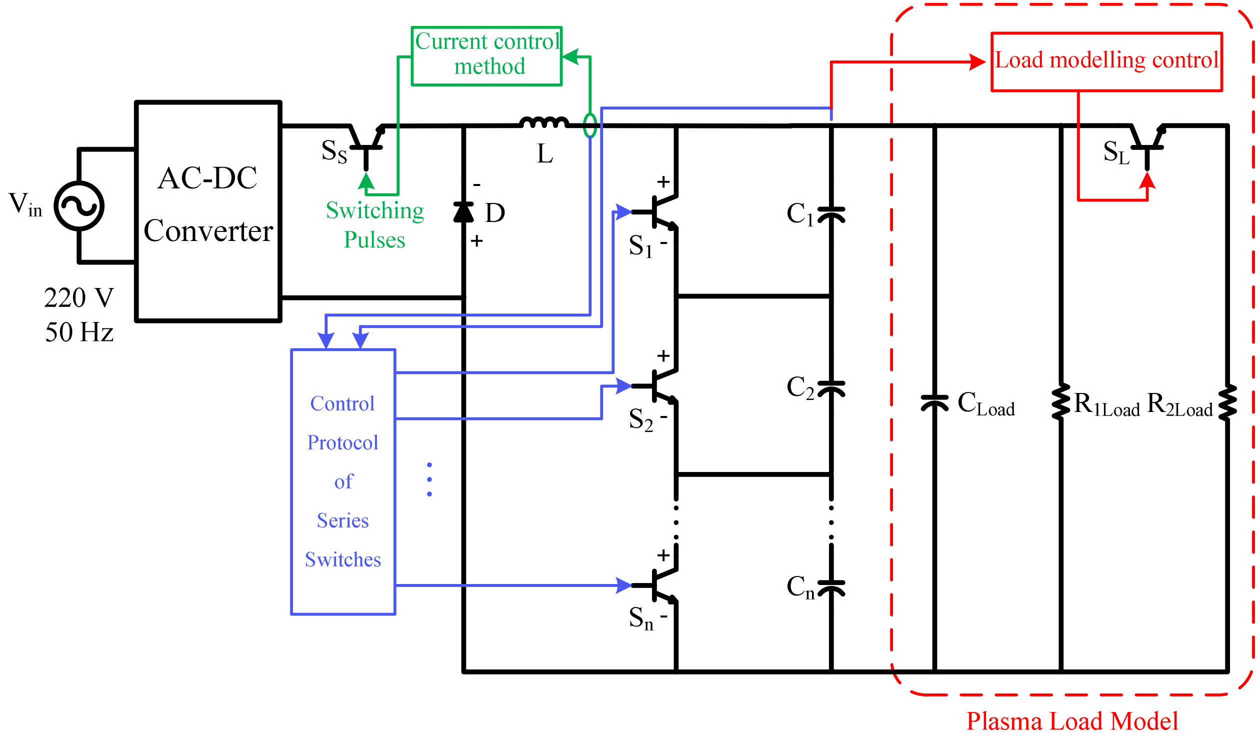
A Novel High Voltage Pulsed Power Supply Based on Low Voltage Switch-capacitor Units

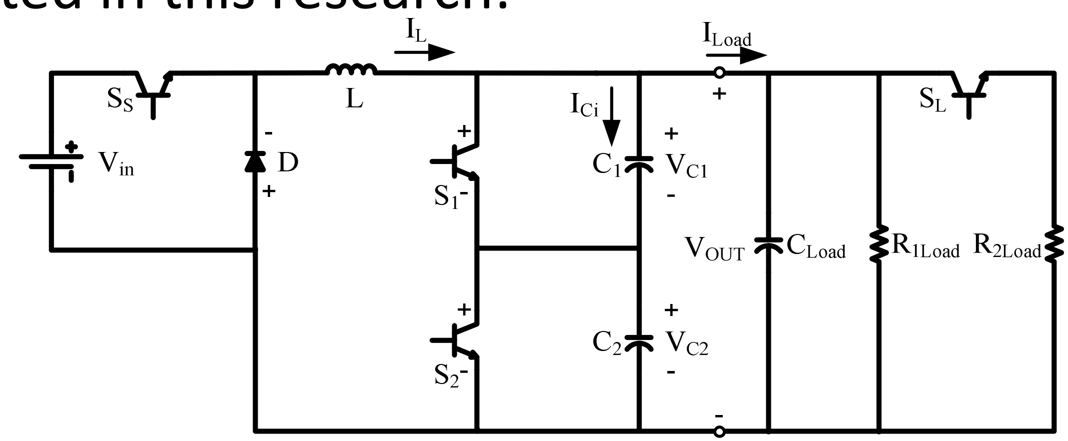
S. Zabihi, F. Zare, G. Ledwich, A. Ghosh

