UNIWERSYTET ZIELONOGÓRSKI

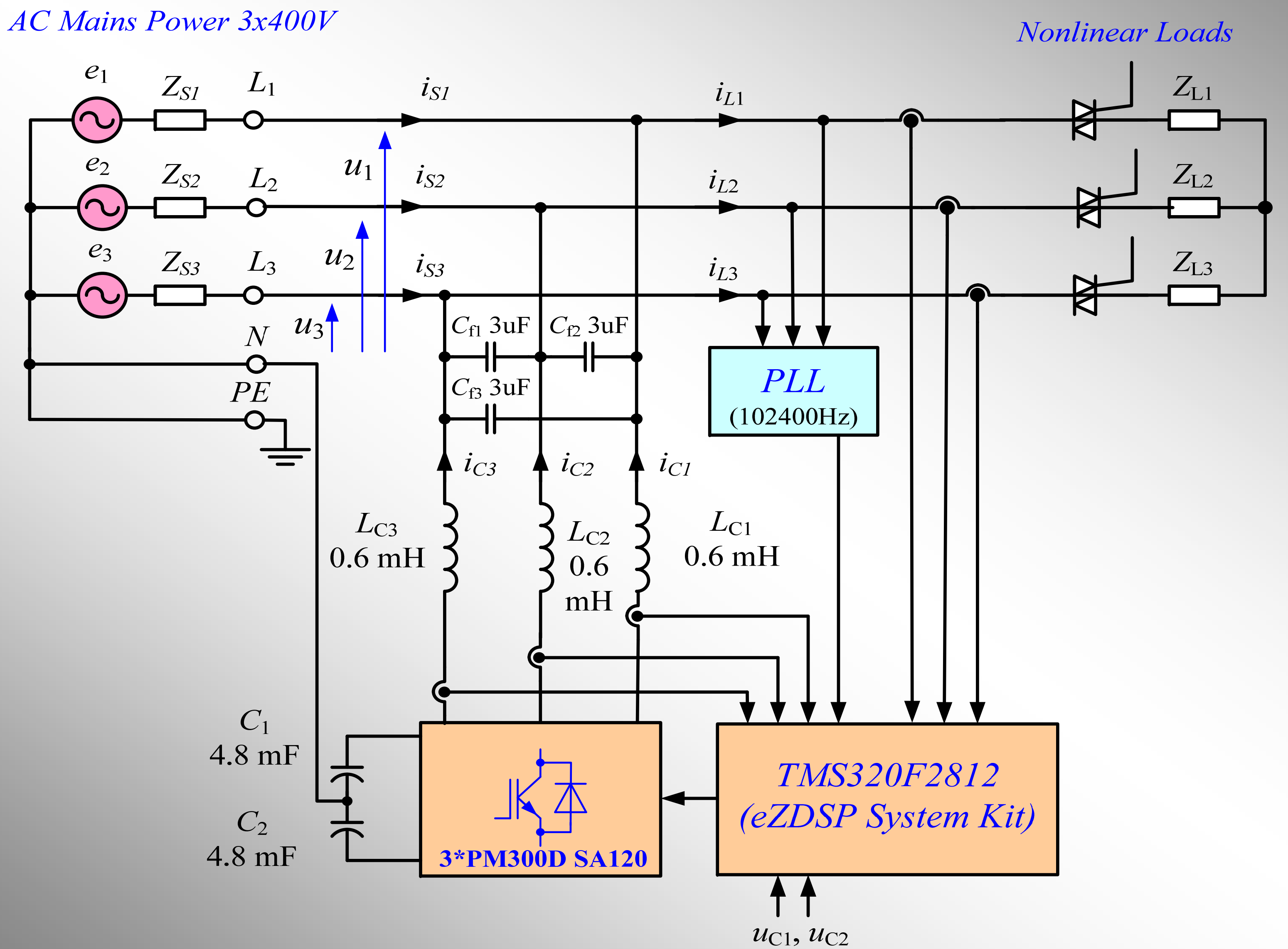
University of Zielona Góra, Poland
Institute of Electrical Engineering

Krzysztof Piotr Sozański

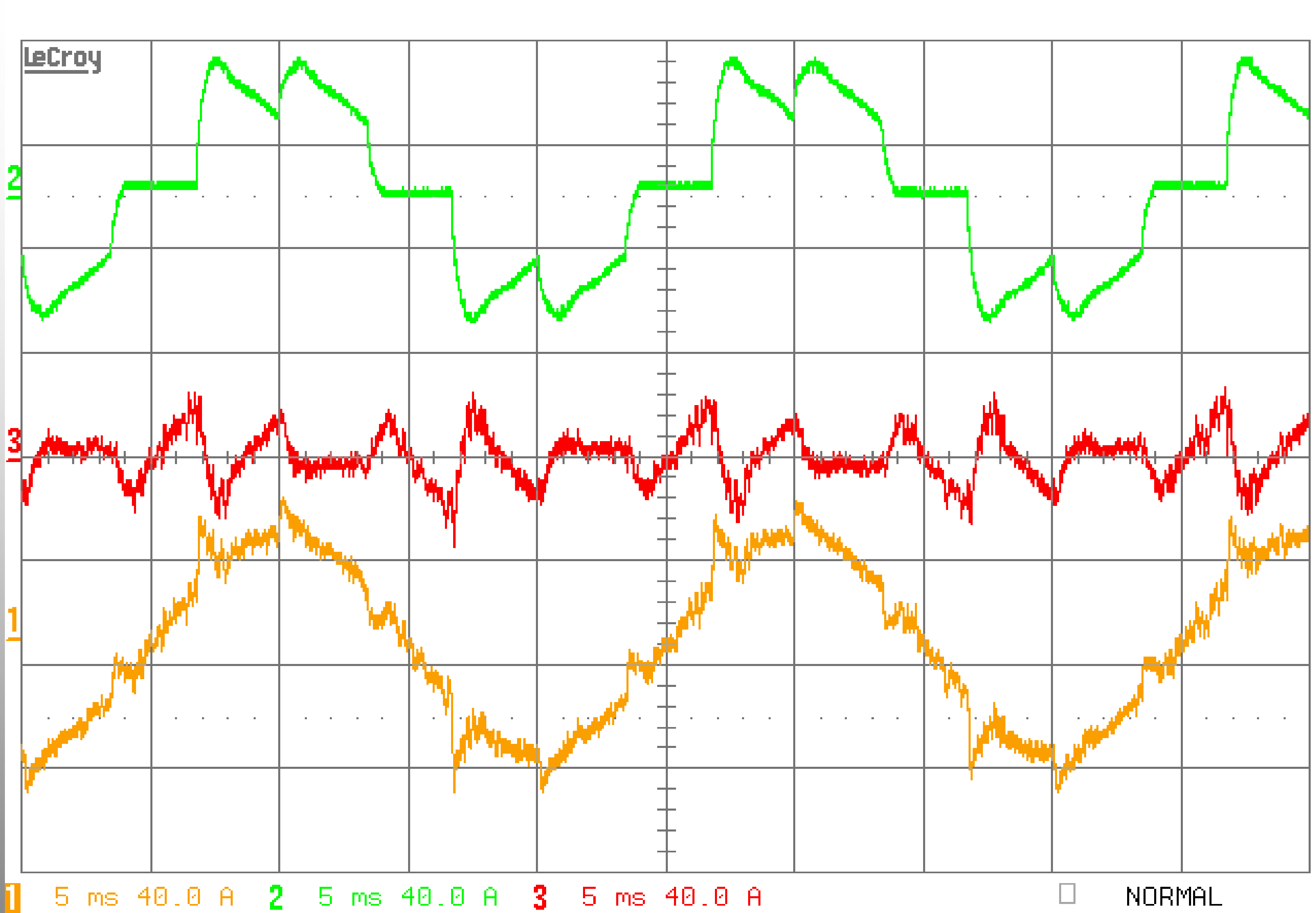
The Shunt Active Power Filter with Better Dynamic Performance

