

**3M** Science.  
Applied to Life.™

# 3M™ Twin Axial Cable Assemblies

Electronics Materials Solutions Division

2017

# **Our Vision**

**3M Technology Advancing Every Company**

**3M Products Enhancing Every Home**

**3M Innovation Improving Every Life**

Our Vision  
 3M Technology Advancing Every Company  
 3M Products Enhancing Every Home  
 3M Innovation Improving Every Life

Our Strategies

- Expand Relevance to our Customers and our Presence in the Marketplace
- Gain Profitable Market Share and Accelerate Market Penetration Everywhere
- Invest in Innovation: Invigorate Existing Market Opportunities and Focus on Emerging Megatrends

3M's Code of Conduct

The Fundamentals

**Be good**

Obey the law and 3M's Code of Conduct.

**Be loyal**

Protect 3M's interests, assets, and information.

**Be honest**

Act honestly.

**Be accurate**



3M



Portfolio Management



Investing in Innovation



Business Transformation

# Bringing Solutions to Markets Through Our Business Groups

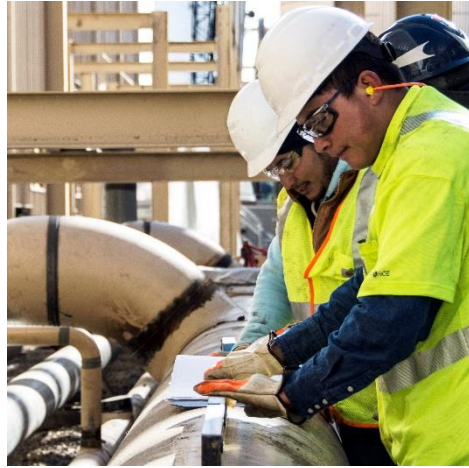
2016 Results

**3M** \$30.1B Revenue



Health Care

**\$5.5B**



Safety & Graphics

**\$5.7B**



Industrial

**\$10.3B**



Electronics & Energy

**\$4.8B**



Consumer

**\$4.5B**



# Electronics & Energy Business

2016 Sales \$4.6B



- High performance films
- Electronics design materials
- Sustainable chemistry
- Semiconductor solutions



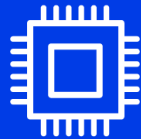
- Connecting components
- Electrical tapes & supplies
- Coatings & adhesives

# 3M Electronics Materials Solutions Division

Enabling our customers' next generation of technology to advance a more connected world



Sustainable  
Chemistry



Semiconductor



Device  
Components &  
Assembly



Signal  
Management

Sustainable chemistry and materials solutions across the electronics ecosystem

# Solutions for Data Centers

## Market Needs

Greater data demand and pursuit of operational efficiencies driving continued growth of hyperscale data centers

Increased bandwidths and speeds driven by data demand growth and need for decreased latency

Compute-intensive neural networks to enable machine learning and artificial intelligence

Growth of data centers closer to the edge to address the latency demands of IoT

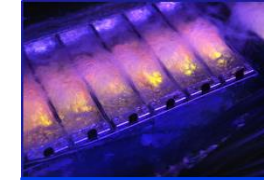
## 3M Solutions



Twin axial cable assemblies



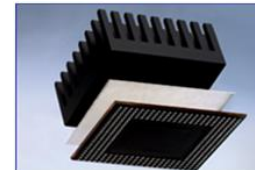
Moisture & corrosion protection coatings



Immersion cooling



Fire suppression



Thermal management



EMI/EMC materials



Vibration & acoustic control solutions



Bonding materials

# Contents

- 3M™ Twin Axial Cable technology
  - Unique construction
  - Electrical performance
  - Thin and foldable
  - Improved terminations
- 3M™ Twin Axial Internal Cable assemblies
- 3M™ Twin Axial External Cable assemblies

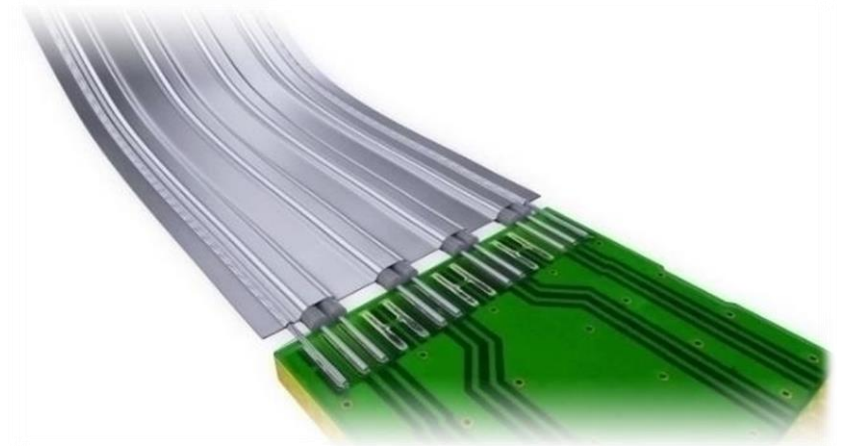


**3M™ Twin Axial Cable technology**

# 3M™ Twin Axial Cable has a unique continuously laminated shield

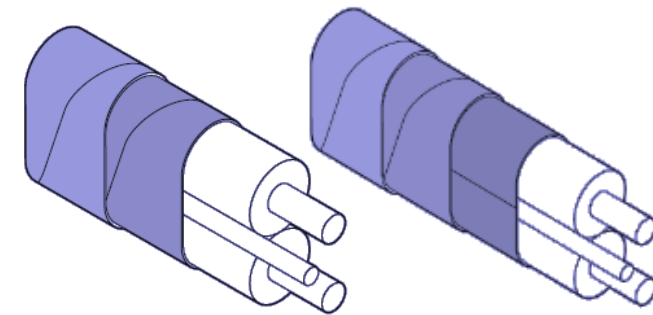
3M employs a unique precision-formed continuously laminated shield over entire cable, to deliver:

- Precision and control
- Thinness & flexibility
- Creasability without loss of performance



Competition uses spiral/longitudinal wrapped shield around individual pairs, optionally further laminated together:

- Thicker, less flexible
- Performance degrades in tight bends



# Valuable attributes are provided by the unique construction

## Electrical Performance

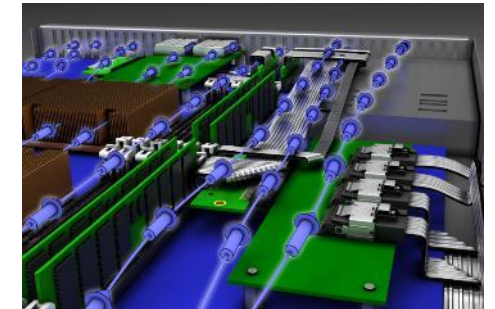
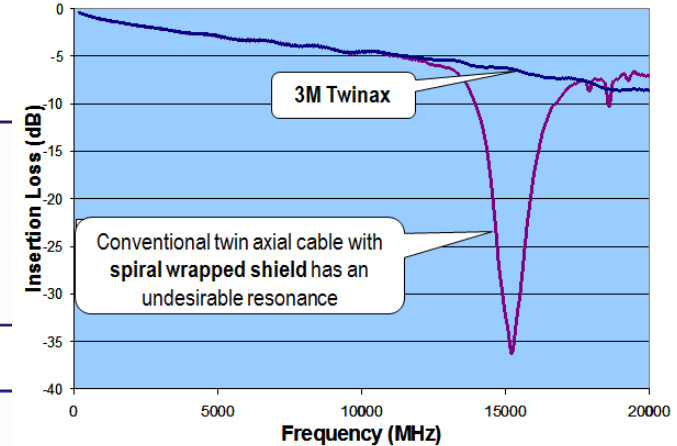
- **High Bandwidth** - resonance-free beyond 20 GHz
- **Excellent SCD21 & skew**

## Thin and Foldable


- Allows cable to be run through “non useable” space
- Can be oriented to avoid blocking airflow, **increasing cooling efficiency**
- Can be folded at very **tight bend radii** without SI degradation

## Improved Terminations

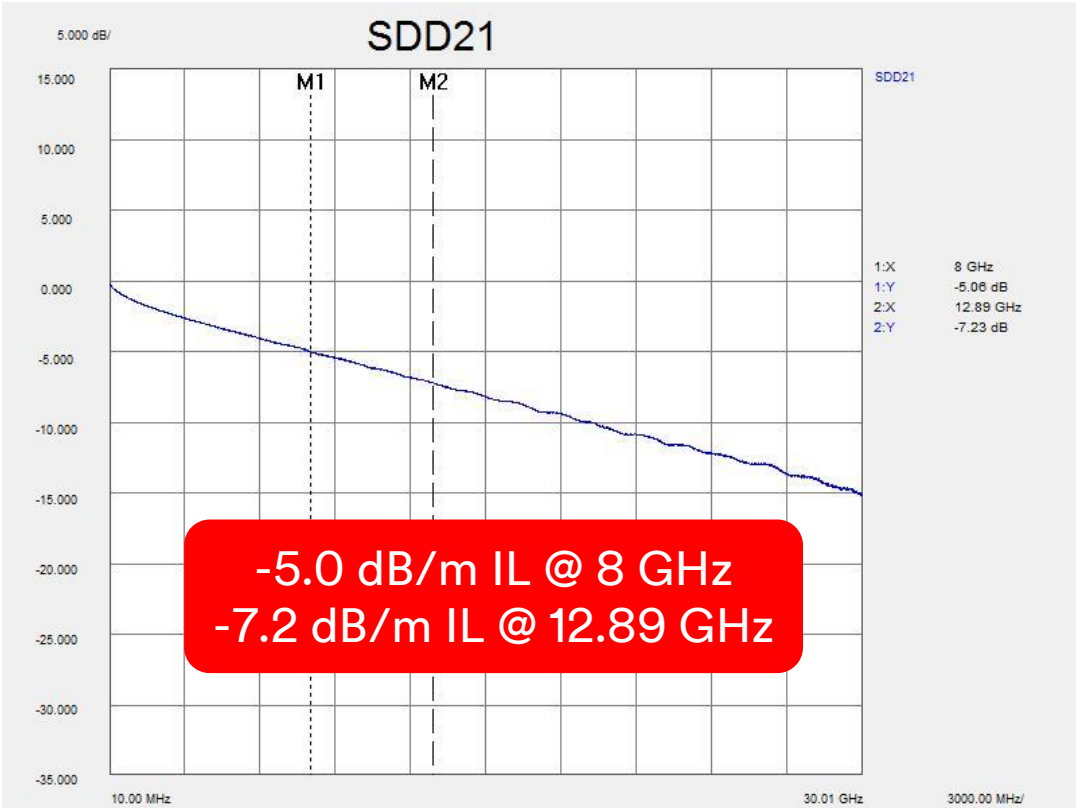
- Ribbon construction **fixes locations** of signals and grounds
- **Efficient termination** process with no wire routing errors
- Ribbon construction minimizes termination variability for more **reliable and repeatable** processes



