

# GENERIC PCB CONNECTOR ROADMAP

Parameter	Metric	Pressure Pt	2003	2005	2007	2011	2017
<b>Mechanical</b>							
Contact Material	Alloy Metal	2012	Br, PhBr, BeCu			PhBr, Designer Alloys	
Contact Size	Min. Thickness - $\mu\text{m}$	2012	150	125	100	100	<100
Contact Shape	Pin, Beam, $\mu\text{Contact}$	2015	Pin-Beam				$\mu\text{contact}$
Typical Pitch	Center Line - mm	2015+	2.0	2.0	1.0	1.0	1.0
Limit-stamped	Center Line - mm	2010	0.5	0.4	0.3	0.25	0.2
Thin Film - MEMS	Center Line - $\mu\text{m}$	2012	100	50-75	30-50	30-50	20-40
Plating	Alloy	2015	Gold plating will remain choice – highly selective, some Ag, Pd				
Contact Lubricants	%	2009	10%	15%	20%	30%	50%
Mating Force (LGA)	Grams	2012	100	50	40	25	20
Housing Material	Type	2009	PPS, LCP other thermoplastic resins			Halogen-Free, Non-Brominated Flame	
Mounting	TH/SMT	2015+	TH-SM	TH-SM	TH-SM-BGA	TH-SM-BGA	SM-Embedded
Solder Plating	Pb – Pb-Free (Sn)	2006	RoHS July 2006 – 80% Compliant (Sn Plated Pins) -Exemptions				
<b>Electrical</b>							
Contact Resistance	m $\Omega$	2015+	20	20	20	20	20
Insulation Resist.	M $\Omega$	2015+	5,000	5,000	5,000	5,000	5,000
Voltage Rating	V	2015+	1000	750	750	750	500
Current Rating	A (*Peak Current Issue)	2015+	2.0	1.0	1.0*	0.5*	0.5
Inductance	nH	2015+	<3.0	<2.0	<1.0	0.8	0.5
Capacitance	pF	2015+	<1.0	<1.0	<1.0	<1.0	<1.0
Near end X-talk	dB	2010	3.5	3.0	2.0	1.0	1.0
Char. Impedance	Single End/Differ $\Omega$	2015+	50/100	50/100	50/100	50/100	50/100
Max Speed	Gbps	2015	4.0	10	10-15	10-15	25-40
<b>Cost (Mated Line)</b>							
Low Cost/High Volume	Cents	2001	1-2	1-2	1	1-2	1-3
Area Array $\geq$ 500 Pins		2002	4-6	4-6	5-8	4-7	5-10
Cost - Perf		2009	3-5	3-5	3-4	3-5	3-5
High Perf		2012	10-25	10-25	10-20	10-15	10-15

Notes: *Designer Alloys* = application-engineered alloy formulations, *contact* = spring, button, FEC, other, *TH* = Thru Hole, *MEMS* = Bulk Micro-machined Contacts, *Compressive* = Z-Axis interconnect such as Metallized Particle, Super Button or other.

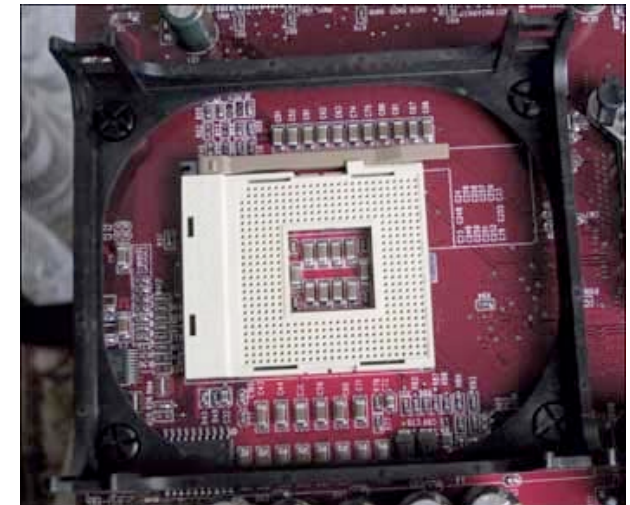
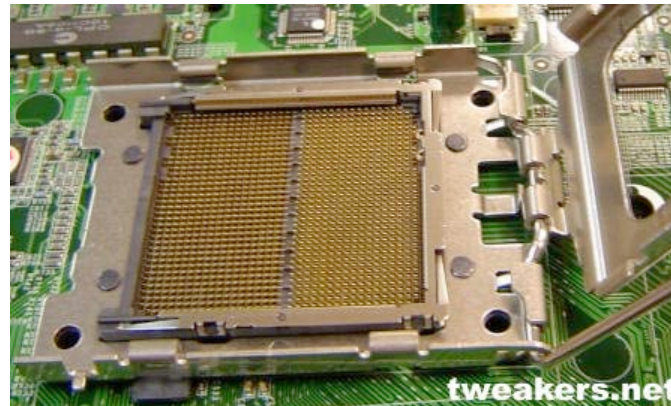
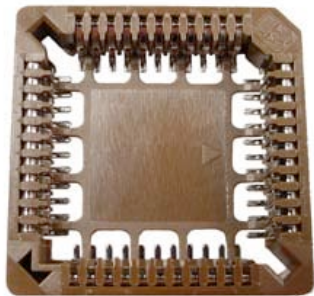
**100s of PCB Connectors** will continue to evolve toward **SM**. **Key areas:** Cost/Materials Pressures, Globalization of Supply Chain, Miniaturization/Mated Ht/Pin Pitch, SiP, SoC & other SI Innovations, PCB Technology Trends (Integration), Circuit Speed, Recycling.