Active Power Filter in Our Laboratory

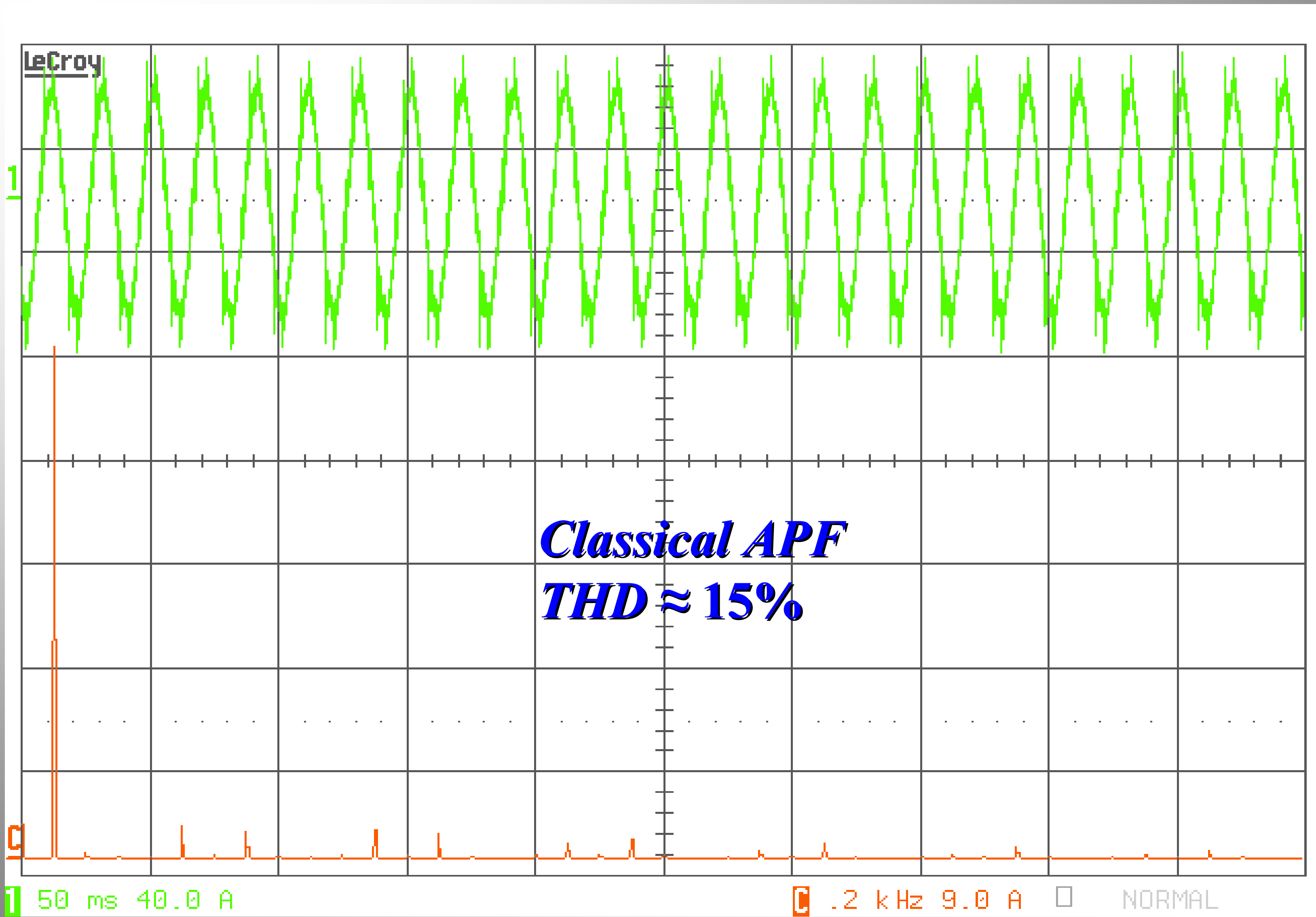
Block Diagram of Classical Three-phase Shunt Active Power Filter



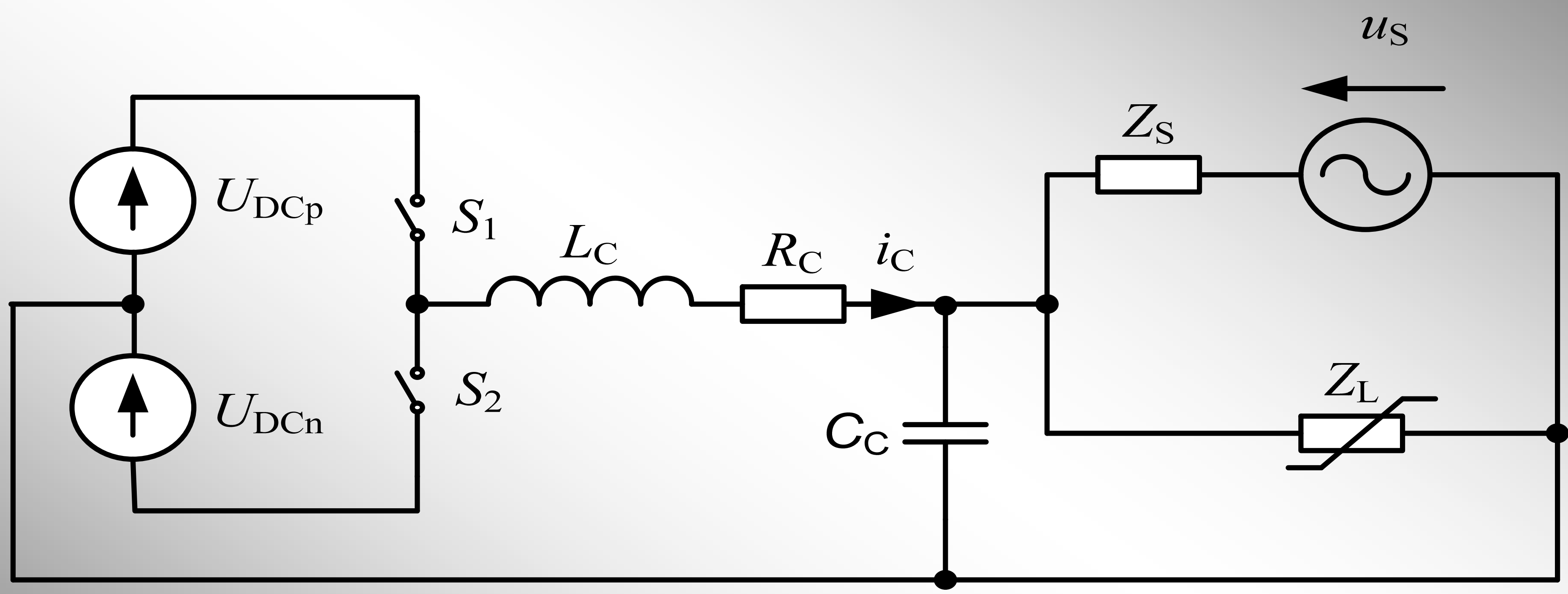
Experimental Waveforms of the Active Power Filter in Steady-state with the Resistive Load