# Excellent electrical performance

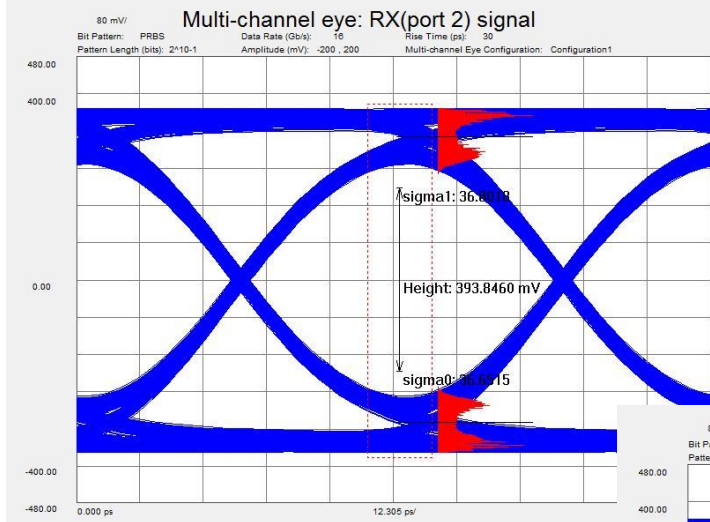
Cable construction: 

## Measured loss (85Ω, 30 AWG, 1 m)



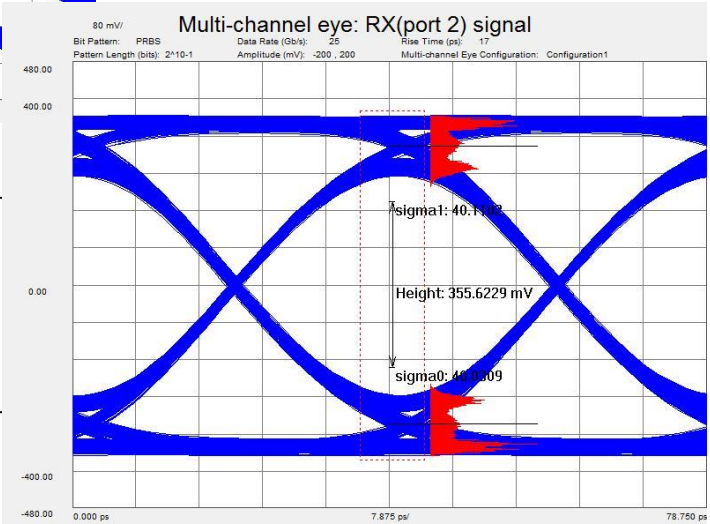
Test IR9471

## Simulated eyes (Rx FFE equalization 2 pre & 5 post taps)



**16 Gbps**  
**Eye = 64% open**  
**Tx Pre-emphasis: none**

**25 Gbps**  
**Eye = 60% open**  
**Tx Pre-emphasis: none**



# Alternative for unacceptable losses in PCB transmission

Driving adoption inside servers in switches

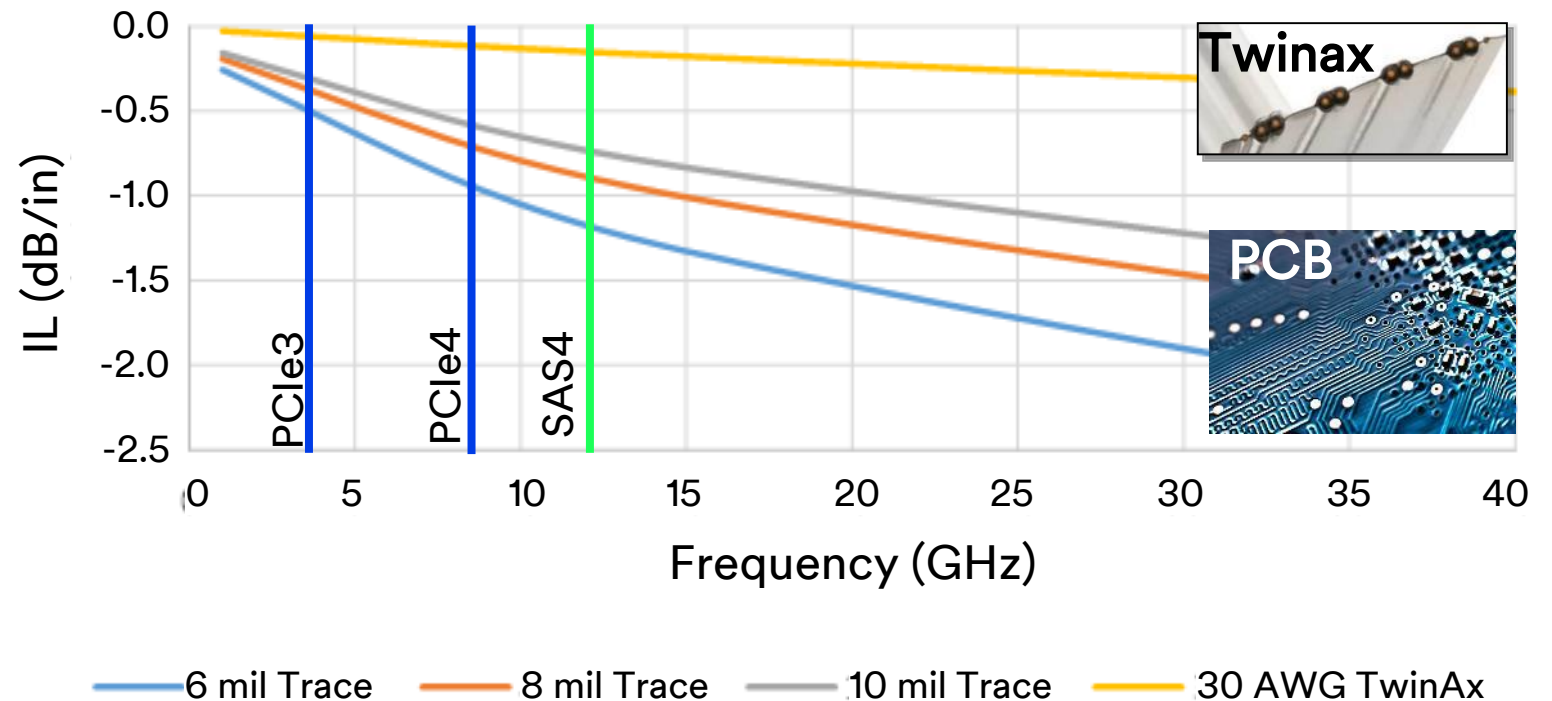
Significant growth in internal server cabling to connect increasingly dense layouts:

- CPU – CPU
- CPU – GPU
- Controller - NVMe SSDs

Typical distances: ~30cm → 1.5m

Cabling need likely to expand with migration to PCIe4 & SAS4

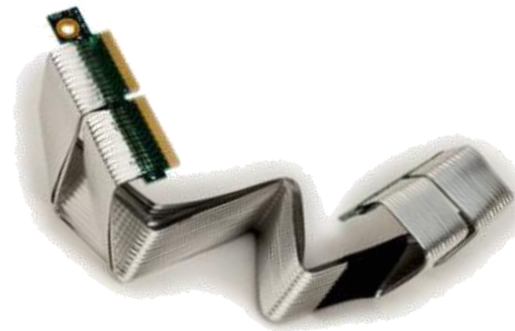
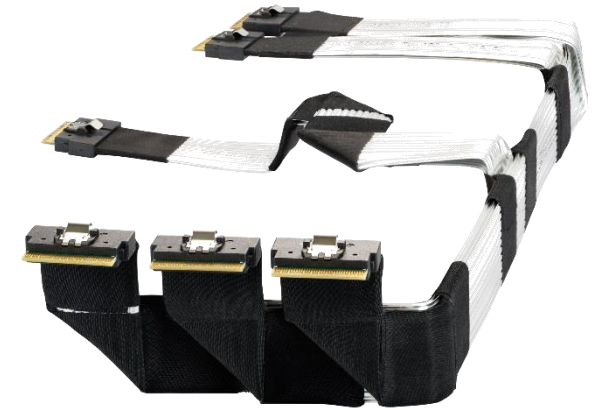
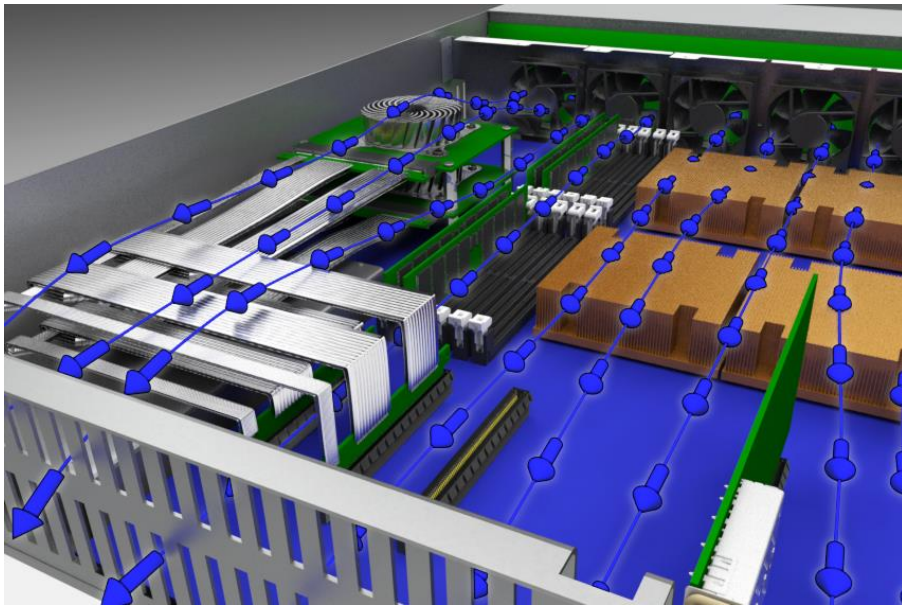
**Transmission losses (dB/in) by frequency:**  
*Coupled microstrip pairs in Megtron 6 vs 30 AWG 3M™ Twin Axial Cable*