## IC SOCKETS (LGA-PGA-other - for Processors, ASICs, etc.)

Applications	Parameter	Metric	2000	2005	2011	2017	Roadblock	When	Comments
Mobile Systems	Major package types	Type	PGA	mPGA	BLGA	XGA	Cost & Size	2010	CPU Socket Trends: 1207 Pin Opteron Socket F 2000+ RISC CPU Wintel Stds Land Grid Array Dual/Multi Core CPU BGA/SM Organic Substrates 1000+ Pins Higher speed/power
	Mated Ht.	mm	5.0	3.0	2.5	2.0	Thinness	2010	
	Max. # Pins	#	500	1000	5000	5000	# of Pins	2010	
	Pin Pitch	mm	2.54	1.27	1.0	0.5	Pin Spacing	2015	
Desktop Systems	Mounting	Type	TH	TH/BGA	BGA	BGA/Embedded			
	Housing	Material	LCP	LCP	LCP	LCP			
Bus. Equip.	Voltage Rating	V	100	100	100	100			
	Max Current	A	1.0	1.5	2.0	3.0	Peak Current	2010	
	Max. Operating temp.	°C	150	150	150	150			
Telecom	Max Speed	MHz	2GHz	5GHz	10GHz	15GHz	Speed/Bandwidth	2010	
	Technical Issues	Type			Peak current ratings will become an issue but will be managed				
Other	Supply Chain Issues	Type		Global supply chain & dependence on China mfg					
	T	Type	Card edge/daughtercard, mezz card, BGA direct attach alternatives. $\mu$ BGA in future						
Trends	Current trend is toward ball-attach [BLGA designs], higher pin counts, chip speeds and peak current requirements. Products include PGA, $\mu$ PGA [short pins], LGA and PLCC [Plastic Leaded Chip Carrier]. IC socketing will continue to be challenged by direct-attach [BGA], yet will remain compelling due to sourcing, duties, repair and upgrade of expensive CPUs and ASICs.								

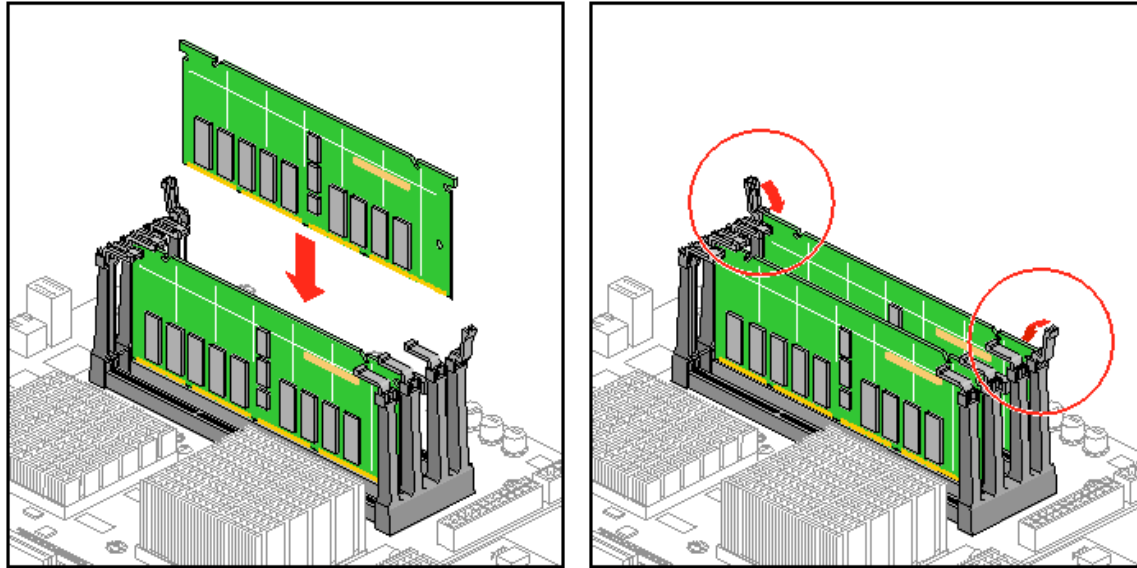
BLGA=LGA with ball attach, XGA=future area array design, LCP=liquid crystal polymer, mPGA= $\mu$ PGA, Wintel=Windows/Intel Stds.



