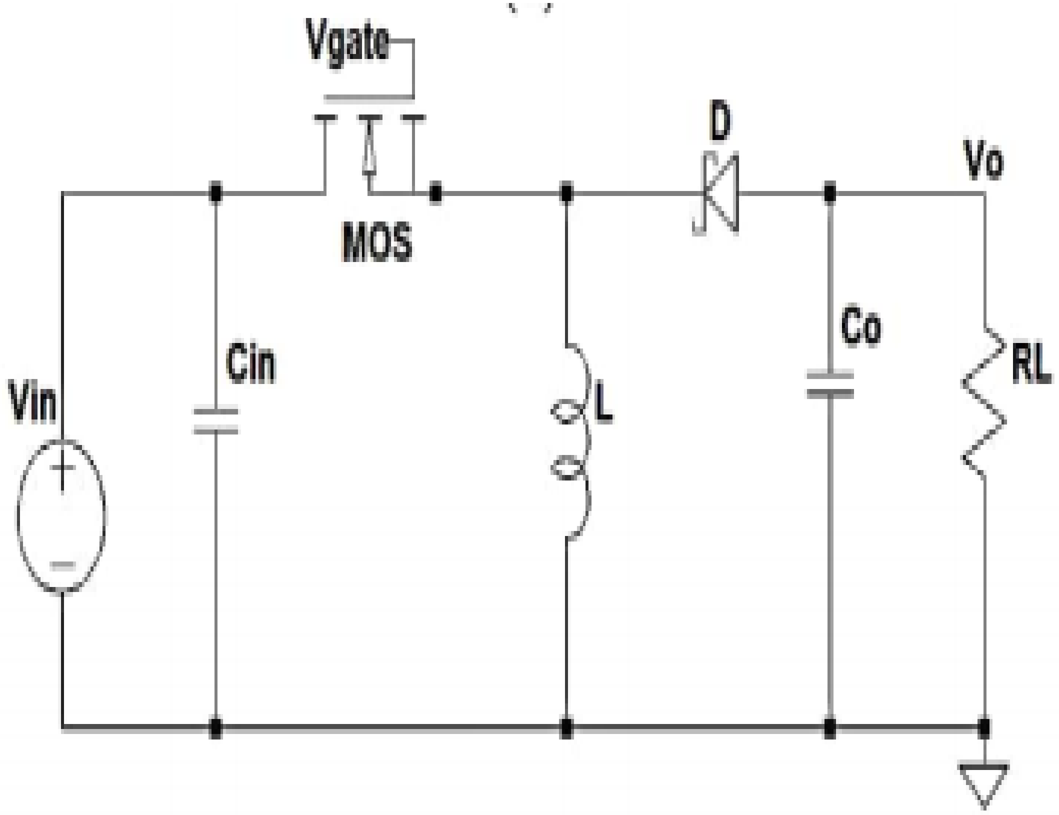
- The inductor current is increasing nearly to the peak value I_L.
- $V_o = (1/1\text{-}D)V_{in}$
- $R_{in} = (1\text{-}D)^2 R_L$
- In boost converter $R_{in} < R_L$



TOPOLOGIES OF DIFFERENT CONVERTERS (cont..)

Buck-Boost converter (DCM)