# Thinness and foldability enables “hard good” cable assemblies optimized for installation and airflow

- Thin ribbon and folding capability utilized to improve airflow
- Pre-folded assemblies help to:
  - Enable clean, consistent routing
  - Simplify installation



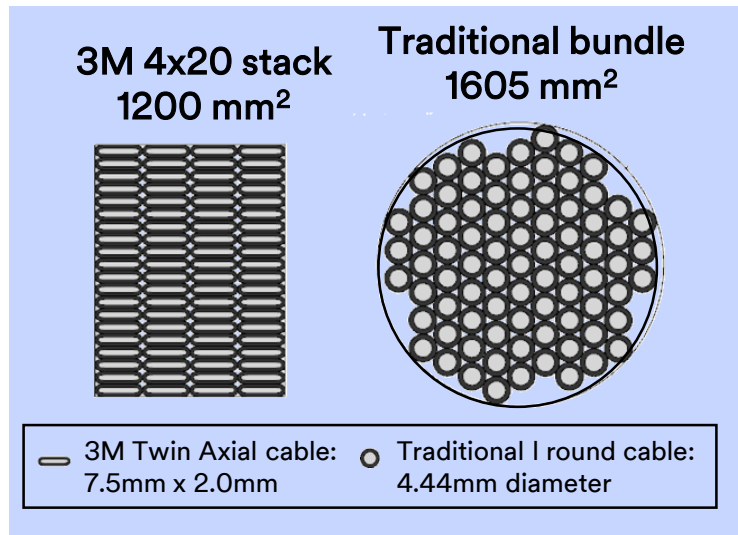
# Thin and foldable cable benefits for external cabling

## Space savings

With the flat, thin cable construction, 3M™ Twin Axial Cable helps to provide space savings.

Illustrating the difference in space saving, a bundle of 80 - 30AWG SFP+ cables is compared – 3M Twin Axial Cable versus traditional round cable.

### 25% savings of cross-sectional space

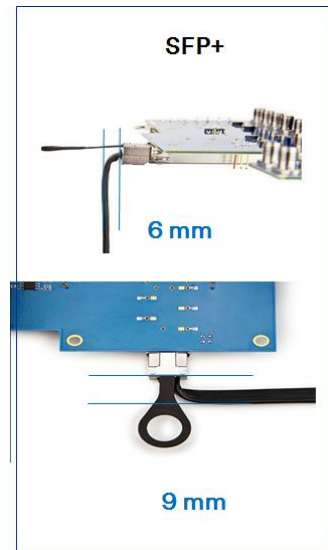


## Tight bends at the connector

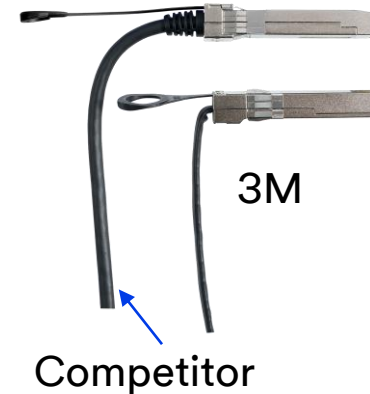
With the foldable cable construction, 3M Twin Axial Cable is able to make tight bends at the connector

For SFP+ and QSFP+ at the connector:

- Minimum bend space up/down is 6mm
- Minimum bend space left/right is 9mm



### SFP28 bend at connector:



## Small bend radius

3M™ QSFP+ Twin Axial Cable Assemblies have a smaller bend radius than traditional twin axial cable assemblies.

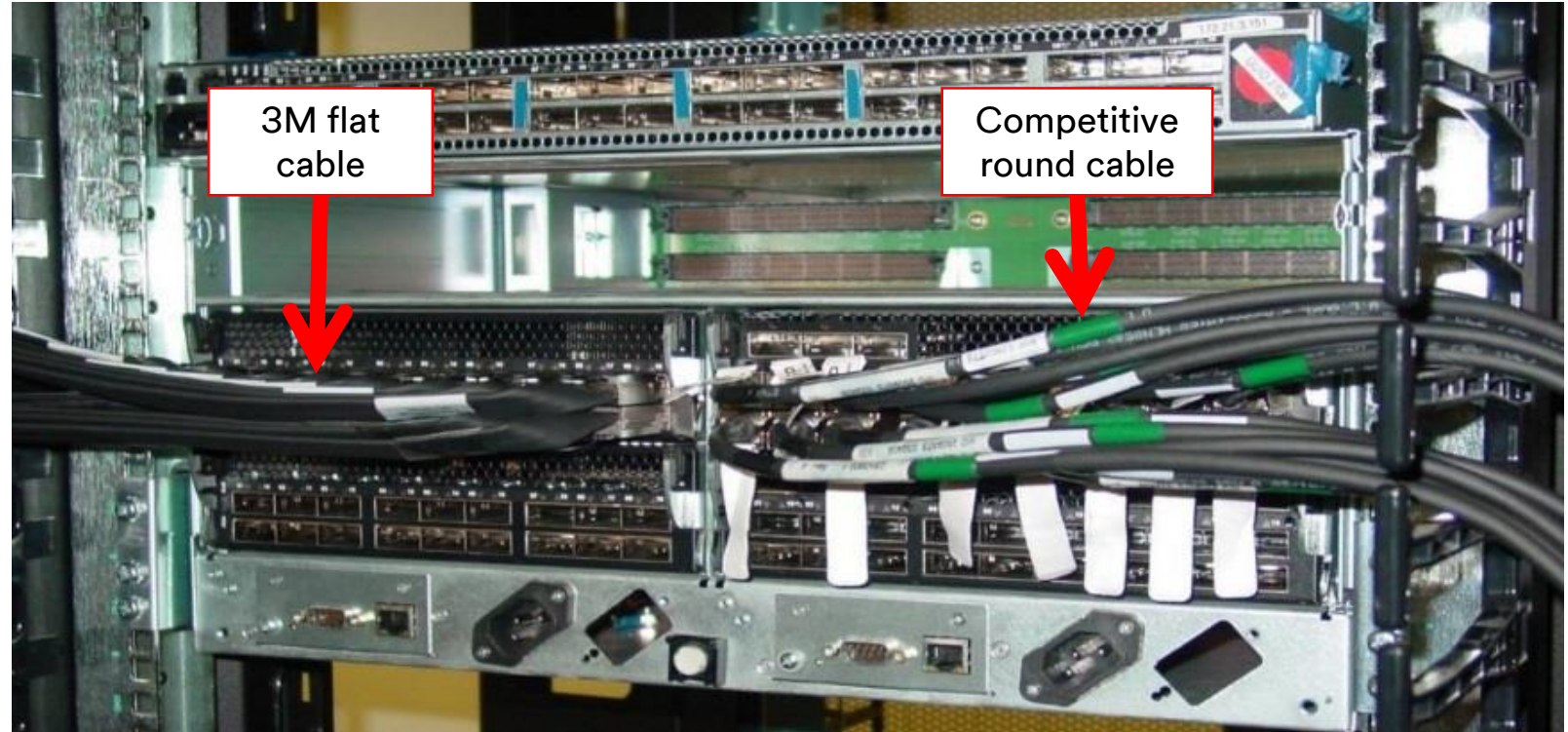
When managing cables in the rack, this allows for efficient routing of cables with tight bends and folds to minimize obstructions to airflow and allow for better access to ports.