## DUAL INLINE MEMORY SOCKETS (DIMM Sockets)

Applications	Parameter	Metric	2000	2005	2011	2017	Roadblock	When	Comments
Desktop	Predominant package type	Type	DIMM	DIMM	DIMM	2 pc, BGA?	Memory Tech. Change	>2012	Cost/Design Evolution
	Memory technology	Type	SD/DDR	DDR2	DDR3	New	CPU Integration		Moore's Law
	Q	quantity	184	240	300	500	Memory Capacity		JEDEC Standardization
Servers	Pitch/spacing $\geq$	mm	1.27	1.00	1.0	0.8			GB+ chips
	T	Type	TH	TH	TH, SM	SM			DDR3, 4
Office Equip	Housing	Materials	EP/TP	EP/TP	EP/TP	EP/TP			Advanced Memory
	Voltage rating $\leq$	V	100	100	100	100			Design Evolution
Telecom	Max current $\leq$	A	1.0	1.0	1.0	1.0			Matls Evolution
	Max. operating. temp. $\leq$	$^{\circ}$ C	85	85	125	125			2 Pc Socket (Cost?)
Other	Max speed $\leq$	MHz	266mb	667gb	2gb	4gb	Bus Speed	2012	BGA Attach
	Technical issues	-			Speed may become an issue, dictating a new 2 pc design				
	Supply Chain Issues	-		High Vol, High Tech, Low Cost - Global Supply Chain Quality Issues					
	Encroaching Technologies	-		Increasing Memory Capacity may Limit # of Sockets					
Trends	SD-RAM/DIMM remains dominant package re: JEDEC standardization. Massive mfg. capability of this type of package. Speed will become more and more of an issue until an alternative package is launched, which may include a two piece connector design. GB memory cells will limit number of sockets per system. Advanced memory developments by Intel, HP and others will force changes. Cost will remain a dominant factor in package selection.								

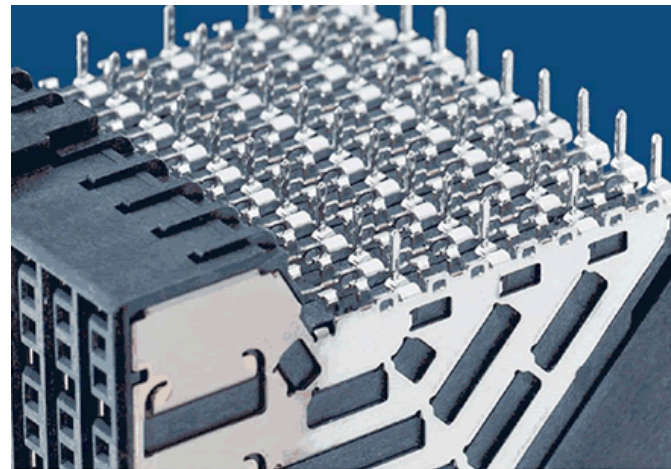
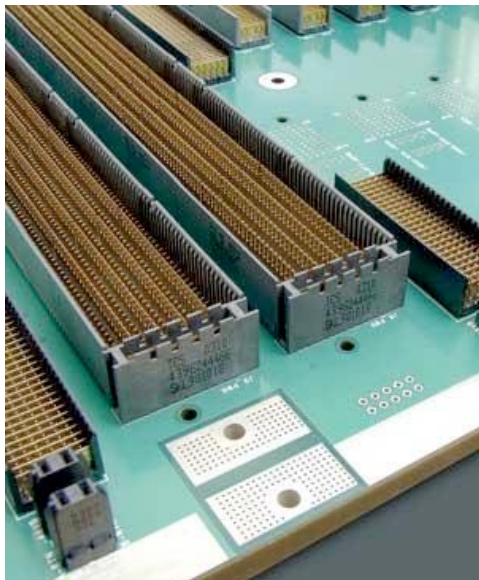
EP=Eng. Plastic , TP Thermo-Plastic resin, DIMM=Dual Inline Memory Module, RDRAM=Rambus memory, GB=gigabyte, MRAM=Non-Volatile Mag. Memory. SODIMM=Small Outline DIMM