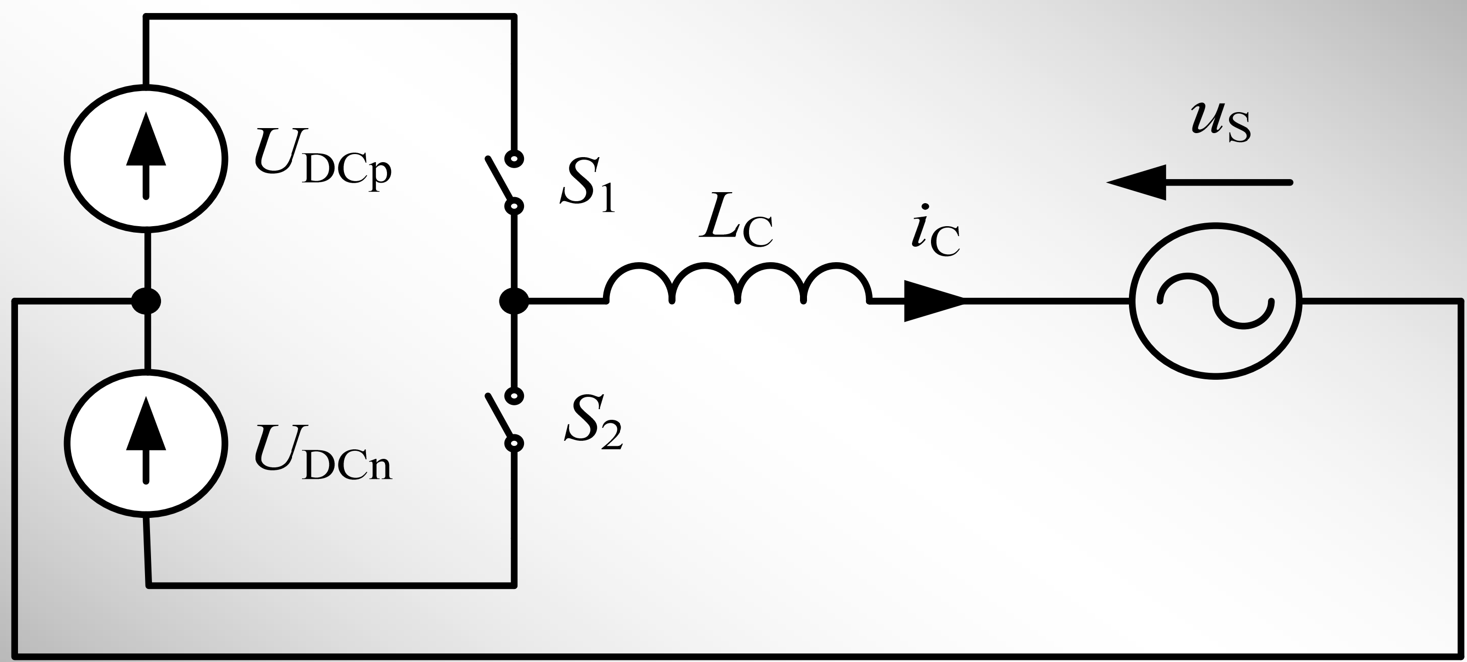
Frequency Spectrum of Line Current i_S



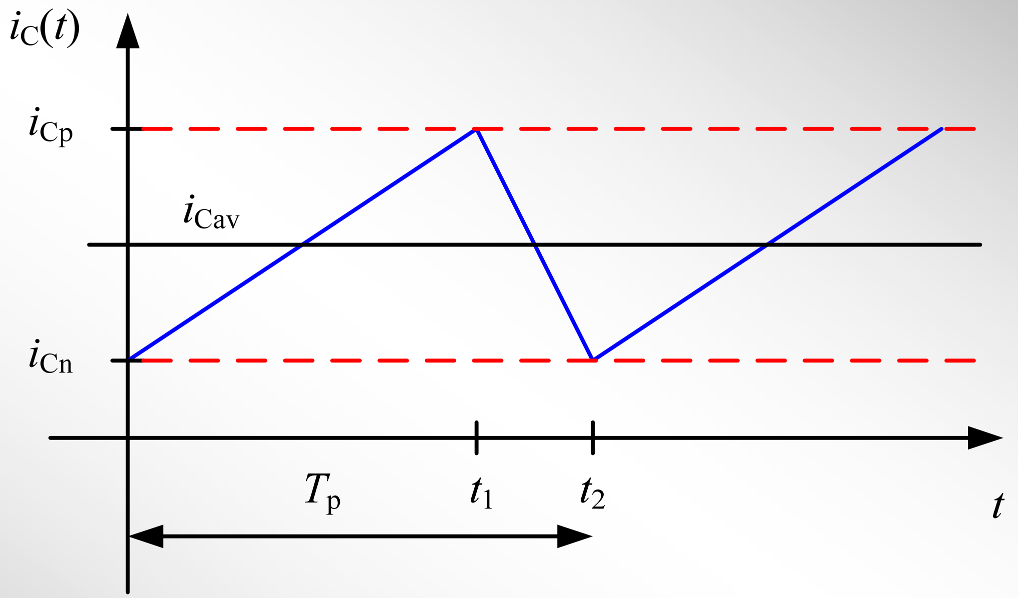
Simplified Diagram of Modified Inverter Model Connected to the Mains Power



Simplified Diagram of the Inverter Model Connected to the Mains Power, Used for Current Ripple Calculation



Time Diagram of Idealized Compensating Current i_C



$$\Delta i_C(t) = \left| \frac{U_{DCp} - u_S(t_0)}{L_C} t_1 \right| = \left| \frac{-U_{DCn} - u_S(t_0)}{L_C} t_2 \right|$$

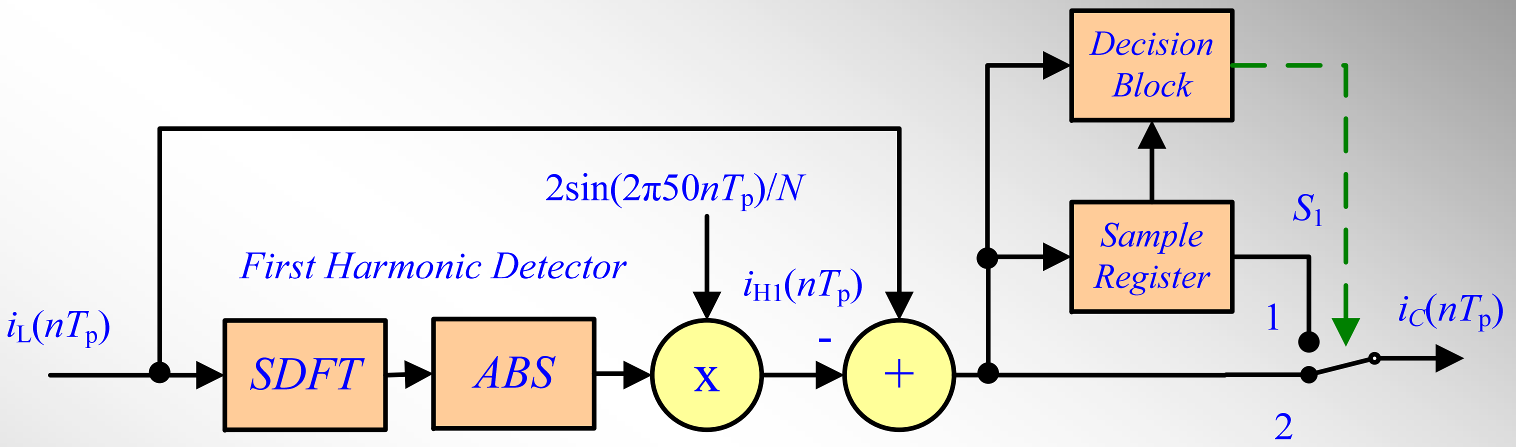
Right Value of the Inductor?

Bigger value of inductor		Lower value of inductor	
Positives	Negatives	Positives	Negatives
- low current ripple - lower transistor switching frequency	- slow transitions response - bigger cost and weight	-fast transitions response - lower cost and lower weight	- higher value of current ripple -higher switching frequency - bigger influence from the switching transition

Possible Solution ?

For predictable loads	For unpredictable loads
Typical APF with non-causal control algorithm	High speed APF
	Set of two APFs: - high power low speed APF - low power high speed APF