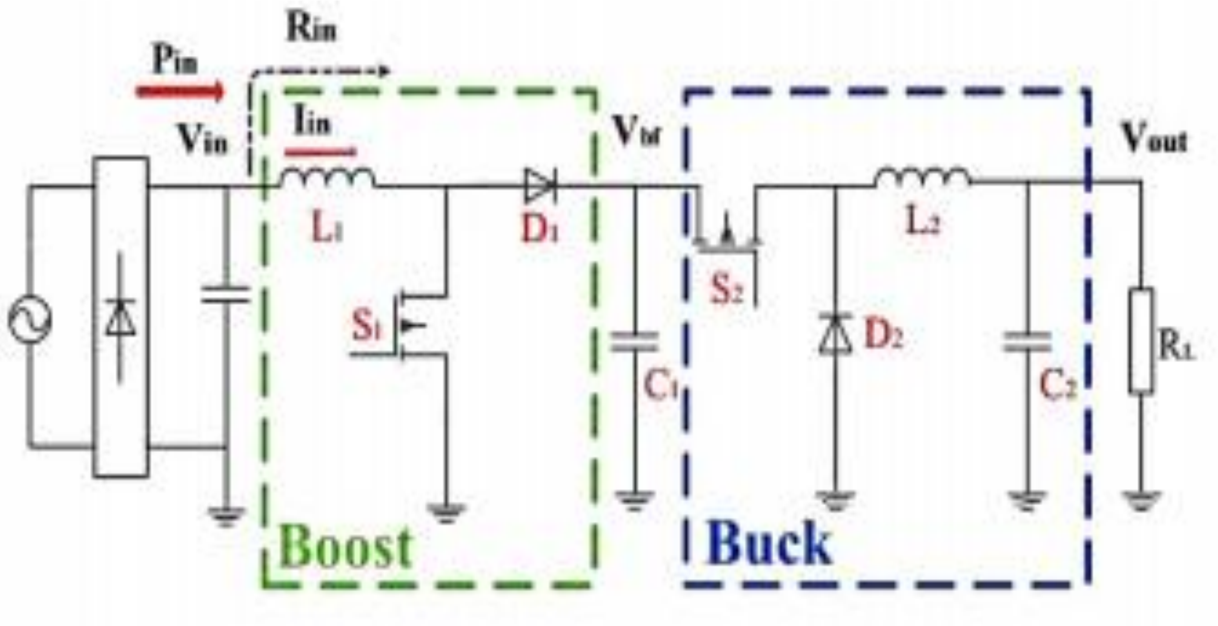
- $I_0 = \delta\,(I_{LP}/2)$
- $P_0 = \dfrac{D^2 T\, Vin^2}{2LI_0}$
- $Rin = \dfrac{2Lfsw}{D^2}$
- fsw is the frequency of the Vgate
- Rin is independent of the input Voltage and load resistance RL



TOPOLOGIES OF DIFFERENT CONVERTERS (cont..)

