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# Connectors

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The term connector applies to virtually *any* product that connects devices. For the scope of this primer, the term **connector** will be applied to the specific range of electronic products whose sole purpose is to connect devices to one another. This connection is usually established through coupling of male and female connectors. Male connectors contain exposed pins or other form of contacts while female connectors contain holes, or sockets, in which the exposed pins are meant to be inserted. Male/female connectors are used in cases where convenience or manufacturing guidelines call for it.

**Circular connectors** are used for external device interfacing. They come in many sizes, differentiated by the number of contacts (pins and sockets) and contact diameter. In North America, the standard for contact diameter is the American Wire Gauge (AWG) standard<sup>1</sup>.

**PCB connectors** mount onto Printed Circuit Boards (PCB); they use pins on the connector, they "mate" with holes on the PCB, and together they are then soldered. PCB connectors are used in cases where PCBs, such as boards and cards, are used. Some commonly found PCB connectors are Peripheral Component Interconnect (PCI), Deutsches Institut für Normung (DIN), Accelerated Graphics Port (AGP), and Personal Computer Memory Card International Association (PCMCIA).

**Rectangular connectors** comprise a large group of electronic connectors. Common rectangular connectors are the smaller Universal Serial Bus (USB) and IEEE 1394 Firewire<sup>®</sup> connectors<sup>2</sup>.

**Telephone/telecom connectors** are types of modular connectors, meaning that they are made of "plug-in" units consisting of multiple, parallel contacts and can be added together to increase the size or capabilities of the system<sup>4</sup>.

**Registered Jack (RJ) connectors** are a common type of telephone/telecom connector.

**Fiber optic connectors** enable the interconnection of separate fiber systems through fiber cables. Since fiber cables and systems rely on optical transmission through glass strands, the allowance for error in connecting systems is extremely low. Many standards for fiber system installation and manufacturing have been created because of this sensitivity and need for precision. Fiber optic connectors consist of multiple ferrules and an aligning

sleeve to properly align the two optical surfaces, and a coupling sleeve to facilitate a secure connection<sup>14</sup>.

## The Product

### Applications and End Uses

Connectors are used in almost every electronics market segment. Figure 1 shows a few of the segments with common examples of how connectors are used. Common end-use applications for circular connectors are industrial equipment and machines, computers and peripherals, medical equipment and audio and video equipment<sup>1</sup>. One of the larger end-use applications for rectangular connectors is PCs and peripherals<sup>5</sup>. RJ connectors are used in voice and data systems<sup>4</sup>. Fiber optic connectors are widely used in datacom, telecom, networking, security, and military applications<sup>14</sup>.

Figure 1: Applications for Connector Products

Segment	Consumer Application
Computers	mainframes, PCs, printers, modems
Consumer Appliances	dishwashers, dryers, washing machines, refrigerators, ranges
Telecom	data communication, telephones, radio and television
Aerospace	aircraft and space applications
Automotive	cars, trucks, farm equipment

### Product Features and Benefits

Figure 2: Features and Corresponding User Benefits for PCB Connectors

Product Features	User Benefits
Kinked Pins	Maintains the connector securely in the PCB even allowing for the weight of cable during the solder process. "Beet" pins allow the assembly/solder process to continue without worry that the connector may slip from the board <sup>12</sup> .
Polarized Molding	Allows connectors to properly mate in only one way, assuring proper connection <sup>13</sup> .
Threaded Fasteners	PCB connector is held to other connectors with screws or nuts, insuring that connectors maintain a proper connection.

Figure 3: Product Features and User Benefits of Fiber Optic Connectors

Product Features	User Benefits
Push/Pull Coupling	Connectors remain properly connected until the coupling is pushed in a specific direction, freeing the opposite connector, insuring that connectors stay connected even through rough movement <sup>4</sup> .
Low-Profile Latching System	Allows for smooth mating and de-mating of a connector, resulting in less risk of damage or improper connection or disconnection <sup>6</sup> .
Automatic Internal Shutter	Blocks out stray light, maintaining signal accuracy, and restricts contact between fiber core and ferrule endface, preventing damage <sup>6</sup> .

Figure 4: Product Features and User Benefits of Coaxial Connectors

Product Features	User Benefits
Snap-In Connection	Easy connection, signaled by parts snapping together, ensuring a proper connection is established <sup>10</sup> .
Sequenced Mating	Mating sequence touches outer contacts before center contacts, reducing female center contact damage during mating, resulting in longer product life.
Extended Coupling	Plug coupling nut extends beyond the male center contact, protecting the contact while not mated.