Simplified Block Diagram of Harmonics Compensation with Non-causal Circuit

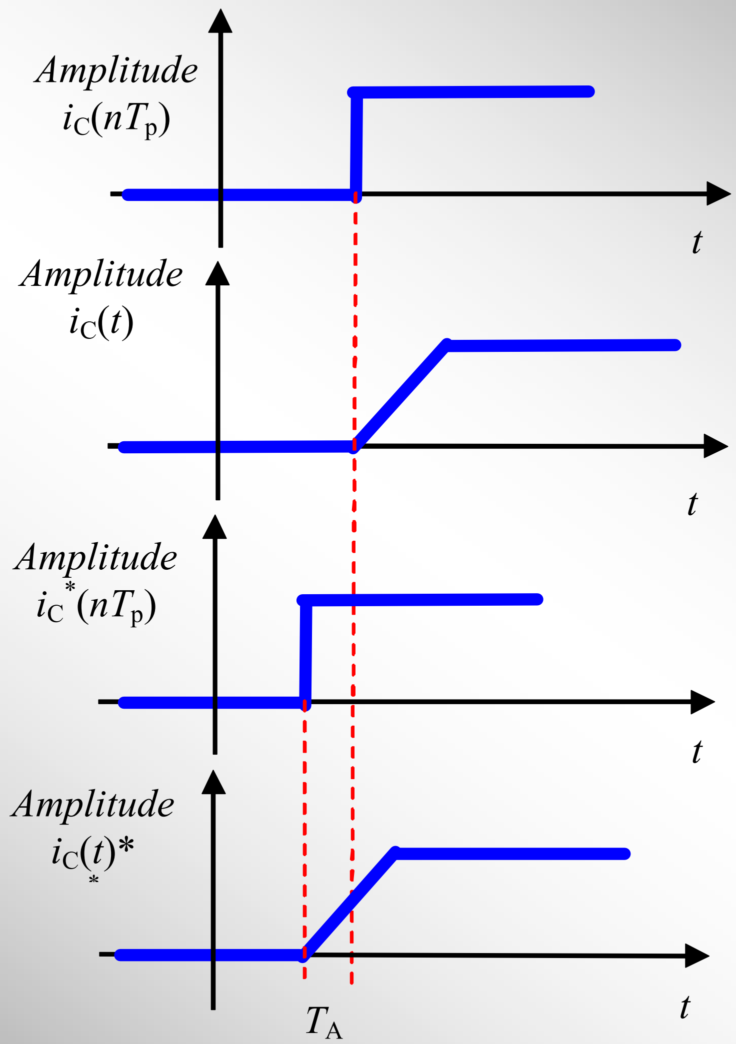


- Previous current compensation signal samples $i_C(nT_{p1})$ are stored in memory, and are sent to present output in advance.
- In the experimental circuit the timing T_A was about several hundred microseconds in advance.
- Because the time constant is dependent on load parameter an adaptive algorithm to calculate time ahead was employed.

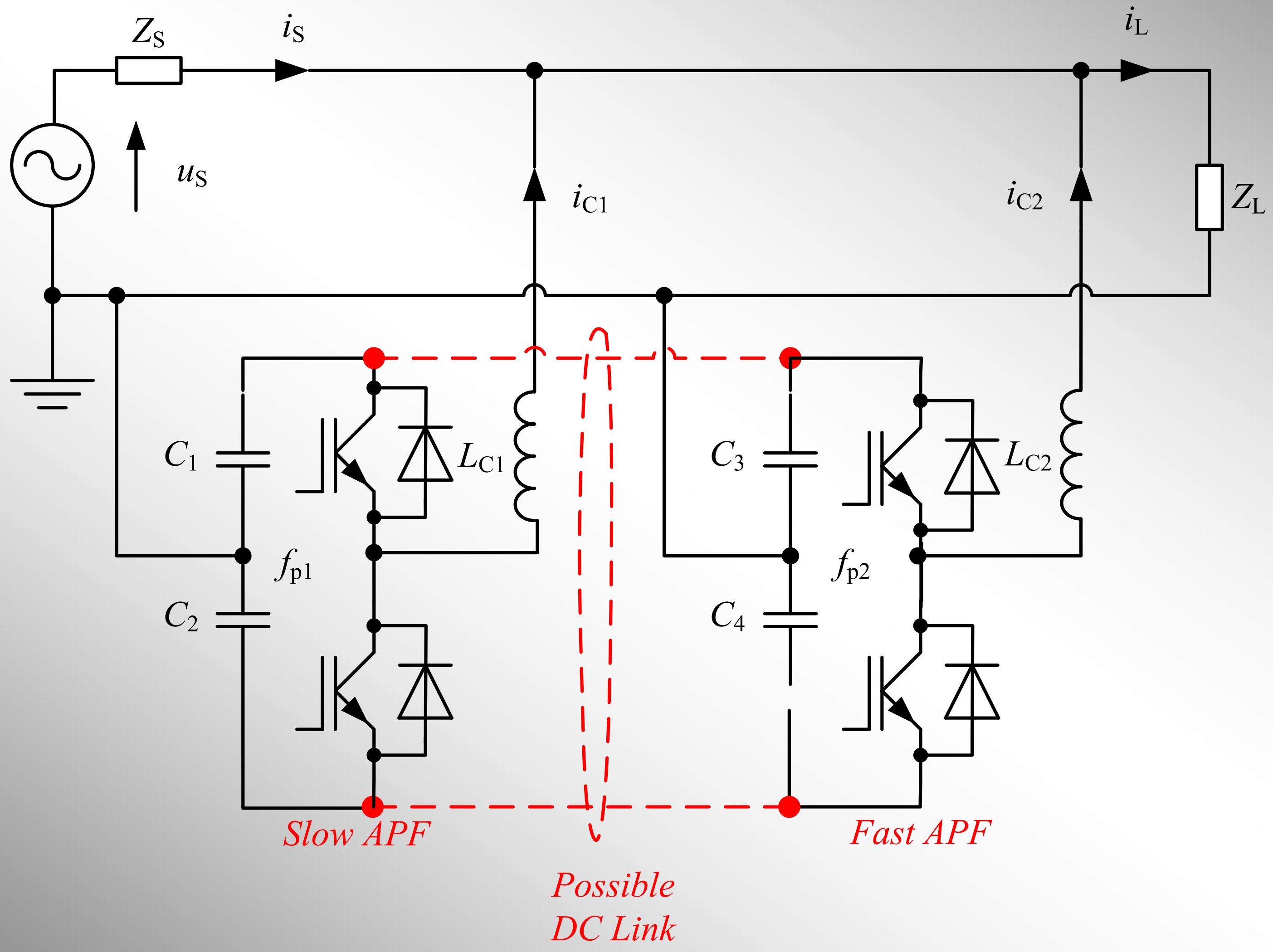
Transient Response of APF Current Compensating Signal $i_C(nTp)$ and Inverter Output Current $i_C(t)$