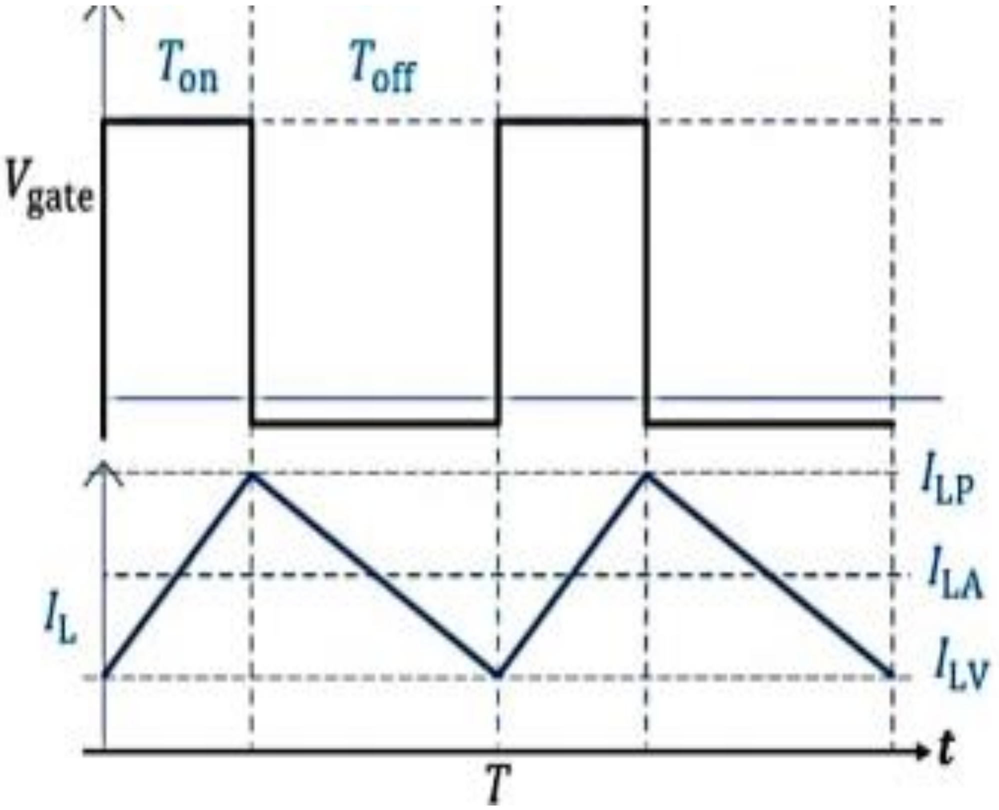
Cascaded Boost-Buck converter

- It uses the combination of boost and buck converter
- Compared to one switch topologies the boost-buck two switch topologies provides more flexibility.
- It has two control modes , fixed load mode and variable load mode.

