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Time-variant Current Modeling Corresponding to Access Impedance Measurements on the Power Line Network

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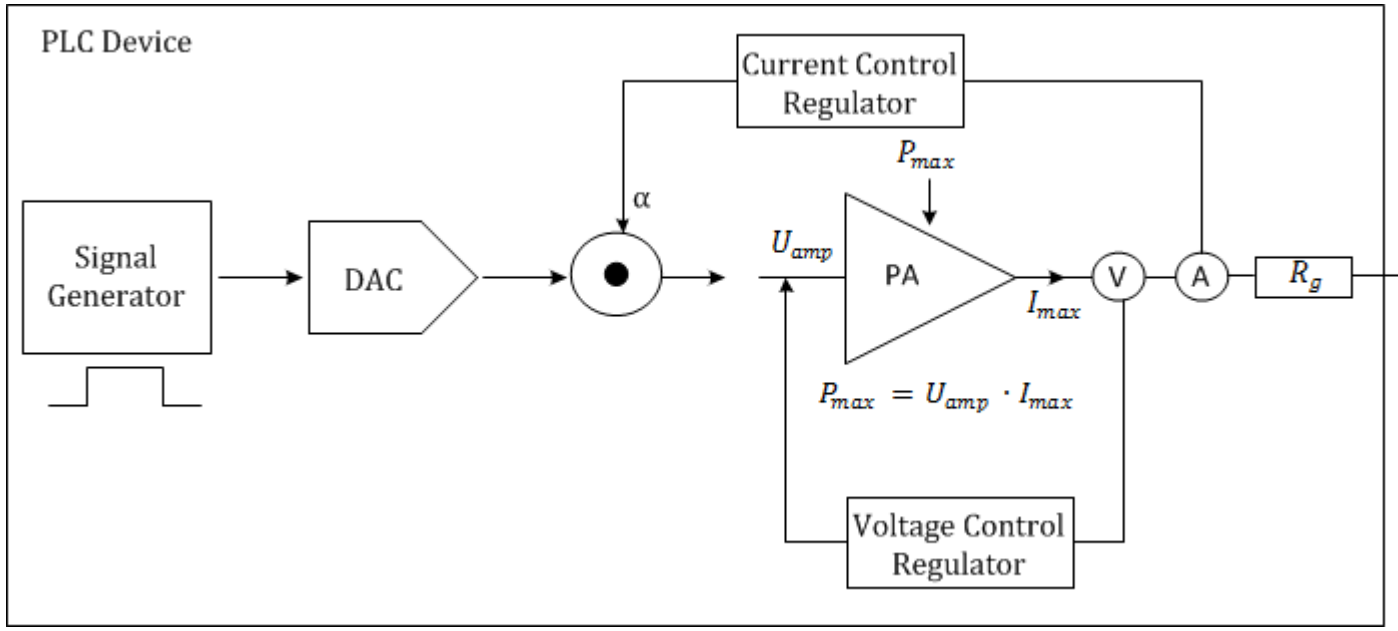
Outline

- Problem statement
- Current modeling algorithm
- Simulation results
- Conclusion

Problem statement

- The Power Line Communication (PLC) channel characteristics affected by the connected loads.
- Access impedance of the PLC channel is time and frequency variant.
- Reduction of the power amplifier output level of PLC devices.

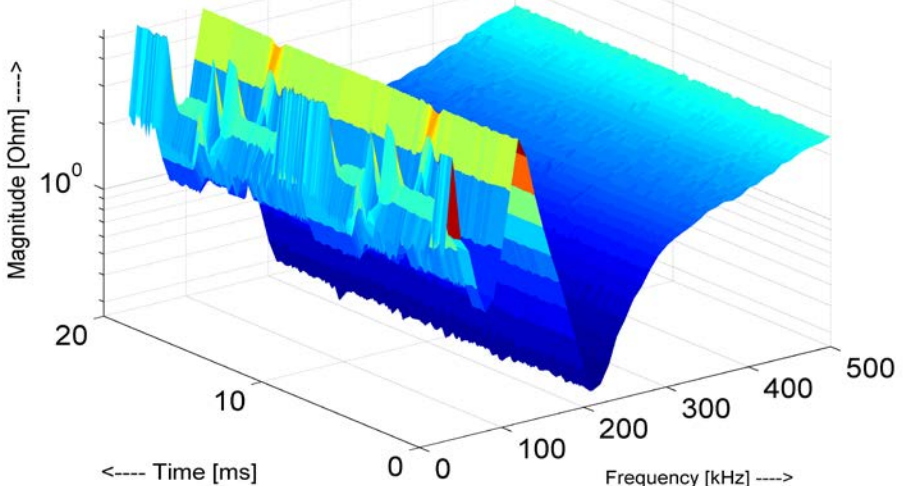


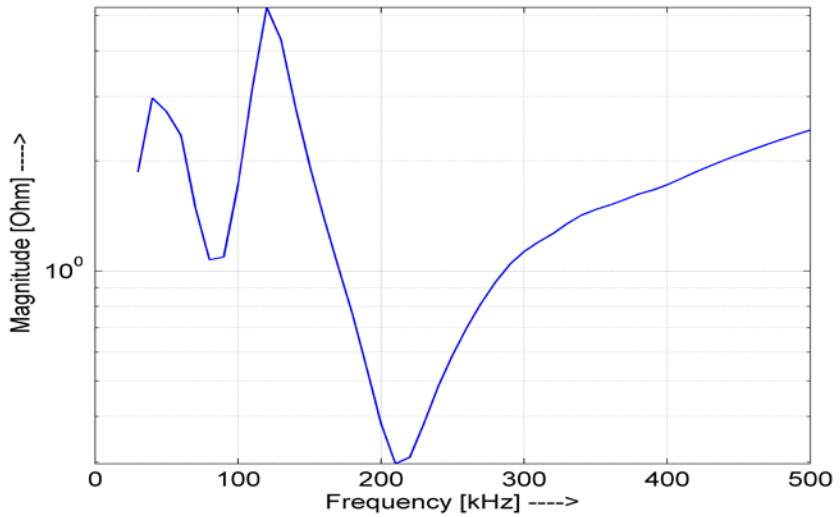
Current Modeling is needed!

