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8 KEY FACTORS FOR **AUTOMATED EOL** (END OF LINE) **TESTING INTERCONNECTS** & **DOCKING**

EXTRACT

Manufacturers of electronics have many decisions to make when a product moves from engineering to manufacturing and production, the least of which is the development of a robust test plan. Testing a manufactured unit at the end of the assembly line is a critical step in the production process and considered a key aspect to meeting customer expectations is the delivery of fault free product. Defective products or even those outside of the specification limits must be separated from the functional units shipped to the customer. When deploying a new line, the test plan should also consider key factors as critical part of component selection.

ELECTRO-MECHANICAL

A stable electromechanical design is every bit as important here as high-performance hardware and software architecture. Additionally, the flexibility afforded by incorporating a modular design can help future proof a testing interface for future product or upgrades. In this instance we will consider the interconnect as a key component, both as an electrical interface and mechanical sub component that directly impacts test and measurement.

Organizations are investing in smarter test systems and automated test equipment (ATE) that scale with their requirements. This helps them shorten time to market and drive down cost and deployment times while allowing for flexibility when transferring capability from line to line. Test systems must accurately check the functionality of electrical systems, electronics, and other components, under sometimes harsh conditions of the manufacturing environment. Reliable automated and end of the line testing equipment is vital to enable zero-defect manufacturing and guarantee reliable quick results at the highest-possible product safety. In series production, a high testing throughput rate is crucial. For this reason, the test procedures are optimized in order to achieve a short cycle time and reduce costs when compared to manual or semi-automated testing.

WHY AUTOMATE?

Test Automation is mainly considered to avoid repeated manual work, gain faster response, cut down the time for running tests, and ensure that our tests are consistent with the expected presumptions and objectives. Moreover, automation can help eliminate manual errors while executing the tests repeatedly. There are also chances that the manual execution or semi-automated tests might not give similar results each time. The end product or tested subcomponent is frequently referred to as the Device Under Test (DUT), Equipment Under Test (EUT) or Unit Under Test (UUT). When measuring the product of any process, there are two sources of variation: the variation of the process itself and the variation of the measurement system. When one or both variables can be minimized or eliminated, through means such as automation, the process itself becomes inherently more stable and repeatable.

COLLABORATIVE DEVELOPMENT

Automation system optimization stems from open communication between electrical and mechanical engineers early in the development process. Effective collaboration between the two fields facilitates timely and efficient development of the proper integrated solution. More companies strive to integrate completely 100 % automated test solutions, which result in the reduced need of operators, but increase the dependence on engineering. It is important that that mechanical and electrical engineers collaborate to understand how their applications will function together and also include expertise from suppliers.

8 FACTORS OF SUCCESS

A good base and preselection of subcomponents is required to make the testing unit cost-effective, repeatable, accurate, and to meet the desired quality objectives. To achieve the best results using automation to quickly perform measurements and evaluate the test results, key factors must be considered. Every engineer that has developed systems, knows critical success factors through some methodology of quality training. But how do these requirements filter down to component selection. A key interface for the testing, considered a critical link by many is the electrical connector or interconnect which undergoes the cycling and must maintain stability over time.

1. PRODUCT UPGRADABILITY AND FLEXIBILITY

The testing unit should allow for changes, upgrades, modifications and transferability. When functionality is added or the equipment undergoes a revision with additional capability, the testing unit should likewise be able to be upgraded through modifications. Today it's important to have a flexible test platform. Selecting the right tools is absolutely critical when designing a system from the ground up, but future proofing designs, or including headroom for modifications can literally save a project timeline. Let's look at real world examples just as they apply to the interconnect. A high speed data protocol may be specified as USB® 2.0[1] and then eventually migrate and be upgraded to USB® 3.2 Gen 1x1[1].

- Do your I/O connectors have the same flexibility as your docking style connectors?
- Is the system being built modular and/or allows for expansion in the future?
- Does the Interconnect check all my current requirements and future possibilities?
- Does the system allow for low system cost system upgrades?

A modular system lends itself well for flexibility. Allowing for various modules, data types, and media such as pneumatics, hydraulics, high speed data (Like USB®1 and HDMI®1), fiber optic, coax, high voltage, high current. Interconnects are typically well designed for one set of criteria, but may be well short of selection for multiple types. The ODU-MAC® Blue-Line has 31 modules to select from and the ODU-MAC® Silver-Line has an even more impressive 36 modules that can be configured across 7 mounting frames.