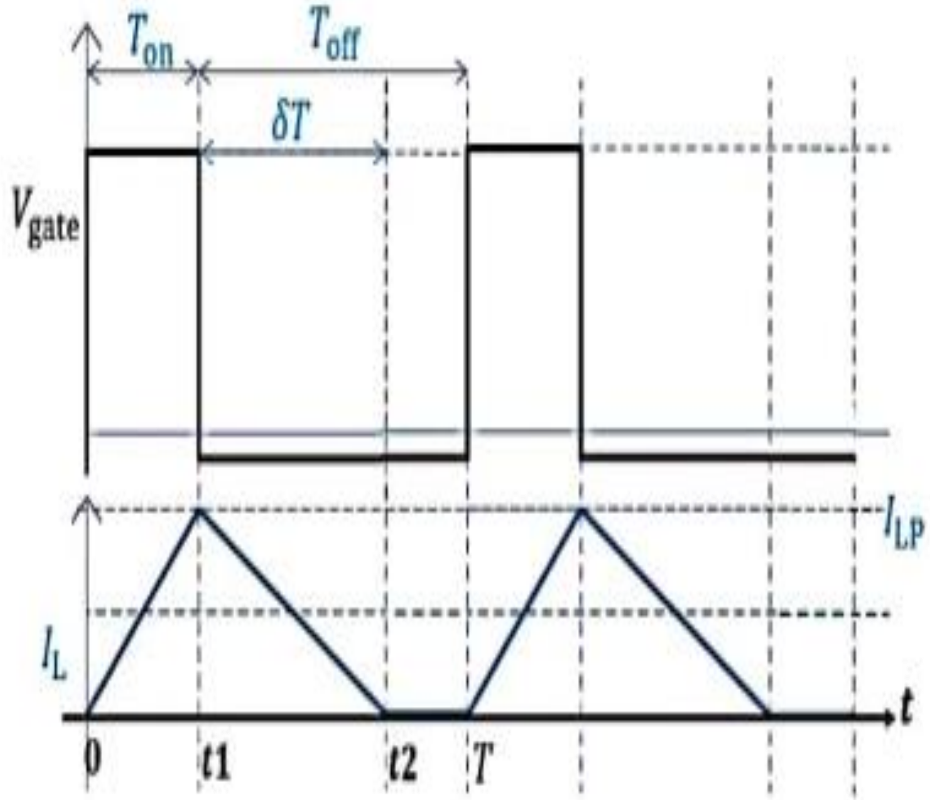


WAVEFORMS OF DC-DC CONVERTERS IN CCM AND DCM

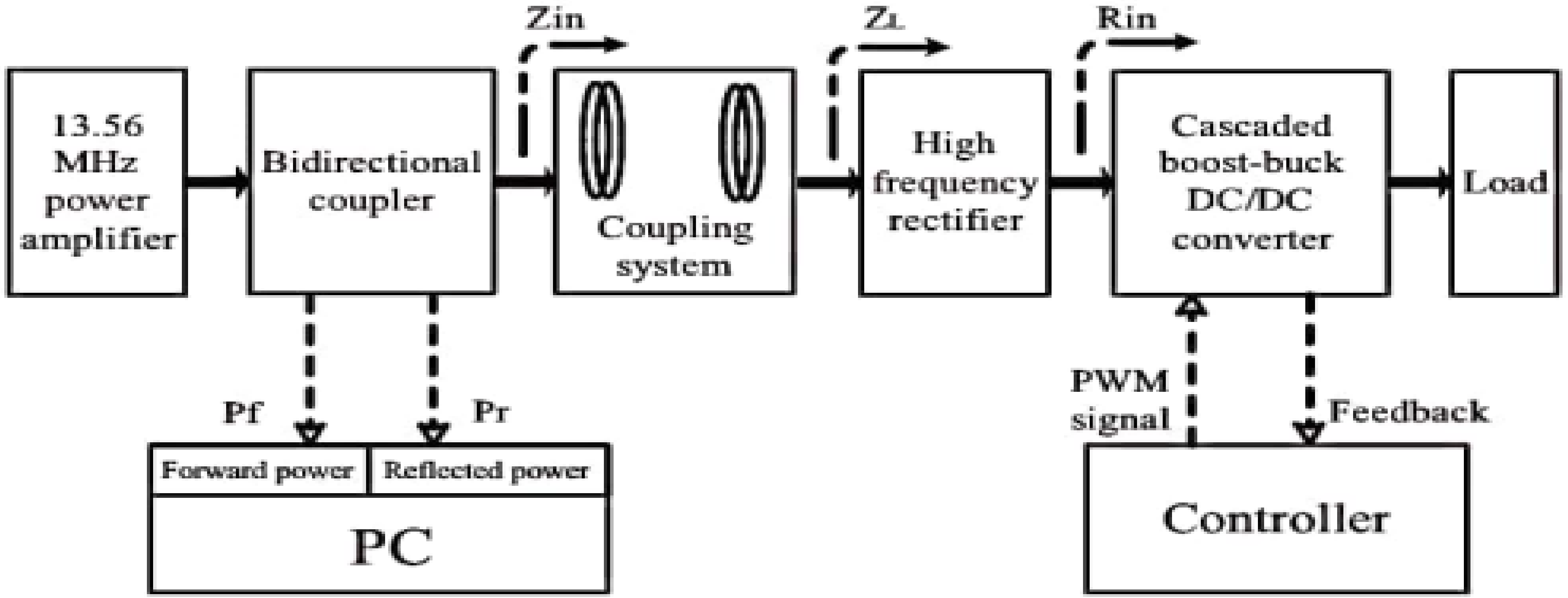
CCM



DCM



BLOCK DIAGRAM OF WPT



WORKING OF THE PROPOSED SYSTEM

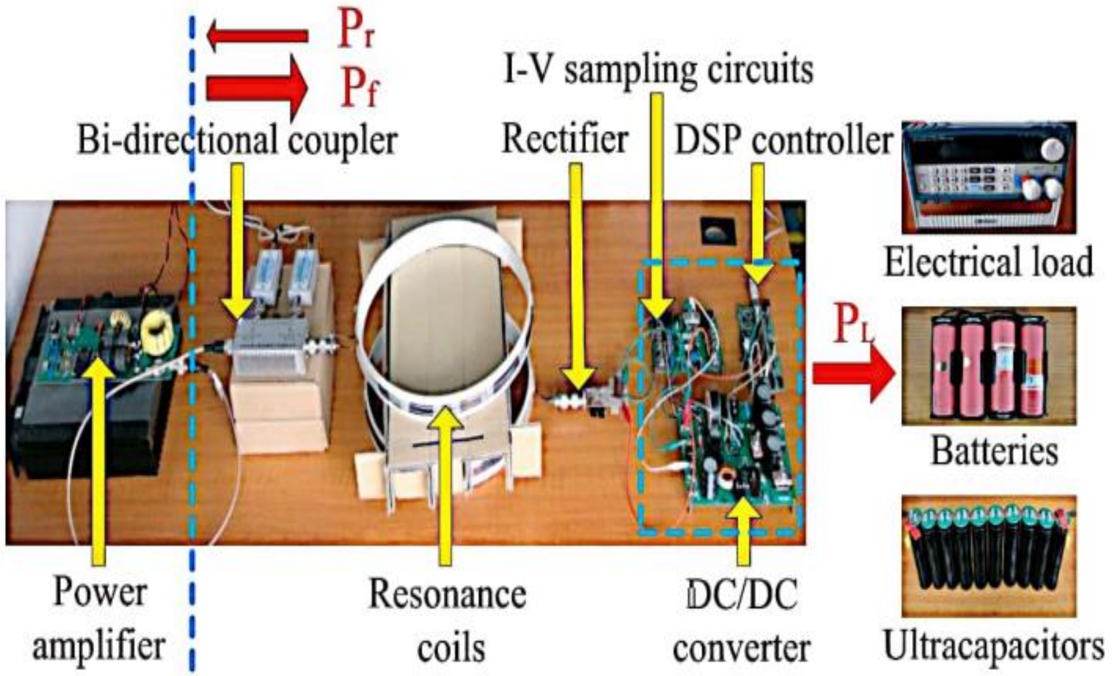
- Here we consider a wireless power transmission system in which the resonant coupling operating at 13.56MHz.
- In order to achieve a high efficiency in WPT system each element should have proper impedance matching
- Optimal load impedance at the receiving coil is designed to minimize power loss