Access impedance problem

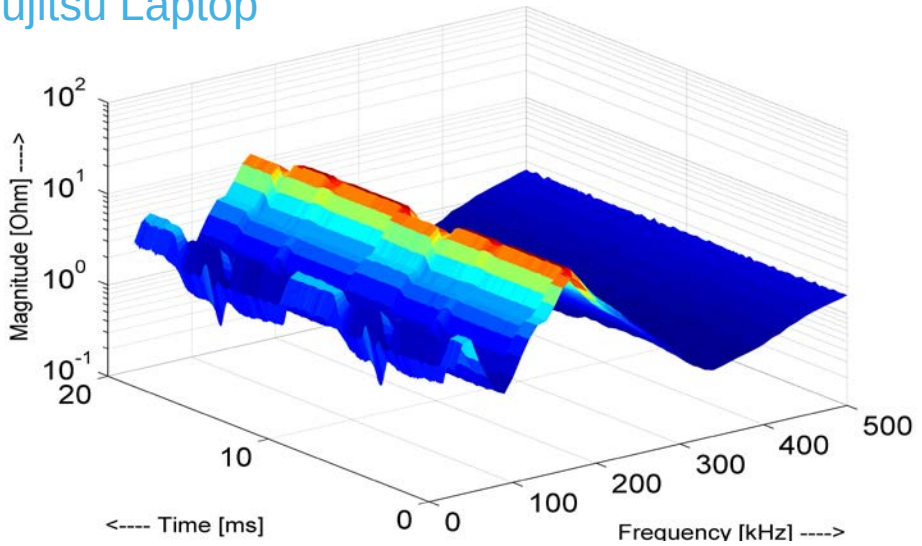
- Impedance is very low and time variant!

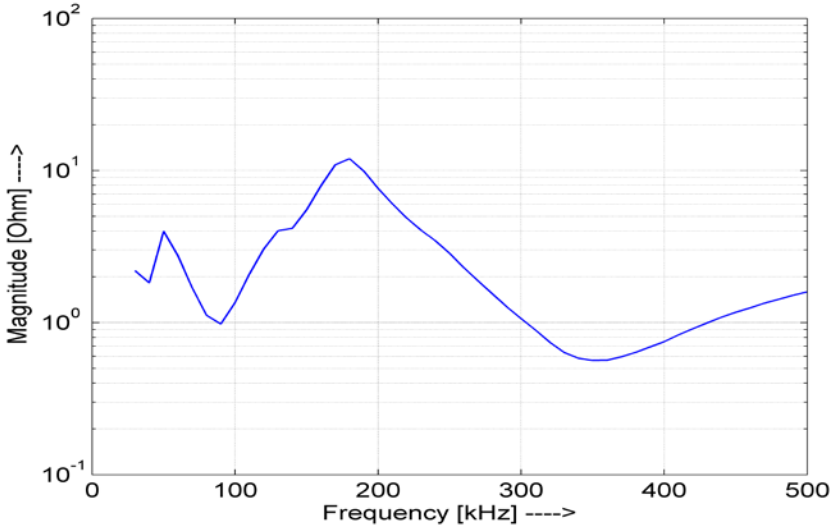
Monitor P2250





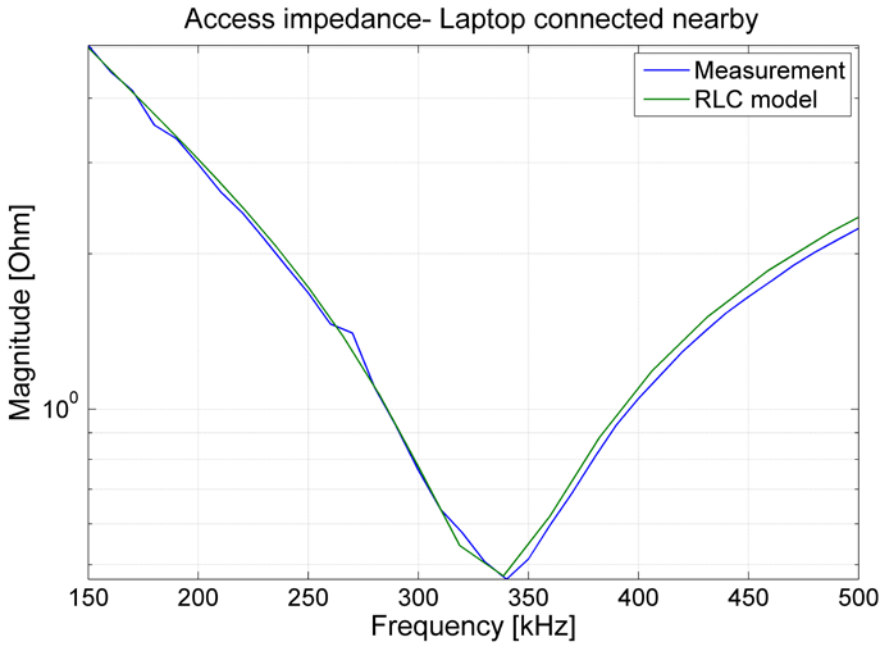
Fujitsu Laptop

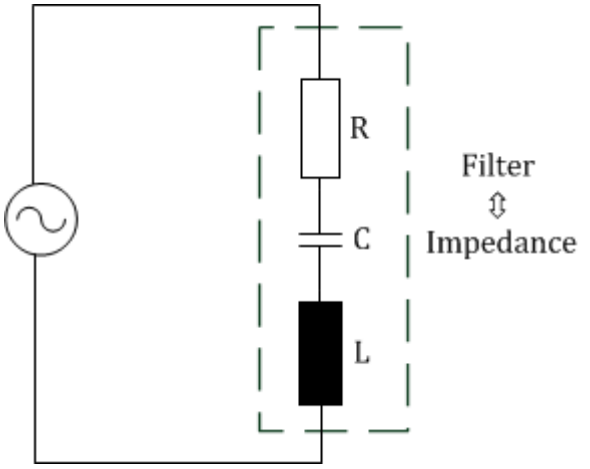




Current modeling algorithm (1/4)

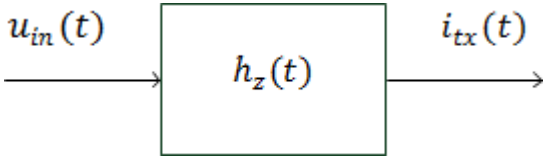
- Filter design based RLC circuit that represents the impedance behavior.
- RLC Filter parameters are based Spice simulation.
- R= 0.47 Ohm, C= 0.17 µF, L=1.33 µH.