VARIETY OF MODULES	ODU-MAC® Silver-Line	ODU DOCK Silver-Line	ODU-MAC® White-Line	ODU-MAC® Blue-Line	ODU-MAC® PUSH-LOCK Blue-Line
Signal	Up to 27 A / 1.5 mm²	Up to 27 A / 1.5 mm²	Up to 27 A / 1.5 mm²	Up to 33 A / 2.5 mm²	Up to 33 A / 2.5 mm²
Power	Up to 119 A / 16 mm²	Up to 119 A / 16 mm²	Up to 119 A / 16 mm²	Up to 58 A / 6 mm²	Up to 58 A / 4 mm²
High current	Up to 225 A / 50 mm²	Up to 225 A / 50 mm²	Up to 225 A / 50 mm²	Up to 225 A / 50 mm²	Up to 58 A / 4 mm²
High voltage	Up to 6.3 kV / 1.5 mm²	Up to 2.5 kV / 1.5 mm²	Up to 6.3 kV / 1.5 mm²	Up to 2.5 kV / 6 mm²	Up to 2.5 kV / 4 mm²
Coax	Up to 9.0 GHz	Up to 9.0 GHz	Up to 9.0 GHz	Up to 12 GHz	Up to 12 GHz
Compressed air	Up to 20 bar	Up to 20 bar	Up to 20 bar	Up to 12 bar	Up to 12 bar
Fluid	Up to 25 bar	Up to 25 bar	Up to 25 bar	Up to 10 bar	Up to 10 bar
Fiber optic POF / GOF	●	●	●	● (on request)	● (on request)
Transfer rates / high-speed	CAT 6_A / USB®1 / HDMI®1	CAT 6_A / USB®1 / HDMI®1	CAT 6_A / USB®1 / HDMI®1	CAT 6_A / USB®1	CAT 6_A / USB®1
Optional pin protection	Module can be freely positioned		Module can be freely positioned	Integrated with 20-pin signal module	Integrated with 20-pin signal module
Termination technology	Crimp / solder / print	Crimp (solder on request)	Crimp / solder / print	Crimp / solder / print	Crimp / solder / print

[1]These ODU specific connectors can transmit common data transmission protocols such as USB® 3.2 Gen 1x1, USB® 2.0 and HDMI®, but they are not USB®-, or HDMI®-standard connectors.

2. REPEATABILITY & CYCLE TIME

100 % automatic testing replaces more and more subjective testing by human operators to shorten the production cycle and to improve the reproducibility and comparability of the results. Additionally, the flip side of repeatability is cycle time. The process cannot be so slow as to impede series production; a high testing throughput rate is crucial. For this reason, automated test equipment developed should be optimized in order to achieve a short cycle time. Repeatable results from an interconnect are quite often the result of the contact systems used in conjunction.

