Type VRLTC™ tap changer

Ruggedized electronics systems specification & type test data

Product                   Type VRLTC, on-tank, vacuum reactance load tap changer
Style No                  All versions
Rating                    25 kV, 1500 A
By                        Bill Teising and Jon Brasher

1 Introduction

The type VRLTC tap changer contains sub systems which monitor and control the entire tap changing functions. The heart of these controlling sub systems is Tap Logic Monitoring System™ (TLMS).

The TLMS is a solid state device which monitors and collects data from the various sensors within the tap changer. The TLMS detects any abnormality, it is programmed to issue an alarm or an alert depending on the severity of the abnormality. The TLMS is also on constant alert monitoring and self-checking for any sign of a problem.

We have designed the TLMS to perform correctly in the harsh electromagnetic environment of an electric substation. The circuit boards are hardened against electromagnetic radiation by design and by selection of individual components.

We put the TLMS through a series of severe environmental and electromagnetic radiation tests according to ANSI and IEC standards to ensure that the design would operate properly in its intended environment. All results can be found on test report R-14101.

2 Type test summary

ABB applied both ANSI and IEC standards to proscribe the testing necessary to demonstrate immunity from radiated electromagnetic disturbances. The following standards measure the ability of the servo motor drive to withstand electromagnetic radiation.
2.1 EMC immunity test
IEEE standard  ANSI C37.90.1:2002, fast transient and 1MHz oscillatory wave
             ANSI C37.90.0, dielectric withstand and voltage impulse

IEC standard  IEC 61000-4-2, Electrostatic Discharge
             IEC 61000-4-3, Rad. Immunity, 80 MHz - 1 GHz, 1.4 GHz - 2.7 GHz
             IEC 61000-4-4, Electrical Fast Transient / Burst, Power Ports
             IEC 61000-4-4, Electrical Fast Transient / Burst, I/O Ports
             IEC 61000-4-5, Surge, Power Ports
             IEC 61000-4-5, Surge, Power, IO Ports
             IEC 61000-4-6, Conducted Immunity, Power Ports, 0.15 to 80 MHz
             IEC 61000-4-11, Voltage Dips and Interrupts
             IEC 61000-4-12, Damped Oscillatory Wave, Power Leads
             IEC 61000-4-12, Damped Oscillatory Wave, I/O Ports

2.1.1 ABB report number
R-14101

2.1.2 Description
Test the ability of the motor-drive system (motor, digital drive, TLMS, etc.) to withstand electromagnetic radiation according to the standards cited above.

2.1.3 Results

<table>
<thead>
<tr>
<th>Immunity</th>
<th>Enclosure port</th>
<th>Process I/O ports</th>
<th>Mains ports</th>
<th>Earth ports</th>
<th>Results / Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiated RF fields</td>
<td>15 V / m</td>
<td></td>
<td></td>
<td></td>
<td>Passed / A</td>
</tr>
<tr>
<td>Conducted RF voltage</td>
<td></td>
<td>10 V</td>
<td>10 V</td>
<td>10 V</td>
<td>Passed / A</td>
</tr>
<tr>
<td>Fast transient / burst</td>
<td>4 kV</td>
<td>4 kV</td>
<td>4 kV</td>
<td></td>
<td>Passed / A</td>
</tr>
<tr>
<td>Electrostatic discharge</td>
<td>8 kV contact, 15 kV air</td>
<td></td>
<td></td>
<td></td>
<td>Passed / A</td>
</tr>
<tr>
<td>Surge pulse</td>
<td>4 kV (CM)</td>
<td>4 kV (CM)</td>
<td>2 kV (NM)</td>
<td></td>
<td>Passed / A</td>
</tr>
<tr>
<td>Power frequency magnetic field</td>
<td>1000 A / m</td>
<td></td>
<td></td>
<td></td>
<td>Passed / A</td>
</tr>
<tr>
<td>Power voltage variation</td>
<td>±10%, 15 s</td>
<td></td>
<td></td>
<td></td>
<td>Passed / A</td>
</tr>
<tr>
<td>Damped oscillatory wave</td>
<td>2.5 kV</td>
<td>2.5 kV</td>
<td></td>
<td></td>
<td>Passed / A</td>
</tr>
</tbody>
</table>
2.2 Type test, EMC emission
IEEE standard C37.90
IEC standard CISPR 11, G 1, Class A, conducted emissions, 150 kHz to 30 MHz
CISPR 11, G 1, Class A, radiated emissions, 30 MHz to 1 GHz

2.2.1 ABB report number
R-14101

2.2.2 Description
Measure the amount of electro-magnetic radiation emitted by the motor-drive system (motor, digital drive, TLMS, etc.).