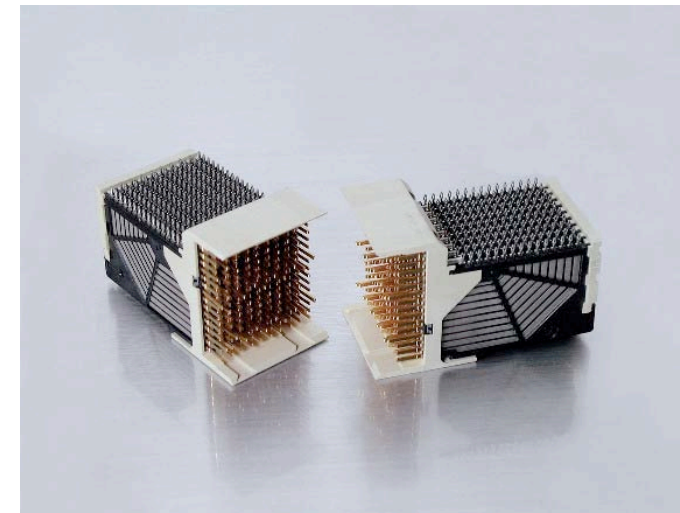
# HIGH PERF. BACKPLANE CONNECTORS (Various OEM Designs)

Applications	Parameter	Metric	2000	2005	2011	2017	Roadblock	When	Other Comments
Central Office	Predominant Package	type	2pc Box	Box, EC	Box, EC	Box, EC	TH: 10-12Gbps	2007	Hi Perf Computer - Commun. Highest Tech Connectors. Architecture Changes.
	Max. # pins/in $\leq$	quantity	120	150	200	240	High Perf:	2010	
	Pitch/Spacing	mm	>2	>2	<2	<2	10-20 Gbps		
Base Station	Mounting	Type	PF	PF	PF/SM	SM	Future: 20-30Gbps	2012-15	Adaptive Signal Control Pkg Evolution.
	Housing	Matls	EP	EP	EP	EP			
Server	Voltage rating	v	100	100	100	100			Design Evolution.
	Max Current	a	1.5	1.5	2.0	2.0			Matls Evolution.
Indus PC	Operating temp. $\leq$	$^{\circ}$ C	70	70	85	85			SM vs. Press Fit (Perf)
	Max Frequency $\leq$ Gbps	Gbps	1	10	20	40	Speed/PCB	2010	Hybrid Optical Backplanes
Other	Technical issues	type		RoHS	Bus Speed vs. PCB Trace Design, Length, SM Mech. Strength				
	Supply Chain issues	type			High Volume, Hi Tech, PCB Technology x-Linkages				
	Encroaching Technologies	type		New Backplane Architectures: Orthogonal High Speed, EO					
Trends	New backplane architectures incl. orthogonal. New signaling chips extend range of high speed Cu trace/printed circuits, Numerous new HP backplane connector designs are stretching performance to new multi-gigabit heights. Mostly telecom & HPC. These new developments delay need for embedded optical interconnect, although some optical transceiver & board-to-board fiber will be specified in high end equipment.								

EC= Edge Card. Backplane examples: Teradyne VHDM, Aptera, FCI AirMax, Tyco Multigig, etc.