School of Electrical Engineering,
Queensland University of Technology
Brisbane, Australia.
Presenter: Prof. Firuz Zare
f.zare@qut.edu.au

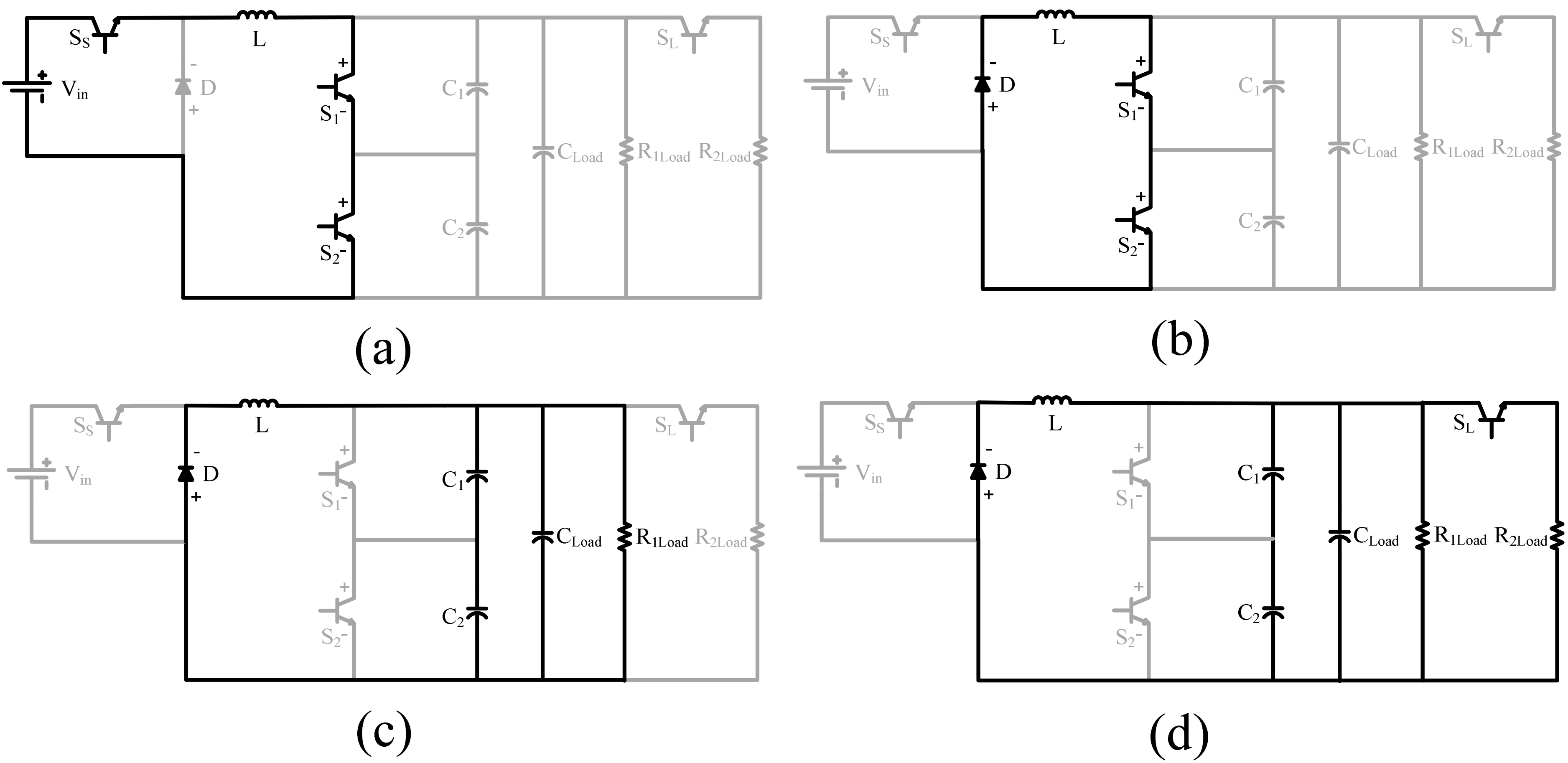
Pulsed power supply configuration with multi switch-capacitor units:



