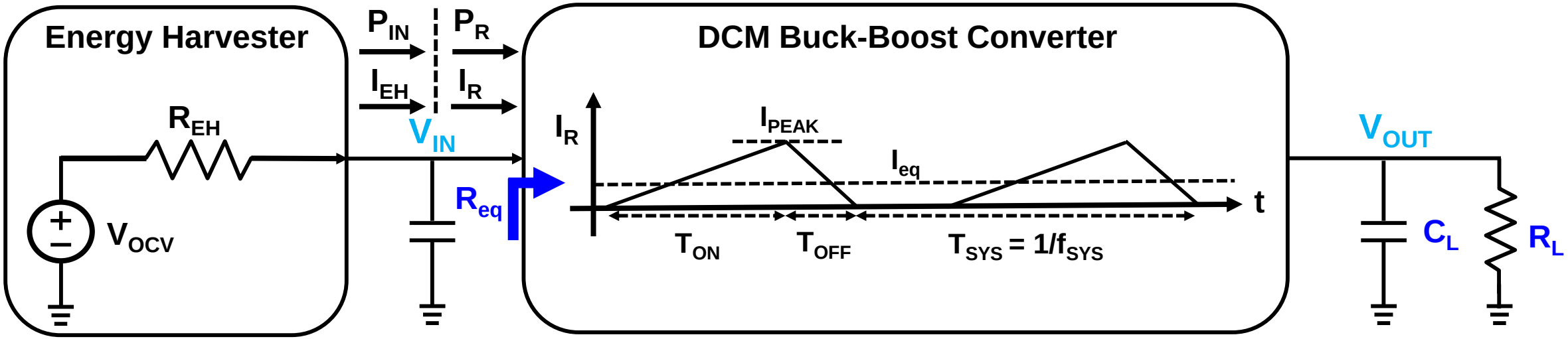
PBL - Implementation of MPPT

Concept

- **From PBL part 1 conclusion:**
  To achieve MPPT, the buck-boost converter should be well controlled to obtain the impedance matching : $R_{EH} = R_{eq}$

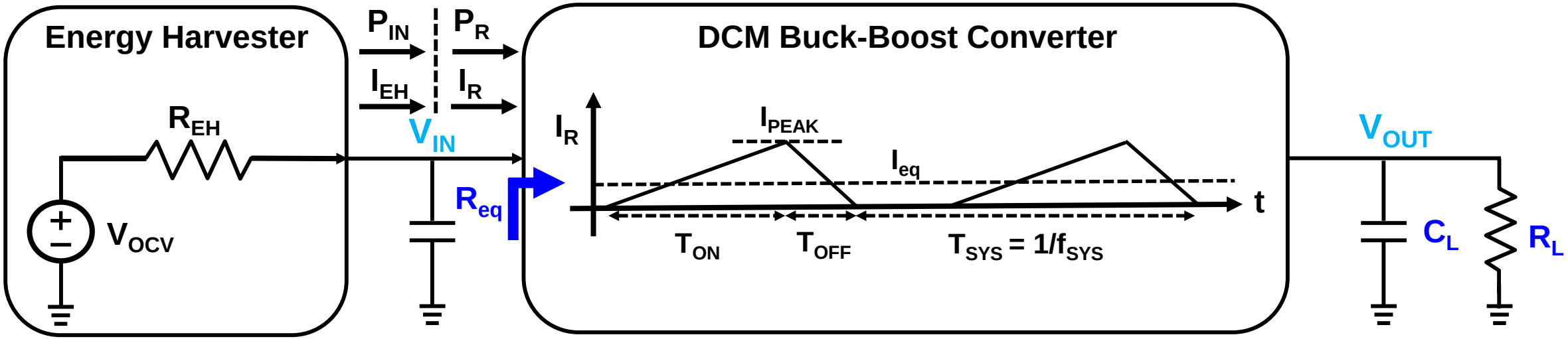
$$R_{eq} = V_{IN} / \left(\frac{0.5 * I_{PEAK} * T_{ON}}{T_{SYS}}\right)$$