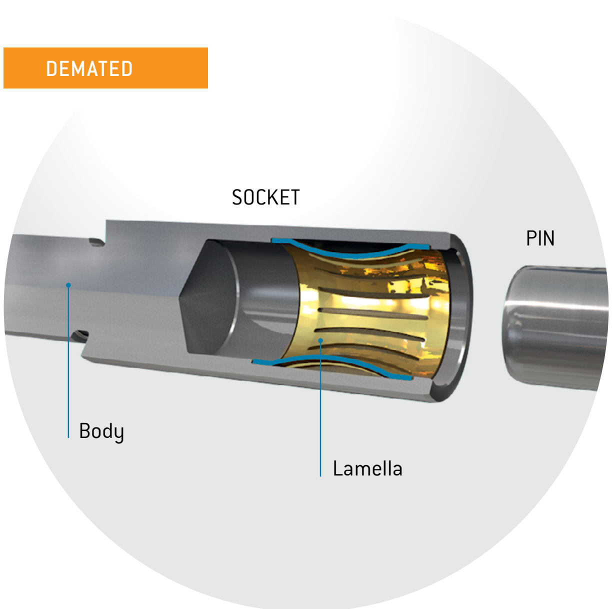
3. DURABILITY

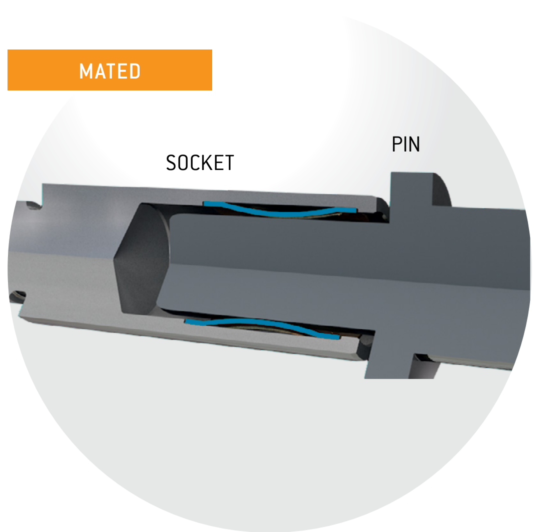
Durability is the attribute of a product that describes its usable service life or the duration of time that a product, part, material or system performs to its stated specification. Whether measured in years, minutes cycles, or periods, the more durable the product, the longer it can perform its intended function. When evaluating durability, one needs to think about the repeated performance necessary in a continuous production cycle or routine, ordinary use case of the product – repeated with realistic frequency. When discussing interconnects, typically this is measured in mating cycles or 1 cycle of mating and de-mating that results in a long continuous useful life, without requiring an inordinate degree of maintenance or degradation in performance over time. The ODU-MAC® Silver-Line product has been tested for >100,000 mating cycles . As mentioned the durability is typically determined by the EAU of product to be tested, and in some cases the ODU-MAC® Blue-Line can be used for applications >10,000 mating cycles.

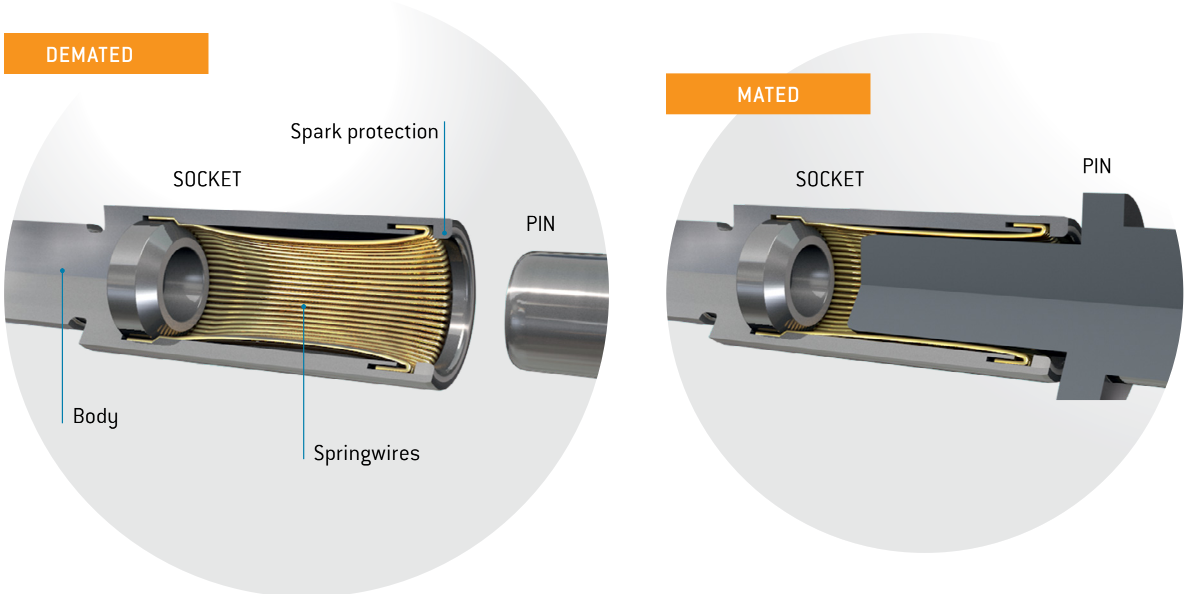
	ODU-MAC® Silver-Line	ODU DOCK Silver-Line	ODU-MAC® White-Line	ODU-MAC® Blue-Line	ODU-MAC® PUSH-LOCK Blue-Line
Mating cycles	> 100,000	> 100,000	> 100,000	> 10,000	5,000
Mating principle	Automatic docking	Automatic docking	Manual mating	Manual mating, automatic docking	Manual mating
Automatic docking	7 Frame varieties, Quick-change head option	3 Sizes, Quick-change head option		1 Frame variety, 4 sizes	
Locking			Spindle / lever locking Snap-In (ZERO)	Spindle / lever locking	Push-pull locking
Housing		3 housing varieties available in plastic and metal	Available in plastic and metal	Available in plastic and metal	Plastic sleeve / Metal frame
Strain relief	•	•	•	•	•
Highest packing density on the market	•	•	•	•*	•
Non-magnetic version	•		•		

