Control Circuit for Active Power Filter with an Instantaneous Reactive Power Control Algorithm Modification

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June, 2010

Plan of presentation

- Problem: APF dynamic distortion

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- Solution of problem: APF with non-causal control algorithm

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- Implementation: modification of instantaneous reactive power control algorithm

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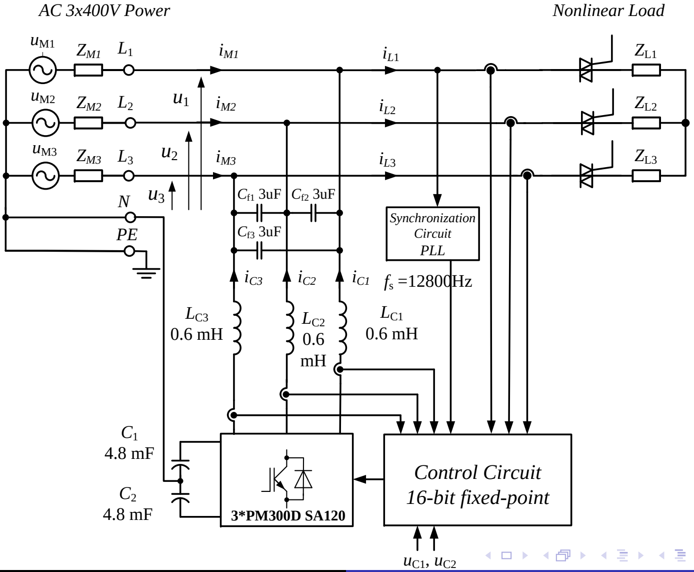
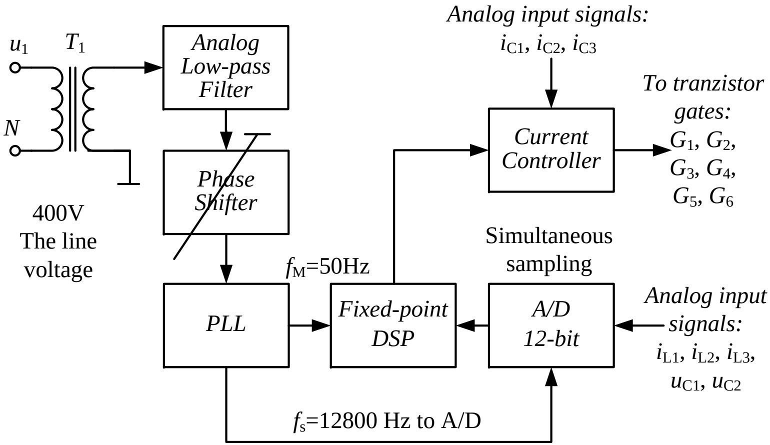
- Implementation: modification of instantaneous reactive power control algorithm
- Experimental results
- Conclusion

Simplified diagram of compensation circuit with 75 kVA shunt active power filter EFA1

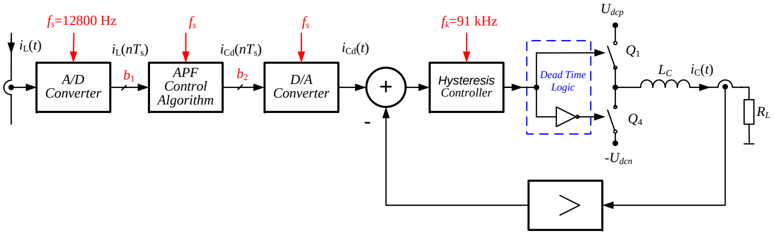


The 75 kVA shunt active power filter EFA1

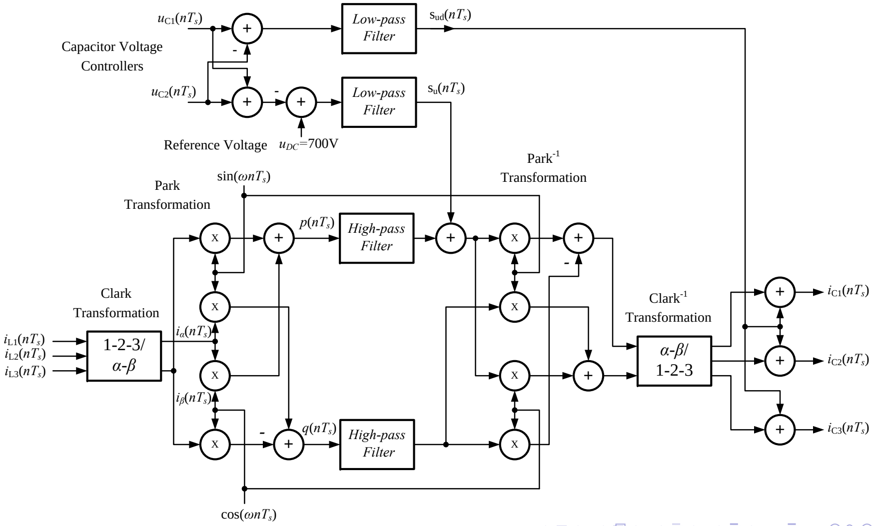
Simplified diagram of control and synchronization circuit