### Life Cycle

Registered jack systems, and therefore RJ connectors, have been in use for many years and have held their position at the peak of maturity. With a few exceptions, almost every telephone and computer networking system uses a form of RJ connector: RJ-45 for most computer networks and RJ-11 for a majority of telephone systems. With limited connection alternatives in the market in terms of modular capability and ease of use, the RJ classification of connectors will likely hold its position for many more years.

Universal serial bus connectors have, for lack of a better term, taken the world by storm; new devices everywhere use USB interconnect capabilities. Wireless phones are now able to use a USB adapter not only to facilitate data exchange to more efficiently organize contact information and calendar events, but to even act as a phone charger when an electrical outlet may not be readily accessible. In addition to wireless phones, USB has also made a huge impact in the computer peripheral market. Devices such as controllers, printers, digital

imaging equipment, and even hard disk drives are now instantly available to PCs through a single USB connection. While too broad to discuss in detail, the impact and utility that USB interconnection offers holds it at peak maturity.

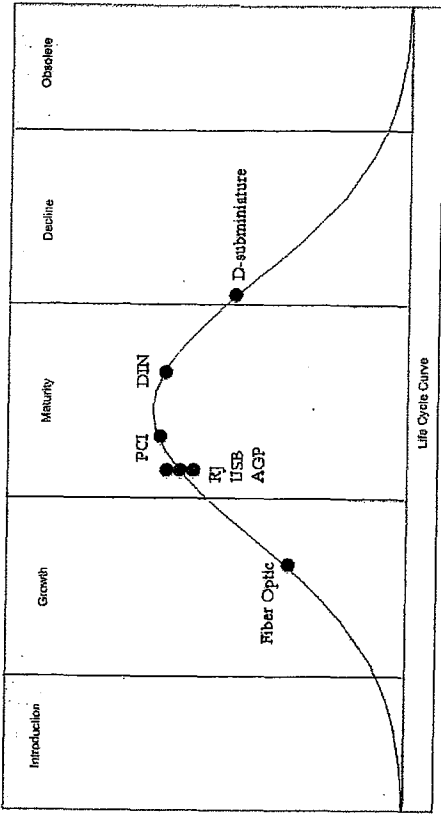
Accelerated graphic port connectors are used heavily in the PC market segment. Once an optional replacement for a PCI connector, AGP connectors for mainboards have become more of a norm than an option. This is due to the ever-increasing capabilities and demands of video-centric computing fields, such as three-dimensional imaging abilities and high-bandwidth requirements for PC applications. AGP connectors are secured, for the time being, at peak maturity; they're common enough to be somewhat of a commoditized product, yet so heavily used as to not begin the downhill trek toward obsolescence.

PCI connectors, while replaced by AGP connectors for video hardware use, are still widely used. PCI connectors are what connect a motherboard on a PC with sound cards, networking cards, various extensions, and more. The capabilities of PCI connectors are still adequate for these functions; however, with the inevitable technological advancements of the future, PCI will likely see a further steady decline in usage.

With the introduction of USB, D-subminiature and DIN connectors have lost market momentum. Keyboards and other peripheral devices that once drove widespread use of D-subminiature and DIN connectors are now being replaced by simpler, more efficient connector systems such as USB and IEEE 1394 Firewire™ systems.

On the maturing side, fiber optic connectors will see an increase in use as systems become easier to use and connectors and networking become more standardized and efficient. Currently fiber optic connectors are used in military, networking, datacom/telecom, and security systems applications<sup>14</sup>.

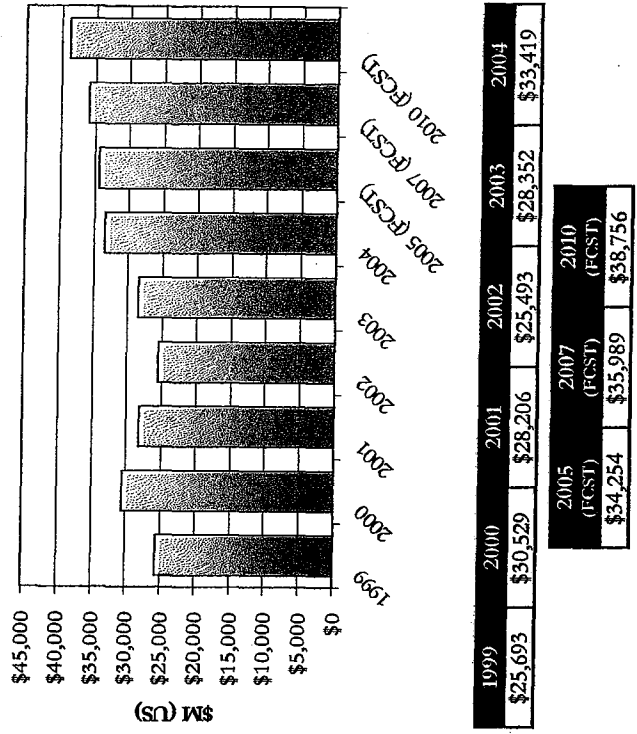
Figure 5: Life Cycle Curve for Select Connectors