Question

- **Part1:**

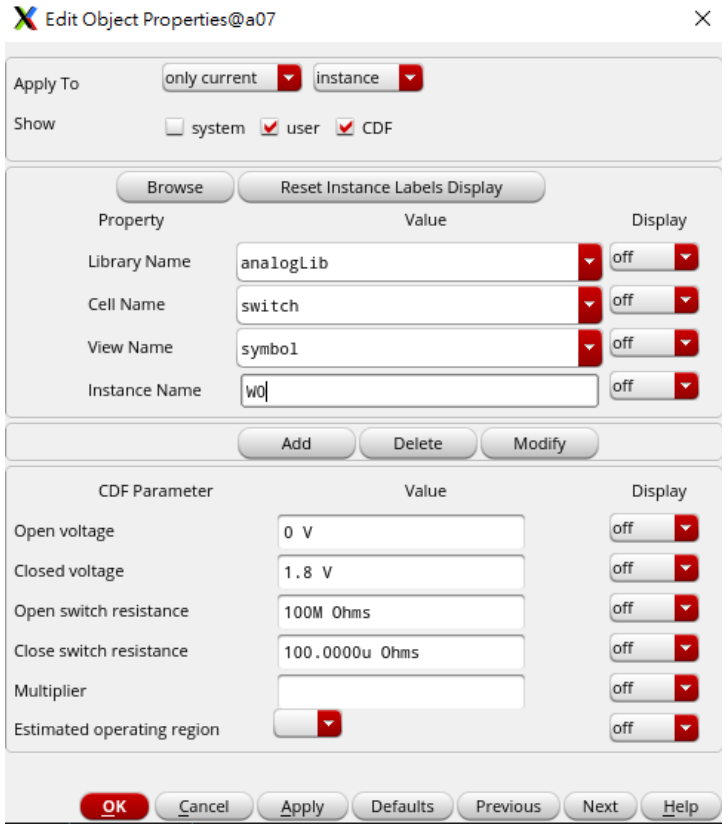
  用理想開關實現 buck-boost converter，並觀察其不同R_{eq}下的V_{IN}，並記錄該V_{IN}可提供給輸出的功率，對照所學。