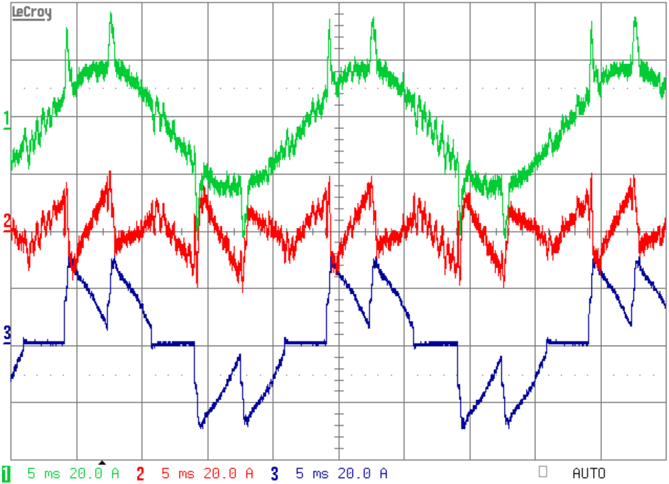
Block diagram of control circuit for one phase of shunt APF



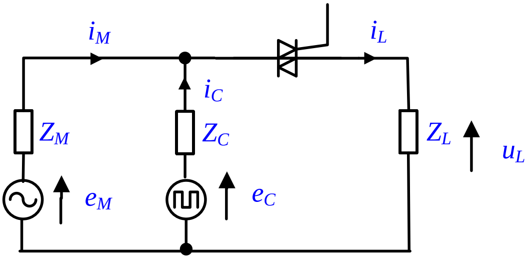
Block diagram of digital instantaneous reactive power control algorithm



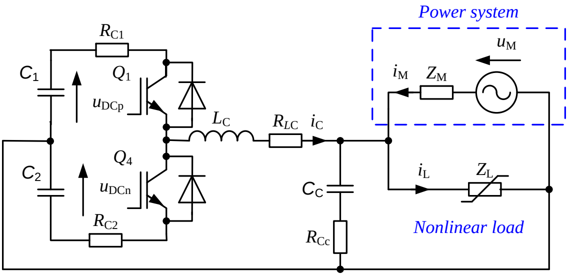
Experimental waveforms of the classical three phase active power filter in steady-state with the resistive load for power controller



Simplified diagram of AFP connected to the power line



Simplified model of one phase of compensation circuit



Right value of the inductor?

Bigger value of inductor

Pros

- low current ripple

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- low current ripple
- low transistor switching frequency

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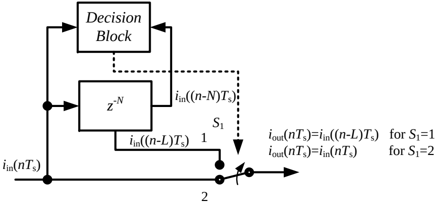
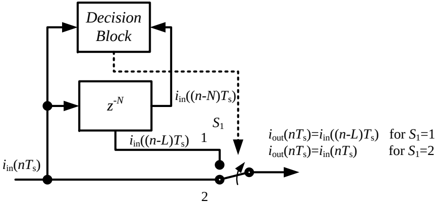
- high value of current ripple
- high switching frequency and high power losses
- big influence from the switching transition

Block diagram of non-causal control circuit



Block diagram of non-causal control circuit



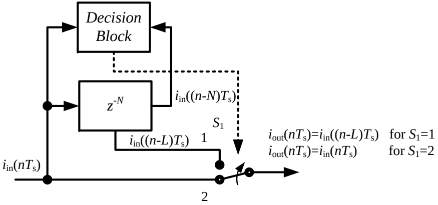
T_A

In the considered APF the discrete advance time T_A is

$$T_A = N_A T_s, \tag{1}$$

where: N_A - number of samples send ahead.

