

REFERENCE: M10 SOLAR EQUIPMENT GMBH

Versatility is everything

Shingle-matrix solar modules combine aesthetics, efficiency and flexible applications – manufactured on highly automated M10 Solar production systems powered by Siemens technology.

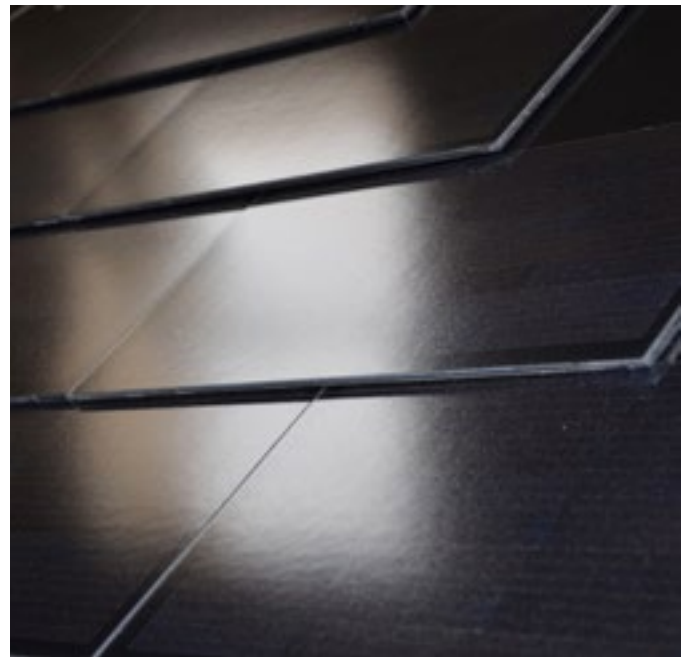


Aesthetics, efficiency, and mechanical adaptability – all three are combined in the shingle matrix solar modules manufactured on systems from Freiburg-based company M10 Solar Equipment GmbH. Initial market success across areas as diverse as vehicle-integrated and building-integrated photovoltaics, space PV, and classic building-applied PV shows there is strong demand for these special characteristics in many different sectors. To get the very best out of its production systems, M10 Solar relies on automation, drive, digitalization, and simulation technology from Siemens, and it sees enormous potential in combining edge computing with artificial intelligence.

The SURFACE stringer system developed by M10 Solar Equipment GmbH (M10 Solar), a company based in the German city of Freiburg, is the world's first and, so far, only series-ready machine for shingle matrix solar modules. Instead of aligning the cells vertically and interconnecting them with snaking wires, SURFACE takes cells that have been cut into strips and arranges them in a brickwork-like pattern over the entire surface of the module, connecting them to each other like roof tiles (shingles). This results in a consistent module matrix through which solar power passes, both in parallel and in series at the same time and covering the entire surface. The shingle matrix concept has its roots in the 1960s, when the first "shingle strings" were developed. Another development milestone came in the 1990s, when the matrix arrangement was introduced. The concept was then taken further in Germany by the Fraunhofer Institute for Solar Energy Systems (ISE) and M10 Solar as part of the SHIRKAN project (funding reference 03EE1026B). While the Fraunhofer ISE drove the research side of the project, M10 Solar focused on the industrialization of the technology. With a production rate of up to 12,000 crystalline PV cell strips an hour (for cells of any type and format), the system is one of the most productive ECA cell connecting machines worldwide. "The technology is setting a new industrial standard, which is happily now starting to translate into success on the international market," says Marco Saladin, who is a Managing Director of M10 Solar Equipment GmbH alongside Philipp Zahn.

Building-integrated and building-applied photovoltaics

The term building-integrated photovoltaics (BIPV) refers to solar modules that are integrated directly into the fabric of a building and take the place of conventional construction materials to become part of the roof, facade, or windows. These modules generate electricity, protect against the elements, provide shade, and offer additional architectural design options. This is exactly where the matrix photovoltaic module comes into its own, since maximum usage of space, a high shading tolerance, and visual appeal are



By utilizing the flexible automation options that M10 Solar systems bring to production operations, project partner Freesuns, a Swiss-based solar roof specialist, has been able to manufacture the newly developed matrix shingle roof tiles on a pilot scale at the Module-TEC. This achievement brings full series production a step closer. Image source: Fraunhofer Institute for Solar Energy Systems ISE

all key requirements. As part of the EU-funded SPHINX research project, the Fraunhofer ISE therefore set up a pilot line for PV roof tiles at its Module Technology Evaluation Center (Module-TEC) in Freiburg. By utilizing the flexible automation options that M10 Solar systems bring to production operations, project partner Freesuns, a Swiss-based solar roof specialist, has been able to manufacture the newly developed matrix shingle roof tiles on a pilot scale at the Module-TEC. A total of 4,000 roof tiles with shingle matrix technology have rolled off the near-industrial-scale production line, bringing the project team a step closer to full series production. The shingle matrix modules have been in production since March 2025, and are destined for four roofs that Freesuns is installing on existing buildings

in Switzerland. The SPHINX project is also trialing the use of this technology for facades, noise barriers, and even planters. A follow-up research project centered on the innovative new cell technologies is already starting to take shape.

