Power conversion issues with energy harvesting

Note Title 11/23/2011

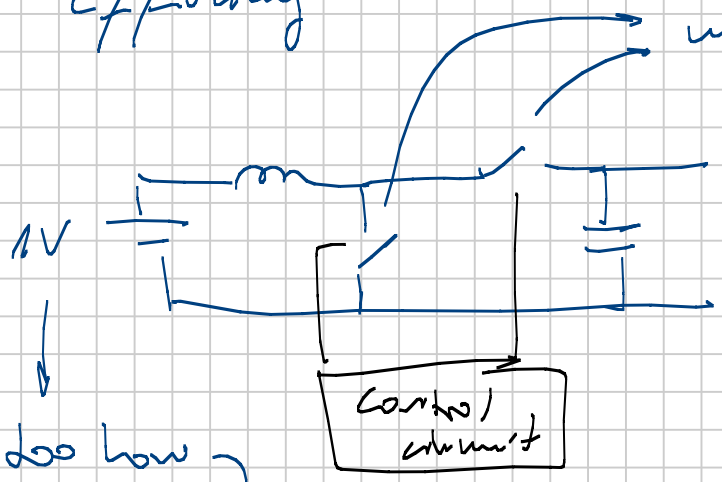
- Some typical applications of less conventional power generation through energy harvesting include → wave energy
  - → human (or some other kind) movement
    - e.g. piezoelectric generator using the energy exchange in each step.

Common problems → Need for small volume (high density)

vs.

power source → low frequency (pulses in the order of Hz)
- → low voltage (≅ 1V)

Consider a synchronous boost for improved efficiency → we need MOSFETs with very low R_{DSON}.

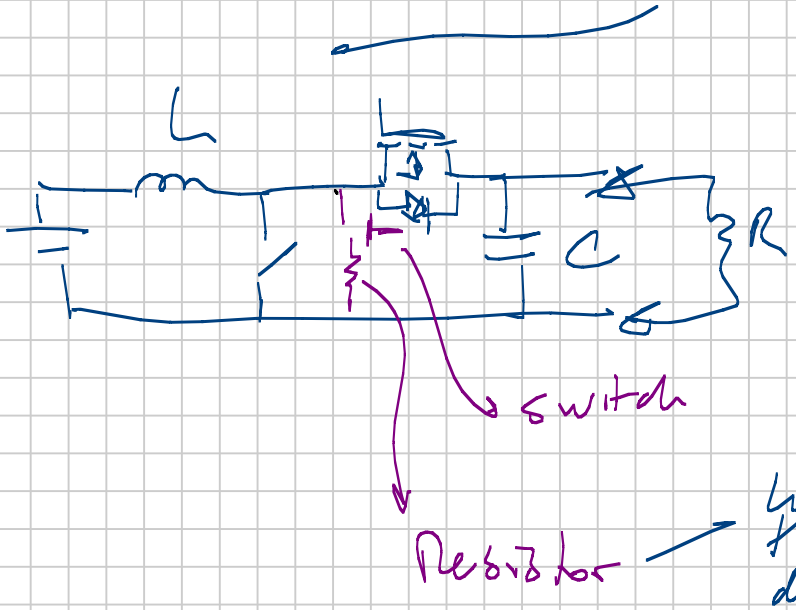


too low →

the control circuit must be powered from the higher voltage output

↓

Hence, we need a start up circuit.



Resistor → limits the current through the inductor during startup.