4. ACCURACY

Accuracy describes how closely a manufacturing machine's output conforms to a tolerance within a specified dimensional range. Repeatability captures the equipment's capability to produce consistent output, time after time. We always address accuracy with consistency. With respect to a connector, the accuracy can be affected by the quality of the connector overall. Most importantly, how many points of contact are made through the cycling which can reduce contact resistance and help mitigate effects such as vibration and misalignment. One technology feature is the ODU Springtac® and ODU Lamtac® contacts that provide 360 degrees of coverage and multiple contacts points for maximum reliability.





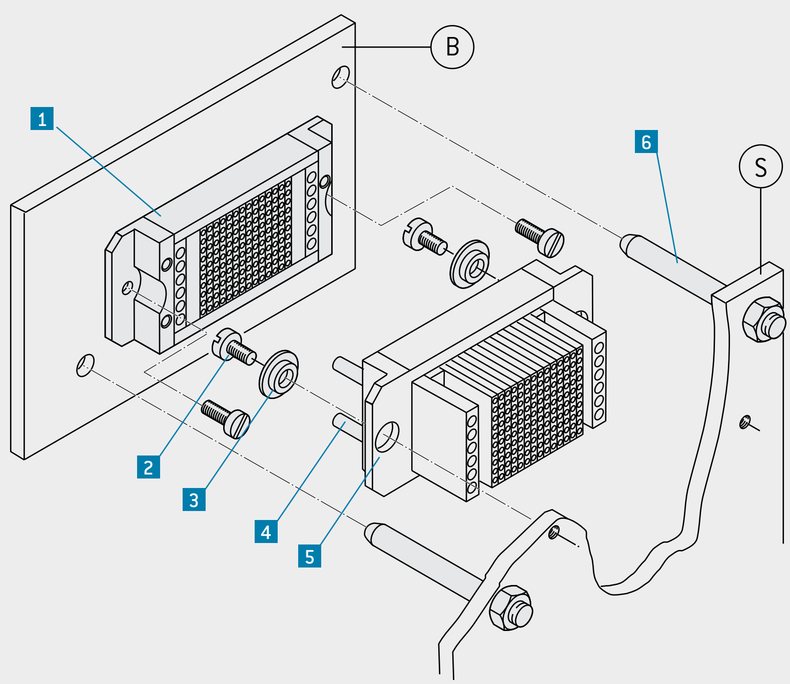


5. ASSEMBLY AND REPARABILITY

Ability of a damaged or failed equipment, machine or system to be restored to acceptable operating condition within a specified period (repair time). While many industrial applications utilize screw terminations frequently present on terminal blocks, for improved reliability and durability alternate methods must be used such as solder or crimp. The reparability of contact systems is dependent on the insulator and contact.

- Can the product be easily assembled and disassembled?
- Are fixing features, guiding features or attachments conventional and easily accessible?
- One important element with respect reparability is how the wires are connected, terminated and installed but also conversely disassembled.
- Can contacts be removed, replaced and repaired individually?
- How easy are modules arranged and replaced inside docking frames?

EXAMPLE OF AN S FRAME SYSTEM



Strain relief for cables / braids must be provided by the customer.