However, the team at M10 Solar isn't just working with the Fraunhofer ISE in Freiburg. Its reputation now transcends international borders. "We are proud to be working with CEA INES in France, CSEM in Switzerland, and NISE in India as well," says Saladin.

Moving away from research, IBC Solar – an international full-service supplier of photovoltaic and power storage solutions – has already put M10 Solar technology into practice. Its IBC Module Transparent DT-TX1 double-glass modules utilize 2D matrix technology, which connects solar cells in a two-dimensional matrix of both rows and columns, rather than the conventional series circuit.

This significantly reduces the impact of shading, as the current flow can take alternative paths through the cell network. Even if individual cells are shaded or faulty, a large portion of the module's output is retained. This improves energy yield, increases module reliability, and can extend



The IBC Module Transparent DT-TX1 double-glass modules from IBC Solar utilize 2D matrix technology, which connects solar cells in a two-dimensional matrix of both rows and columns, rather than the conventional series circuit. Image source: IBC Solar

service life, especially under real conditions such as partial shading.

Vehicle-integrated photovoltaics

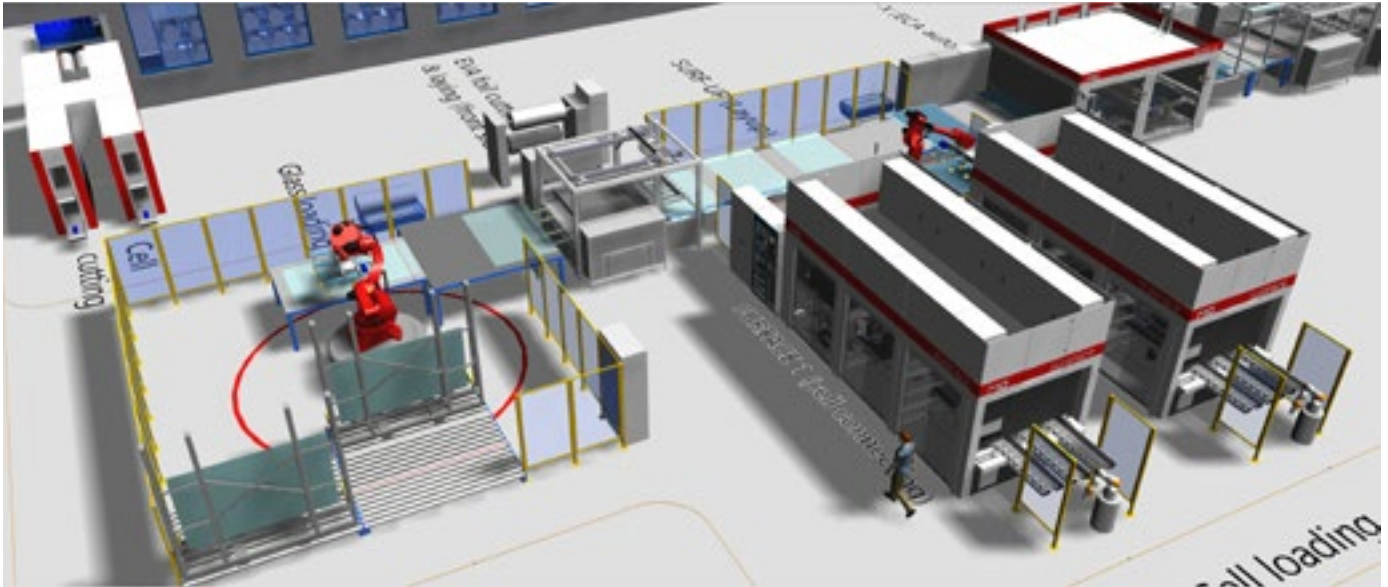
The proven performance of shingle matrix technology in and on buildings has also impressed the automotive sector. In vehicle-integrated photovoltaics (VIPV), solar modules are embedded directly into the outer skin of vehicles – the roof, hood, and side panels, for example – and supply power for the drive or auxiliary consumers. "This is where shingle matrix modules really come into their own," explains Saladin. That has also come to the attention of a company that supplies end-to-end solar solutions to the automotive sector and covers applications ranging from recreational vehicles to trucks. Its innovative off-grid modules have been specially designed for automotive requirements and provide a self-sufficient, sustainable energy source – based on shingle matrix technology.

Space photovoltaic modules

"Probably the most surprising inquiry came from the USA," recall Saladin and Zahn. Source Energy Company is committed to space power, and its proven space-grade solar modules are designed for maximum reliability under the extreme conditions of space. They achieve specific powers up to 303 W/kg, feature full electrical redundancy, are tolerant to micrometeorites and localized shading, and are built using durable, space-stable materials. Reference projects include the Transporter-8 and 9 missions, and there are already plans for their products to be used in future rideshare flights. Across all these projects, M10 Solar and its shingle matrix technology are always on board. "We are hugely excited about this, because space travel holds enormous potential and we have broken into a new market in the USA," Saladin reveals.