causal case

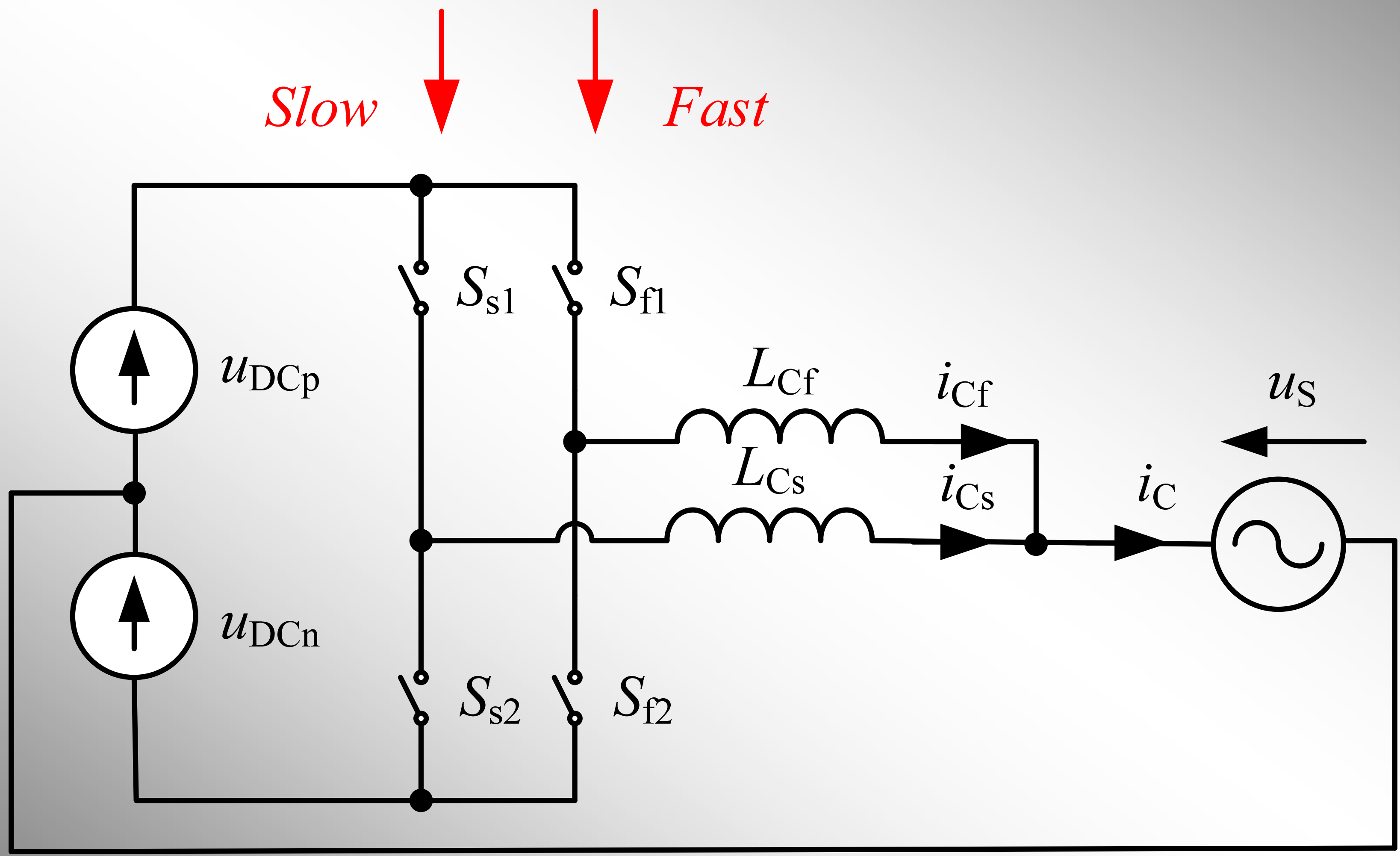
non-causal case



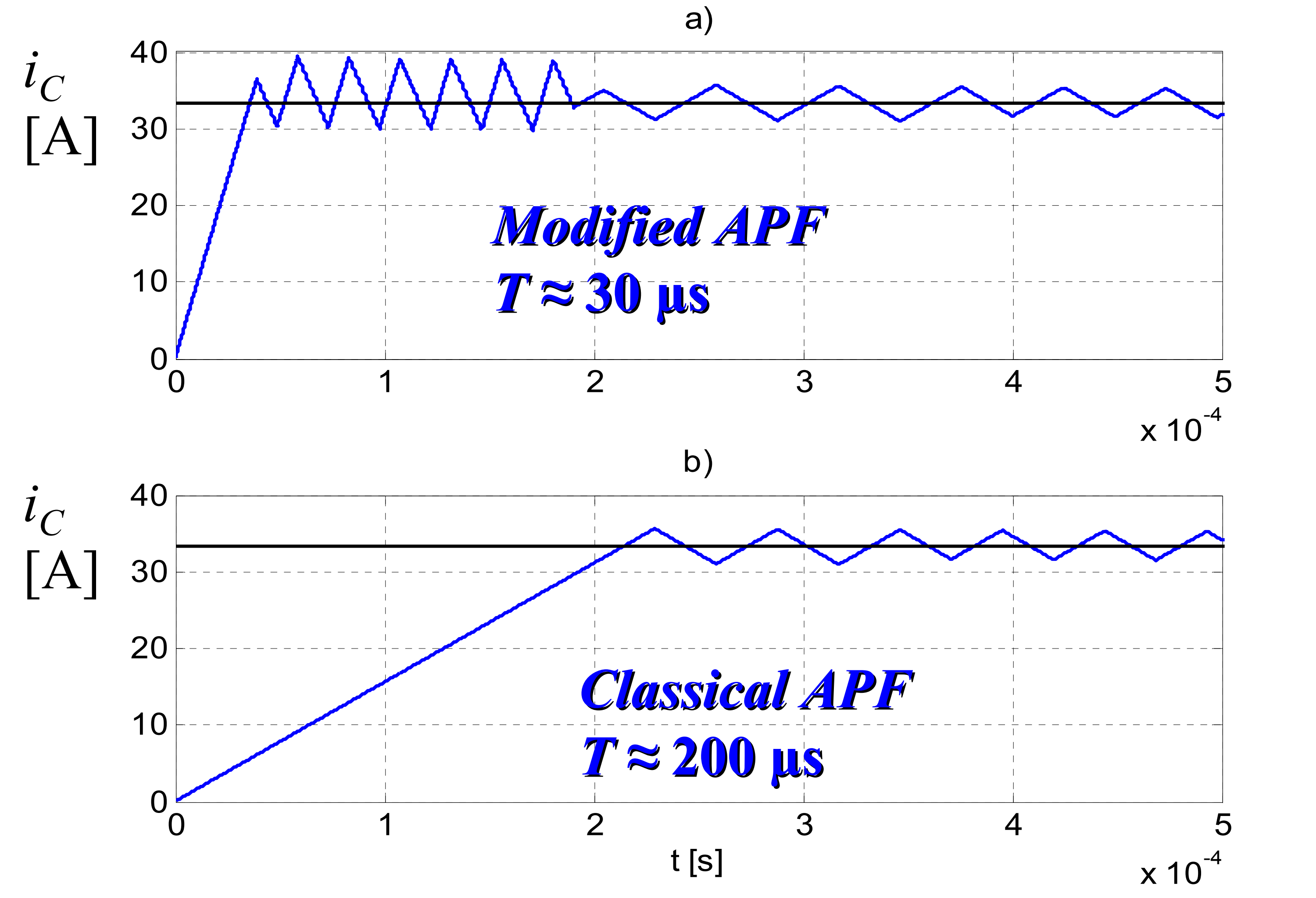
Slow and Fast Active Power Filters



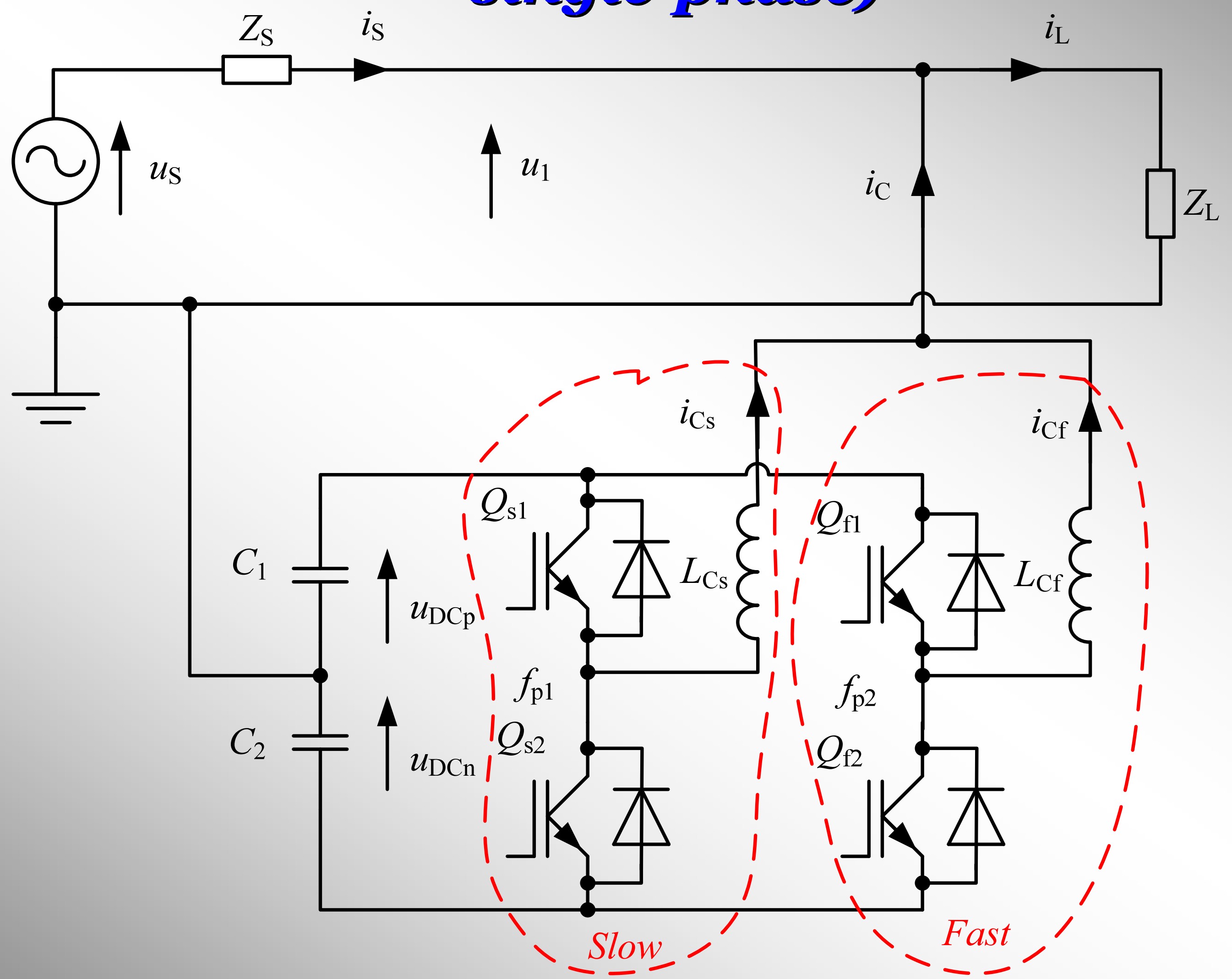
Simplified Diagram of Modified Inverter Model Connected to the Mains Power