Block diagram of non-causal control circuit



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In the considered APF the discrete advance time T_A is

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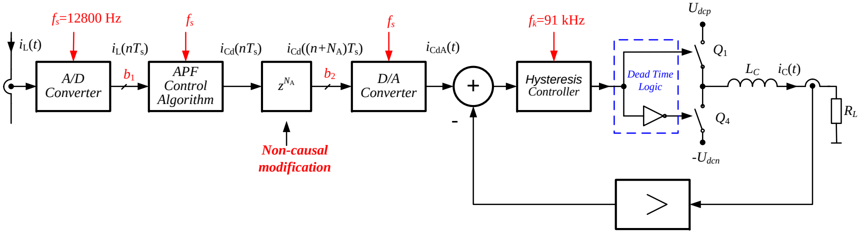
where: N_A - number of samples send ahead.
The length of sample buffer can be calculated by the formula

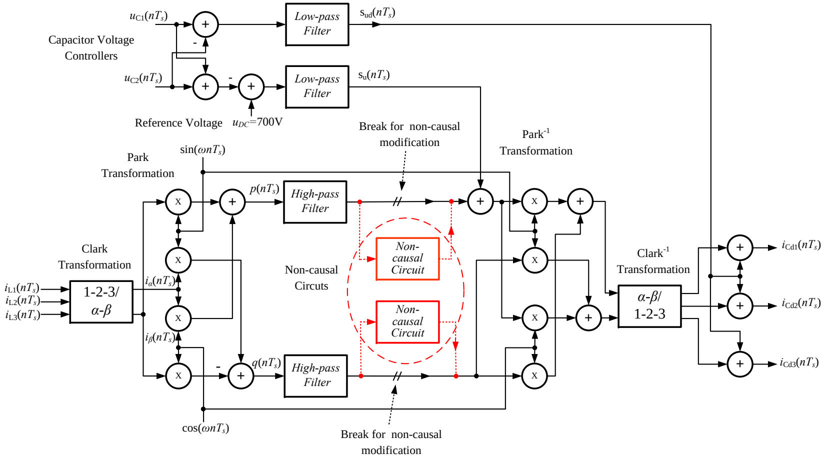
$$L = N - N_A. \tag{2}$$

where: N - number of samples per mains period.
In the APF: $N = 256$, $T_s = 78,125\mu s$, $T_A \approx 300\mu s$ then $N_A = 3$.

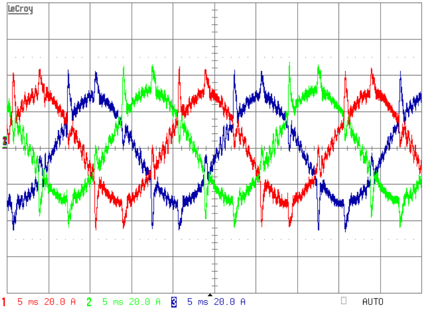
Block diagram of non-causal control circuit for one phase of shunt APF

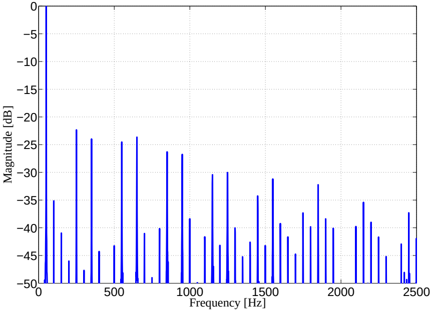


Block diagram of instantaneous reactive power control algorithm with non-causal modification

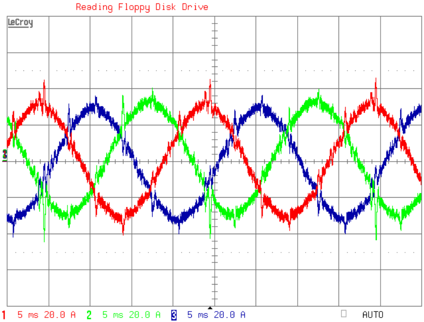


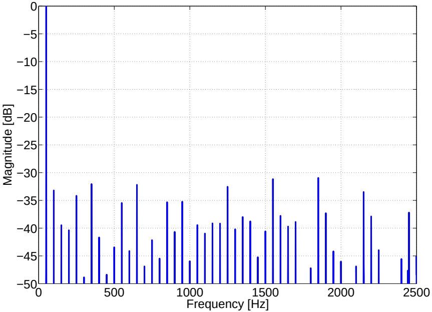
Experimental waveforms of the modified three phase active power filter in steady-state with the resistive load for $N_{ah} = 0$, line currents, normalized magnitude spectra of line current i_{M1}