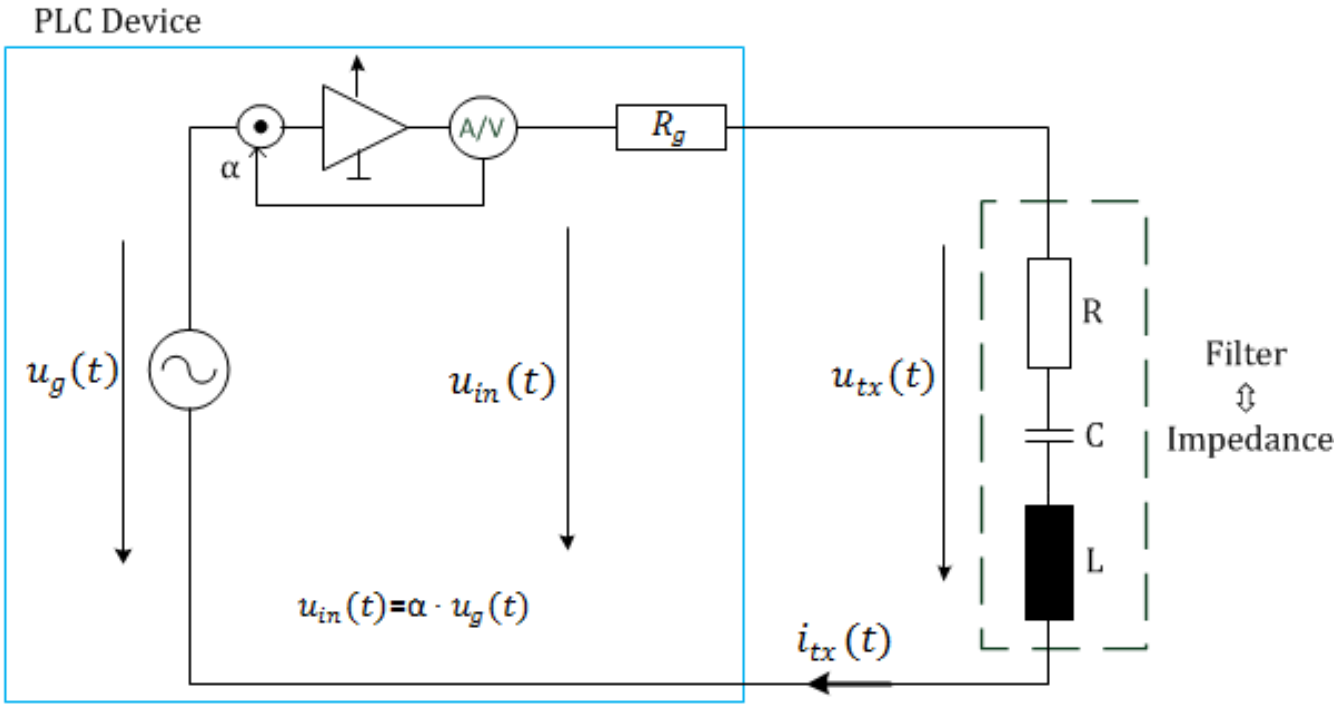




Current modeling algorithm (2/4)

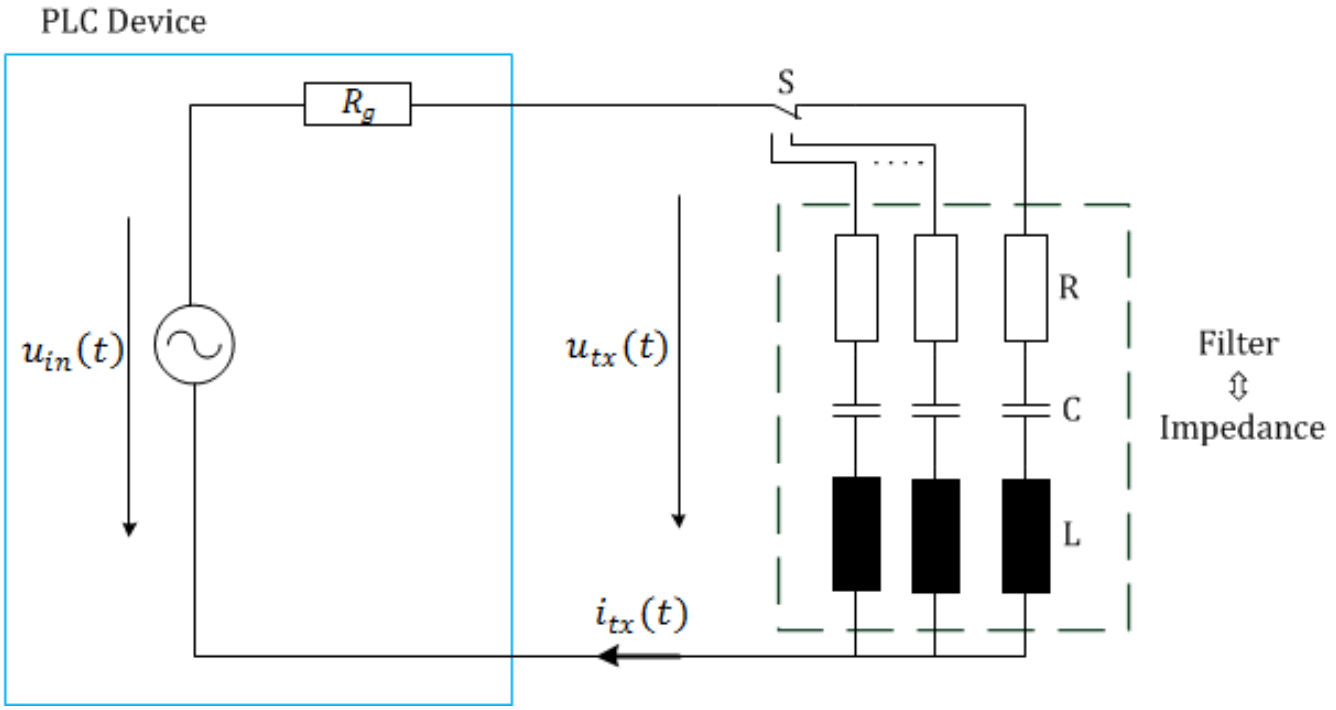
- Linear system view is considered.
- $i_{tx}(t) = u_{in}(t) * h_z(t)$;
  $h_z(t)$ is the impulse response of the RLC filter