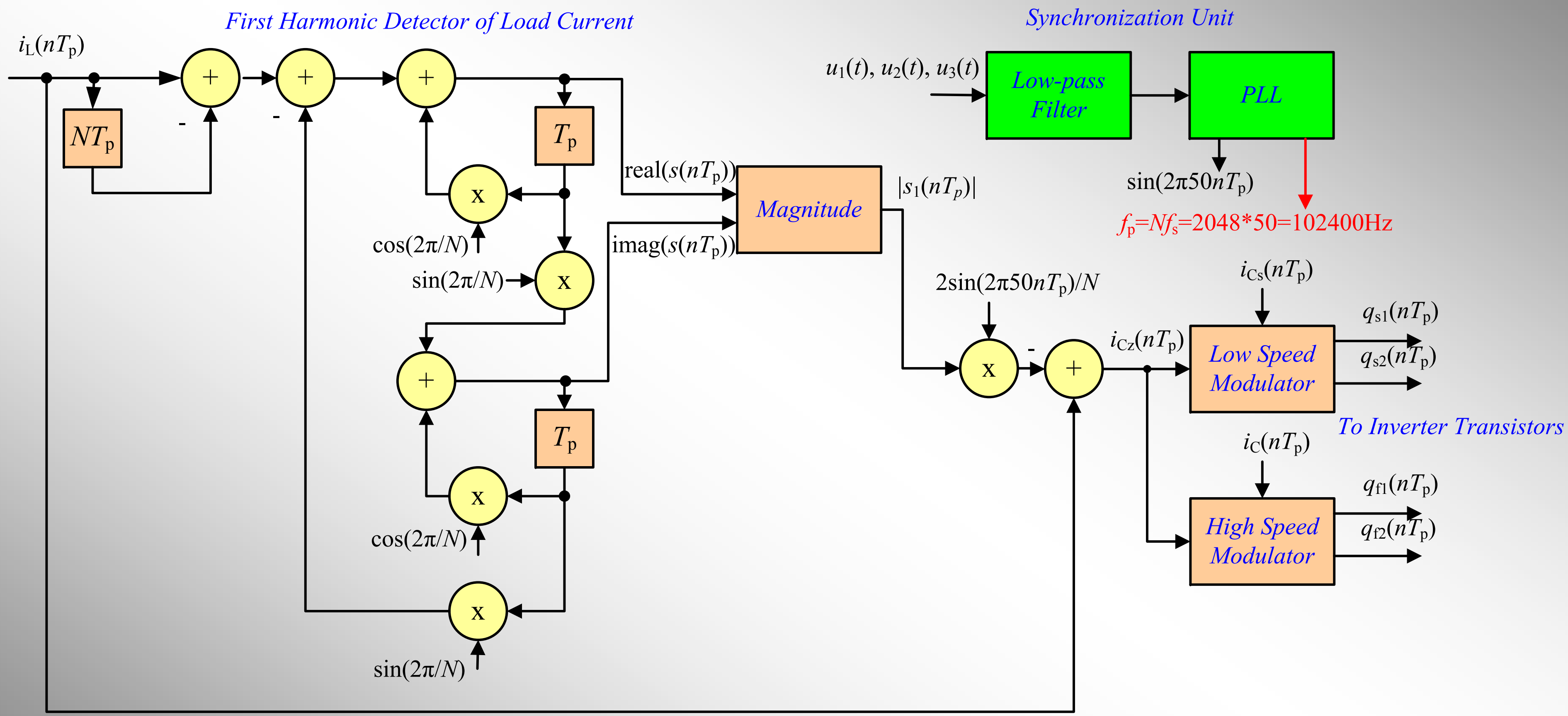
Simulation Waveforms of the APF Inverters Step Response (current i_C), for: L_{Cf}=0,5mH, L_{Cs}=2,5 mH, U_{DC}=390V, fp2=51200kHz, fp1= 25600 kHz



Active Power Filter with Modified Inverter, Test Circuit (for single-phase)

