



Application Note: ACGRID-LROV-Cert
Revision: 071318

CPS LOAD REJECTION OVERVOLTAGE (LROV) PERFORMANCE

BACKGROUND: IEEE1547-2018 (section 7.4.2) has a requirement for LROV **field** performance. However, the equivalent inverter certification requirements (UL1741) and test conditions (IEEE1547.1) have not been revised to date. It is essential to have inverter requirements that correlate to actual field performance to provide field performance confidence. The test conditions must reflect the worst case – field conditions – or a close to (near) DG open circuit fault. While in reality an open circuit fault at the POI will not cause Utility Customer equipment damage, it is the easiest to test but yields the most conservative results. Since the exact Inverter laboratory test requirements have not been formalized, CPS has performed the tests under the following conditions based on documents from HECO Rule 14 and NREL (*Inverter Load Rejection Over-Voltage Testing SolarCity CRADA Task 1a Final Report*) on this topic.

DESCRIPTION:

- The L-L and L-N terminal voltage is lower than 1.3pu during LROV test for CPS SCA50KTL-DO/US-480 and CPS SCA60KTL-DO/US-480. The duration above 1.3pu is 0.0ms.
- The test conditions are based on the following:
 - DC Input Voltage 735Vdc (nominal)
 - AC Input Voltage 480Vac-rms (nominal)
 - Data Sample Rate 25 kHz
 - The inverter is tested at different output power and load combinations based on the requirement of HECO and NREL.
 - Test was performed 5 times and the maximum observed values presented for L-L and L-N connections to the AC Power Source based on the requirement of HECO Rule 14 and NREL document.
 - DSP Firmware Version is 5.00 and greater for CPS SCA50KTL-DO/US-480 and CPS SCA60KTL-DO/US-480.
- The test based on the following documents from HECO and NREL:
 - Load-Rejection Overvoltage Test Plan
 - Transient Overvoltage Limits Guideline
 - Transient Over-Voltage and Frequency & Voltage Ride-Through Requirements for Inverter-Based Distributed Energy Resources

TEST RESULTS:

- CPS SCA50KTL-DO/US-480; The LROV test results are shown in Table 1 and Table 2;
- CPS SCA60KTL-DO/US-480; The LROV test results are shown in Table 3 and Table 4.
- For both Inverters the L-L and L-N terminal voltage is lower than 1.3pu during LROV test when tested under the specific guidelines of HECO Rule14 and NREL.

Table 1

| Test No. | The test conditions (L-L) | | | | Method 1:Total Duration Above a Given Voltage Level (mS) | | Method 2:Total Continuous Duration Above a Given Voltage Level (mS) | |
|----------|---------------------------|----------------|--------------------|-------------|--|------|---|------|
| | DC Volt | Load Power (%) | Inverter Power (%) | Penetration | 110% | 120% | 110% | 120% |
| Test#1 | 735 | 10% | 100% | 1000% | 2.20 | 0.44 | 2.16 | 0.64 |
| Test#2 | 735 | 10% | 100% | 1000% | 1.82 | 0.72 | 1.92 | 0.68 |
| Test#3 | 735 | 10% | 100% | 1000% | 2.08 | 0.76 | 2.04 | 0.72 |
| Test#4 | 735 | 10% | 100% | 1000% | 2.08 | 0.52 | 2.04 | 0.64 |
| Test#5 | 735 | 10% | 100% | 1000% | 2.08 | 0.76 | 2.04 | 0.72 |

Table 2

| Test No. | The test conditions (L-N) | | | | Method 1:Total Duration Above a Given Voltage Level (mS) | | Method 2:Total Continuous Duration Above a Given Voltage Level (mS) | |
|----------|---------------------------|------|----------|-------------|--|------|---|------|
| | DC Volt | Load | Inverter | Penetration | 110% | 120% | 110% | 120% |
| Test#1 | 735 | 10% | 100% | 1000% | 2.20 | 0.52 | 2.20 | 0.80 |
| Test#2 | 735 | 10% | 100% | 1000% | 2.48 | 0.56 | 2.48 | 1.08 |
| Test#3 | 735 | 10% | 100% | 1000% | 2.16 | 0.04 | 2.12 | 0.00 |
| Test#4 | 735 | 10% | 100% | 1000% | 1.84 | 0.00 | 1.80 | 0.00 |
| Test#5 | 735 | 10% | 100% | 1000% | 2.24 | 0.28 | 2.12 | 0.76 |

