EXHIBITOR STAGE

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9 – 11.6.2026
NUREMBERG, GERMANY

Advanced Conversion Capacitor Technology and Solutions

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Messe Frankfurt Group

Agenda

- Introduction
- Film versus Form Factor
  - The Power Ring Advantage
- Packaging and Connections
- Examples
- Engineering Pre-Study
- High temperature capabilities
  - Peak NanoPlex™
  - Gore® High Temperature Film
- Conclusion
- Questions

Introduction

- Advanced Conversion offers next generation metallized film capacitor technology
- We have a unique winding capability to make high performance annular capacitors
  - High temperature film options
- We specialize in complete capacitor solutions that are part of the ecosystem for fast switching
  - Packaging and mounting
  - Optimized connections to the customer system

Introduction (cont)

- Facilities
  - Barre, Vermont, USA – ISO 9001:2015
    - US production and corporate headquarters
  - Loveland, Colorado, USA – AS9100D
    - Design and prototype production
  - Xiamen, China
    - Asia production
    - Sub-assemblies

Introduction (cont)

- Markets include
  - Medical laser
  - Pulsed power
  - DC link
    - Traction drive
    - Grid (HVDC)
    - DC – DC
    - Aviation
    - Network power

- Product offerings
  - Standard parts
    - Discrete Power Rings
    - Universal buses
    - Integrated DC link test kits
  - Custom designs
    - Fully integrated capacitor/bus solutions
    - In-house bus design and fabrication

Film versus Form Factor

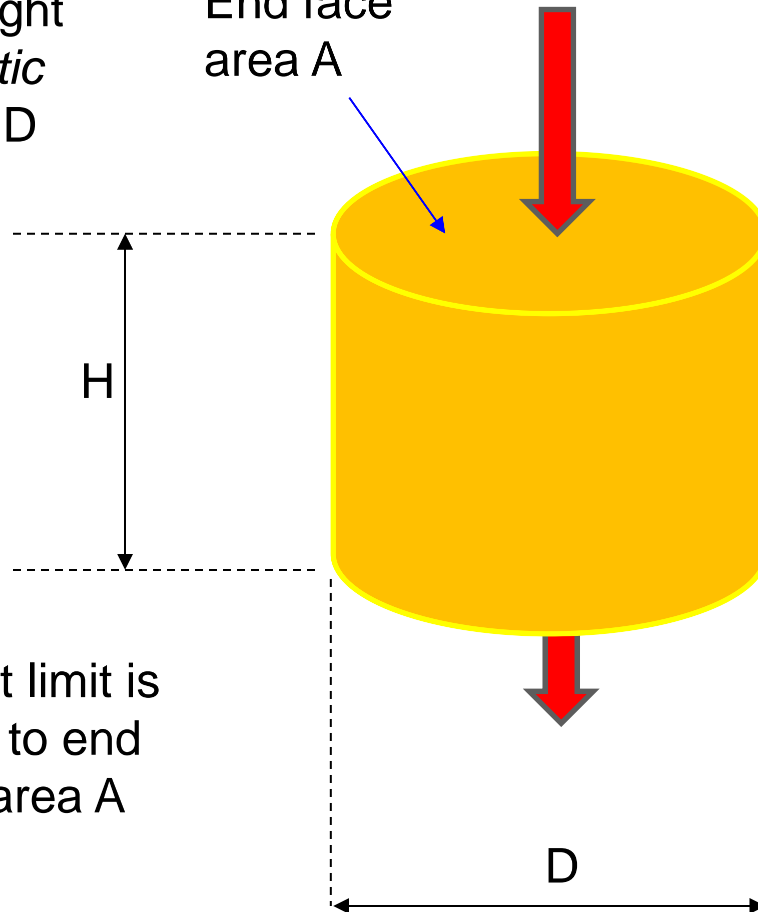
- The capacitor film defines some parameters
  - Dielectric constant
  - Dissipation factor (of the dielectric)
  - Voltage breakdown strength
  - Self-healing capability
  - DC leakage
  - Thermal conductivity
  - Heat capacity

Film versus Form Factor (cont)

- The capacitor winding form factor (shape) defines additional parameters
  - Equivalent series resistance (ESR) of the metallized electrodes
    - Ohmic losses
  - End connection peak current capability
  - Thermal resistance to hotspot
  - Possibilities for mounting

