AUTOMATIC NETWORK RECONFIGURATION IN SPLIT AIRPORT

pilot project of complete MV grid automation

KONČAR – Power Plant and Electric Traction Engineering Inc. Zagreb
Boris Brestovec, B.Sc.El.
EXISTING AIRPORT POWER GRID:

- Double power supply from the 35/10kV SS (SS Kastela and SS Divulje)
- Normal situation – both SS-1 and SS-2 are connected to SS Divulje
- Power loss from SS Divulje – manual reconfiguration and connection to SS Kastela
- Manual reconfiguration – is slow due to switching procedure from operators in DC and operation staff and is measured in tens of minutes depending of their availability
SS AIRPORT 1 AND SS AIRPORT 2:
- Airport power grid is supplied by 2 10/0,4kV SS (SS Airport 1 and SS Airport 2)
- Each SS has its own diesel backup generators (no-break switchover)
- Each SS has 2 630 kVA TR

Automatic Network Reconfiguration – Split Airport
PROBLEMS OF POWER SUPPLY ON SPLIT AIRPORT:

- Old unreliable switchgear with no motor drives for automation
- Manual on site operation required in case of power failure
- Reaction time depends on the availability of local operations team (summer season problems)

GOALS OF THE PROJECT:

- Retrofit of the primary switchgear on 2 10/0,4 kV SS
- Installation of the remote control and supervision system (RTU)
- Implementation of advanced algorithm for automatic reconfiguration of the supply grid
- Fault detection and localization
RELIABILITY OF SUPPLY BEFORE ANR:

- HEP ODS due to obligations must archive all outages longer than 3 min.
- Total of 36 outages lasted in average longer than 100 min (2006. – 2011.)

<table>
<thead>
<tr>
<th>Outage type</th>
<th>Nr. Outages</th>
<th>Duration (min)</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned</td>
<td>1</td>
<td>8</td>
<td>Fault clearing</td>
</tr>
<tr>
<td>Planned</td>
<td>2</td>
<td>200</td>
<td>Maintenance</td>
</tr>
<tr>
<td>Planned</td>
<td>4</td>
<td>1248</td>
<td>Grid construction</td>
</tr>
<tr>
<td>Not planned</td>
<td>8</td>
<td>358</td>
<td>Grid congestions</td>
</tr>
<tr>
<td>Not planned</td>
<td>21</td>
<td>1854</td>
<td>Fault</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>36</strong></td>
<td><strong>3778</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Year average (6y)</strong></td>
<td><strong>6</strong></td>
<td><strong>611</strong></td>
<td></td>
</tr>
</tbody>
</table>

Reliability of supply was not satisfactory for priority customer like airport!
Automatic Network Reconfiguration – Split Airport

PROJECT DETAILS:

Investor/End User: HEP – ODS, Airport Split

Duration: 4 months (low tourist season – winter 2012.)

Switchgear: VDAP, KONČAR (Vacuum compact cubicles, SF6 insulated)

RTU: RTU540, ABB – (560CMD11+remote IOs), PLC functions according to IEC 61131

Fault & Voltage sensors: IK-10 & IN-10, IEL Croatia

CV Transducers: 560CVD03, ABB

Airport MV SCADA: PROZANET, KONČAR

Com. Protocols:

IEC 61850 – data exchange between SS-1 and SS-2
IEC 60870-5-104 – SCADA/DMS DC HEP-ODS
IEC 60870-5-101 – Airport MV SCADA
MODBUS RTU – Local HMI, Fault sensors, CVT
Automatic Network Reconfiguration – Split Airport

ANR SYSTEM OVERVIEW
MAIN FUNCTIONS OF NEW SYSTEM:

• Remote and Local monitoring and control of the SS

• Detection of power outage on the incoming feeders

• Automatic reconfiguration to different available power source - PLC functions

• Fault detection, localization and isolation of part of the SS
Automatic Network Reconfiguration – Split Airport

ANR ALGORITHM STRUCTURE:

- PLC functions (IEC 61131) – FBD & ST
- Master PLC RTU: SS-1 (calculates all algorithm and issues commands)
- Slave PLC RTU: SS-2 (no calculation just command processing from SS-1)
- ANR FB:
  - Grid start state FB
  - Start conditions FB
  - Safety interlocking FB
  - Reconfiguration sequence FB
- PLC Function cycle: 100 ms
- Time delay: 1 s (due to AR in HV grid)
GRID START STATE FB:

