AN AC-DC CONVERTER WITH MAXIMUM POWER TRACKING FOR MULTI-INPUT ELECTROMAGNETIC ENERGY HARVESTER

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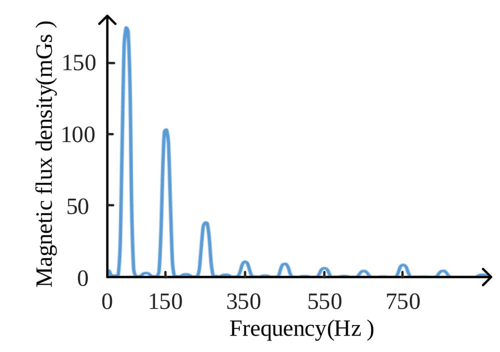
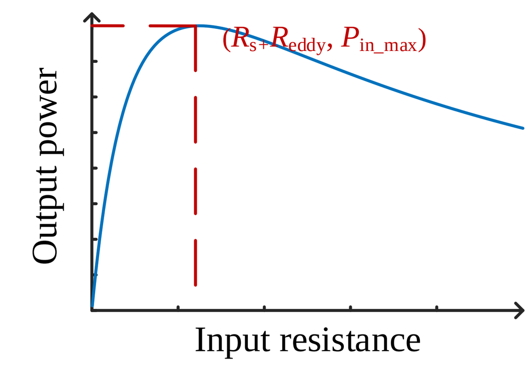
A NEW AC-DC CONVERTER BASED ON FEEDFORWARD CONTROL TO REALIZE VARIABLE INPUT IMPEDANCE UNDER DIFFERENT INPUT FREQUENCIES TO EXTRACT ALL ENERGY FROM ELECTROMAGNETIC ENERGY HARVESTERS(EMEHS).

- Multiple frequency bands of magnetic field energy exist in the power grid. Electromagnetic energy harvesters (EMEHs) have the potential to harvest various energy forms from different frequencies.
- Impedance match is significant to realize maximum power point tracking (MPPT), considering EMEH is a non-ideal voltage source with a series equivalent impedance.
- EMEHs' equivalent **impedance vary with frequency** while the state-of-art AC-DC converter can only realize fixed impedance match at one frequency.
- Proposed AC-DC converter realizes **variable input resistance to extract all energies from EMEHs in different frequencies**.

