SOLUTIONS GUIDE

AVNET®
Reach Further™

WIRELESS COMMUNICATIONS

TE connectivity

WIRELESS COMMUNICATIONS

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SOLUTIONS FOR WIRELESS CONNECTIVITY

Browse Products: avnet.com/te-connectivity-industrial-iot

VIRTUAL SAMPLE KIT FOR WIRELESS CONNECTIVITY

SOLUTIONS FOR WIRELESS CONNECTIVITY

As the world becomes more connected, reliable device-to-device communication is key. For connections inside a device, TE connectors, antennas and board-level shields help bring reliable and clear connectivity to mobile and smart devices.

Below we've highlighted a few of our leading solutions. Click on each part number to learn more or order a sample. Have a question? **HOW CAN WE HELP?**

Antennas

4G World Band Antenna
2118308-1

PCB Antenna
1513259-1

Molded Stamped Antenna
1513164-1

Board Level Shielding

Standard Shield
2118712-2

Shield Frame
2118732-2

Shield Cover
2118731-4

Spring Fingers

Spring Fingers
1565158-1
1544901-1
1827625-1

SFP+ Pluggable I/O

2x6 Cage Assembly
2007562-5

1x4 Cage Assembly
2169260-1

1x1 Cage Assembly
2007464-1

RF Connectors

SMA
1-1478924-0

BNC Plug
2-5221128-1

MMCX End Launch
1408150-1

VIRTUAL SAMPLE KIT FOR WIRELESS CONNECTIVITY

Barrier Strips

Barrier Strips
1-1986469-2
1986469-2
1986469-3

Chassis Panel Mount Resistors

Resistors
1879456-1
2-1879450-5
2-1879452-5

ALCOSWITCH DIP Switch EDS/EDSP Series

DIP Switch EDSP Series
2319764-1

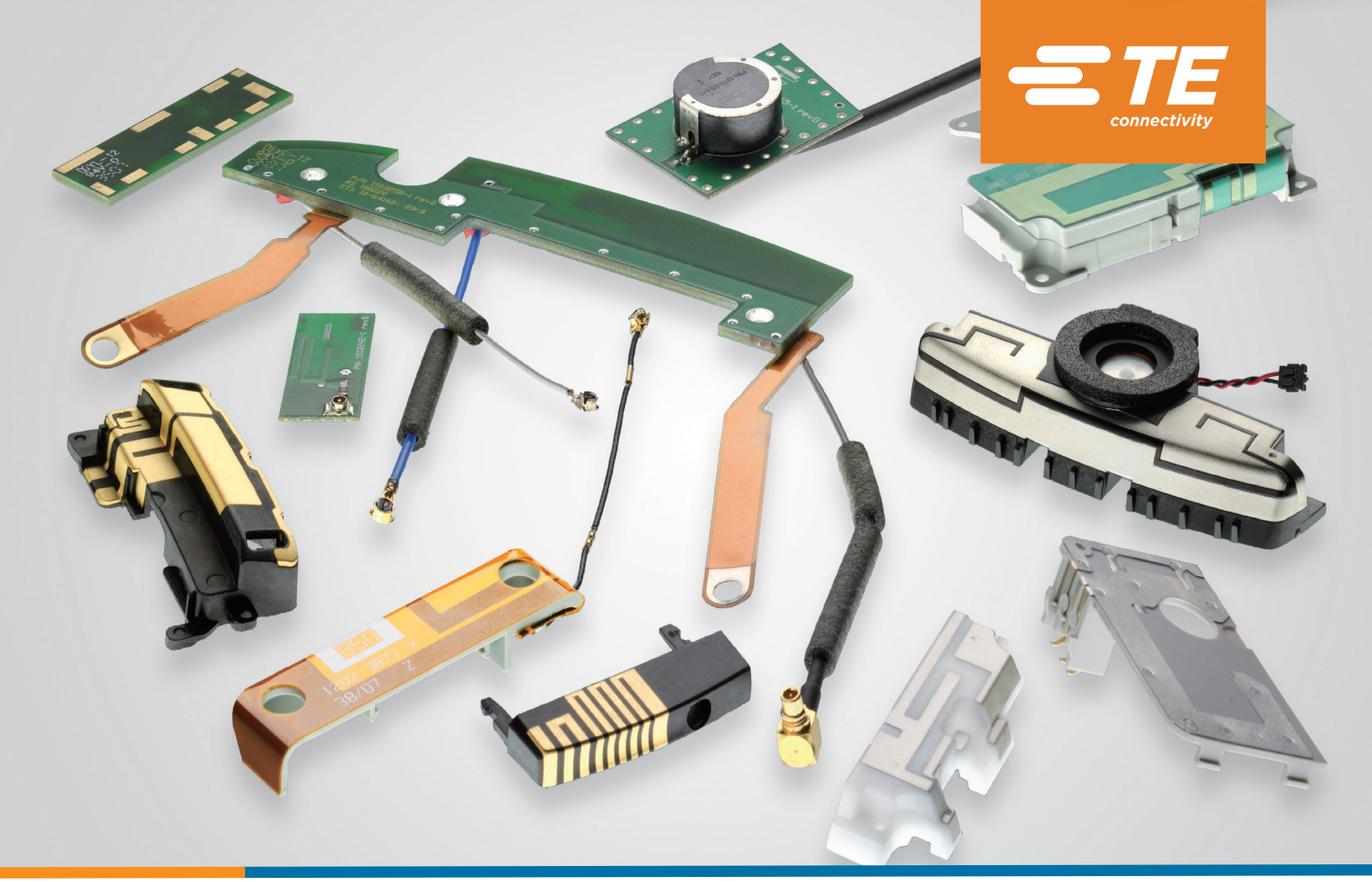
Click on each part number to learn more or order a sample. Have a question?

HOW CAN WE HELP?

WIRELESS COMMUNICATIONS

ANTENNA PRODUCTS - STANDARD AND CUSTOM SOLUTIONS

Browse Products: avnet.com/te-connectivity-industrial-iot



Antenna Products

Standard and Custom Solutions

TE Connectivity Antenna Benefits

- High performance and innovative products
  - High reliability: high performance and isolation
  - High efficiency: optimized throughput, minimal losses
- In-house testing and validation
- State-of-the art antenna laboratories and personnel, deployed globally
- Innovation leader with leading patent portfolio
- Quick-turn designs and prototypes
- World class manufacturing capabilities
- Thrive on opportunities to solve problems together with our customers
- Community leader listed on Dow Jones Sustainability Index and named one of World's Most Ethical Companies by Ethisphere® Institute

www.te.com/antennas

GLOBAL ANTENNA FOOTPRINT

TE Connectivity is a leading developer and manufacturer of high performance embedded and external antennas for diverse wireless applications in various industries. TE has a global presence with manufacturing and design locations around the world.

Antenna Laboratory & Design Locations:

- Harrisburg, Pennsylvania USA
- Aptos, California USA
- Fremont, California USA
- Auburn Hills, Michigan USA
- Hertogenbosch, Netherlands
- Stuttgart, Germany
- Taipei, Taiwan
- Kawasaki, Japan
- Seoul, Korea
- Kunshan, China

Manufacturing Locations:

- Qingdao, China
- Shenzhen, China

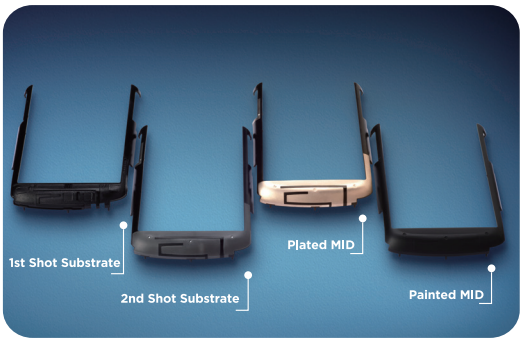
MANUFACTURING TECHNOLOGIES

Molded Interconnect Device (MID) Technology

TE is one of the leading providers of molded interconnect device (MID) technology with more than 25 years mass production experience. In its most basic form, MID technology is defined as a process that results in selectively plated plastic parts. This technology is most often used in three basic ways: electro-mechanical (signal or current carrying traces), RF technology (antennas), and shielding applications. MID technology can integrate electrical and mechanical elements into almost any shape of interconnect device allowing entirely new functions to be created while facilitating the miniaturization of products.
TE utilizes two different technologies to manufacture MID antennas: Two Shot molding and laser direct structuring (LDS).

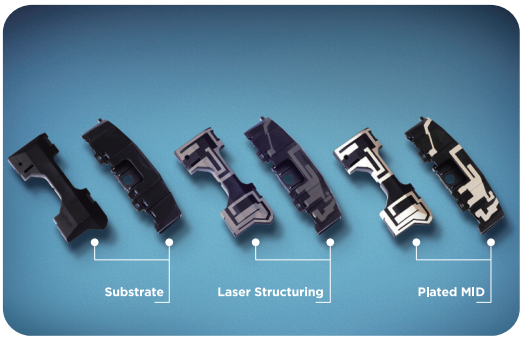
Two Shot Molding

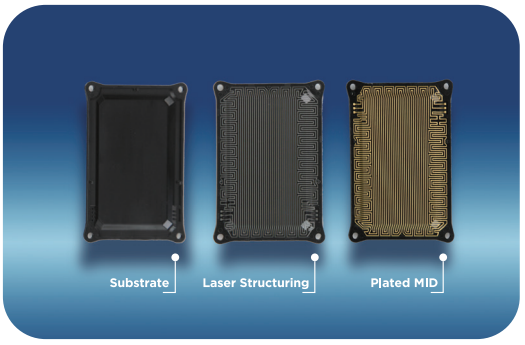
Two shot molding is a mature and well understood process that remains viable for cost effective and repeatable production of MIDs. The basic process has only two steps, injection molding of two distinct thermoplastic polymers and the electroless plating process, resulting in a selectively plated component. In order to achieve the selectivity during plating, a catalyst doped "plateable" resin is molded in conjunction with a standard non-plateable resin to define the desired area to be plated. This area is metalized initially with copper, followed by nickel and, optionally, gold plating. The following are just a few of the several advantages that MID two shot technology delivers compared to alternative technologies:



- Design flexibility for complex 3D geometries
- Ability to integrate multiple functions into one component
- Tightest tolerance for pattern registration to carrier
- Fewest manufacturing steps and processes
- Higher yields
- Improved scalability

Laser Direct Structuring (LDS)





LDS is an exciting technology used to create MIDs. Through the use of a dedicated laser system and resins, LDS opens up many possibilities to create 3 dimensional MIDs with finer line width and spacing than what is possible with the conventional MID processes. The LDS is a three-step process. First, the part is molded in a standard single shot mold using one of the LDS resins. Second, the desired pattern is directly structured onto the part by the 3D laser system. Finally, the pattern is plated using the industry-standard methods where the plating adheres only to the plastic that has been activated by the laser, thus creating a conductive pattern. LDS offers the same advantages as the two shot technology mentioned above plus additional ones:

- Ability to produce thin (0.15 mm) traces
- Flexibility for pattern changes during production
- Simple/fastest/lowest cost tooling

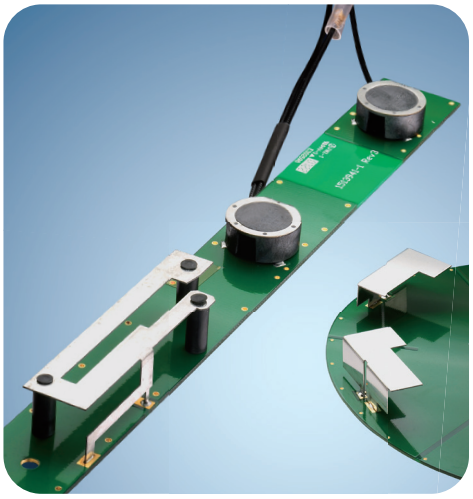
TE is leading the market in new LDS Thin Film technology process and product development. Contact us for more details on this latest manufacturing technology.