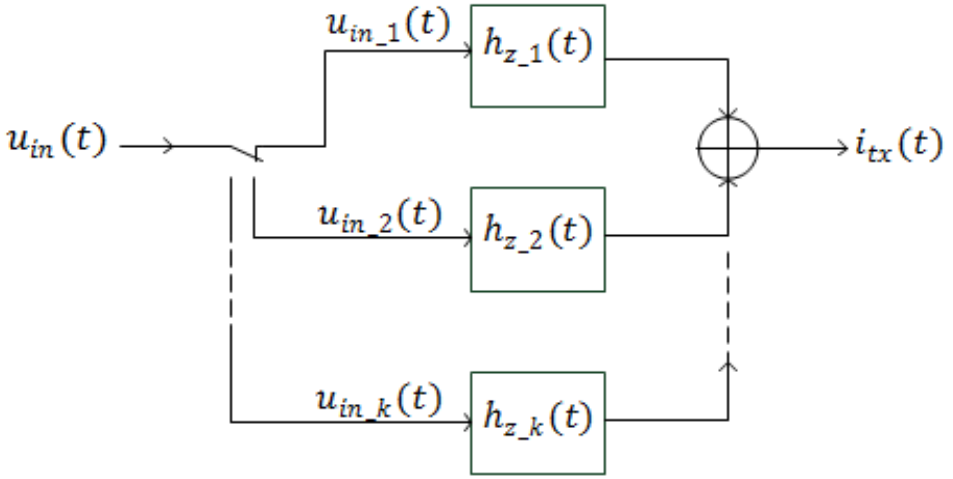
Current modeling algorithm (3/4)

- Toggle switch for current analysis.
- Monitoring the current behavior at the specific time slots where the impedance is relatively constant.



Current modeling algorithm (4/4)

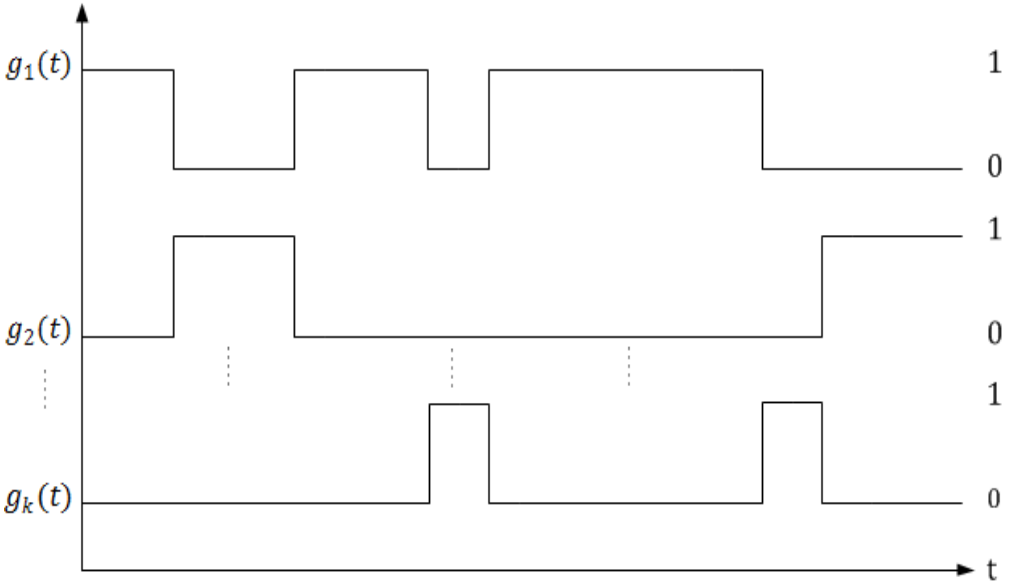
- $i_{tx}(t) = \sum_{k=1}^{K} u_{in\_k}(t) * h_{z\_k}(t)$; K is number of filters.



- $u_{in\_k}(t) = u_{in}(t) \cdot g_k(t)$;

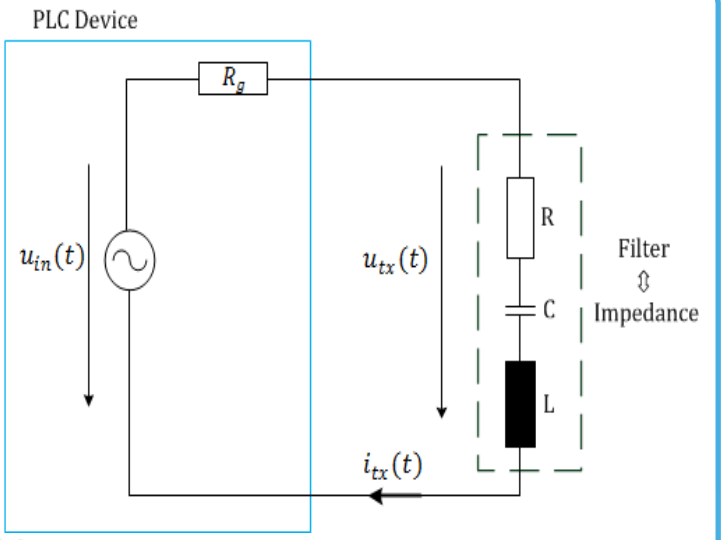
- $g_k(t) = \begin{cases} g_k(t) = \in \{0; 1\} \\ \sum_{k=1}^{K} g_k(t) = 1 \\ g_k(t) = g_k(t + l \cdot T_p) \end{cases}$;

  $l \in \mathbb{Z}$ and T_p is the time period over the mains frequency.