## The Market

### Market Trends

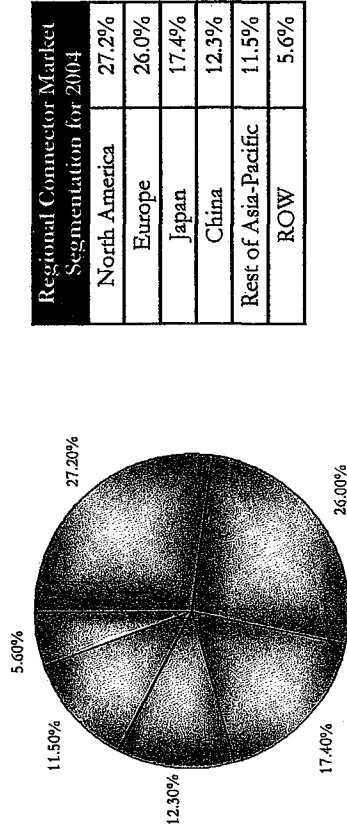
Figure 6: Past and Forecasted Worldwide TAM (\$M)<sup>7, 8</sup>



## Regional Segmentation

The worldwide connector market took a noticeable decline from 2000 to 2002 but regained market momentum beginning in 2003 and continuing into 2005 (as of time of publication). China's increase in shipment dollars marks an impressive show of the country's ability to swiftly and surely influence the world electronic connector market, surpassing the balance of the Asia-Pacific region in 2004.

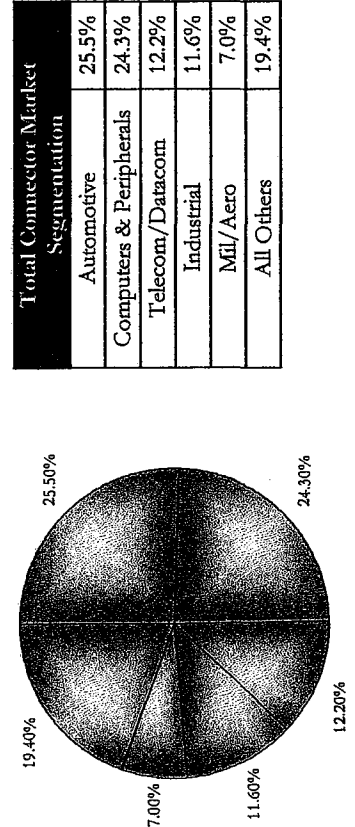
Figure 7: Regional Connector Market Segmentation for 2004<sup>8</sup>



With the entry of China in the world connector market and the country's astounding growth, this return has been hastened. Forecasted values using a Compound Annual Growth Rate (CAGR) over the past five years puts the North American market at a decline while Europe and China experience the highest growth rates.

## Market Segmentation

Figure 8: Total Connector Market Segmentation for 2004<sup>8</sup>



## The Players

### Key Players

The electronic connector industry varies somewhat from "traditional" numbers in that the top ten electronic connector manufacturers only contribute 57.7% of worldwide shipments. Tyco Electronics, however, currently has a lead on the rest of the market, taking up 21.5% of worldwide shipments. The next two leaders are Molex, Inc. with 7.7% of worldwide share and FCI with 5.7%.

Figure 9: Worldwide Top Three Electronic Connector Suppliers<sup>9</sup>

Supplier	Website	Distributors	Revenue \$M (US)	Market Share %
1 Tyco Electronics	www.tycoelectronics.com	Arrow; Avnet Premier Farnell; TTI	\$4,962	21.5%
2 Molex, Inc.	www.molex.com	Avnet; RS Electronics; Sager; TTI	\$1,789	7.7%
3 FCI	www.fciconnect.com	Avnet; Future; Premier Farnell; TTI	\$1,321	5.7%