Marine Renewables
Connection systems solutions for Tidal & Wave Energy Devices

Wet mateable medium voltage power, low voltage auxiliary and fibre optic systems

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ONE SIEMENS
- Gearboxes
- Generators
- Power Conditioning
- Transformers
- Control Systems
- CONNECTION SYSTEMS
- Subsea Hubs
- Onshore Grid Connection
One Siemens

By embracing the 'One Siemens' philosophy, all parts of the marine renewables power generation system can be provided through a single source of supply. From gearboxes, generators, power conditioning and transformation to connection and control systems, subsea hubs and onshore power grid connection, 'One Siemens' can provide the solution.

Connection Systems Contents

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Siemens Subsea Connectors

For over 30 years Siemens Subsea Connectors have been delivering ultra reliable subsea connection systems. Siemens Subsea Connectors are recognised throughout the global subsea industry as a world leader in the design, manufacture and termination of wet mateable electrical and optical connection systems.

Marine Renewables

Formed in 2011, Siemens Subsea Connectors Marine Renewables line of business can supply connection systems that have been optimised for deployment with tidal turbines and wave energy conversion devices.

Siemens Subsea Connectors understand the extreme challenges encountered during offshore installations; from high tidal flows and high sea states to harsh subsea environments. Wet mate connection systems provide the most reliable solution to meet these challenges and allow connection between the subsea cable and tidal device, wave device or subsea hub, not only quickly but safely.

Economical electricity production from the ocean requires simple, cost-effective installation, maintenance and repair of subsea devices. Siemens Subsea Connectors understand that simple, safe and quick recovery of devices and easy disconnection from subsea cable is not only of major importance but also a major challenge. Wet mate connection systems are the enabling technology for removal or replacement of a turbine nacelle from its foundation or disconnection of floating devices from their mooring and cable system.
Integrated Scope of Supply

Siemens Subsea Connectors offer an integrated scope of supply encompassing everything from the end of a subsea cable through to penetration into a device including design, engineering development and the qualification testing required for a customers’ project.

A Siemens Subsea Connectors wet mate connection system will enable 3 phase power, low voltage auxiliary power and data transfer connection lines to be mated in one operation.

Although the physical appearance of the connection systems may differ, dependent on the device specific application, the philosophy remains the same: an ability to provide our customers with an integrated scope of supply from the subsea export cable, via a subsea mateable connection system, to a watertight device penetration, all under a single contract.

Siemens Subsea Connectors are able to design and supply wet mate connector systems that are specific for a wide range of marine renewable applications. Currently, a distinction can be made between connection systems that are designed for the following applications.

- A connection between a subsea cable and a turbine foundation or subsea hub
- A connection between a turbine foundation and removable turbine nacelle
- A connection between dynamic cables and floating devices

6.6kV cable and wet mate connector assembly supplied for a tidal device deployment at EMEC.

10kV Penetrator & Receptacle oil tube harness assembly.
Marine Renewables Applications

Illustrated are examples of different tidal turbines and wave energy conversion devices where Siemens Subsea Connectors connection systems can be utilised.
A connection between dynamic cables and floating devices
Siemens Subsea Connection Systems
(Example Systems)

Siemens Subsea Connectors offer a complete integrated scope of supply; one supplier for everything required to connect the subsea cable to the tidal device, wave device or subsea hub.

Connection between a subsea cable and a turbine foundation or subsea hub

The connectors are housed in a dynamic plug assembly terminated directly to the export or inter-array cable, the fixed socket assembly is bolted directly to the turbine or subsea hub foundation.

Connection between a turbine foundation and removable turbine nacelle

Connectors mounted on two stab plates, one attached to the turbine foundation tower and the other attached to the removable turbine nacelle.

Wet mate connector options: SpecTRON 690V to 11kV, DigiTRON low voltage auxiliary power and FoeTRON fibre optic
Connection between dynamic cables and floating devices

Connectors mounted on two stab plates, one attached to the end of the dynamic cable and the other attached to the floating device. The two stab plates are brought together by the same means as the mechanical mooring system for the device.
Siemens Subsea - SpecTRON Medium Voltage Power Connectors

The SpecTRON range of medium voltage connectors has a heritage that has been built up over 25 years of subsea deployments. The unparalleled track record of this market leading technology has resulted in a Mean Time Before Failure (MTBF) figure (5,422,400 hours, or 660 years), that can’t be matched by any of its competitors.