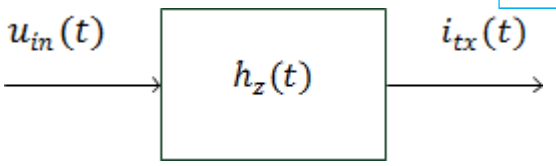


Filter design (1/2)

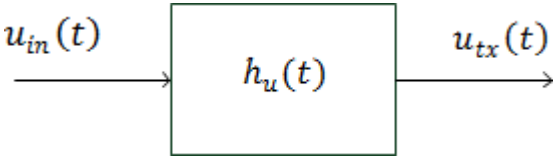
- Filter design based Laplace transformation.



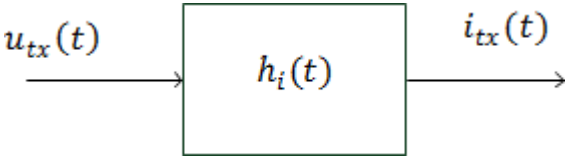
- $H_z(s) = \frac{sC}{s^2CL+sC(R+R_g)+1}$



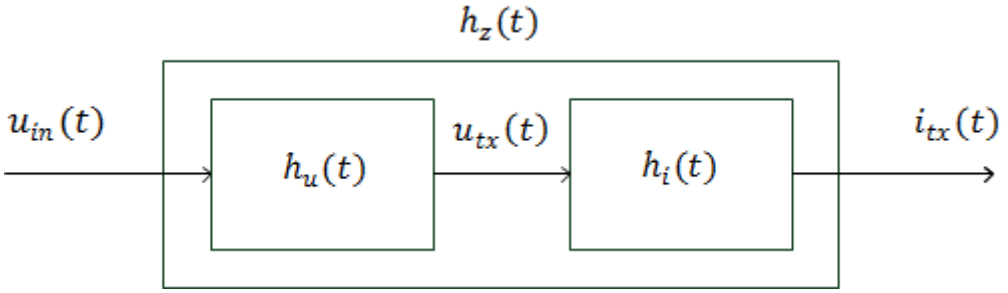
- $H_u(s) = \frac{s^2CL+sCR+1}{s^2CL+sC(R+R_g)+1}$



- $H_i(s) = \frac{sC}{s^2CL+sCR+1}$

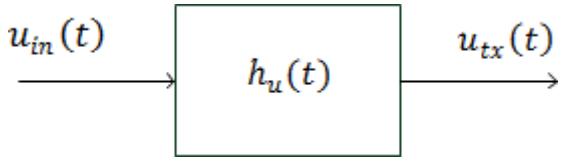


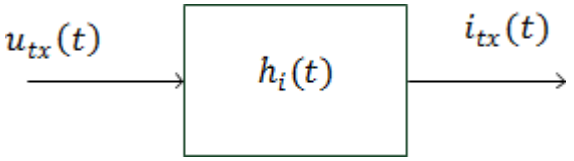
- Full system model:
  $H_z(s) = H_u(s)\ .\ H_i(s)$

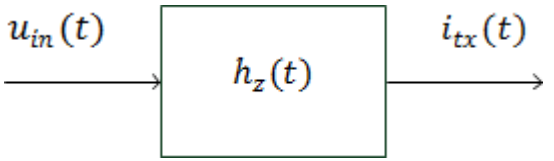


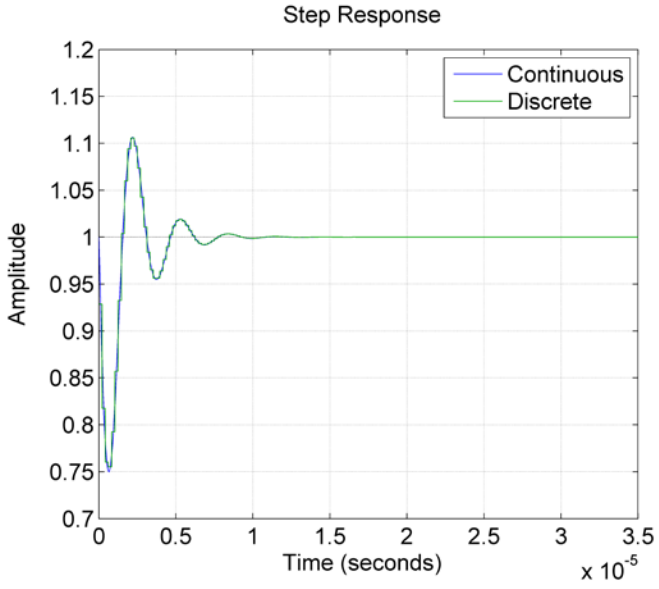
Filter design (2/2)

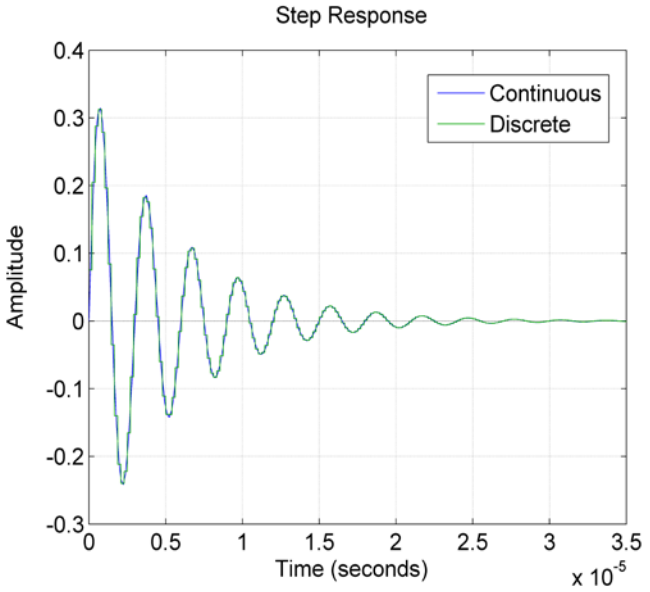
- S-domain to Z-domain using First-order hold (FOH) method.