MANUFACTURING TECHNOLOGIES

Stamped Metal, Printed Circuit Board (PCB) and Flexible Printed Circuit (FPC) Technology

TE has significant experience in antenna design and manufacturing and provides customized antenna solutions, accommodating the wireless industry's move towards increased complexity and demand for miniaturization. Our manufacturing technologies deliver optimal and well-proven solutions for a variety of wireless applications. In addition to MID technology, TE most commonly utilizes stamped metal, printed circuit board (PCB) and flexible printed circuit (FPC) technology for its antenna products.

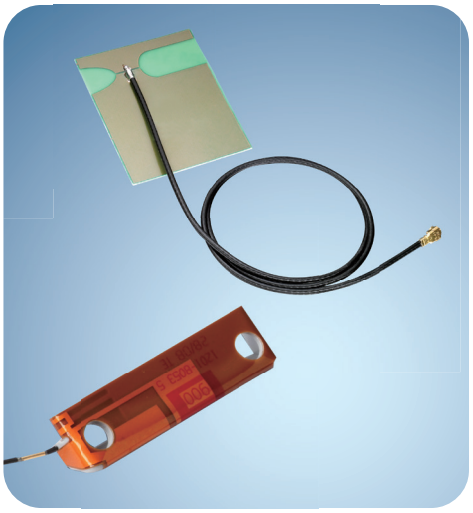
Stamped Metal Antennas



TE has developed a standard line of low profile, high performance stamped metal antenna solutions, and we can provide custom designs as well. Stamped metal antennas offer customers a low cost and highly repeatable manufacturing solution with a number of standard "off the shelf" or customized antenna designs. Stampings are a proven solution with several advantages such as:

- Lowest cost
- Integrated contacts
- High volume production dies
- Rapid prototyping capability

Flexible Printed Circuit (FPC) and Printed Circuit Board (PCB) Antennas



Flexible printed circuits (FPCs) and printed circuit boards (PCBs) are suitable for multi-band antennas, allowing virtually any wireless device to operate at different frequencies without the need for multiple antennas.

TE offers a broad range of low profile, high performance FPC and PCB antennas. Similar to our stamped metal antennas, FPC and PCB antennas offer OEMs a low cost and highly repeatable manufacturing solution in a number of "off the shelf" or customized antenna designs. FPC and PCB antennas address the needs of a variety of wireless applications and offer several advantages such as:

- Low cost tooling investment
- Flexibility for pattern changes during production
- Shortest lead time for tool build
- Patented material and patterns for optimal efficiency and performance

APPLICATIONS

TE Connectivity (TE) designs and manufactures antennas that comply with the most stringent operating requirements. TE has extensive experience providing customized embedded antenna solutions to accommodate the wireless industry's move towards increased complexity and demand for miniaturization combined with the need to integrate a multi-radio environment into one component.
Our antennas utilize diverse technologies and offer optimal solutions for each of the following examples:

Applications by Protocol

WLAN / Wi-Fi

- 802.11 (a/b/g/n/ac): 2400 - 2483.5 & 4900 - 5875 MHz
- Single band, Dual band, MIMO, Wave2, MU-MIMO embedded and ground plane independent antennas

Cellular / WWAN

- 2G, 3G, 4G, 5G from single to all band antennas
- LTE: 698 - 787; 2500 - 2690 & 3410 - 3600 MHz
- GSM/CDMA 850: 824 - 894 MHz
- GSM 900: 880 - 960 MHz
- GSM 1800: 1710 - 1880 MHz
- GSM/CDMA 1900: 1850 - 1990 MHz
- IMT-2100 (3G, UMTS): 1920 - 2170 MHz
- WiMAX: 2300 - 2700 & 3300 - 3800 MHz

Others

- ISM 900/ZigBee: 902 - 928 MHz
- Bluetooth: 2400 - 2483.5 MHz
- ZigBee: 2400 - 2483.5 MHz
- UWB: 3168 - 10560 MHz
- GPS: 1565 - 1585 MHz
- DVB-H: 1670 - 1675 MHz
- LoRa, Z-Wave, BTLE (Bluetooth low energy)
- GPS, Glonass, GNSS

Product Applications

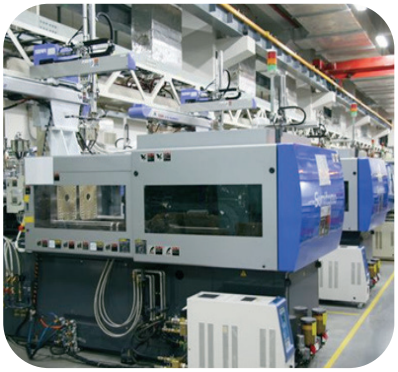
- Wireless Routers
- Smart Home Products
- Access Points & Mini Cells
- Point of Sale (POS) Terminals
- Security & Monitoring Systems
- Smart Meters & Smart Lighting
- Small & Large Home Appliances
- Industrial & Smart Grid Products
- IoT & M2M
- Set Top Boxes
- Televisions & Wireless Audio
- Desktop & Notebook Computers
- Mobile Phones & Handheld Products
- Printers & Business Equipment
- Medical Equipment
- Vehicle Tracking & OBD Products
- Wearables (Smart Watch, Cameras, etc.)
- Distributed Antenna Systems (DAS)
- Most High-Volume Wireless Products

VALUE-ADDED INTEGRATION

TE has manufacturing and design locations around the world, providing a full range of value-added production processes on-site. We also have state of the art measurement capabilities ensuring all of our antennas satisfy today's most discriminating performance and quality requirements.

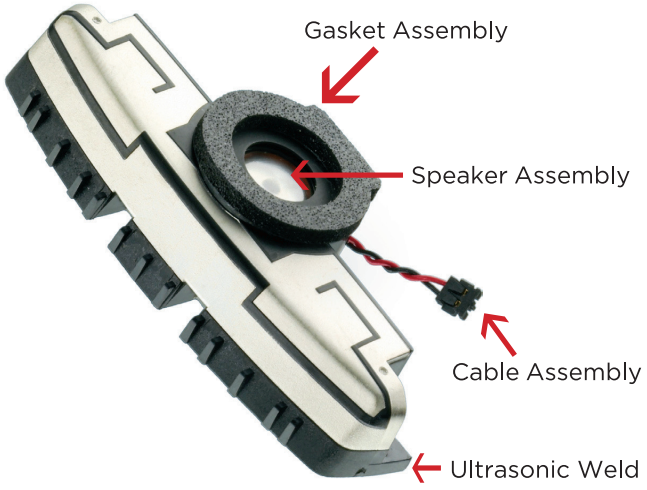
Enhanced Value Through On-Site Manufacturing Processes

- Molding
- Plating
- Cable and Acoustic Assembly
- Ultrasonic Welding and Heat Staking
- Reflow Soldering
- Wave Soldering
- Hand Soldering
- Press Fit
- Painting



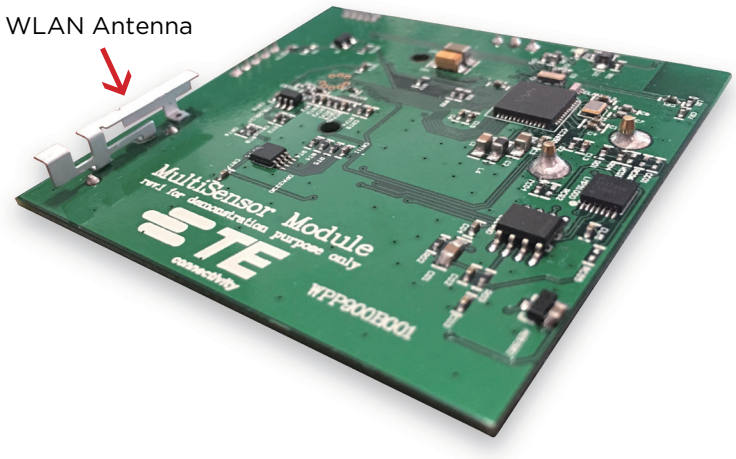
Example: Mid 2-Shot Antenna Assembly

Speaker Acoustic Module with Gasket & Wire Assembly



Example: Antenna Integration with Sensor

Stamped Antenna on Multi-Sensor Module



100% RF Performance Verification
100% Acoustic Performance Verification

EXTERNAL ANTENNAS

Most TE external antenna assemblies are designed to support WiFi and WiMAX enabled products and applications, while exhibiting excellent performance through 6 GHz. These external antennas can be provided with a wide variety of cable and connector types, with one option being an innovative 3-port connector eliminating the need for three separate SMA (or other interface) connectors.

Additionally, TE offers an external antenna that includes a 3-port omni-directional antenna assembly designed to support both in-door and outdoor cellular type of applications, such as distributed antenna systems.