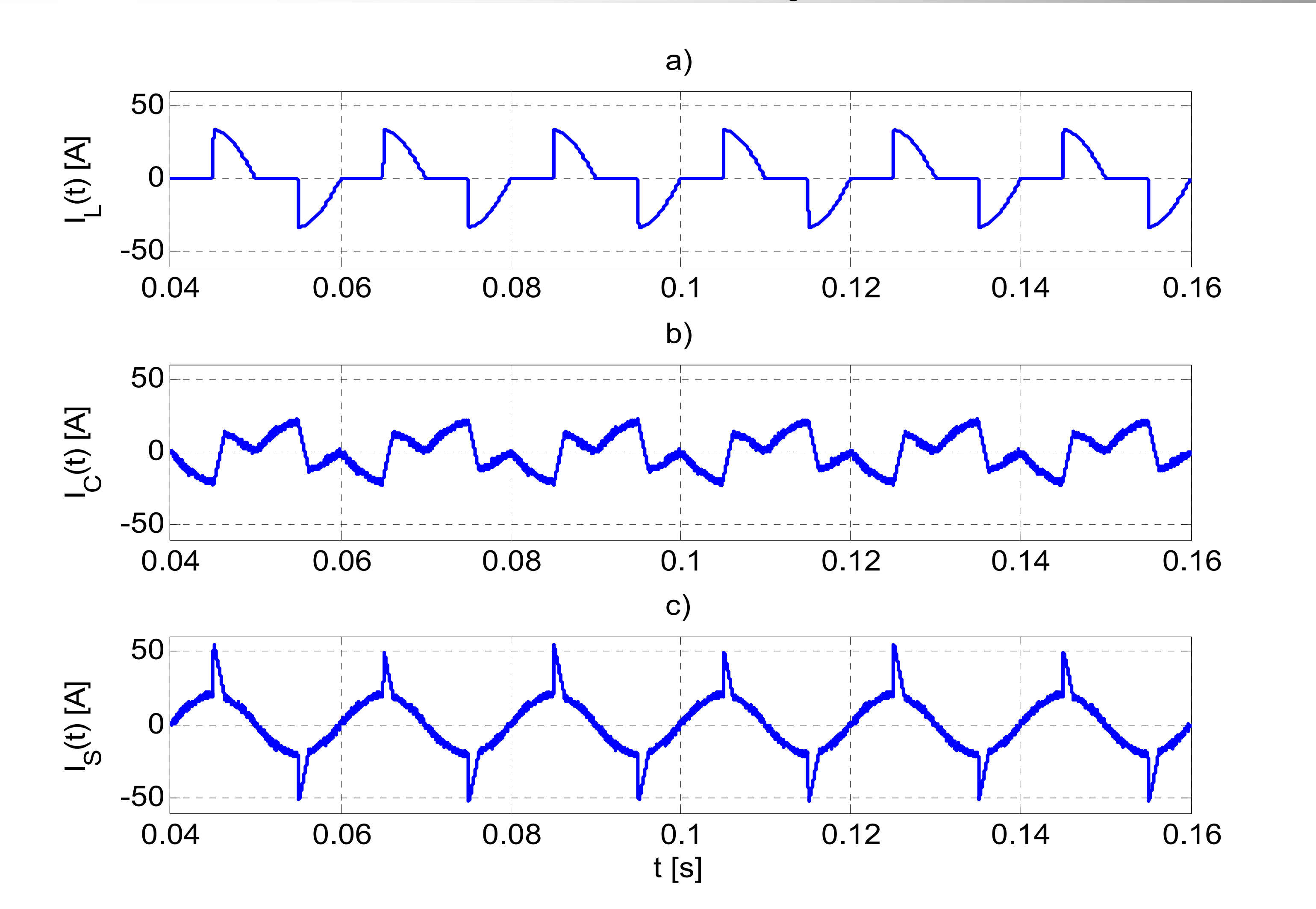


Block Diagram of APF Control Algorithm

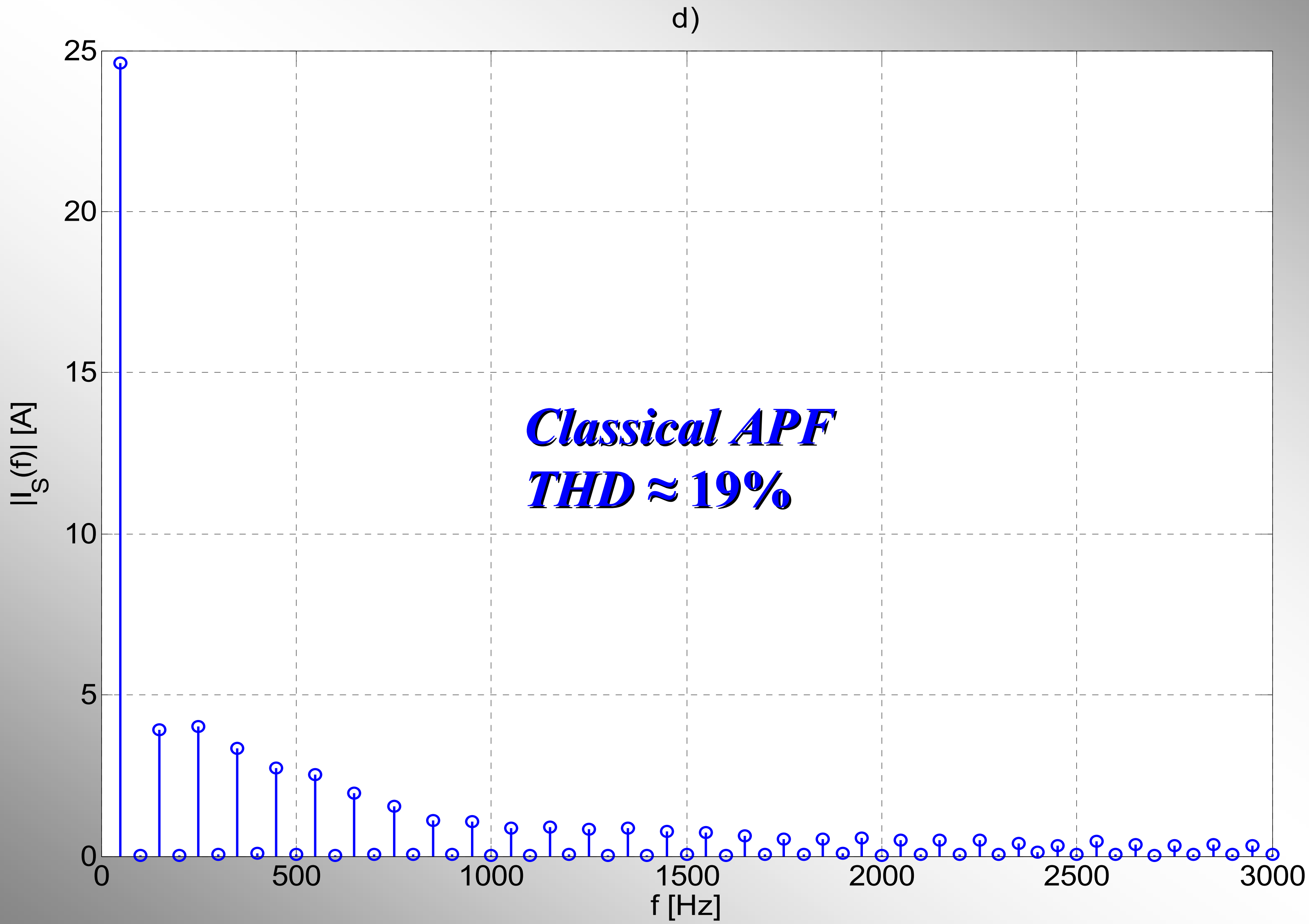


Simulation Waveforms of Single-phase Active Power Filter in Steady-state with the Resistive Load, Classical Inverter ,

L_{Cs} = 1,5 mH, U_{DC} = 390 V, f_{p1}= 25600 Hz

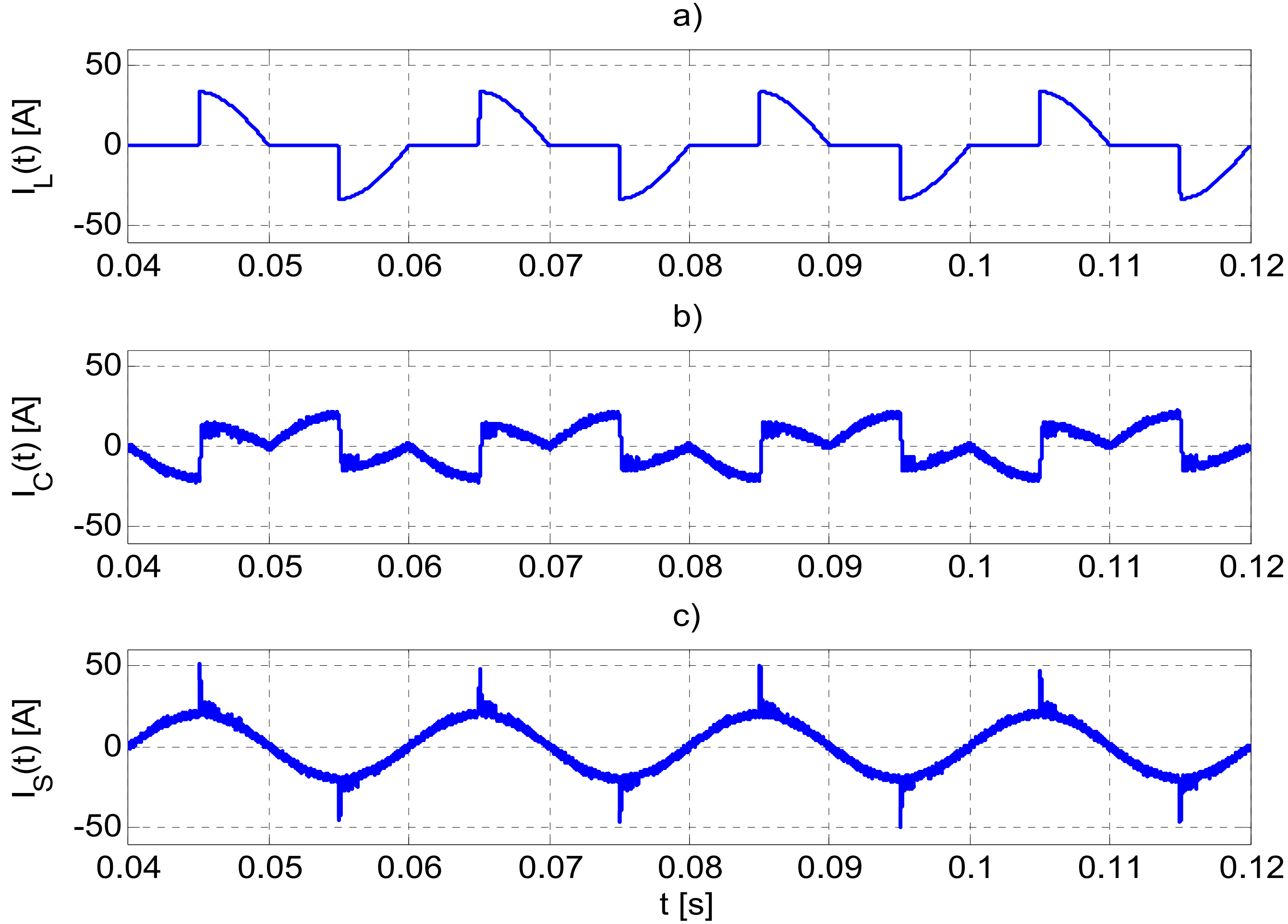


Frequency Spectrum of Line Current i_S.