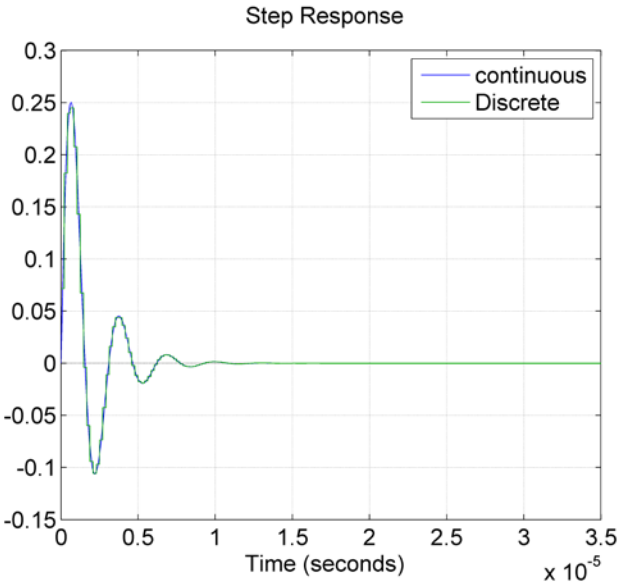








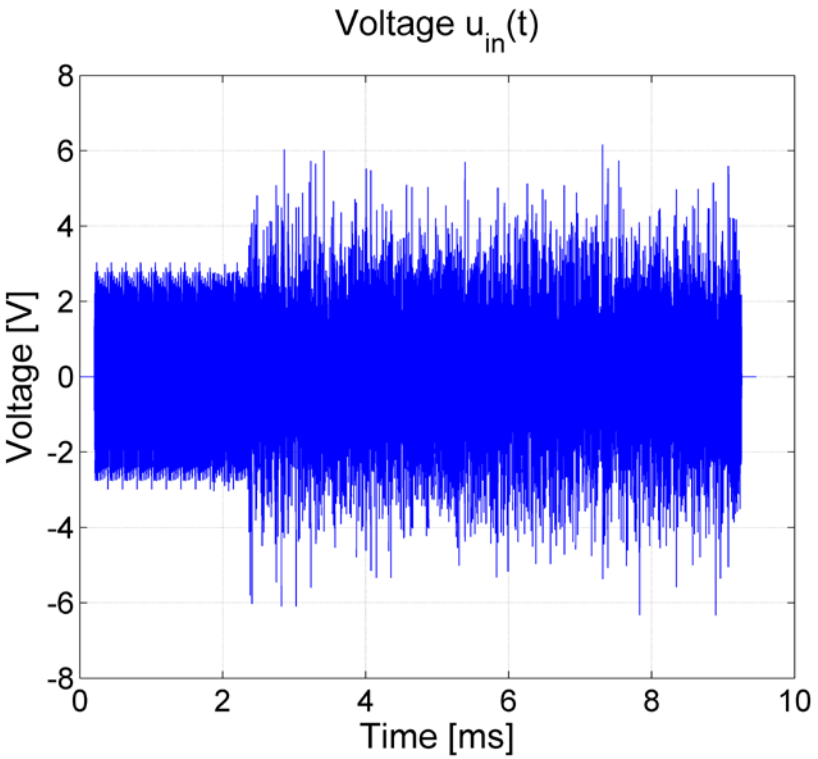




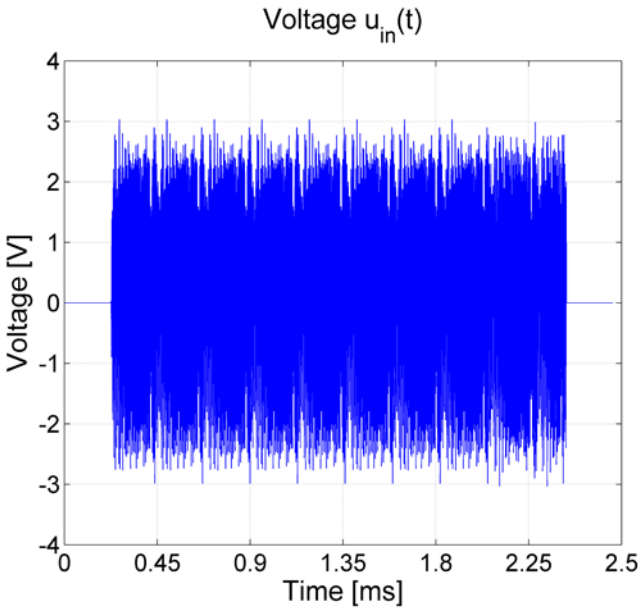
Simulation Results (1/3)