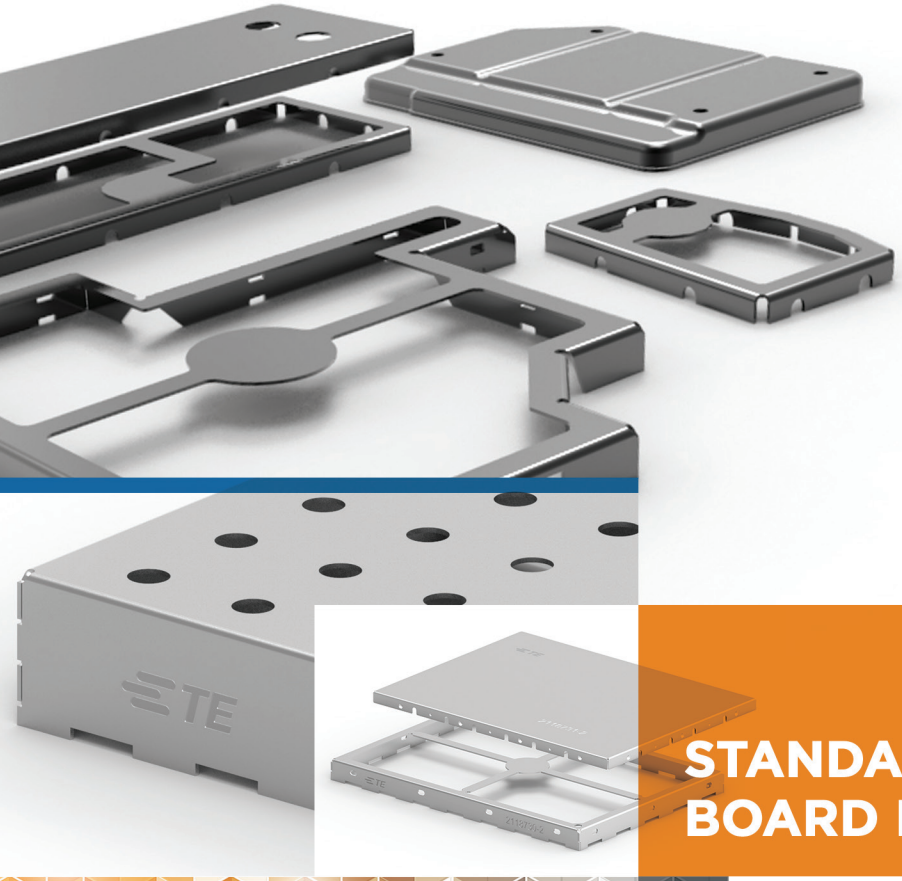
Applications

- Wireless Routers
- Smart Home Products
- Access Points & Mini Cells
- Point of Sale (POS) Terminals
- Safety & Security Systems
- Set Top Boxes
- Televisions & Wireless Audio
- Desktop Computers
- Distributed Antenna Systems (DAS)

WIRELESS COMMUNICATIONS

STANDARD AND CUSTOM BOARD LEVEL SHIELDING (BLS)

Browse Products: avnet.com/te-connectivity-industrial-iot



STANDARD AND CUSTOM BOARD LEVEL SHIELDING (BLS)

As complexity and functionality increases, there is a growing need for thinner devices with multiple antennas, higher data rates and increased operating frequencies. EMI (Electromagnetic Interference) shields from TE Connectivity (TE) are stamped one and two-piece metal cages that help provide isolation of board level components, minimize crosstalk and reduce EMI susceptibility without impacting system speed.

ON DEMAND OR AT YOUR COMMAND

Whether you need a custom design or an off-the-shelf solution that is immediately available, we've got you covered. Our new standard BLS portfolio is available in both industry-standard cold rolled steel (CRS) and aluminum material. Aluminum offers enhanced benefits which include:

Weight Savings
– Aluminum is 1/3 the density of CRS material while still offering similar EMI suppression

Improved Thermal Conductivity
– Aluminum can provide up to 5 times better thermal conductivity than CRS

TE CONNECTIVITY BLS ADVANTAGE

- NEW standard portfolio on-demand in CRS and aluminum material
- Proven designed-in features
- Core competencies of stamping, plating and automation for more than 50 years
- Rapid turn tooling/prototyping within each region (3-5 day)
- Streamlined, automated and continuous production line
- Local FAE support
- Complex custom high volume support
- In house EMI expertise
- One of the largest suppliers of connectivity solutions addressing a range of industries
- Global scale and low cost manufacturing
- Broad portfolio enables vendor reduction for your project

APPLICATIONS:

Anywhere board level EMI suppression is needed, including:

- Mobile phones & Tablets
- 2-in-1 notebooks
- Game consoles
- Routers (commercial & enterprise)
- Point of Sale (POS) equipment
- Wireless meters
- Wireless speakers
- Wearables & IoT
- Drones
- Virtual Reality (VR) headsets
- Femto cell
- Servers

DESIGN DIMENSIONS *

- Minimum size: 5mm(L) x 5mm(W) x 0.80mm(H)
- Maximum size: 100mm(L) x 100mm(W) x 5mm(H)

* Contact TE for other size requirements.

PACKAGING

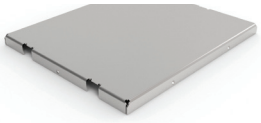
- Tape & reel
- Vacuum formed tray

CUSTOMIZED SOLUTIONS

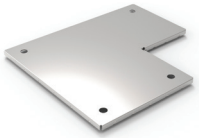
SHARED FEATURES OF TWO PIECE AND ONE PIECE SHIELDS

Basic shapes have been defined to enable 24-hour generation of 2D and 3D drawings, as well as efficient, rapid prototyping within 72 hours.

Rectangle



Pentagon

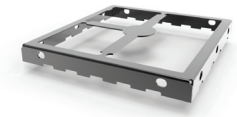


L-Shape

- 2 Piece solution, (min 0.90mm height)
- 1 Piece solution, (min 0.50mm height)
- Common materials and thicknesses
- Use of common, proven design features
  - locking holes
  - SMT (castellations)
  - thru holes
  - corner shape
  - bending radii
  - pins/tab
  - carrier attachment
  - pick and place features

Pick and place

Locking holes

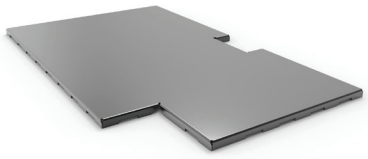


SMT castellations

ONE PIECE PRODUCT FEATURES:

One Piece: Formed

- Pitch of solder barriers: 3.0mm min
- Material: Nickel silver, galvanized & pre-plated CRS *
- Material thickness: 0.10mm min
- Inner bending radius: 0.10mm min
- Co-planarity: 0.08mm, size dependent
- Height: min 0.50mm



One Piece: Deep Drawn

- Material: Nickel silver, galvanized steel *
- Material thickness: 0.15mm min
- Co-planarity: 0.1mm, size dependent
- Height: max 3.00mm

* Other material may be available, please consult with your TE representative.

STANDARD BLS OFFERING

ONE PIECE SHIELDS				PACKAGING		
CRS	**Aluminum**	**Thickness (mm)**	**Size (L x W x H) (mm)**	**Diameter (mm)**	**Pcs/Reel**	**Pcs/Box**
2118706-2	2118706-4	0.20	13.66 x 12.70 x 2.54	330	900	3600
2118707-2	2118707-4	0.20	16.50 x 16.50 x 3.60	330	550	1650
2118708-2	2118708-4	0.20	26.21 x 26.21 x 5.08	380	280	840
2118709-2	2118709-4	0.20	32.00 x 32.00 x 6.00	380	166	498
2118710-2	2118710-4	0.20	38.10 x 25.40 x 6.00	380	216	648
2118711-2	2118711-4	0.20	36.83 x 33.68 x 5.08	380	186	558
2118712-2	2118712-4	0.20	44.37 x 44.37 x 9.75	380	90	180

One Piece Shields

Two Piece Shields

TWO PIECE SHIELDS - COVER				PACKAGING	
CRS	**Aluminum**	**Thickness (mm)**	**Size (L x W X H) (mm)**	**Type**	**Pcs/Box**
2118713-2	2118713-4	0.15	14.06 x 13.10 x 2.00	Bulk/Bag	3000
2118715-2	2118715-4	0.15	16.90 x 16.90 x 2.00	Bulk/Bag	3000
2118717-2	2118717-4	0.15	26.71 x 26.71 x 2.00	Bulk/Bag	3000
2118719-2	2118719-4	0.15	32.50 x 32.50 x 2.00	Bulk/Bag	3000
2118721-2	2118721-4	0.15	38.60 x 25.90 x 2.00	Bulk/Bag	3000
2118723-2	2118723-4	0.15	37.33 x 34.18 x 2.00	Bulk/Bag	1800
2118725-2	2118725-4	0.20	44.97 x 44.97 x 2.00	Bulk/Bag	1800
2118727-2	2118727-4	0.20	29.96 x 19.10 x 2.00	Bulk/Bag	3000
2118729-2	2118729-4	0.20	44.60 x 31.10 x 2.00	Bulk/Bag	1800
2118731-2	2118731-4	0.15	51.30 x 38.60 x 2.00	Bulk/Bag	1200

TWO PIECE SHIELDS - FRAME			PACKAGING		
CRS	**Thickness (mm)**	**Size (L x W x H) (mm)**	**Diameter (mm)**	**Pcs/Reel**	**Pcs/Box**
2118714-2	0.20	13.66 x 12.70 x 2.54	330	900	3600
2118716-2	0.20	16.50 x 16.50 x 3.60	330	550	1650
2118718-2	0.20	26.21 x 26.21 x 5.08	380	280	840
2118720-2	0.20	32.00 x 32.00 x 6.00	380	166	498
2118722-2	0.20	38.10 x 25.40 x 6.00	380	216	648
2118724-2	0.20	36.83 x 33.68 x 5.08	380	186	558
2118726-2	0.20	44.37 x 44.37 x 9.75	380	90	180
2118728-2	0.20	29.36 x 18.50 x 7.00	380	280	840
2118730-2	0.20	44.00 x 30.50 x 3.00	380	340	1020
2118732-2	0.20	50.80x 38.10 x 5.08	380	170	340

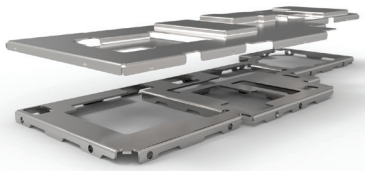
PRODUCT TYPE: TWO PIECE

Frame Component

- Pitch of castellation: 3mm min
- Pitch of locking holes: 3mm min
- Material: Nickel silver, galvanized & pre-plated CRS *
- Material thickness: 0.10mm min
- Inner bending radius: 0.10mm min
- Co-planarity: 0.08mm, size dependent

Cover Component

- Pitch of dimples: 3mm min
- Material: Stainless steel, galvanized steel, pre-plated CRS & aluminum
- Material thickness: 0.08mm min
- Inner bending radius: 0.10mm min



* Other material may be available, please consult with your TE representative.