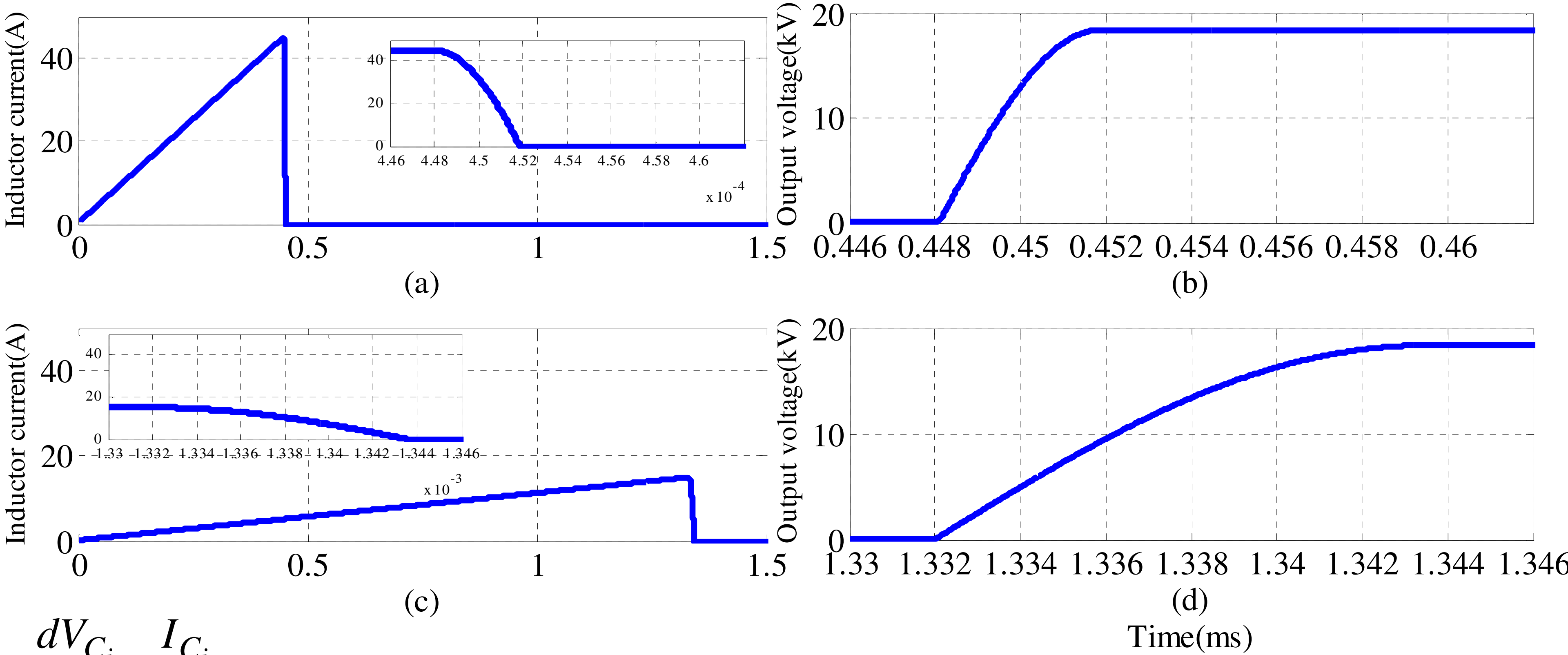
A simplified two switch-capacitor unit pulsed power supply and the load model investigated in this research:



Switching states of the proposed power supply circuit :
(a) Current source, charging mode (b) Current source, discharging mode (c) Voltage source charging mode (d) Load supplying mode



dv/dt s generated by different inductors with the similar inductive energy:
(a) current (b) output voltage waveform with 1mH inductor
(c) current (d) output voltage waveform with 9mH inductor