1. ODU-MAC® socket piece (fixed) (screwed tight without play to wall B)
2. Fastening screw
3. Tolerance compensation in the example of an S frame:
   Axial play: 0.2 mm
   Radial play: +/– 0.6 mm
4. Pins for self-centering of ODU-MAC®
5. ODU-MAC® pin piece (floating) (with play via centering socket; screwed tight to wall S)
6. Pin for guiding walls B and S (customer performance)

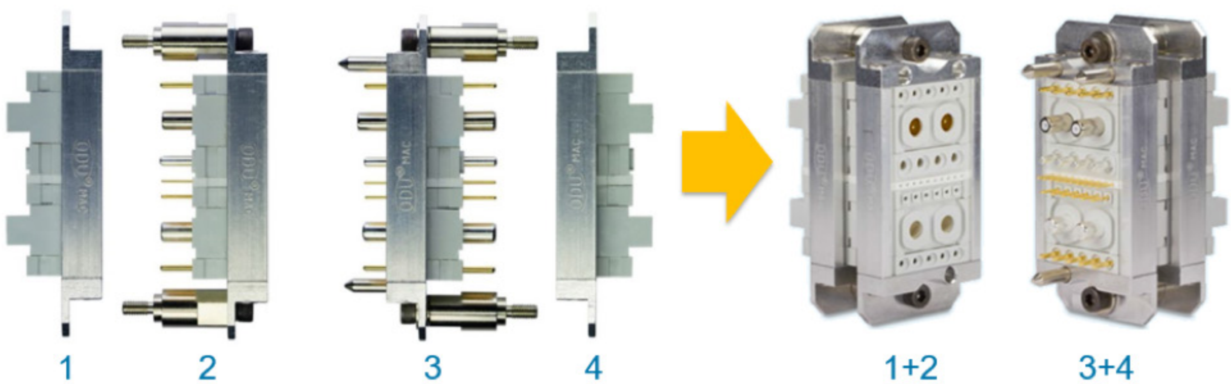
The values for the connected condition (pin S in B) result from the axial play of the centering sockets.

NOTE: AUTOMATIC DOCKING SYSTEMS

- The pin piece of the ODU-MAC® S is to be fixed with the accompanying centering sockets and has mounted floating
- The guiding system of the ODU-MAC® requires additional guiding hardware for the system
- The maximum permissible gap between socket and pin pieces is 0.5 mm as standard. Extension with long contact pins is possible.
- An alignment system (e.g. guide rails, etc.) is necessary to achieve high mating cycles. The max. permissible alignment error is, for example, with the ODU-MAC® S frame, less than +/– 0.6 mm radial
- Strain relief for the cables / braids must be provided by the customer.

6. PRODUCTION PLANNING AND EMERGENCY MANAGEMENT

A primary concern for any production environment is a line down situation. With proper MRO planning for vital equipment any potential risk of downtime can be mitigated greatly. When dealing with interconnects, a simple solution is the inclusion of Quick Change Heads (QCH) also commonly referred to as Connector Savers or Adapters. If an essential component is damaged, the use of an intermediary interface (swappable component), can be used for quick change and repair within a manner of minutes or just seconds. Future proofing the design through a replaceable exchange component allows for quick maintenance and/or repair, when it MATTERS THE MOST.



7. SUPPORT & CONFIGURATION

As with all product, the support offered should reduce decision making time and improve the selection process to marry the ideal product to the application(s). Efficiency, familiarity and support can be as important as the product performance during engineering evaluation and product selection. Is there real time, local support or conversely is there global support?

- Is there local expertise and partners that you can call directly?
- How easy are the web tools? Are there configuration tools?
- Is information easily obtained? Drawings? Engineering Models?
- Is cable assembly or other value-add services an option?
- Short delivery time

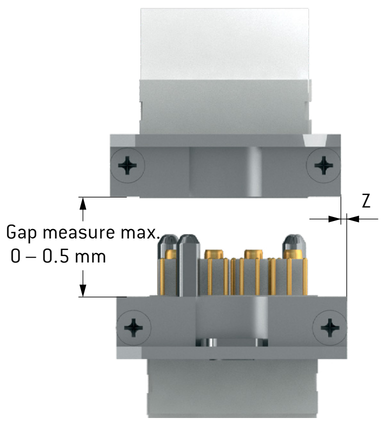
8. OTHER MECHANICAL CONSIDERATIONS

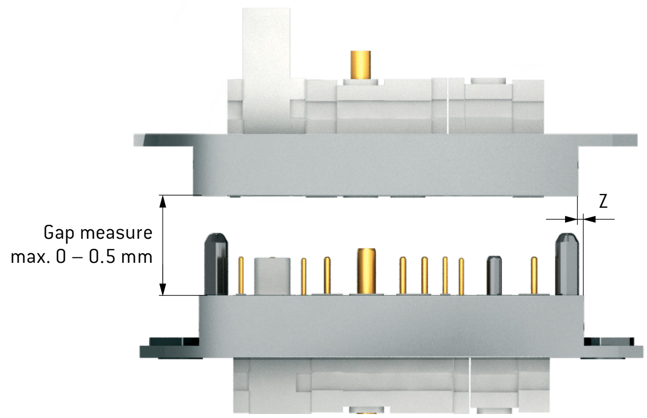
An example of one simple design aspect that impacts reliability and is vital to the final product performance over time, one doesn't need to look any farther than an evaluation of the guidance system.