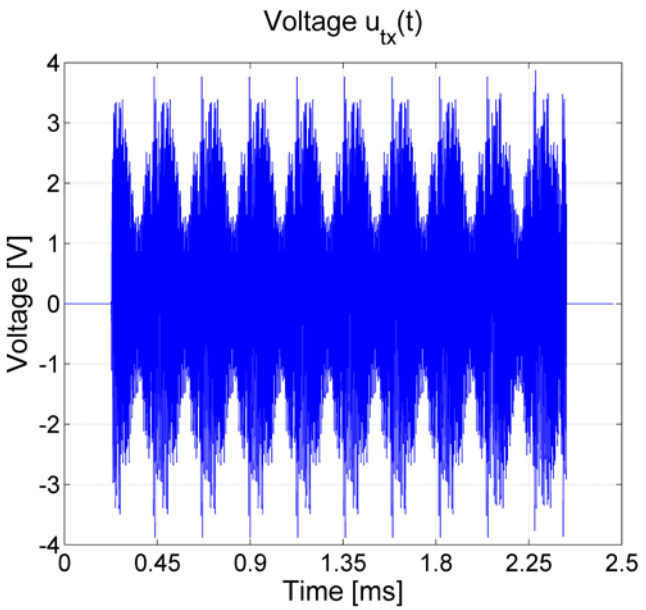
- Transmitted signal based NB PLC IEEE 1901.2: (9.5 preamble+12 FCH+ data)
- We consider the signal preamble for evaluation.
- IEEE 1901.2 signal preamble are chirp signals.

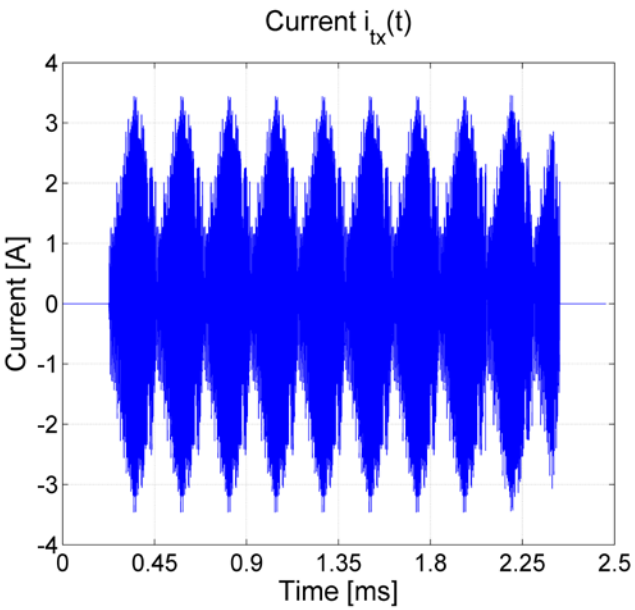
Simulation parameters	
FCC-above-CENELEC	154.6875 to 487.5 kHz
Sampling frequency	1.2 MHz

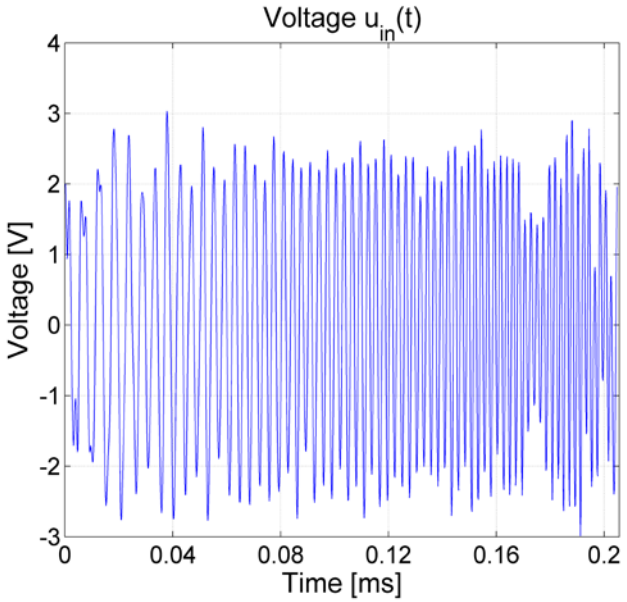


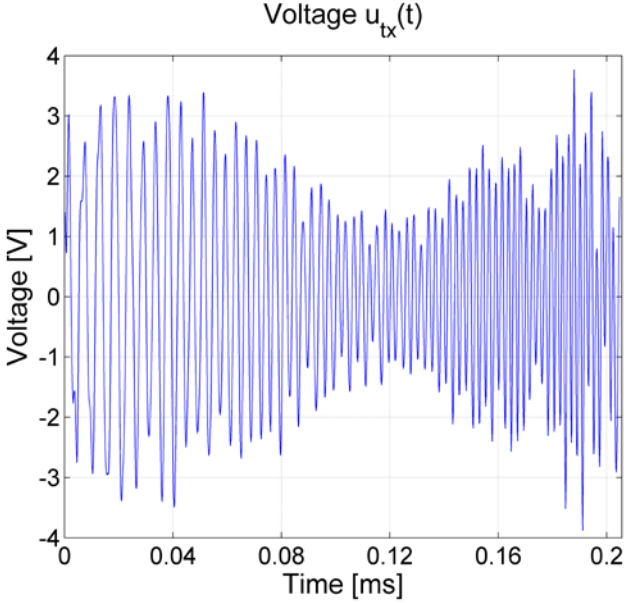
Simulation Results (2/3)