$$\frac{dV_{C_i}}{dt} = \frac{I_{C_i}}{C_i}$$

$$C_{eq} = \frac{C_i}{n}$$

$$V_{out} = \sqrt{\frac{L}{C_{eq}}} \cdot I_L$$

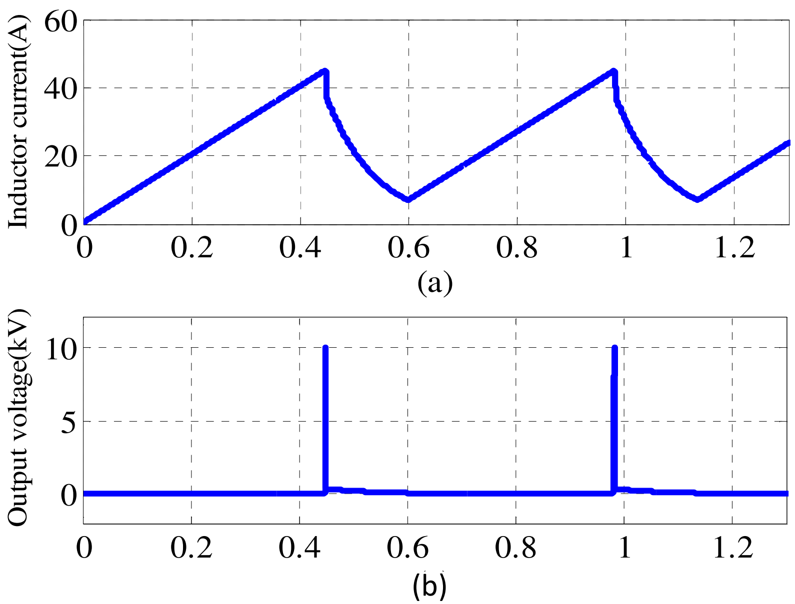
$$V_{out} = n \cdot V_{C_i}$$

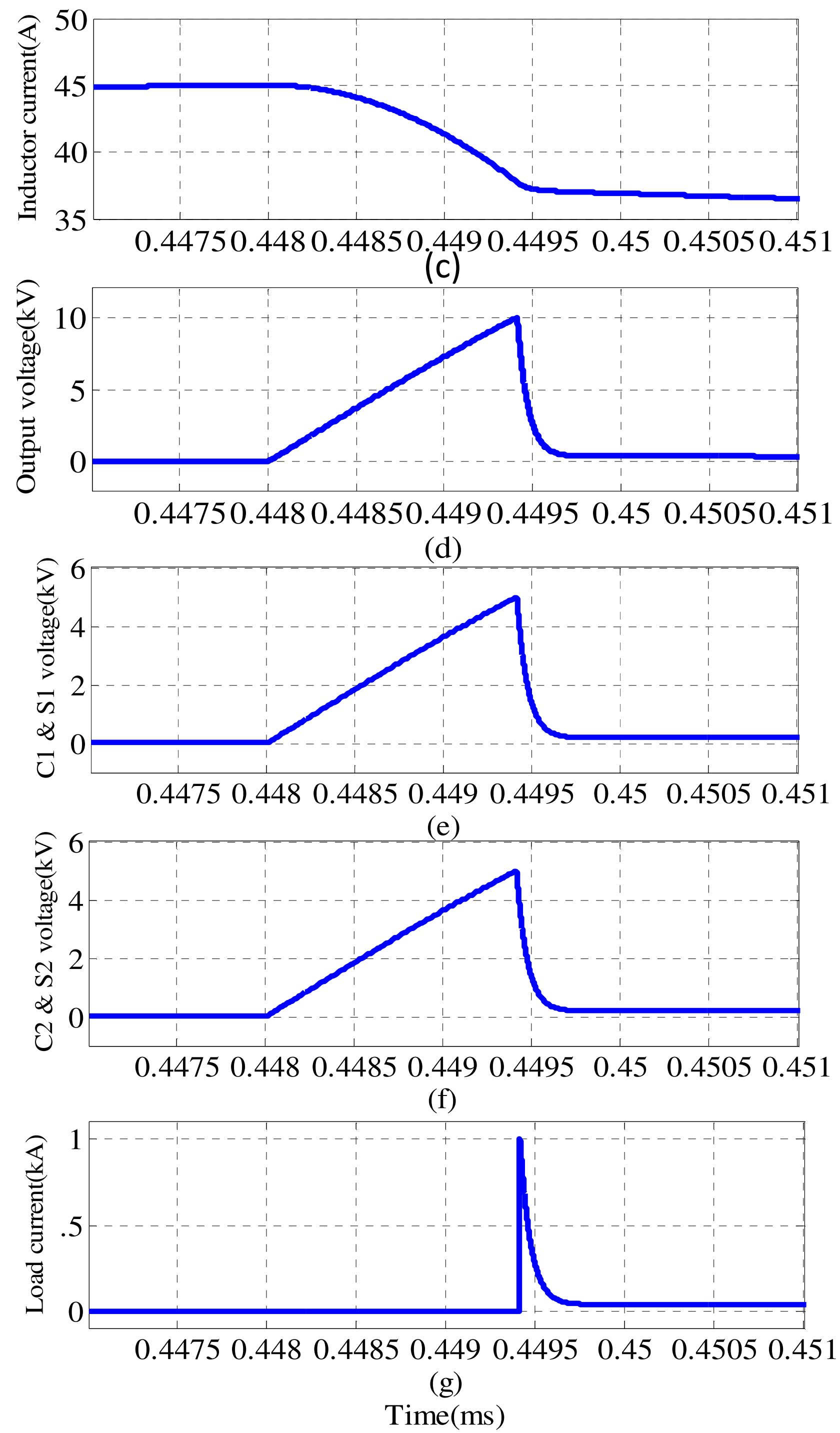