WORKING OF THE PROPOSED SYSTEM(cont..)

- Then the AC signal is converted back to DC using suitable rectifying circuit
- Here we use cascaded Boost-Buck converter to control the equivalent resistance
- In fixed load mode $V_0 = D2V_{bf}$
- Assuming constant power loss $Vin^2 / Rin = Vout^2 / R_L$
- $Rin = \frac{(1-D1)^2 R_L}{D2^2}$
- So resistive load can be matched by using the constant duty cycle control

WORKING OF THE PROPOSED SYSTEM(cont..)

- In variable load mode for the dynamic control of the Rin the duty cycle D1 is controlled to maintain a fixed Rin.
- D2 is controlled to provide a $V_{bf} = kV_{in}$
- Where $R_{in} = \frac{V_{bf}^{2} (1-D)^{2}}{P_{in}}$

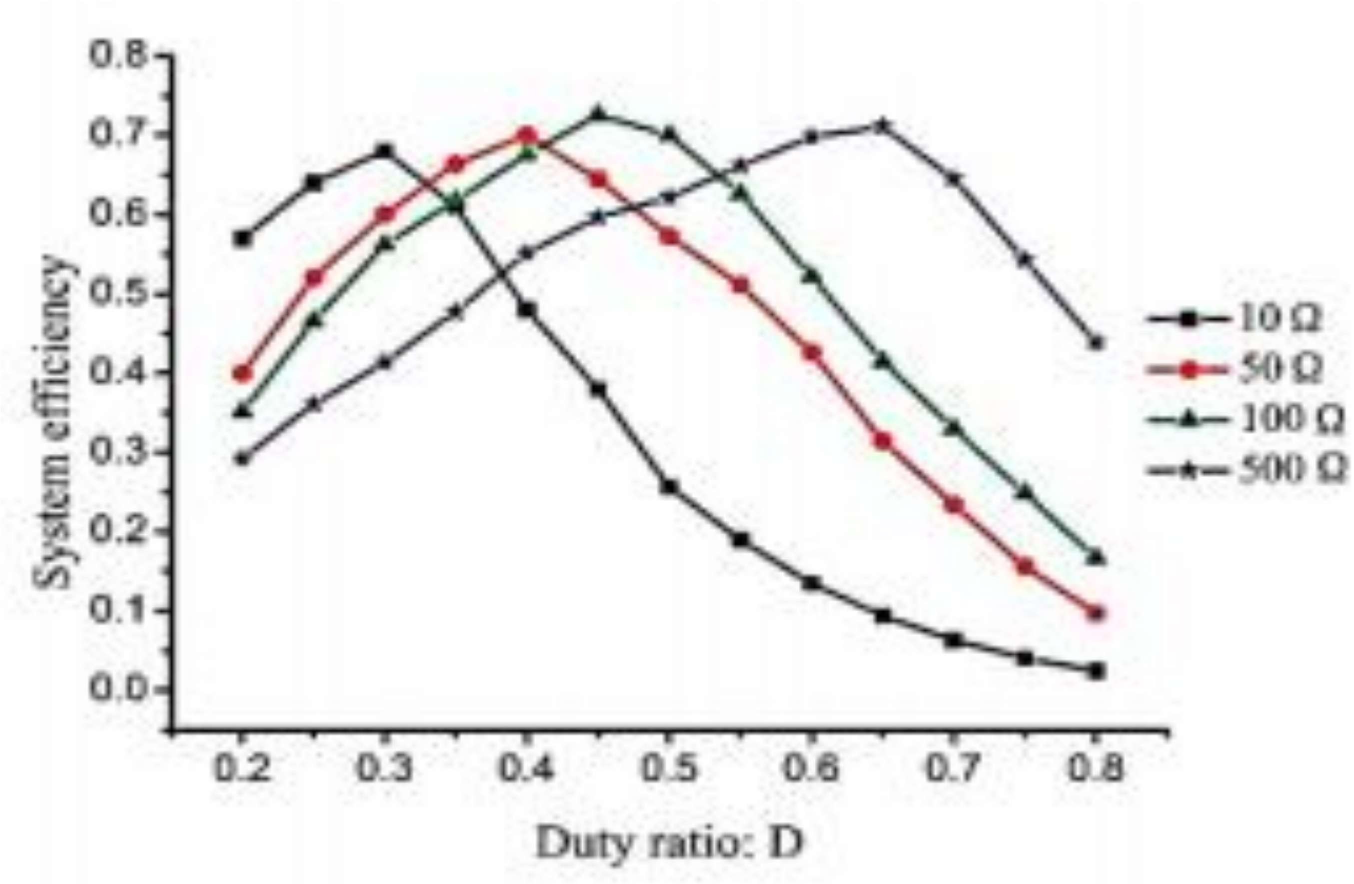


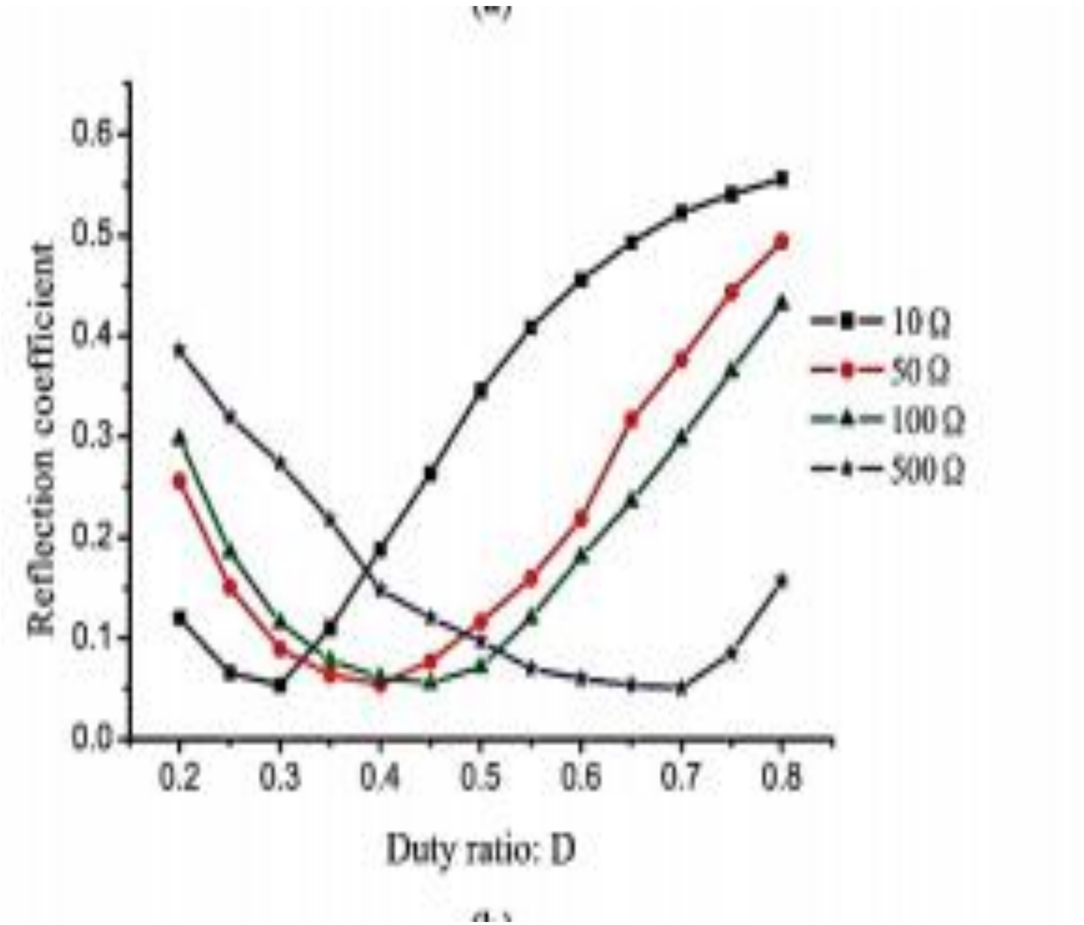
WORKING OF THE PROPOSED SYSTEM(cont..)