### SFP28 bend radius: 3M vs Competitor



# Thin and foldable cable helps optimize cable management – helping save energy and space and improving serviceability

- ✓ Helps improved rack cable management
- ✓ Helps save energy with better air flow management using flat, flexible cables
- ✓ Helps improved serviceability – easier to access ports
- ✓ Space saving





# Folding comparison: 3M™ Twin Axial Cable vs competition

## Test set-up

**Objective:** Characterize/quantify benefit of 3M Twin Axial Cable design/construction on folded signal integrity performance, relative to more conventional twinax constructions

### 3M sample:

3M™ Twin Axial Cable SL8802/08-20DN5-00

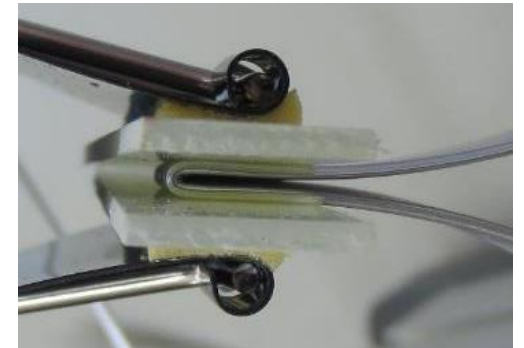
(4-pair ribbon, 30 AWG, silver-plated signal)

### Competitive samples:

All are 30 AWG, silver-plated, foamed dielectric

- Vendor “A”
- Vendor “B”
- Vendor “C”

Results archived under 3M test request IR9280



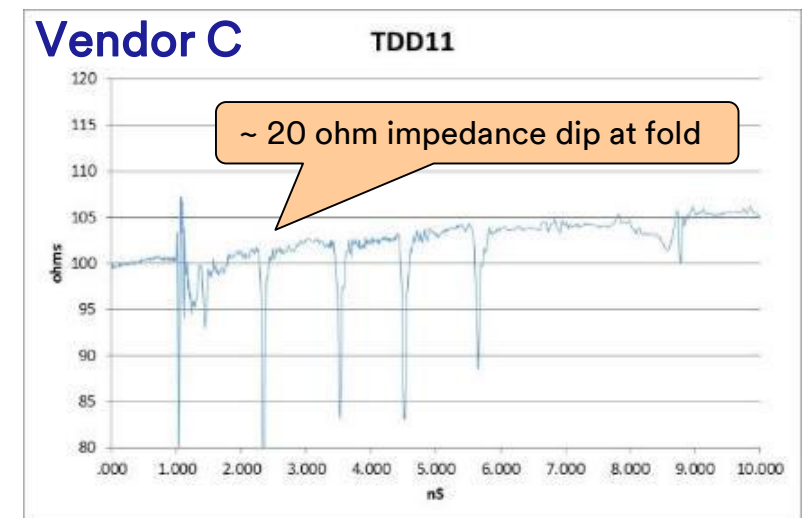
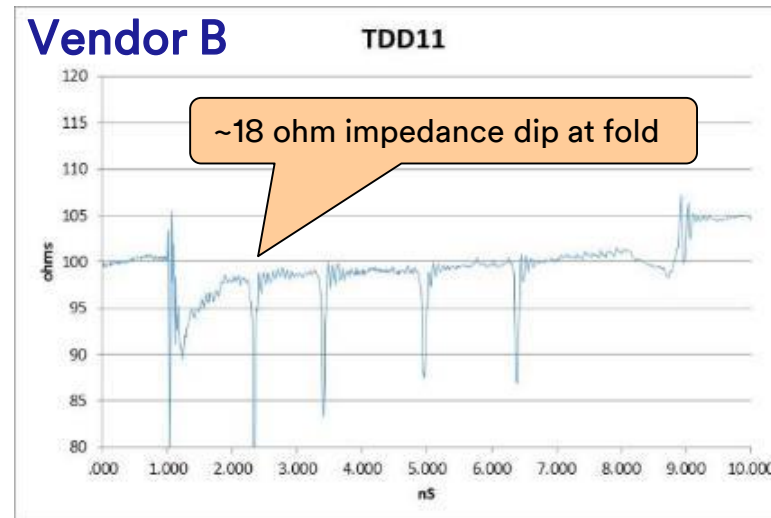
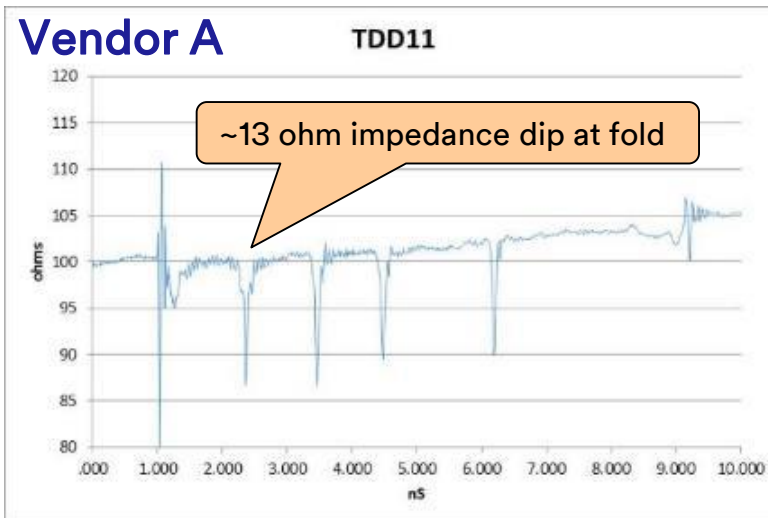
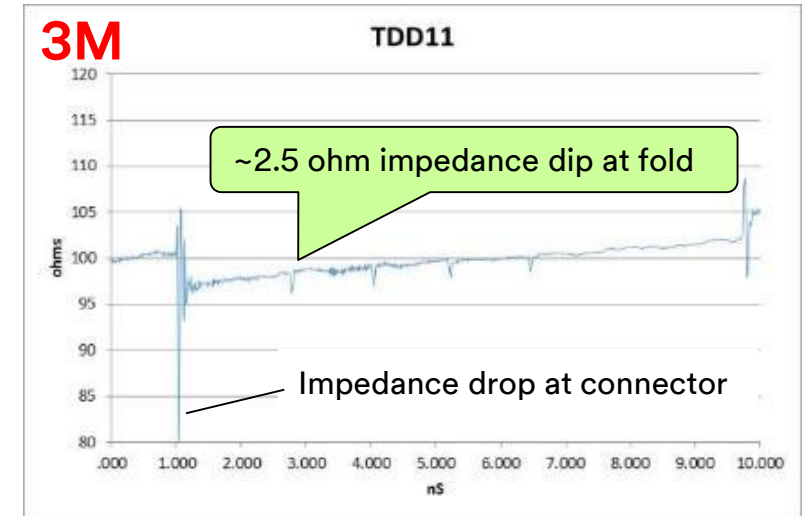
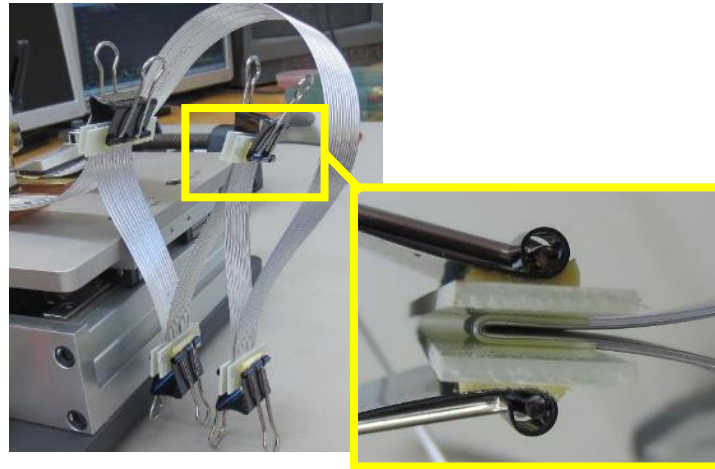
# Results of folding comparison

## 4-fold differential impedance measured with 11ps rise time

**Test:** Characterize/quantify benefit of 3M™ Twin Axial Cable on folded signal integrity performance relative to conventional twinax constructions

**Test samples:**

- 3M™ Twin Axial Cable SL8802/08-20DN5-00 (4-pair ribbon, 30 AWG, silver-plated signal)
- Competitive samples: 30 AWG, silver-plated, foamed dielectric





# Cable folding evaluation – 180 degree, static folding

## Test set-up

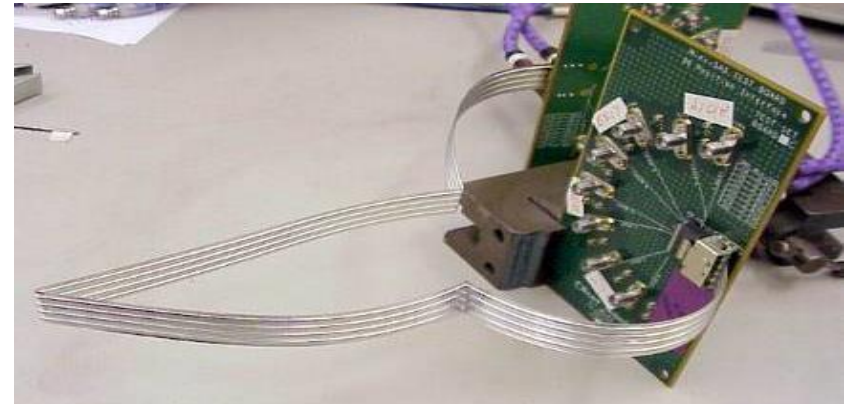
**Objective:** Evaluate effect of static folds on signal-integrity performance of 3M™ Twin Axial Cable, SL8800 Series