$$dV_{out} = n \cdot dV_{C_i}$$

$$I_{L_2} = \frac{1}{\sqrt{n}} \cdot I_{L_1}$$

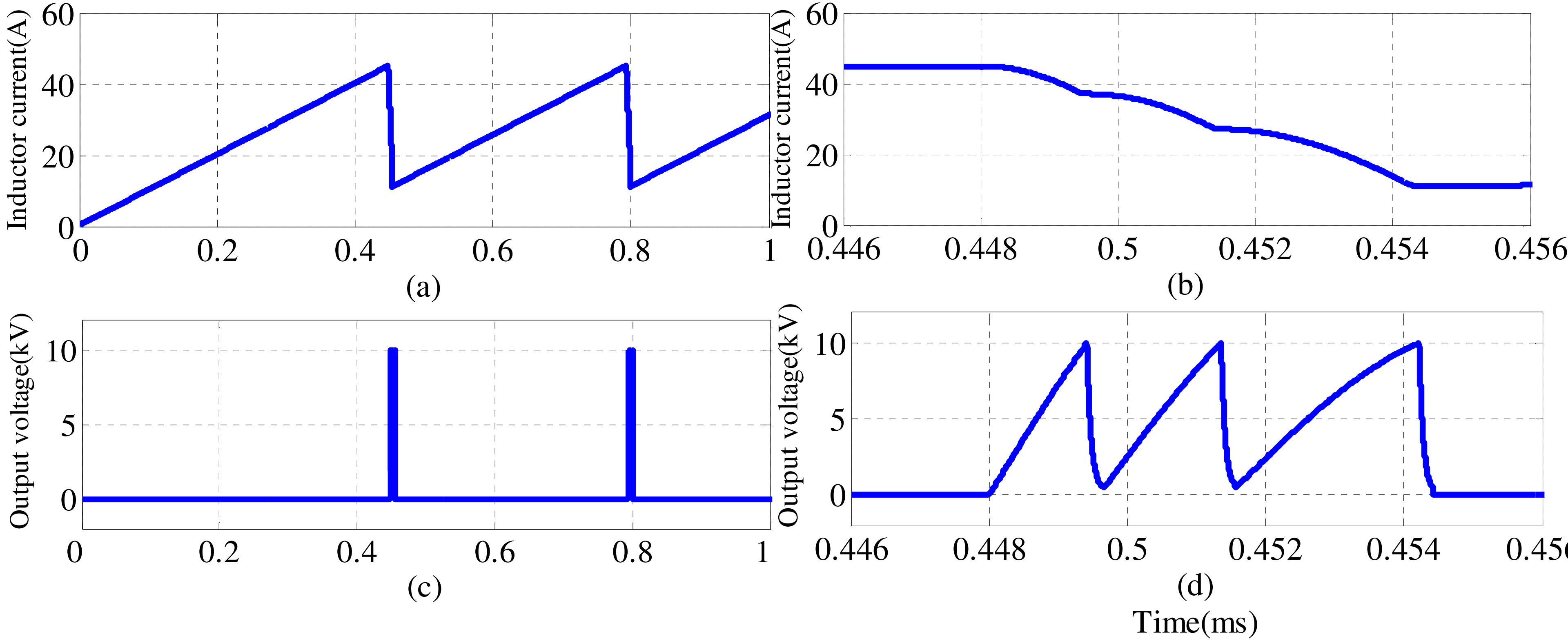
$$\frac{1}{2} L_1 \cdot I_{L_1}{}^2 = \frac{1}{2} L_2 \cdot I_{L_2}{}^2$$