CUSTOM BLS DESIGN SPECIFICATIONS

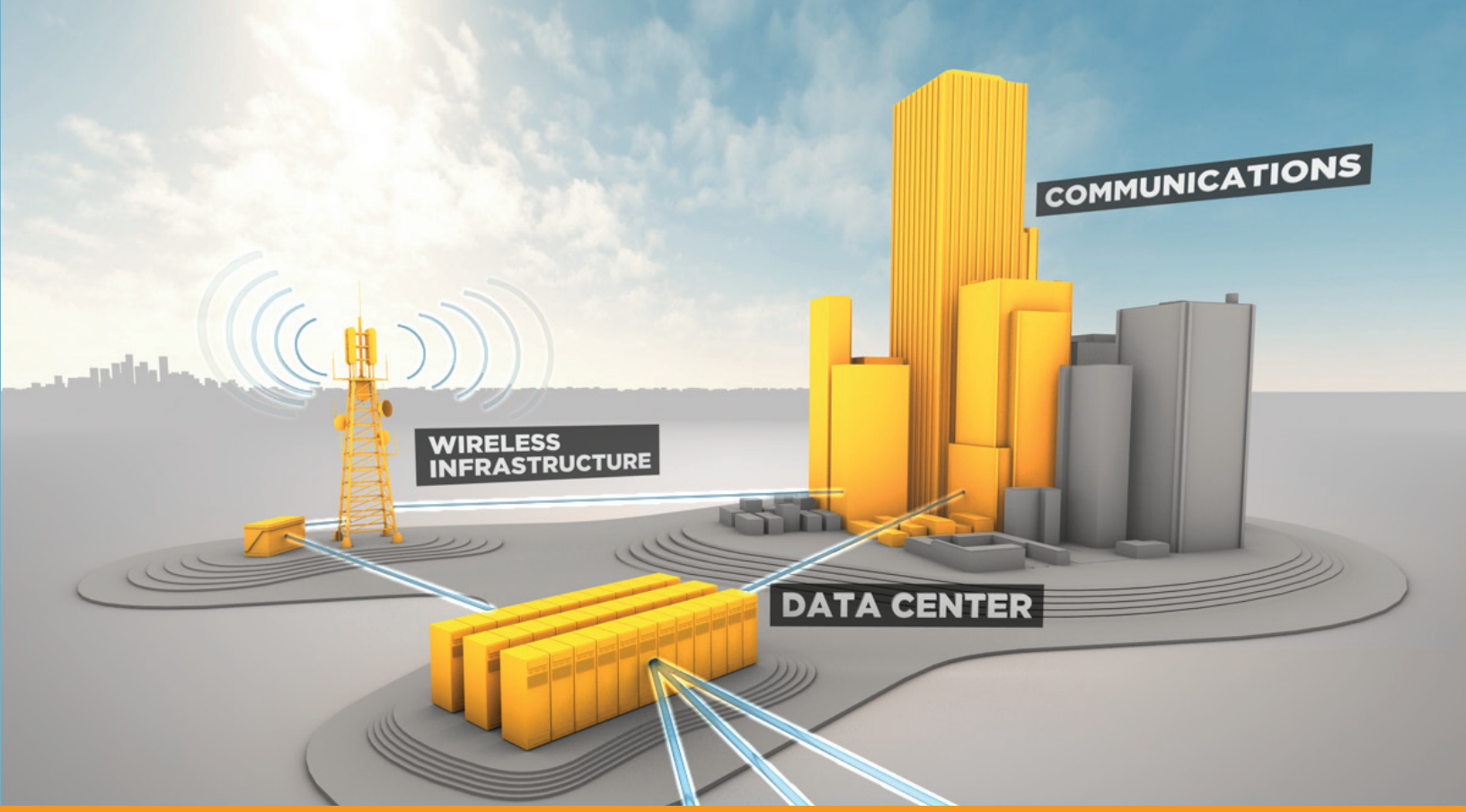
We offer a wide array of customized solutions for various applications, so we have created this form to help you gather the requirements we need to better understand your customized project(s).

Prototype schedule and quantity:	Desired material, plating and thickness:
Mass production schedule and projected quantity:	Drawings needed: ☐ 3D model ☐ 2D print ☐ Both
Program Life:	
Size requirements:	Co-planarity requirement:
Length:	Frequency to be shielded:
Width:	Engineering Point of Contact:
Height:	Name:
Access needed beneath shield? ☐ Yes ☐ No	Email:

WIRELESS COMMUNICATIONS

DATA COMMUNICATIONS PRODUCT GUIDE

Browse Products: avnet.com/te-connectivity-industrial-iot



TE Connectivity Data Communications Product Guide:

Providing technology leadership for your next-generation high-speed architectural platforms

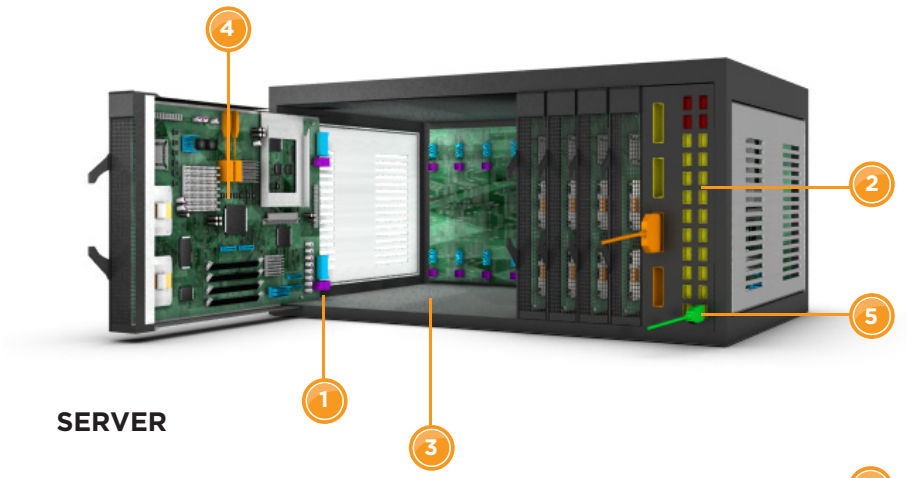
Success in today and tomorrow's data communications relies on dependable high-speed interconnections. From the data center, central office, enterprise communications and the wireless infrastructure, TE Connectivity provides a broad portfolio of high- speed products. This expansive portfolio addresses the increasing data rate demands for data communications.

This guide provides TE's high-speed product portfolio and capabilities for next-generation data communication architectures.

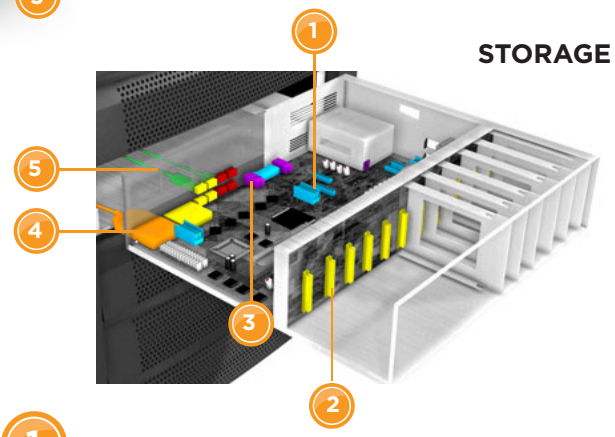
TE connectivity

TE Connectivity

DATA CENTER - SERVER



SERVER



STORAGE

BOARD-TO-BOARD CONNECTORS 1

BackPlane

STRADA Whisper connector
www.te.com/products/STRADAwhisper

IMPACT connector
www.te.com/products/Impact

Z-PACK TinMan connector
www.te.com/products/tinman

Z-PACK TinMan Plus connector
In Development
Please contact technical support team on back page

Z-PACK Slim UHD high-speed connector
www.te.com/products/zpackUHD

Z-PACK HM-Zd connector
www.te.com/products/HMZD

Z-PACK HM-Zd Plus connector
www.te.com/products/hmzdplus

MULTIGIG RT connector
www.te.com/products/multigigrt

Slim UHD connector
In Development
Please contact technical support team on back page

Mezzanine

STRADA Mesa connector
www.te.com/products/STRADAmesa

STEP-Z connector
www.te.com/products/STEP-Z

CoPlanar

Z-PACK HM-Zd connector
www.te.com/products/HMZD

Z-PACK HM-Zd Plus connector
www.te.com/products/hmzdplus

Z-PACK Slim UHD high-speed connector
www.te.com/products/zpackUHD

STRADA Whisper Connector
In Development
Please contact technical support team on back page

KEY CODE

- Data Rate: 25+ GB/s
- Data Rate: 20-25 GB/s
- Data Rate: 15-20 GB/s
- Data Rate: 10-15 GB/s
- Data Rate: 10G
- Data Rate: 1G
- Data Rate: 10/100
- Available
- In Development

** Data Rates based on current TE Connectivity road maps. Subject to change.

TE Connectivity

COMMUNICATION - SWITCH / ROUTER

I-O 2

Pluggable

Mini SAS HD connector
www.te.com/products/MiniSASHD

MultiLink SAS connector
In Development
Please contact technical support team on back page

Quad SAS connector
In Development
Please contact technical support team on back page

12G SAS connector
In Development
Please contact technical support team on back page

SFP+ connector
www.te.com/products/SFPplus

zSFP+ connector
In Development
Please contact technical support team on back page

QSFP+ connector
www.te.com/products/QSFP

zQSFP+ connector
www.te.com/products/zQSFPplus

CXP connector
www.te.com/products/CXP

zCXP connector
In Development
Please contact technical support team on back page

CFP connector
www.te.com/products/cfp

Quadra connector (CFP2 & CFP4)
In Development
Please contact technical support team on back page