Start up procedure → 1) Switch is closed and L is charged

2) Switch is released

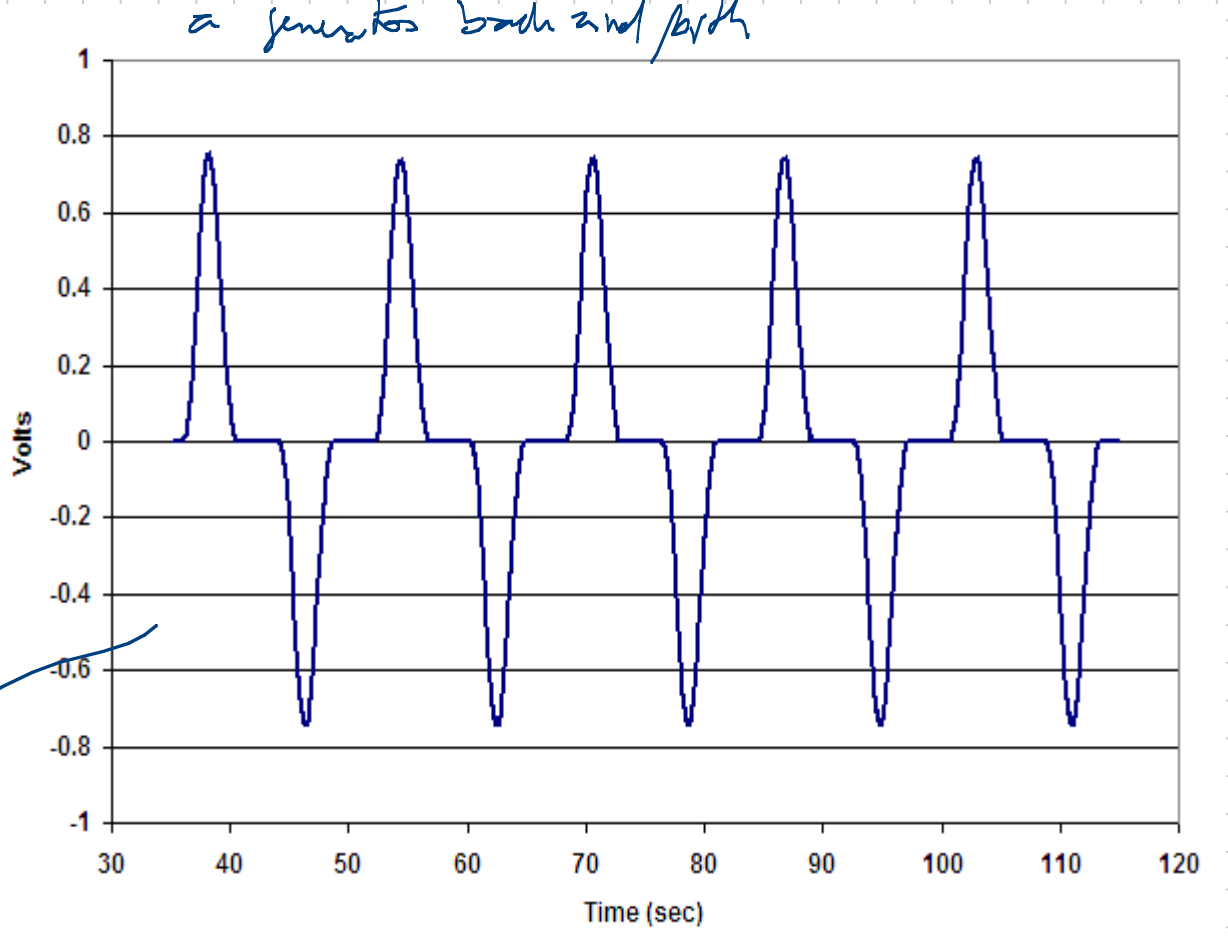
3) Current from the inductor

flows to the output capacitor

the output voltage increases and the controller and gate drive can be powered.

Now consider a source like this:

e.g. a wave moving a generator back and forth

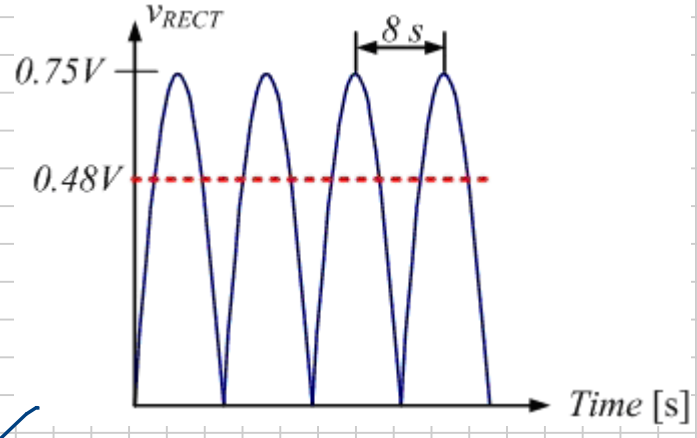


62.5 mHz

Power converter output → 14 Vdc (to charge a battery)
→ 1,000 W

when the signal is rectified with a synchronous rectifier with MOSFETs with $R_{DSON} = 0.1\ m\Omega$