Film versus Form Factor (cont)

Capacitance is *linear* with height H and *quadratic* with diameter D



Peak current limit is proportional to end connection area A

End face area A is proportional to D^2

Electrode resistance is proportional to H/A

Dielectric dissipation loss depends on capacitance and frequency NOT form factor

ESR includes electrodes and dielectric dissipation

Thermal resistance R_{th} is proportional to H/A

$\Delta T = I^2 \times ESR \times R_{th}$

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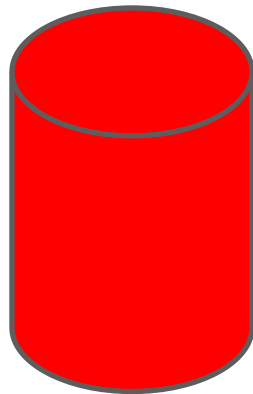
Film versus Form Factor (cont)

Consider two windings with the same capacitance value and different form factors

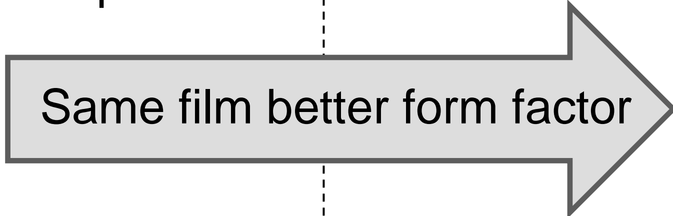
1. Higher electrode losses
2. Higher thermal resistance
3. Same dielectric loss
4. Lower peak current
5. Easy to wind on standard equipment



"Can" style capacitor

"Ring" style annular capacitor

1. Lower electrode losses
2. Lower thermal resistance
3. Same dielectric loss
4. Higher peak current
5. Proprietary technology and winding
6. Lighter metallization supports higher voltage stress with no ESR penalty



10x lower electrode ESR
10x lower R_{th}

Lower performance, capacitor is not the limit

Higher performance, capacitor enables system level win

The Power Ring Advantage

- Film is film to all capacitor vendors (in general)
- The Advanced Conversion Power Ring winding provides the highest A/uF rating for ANY film
  - Minimize uF/kW and improve power density
- A single monolithic winding can be more space efficient
  - Don’t waste volume on duplicated packaging with multiple discrete parts
- Design, simulation, and testing to support demanding applications

Packaging and Connections

- An optimal winding is only part of the answer…how do we help get the most value out of expensive switching elements?
  - Connections
    - Minimize equivalent series inductance (ESL) to enable fast switching
    - Control the current distribution
    - Support effective paralleling of devices
  - Packaging
    - Enable efficient heat transfer
    - Mechanical mounting - use hollow cores of windings rather than an external flange and reduce footprint

Packaging and Connections (cont)

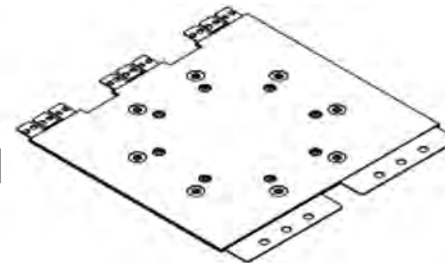
- Optimize capacitor connections to minimize the loop area as much as possible
- Provide a properly designed bus bar to extend optimized capacitor connections to the customer system
- Capacitor design must be able to manage thermal expansion, shock, and vibration

Examples - DC Link

Good
ESL < 5nH for the capacitor if properly connected

Standard discrete capacitor with distributed parallel terminals

Better
ESL 3-5nH for cap/bus, module connection is the limit, 8-12nH



Discrete capacitor with a "universal busbar" that provides DC input and optimized module connections

Best
ESL 2-3nH for cap/bus, module connection is the limit, 4-10nH

Integrated test kit with windings "surface mounted" on the bus eliminates duplicate copper and reduces height. Optimized DC input and module connections.