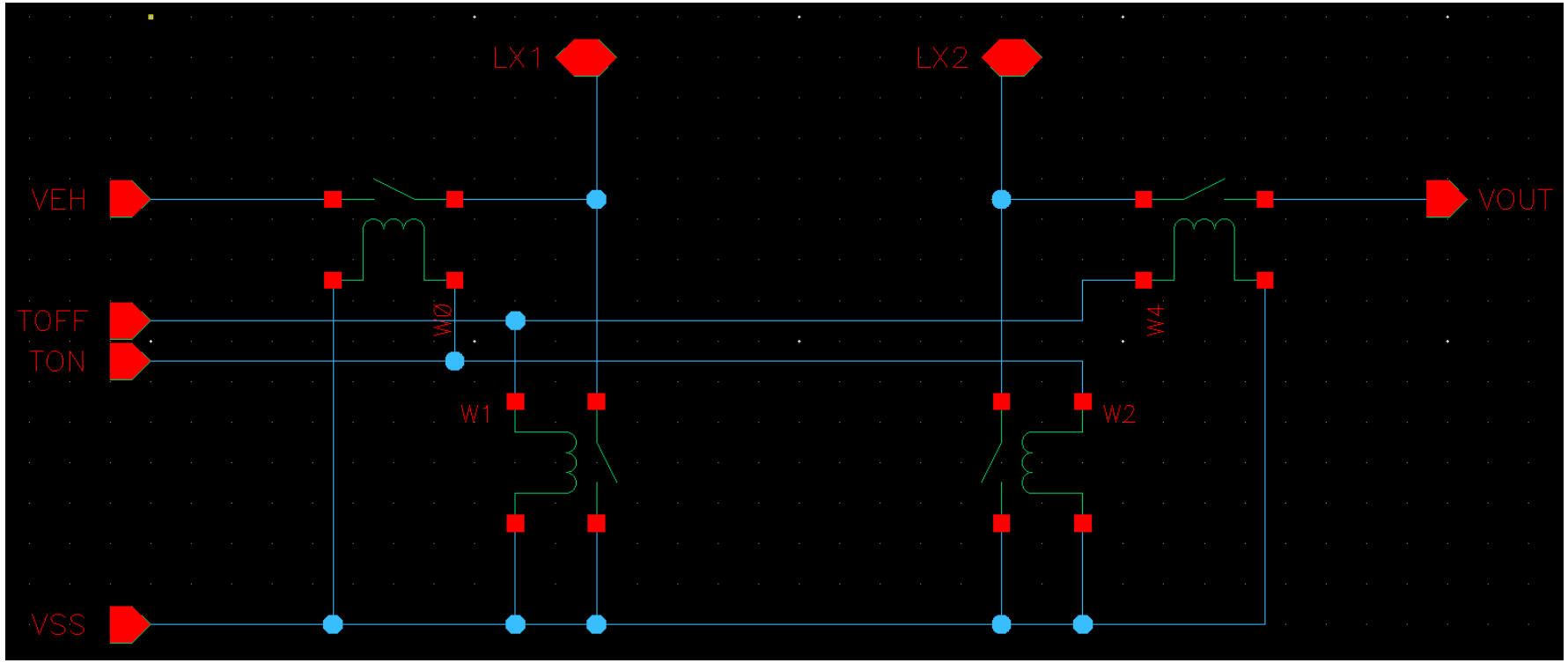


Schematic of Buck-Boost Converter

- **Step 1:**

  建一個ideal buck-boost的schematic

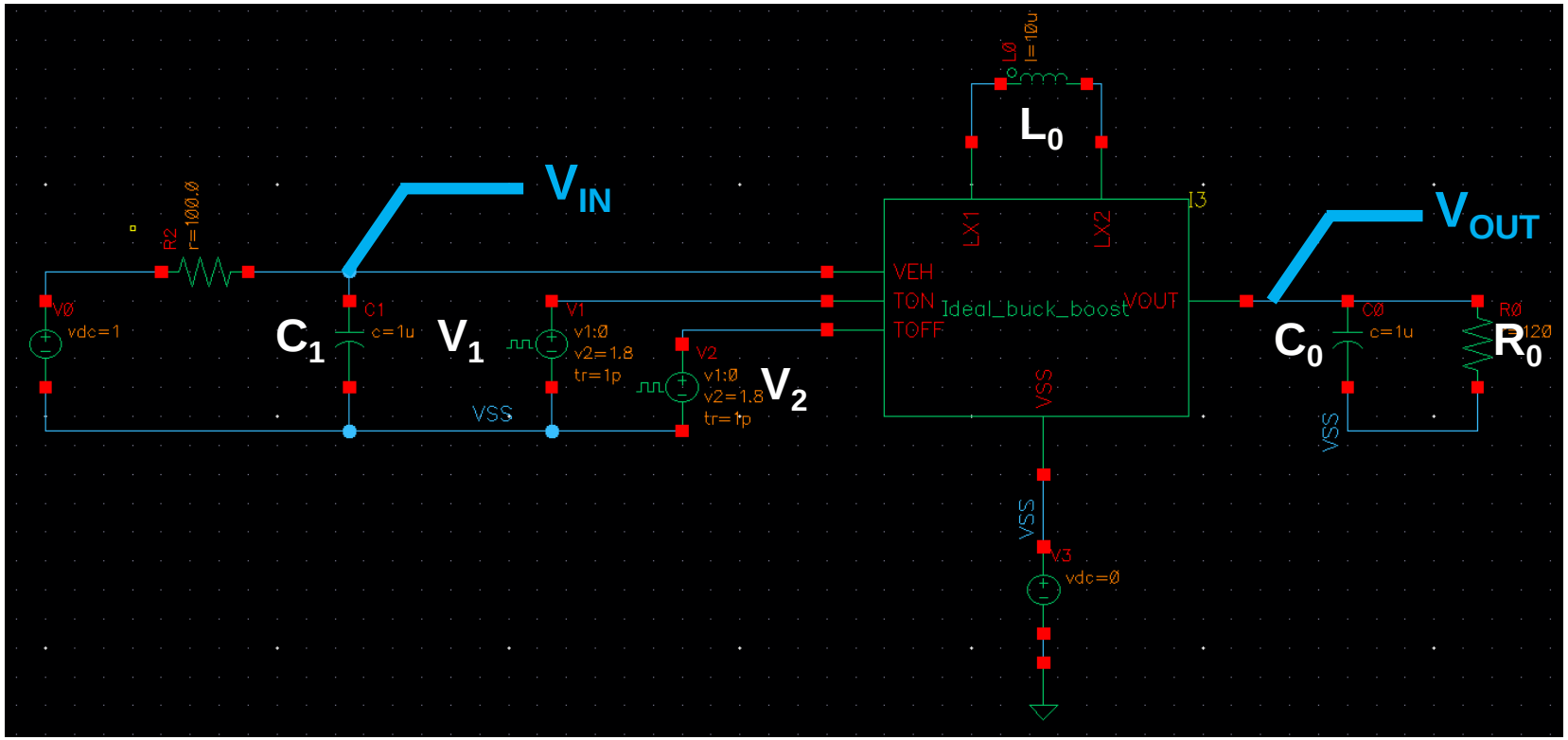




Circuit Simulation

- **Step 2:**

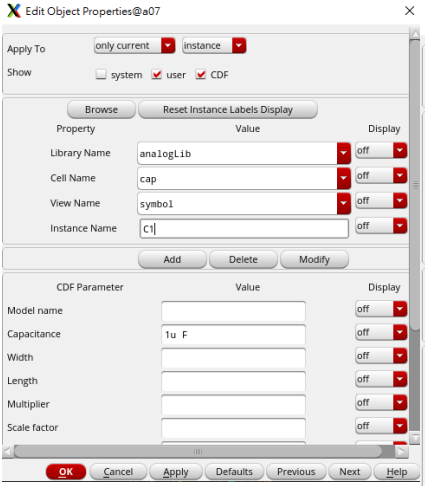
  建立testbench，使用1V串聯100ohm電阻作為energy harvester，C_1為輸入電容、V_1為T_{ON}訊號、V_2為T_{OFF}訊號、C_0為輸出電容、R_0為輸出負載