Table 3

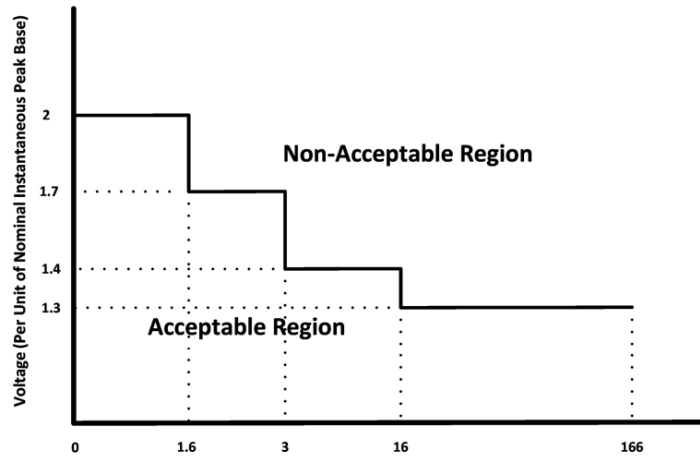
| Test No. | The test conditions (L-L) | | | | Method 1:Total Duration Above a Given Voltage Level (mS) | | Method 2:Total Continuous Duration Above a Given Voltage Level (mS) | |
|----------|---------------------------|------|----------|-------------|--|------|---|------|
| | DC Volt | Load | Inverter | Penetration | 110% | 120% | 110% | 120% |
| Test#1 | 735 | 10% | 100% | 1000% | 2.40 | 1.16 | 1.68 | 1.20 |
| Test#2 | 735 | 10% | 100% | 1000% | 2.32 | 0.80 | 2.28 | 1.20 |
| Test#3 | 735 | 10% | 100% | 1000% | 2.28 | 0.80 | 2.28 | 1.40 |
| Test#4 | 735 | 10% | 100% | 1000% | 2.20 | 1.24 | 2.20 | 1.44 |
| Test#5 | 735 | 10% | 100% | 1000% | 2.36 | 0.76 | 2.32 | 1.20 |

Table 4

| Test No. | The test conditions (L-N) | | | | Method 1:Total Duration Above a Given Voltage Level (mS) | | Method 2:Total Continuous Duration Above a Given Voltage Level (mS) | |
|----------|---------------------------|------|----------|-------------|--|------|---|------|
| | DC Volt | Load | Inverter | Penetration | 110% | 120% | 110% | 120% |
| Test#1 | 735 | 10% | 100% | 1000% | 2.44 | 0.64 | 2.44 | 1.12 |
| Test#2 | 735 | 10% | 100% | 1000% | 2.40 | 1.08 | 2.36 | 1.48 |
| Test#3 | 735 | 10% | 100% | 1000% | 2.44 | 1.12 | 2.48 | 1.80 |
| Test#4 | 735 | 10% | 100% | 1000% | 2.48 | 0.96 | 2.52 | 1.16 |
| Test#5 | 735 | 10% | 100% | 1000% | 2.28 | 0.28 | 2.32 | 0.80 |

SUMMARY:

- CPS SCA50KTL-DO/US-480 and CPS SCA60KTL-DO/US-480 inverters do not experience LROV that exceed 1.4pu for greater than 1mS when tested under the conditions outlined above – and thus meet the ISO-NE LROV requirements.
- For both Inverters the L-L and L-N terminal LROV is lower than 1.3pu when tested under the specific guidelines of HECO Rule14 and NREL document as outlined above.
- The performance data fall within the acceptable region of the IEEE1547-2018 section 7.4.2 Figure 3 as depicted below.
- Much more data is available on request representing various load conditions. The 10%/100% condition is presented because it more closely represents the conditions when tested at the Point of Interconnection with the grid.



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DATE