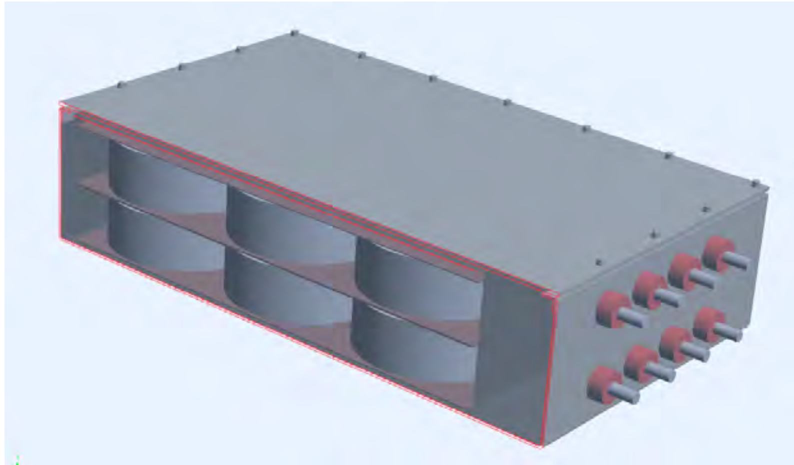
Examples – DC Link (cont)

- Full range of test kits and modules supported
  - Infineon HybridPACK™ Drive
  - Cissoid CPAK-HPC
  - onsemi VE-Trac™
  - Hitachi RoadPak
  - Semikron Danfoss DCM™
- Custom designs with fully integrated bus
  - Bus technologies include laminated, powder coated, and specialty dielectric coating
  - Fast prototyping

The Engineering Pre-Study

- Custom designs are *challenging*…consider a small funded engineering study prior to committing to a full prototype design
  - Define and clarify specifications
  - Look at capacitor winding options to implement the requirement
  - Run lumped models to estimate hotspot temperature rise
  - Correlate temperature and voltage with life data
  - Topology concept for optimized interface
  - Formal presentation and budgetary quote for prototype development

Examples - HVDC



The dielectric dissipation losses are the same as conventional part

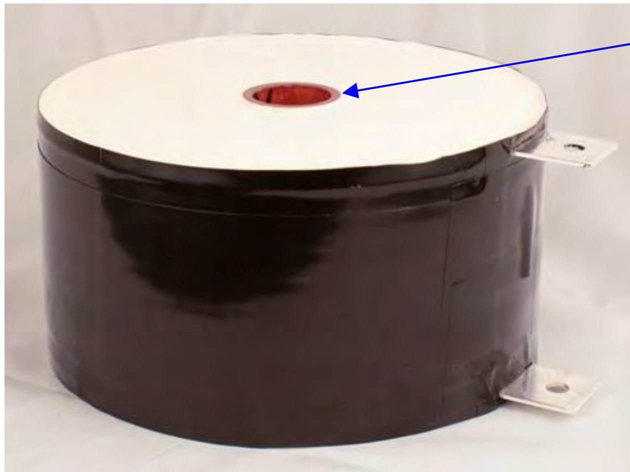
Electrode ESR can be reduced by up to 3x with optimized form factor windings

Path forward for reduced ESL… Windings surface mounted on a bus that extends over switch modules

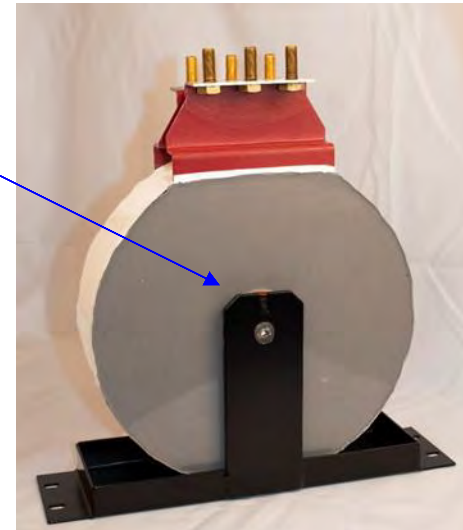
Examples - Pulse

Very large end connection can handle peak currents up to 100kA using metallized dry film rather than foil

Core mounting to make a low-cost high-performance cap with no box required



Hollow core enables useful mounting options



Standard part series offer a range of capacitance values up to 8kV

Custom designs are also available

High Temperature

- We can now support three temperature regimes
  - Polypropylene: Up to 105C
  - Peak NanoPlex™ LDF: Up to 135C
    - Replacement for Kaladex™ PEN HV
    - Low dissipation factor and high breakdown strength
  - Gore® High Temperature Film: Up to 200C
    - Proprietary PTFE-based film with excellent self-healing and no voltage de-rating required
    - Key enabling technology for down hole (oil, gas, and geothermal) and aerospace applications