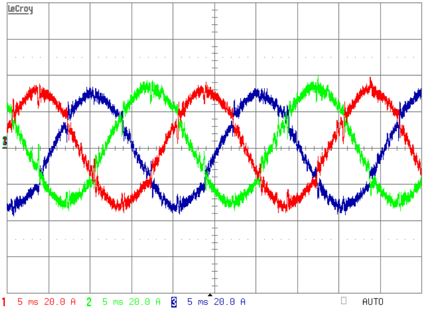


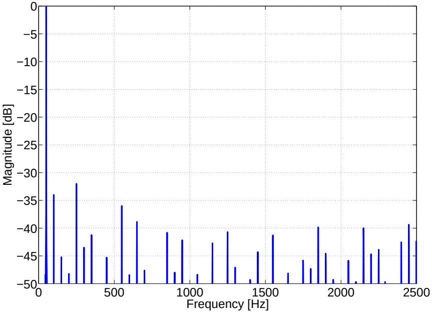
Experimental waveforms of the modified three phase active power filter in steady-state with the resistive load for $N_{ah} = 2$, line currents, normalized magnitude spectra of line current i_{M1}



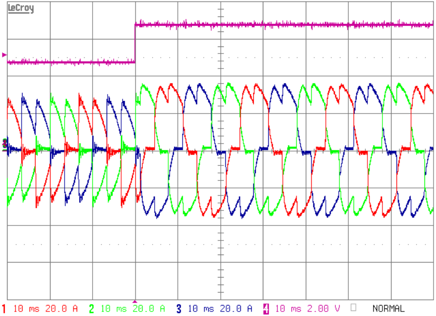


Experimental waveforms of the modified three phase active power filter in steady-state with the resistive load for $N_{ah} = 3$, line currents, normalized magnitude spectra of line current i_{M1}





Experimental waveforms of line currents: i_{M1}, i_{M2}, i_{M3} for step response of the load currents



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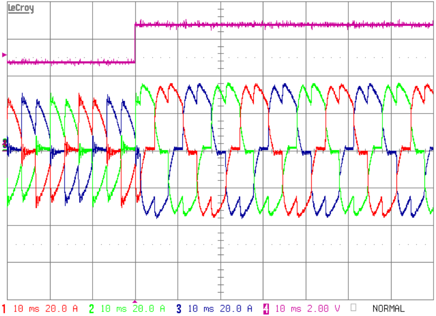
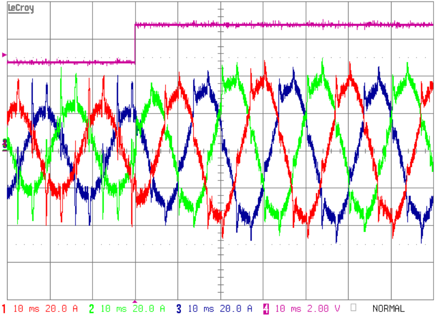


Without APF



With classical APF

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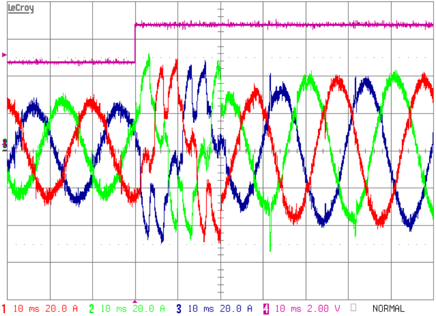

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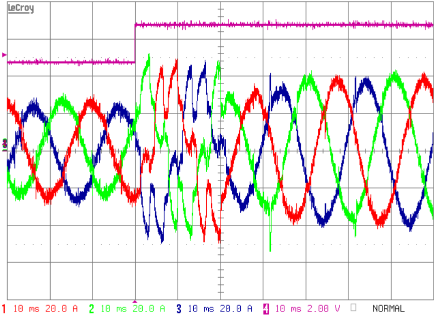
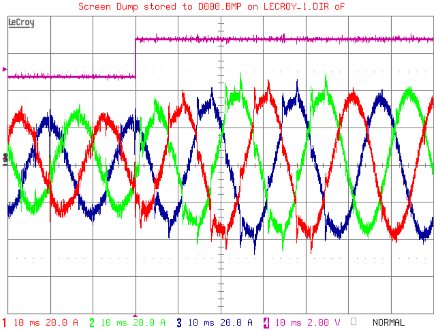


With non-causal algorithm constantly switched on



With automatic switch

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 useful and is possible to decrease harmonic contents over ten percent.

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- This modification is very simple and can be easy implemented in existing APF control circuit.

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- 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 useful and is possible to decrease harmonic contents over ten percent.
- This modification is very simple and can be easy implemented in existing APF control circuit.
- For predictable nonlinear loads which vary very slowly it is possible to switch on non-causal algorithm all the time.