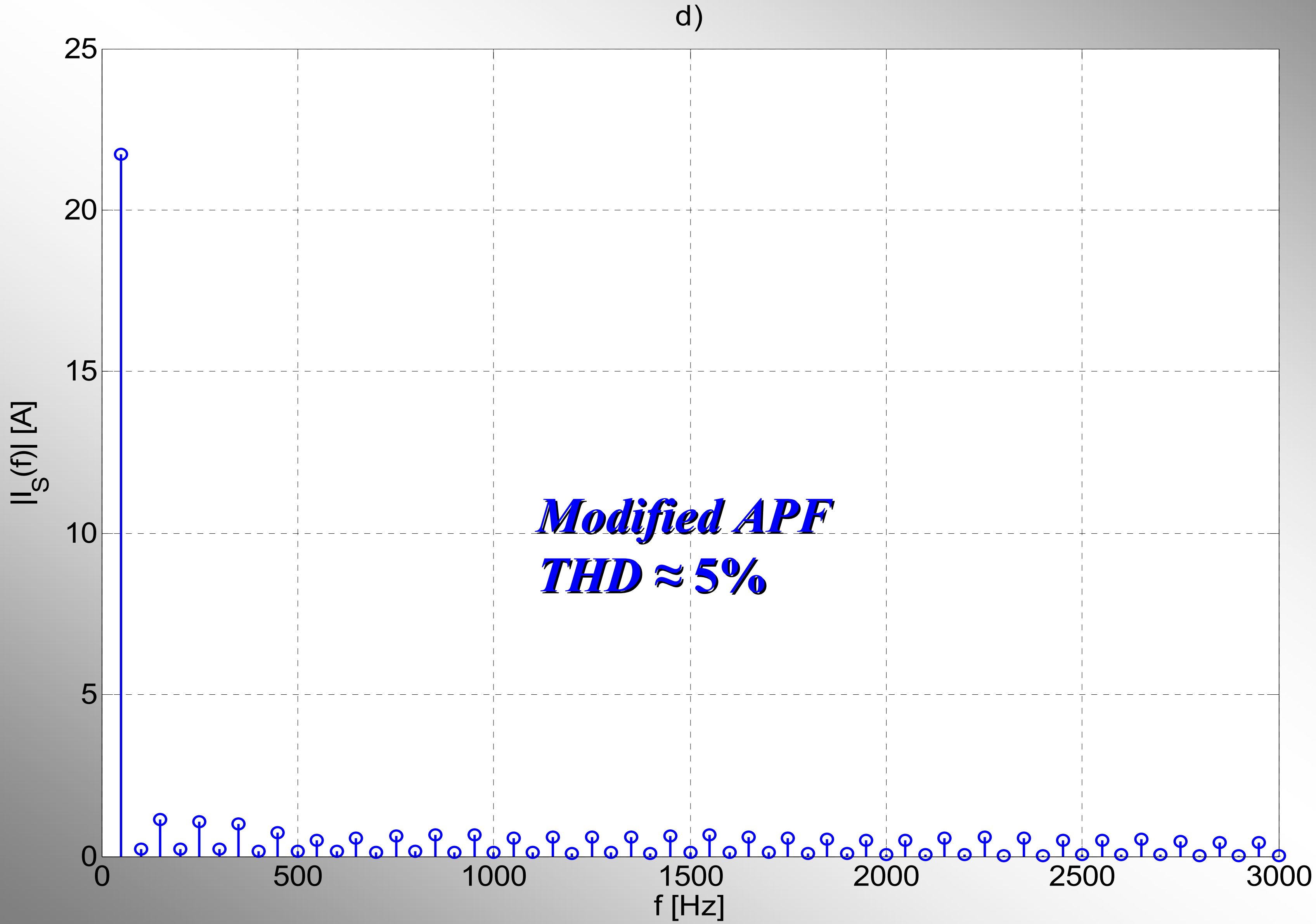


Simulation Waveforms of Single-phase Active Power Filter with Modified Output Inverter in Steady-state with the Resistive Load, Modified Inverter,

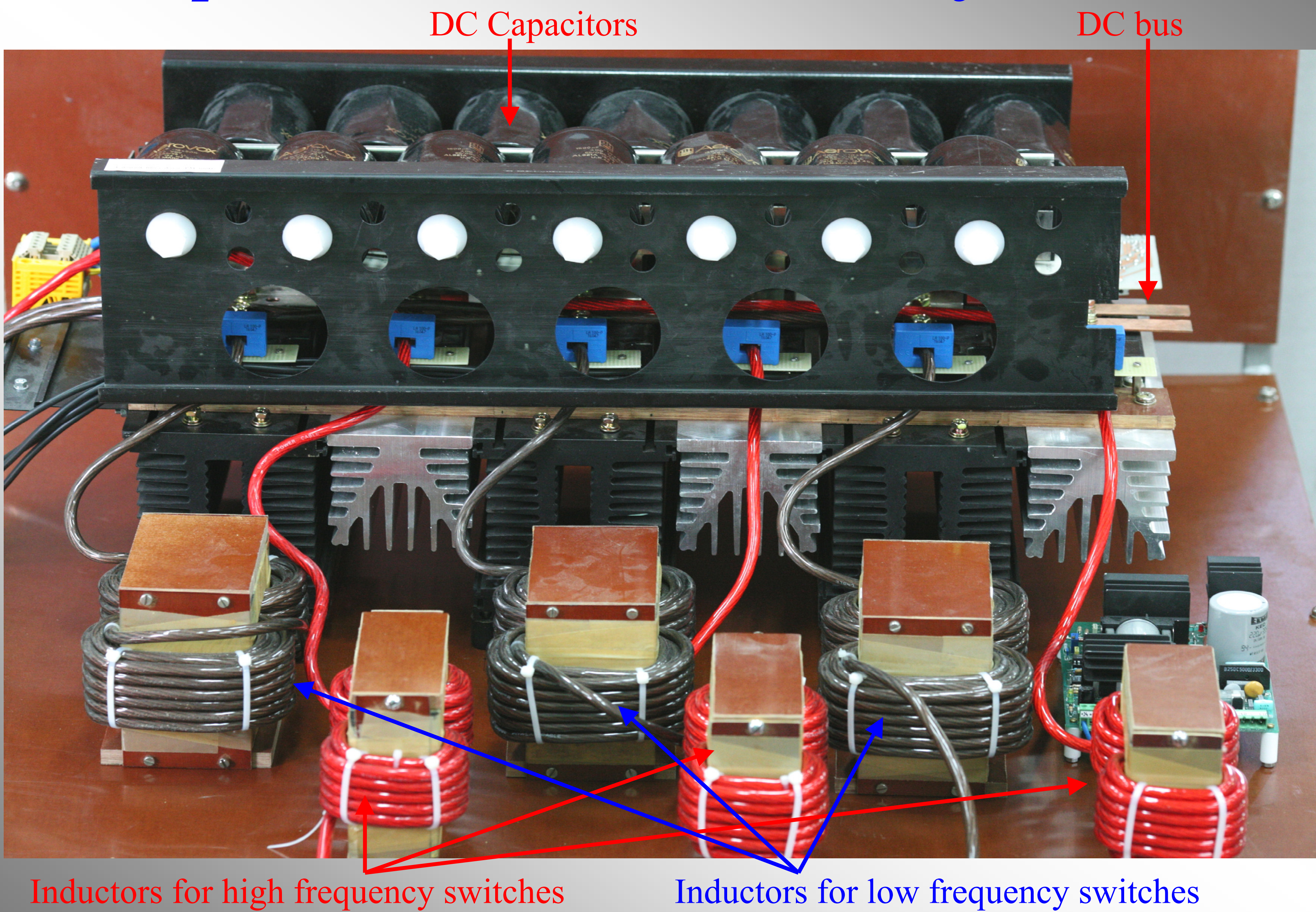
L_{Cf}=0,2mH, L_{Cs}=1,5mH, U_{DC} 390V, f_{p2}=51200 Hz, f_{p1}=25600 Hz



Frequency Spectrum of Line Current i_S.



Three-phase Active Power Filter Modified Inverter



*Output inductor 1.5 mH, 6*U100/57/25, lp=2.6 mm*

Conclusion

- **For predictable nonlinear loads which vary slowly compared to line voltage period (rectifiers, motors etc.) it is easier to predict current changes. For such loads shunt active power filter with non-causal algorithm is possible to decrease harmonic contents.**
- **For noise type nonlinear loads (like in arc furnace) the load currents are non periodic and stochastic, proposed APF with improved dynamic performance is good solution.**