2002 Roundup of Japanese Automotive Electronics Suppliers

Aisin Seiki
FY 2002 Consolidated Sales: ¥1,408 billion ($12 billion)
Change from FY 2001: up 15.2%
FY 2002 Net Profit: ¥76.6 billion ($653 million), 5.4% of sales, considerably better than the company's ¥25.7 billion ($219 million) net profit the prior year
FY 2003 Estimated Sales: ¥1,500 billion ($12.8 billion), 6.5% growth over FY 2002
FY 2003 Estimated Profit: ¥80 billion ($682 million)
Transmission related products accounted for 42.3% of Aisin Seiki's sales; engine related parts accounted for 9.4%. Toyota, which owns 24.5% of Aisin Seiki, is also its largest customer.
Aisin's North American subsidiary, Aisin World Corp. of America, based in Plymouth, Michigan, contributed $1.1 billion in sales in fiscal 2002 and the company expects that figure to double by 2005.

Alpine Electronics
FY 2002 Consolidated Sales: ¥222.3 billion ($1.9 billion)
Change from FY 2001: up 13.4%
FY 2002 Net Profit: ¥6.1 billion ($52 million), or 2.7% of sales, compared with 2.0% of sales in FY 2001
FY 2003 Estimated Sales: ¥205.0 billion ($1.75 billion), 7.8% less than FY 2002
FY 2003 Estimated Profit: ¥5.5 billion ($46.9 million), or 2.7% of sales
Car audio sales accounted for 67.7% of total sales; car navigation and audiovisual products accounted for 30%

Motor-Driven Power Steering Starts Slow in U.S.

GM Leads the Way
For more than two decades we have been watching as electronics and electrical parts have replaced or been applied to mechanical controls to add features, improve fuel efficiency, drive down emissions, save costs and improve safety, quality and reliability. Implementing these improvements can be a lengthy process. During the past 15 years we've watched the slow evolution of power steering from belt-driven hydraulic pump systems to engine-independent electro-hydraulic power steering (EHPS), which maintains oil pressure with an electric motor-driven pump, and electric power steering (EPS), which does away with all the hydraulics, relying instead on direct motor drive of the steering mechanism.

While EPS and EHPS have made inroads in Europe and Japan, U.S. carmakers have been far less motivated to replace their proven reliable hydraulic systems with higher cost electric systems, the benefits of which are largely unnoticeable—and the added cost unjustifiable—to consumers. Better fuel economy is the keybenefit of EPS, but the electric motor-driven steering systems available today are insufficient to handle large-sized cars, minivans, trucks and SUVs.

Conventional hydraulic power steering relies on a hydraulic pressure pump tied directly through a belt and pulleys to the engine. The pump cannot be shut off without shutting down the engine, so it constantly pumps, even when power steering is not needed. That produces friction, which wastes a significant amount of the engine's output. Electric power steering is powered by a motor that rotates only when steering-assist power is required. Electro-hydraulic power steering systems have to maintain the inertia of the hydraulic fluid, so the pump isn't turned completely off, which makes EHPS slightly less energy efficient than EPS. Motor-driven power steering systems can reduce fuel consumption by 2% to 5%

The demand for EPS systems around the world would be far more impressive if fuel prices in the United States, China and elsewhere were significantly higher. Europe is the world's largest EPS market.

Benefits of EPS or EHPS Compared to Hydraulic Power Steering

- Improves vehicle fuel economy by 2% to 5%
- Independent of the engine: No hoses, no pump, no hydraulic fluid, no belts, no pulleys
- Lower emissions
- EPS can be integrated with other vehicle control systems including lane-keeping assistance, electronic stability control, electronic parking assist, headlamp steering and active roll control. Sensors can be shared.
- Built-in diagnostics
- Since it's programmable, EPS is easier to tune for best feel and ride, including return-to-center attributes.
- EPS can be programmed to eliminate steering-wheel kickback caused by rough roads.
- Easier to install, saves up to 3.5 minutes of vehicle assembly time
- Reduces underhood noise
- Extends power steering applications to smaller-engine vehicles

Key Disadvantage: EPS is more costly than hydraulic power steering.
Roundup...

