Raising the Bar in PV Connectors Technology

Frank Rosenkranz – Global PM
Royer Zuleta – BDM Renewables
About the Presenters

Frank Rosenkranz
- Product manager of SOLARLOK solar connectors
- 38+ years of experience in sales & product management
- Contributor to new product innovation and development of the 1st generation of SOLARLOK connector and inventor of the new SLK 2.0

Royer Zuleta
- Business Development Manager for renewable energies
- 16+ years of experience in electrical products manufacturing including R&D, engineering, product management and business development.

About TE’s SOLARLOK Product Range

1979
SOLARLOK trademark registered by AMP

2001
New SOLARLOK Connector

2016
New PV4-S (1500V) Standard Solar Interface

2021
Introduction of the SLK 2.0 DC Splice Connectors

1983
First SOLARLOK catalogue

2012
New PV4 (1000V) Standard Solar Interface

2020
Introduction of the SLK 2.0 DC Plug Connectors

TE PV Connectors History
With You Every Step of the Way to Keep Your Grid Connected

+ EQUALS MORE

Comprehensive solutions and services from a single partner:
- Cable Accessories
- Connectors & Fittings
- Insulation & Protection
- Metering
- Installation Training

Enabling more than 85 GW solar generation worldwide over the past ten years
Solar Market Trends

- High performance solar panels (600+ W)
- Larger central inverters (4,6+ MW)
- Larger string inverters (750+ kW)
- Larger installations (1+ GW)
- More power out

Leading to:
- Improved ROI
- Better LCOE
- Less time for execution
- Minimum/optimal O&M
- Harsher environments
- Energy storage required

Highest confirmed conversion efficiencies for research cells for a range of photovoltaic technologies, plotted from 1976 to the present

Source: NREL - National Renewable Energy Laboratory of the U.S. Department of Energy. 2020
Reasons for Downtime

- Corrective maintenance
- PV connectors need replacing
- DC cable needs replacing
- Micro inverters high internal temperature alarm
- Soiling, dirt or dust removal
- Damaged panels need replacing
- Wind or swell damages
Potential Failure Points

Performance implications of poor installations:

- Poor crimping (burnt connectors)
- Poor PV connector insertion (hot spots)
- Improper plug assembly (power loses)
- Cross pairing (high contact resistance)
- “Overcrowded” DC combiner boxes (blown fuses)
- Improper module handling (damaged panels)
- Poor lug installation (no torque monitoring)
- DC cabling on sharp edges (DC Cable damages)

PV Connectors Technology

EVERY CONNECTION COUNTS
Common PV Connector Challenges

Missing Parts (contacts, pinch rings, hex nuts,...)

You have to grab new parts or worst case go find them

Incorrect Conductor Insertion (insert wrong gender or via interface)

All parts are pre-assembled and ready to install

Special Hand Tool Required (produced by the connector manufacturer)

Wouldn't it be easier to simply use this universal tool?

Improper IP (internal) protection

Over torqued = cable insulation issue
Under torqued = not as tight as defined
Common PV Connector Challenges

Improper Crimping

Using the wrong tool or a defective tool can cause electrically unstable crimps \[ P = I^2 \times R \text{ crimp} \]

- Voltage drops \(\uparrow\)
- Live cycle \(\downarrow\)
- Losses \(\uparrow\)
- Reliability \(\downarrow\)

Cross-section of crimp shows:
- Weak compression of strands, airgaps visible
- Crack across the barrel
- Crimp is asymmetrical shaped

Bad part

With these defects, the expected lifetime of 25+ years is very unlikely!

---

Crimp pull out force vs. Crimp quality

1. Dark green = Correct crimp
2. Red = 12 strands cut
3. Light green = Incorrect tool

EN 60352-2 defines 310N min.
Common PV Connector Challenges

Incorrect Cable Stripping and Crimping

Use of standard PV connectors requires correct stripping of the insulation. If done improperly it influences the connection quality and lifetime.

Thermography [°C] vs crimp quality @22°C

<table>
<thead>
<tr>
<th>Sample</th>
<th>Temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>62</td>
</tr>
<tr>
<td>middle</td>
<td>54</td>
</tr>
<tr>
<td>right</td>
<td>37</td>
</tr>
</tbody>
</table>

Left side: Incorrect tool
Center: 12 strands cut
Right side: Correct crimp

ΔT= 40°C  32°C  15°C
SLK 2.0 DC Plug and Splice Connectors Solving your Challenges

SLK 2.0 – IDC System 1500V approved per IEC 62852 & UL 6703

The whole connector inside is filled for IP protection IP X8 (1m/24 hrs.)

Insulation Displacement Connection (IDC)
with special designed points of contact to cut insulation & touch strands for a wide range of cable diameters (2.5mm² & 4mm² & 6mm² // AWG 14-10).
All 3 ranges covered in ONE connector.

IDC is a proven, trusted and widely used technology that has passed critical parameter tests:
• Cross-section
• No impact on resistance after temperature cycle
• T-rise

It is more than 30 years in the filed used in various industries including: Automotive, Industrial, Lighting, Medical, Rail...
SLK 2.0 DC Plug and Splice Connectors Installation Steps

**SLK 2.0 SPLICE**

1. **Step 1:** Insert First Cable
2. **Step 2:** Push First Button
3. **Step 3:** Insert Second Cable
4. **Step 4:** Push Second Button

**Watch SLK 2.0 Splice Installation Video**

**SLK 2.0 CONNECTOR**

1. **Step 1:** Insert Cable
2. **Step 2:** Push Button
3. **Step 3:** Fully Close

**Watch SLK 2.0 Connector Installation Video**

**Necessary Tool**

- TE’s SOLARLOK hand tool
- Standard channel lock plier

80% installation time reduction compared to traditional PV connectors
Traditional Solar Crimp Connectors
VS SLK 2.0 Installation Steps

SLK 2.0
1 Tool required

TE’s SOLARLOK hand tool
or

Standard channel lock plier

Termination time up to 30 seconds per set!

STEP 1
Insert un-prepared cable

STEP 2
Push button down

PV4-S (traditional con.)
3 Tools required

Step 1
Prepare cable with wire strippers to specific dimensions

Step 2
Insert correct contact into crimp tool

Step 3
Insert prepared wire into contact

Step 4
Make correct crimp and remove from tool

Step 5
Push crimped contact/cable into correct connector

Step 6
Check the correct position in housing (slight pull back)

Step 7
Screw nut into final seated position

Step 8
Torque to defined Nm (check specification)

Termination time up to 4 minutes per set!

SOLARLOK 2.0
1,500V PV Connector

Pin
Socket

Standard channel lock plier

Termination time up to 30 seconds per set!
SOLARLOK
Solar Connectors Range

SOLARLOK 2.0 Connector
AVAILABLE for UL and IEC

SOLARLOK 2.0 “T”
Coming

SOLARLOK 2.0 Splice
AVAILABLE for UL and soon as well IEC

PV4-S
AVAILABLE

SLIM LINE
AVAILABLE

Grounding solutions
AVAILABLE

Jumpers
with PV4 or competition connectors
AVAILABLE

In Line Fuse with Gelbox
Coming
EVERY CONNECTION COUNTS