**Material tested:** 30AWG ribbon Twin Axial Cable, silver-plated signal wire (3M Twin Axial Cable SL8803/08-101N5-00)

**Samples:** From IR8175 qualification test samples; Previously subjected to 85C/1000 hours heat aging

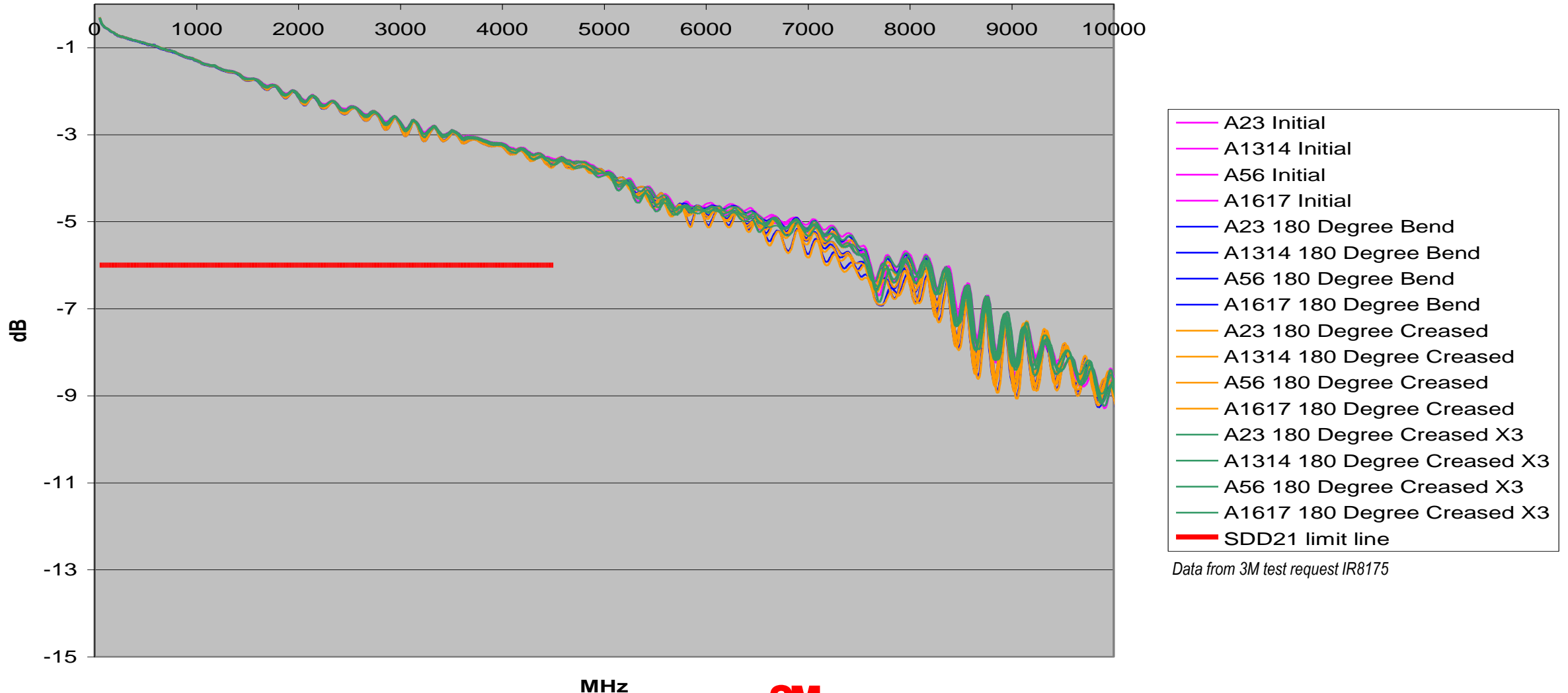
### Test:

- 180 degree fold orientation (i.e. cable folded back on itself)
- S-parameters and Impedance measured before and after folding
- Conditions evaluated:
  - No folds
  - Fold around 1 mm radius pin
  - Hard crease (no mandrel to limit fold radius)
  - 3x hard creases



# Cable folding evaluation – SDD21, Insertion Loss

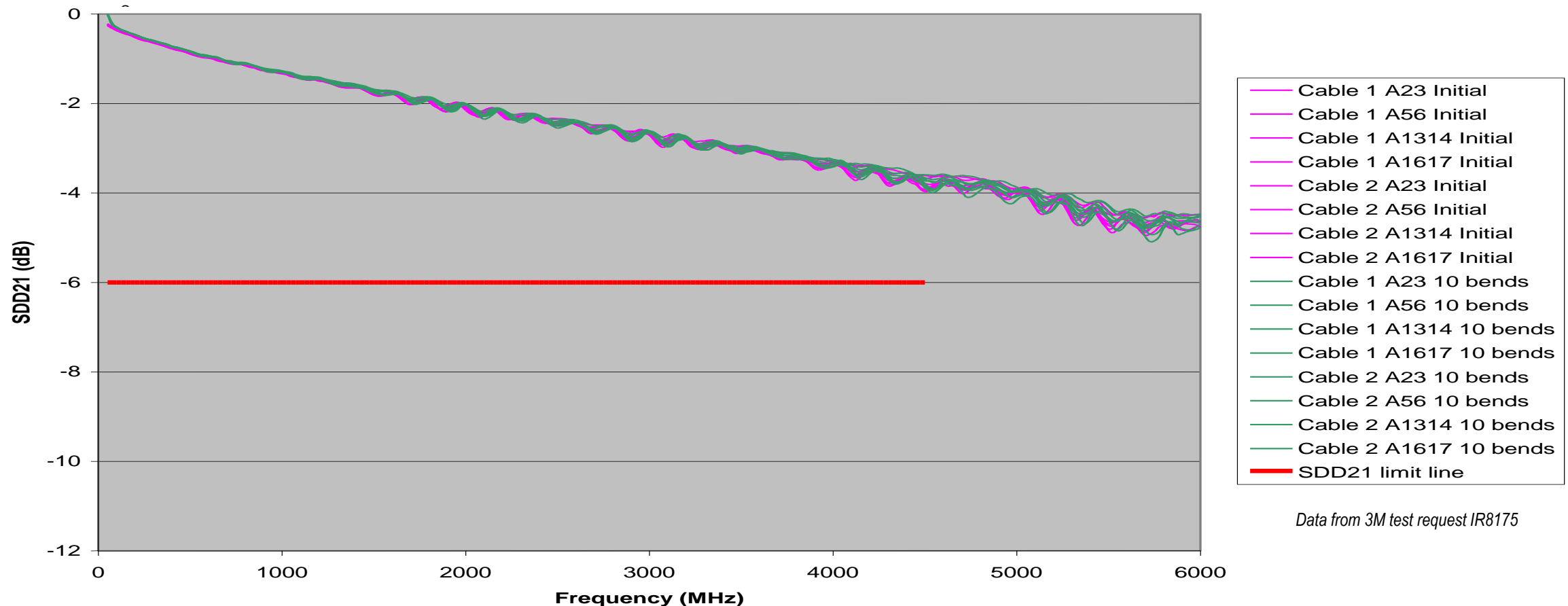
100Ω, 30AWG Twin Axial Cable



Data from 3M test request IR8175

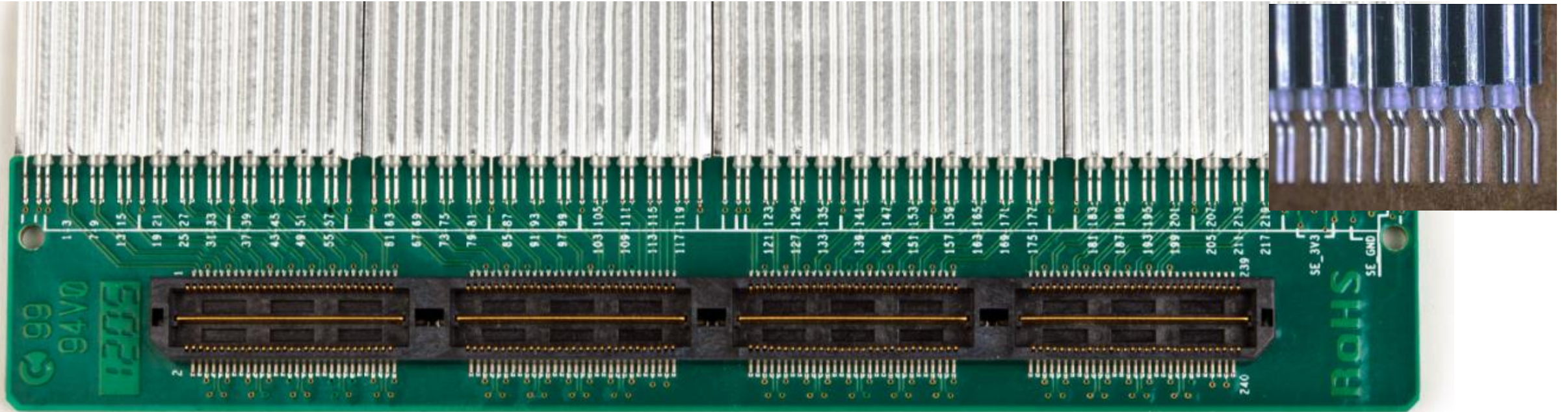
# Effect of repeated folding - SDD21, Insertion Loss

100Ω, 30AWG Twin Axial Cable



- 180 degree bend about a 1 mm radius pin gauge
- 10 bend sample was folded and unfolded 10 times (same bend location)
- SDD21 shown - Examined all 5 SAS S-parameter requirements and similar minimal impact on each

# Ribbon construction minimizes termination variability for more reliable and repeatable processes



- Ribbon construction precisely fixes signal and ground locations for soldering
- Efficient termination process with no wire-routing errors
- Ribbon construction minimizes termination variability for more reliable and repeatable processes











# **3M™ Twin Axial Internal Cable Assemblies**



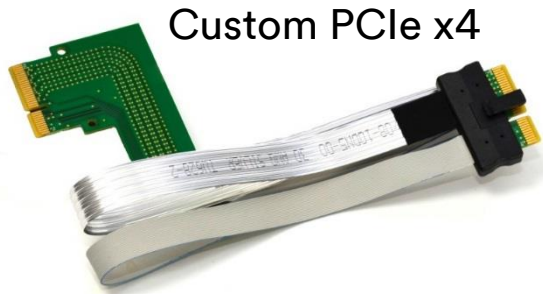
# 3M™ Twin Axial Cable Internal Assembly portfolio