Continued from page 1

Calsonic Kansei
FY 2002 Consolidated Sales: ¥545 billion ($4.6 billion)
FY 2002 Net Profit: ¥6.4 billion ($54.4 million), or 1.2% of sales
FY 2003 Estimated Sales: ¥569 billion ($4.8 billion), 4.4% growth
FY 2003 Estimated Profit: ¥11.5 billion ($98 million) or 2.0% of sales

Nissan remains Calsonic Kansei’s largest customer by far, accounting for 65.5% of sales in FY 2002. Twenty percent of FY 2002 net sales came from front-end and cockpit module sales. The company expects that to increase to over 30% in FY 2003.

Clarion
FY 2002 Consolidated Sales: ¥185.5 billion ($1.6 billion)
Change From FY 2001: down 1.3%
FY 2002 Net Profit: ¥5.8 billion ($49.1 million) or 3.1% of sales; profits improved from FY 2001 when net margin was less than one percent of sales.
FY 2003 Estimated Sales: ¥171.0 billion ($1.5 billion)
FY 2003 Estimated Profit: ¥6.2 billion ($52.8 million), 3.6% of sales

Denso
FY 2002 Consolidated Sales: ¥2,332.8 billion ($199.9 billion)
Change From FY 2001: Denso’s fiscal year ending March 31, 2002 included 15 months of sales for 45 subsidiaries, which were changing their fiscal years to correspond to the parent company’s. Excluding the effects of the irregular reporting period, Denso’s sales grew 6.9%. Compared to the 15-month period reported in FY 2001, sales decreased 2.9%.
FY 2002 Net Profit: ¥111.0 billion ($946.3 million), or 4.8% of sales. Net profit improved 54% over the prior year due mainly to gains on the release of future responsibility for government pension funds.

Pioneer
FY 2002 Consolidated Sales: ¥712.3 billion ($61.1 billion); car electronics sales, which account for 40% to total consolidated revenue worldwide, grew 9.1% to ¥281.1 billion ($2.4 billion). Car electronics sales in Japan increased 10.6%.

Change from FY 2001: up 7.6%
FY 2002 Net Profit: ¥16.1 billion ($137 million), 2.3% of sales
FY 2003 Estimated Sales: ¥760 billion ($65.5 billion), 7% growth
FY 2003 Estimated Profit: ¥20 billion ($170 million), 2.6% of sales

Pioneer attributes its solid growth in Japan to strong sales of navigation equipment, both DVD models and HDD (hard disk drive) systems. Overseas sales growth was driven by CD player sales in the after-market and car audio sales to OEM’s. DVD related products have become one of Pioneer’s core businesses.

Tokai Rika
FY 2002 Consolidated Sales: ¥244 billion ($21.1 billion)
Change From FY 2001: up 9.9%
FY 2002 Net Profit: ¥7.5 billion ($64 million), or 3.1% of sales; compared with 2.1% margin in FY 2001. A dividend income came from the release of future responsibility for contributions to government pension plans.

Change from FY 2001: up 9.9%
FY 2003 Estimated Sales: ¥244 billion ($21.1 billion), flat
FY 2003 Estimated Profit: ¥10 billion ($85.2 million), flat

Sales to Toyota Group companies represent approximately 80% of sales. In October 2002, Tokai Rika, Furukawa Electric and Shinchang Electrics formed a joint venture in Korea to produce automotive electronics components. Tokai Rika owns 35% of the JV.
Steering...

Limited Benefits Now—More to Come

EPS and EHPS offer some benefits beyond the modest fuel-economy improvement and reduced emissions. Since they draw energy not from the engine but from the battery, electric or electro-hydraulic power steering will work even if the engine shuts down, so the driver can at least steer the vehicle off the road in the event of engine failure.

Although EHPS doesn’t match the fuel savings produced by EPS, it does offer a few advantages over the fully electric system. EHPS can be easily mounted in a number of different places in the engine compartment. TRW has developed a power pack consisting of electric motor, pump and oil reservoir. The power pack is connected by hose to a hydraulic gear on the steering mechanism. An example of

Continued from page 1

Continued on page 8

OE Fractional HP Elec. Motors

According to Frost & Sullivan’s new report, North American Automotive Original Equipment Fractional Horsepower Electric Motor Markets, an average of at least 19.64 electric motors were installed on each vehicle produced in North America in 2002. The complete report, published March 2003, is available for $4,150 and can be ordered through the company’s Web site, www.frost.com, or by calling 1-877-463-7678.

