Automatic Bussing Machines in PV Module Production

A Technical Overview of Interconnection Soldering in Solar Manufacturing

Content Partner: J. v. G. technology GmbH

Turnkey solar module production lines — since 1997

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A Technical Overview of Automatic PV Bussing Machines

Created as part of the PVKnowHow Knowledge Network

Prepared by J.v.G. Technology GmbH

European specialists in turnkey solar module production lines

Role of Bussing in PV Module Production

What Is Bussing?

- Process of soldering flat copper ribbons (busbars) across multiple cell strings
- Electrically connects individual cell strings in series or parallel
- Bridges the gap between stringing and final module assembly
- Determines current collection efficiency of the finished module

Why It Is Critical

- Poor bussing quality leads to resistive losses and hotspots
- Directly affects power output and long-term module reliability
- Defects introduced here cannot be corrected after lamination
- Precise alignment required for cell strings up to 210 mm cell formats

What an Automatic Bussing Machine Does

String Positioning

Cell strings are precisely positioned and aligned on the machine conveyor for consistent contact placement

Busbar Application

Copper ribbon busbars are dispensed, cut to length, and placed across string endpoints with automated handling

Infrared / Contact Soldering

Busbars are soldered to cell tab contacts using controlled IR or contact heat — no manual intervention required

Vision System Inspection

Integrated cameras verify solder joint quality, ribbon alignment, and cell gap tolerances in real time

Transfer to Lay-Up

Completed bussed string matrix is transferred automatically to the next stage: module lay-up or stringer output buffer

Key Machine Data

~150	20–22s	2500…	156–210
Modules / Hour	**Cycle Time**	**Max Module Size**	**Cell Size (mm)**
Rated throughput capacity of a fully automated bussing system	Per module cycle including busbar placement, soldering, and inspection	Maximum supported module length (up to 2500 × 1400 mm format)	Compatible cell formats from standard M6 to large-format M10/G12

Process: Interconnection soldering (bussing) · Application: Crystalline silicon PV module production · Automation level: High / fully automated · Source: PVKnowHow / J.v.G. Technology GmbH

Key Features: Automation, Soldering & Vision

Automation System

- Servo-driven ribbon feed and cut — no manual ribbon handling
- Robotic or gantry-based string placement with sub-millimeter repeatability
- PLC control with recipe management for different module formats

Soldering Technology

- IR lamp or contact soldering with closed-loop temperature control
- Flux application integrated into the process sequence
- Consistent solder joint quality independent of operator skill

Vision Inspection

- High-resolution inline cameras inspect every solder joint
- Detects ribbon misalignment, missing contacts, and cold solder joints
- Automatic reject or flag — prevents defective strings from advancing

Format Flexibility

- Quick-change tooling supports multiple cell sizes (156–210 mm)
- Adjustable conveyor width accommodates varying module formats
- Software recipe switch minimizes changeover downtime

Technical Specifications at a Glance

Parameter	Specification	Notes
Throughput capacity	~150 modules/hour	Fully automated configuration
Cycle time	20–22 seconds	Per module, incl. inspection
Max module dimensions	2500 × 1400 mm	Large-format G12 compatible
Cell size range	156–210 mm	M6 to G12 / M10 formats
Soldering method	IR / contact soldering	Closed-loop temp. control
Automation level	High / fully automated	PLC + vision system integrated
Inspection system	Inline vision cameras	100% coverage per module

Operational Benefits: Efficiency, Precision & Scale

Throughput Efficiency

- Continuous operation at ~150 modules/hour with minimal downtime
- Eliminates manual bussing bottleneck in medium-to-high volume lines
- Integrated buffer handling reduces idle time between process steps

Process Precision

- Sub-millimeter ribbon placement accuracy reduces resistive losses
- Consistent solder temperatures eliminate cold joints and voids
- Vision-verified output ensures only conforming strings proceed

Scalability

- Modular machine design supports line capacity expansion
- Software recipes enable rapid format change for bifacial or large-cell modules
- Compatible with next-generation cell formats (210 mm and beyond)

Cost & ROI Considerations

Investment Factors

- Higher upfront capex than manual or semi-manual bussing stations
- Total cost of ownership includes tooling, maintenance, and consumables (ribbons, flux)
- Multi-format tooling kits add to initial setup cost
- Integration with upstream stringer and downstream lay-up may require line redesign

Return on Investment

- Reduced scrap rate from vision-controlled inspection lowers material waste
- Lower labour cost per module at production volumes above ~50 MW/yr
- Fewer field warranty claims due to consistent solder joint quality
- Faster payback at higher throughput — ROI sensitive to line utilization rate

Risks and Limitations

Technical Risks

- Vision system false-reject rates increase with contaminated optics — requires regular cleaning
- Soldering temperature drift can cause cold joints if calibration is not maintained
- Ribbon feed jams or misfeed require operator intervention and cause downtime

Process Limitations

- Not suitable for shingled or back-contact cell architectures without significant redesign
- Cell format changes require tooling swap — limits agility for mixed-product lines
- Flux residue management must meet IEC 61215 cleanliness requirements

Operational Risks

- Machine availability directly impacts line output — no manual fallback at high automation levels
- Spare parts lead times (servo motors, IR lamps) must be managed proactively
- Operator skill requirements shift from manual dexterity to machine setup and diagnostics

Strategic Role in Modern PV Factories

Quality Control Node

Bussing is the last correctable step before lamination — inline vision inspection here prevents defects from becoming permanent

Throughput Enabler

At 20–22 s cycle time and ~150 modules/hour, automated bussing must be matched to stringer output to avoid becoming a line bottleneck

Technology Readiness

Support for 210 mm cell formats and large-area modules positions automated bussing as essential infrastructure for next-generation PV lines

Automated bussing solutions are a core component of integrated turnkey PV production lines — enabling consistent interconnection quality at industrial scale across cell generations and module formats.

About the Content Partner

J. v. G. technology GmbH — The DESERT Company

Founded in 1997 in Bavaria, Germany. Family-owned engineering company specializing in turnkey solar module production lines.

More than 90 factory projects delivered worldwide.
On-site team training included — no prior manufacturing experience required.

Key areas:

Turnkey PV manufacturing lines | DESERT Technology® | TÜV-certified module designs | Factory planning to production

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