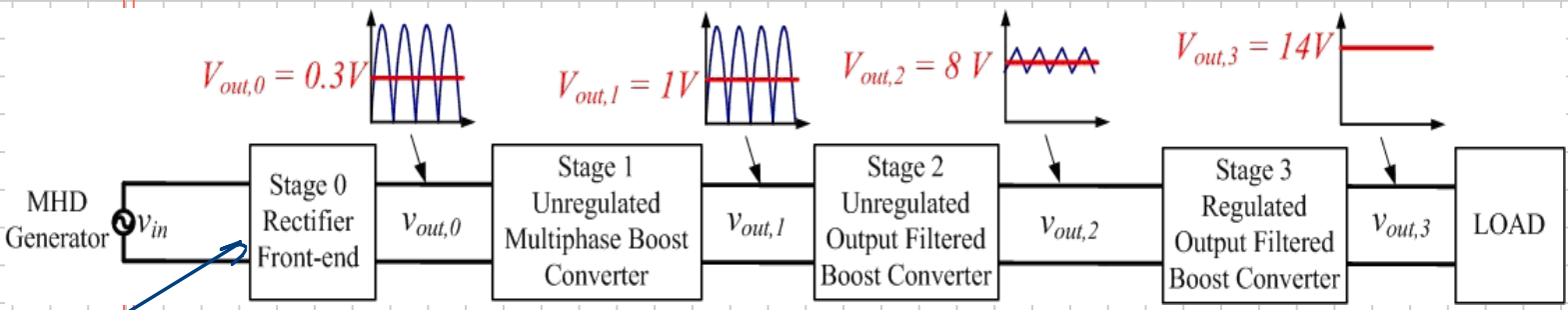
↓ in parallel of MOSFETs



If $P = 1000W$
$\Delta V = 0.2V$
$f = 0.125\ Hz$

$C = 66\ F$ → too big.

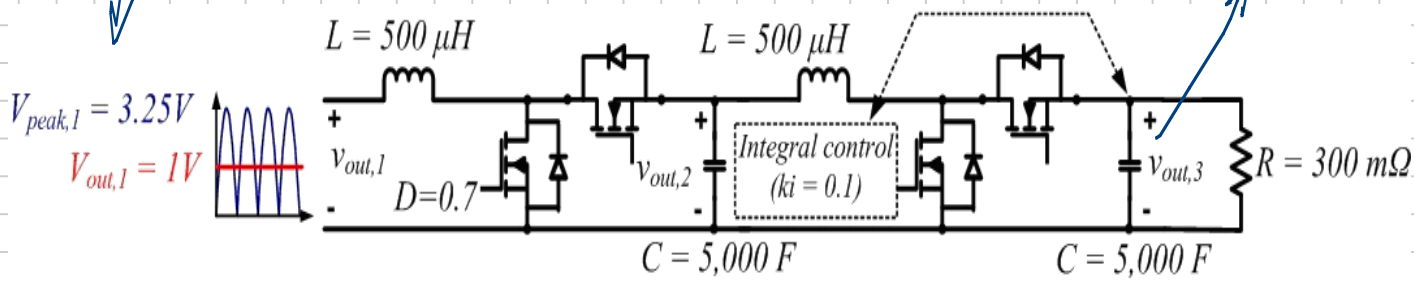
Solution: → Divide the rectifier in → rectification + filter

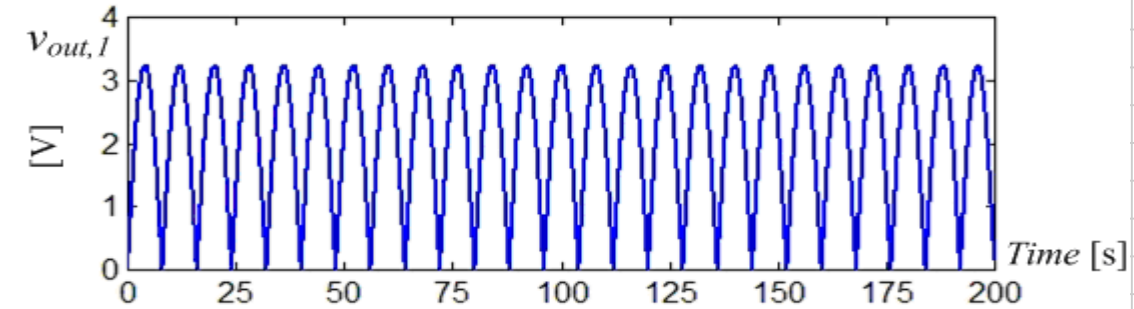


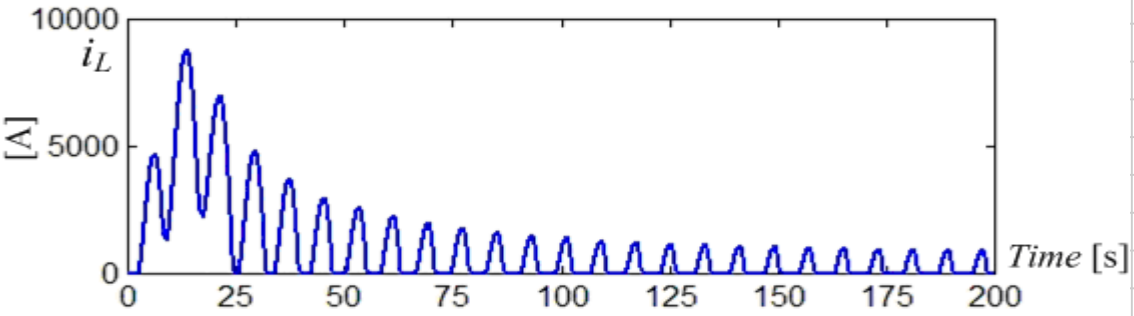
Plain rectifiers

e.g.