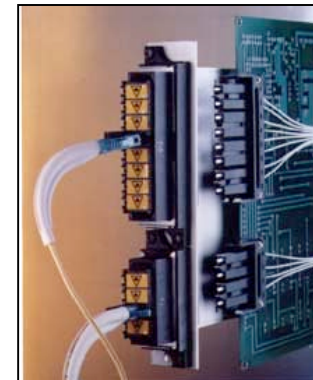
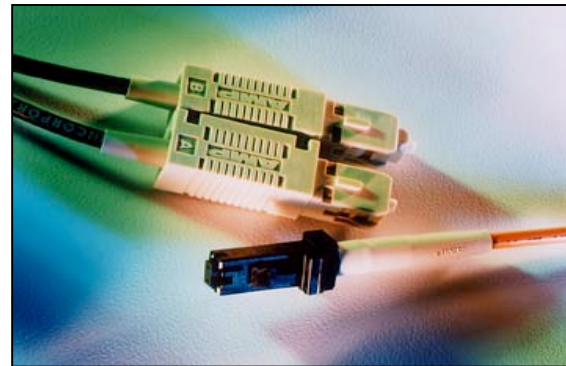
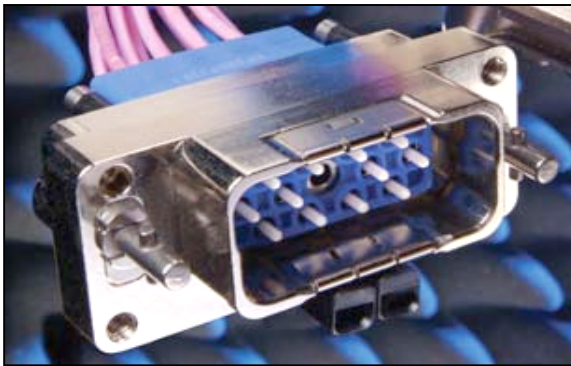


Metal structure around signal pins



# FIBER OPTIC CONNECTORS

Applications	Parameter	Metric	2003	2007	2011	2017	Roadblock	When	Comments
Telecom	Predominant package types	Type	Cl,R,M	Cl,R,M	Cl,R,M	Cl,R,M	Cost	1980s Telco	Many styles avail. Cu cross-over remains elusive due to Trx cost, improving Cu performance. FO is in Telecom, Storage, HPCC.
	Fiber types	Type	MM,SM	MM,SM	MM,SM	MM,SM	Cu Performance	1990s Comp	
Computers	Max. # pins	Quantity	24	72	104	144	EOICs	1990s R&D	
	Max. Wavelength	nm	1565	1625	1675	2000	EO Packaging	2000 Bust	
Special Applic.	Housing/Ferrule	Material	G,C,EP,Me	G,C,EP,Me	G,C,EP,Me	G,C,EP,Me	System Design	2006 HPCC	
	Attenuation range	db	0.3-1.0	0.15-1.0	0.1-1.0	0.1-.8	Design Tools	2007 FTTC	
	Max. operating temp.	°C	85	85	85	85		2017 High Vol Level 2-6	
	Max circuit speed	GHz	Essentially Unlimited						
	Alternative technologies	-	Advances in Cu interconnect & circuitry, UWB						
	Technical issues	-	End Face Prep, Assembly, Alignment, Attenuation						
	Supply chain issues	-							
	Encroaching Technologies	-	UWB Wireless						
Trends	<p>Fiber Optics=multi-tiered technology. 1]Low cost LED/POF specialty applications in copiers, automotive, sensors, etc; 2] telecom applications in the local, distribution loop, central office and long haul networks; 3] high speed LANs and SANs; 4] high perf. electronic equipment interconnects. FTTP at from 30 to 100Mbps is in initial roll-out after decades of planning – beginning with Verizon and Bell South. FO future tied to success of broadband FO deployment + degree of UWB wireless competition to wired telecom. Massive investment over the past 2 decades in fiber optics R&amp;D has produced a stable of technology that is yet to be fully realized in commercial application. EO is capable, albeit at 2 to 10X the cost of Cu, of satisfying any foreseeable roadblock related to speed or bandwidth, but will see only high end use in OEM equipment thru 2010-15. FO connectors tooled and available for production use include: ST, FC, LC, SC, FDDI, MT/RJ, MU, E2000/3000 &amp; MT Ferrule based MPO, MPX &amp; others. POF remains a specialty. Connectorized transceivers are also available [GBIC/SFP]. ATM/Sonet frequencies from OC-3 [155Mb] to OC-192 [10Gb]. Fiber flex, ribbon fiber, free space and embedded optical trace technologies are also available when on-board optics is required, as are optical backplane interconnects – including hybrid Fiber-Cu devices/systems.</p>								



Cl=Circular, R=Rectangular, M=Modular, G=Glass, C=Ceramic, EP=Eng. Plastics, Me=Metal, MM=Multimode, SM=Singlemode

- ⇒ FO Migration from Long Haul Telecom Inward to Equipment IO Ports – To Inside Equipment.
- ⇒ Data Rates of 1-10Gbps encourage more FO Use
- ⇒ Developments coming in EOICs, Waveguides, PCBs. Hybrid Cu/FO Systems are already here.
- ⇒ **FO Interconnects are available today to satisfy applications beyond reach of Cu circuitry.**