This technology has also undergone recent design and engineering work to enhance its applicability for deployment on Marine Renewables Projects.

Industry-Leading Engineering
- Industry-leading Research and Development facilities
- Industry-leading HV electrical testing facilities
- Industry-leading design and analysis
- Industry-leading experience

Reliability
- Reliability through design and experience
- Reliability through world-class production facilities
- Reliability through materials and manufacturing process
- Reliability and risk management through upfront simulation and experience
- Qualified for HV breakdown greater than 6U0.

SpecTRON 2
2kV (U) 1100A Connectors
SpecTRON 8
8kV (U) 300A Connectors

<table>
<thead>
<tr>
<th>SpecTRON 2 Connectors</th>
<th>SpecTRON 8 Connectors</th>
<th>SpecTRON 10 Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phases</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Connector current rating</td>
<td>1100 Amps</td>
<td>300 Amps</td>
</tr>
<tr>
<td>Maximum power throughput @ nominal system voltage</td>
<td>1.3MW @ 690V</td>
<td>1.7MW @ 3.3kV</td>
</tr>
<tr>
<td>Connector voltage rating U0/U (Um)</td>
<td>1.2/2 (2.4) kV</td>
<td>5/8.7 (10)kV</td>
</tr>
<tr>
<td>Typical Contact Resistance</td>
<td>-</td>
<td>&lt;0.1MΩ</td>
</tr>
</tbody>
</table>

Connector Selection

<table>
<thead>
<tr>
<th>Device Output</th>
<th>690V</th>
<th>1kV</th>
<th>2.2kV</th>
<th>3.3kV</th>
<th>6.6kV</th>
<th>11kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpecTRON product range</td>
<td>SpecTRON 2</td>
<td>SpecTRON 2</td>
<td>SpecTRON 2</td>
<td>SpecTRON 8</td>
<td>SpecTRON 8</td>
<td>SpecTRON 10</td>
</tr>
</tbody>
</table>

SpecTRON 10
11kV (U) 630A Connectors
Siemens Subsea- DigiTRON+ & DigiTRON e
low voltage auxilliary power and data connectors

DigiTRON+

DigiTRON+ is the latest generation of Siemens Subsea Connectors’s low voltage (1000V AC, pin to earth) connector. Once again, reliability of performance is central to the design and manufacture of this connector range. With over 250,000 connectors in service worldwide and a MTBF of over 414,000 years the DigiTRON range is unquestionably the world’s leading connector technology in its class.

Available in 4, 7 and 12 pin variants, the modular design of this connector range provides our customers with a wide range of possible configurations, meaning that a standard connector can be supplied for any subsea application.

<table>
<thead>
<tr>
<th>Electrical Specification - DigiTRON+</th>
<th>4 way connector</th>
<th>7 way connector</th>
<th>12 way connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum working voltage (pin to earth)</td>
<td>1000V rms (1414V peak)</td>
<td>1000V rms (1414V peak)</td>
<td>1000V rms (1414V peak)</td>
</tr>
<tr>
<td>Maximum working voltage (pin to pin)</td>
<td>2000V rms (2828V peak)</td>
<td>2000V rms (2828V peak)</td>
<td>2000V rms (2828V peak)</td>
</tr>
<tr>
<td>Maximum working current</td>
<td>35-40 Amps</td>
<td>22-32 Amps</td>
<td>20-28 Amps</td>
</tr>
<tr>
<td>Working current in air</td>
<td>18 Amps</td>
<td>14 Amps</td>
<td>11 Amps</td>
</tr>
<tr>
<td>Typical contact resistance</td>
<td>&lt;4 milliohms</td>
<td>&lt;4 milliohms</td>
<td>&lt;4 milliohms</td>
</tr>
<tr>
<td>Typical pin to pin resistance (connectors only)</td>
<td>&gt;100 Gigaohms</td>
<td>&gt;100 Gigaohms</td>
<td>&gt;100 Gigaohms</td>
</tr>
</tbody>
</table>

Stab Plate Deployment
- The stab plates provide movement and clamping force for mate / demate
- Compliant mounts on one connector accommodate misalignment

DigiTRON e

The most recent development in the DigiTRON connector range is our Ethernet compatible DigiTRON e connector.