	SATA	miniSAS	miniSAS HD	SlimLine	PCIe
					
<b># of Lanes</b>	1	4 or 8	4	4 or 8	4, 8, or 16
<b>Impedance</b>	100 ohms	100 ohms (SAS)	100 ohms (SAS)	85 ohms (PCIe)	85 ohms
<b>Protocol</b>	SATA and SAS	SATA and SAS	SATA and SAS	SATA, PCIe	PCIe
<b>Speeds</b>	Up to 6.0 Gbps	Up to 6 Gbps per channel	Up to 12 Gbps	PCIe 3.0: 8 Gbps	PCIe 3.0: 8 Gbps
<b>Types of Application</b>	Motherboard to drive	Motherboard or controller to drive backplane	Motherboard or controller to drive backplane	Motherboard or controller to drive backplane	Extender: Flexible “riser” Jumper: Motherboard to motherboard
<b>Standard Lengths</b>	Up to 1 meter	0.5 to 1 meter	0.5 to 1 meter	0.5 to 1 meter	250-500 mm
<b>Specification</b>	n/a	SF-8087	SFF-8643	SFF-8654	n/a
<b>Series</b>	5602	8F	8U	8E	n/a

# Key benefits of 3M™ Twin Axial Internal Cable Assemblies

Key benefits	Excellent electrical performance	Thin	Routable/ Foldable	Cable construction / Improved terminations
Meets/exceeds signal integrity specification	●			
Reduced obstruction to air flow		●	●	
Optimizes use of space		●	●	
Reduced BOM with “hard good” cable assembly			●	
Easier assembly with “hard good” cable assembly			●	
Reliable, repeatable termination process				●

# 3M™ Twin Axial Internal Cable Assemblies



Custom PCIe x4



Custom PCIe x16



Custom SlimLine



PCIe x8



SFF-8087  
(MiniSAS)

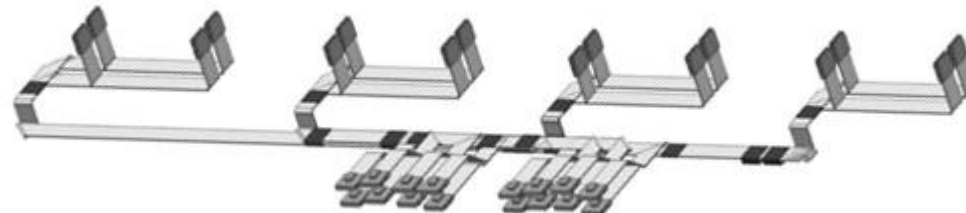
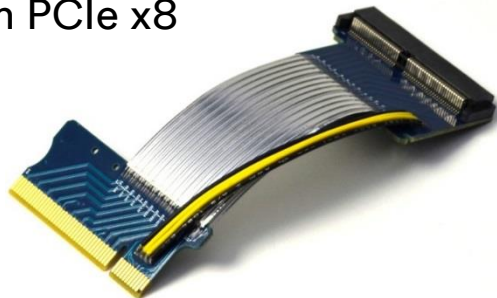
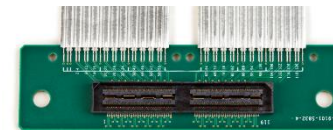
Custom PCIe x32



SFF-8088 to  
MiniSAS HD



Custom PCIe x8



SFF-8087 68p harness

# 3M™ SlimLine Twin Axial Cable Assemblies

## Standard products features

- SlimLine connector on both ends (SFF-8654)
- Straight or right angle plug options
- x4 or x8 configuration
- 30AWG or 31AWG
- 85 ohm (PCIe)
- Typical cable length: 0.5m - 1.0m
- RoHS compliant

## Custom options also supported

- Lengths
- Folding

## With all Twin Axial cable assemblies from 3M:

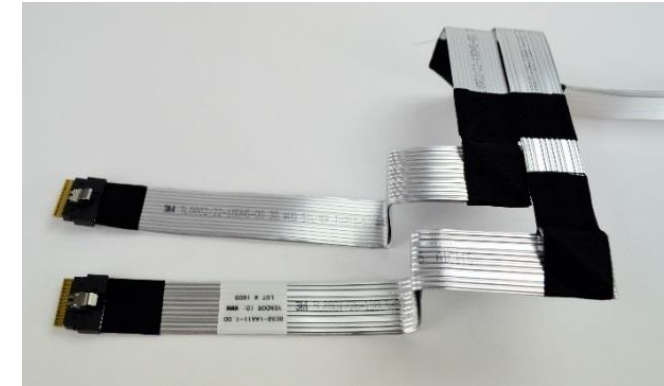
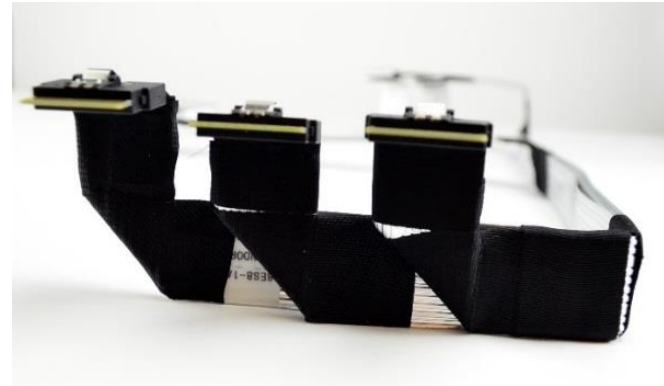
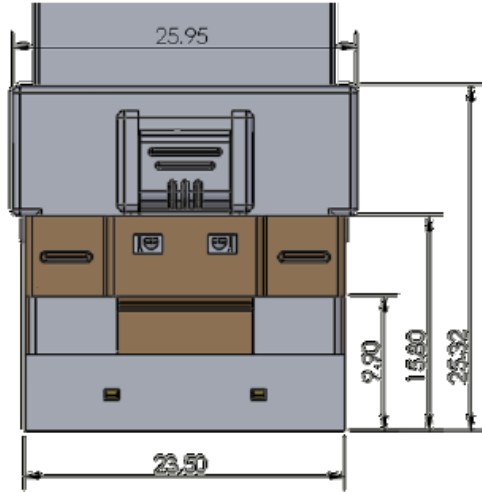
- Thin cable profile
- Easy bending and folding along chassis
- Meets / exceeds signal integrity specifications





# 3M™ SlimLine Twin Axial Cable Assembly Examples

For PCIe3+ Applications

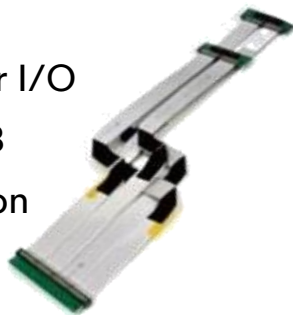


# PCIe application examples

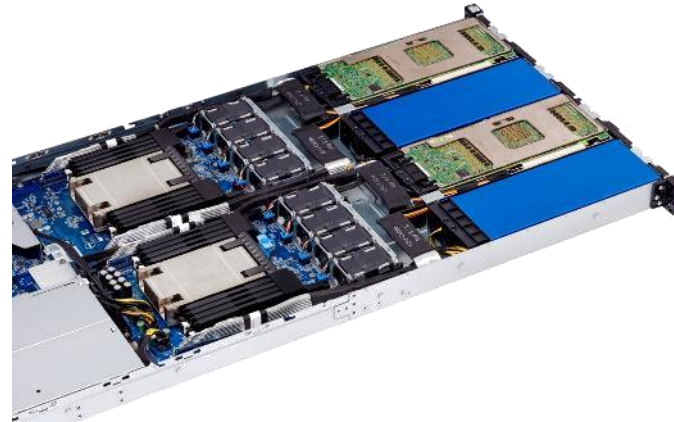
## Cray® XC™ Series supercomputers



- X32 assembly
- Only a few mm gap for I/O
- Blade too long for PCB
- Re-driving not an option
- Custom termination



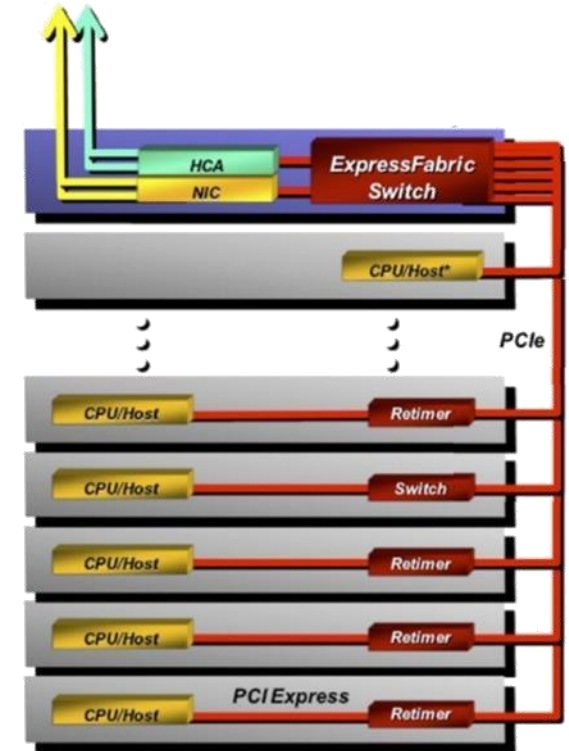
## Dell PowerEdge™ C4130 Server



- Extremely dense box - 4 GPGPU in 1U
- Excellent airflow
- Cable part of box infrastructure