XFP connector
www.te.com/products/xfp

X2 connector
www.te.com/products/x2

Cat 6A (10GBase-T) connector
In Development
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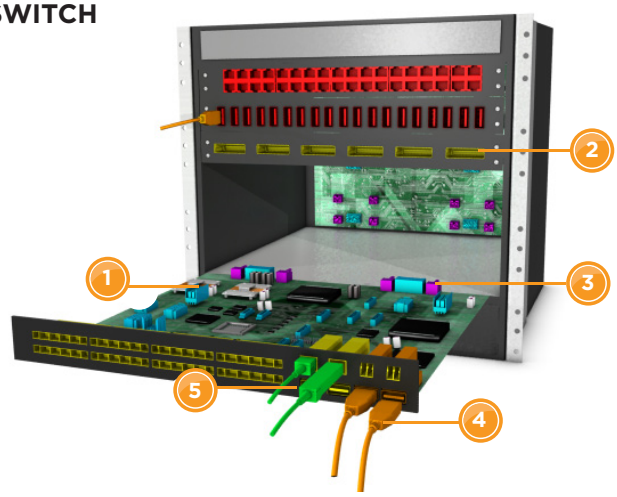
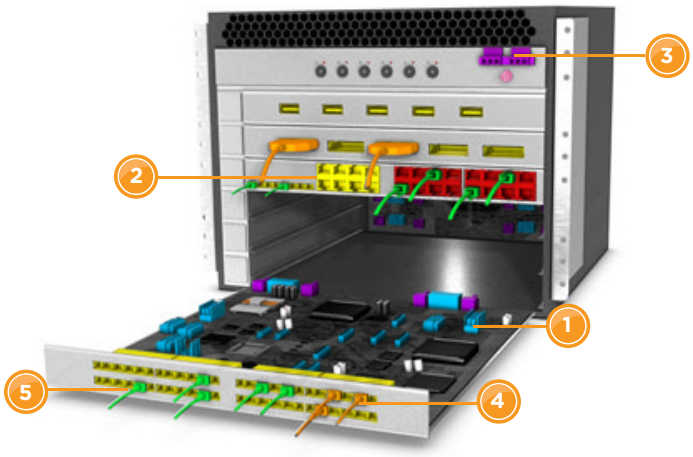
RJ *point five* connector system
www.te.com/products/rjpointfive

SWITCH





ROUTER

POWER CONNECTORS 3

MULTI-BEAM XLE connector
www.te.com/products/MULTIBEAMXLE

MINIPAK HDL connector
www.te.com/products/minipakhdl

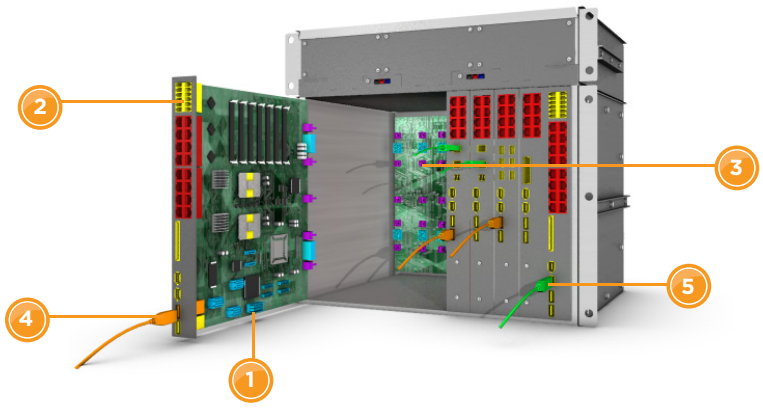
MULTI-BEAM XL connector
www.te.com/products/MULTIBEAMXL

ET Power connector
www.te.com/products/Etpower

CROWN LINE connector
www.te.com/products/CROWNLINE

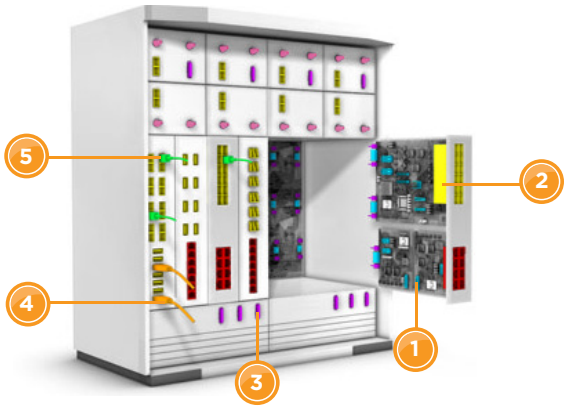
TE Connectivity

WIRELESS INFRASTRUCTURE - MOBILE SWITCH



MOBILE SWITCH

BASE STATION



FIBER OPTICS 4

Active Optical Cable Assemblies

QSFP cable assemblies
www.te.com/products/QSFP

QSFP+ cable assemblies
In Development
Please contact technical support team on back page

zQSFP Cable Assemblies
In Development
Please contact technical support team on back page

zSFP Cable Assemblies
In Development
Please contact technical support team on back page

Hybrid cable assemblies
In Development
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Active Optical Modules (Transceivers)

QSFP modules
www.te.com/products/QSFP-modules

QSFP+ modules
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Advanced Packing Solutions

Mid-board optics
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COPPER CABLE ASSEMBLIES 5

4X cable assemblies (SAS, Fibre Channel, Infiniband, 10G Ethernet)
www.te.com/products/4X12X

HM-Zd cable assemblies
www.te.com/products/high-speed-cable-assemblies

QSFP+ cable assemblies
www.te.com/products/QSFP

zQSFP+ cable assemblies
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SFP+ cable assemblies
www.te.com/products/SFPplusca

zSFP+ cable assemblies
In Development
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XFP cable assemblies
www.te.com/products/XFP

RJ *point five* connector system cable assemblies
www.te.com/products/rjpointfive

Mini SAS cable assemblies
www.te.com/products/minisascableassy

Mini SAS HD cable assemblies
www.te.com/products/MiniSASHD

InfiniTwist cables
www.te.com/products/InfiniTwist

TE Connectivity

HIGH-SPEED PRODUCT DEVELOPMENT CAPABILITIES AND TECHNOLOGIES

Signal Integrity Capabilities

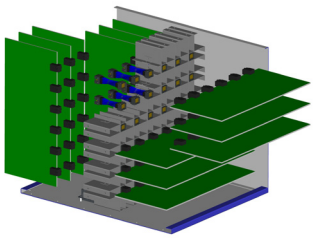
TE has leading edge signal integrity and Electro-Magnetic-Interference (EMI) modeling and testing capabilities required for ever increasing data rates. Our global team can function as your initial design and consultation resource to perform electrical modeling and simulation of high-speed connectors and cable assemblies. Additionally, we provide test and validation of electrical performances across your complete channel or system. So whether you're looking to validate a current system layout or developing the next-generation high-speed system, our signal integrity team can provide support for all areas of your analysis.

For more information about TE's signal integrity capabilities, visit our landing page at:
http://www.TE.com/documentation/electrical-models/

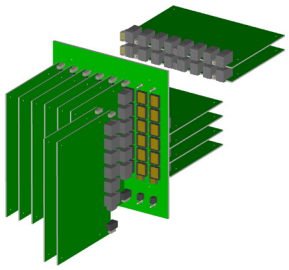
High-Speed Products Enabling Next-Generation Architectures

High-Speed Backplane

- Broad portfolio of high-speed, high-performance backplane connectors and cable assemblies for aggregate data rates greater than 100 Gbps (up to 40 Gbps per differential pair)
- Enables orthogonal and cabled backplane architectures
- Reduced connector noise and insertion loss
- Optimized PCB footprints



Cabled Backplane Architecture

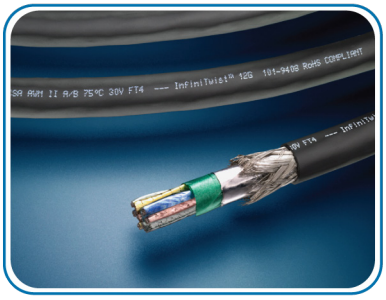


Traditional Orthogonal Backplane Architecture

High-Speed Copper Cables

- Wide array of high-speed, high-performance cables and cable assemblies for next-generation industry standard applications
- Conductor sizes of 32, 30, 28, 26 and 24 AWG available
- Capable of aggregate data rates greater than 100 Gbps (up to 40 Gbps per differential pair)

QSFP Cable Assembly

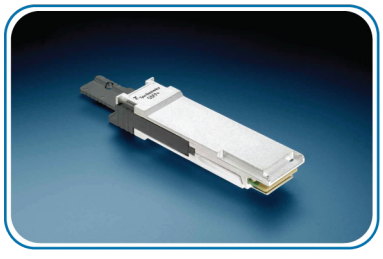


InfiniTwist Cable

High-Speed Fiber Optics

- Complete product solution set including passive and active optical cables and transceivers
- Our portfolio enables a wide range of applications including chip-to-chip, optical backplanes and fiber-to-the-antenna
- Capable of aggregate data rates greater than 100 Gbps (up to 40 Gbps per wave length)