Installation Rates of Common Electric Motors in North America, 2002

| Application | Installation Rate | Average Units per Equipped | All
<table>
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<td></td>
<td></td>
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<tr>
<td>ABS</td>
<td>75%</td>
<td>1.00</td>
<td>0.75</td>
</tr>
<tr>
<td>Blower</td>
<td>100%</td>
<td>1.08</td>
<td>1.08</td>
</tr>
<tr>
<td>Cruise control†</td>
<td>71%</td>
<td>1.00</td>
<td>0.71</td>
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<tr>
<td>Fuel pump</td>
<td>100%</td>
<td>1.06</td>
<td>1.06</td>
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<tr>
<td>Power door lock</td>
<td>85%</td>
<td>3.07</td>
<td>2.69</td>
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<tr>
<td>Power mirror</td>
<td>81%</td>
<td>4.00</td>
<td>3.24</td>
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<tr>
<td>Power seat</td>
<td>47%</td>
<td>5.40</td>
<td>2.53</td>
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<tr>
<td>Power window</td>
<td>83%</td>
<td>3.06</td>
<td>2.55</td>
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<tr>
<td>Radiator and condenser fan</td>
<td>50%</td>
<td>1.60</td>
<td>0.80</td>
</tr>
<tr>
<td>Sunroof</td>
<td>16%</td>
<td>1.00</td>
<td>0.18</td>
</tr>
<tr>
<td>Vent flap actuator</td>
<td>50%</td>
<td>1.52</td>
<td>1.52</td>
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<tr>
<td>Washer pump</td>
<td>100%</td>
<td>1.31</td>
<td>1.31</td>
</tr>
<tr>
<td>Wipers</td>
<td>100%</td>
<td>1.31</td>
<td>1.31</td>
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</tbody>
</table>

†Some cruise control systems use electronic throttle control instead of a dedicated cruise control motor.

Source: Frost & Sullivan

primarily because the price of gasoline, including taxes, is so high. At $5.07 per gallon, the U.K.’s price is highest among major countries of the world. Second highest is Germany at $4.55 per gallon. At those prices, the energy savings of motor-driven power steering has sufficient impact to offset the added cost of the system.

The high cost of EPS and EHPS limits consumer demand around the world. According to Aly Badawy, vice president of steering systems engineering for TRW Automotive, EPS systems sufficiently robust to work in a C-segment vehicle such as the G M Saturn, are priced to the OEM

A General Motors’ steering subsystem manager, the least powerful and least expensive electric power steering system is the column-mounted type that uses a brushed motor. Next most powerful and expensive is a column system using a brushless motor. A steering rack-mounted EPS system can provide the greatest turning torque and it costs the most.

In addition to high costs, the market for EPS is further limited by the fact that large cars and trucks—a good chunk of U.S. vehicle production—can’t benefit from electric motor-driven power steering. Large vehicles require too much torque to steer the wheels at a standstill. A motor big enough to steer the wheels on a full-sized SUV would draw more current than the 14-volt alternator can provide, running down the battery. Installing EPS in larger vehicles, including minivans and trucks, would force carmakers to install 42-volt alternators, which can produce considerably more power than 14-volt alternators. But 42-volt power supplies are significantly more expensive than 14-volt types, and for now, carmakers have abandoned plans to introduce 42-volt systems in conventional vehicles.

According to Delphi, the 2004 model-year Chevy Malibu will be the largest production light vehicle manufactured with motor-driven power steering installed. In the next few years heavier cars possibly will be tackled. “We think our EPS can cover the mid-sized cars, for example, the GM Impala or the Pontiac Grand Prix,” explained GM’s Ebram Handy. “You could stretch a rack type EPS system to that size vehicle,” he said.
The Company Profile... Tyco Electronics Corp.