Mason Wolak is presenting *High Temperature Metallized Film Capacitors Utilizing Low Dissipation Factor (LDF) Nanolayered Film*
Wed June 10 at 15:30

High Temperature (cont)

- Peak NanoPlex^{TM} LDF
  - Moving to commercial scale with multiple thickness options
  - Excellent fit for Advanced Conversion winding technology

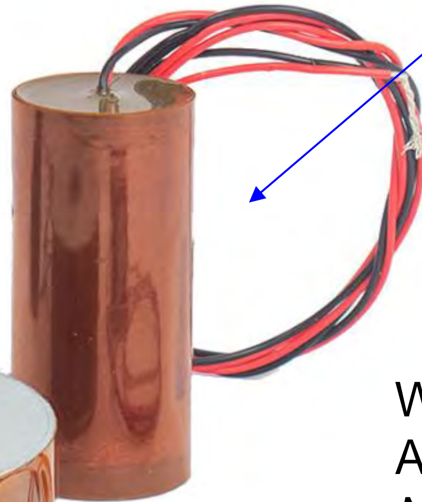
Advanced Conversion is now offering preliminary 910A series DC link test kits for Infineon, Cissoid, and onsemi, six pack modules!

High Temperature (cont)

Gore® High Temperature Film
Advanced Conversion Production Line

Power Ring Winding with better form factor

Wrap and Fill with Flying Leads



Standard Products
- 400Vdc
- 600Vdc

W. L. Gore and Associates and Advanced Conversion paper:
Next Generation 200ºC Film Capacitors Enable Optimized Power Conversion Solutions for Harsh Environments
June 11 at 14:20

High Temperature (cont)

- W.L. Gore has tested Advanced Conversion capacitors to validate performance in extreme environments
  - Insulation Resistance (DWV) MIL-STD-202G, Method 301, Condition A (600 V), Pass
  - Thermal Cycling MIL-STD-883J, Modified Condition D (-30°C to +170°C), Pass
  - Lead Pull MIL-STD-202G, Method 211A, Test Condition A (5 lbs), Pass
- Customers have also performed in-situ shock and vibration testing
- Please attend our paper on life testing…

Higher Temperature (cont)

- APCS winding technology enables full utilization of new films with our optimized form factor
- Very low ESR and R_T exploits higher hotspot limit
  - Higher temperature rise due to ripple current
  - Higher ambient temperature
- Numerous lead attachment and packaging methods in development

High Temperature (cont)