- How is the load guided?
- How will the guiding system improve the electrical or interconnect system?
- Is strain relief of wire and cables necessary?
- Is there need for environmental sealing?

This consideration is often overlooked during the development process. There are multiple ways to guide a load, including V-groove, profile rail, guide pins, and guide rails etc… Regardless of what is being moved, there must be a way to support it. Simply put the electromechanical interface is primarily electrical for the purposes of test and measurement. The guiding systems must be able to allow for alignment within the connector tolerances. Fortunately, there is a wide range of connector tolerances which exceed most docking applications available from ODU. As an example the P+ frame allows for Radial and Axial tolerance of up to 2.5 mm.

MAXIMUM PERMISSIBLE OFFSET + STANDARD GAP MEASURE IN MATED CONDITION (RADIAL PLAY)



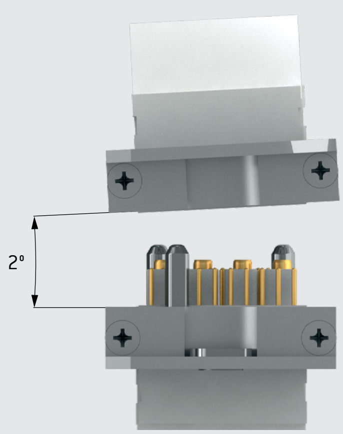


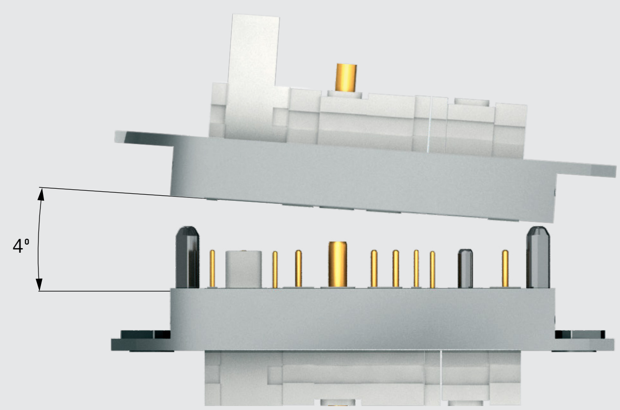
Frame	Tolerance z
S	+/– 0.6 mm
M+	+/– 0.6 mm
T	On request

Frame	Tolerance z
P+	+/– 2.5 mm
QCH	+/– 0.6 mm

The maximum permissible gap between socket and pin pieces is 0.5 mm as a standard. Extension with long contact pins is possible.

MAXIMUM PERMISSIBLE ANGLE DEVIATION WHEN MATING





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CONCLUSION

Once it is decided to create an automated test system, the aim is to develop the process and equipment that meet your primary objectives through best practices for robust test automation. When designing automated industrial systems, first consider the functionality of mechanical components but not without the disregard for the electrical test requirements. As stated before, collaboration up front can help reduce the overall deployment time and create a more stable test system. It is important to define the initial requirements including the ideal interconnects (docking connectors) for the correct manufacturing life. It is also important to consider flexibility into test platform, reducing the variability with each docking connection through integration of modular designs and associated tolerance stacking in a docking solution. Testing a manufactured unit at the end of the assembly line is a critical step in the production process. 100% automatic testing replaces more subjective testing by human operators to shorten the production cycle and to improve the reproducibility. The interconnect can be the first building block for collaboration between electrical and mechanical designs, or it can be the last component selected.

AUTHOR

Gary Reed
Head of Product Management,
ODU-USA

ODU-USA, Inc.
300 Camarillo Ranch Road, Suite A, Camarillo, CA 93012, United States of America
Phone: +1 805 484 - 0540, Fax: +1 805 484 - 7458, E-mail: sales@odu-usa.com

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