- Cyclically calculates the state of the switchgear of the Airport grid
- Only the incoming and connection feeders are taken into account (4 breakers)
- The algorithm defines 5 correct start grid states (22 different start scenarios)
- Depending of the grid state the reconfiguration procedure is different
- Input signals: Breaker positions of the 4 feeders
- Output signals: Grid start state 1,2,3,4,5
START CONDITIONS FB:
• Checks if the start conditions are met - equipment and grid conditions
• Equipment conditions – checks if all the ANR system devices are running without errors
• Grid conditions – checks if no faults on relevant feeders and the voltage is present
• Input signals: UPS status, MCB status, PLC program status, Fault & Voltage sensors
• Output signals: Start conditions OK

SAFETY INTERLOCKING FB:
• Enables blocking (starting) of the reconfiguration sequence if one of the predefined (input) signals occur
• Input signals: Earth position of the apparatus, Local/Remote switch
• Output signals: Interlocking disabled
RECONFIGURATION SEQUENCE FB:

• ANR algorithm is ARMED - start conditions are OK
  - no safety interlocking
  - grid start state in 1 thru 5

• Once armed the ANR algorithm will start the reconfiguration sequence if one of the following triggers occurs:
  1. Voltage loss on one of the incoming feeders (from SS Divulje and SS Kasela),
  2. Fault indications in one of the incoming feeders (from SS Divulje and SS Kasela),
  3. Fault indications in one of the connection feeders (connection SS1 to SS2)

• Input signals: Grid start state, start conditions, safety interlocking, trigger
• Output signals: Open/Close commands, Fault location, ANR success status
FAULT DETECTION, LOCALISATION AND ISOLATION:

- Fault sensors detect location of fault (Fault on SS-1, SS-2 or on the connection feeder)

  - Voltage sensor
  - Fault sensor – \( l>>, lo> \)
RELIABILITY OF SUPPLY AFTER ANR:

- Switching operations of ANR matrix

<table>
<thead>
<tr>
<th>TRIGGERS</th>
<th>PS1.1</th>
<th>PS1.2</th>
<th>PS1.3</th>
<th>PS1.4</th>
<th>PS2.1</th>
<th>PS2.2</th>
<th>PS2.3</th>
<th>PS2.4</th>
<th>PS3.1</th>
<th>PS3.2</th>
<th>PS3.3</th>
<th>PS3.4</th>
<th>PS4.1</th>
<th>PS4.2</th>
<th>PS4.3</th>
<th>PS4.4</th>
<th>PS4.5</th>
<th>PS5.1</th>
<th>PS5.2</th>
<th>PS5.3</th>
<th>PS5.4</th>
<th>PS5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>IK 1 (TS2 J02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IK 2 (TS2 J01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IK 3 (TS1 J02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IK 4 (TS1 J01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN TS1 (J01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN TS2 (J02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FAULT DETECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAULT SS1</td>
</tr>
<tr>
<td>FAULT SS2</td>
</tr>
<tr>
<td>FAULT SS1-SS2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SWITCH. OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS2 J02 Q2 - UK</td>
</tr>
<tr>
<td>TS2 J02 Q2 - ISK</td>
</tr>
<tr>
<td>TS2 J01 Q1 - UK</td>
</tr>
<tr>
<td>TS2 J01 Q1 - ISK</td>
</tr>
<tr>
<td>TS1 J02 Q1 - UK</td>
</tr>
<tr>
<td>TS1 J02 Q1 - ISK</td>
</tr>
<tr>
<td>TS1 J01 Q1 - UK</td>
</tr>
<tr>
<td>TS1 J01 Q1 - ISK</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEQUENCE PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3s 7.5s 3s 2.5s 3s</td>
</tr>
<tr>
<td>3s 2.5s 8.5s 2.5s 8s</td>
</tr>
<tr>
<td>2s 1.5s 2s 1.5s 2s</td>
</tr>
<tr>
<td>2s 8s 2s 2s 8s</td>
</tr>
<tr>
<td>1.5s 2s 1.5s 2s 1.5s</td>
</tr>
</tbody>
</table>
LIVE EXAMPLE OF ANR:

Automatic Network Reconfiguration – Split Airport
CONCLUSION:

- Average power outage time lowered to < 3s (compared to tens of minutes)
- Pilot project for automation of MV distribution grid
- Remote control and monitoring of the power grid
- Lower load of the operations staff
- Highly reliable and safer power supply
- Satisfied customer
- Higher safety of air traffic
THANK YOU FOR ATTENTION!