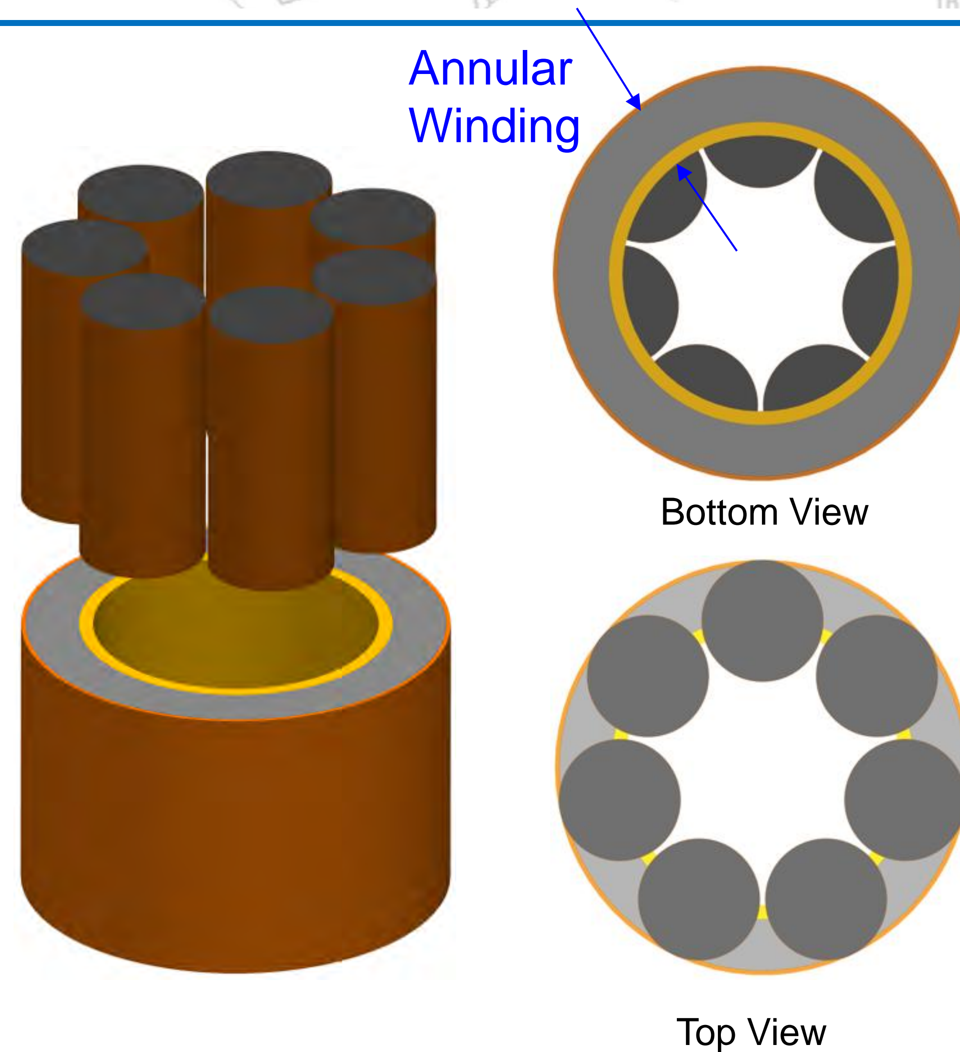
- Down hole applications fit into round pipes
  - Why not make a more efficient single Power Ring to replace an array of discrete parts?

909D127*
170uF at 400Vdc
40Arms at 175C
Core ID 2.5”
Distributed connections

*Uses the same materials and process as smaller standard wrap and fill products

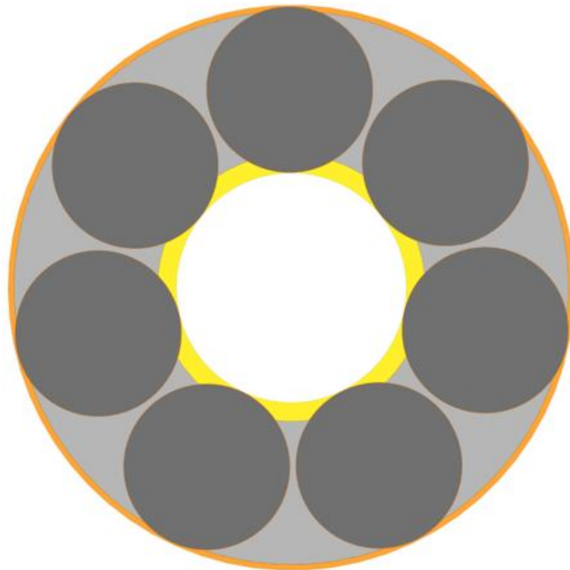
High Temperature (cont)

- Consider an array of 7x 25uF discrete parts to achieve 175uF
  - The height is the same
  - The discrete parts take up a lot more cross section…



High Temperature (cont)

- If the inner diameter of the Power Ring winding is reduced to match the array of discrete parts, the capacitance will be 310uF



More than 75% improvement on volume efficiency

The 7x discrete parts only add up to 175uF

Future Work

- We are now developing higher voltage DC link capacitors
  - Devices are now driving DC voltages into the 6kV range
- We have some unique capability to utilize existing films for higher voltage
  - Single section design is critical to eliminate concerns of voltage balancing and poor capacitance density
- Stand by…

Please Visit Our Booth 9-542

- We are happy to discuss your unique system requirements and goals
  - High temperature film experts are attending
    - W. L. Gore and Associates (Connor Carr)
    - Peak Nano (Mason Wolak)
- Hardware examples on hand for discussion

THANK YOU FOR YOUR ATTENTION

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This presentation is available at the PCIM website

Thank you for your attention!

I'm pleased to answer your questions:

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