# FIBER OPTIC CONNECTOR NARRATIVE

## Situation Analysis:

Fiber Optic connectors have been avail. since the 1980s. Their growth was the conversion of the telecom physical plant to fiber – single mode in the long haul network, multimode in telecom equipment, cross-connect boxes and networks. This is almost 100% complete. The latest Telco development, which has had a very long gestation period (way behind Broadband Coax), is Fiber to the Home, with Bell South/AT&T and Verizon rolling out fiber optic voice, high speed internet and video systems.

## Roadmap Question – Where Will Fiber Optics be Used:

### NOW

- ⇒ Telco: Metro,
- ⇒ High Perf. Networks, Computing, Storage, Equip Cabling
- ⇒ Fiber-to-the-Curb
- ⇒ Medical Electronics
- ⇒ Digital Audio
- ⇒ Some Automotive & Office Equip.
- ⇒ Transportation, Elec Power
- ⇒ Mil-Aerospace

### FUTURE

- ⇒ Enterprise Servers & Storage Equip
- ⇒ Desktop Super Computers
- ⇒ High End Audio/Video Equip
- ⇒ **Widespread Use in Electronic Packaging ~**  
Future Developments in Cu Circuitry, ICs & PCBs,  
EOIC Developments & Major OEM Adoption (Intel)  
Mainstream EOIC System Packaging – Circa 2017

## What Elements of an All-Photonic System are Available?

GaAs, InPh Lasers, WDMs, Planar Lightwave Circuits (PLCs) in Si & InPh, Transceivers, Connectors, Waveguides, Cables. These can address High Speed Backplanes to 20Gbps or more. Available Waveguides include traditional Glass Fiber + High Index Delta for Small Bend Radii, Polymer Waveguides, & Plastic Optical Fiber (POF) that achieve High Bandwidth through Graded Index Cores.

## Near-Term Developments:

- ⇒ Intel: Si Haman Lasers, Waveguides, Si Laser Sources
  - ⇒ PCBs w/ Integrated or Stand-alone Waveguides
  - ⇒ Multiple SiP w/Optical Interconnect
  - ⇒ 3D Chip Stacking w/EOICs
- ⇒ 20-40 Gbps Cu Backplanes would delay FO Implementation

## Conclusion:

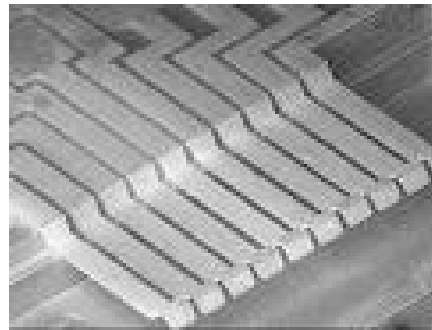
Cost Constrains & other Factors will delay widespread use of Fiber Optics inside Electronic Systems till 2017 or Beyond. This assumes continuing evolution of Cu Circuitry. There will be a gradual adoption of FO – and some Significant New Applications in FTTC, HPCC, Medical, ITHS and other Applic.

# IF NOT CONNECTORS...WHAT

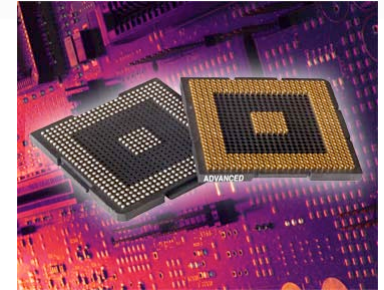
Wireless



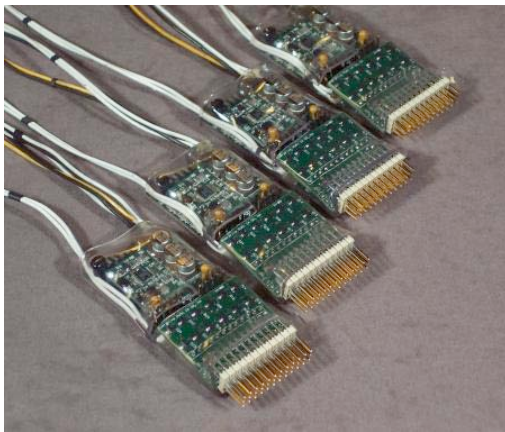
MEMS



BGA



“System-on-Chip” or System-in-Package”



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