Motor Drives for Oil and Gas Applications
- potential application areas and benefits of SiC devices

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Electric drives play a major role in the O&G production and distribution infrastructure

- pumping systems for oil; compression drive trains for gas infrastructure
US Shale Gas boom

Technology as driver for US O&G production

Conventional Reservoirs
small volumes, easy to develop

Un-Conventional Reservoirs
Large volumes, difficult to develop

Source: Steve Holditch, Texas A&M

Electrical Submersible Pumps
Challenges & Opportunities

Conventional Oil
VFD-driven pump motors

Challenges:
- High-temperature harsh environment for down-hole motor
- High power quality for top-side drive

Opportunities:
- high temperature
- reliability
- size & power

Unconventional Oil
Enabler: horizontal drilling

Challenges:
- Tight angles
- multi-phase flow

Opportunities:
- Power density
- Strong dynamic load changes
Mechanical & Electrical Compression Trains

“more electric” trend
Why Electric?

Mechanical Driven
- Gas Turbine 8MW Iso Range 34%
- Inlet 98%
- Average degradation 97%
- Auxiliaries 97%
- Exhaust 99%
- Compressor 82%

Efficiency 25.4%

Electric Driven
- Compressor + Aux. 78%
- Motor 96.5%
- VFD 98%
- Transformer Transf 99%
- Substation Transf 99%
- Transmission 95%
- Power Generation (Combined cycle) 58%

Efficiency 39.8%

- Electrical solution +50% more energy efficient than gas fired solution
- 45% saving on CO2 emission
Integrated Electrical-Mechanical Systems

Technology progression:
Geared electric --> direct drive electric --> fully integrated electric compressor
Evolution of Subsea Production

- Long Stepout ... 100-600 km
- Deeper waters ... 3 km depth
- Increased power ... 100 MW class
- Multiple loads

Reliability ... Availability
World’s first motor-compressor & subsea VSDs

<table>
<thead>
<tr>
<th>Blue-C Moto-Compressor</th>
<th>Compressor VFD</th>
<th>Pump VFD</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td>5.6 m (h) x 2 m (d)</td>
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<tr>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td>10.5 m (h) x 3 m (d)</td>
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- High frequency drive ... 100 bar pressure, 10 yrs maintenance
Typical Drive for High Speed Motors

- Multi-level drive with series connected devices
- Selective harmonic elimination
  - optimized to reduce losses in drive plus motor
- Output filter to reduce $\text{dv/dt}$ and harmonics

✓ 10kV+ SiC devices will allow compact, efficient two-level high speed drives
Typical high speed motor vs drive

Power Density challenge:
State-of-the-art Drives are 3-5x Motor size
Typical Drive for ESP

- LV drives are typically used instead of MV drives
  - lower cost
  - better waveform quality due to faster switching speeds

- Sine wave filter plus transformer for step-up

- SiC MV drive with high power quality can provide a compact alternative
Opportunities for Silicon Carbide

Wide range of demanding motor drive applications for O&G

Some high-power compressor motors are high speed
Most high-power motors are VFD-driven,
AND they will benefit from SiC advantages of

- compactness
- high-temperature capability
- fast switching (reduced filters, cleaner motor currents)
- high efficiency
Thank you