QSFP Active Optical Cable Assembly



QSFP+ Transceiver

WIRELESS COMMUNICATIONS

MASS CONNECTIVITY IN THE 5G ERA - PREPARING NOW FOR THE FUTURE

Browse Products: avnet.com/te-connectivity-industrial-iot

MASS CONNECTIVITY IN THE 5G ERA

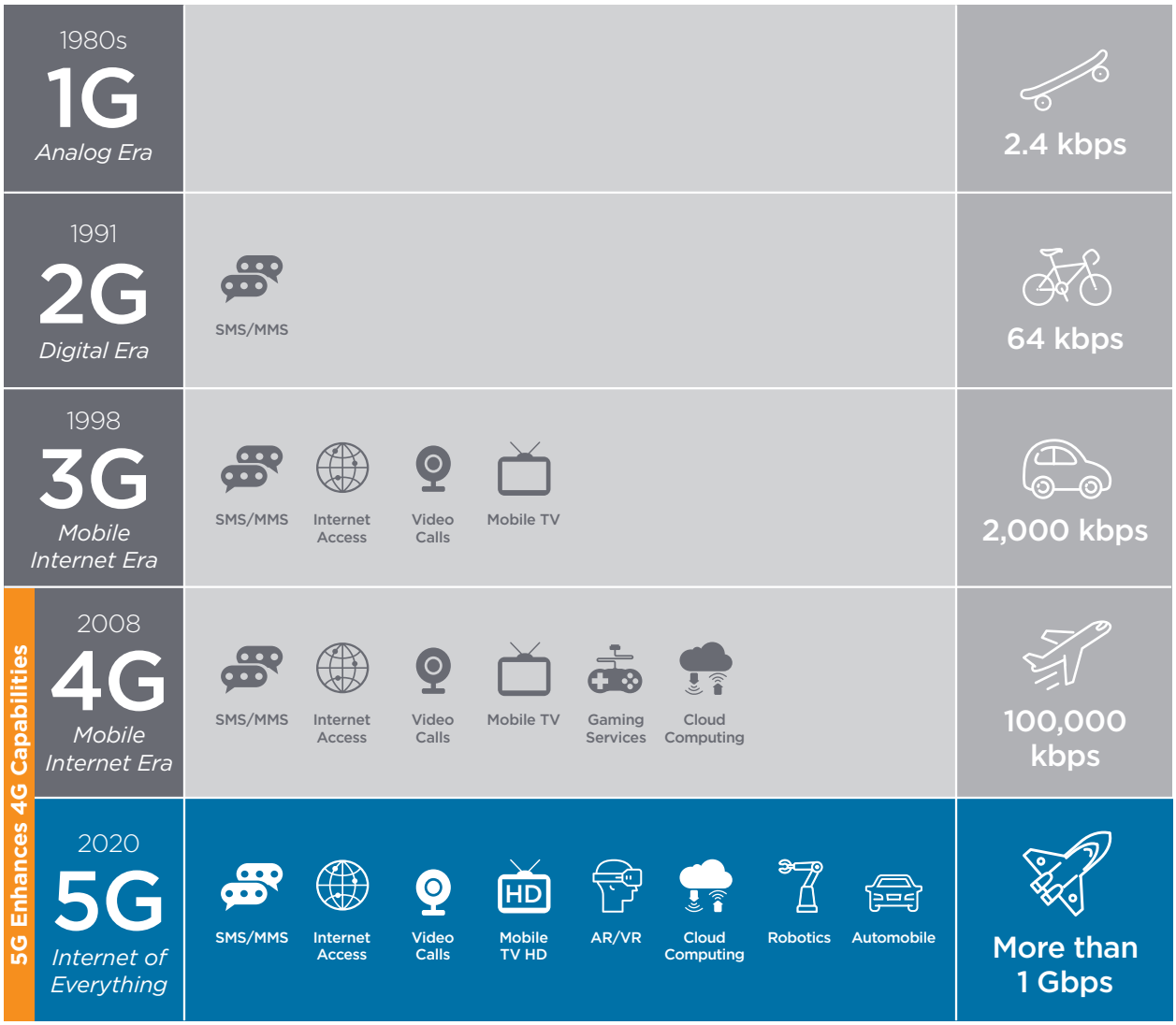
Preparing Now for the Future

5G Enabling a Fully Connected World

The fifth generation of mobile networks (5G) is about to enable a fully connected world.

With a dramatic increase in data rates and the number of connected devices, we will soon be able to enjoy expanded communication between devices (Figure 1) and no longer be limited to user-to-user and user-to-device communication. By 2025 an enormous 25 billion devices are expected to be connected under 5G.[1]

Figure 1. Evolution from 1G to 5G



5G, which can be considered an overlay to the existing 4G network, represents not only a change to cellular networks but also an integration with communications networks such as Wi-Fi and telemetry (Table 1).

[1] © GSMA Intelligence (2018) - The Mobile Economy 2017

5G Enabling a Fully Connected World

Table 1. What 5G can do that 4G cannot

Networks	Data Rate	Latency	Mobility	Spectrum Efficiency	Connection Density
5G Target	>100Mb/s (avg) >10,000Mb/s (peak)	~ 1ms	>500km/h	Target is more than 2x 4G	>100,000
4G	>25Mb/s (avg) >150Mb/s (peak)	Typically ~50ms 10ms for 2-way Radio Access Network	Functional up to 350km/h	Download: 0.1-6.1 b/s/Hz Upload: 0.1-4.3 b/s/Hz	Typical ~2000 active users/km²

According to the Next Generation Mobile Networks (NGMN) Alliance, "5G is an end-to-end ecosystem to enable a fully mobile and connected society. It empowers value creation for customers and partners, through existing and emerging use cases, delivered with consistent experience, and enables sustainable business models."[2]

Imagine a future where 5G connectivity is embedded into nearly everything you can virtually try on clothing and shop at home using a virtual reality (VR) headsets your autonomous vehicle can self-navigate and drive you to your favorite restaurant for dinner: your thermostat can preheat/precool at a desired temperature by retrieving the arrival time of your car as well as current and forecasted weather conditions.

Possible 5G Enhancements

- ☑ Realistic and seamless video streaming
- ☑ High definition video downloads in a matter of seconds
- ☑ Connected and autonomous driving vehicles
- ☑ Connect all your devices and smart home equipment through the IoT ecosystem enabled by 5G
- ☑ Increase in internet-enabled tech: smart traffic lights, wireless sensors, mobile wearables, and car-to-car communication

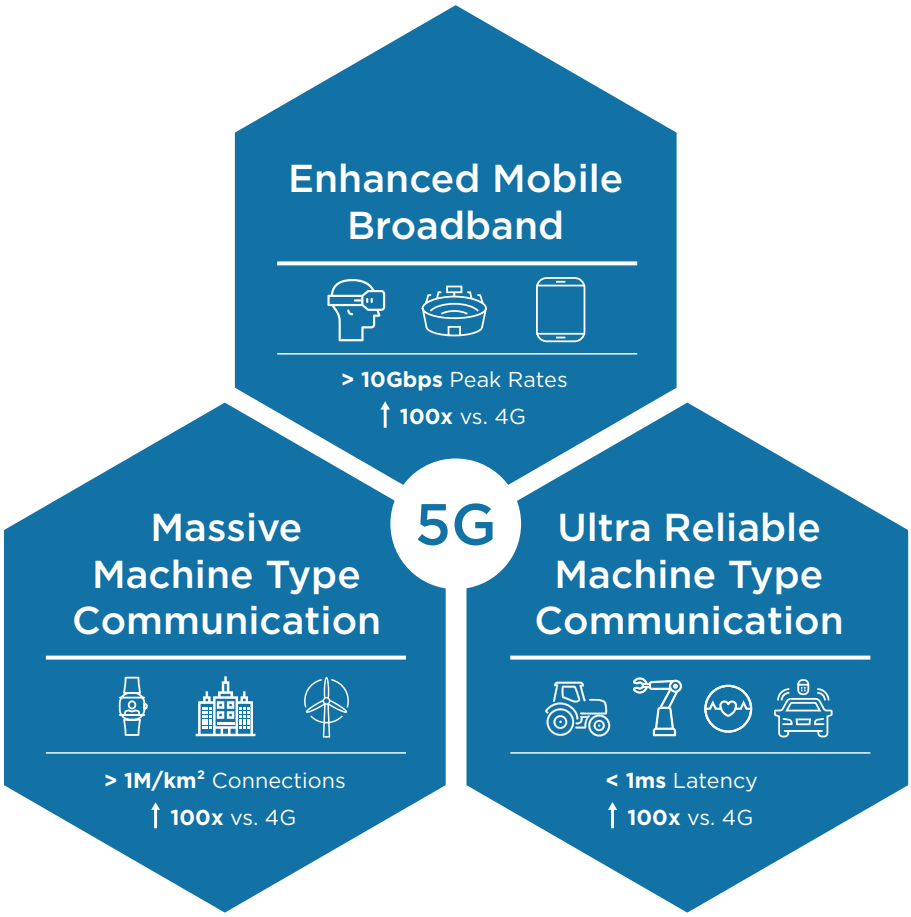
> ***5G technologies could integrate and enable the full potential of mobile technology, big data, IoT, and cloud computing while supporting digital transformation across various sectors, including healthcare, smart vehicles, smart home, industrial automation, and more.***

[2] © GSMA Intelligence (2014) - Understanding 5G: Perspectives on future technological advancements in mobile, December 2014.

5G Enabling a Fully Connected World

Advanced and reliable connectivity is one of the most critical drivers to enable 5G-powered use cases, which can be summarized into three family categories (Figure 2).

Figure 2. Three 5G use categories



Mobile Subscribers

The number of unique mobile subscribers is estimated to reach 5.9 billion by 2025, equivalent to 71 percent of the world's population. (© GSMA Intelligence (2018) The Mobile Economy 2018)

Mobile Data Traffic

Globally, mobile data traffic is expected to increase sevenfold between 2016 and 2021. Mobile data traffic will grow at a CAGR (Compound Annual Growth Rate) of 46 percent between 2016 and 2021, reaching 48.3 EB (exabyte) per month by 2021. (Cisco Visual Networking Index: Forecast and Methodology, 2016–2021)

5G Enabling a Fully Connected World

eMBB (Enhanced Mobile Broadband) focuses on providing services that pose high bandwidth requirements, based on user demand for an increasingly digital lifestyle. Typical applications include Virtual Reality (VR) and Augmented Reality (AR), 8K video, and 3D video. eMBB use cases are expected to grow rapidly, led by Asia-Pacific countries, particularly Olympic hosts South Korea and Japan. The recent 2018 Pyeongchang Winter Olympics stands as one of the industry's first non-test environments of a 5G network. The pilot project contained live or on-demand VR coverage for 30 events, powered by 5G's ubiquitous coverage across venues, as well as low latency to enable real-time control.

uRLLC (Ultra-Reliable and Low-Latency Communications) aims to cater to the demanding digital industry and focuses on latency-sensitive services. Typical applications include autonomous vehicles, public and mass transit systems, drones, remote healthcare, and smart grid monitoring and control. Latency can also be critical for cloud VR use cases where sub-millisecond latencies will be important to ensure a compelling user experience.

mMTC (massive Machine Type Communications) aims to address demands for a further developed digital society and focuses on services that pose high requirements on connection density as the expansion of the service scope for mobile networks also enriches the telecommunications network. Typical applications include smart cities, industrial automation, and farming.

