Camilo Garzón, Shrinath Kannan, Ana María Blanco, Miguel Romero, Jan Meyer, Andrés Pavas

Power Quality in AC Islanded Microgrids
Mitigation and Commonly Used Control Strategies

SICEL, October 14th, 2021
Content

1. CONTROL STRATEGIES FOR POWER QUALITY ENHANCEMENT IN ISLANDED MICROGRIDS
   1. Control technique for Unbalance and harmonics mitigation
   2. Techniques for harmonic impedance monitoring

2. STANDALONE DEVICES FOR POWER QUALITY IMPROVEMENT IN ISLANDED MICROGRIDS
   1. Filters and Compensation Devices
   2. Compensator interface topologies
   3. Energy Storage Devices

3. MEASUREMENT AND MONITORING ISSUES RELATED TO MICROGRIDS
Control Strategies for Power Quality Enhancement in Islanded Microgrids

1. Ensure successful operation by supplying the power demand for **various kind of load**.
2. Ensure **ideal** operating conditions in terms of power quality.
Control Strategies for Power Quality Enhancement in Islanded Microgrids

Control Technique for Unbalance and Harmonic Mitigation


Control Strategies for Power Quality Enhancement in Islanded Microgrids
Techniques for Harmonic Impedance Monitoring


# Standalone Devices for Power Quality Improvement in Islanded Microgrids

<table>
<thead>
<tr>
<th>Device</th>
<th>Acronym</th>
<th>Purpose</th>
<th>Principle</th>
<th>Main Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed Static Synchronous</td>
<td>STATCOM</td>
<td>Improve transient stability</td>
<td>Supply/Demand AC reactive power</td>
<td>Capacitor and power electronic-based source</td>
</tr>
<tr>
<td>Compensator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic Voltage Restoration</td>
<td>DVR</td>
<td>Overcoming voltage sags and swells</td>
<td>Inject voltage</td>
<td>Capacitor and power electronic AC/DC inverters</td>
</tr>
<tr>
<td>Active Power Filter</td>
<td>APF</td>
<td>Harmonic attenuation</td>
<td>Inject active power</td>
<td>Power electronics based source</td>
</tr>
<tr>
<td>Static VAR Compensator</td>
<td>SVC</td>
<td>Improve transient stability and harmonic</td>
<td>Demand reactive power and current harmonics.</td>
<td>Reactors and power electronic-based switch</td>
</tr>
<tr>
<td>Compensation</td>
<td></td>
<td>attenuation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universal Power Quality Conditioner</td>
<td>UPQC</td>
<td>Compensate power quality disturbances</td>
<td>Supply/Demand AC reactive power and current</td>
<td>Capacitor and power electronic-based source</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>harmonics</td>
<td></td>
</tr>
</tbody>
</table>

## Common Methods:
1. Sequence current components as reference.
2. Harmonic current injection
3. Virtual impedance

## Advantages:
1. Flexibility
2. Reliability
3. Power quality improvement
4. Reduce harmonic emissions from DG's
5. Losses reduction in lines
6. Allow to compensate harmonics and unbalance
# Standalone Devices for Power Quality Improvement in Islanded Microgrids

<table>
<thead>
<tr>
<th>Device</th>
<th>Acronym</th>
<th>Purpose</th>
<th>Principle</th>
<th>Main Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed Static Synchronous Compensator</td>
<td>STATCOM</td>
<td>Improve transient stability</td>
<td>Supply/Demand AC reactive power</td>
<td>Capacitor and power electronic-based source</td>
</tr>
<tr>
<td>Dynamic Voltage Restoration</td>
<td>DVR</td>
<td>Overcoming voltage sags and swells</td>
<td>Inject voltage</td>
<td>Capacitor and power electronic AC/DC inverters</td>
</tr>
<tr>
<td>Active Power Filter</td>
<td>APF</td>
<td>Harmonic attenuation</td>
<td>Inject active power</td>
<td>Power electronics based source</td>
</tr>
<tr>
<td>Static VAR Compensator</td>
<td>SVC</td>
<td>Improve transient stability and harmonic attenuation</td>
<td>Demand reactive power and current harmonics.</td>
<td>Reactors and power electronic-based switch</td>
</tr>
<tr>
<td>Universal Power Quality Conditioner</td>
<td>UPQC</td>
<td>Compensate power quality disturbances</td>
<td>Supply/Demand AC reactive power and current harmonics</td>
<td>Capacitor and power electronic-based source</td>
</tr>
</tbody>
</table>

**Issues:**
1. High operation cost
2. Optimum location
   1. Performance of the compensator can be affected by grid conditions like DG location or R/X ratio of lines
   2. Improvement at the location of the DG, but gets worse at other sites
   3. Impact no well defined
3. Sizing
4. Control
1. Power quality monitoring standards: IEC 61000-4-7 and IEC 61000-4-30

2. Amount of information and the required calculation algorithms imply high computational requirements.
   2.1 Monte Carlo simulation to extract random samples from the 200ms time window

3. Higher amount of monitored locations and distributed power quality monitoring systems in MGs

4. Many systems are not capable of processing and sending real-time data.
Conclusions

- A comprehensive design approach of control strategies to mitigate typical power quality issues and resonances can significantly contribute to a reliable (ideal) operation of MGs under all scenarios.

- MGs tend to need higher visibility of the network and consequently denser monitoring.

- Not only the connected loads but also the electronic-based power sources can cause power quality disturbances in islanded MGs.

- There is certain evidence that just taking over the EMC coordination (compatibility levels, emission limits, immunity limits) from traditional (interconnected) grids is not suitable and optimal for islanded MGs.
Thank you for your attention

Contact:
Camilo Garzón
Research Assistant

Universidad Nacional de Colombia
Programa de Adquisición y Análisis de Señales Electromagnéticas (PAAS-UN)
Email: cagaron@unal.edu.co