- By proper impedance matching we can transfer maximum power hence we can improve the efficiency in WPT
- In practical case the load may not be resistive because the electrical impidence chnanges during the charging time
- The proposed cascade boost-buck converter can automatically adjust the duty ratio for optimal system efficiency

RESULT

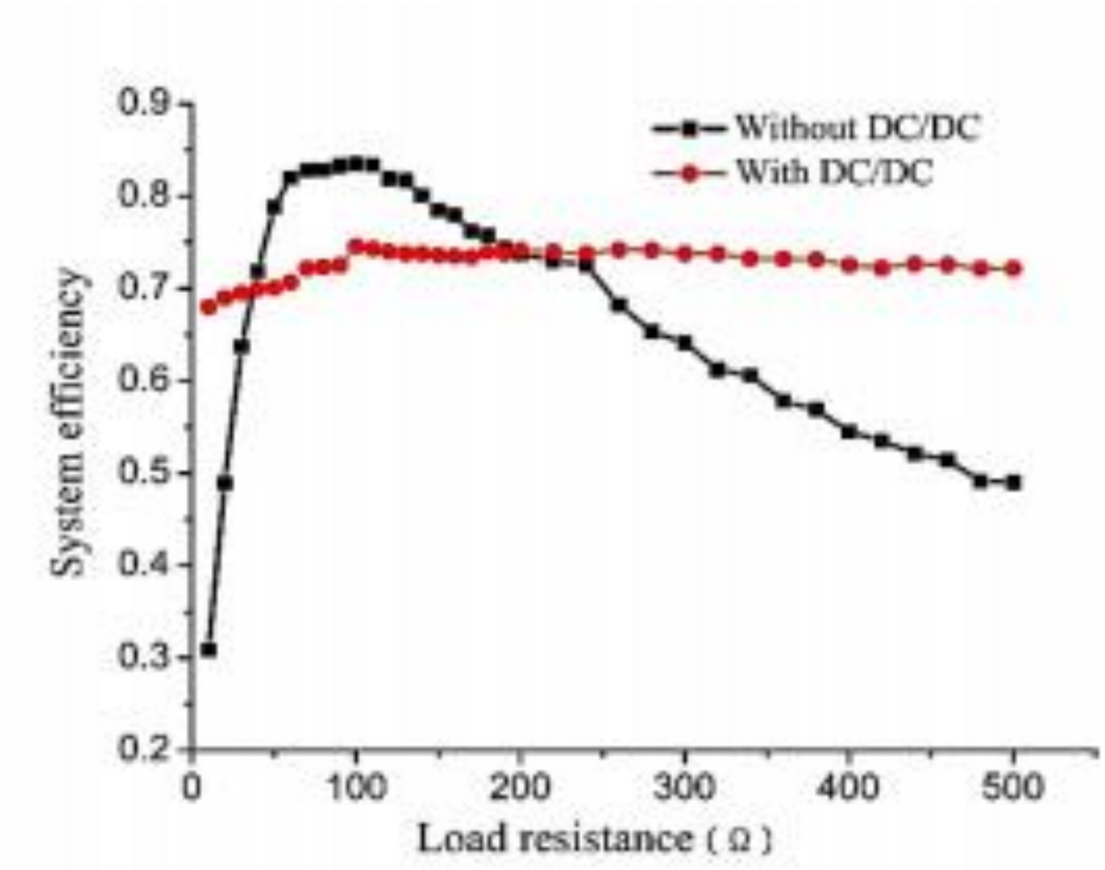
System efficiency and reflection coefficient with various duty cycle