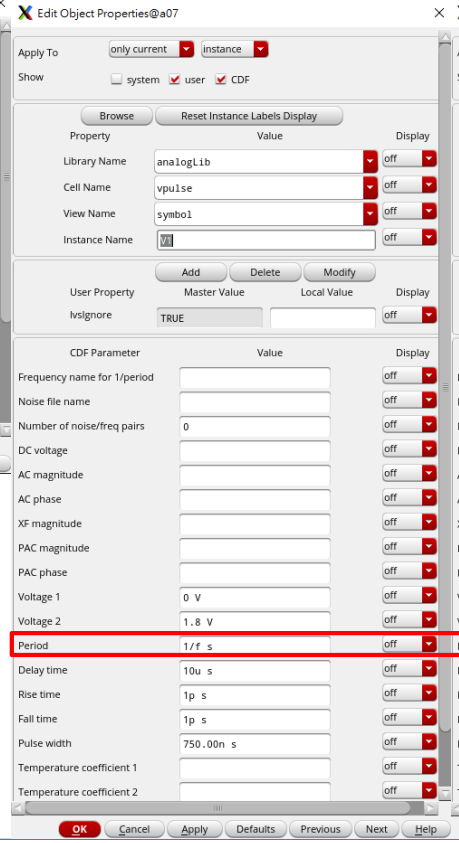
Circuit Simulation

Step 2各元件參數

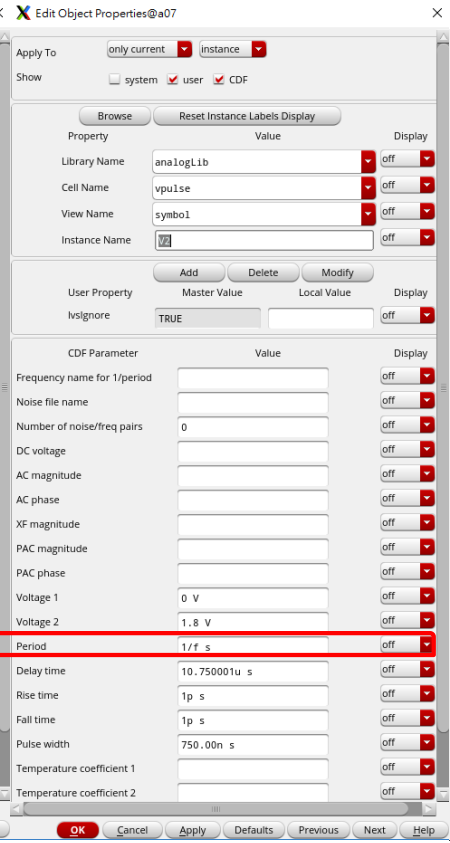
C_1



V_1

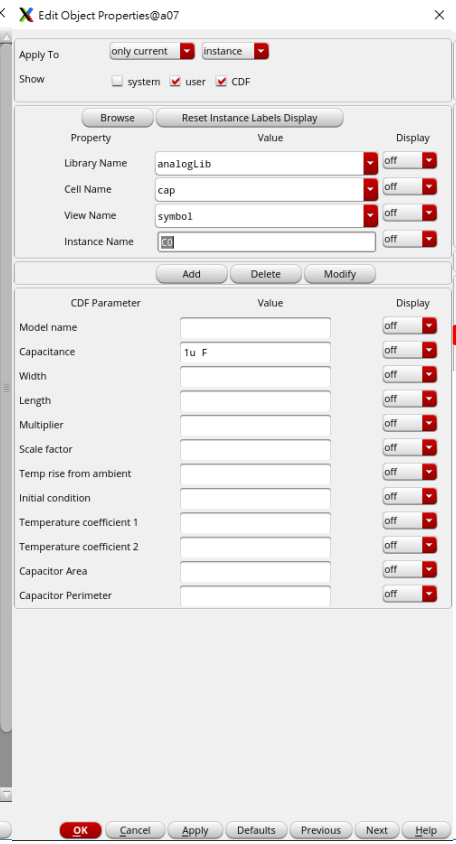


V_2

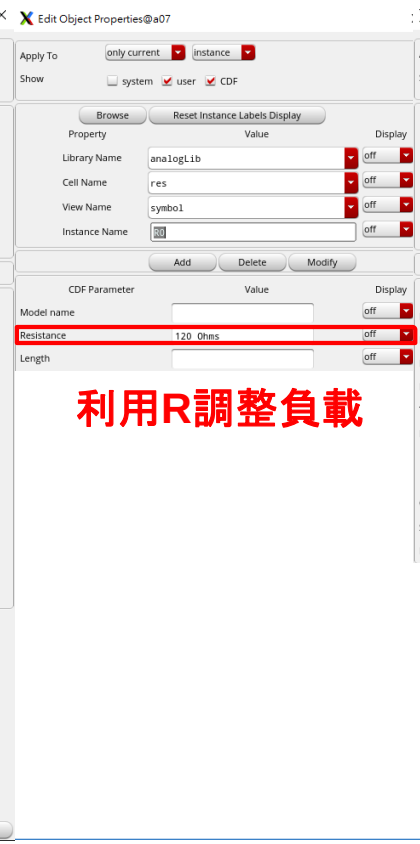


利用f改變R_{eq}

C_0



R_0



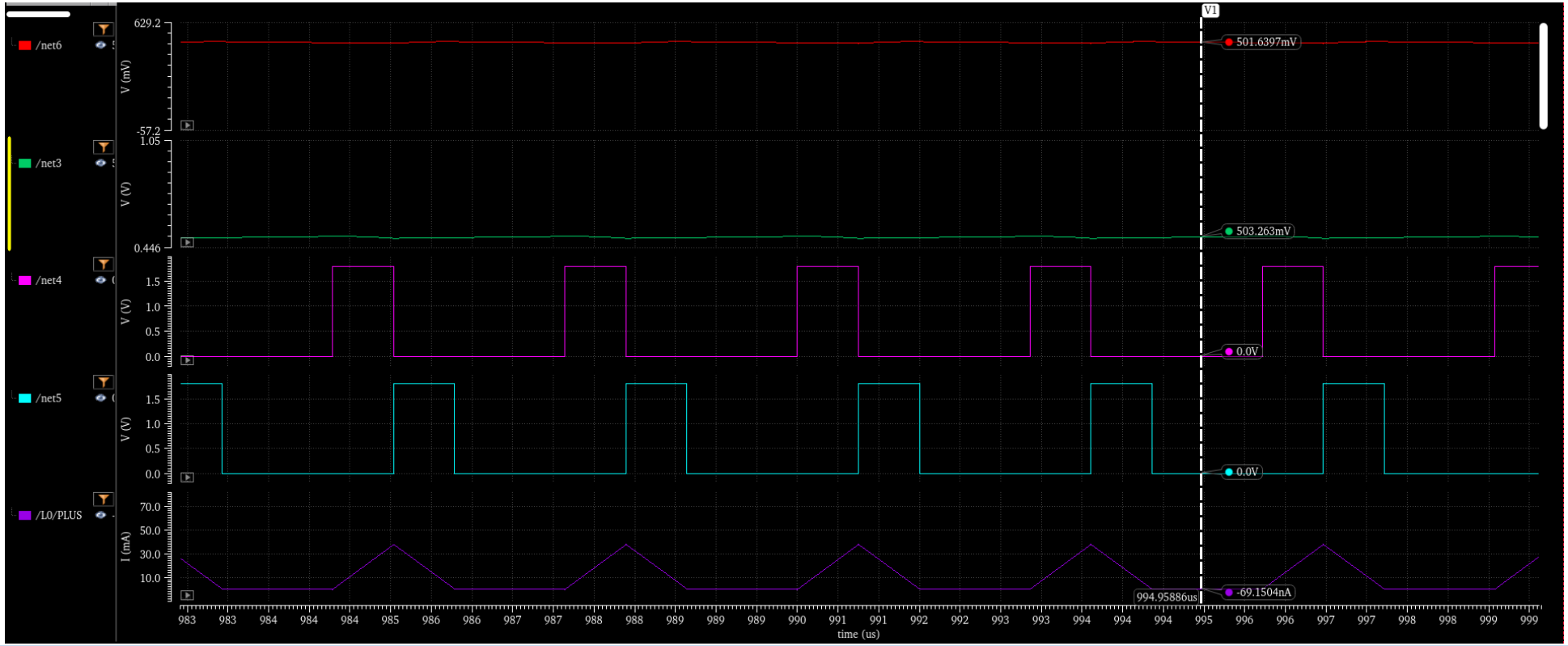
利用R調整負載

L_0

Circuit Simulation

- **Step 3 – Simulation:**