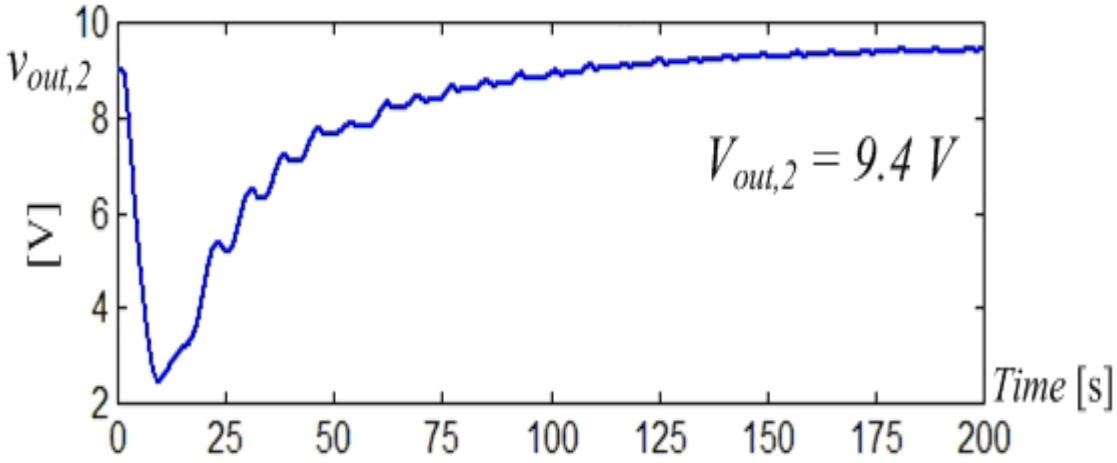
Ultracap.

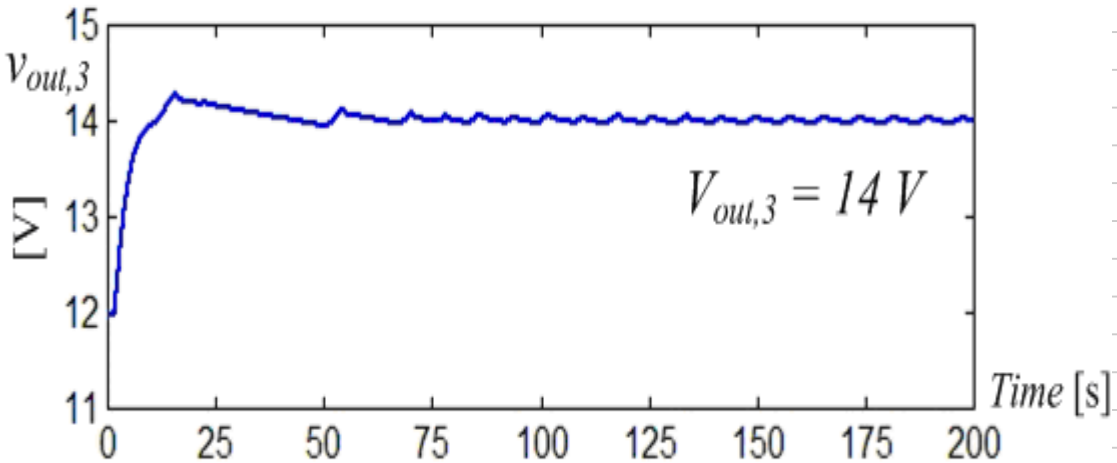



$v_{out,1}$
[V]
4
3
2
1
0
0
25
50
75
100
125
150
175
200
Time [s]


10000
i_L
[A]
5000
0
0
25
50
75
100
125
150
175
200
Time [s]

Later steps:


$v_{out,2}$
[V]
10
8
6
4
2
$V_{out,2} = 9.4\ V$
0
25
50
75
100
125
150
175
200
Time [s]


$v_{out,3}$
[V]
15
14
13
12
11
$V_{out,3} = 14\ V$
0
25
50
75
100
125
150
175
200
Time [s]

Additional problem → efficiency of intermediate steps with low input and $V_{in} < 1V$ an inductor with $R = 0,1\ m\Omega$ is too high → Very low efficiency

Solution: multiphase boost

like a multiple-input boost

As a result overall efficiency is about 60%