4K TV sets: By 2021, more than half (56 percent) of connected flat panel TV sets are expected to be 4K, up from 15 percent in 2016. Installed/in-service 4K TV sets will increase from 85M in 2016 to 663M by 2021.[3]

Virtual Reality and Augmented Reality: traffic is expected to increase 20-fold between 2016 and 2021, at a CAGR of 82 percent.[4]

Connected Vehicle: By 2020, it is anticipated there will be a quarter billion connected vehicles on the road, enabling new in-vehicle services and automated driving capabilities.[5]

IoT Connections: The number of Internet of Things (IoT) connections (cellular and non-cellular) is expected to increase more than threefold worldwide between 2017–2025, reaching 25 billion.[6]

Mobile Technologies and Services : In 2017, mobile technologies and services generated 4.5 percent of GDP (Gross Domestic Product) globally, a contribution that amounted to $3.6 trillion of economic value added. By 2022, this contribution is expected to reach $4.6 trillion, or 5 percent of GDP.[7]

[3]Cisco Visual Networking Index Predicts Global Annual IP Traffic to Exceed Three Zettabytes by 2021

[4]Cisco Visual Networking Index Predicts Global Annual IP Traffic to Exceed Three Zettabytes by 2021

[5]https://www.gartner.com/newsroom/id/2970017

[6]© GSMA Intelligence (2018) - The Mobile Economy 2018

[7]© GSMA Intelligence (2018) - The Mobile Economy 2018

Wave to Greater Capacity

5G is expected to provide an order of magnitude improvement in performance in the areas of greater capacity, lower latency, more mobility, more accuracy of terminal location, increased reliability, and availability.[8]

> ***To address the expected high capacity of 5G, there are three methods to be considered from the radio perspective: 1) densifying networks with small cell deployments, 2) delivering high spectral efficiency, 3) gaining access to more spectrum. There are all closely linked to strategic spectrum deployment.***

As a critical but scarce resource in the 5G era, spectrum in three key frequency ranges, each with unique features, is expected to deliver widespread coverage and support all 5G use cases: sub-1 GHz, 1-6 GHz, and above 6 GHz. The first two are often referenced as sub-6GHz.

This is important as cellular data traffic continues to rise, and eMBB is set to become the core consumer value proposition. We expect both the USA and China to lead the first wave of 5G deployments, with different approaches. China, in our opinion, will focus initial deployments in the C-band (3-5 GHz) targeting IoT use cases. The USA, on the other hand, will focus initial deployments on fixed wireless access through mmWave (above 24 GHz) frequency spectrum, as well as deployments in low bands (600 MHz).

In the long run, we believe C-band spectrum may be challenged to deliver enhanced mobile broadband due to limited spectral efficiency and system capacity improvements, as well as less than 10 ms latency. To support the requirements for wide contiguous bandwidths, mmWave bands may need to be considered.

> ***Due to the fast-growing 4K/8K ultra-HD video applications and the ever-increasing use of AR and VR applications, 5G is needed to supplement the capacity of 4G networks.***

> ***Considering the current technical maturity and economic feasibility, a hybrid network is very likely - in major urban areas, mmWave will be deployed, while sub-6GHz is expected to deploy in suburban areas or small cities. Of course, 5G will also co-exist with 4G.***

[8] The 5G Infrastructure Public Private Partnership (5G PPP): 5G Vision

These bands can support large capacity increases for high bandwidth applications. In addition, with techniques like beam forming, wireless signals could be made highly directional without causing much interference, allowing for improved spectral efficiency. However, with increasing carrier frequency, both path loss and diffraction loss become more severe, and the atmospheric effects must be considered.

Currently, there are a large number of preliminary 5G tests worldwide that are using various spectrum bands, particularly 3.5 GHz and 26/28 GHz. In more than 30 regions, there are plans to assign spectrum in two bands over the next two years. (Figure 3)

Designed for Diverse Spectrum Bands/Types

Figure 3. Global snapshot of 5G spectrum bands allocated or targeted[9]

	<1GHz		3GHz	4GHz	5GHz	24-28GHz	37-40GHz	64-71GHz
USA	600MHz (2x35MHz)	2.5GHz (LTE B41)		3.45-3.55GHz 3.55-3.7GHz 3.7-4.2GHz	5.9-7.1GHz	24.25-24.45GHz 24.75-25.25GHz 27.5-28.35GHz	37-37.6GHz 37.6-40GHz 47.2-48.2GHz	64-71GHz
Canada	600MHz (2x35MHz)			3.55-3.7GHz		27.5-28.35GHz	37-37.6GHz 37.6-40GHz	64-71GHz
EU	700MHz (2x30MHz)			3.4-3.8GHz	5.9-6.4GHz	24.5-27.5GHz		
UK	700MHz (2x30MHz)			3.4-3.8GHz		26GHz		
Germany	700MHz (2x30MHz)			3.4-3.8GHz		26GHz		
France	700MHz (2x30MHz)			3.46-3.8GHz		26GHz		
Italy	700MHz (2x30MHz)			3.6-3.8GHz		26.5-27.5GHz		
China				3.3-3.6GHz	4.8-5GHz	24.5-27.5GHz	37.5-42.5GHz	
Korea				3.4-3.7GHz		26.5-29.5GHz		
Japan				3.6-4.2GHz	4.4-4.9GHz	26.5-28.5GHz		
Australia				3.4-3.7GHz		24.25-27.5GHz	39GHz	

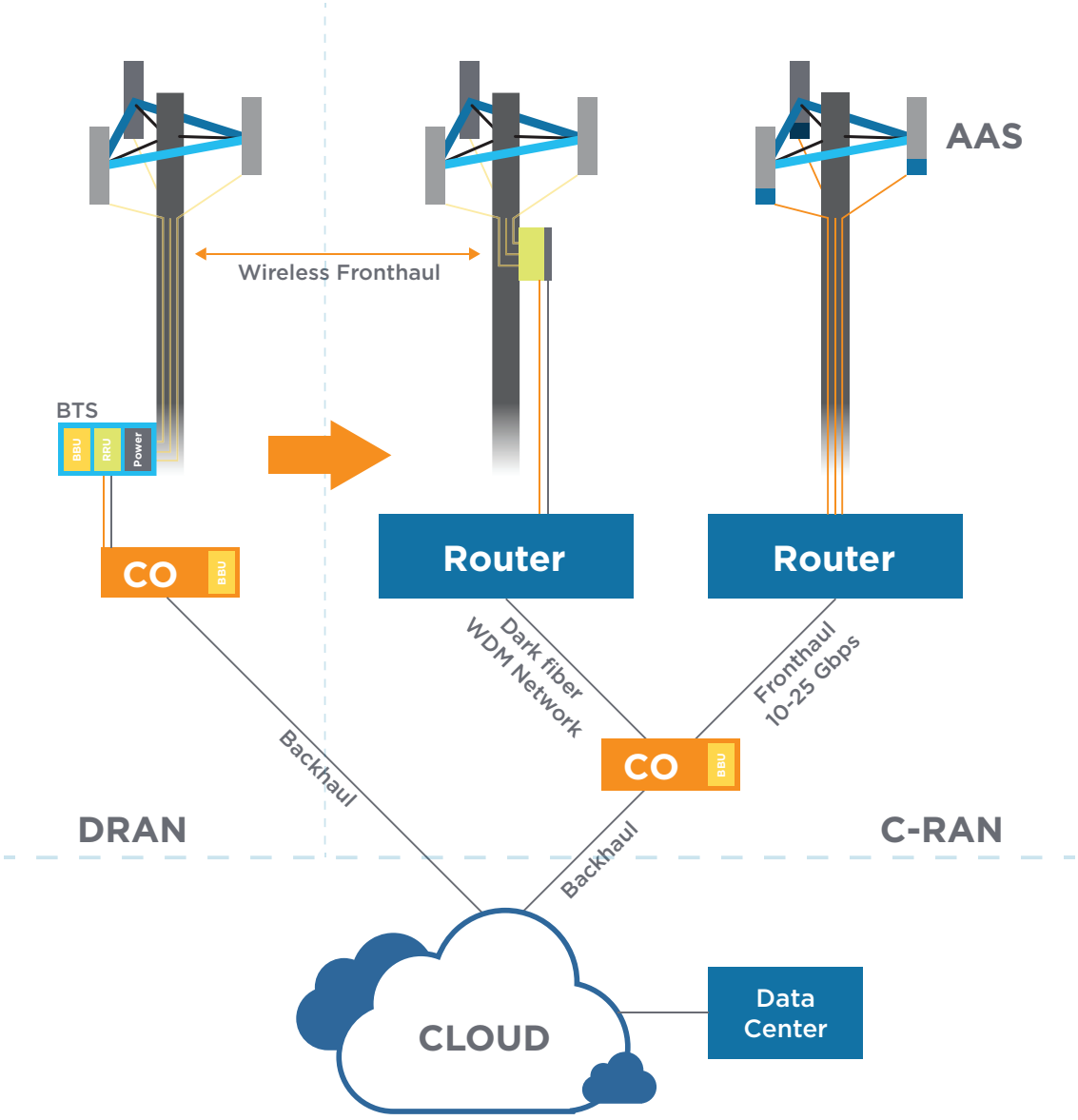
New 5G Band — Licensed — Unlicensed/shared — Existing band

[9] Qualcomm Technologies, Inc.

The Evolving Architecture

Large amounts of spectrum are required to deliver massive increases in capacity to achieve higher speeds and lower latency. Thus, upgraded architectures and further advances in connection technologies are expected to assist the realization of 5G's full potential (Figure 4). There are three key architectural shifts that impact 5G connectivity.