1.令 f = 350kHz, R_0 = 100ohm, run transient analysis，可以發現V_{IN}與V_{OUT}大致一樣，約為0.5V，此時output power為0.5*0.5/100 = 2.5mW



Circuit Simulation

- **Step 3 – Simulation:**

  2.將頻率增加(a)/減少(b)，並調整R_0直到V_{IN}與V_{OUT}大致相同*，將各參數填入下表，與頻率350kHz之數據做比較，何者的P_{OUT}最大

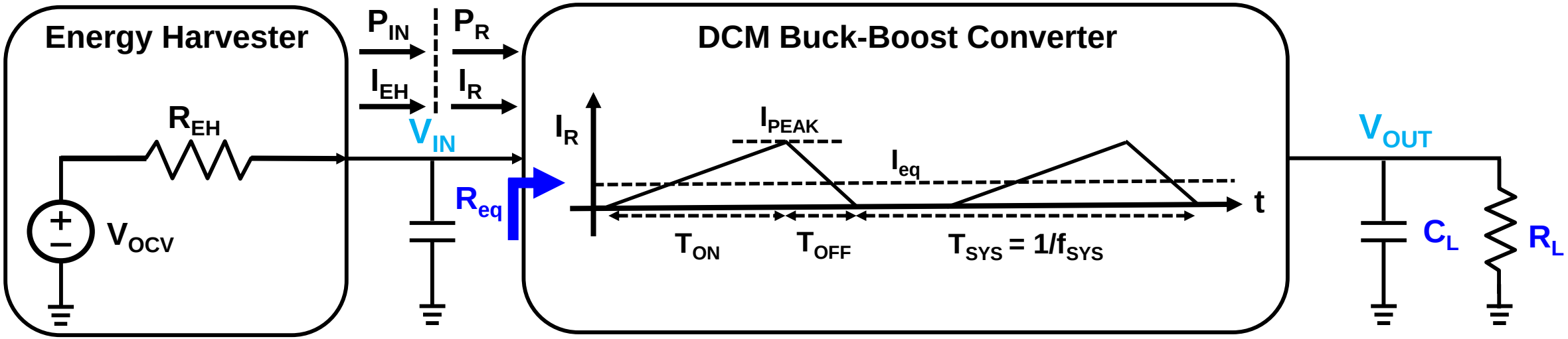
Frequency	R_0	R_{eq}	$V_{IN}=V_{OUT}$	P_{OUT}
(a) 600kHz	Ω	Ω	V	mW
350kHz	100 Ω	Ω	0.5V	mW
(b) 100kHz	Ω	Ω	V	mW