Qualified in compliance with IEEE 802.3, this 12 way connector is capable of carrying 8 Ethernet lines at 100Mbps full duplex and 4 lines of low voltage (600V) auxiliary power, all packaged into the standard DigiTRON 12 way connector body.
Siemens Subsea - FoeTRON subsea fibre optic connectors

FoeTRON is a field proven wet mateable fibre optic connector and is a key element in any subsea communication system.

FoeTRON fibre optic connectors provide the means for optical subsea connectivity while excluding external contamination. This is critical in providing a consistent, low loss optical connection. This advanced product provides a connector capable of repeated mating operations and long term deployment in contaminated subsea environments and hence enables the use of fibre optic cable for communication and sensing applications.

The FoeTRON subsea connector range includes products that will provide wet mateable connectivity, subsea cable termination and fibre management, plus system test capability on the surface and subsea locations.

| Number of ways | 4 |
| Fibre size     | 0.125 mm single or multi mode |
| Fibre type     | 0.9 mm tight buffered |
| Insertion loss - single mode | > -1 dB @ 1310 & 1550 nm |
| Back reflection - single mode | < -25 dB |
| Cross talk     | ≤ -60 dB (between lines) |

The key features of the product are as shown in the table to the left.

FoeTRON ‘CE’ Principle - Sequence of Operations

1. Plug enters receptacle
2. Plug displaces receptacle insert carriage. Receptacle pin enters plug diaphragm
3. Receptacle optical contact is exposed and mates with plug optical contact
Technology Overview

All Siemens Subsea connectors are based on the CE (Controlled Environment) principle. This arrangement ensures the highest level of integrity for long life and repeated subsea mating capability.

- The CE plug features an oil-filled primary diaphragm to prevent water ingress.
  Each electrical socket is further protected within an individual secondary oil-filled diaphragm
- Both diaphragms have individual seals, failure of either seal would not compromise the connector’s integrity
- Shuttle pins prevent water ingress or loss of oil when the connector is not mated
- Insulated pins on the receptacle connector displace the shuttle pins during the mating process. The conductive tips of the pins are wiped twice before making contact with the electrical socket
- The whole assembly is pressure balanced to minimise stress within the sealing areas

Connector Range Design Features
1. Use pressure balancing to minimise material stress.
2. Include at least one level of redundancy (dual barrier) to water ingress.
3. Ensure material compatibility and traceability - the majority of Siemens Subsea Connectors subsea connectors have a 30 year design life with no requirement for servicing.

CE Principle - Sequence of Operations

1. Receptacle & Plug prior to mating
2. Receptacle pin engages with shuttle pin of plug assembly
3. Receptacle pin enters first oil chamber of the primary diaphragm and pushes back the shuttle pin
4. Receptacle pin enters secondary diaphragm and makes full contact with plug contact pin
LCM (Life Cycle Management) Services

Siemens Subsea LCM Services group provides a range of post-sales support. We have an extensive field service team of qualified and fully trained UK installation engineers along with teams based in Brazil, USA and Malaysia, whose expertise is utilised around the world, supporting our customers at both onshore and offshore locations.

**Our LCM Services**
- Connector installation and test
- Offshore deployment support
- Spares and inventory management
- Investigation support
- Condition reports / inspections
- Umbilical test
- Test connector hire

**Global Capabilities**
Our UK based service team has extensive experience of installing the full range of connectors at onshore and offshore locations around the world. Additionally, we provide growing and dedicated in-country support utilising locally based personnel. This not only provides focused in-country resource but also offers indigenous workforces where ‘local content’ is required. In country support is available in the UK, Europe, USA, Brazil, West Africa and Malaysia.

**Capabilities**
- Termination, installation and test of the complete connector range
- 24 hour access to inventory for spares and emergency scenarios
- Priority Service Response mobilisation within 24 - 48 hours
- Fully equipped vehicles and installation containers for large ‘on site’ project requirements
- On-site system interrogation and applications advice
- 24 hour 7 days a week telephone emergency response service
- Installations assured by warranty

- Paperless documentation system available to complement hard copy project records

**Service Team Profile**
Today, our installation engineers boast a combined experience of over 100 man-years and we continue to grow in order to meet market demand. Only our Engineers are certified for the installation and test of the Siemens Subsea connector range, ensuring the highest possible electrical performance throughout the connector life time.