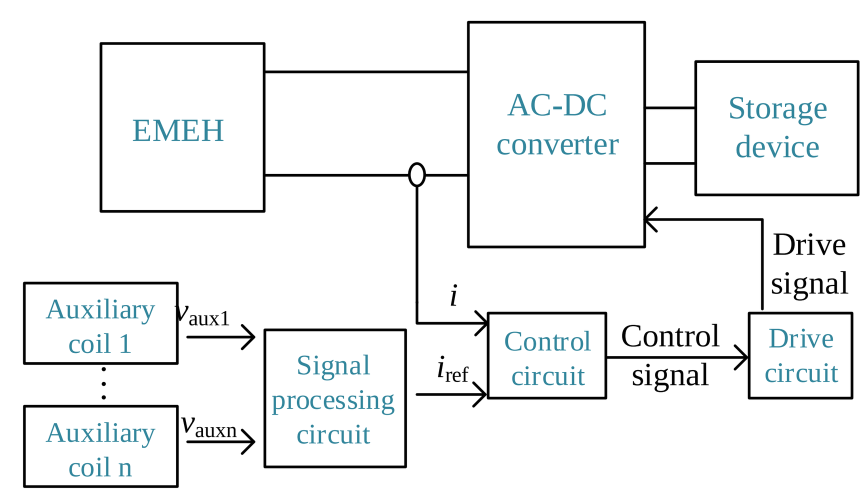


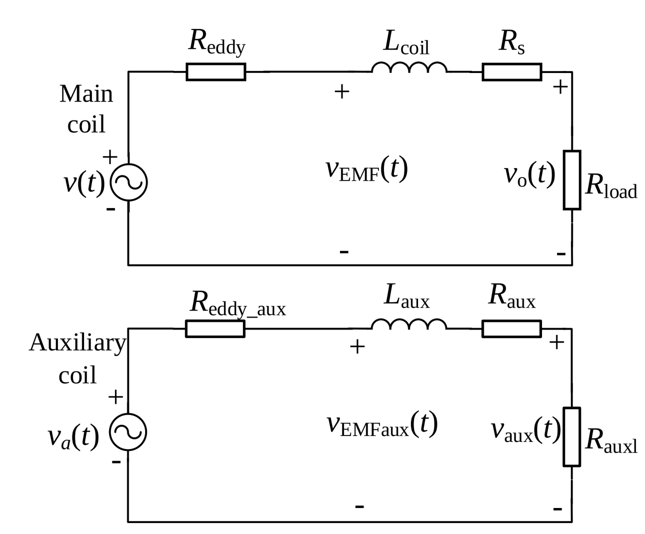


AUXILIARY COIL-BASED SAMPLING METHOD IS PROPOSED TO OBTAIN ACCURATE CURRENT REFERENCE FOR IMPEDANCE MATCH.

- Control of power devices is achieved by hysteresis comparison method by comparing the real-time inductor current with reference current signal. Therefore, the key to current hysteresis control method is to generate **reliable and accurate current reference i_{ref}.**
- Build the model of EMEHs with auxiliary coils. Derive the theoretical calculation formula of the reference current signal $i_{ref}(t)$:

$$i_{ref}(t) = \frac{v_{EMF}(t)}{2R_s + R_{eddy}} = \frac{N_1}{N_2(2R_s + R_{eddy})} v_{EMFaux}(t)$$



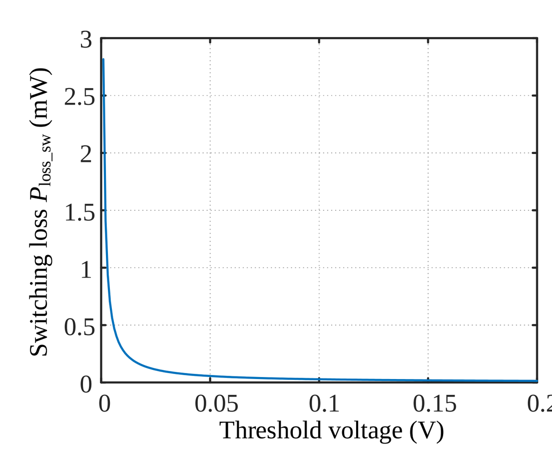


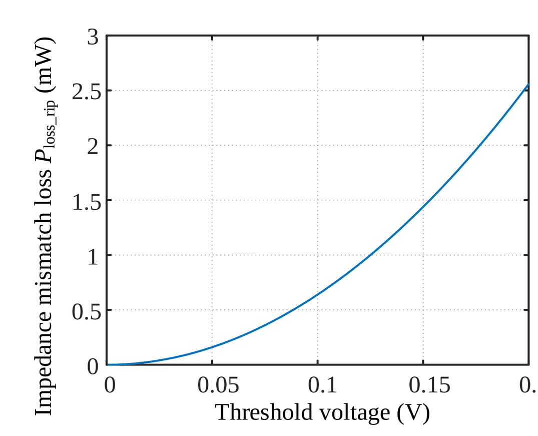
OPTIMAL THRESHOLD VOLTAGE IS OPTIMIZED FOR LOWER TOTAL LOSS, CONSIDERING SWITCHING LOSS AND IMPEDANCE MISMATCH LOSS CAUSED BY CURRENT RIPPLE.