## Rack-scale PCIe connectivity

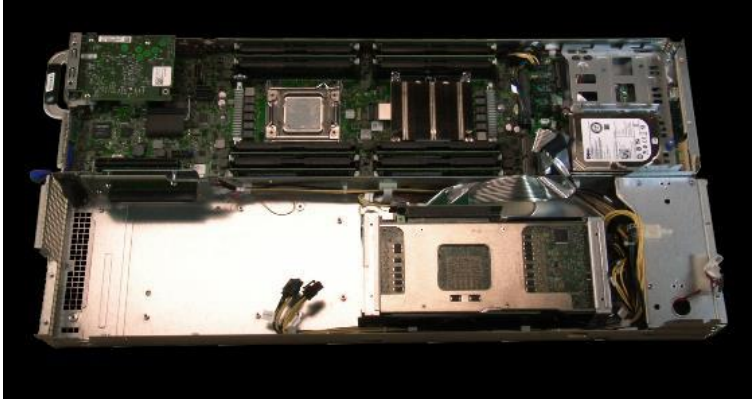


Source: Enterprise Tech, March 2014

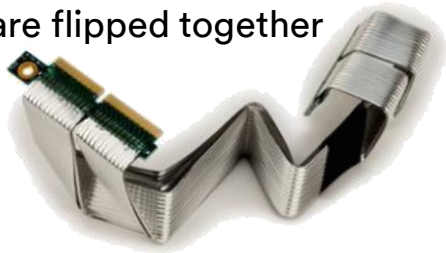
- Long-run PCIe assemblies that extend beyond server chassis

# PCIe application examples

TACC “Stampede” Supercomputer



- PCIe x16
- Functional shape
- Electrical connection between two boxes, top to bottom
- Assembly has spring shape allowing assembly to gather itself inside box as top and boxes are flipped together

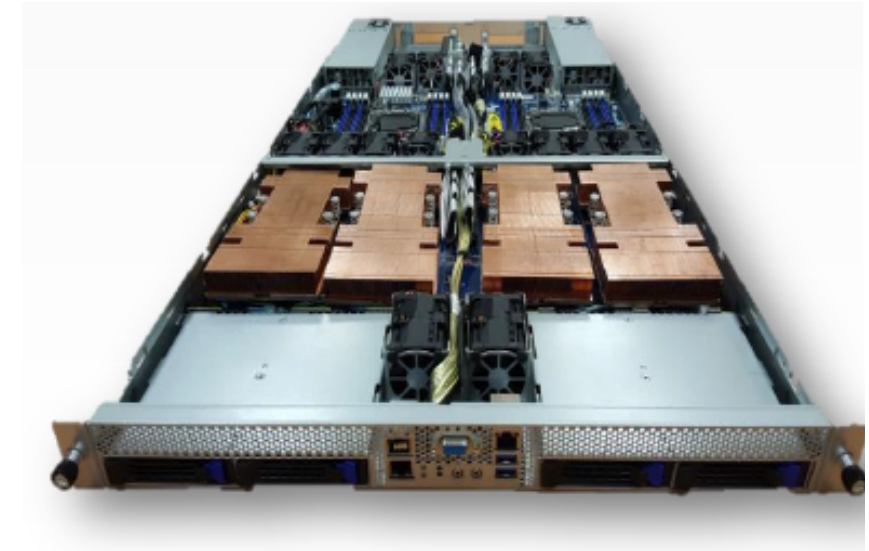


GIGABYTE™ T180 Server Series



- PCIe x16 (Gen 3)
- Extremely dense box - 4 GPGPU in 1U
- Connects to PCIe MD2 cards

GIGABYTE™ G190-G30 Server







- PCIe x16 extender assemblies
- Connects 4 Nvidia NVLink modules
- Connects 2 MD2 cards





# **3M™ Twin Axial External Cable Assemblies**

# 3M™ Twin Axial External Cable Assembly portfolio

	QSFP28 100GbE	QSFP+ 40GbE	SFP+ 10GbE	External MiniSAS
				
<b>Form Factor</b>	QSFP28	QSFP+	SFP+	External MiniSAS
<b>Data Rate</b>	25G/channel (4x25)	10G/channel (4x10) (FDR)	10G/channel (1x10)	6G/channel (4x6)
<b>Lengths</b>	30 AWG: 0.5-2.0 m 26 AWG: 2.0-4.0 m	30 AWG: 0.25-3.0 m	30 AWG: 0.75-4.0 m 26 AWG: 4.0-7.0 m	30 AWG: 0.25-3.0 m 28 AWG: 3.0-6.0 m
<b>Jacket Colors</b>	Black	Black	Red, Blue, Black	Black
<b>Series</b>	9QF6, 9QG0	9QA0	1410, 1412	8G26
<b>Standards</b>	SFF-8665, 8661, 8662 IEEE 802.3bj	SFF-8436 IEEE 802.3ba	SFF-8431 (mechanical) SFF-8432 (electrical) IEEE 802.3ae	SFF-8086/8088 SAS 2.0 & 2.1



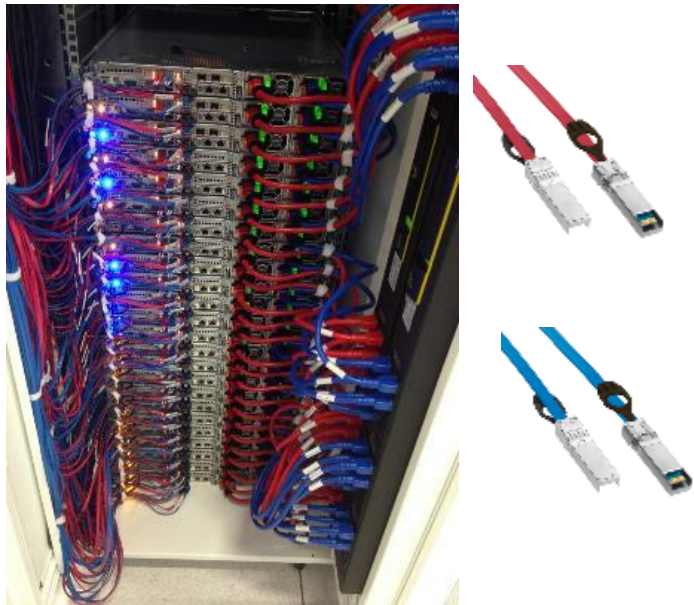
# Key benefits of 3M™ Twin Axial External Cable Assemblies

Key benefits	Excellent electrical performance	Thin/ Stackable cables	Routable/ Foldable/ Flexible Cable	Tight bends at connector	Colored cable option	Lightweight cable
Meets/exceeds signal integrity specification	●					
Improves rack cable management		●	●	●	●	
Save energy by optimizing cooling air flow		●	●	●		
Requires less space in front of port			●	●		
Improved serviceability			●		●	●
Efficient routing of cables		●	●	●		●
Space saving		●				

# External Twin Axial cable application examples

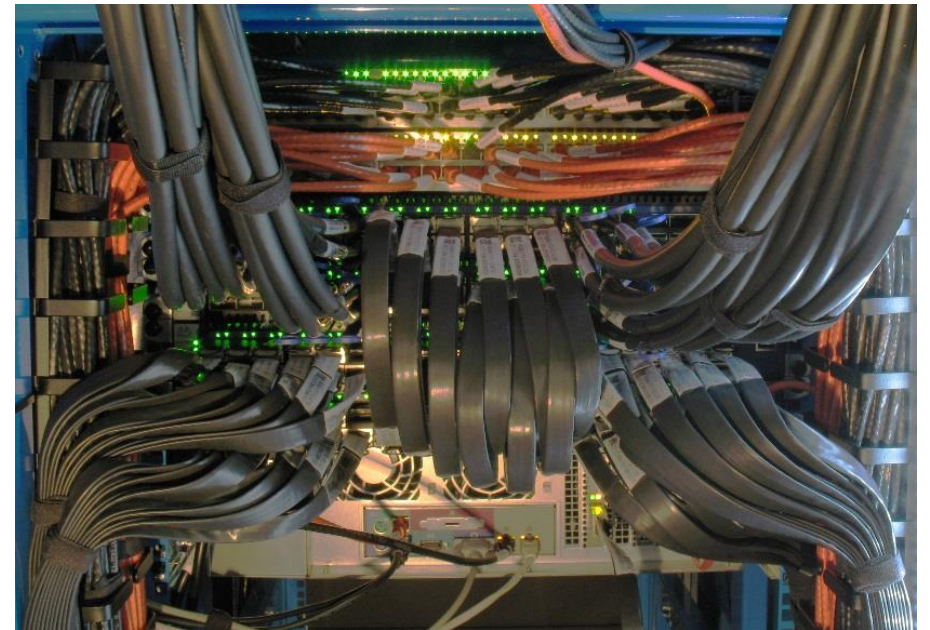
## Customized solutions

- Colored cable helps to differentiate A & B side of redundant system
- Bend radius and low profile allow efficient cable management



## Rack management

- Nor-tech needed a high-density QSFP+ solution that:
  - Allowed for easy maintenance during hot swapping
  - Facilitated air flow



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**Thank you**





# Appendix – Cable assembly offerings

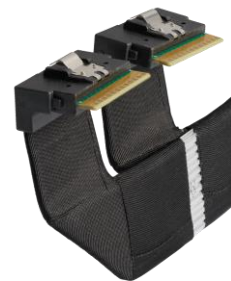
# Internal cable offerings

# 3M™ SlimLine Twin Axial Cable Assembly (SFF-8654)

- Made with 3M Twin Axial Cable technology, resulting in a highly-routable, foldable, and low-profile high-performance assembly
- Available in the following configurations:
  - x4 (8ES4 Series) and x8 (8ES8 Series)
  - SFF-8654 straight and right angle
  - Signal wire size 30 AWG and 31 AWG
  - Standard lengths of 0.5 m, 0.75 m, and 1 m
  - PCIe (85 ohm) applications
  - Custom folded assemblies



Folded and Bent



Thin & Low Profile Harness



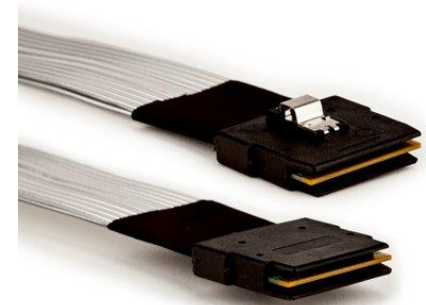
# 3M™ Internal miniSAS Cable Assembly, 8F36/8F68/8S36 Series