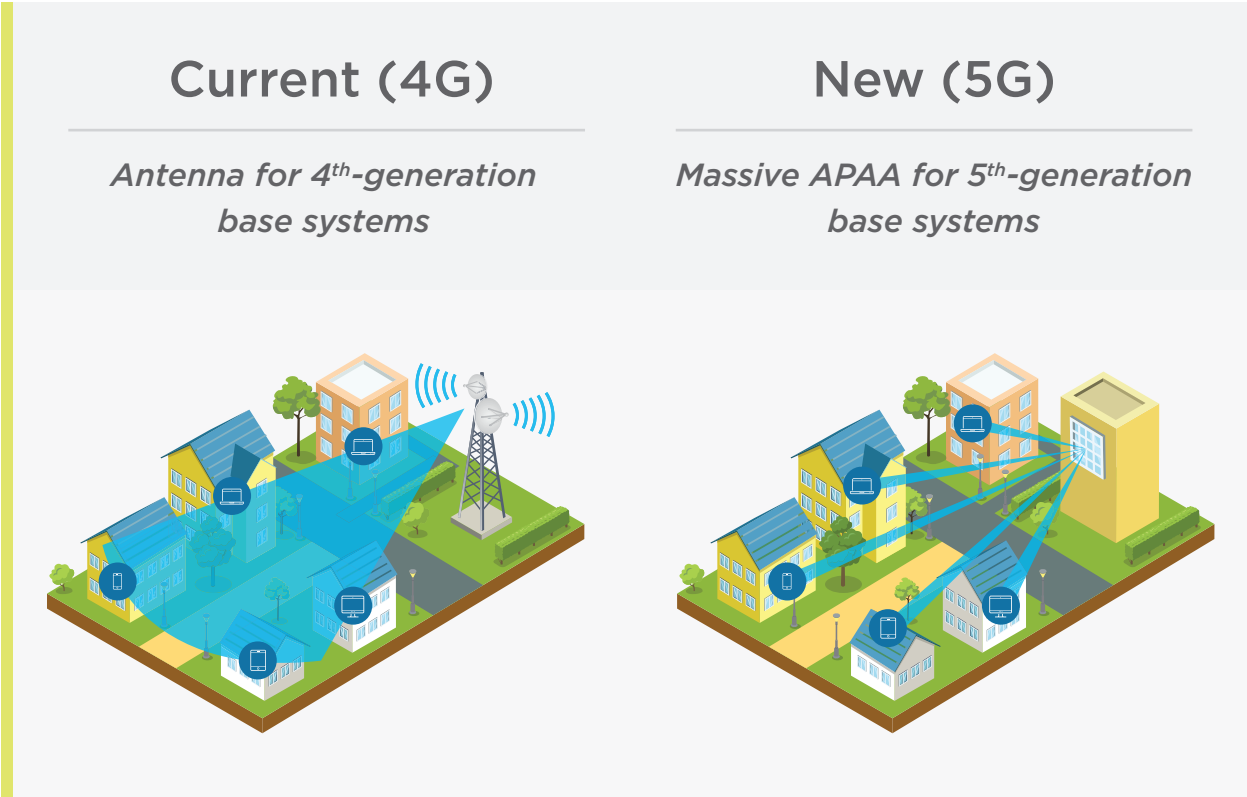
Figure 4. The evolving architecture



1. Adoption of Massive Multi-input Multi-output (MIMO) active antenna systems (AAS)

The 5G ecosystem is expected to support high-density networks by adding new features to the radios and overall system layout. The traditional combination in 3G/4G networks of a remote radio head connected to an external antenna will be extended by active antenna systems (AAS) or active phased-array antennas with massive antenna elements (massive APAA's) (Figure 5), in which the electronics will be embedded in the antenna system and operating over a wide frequency range (600 MHz to 28 GHz and above). This primary system will be supported by complementary systems in dense areas (Figure 6). These complementary systems will have a high number of antennas to support multi-user MIMO (MU-MIMO). These antenna elements will feature their own control electronics, requiring new connectivity solutions. Frequencies above 6 GHz will be predominantely supported by highly integrated systems. These radio frequency integrated circuits (RFIC) often feature integrated antennas on the top surface of the chipset.

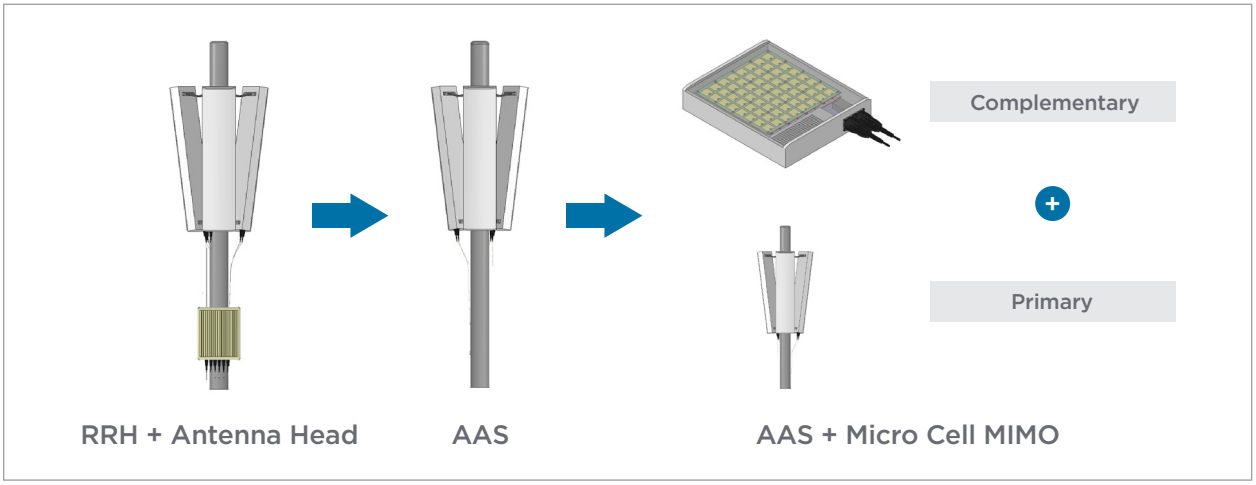
Figure 5. Current 4G compared to new 5G[10]



[10] Mitsubishi Electric Corporation, "Mitsubishi Electric's New Multibeam Multiplexing 5G Technology Achieves 20Gbps Throughput", No. 2984, Tokyo, January 21, 2016

5G massive active antenna systems are anticipated to increase system complexity, requiring greater miniaturization of antennas and greater integration of antennas with filters and power amplifiers. As a provider of customized embedded antenna solutions, TE offers a wide array of customized antenna solutions to accommodate the mechanical constraints of your application and design, in compliance with the most stringent of operating requirements, additionally, TE's high-speed input/output (I/O), internal connector and cabling solutions, cost-effective RF coax solutions, and antenna modules are all well suited for the next generation of antenna systems.

Figure 6. Evolution from remote radio head and antenna to primary and complementary systems.



2. Adoption of New Transmission Technology in Fronthaul

5G will bring very high capacity. For that reason, the fronthaul to the base band unit (BBU), backhaul and transport network will likely need to be upgraded to support increasing traffic requirements. We expect to see greater high-speed optical connectivity in the overall network, with TE's high-speed I/O portfolio, including SFP28, microQSFP, QSFP28, and FullAXS connectors as possible high-speed and dense connectivity solutions.

Small cells will be a key component in the 5G era. They will increase the density of the network and bring short-range solutions, potentially utilizing both sub-6 GHz and mmWave technology. For sub-6 GHz deployments, TE has an extensive portfolio of antennas and products that protect against electromagnetic interference (EMI). Deeper fiber penetration (closer to the small cell location) may also be required to backhaul traffic from small cells leveraging our high-speed product portfolio.

3. The Adoption of C-RAN

In 5G networks, we expect to see greater utilization of cloud-like concepts applied to both the radio access network and core network. C-RAN (Cloud RAN) will focus on both centralizing BBUs and the adoption of cloud technologies like virtualization. The centralization phase is all about moving the BBU to a common location that serves multiple towers, which largely reduces the cost of land, power, cooling and operational expenses. The cloud phase virtualizes hardware-based BBUs, allowing them to run on commercial, off-the-shelf servers. BBU pooling, as well as the adoption of cloud technologies like SDN (Software-Defined Network), NFV (Network Functions Virtualization), network slicing, and virtualization, will all still require high-speed, high-data, high-density, reliable, and rugged connectivity solutions.

TE's connectivity solutions, which are useful for base station and optical transport, push the boundaries of speed and bandwidth within today's architectures and address challenging data rates, signal, and power requirements of emerging 5G mobile networks. In addition to our antenna expertise, our high-speed board-to-board and cabled solutions offer increased bandwidth for backplanes and mid-planes. We can leverage our expertise in data center and cloud technology to provide high-speed I/O solutions, high-speed cabled solutions, high-speed board-to-board solutions, and power solutions.

Against a backdrop of debate and unknown ramifications to the industry at large, the mobile industry is expected to reach numerous milestones leading up to the year 2025, including major progress in 5G with commercial launches anticipated to take place in the United States in 2018 and in major markets in Asia, North America, and Europe over the next three years[11] (Table 2). The official approval of non-standalone 5G new radio (NSA 5G NR) specifications in December 2017, as well as the commercial debut of 5G at the 2018 Pyeongchang Winter Olympics, display the desire for a 5G-powered future.

5G took center stage at Mobile World Congress (MWC) 2018 as an exciting and imminent new technology. The leading equipment manufacturers all announced dozens of innovative products: Huawei unveiled its first commercial 5G customer premises equipment (CPE), a terminal device supporting 3GPP 5G standards with a Huawei-developed Balong 5G01 chipset as part of its end-to-end 5G solution. Ericsson showcased super low latency of 5G (just 6 milliseconds), while Intel showcased the first 5G-enabled 2-in-1 concept PC;.Samsung announced that its complete commercial fixed-wireless access (FWA) 5G solution has become the first globally to receive approval by the United States Federal Communications Commission (FCC).

[11] The Mobile Economy 2018

5G is Just Around the Corner

Table 2. 5G operator rollout plans – timing, spectrum, scope

Country	Operator	5G Rollout Status
China	China Mobile	End of 2018: 5G field tests; pre-commercial 2019; commercial service in 2020
	China Unicorn	2020: 5G commercial launch but gradual uptake; to co-exist with 4G for a long time
	China Telecom	2017-2018: outdoor 5G trial; commercial trial in 2019, scale rollout in 2020 to co-exist with 4G for a while
Korea	KT	2018: pilot tests in 28 GHz during Winter Olympics; commercial service intended in 3.5 GHz and 28 GHz
Japan	NTT	2018: 5G rollout to commence. Has nationwide FTTH network; no spectrum auction in Japan – allocated by Govt. for free
	Softbank	2017: Trials ongoing in 4 / 4.5 GHz / 28 GHz in Tokyo; commercial launch planned for 2020
USA	Verizon	2018: FWA trials in 11 cities; commercial 5G FWA deployments in 2018 using mmWave in 28 GHz, 39 GHz
	AT&T	Late-2018: could launch standards-based 5G network
	T-Mobile	2019: 5G deployments to commence in 600 MHz aimed at IoT; full nationwide coverage in 202
	Sprint	Late 2019: 5G launch in late 2019 in 2.5 GHz
Europe	Multiple Carriers	By 2020: European Regulator pushing for one urban 5G market in each country with rollouts in 3.5 GHz initially. Carriers reserved about 5G plans.
Russia	MTS	2018: Gearing up for 2018 FIFA World Cup and expanding LTE network for increased capacity. 5G will be rolled out in targeted areas but will not have same coverage as LTE.

Get Ready Now

Partner with TE Connectivity

5G will achieve faster transmission rates, more powerful data exchange networks, and more seamless real-time communication, which will enable tremendous growth for advanced and innovative connectivity solutions.

TE is the go-to, one stop solutions provider for all of your connectivity needs.

As a committed innovator, TE enables our partners to capitalize on opportunities in the 5G era with our global footprint, broad product portfolio, and deep-rooted local engineering expertise.

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