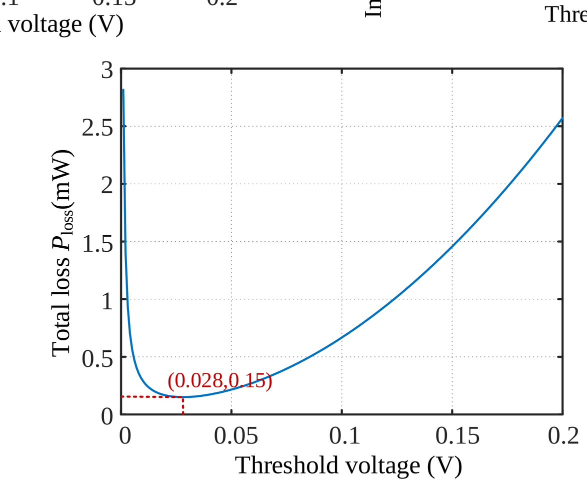
- Derive the theoretical calculation formula to clarify relationship between impedance mismatch loss and current ripple, even threshold voltage ΔU_d :

$$P_{loss\_rip} = \frac{R_{in}\Delta U_d^{\,2}}{3\pi fNR_{samp}^{\,2}k^2}\sum_{0}^{N_1}\frac{(V_p \sin(2\pi\frac{N}{N_i}) + V_o)}{(V_o - V_p \sin(2\pi\frac{N}{N_i}))}$$

- Analyze the switching loss and impedance mismatch loss in different threshold voltage. **A more optimized threshold voltage ΔU_d is determined.**

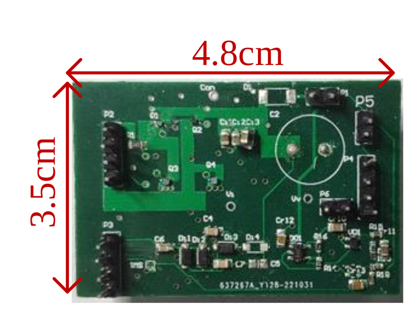


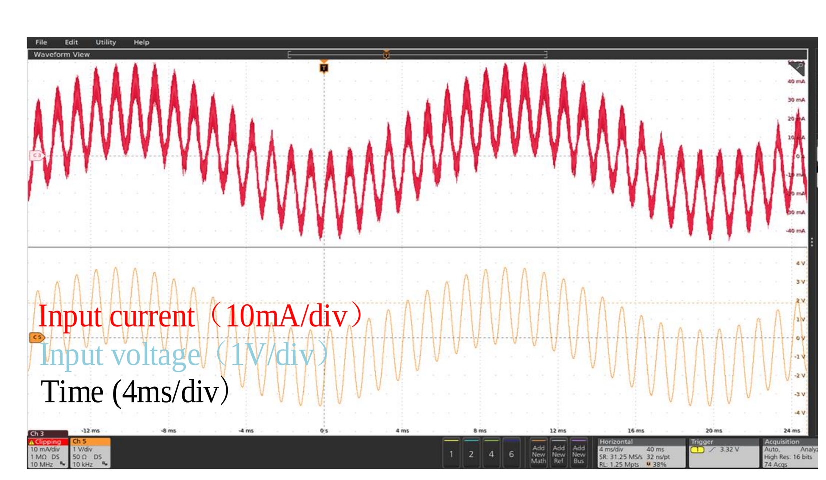




PROTOTYPE OF AC-DC CONVERTER REALIZE MAXIMUM POWER EXTRACTION FROM AN EMEH AT TWO DIFFERENT FREQUENCIES.

- Built the model of auxiliary coil to guide and simplify sampling design.
- Derived calculation formula of impedance mismatch loss to achieve the lowest total loss after optimization.
- Realized maximum power extraction from EMEH under a mixed magnetic field with input sources at 50 Hz and 1000Hz. **Converter achieves 97.8% MPPT efficiency for 50 Hz magnetic field and 98.7% MPPT efficiency for 1000 Hz magnetic field**.





Frequency	Input voltage	Input current	Input power	Maximum input power	MPPT efficiency
50 Hz	1.21 V	14.64 mA	17.71 mW	17.92 mW	98.70%
1000 Hz	1.4 V	12.06 mA	16.88 mW	17.2 8mW	97.68%