Siemens – a constant for innovation

Despite the rapid progress M10 Solar is making across such a diverse range of areas, there is always one constant. From the very outset, Siemens has supplied the building blocks of innovation for the automation, drive, digitalization, and simulation technologies in M10 Solar's systems. "Plant Simulation didn't just help us very quickly find the optimum concept for our stringer system – it also enabled us to calculate maximum throughput," recalls Zahn. That cuts the startup phase for production and saves on time-consuming and costly corrections further down the line. In complete line concepts, Plant Simulation is often used to boost throughput, identify and clear bottlenecks, and reduce stock levels.



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In the stringer system itself, Simatic controllers are the scalable, networked, and reliable intelligent core that brings production to life. The Siemens Simatic S7 1500 T CPU (Technology CPU) is an advanced programmable logic controller (PLC) for complex motion control tasks. The T CPU is part of the S7 1500 family, which boasts excellent computing power, Security Integrated, and a modular design.

MQTT function blocks (FBs) are essential software components in automation technology, and M10 Solar uses them to connect controllers directly to the Manufacturing Execution System (MES). Siemens Opcenter Execution, meanwhile, is a cutting-edge MES for digitalizing, controlling, and optimizing production processes. It boosts productivity, quality, and traceability, connects PLM to the automation level, offers real-time insights (digital twin), and is highly scalable thanks to its cloud capabilities and modular structures.

The MQTT Wrapper function block for PV applications is a single wrapper that combines several PLC data types and function blocks for the specific application. It realizes a vertical MQTT based application between the host system and the underlying equipment systems. These equipment systems are implemented with the Simatic S7 1500 controller.

At M10 Solar, simulation tools, seamlessly integrated engineering, and transparent equipment operation work together in the Siemens TIA Portal. The Totally Integrated

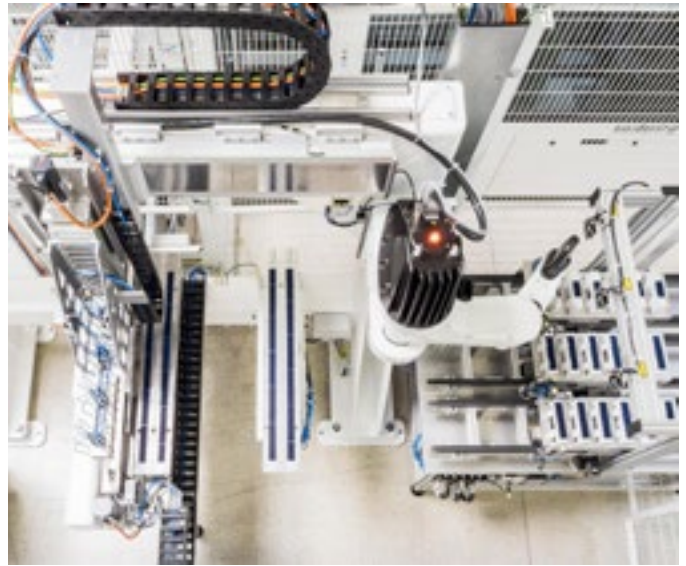
Automation (TIA) Portal is a leading engineering software platform for configuring and programming automation systems.

Also in use at M10 Solar is Simatic WinCC – an innovative, scalable SCADA system that enables efficient visualization, monitoring, and control.

M10 Solar uses Scalance Switches from Siemens as a basis for end-to-end digital data communication. They have been specially developed for industrial uses such as solar applications and meet all the requirements for highly efficient industrial communication networks and bus systems.

"Since the start of this collaboration, we have not just valued the technology Siemens offers, but also the enormous industry expertise of our contacts, to such an extent that we are more than happy to incorporate their know-how into our strategic decisions for the market," explains Zahn. One of these decisions concerns edge computing. "We are opting for Edge Computing from Siemens for the forthcoming generation of machines," says Saladin. The advantages are clear – Siemens Industrial Edge is an open, scalable edge-computing platform that combines OT and IT by means of data processing carried out directly at the machine. Utilizing container-based apps, it enables real-time data processing and therefore enhanced machine performance. A secure cloud connection facilitates centrally administered device management and precise quality checks.

All in all, this constitutes an optimum starting point for AI applications of all types. “Combining edge computing with AI offers enormous potential. We’ve already had good experiences with AI applications that assist equipment operators with their work on the shopfloor,” explains Saladin. The application provides information on the causes of faults and suggests relevant solutions, which reduces downtime on the basis of intelligent knowledge management. “We’re excited about the increasingly impressive power of edge and AI technology. It is helping us make our equipment and machinery that little bit better for our customers with every day that passes,” sums up Saladin.



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