Output voltages and currents of power supply, in case of delivering inductive energy to the load in mono resonant,
(a) & (c) Inductor current (A),
(b) & (d) Output voltage (kV),
(e) First unit’s voltage (kV),
(f) Second unit’s voltage (kV),
(g) Load current (kA)

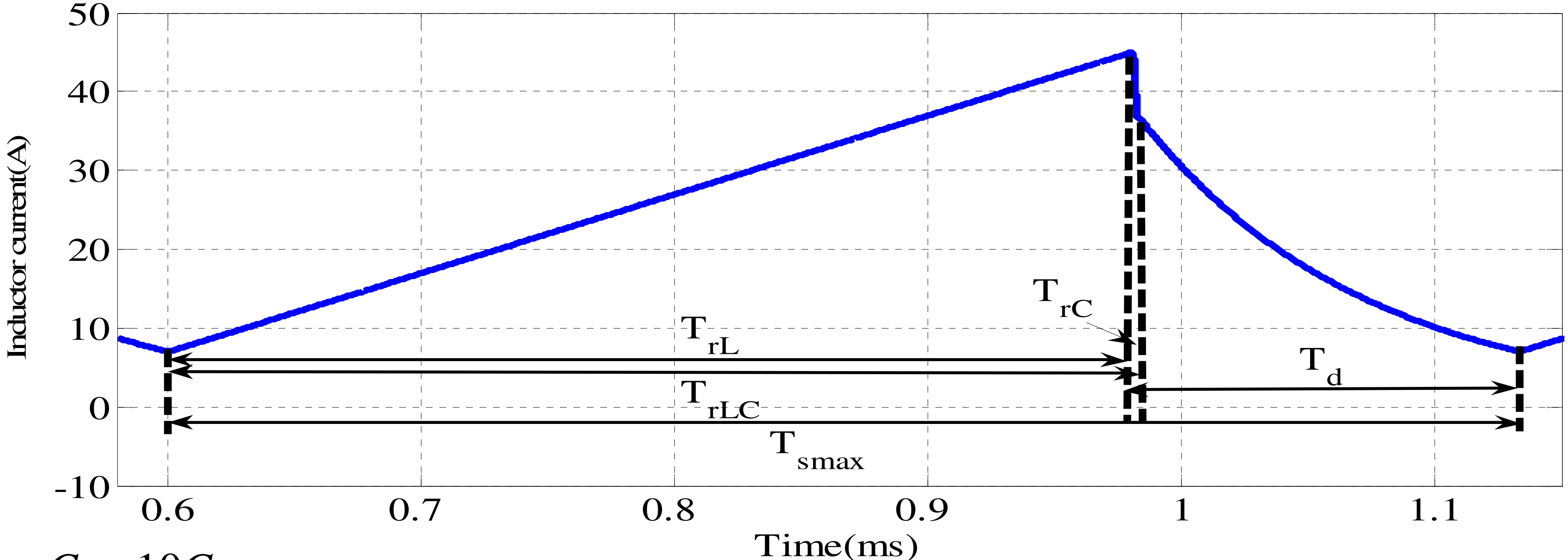




Output voltages and currents of power supply, in case of delivering inductive energy to the load in multi resonant, (a) & (b) Inductor current (A), (c) & (d) Output voltage (kV)



Components determination and energy discussion:



$$C_{eq}=10C_{Load}$$

$$C_{eq}=10n.C_{Load}$$

$$I_L=(C_{eq}+C_{Load}).dV_{out}/dt$$

$$\frac{1}{2}LI_L^2=E_{Load}$$

$$T_{r\_L}=\frac{L.I_L}{V_{in}}$$

$$T_{r\_C}=\frac{(C_{eq}+C_{Load})\cdot V_{out}}{I_L}$$

$$T_{r\_LC}=\frac{L\cdot I_L^2+(C_{eq}+C_{Load})\cdot V_{out}\cdot V_{in}}{V_{in}\cdot I_L}$$

$$f_{s\max}<\frac{1}{T_{r\_LC}+T_d}$$

ENERGY

$$E_{Loss}=\frac{1}{2}C_{eq}V_{off-out}^2=0.5\times 6\times 10^{-9}\times 100^2=30\mu j$$

$$E_{Total}=\frac{1}{2}LI_L^2=0.5\times 1\times 10^{-3}\times 45^2=1012.5mj$$