- Made with 3M Twin Axial Cable technology, resulting in a highly-routable, foldable, and low-profile high-performance assembly
- Available in the following configurations:
  - x4 (36-position) and x8 (68-position)
  - SFF-8087 straight
  - SFF-8087 to 7-position SATA fan-out assemblies
  - Signal wire size 30 AWG, silver or tin options
  - With or without sidebands
- Standard lengths available up to 1 meter
- Custom folded assemblies

8F36



8F68



8S36

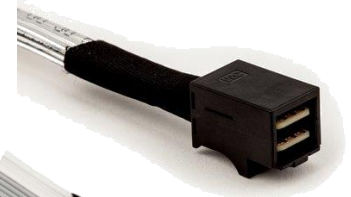


# 3M™ Internal miniSAS HD Cable Assembly, 8US4/8UH4 Series

- Made with 3M Twin Axial Cable technology, resulting in a highly-routed, foldable, and low-profile high-performance assembly
- Available in the following configurations:
  - x4 configuration
  - SFF-8643 straight short body, straight, and right angle (8US4)
  - SFF-8643 hybrid to SFF-8087 (8UH4)
  - Signal wire size 30 AWG
  - With or without sidebands
  - Optional mesh sleeve
- SAS (100 ohm) applications
- Standard lengths available up to 1 meter
- Custom lengths available

## Internal miniSAS HD Cable Assembly (8US4)

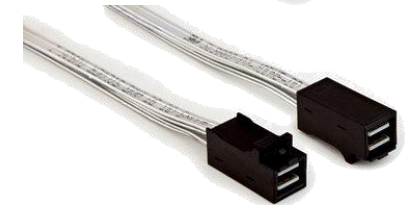
### Straight, shortened connector



### Right angle connector



### Straight connector



## Internal miniSAS HD to Internal miniSAS 36-position hybrid cable assembly (8UH4)





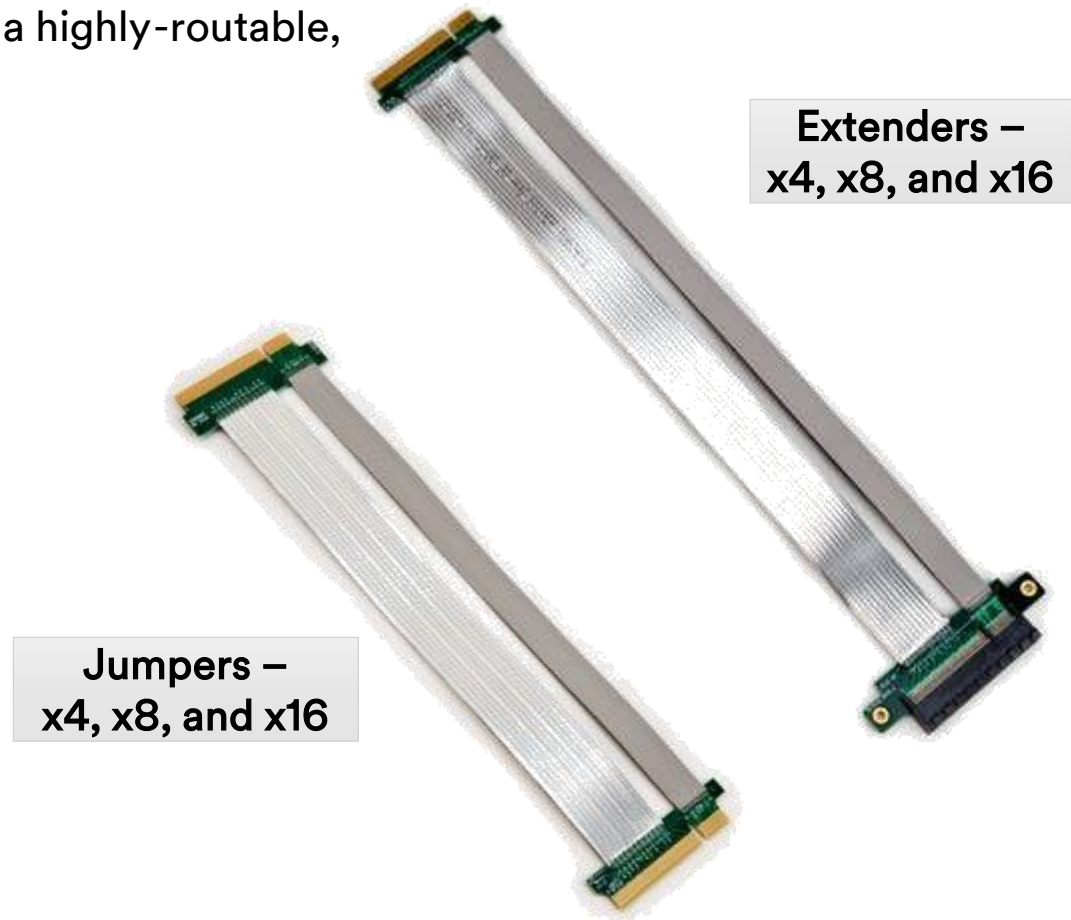
# 3M™ Internal SATA Cable Assembly, 5602 Series

- Made with 3M Twin Axial Cable technology, resulting in a highly-routable, foldable, and low-profile high-performance assembly
- Supports SATA 1.0, 2.0, 3.0 applications
- 7-position configuration
- Available in the following options:
  - Straight and right angle connectors
  - Passive or active latch
- Signal wire size 30 AWG
- Standard lengths available up to 1 meter



# 3M™ Internal PCIe Extender & Jumper Cable Assemblies, 8K Series

- Made with 3M Twin Axial Cable technology, resulting in a highly-routable, foldable, and low-profile high-performance assembly
- PCIe 2.0, 3.0 applications
- x4, x8, and x16 configurations
- Signal wire size 30 AWG
- Includes aux signals
- PCIe (85 ohm) applications
- Standard lengths of 0.25 m and 0.5 m
- Available in the following options:
  - Straight and right angle connectors
  - Passive or active latch
- Signal wire size 30 AWG
- Standard lengths available up to 1 meter



# External cable offerings

# 3M™ 100G QSFP28 Direct Attach Copper Cable Assemblies, 9Q Series

- Made with 3M Twin Axial Cable technology which virtually eliminates high-frequency resonance, allowing the cable to be folded and bent with minimal to no performance impact
- Delivers aggregate data speeds up to 100 Gbps (4x 25 Gbps per channel) with passive copper assemblies
  - Up to 2 meters with 30 AWG
  - 2 to 4 meters with 26 AWG
- Designed to meet the following industry standard protocols:
  - SFF-8665, 8661, 8662; IEEE 802.3bj
  - 100G Ethernet applications
- Tested at Open Networking Interoperability PlugFest (UNH-IOL)
- Custom EEPROM mapping available
- RoHS 2011/65/EU compliant



# 3M Copper Cable Assemblies for QSFP+ Applications, 9Q Series

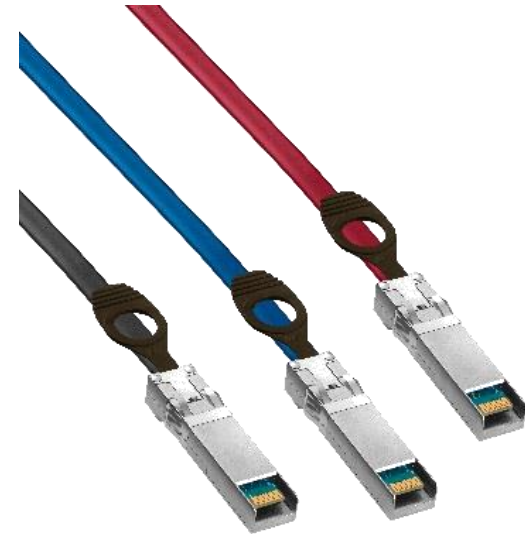
- Made with 3M Twin Axial Cable technology which virtually eliminates high-frequency resonance, allowing the cable to be folded and bent with minimal to no performance impact
- Delivers aggregate data bandwidth of 40 and 56 Gbps with passive copper
  - 40G Ethernet applications
  - InfiniBand DDR (4x5Gbps), QDR (4x10Gbps) and FDR (4x14Gbps)
- Designed to meet the following industry standard protocols:
  - SFF-8436
  - IEEE 802.3ba
- Signal wire size 30 AWG
- Standard lengths available up to 3 meters
- Custom EEPROM mapping available
- RoHS 2011/65/EU compliant





# 3M Copper Cable Assemblies for SFP+ Applications, 1410/1412 Series

- Made with 3M Twin Axial Cable technology which virtually eliminates high-frequency resonance, allowing the cable to be folded and bent with minimal to no performance impact
- Delivers data rates up to 10 Gbps per channel with passive copper assemblies:
  - Up to 5 meters with 30 AWG
  - 4 to 7 meters with 26 AWG
- Designed to meet the following industry standard protocols:
  - SFF-8431 and SFF-8432
  - 10G Ethernet applications
- Available in black, red or blue PVC jacket options designed for port traceability and/or management of redundant network equipment
- Improved EMI shielding achieved with spring metal strap on the backshell
- RoHS 2011/65/EU compliant



# 3M™ External MiniSAS Cable Assembly, 8G26 Series

- Made with 3M Twin Axial Cable technology which virtually eliminates high-frequency resonance, allowing the cable to be folded and bent with minimal to no performance impact
- Delivers data rates up to 6 gigs per channel
- Available in lengths up to 6 meters:
  - Up to 3 meters with 30 AWG
  - 4 to 5 meters with 28 AWG
- Designed to meet the following industry standard protocols:
  - SFF-8086/8088
  - SAS 2.0 & 2.1 requirements
- Available in x4 configuration
- Various keying and custom cable lengths available
- RoHS 2011/65/EU compliant