Headquarters: P.O. Box 3608, Harrisburg, Pennsylvania 17105, USA
www.tycoelectronics.com
FY 2002 Sales: $9.8 billion*
FY 2002 EBIT Margin: 15.6%
FY 2002 Operating Margin: 17%
FY 2002 R&D: 4.1% of sales
FY 2003 Sales (est.): $10 billion
FY 2003 EBIT Margin (est.): 16% to 17%
Employees: 77,000
FY 2002 Automotive Sales: $2.52 billion (including M/A-COM)
Top Automotive Customers: Delphi, Yazaki, Bosch, Ford, VW, DCX
Top Selling Automotive Products: #1 Connectors, #2 relays, #3 distribution boxes, #4 special cable assemblies
*Tyco Electronics sales do not include sales from Tyco Telecommunications (formerly Tyco Submarine Systems/TyCom), which became part of Tyco Electronics in 2002.
Tyco's fiscal year ends on September 30.

Background
Tyco International Ltd., a huge multinational conglomerate and parent of Tyco Electronics, maintains its headquarters in Pembroke, Bermuda, and as a result significantly reduces its U.S. income tax liability. Over the last few years, Tyco International has been hounded by allegations of accounting irregularities and its top corporate officials have been arrested and charged with larceny, fraud or tax violations. Tyco ex-chief executive Dennis Kozlowski, who stepped down in the spring of 2002, has been replaced by Edward Breen. With a new board of directors in place, Mr. Breen has committed corporate management to establishing "clear and uncompromising standards of conduct in every aspect of our management and financial reporting. ..."

Tyco Electronics
According to company literature, Tyco Electronics, with fiscal 2002 sales of $9.8 billion, is the world's largest passive electronic components manufacturer. Despite the enormity of the scandal and Tyco International's financial weakness, Dr. Jürgen Gromer, president of Tyco Electronics, maintained, "The scandal did not impact Tyco Electronics. We know that because we explained the situation to our customers, and they understand our situation. They trust us and see us as a very important supplier."

As a result of Tyco International's financial situation and low stock valuation, Tyco Electronics is no longer acquisitive—its last acquisition was completed in 2002. According to Dr. Gromer, "There had $17.7 billion in current assets vs. $15.4 billion in current liabilities. While working capital improved to $2.3 billion, with a current ratio of just 1.15 the company is still vulnerable to the influence of financial forces. As of June 3, 2003, Standard and Poor's gave Tyco International a rating of BBB— which is the lowest investment-grade rating.

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**Tyco International Stock Price 4/00 to 4/03**

Source: BigCharts.com

Tyco Electronics invested just 4.1% of sales in R&D in 2002, about the same as 2001. Dr. Gromer, however, cautioned, “4.1% understates what is invested in Tyco Electronics’ automotive business. A part from the other businesses, the automotive business is spending about 6% of its sales on R&D.”

**Global Automotive Division of Tyco Electronics**

One of eight business units at Tyco Electronics, the Global Automotive Division cuts across product lines to make a business out of all of the automotive applications within Tyco Electronics. For new automotive business development, Tyco Electronics focuses mainly on carmakers, wiring harness makers, the top-tier systems manufacturers and on contract manufacturers. Tyco International does not break out results for Tyco Electronics’ automotive division in any public filings.

Tyco Electronics’ automotive business is based largely on its 1999 acquisition of AMP, which in 1998 sold $1.3 billion worth of connectors and connector parts to the auto industry. That automotive business accounted for 24% of AMP’s sales. In the fiscal year ending in September 2002, Tyco Electronics sold $2.52 billion worth of parts to the automotive industry, primarily connectors, relays, distribution boxes and cable assemblies. Automotive represented 26% of Tyco Electronics’ sales in 2002. After AMP, other companies with significant automotive experience were acquired: in 1999, Raychem (circuit protection, heat-shrink products, wire and cable) and Siemens Electromechanical Components (relays and sensors); and in 2000, the electronic OEM business of Thomas & Betts (connectors). Thomas & Betts had picked up some significant Ford business when it acquired Augat in 1996.

In 1995, AMP acquired M/A-COM, which makes radar sensors and microwave antennas for mobile GPS and cellular phone applications, as well as microwave and radio frequency components for the military. Despite significant automotive activities, M/A-COM is not part of the Global Automotive Division. M/A-COM maintains its own sales force, since radar and antenna sales have little in common with the relay and connector sales channels of the Automotive Division.

In the automotive business, Dr. Gromer said there are four reasons why customers choose Tyco Electronics instead of its competitors:

- **Customer orientation**—Tyco likes to get involved with its key customers early in the design of a new application.
- **Technology**—Tyco Electronics sees itself as a technology company.
- **Cost competitiveness**
- **Product portfolio**—Tyco Electronics’ product breadth is wider now than it was four years ago when it did business under the AMP name.