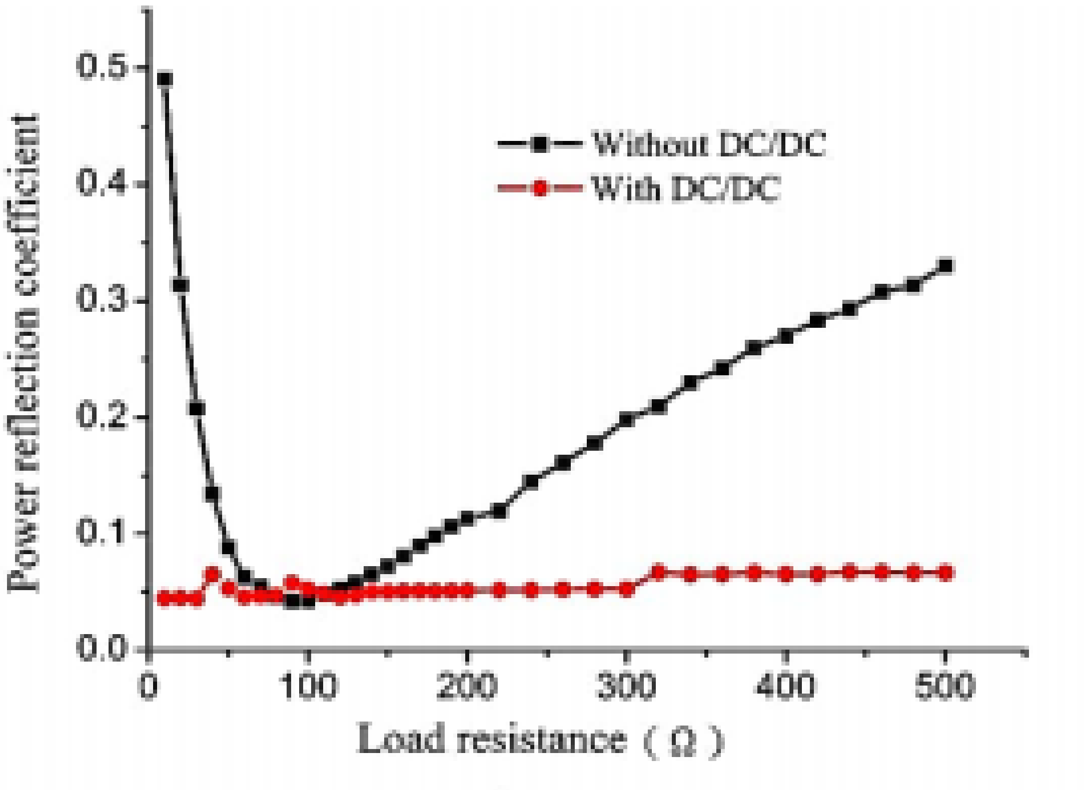




RESULT

System efficiency and reflection coefficient improvement using the cascaded boost-buck DC-DC converter





RESULT

- The best converter topology for the impedance matching in WPT is the cascaded boost-buck converter

- It can help in optimal impedance matching and helps in isolating dynamic load from the system

CONCLUSION

- A new cascaded Boost-Buck converter for impedance matching in WPT system is presented
- This paper explains the working and advantages of boost-buck converter
- This method is universal and applicable for all wireless power transfer technologies

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THANK YOU...