2.2.3 Results

<table>
<thead>
<tr>
<th>Emission</th>
<th>Port</th>
<th>Class</th>
<th>Limits</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiated emissions</td>
<td>Enclosure</td>
<td>A</td>
<td>Limits of EN 55011, Measure distance according to EN 50081-2</td>
<td>Passed</td>
</tr>
<tr>
<td>Conducted emissions</td>
<td>AC Mains</td>
<td>A</td>
<td>Limits of EN 55011</td>
<td>Passed</td>
</tr>
</tbody>
</table>

2.3 Type test, environmental

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard</th>
<th>Test</th>
<th>Requirement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry heat</td>
<td>IEC 60255-1</td>
<td>Test Bd during operation</td>
<td>+ 60 °C for 96 h</td>
<td>Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-2</td>
<td>Test Bd during storage</td>
<td>+85 °C for 24 h</td>
<td>Passed</td>
</tr>
<tr>
<td>Cold</td>
<td>IEC 60255-1</td>
<td>Test Ad during operation</td>
<td>-30 °C for 96 h</td>
<td>Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-1</td>
<td>Test Ab during storage</td>
<td>-50 °C for 24 h</td>
<td>Passed</td>
</tr>
<tr>
<td>Change of temperature</td>
<td>IEC 60255-1</td>
<td>Test Nb</td>
<td>-30 °C to +60 °C</td>
<td>5 cycles x 3 h Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damp heat cycle</td>
<td>IEC 60255-1</td>
<td>Test Db</td>
<td>+25 °C to +55 °C</td>
<td>Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-30</td>
<td></td>
<td>6 cycles x 24 h</td>
<td>Passed</td>
</tr>
<tr>
<td>Damp head steady state</td>
<td>IEC 60255-1</td>
<td>Test Cab</td>
<td>+40 °C, 93% RH</td>
<td>for 240 h Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-78</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.4 Type test, shock/vibration

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard</th>
<th>Requirement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>IEC 60069-2-6</td>
<td>Frequency: 10-150 Hz, 2 g</td>
<td>Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-21-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td>IEC 60255-21-2</td>
<td>30 g, 11 ms</td>
<td>Passed</td>
</tr>
<tr>
<td>Bump</td>
<td>IEC 60255-21-2</td>
<td>10 g, 16 ms</td>
<td>Passed</td>
</tr>
<tr>
<td>Seismic</td>
<td>IEC 60068-2-6</td>
<td>1-35 Hz, 7.5 mm / 2 g</td>
<td>Passed</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-21-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3 Sub component ruggedization

In order to ensure the immunities noted previously, the entire system must be designed to be immune from any radiated energy. This includes using circuit designs which contain error cancelling details and which are inherently stable. The sub components which make up these solid state circuits must also be ruggedized to withstand the radiated energy. The following table describes the major components (see figure 1) found inside the servo motor drive.

3.1 Component selection and design for electromagnetic ruggedness

All components on TLMS motherboard are rated -40°F to +185°F (-40°C to +85°C)
- Operating temperature range is -40°F to +185°F (-40°C to +85°C)
- Humidity is 95% non-condensing
- Conformal coating on:
  TLMS motherboard
  VFD display

3.1.2 TLMS Motherboard

The TLMS motherboard incorporates the following design principles for reliable operation in harsh EMC environments.
- 32-bit microprocessor with proprietary firmware
- Capacitive decoupling (minimize loop currents)
- Optimized PWB zoning layout (isolate digital circuits from analog circuits). Note in figure at right the light colored areas – these are isolation zones.
- Impedance matching of traces on PWB
- MOV protection: 275 Vac / 350 Vdc / 43 J
- PWB level isolation between all major subsystems on TLMS motherboard
  - microprocessor
  - optoisolated digital inputs
  - relay outputs
  - 4-20 mA tap position outputs
  - CT inputs
  - CAN master port
  - Servo drive I/O interface
  - Differential signaling on CT inputs
  - Relay output contact ratings 6 A / 250 Vac
3.1.3 Multi-turn absolute position encoder = Heidenhain EnDat 2.2 (serial data interface)

Benefits of EnDat 2.2 encoder interface:
- 100% serial data transmission
- Automatic self-configuration:
- All information required by the TLMS is stored in the encoder.
- High system security:
- Encoder generates alarms and messages for monitoring and diagnosis.
- High transmission reliability:
- Cyclic redundancy checks (CRC) of transmitted data between TLMS and Heidenhain encoder.

3.1.4 Operational burn-in testing performed on every TLMS unit
- 60°C ambient temperature for 20 hours

3.1.5 Multi-turn absolute encoder specifications
- Operating temperature range: -40°C to +100°C (-40°F to +212°F)
- Protection: IP 67 at housing, IP 64 at shaft inlet
- Resolution: 33,554,432 (25 bits) = 0.0000107 degrees / 0.038 arc seconds
- Accuracy = ± 0.0055 degrees / ± 20 arc seconds
- Passed all EMC type tests