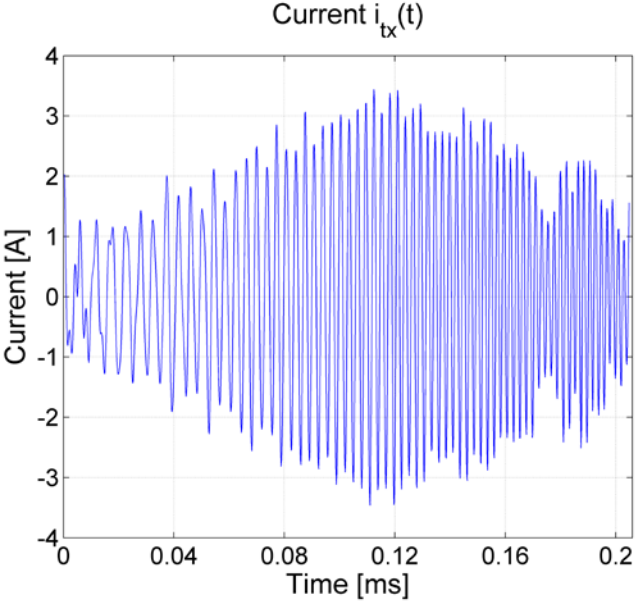






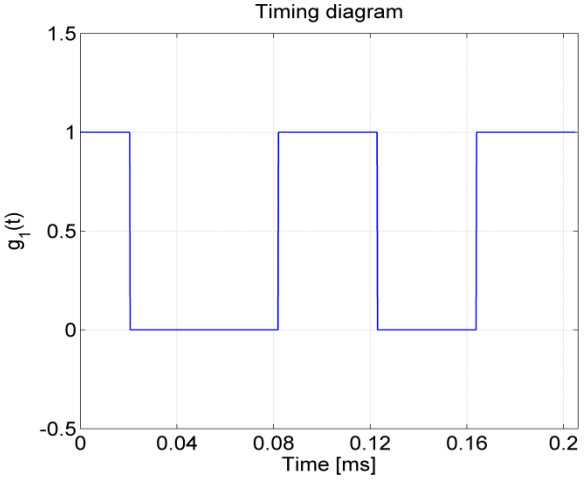


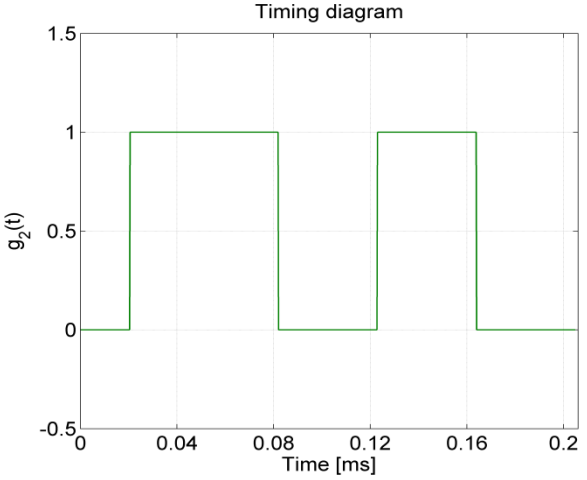


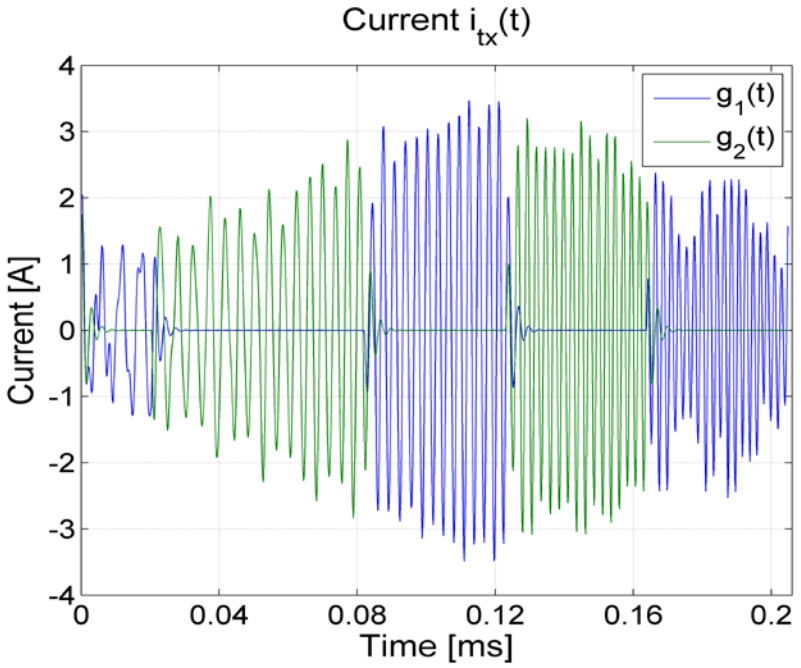


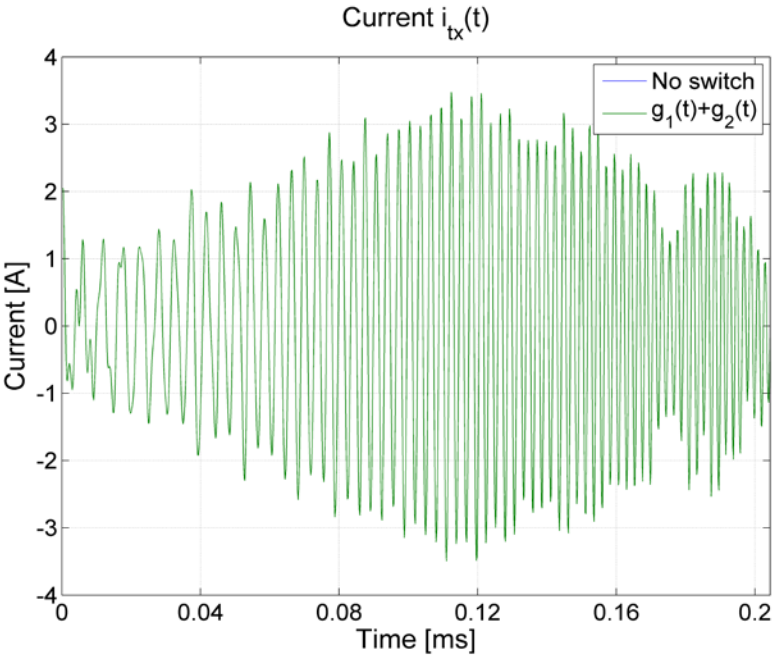
Simulation Results (3/3)

- Method verification of current analysis in respect to time variation .









Conclusion

- Time variant electrical current modeling of PLC devices corresponding to access impedance measurement is presented.
- The modeling algorithm based RLC filter design.
- This model allowed the analysis of the current behavior in respect to time to optimize the transmitted signal of PLC devices.

➢ **Future works:**

- Find the current model using frequency method.
- Simulation results comparison and verification.

Thank you for your attention!