A Current-Source Active Power Filter with a New DC Filter Structure

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Main circuit of the current-source active power filter

- The advantages of current-source active power filter are:
  + Inherent AC current production
  + Easy protection

- And disadvantages:
  - Large number of switching devices
  - Large dc filter inductor
  - High on-state losses
Modified main circuit structure

- The dc filter stores the energy of the compensated load current harmonics
- Relative large dc filter inductor is needed to keep the ripple in dc current in an acceptable level
- 5th and 7th harmonics are dominating components in most symmetrical three-phase loads => 6th harmonic voltage component dominant in dc circuit
- In the proposed dc filter structure high impedance for 6th harmonic component is achieved with relative small filter parameters by using parallel resonance circuit which is tuned for 6th harmonic component
• 1. Conventional dc filter inductor 170 mH (---)
• 2. Modified dc filter: $L_{dc}=30$ mH, $L_r=15$ mH ja $C_r=18.7 \, \mu\text{F}$ (-)
• 3. Conventional dc filter inductor 45 mH (-)

• Impedance of the modified filter high at 1900 rad/s (300 Hz) (6th harmonic) due to parallel resonance
• Impedance of the modified filter low at 2700 rad/s (420 Hz) because of series resonance
• Series resonance should not be close to 12 th harmonic component which is the 2nd dominant voltage component in the dc circuit => ratio of $L_r$ and $L_{dc}$ should be between $1/2...2$
Experimental investigation

- Implemented control system
Experimental investigation

- Control system implementation based on Motorola MPC555 microcontroller
- Modulation frequency 10 kHz
- Sampling times of the feedforward and dc current controllers 50 µs
- Rating of the prototype 5kVA
Experimental results of the conventional dc filter

- The distorted load current produced with three-phase diode rectifier having RL-type load

- Dc filter inductance $L_{dc}=100 \text{ mH}$
Experimental results of the modified dc filter

- The distorted load current produced with three-phase diode rectifier having RL-type load

- \( L_{dc} = 15 \text{ mH}, \quad L_r = 10 \text{ mH}, \quad \text{ja} \quad C_r = 28.1 \mu\text{F} \)
Experimental results of the conventional dc filter

- The distorted load current produced with three-phase diode rectifier having RC-type load

- Dc filter inductance $L_{dc}=170 \text{ mH}$
Experimental results of the modified dc filter

- The distorted load current produced with three-phase diode rectifier having RC-type load

- $L_{dc}=30\,\text{mH}$, $L_r=15\,\text{mH}$ ja $C_r=18.7\,\mu\text{F}$
Experimental results of the modified dc filter

Load current includes 7.1% 3rd harmonic component => 2nd harmonic component in dc circuit voltage

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Conclusions

• In the proposed new dc filter structure the energy of the most important harmonics are stored in resonant circuit => smaller filter size

• The proposed filter structure can be effectively used with symmetrical load if the load current doesn’t include 3rd harmonic component or if it is not compensated

• In practice the input currents of the three-phase diode rectifier with RC-load contains 3rd harmonic component

• The proposed dc filter is suitable, especially, for current-type loads e.g. for three-phase diode rectifier with RL-load