***題目設定是ϕ1 (T_{ON}) = ϕ2 (T_{OFF})。ϕ1電感電流正比V_{IN}、ϕ2電感電流正比V_{OUT}，$V_{IN}=V_{OUT}$才能open loop實現ZCD (若power是無法完全提供輸出，無法公平比較)**

Question

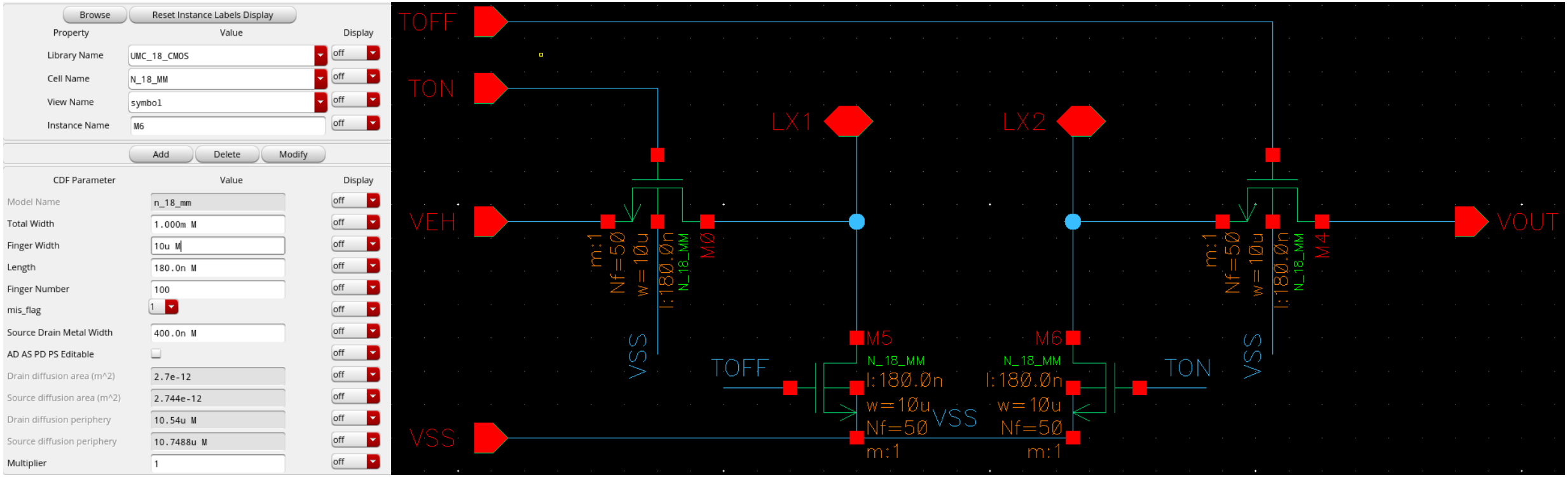
- **Part 2:**

  以NMOS switch組成 buck-boost converter，並觀察其不同R_{eq}下的V_{IN}，並記錄該V_{IN}可提供給輸出的power，對照Part 1



Circuit Simulation

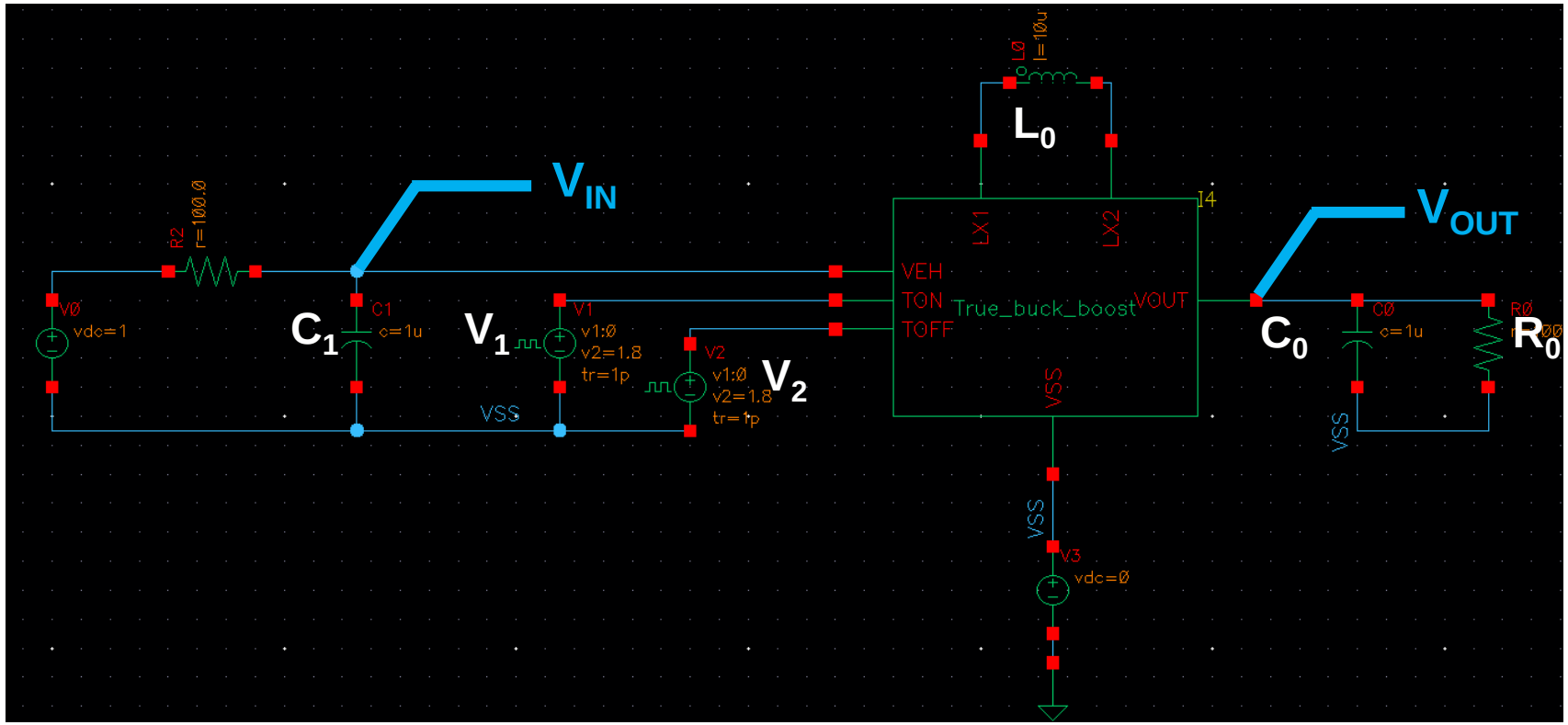
- **Step 1:**
  建一個NMOS buck-boost的schematic



Circuit Simulation

- **Step 2:**

  建立testbench，使用1V串聯100ohm電阻作為energy harvester，C_1為輸入電容、V_1為T_{ON}訊號、V_2為T_{OFF}訊號、C_0為輸出電容、R_0為輸出負載



Circuit Simulation

- **Step 3:**

  以Part 1中350kHz case的設定跑模擬，(a)符不符合MPPT?(b) 修改之使其正常傳輸能量且實現MPPT，並調整R_0直到V_{IN}與V_{OUT}相近，將參數填入下表(c)請問輸出功率有何改變?

T_{ON}	T_{ON}'	T_{OFF}	T_{OFF}'	R_0	R_0'	P_{OUT}	P_{OUT}'
0.75us	us	0.75us	us	100 Ω	Ω	2.5mW	mW

Circuit Simulation

- **Answer**

-電感電流非完全直線，因為實際上MOSFET會有R_{ON}，因此T_{OFF}會略小於T_{ON}
-V_{IN}和V_{OUT}跟原本ideal case不同: V_{IN}變高表示R_{eq}上升，V_{OUT}變低表示輸出的power下降
-需先調整T_{ON}讓V_{IN}在MPP (T_{OFF}先不改)
-接著調整負載電阻讓$V_{OUT} = V_{IN}$ (微調T_{OFF}到零電流切換)
-最後計算發現$V_{IN} = V_{OUT}$ 時負載電阻為R_0’，且$R_0' > R_0$，表示提供給輸出的power減少

參考解答(Appendix Part 2)

Condition: $V_{IN} = V_{OUT} = 0.5V$, f =350kHz

Thanks for your attention!!