The former president of AMP’s global automotive division, Dr. Gromer, in addition to his responsibilities as president of Tyco Electronics, currently serves as acting vice president of its Global Automotive Division, which operates three regional offices around the world. North American headquarters are in Troy, Michigan; European headquarters are in Bensheim, Germany, near Frankfurt; and Asian headquarters are in Tokyo, Japan.

**Relays**

Electromechanical relays are one of Tyco Electronics’ top-selling products, and despite the promise of their alternative—solid state relays—Tyco says that electromechanical relays will continue to dominate automotive applications. Ulrich Baur, responsible for new technology at Tyco Electronics, observed, “In the short term I don’t see the changeover to silicon relays, because the technology can’t compete cost-wise ... For the next 10 years, high-density electromechanical relays are the only option.”

**Tyco Acquisitions with Key Automotive Capability**

<table>
<thead>
<tr>
<th>Company</th>
<th>Year Acquired</th>
<th>Location</th>
<th>Key Auto Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP</td>
<td>1999</td>
<td>Harrisburg, PA, USA</td>
<td>Connectors</td>
</tr>
<tr>
<td>M/A-COM (acquired by AMP)</td>
<td>1995</td>
<td>Lowell, MA, USA</td>
<td>Radar sensors, antennas</td>
</tr>
<tr>
<td>Pretema</td>
<td>2001</td>
<td>Neufarn, Germany</td>
<td>Mechatronics</td>
</tr>
<tr>
<td>Proner Comatel</td>
<td>2001</td>
<td>Chapaillanne, France</td>
<td>Lead frames and connectors</td>
</tr>
<tr>
<td>Raychem</td>
<td>1999</td>
<td>Menlo Park, CA, USA</td>
<td>Polyswitch circuit protectors, heat-shrink, wire/cable</td>
</tr>
<tr>
<td>Siemens Electromechanical*</td>
<td>1999</td>
<td>Munich, Germany</td>
<td>Relays, connectors</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>2000</td>
<td>Memphis, TN, USA</td>
<td>Connectors</td>
</tr>
</tbody>
</table>

*Includes Potter & Brumfield in North America

**Tyco Electronics’ Major Automotive Customers Ranked by Sales**

<table>
<thead>
<tr>
<th>Suppliers</th>
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</thead>
<tbody>
<tr>
<td>1. Delphi</td>
</tr>
<tr>
<td>2. Yazaki</td>
</tr>
<tr>
<td>3. Bosch</td>
</tr>
<tr>
<td>4. Denso</td>
</tr>
<tr>
<td>5. Lear</td>
</tr>
<tr>
<td>Others: Siemens/VDO, Sumitomo, Valeo, Visteon</td>
</tr>
</tbody>
</table>

**Top End-Users (Carmakers)**

<table>
<thead>
<tr>
<th>Carmakers</th>
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</thead>
<tbody>
<tr>
<td>1. Ford</td>
</tr>
<tr>
<td>2. VW</td>
</tr>
<tr>
<td>3. DaimlerChrysler/Mitsubishi</td>
</tr>
<tr>
<td>4. BMW</td>
</tr>
<tr>
<td>5. Toyota</td>
</tr>
<tr>
<td>6. Renault/Nissan</td>
</tr>
<tr>
<td>7. GM/Fiat</td>
</tr>
<tr>
<td>8. PSA</td>
</tr>
</tbody>
</table>
Tyco Electronics

The power density of Tyco relays has been improving dramatically since the 1980s. Tyco has announced that in 2004 it will come out with its new Nano K relay that will be one-tenth the size of its SRK power relay, which debuted in 1971. While the SRK relay has a power density of just 40 watts per cubic centimeter, the new Nano K will handle about 340 watts per cubic centimeter. According to the company, the high power density of the Nano K is the result of: an efficient magnetic circuit; minimizing the resistance of the load circuit and contact resistance by using highly conductive materials, low-resistance internal joints and optimizing the geometry; precise relay parts and assembly equipment; and the introduction of laser welding systems.

Growth Products: Distribution, Fuse and Relay Boxes

One of Tyco Electronics’ most promising automotive product lines is power distribution, fuse and relay boxes, which combine in one compact modular package fuses, relays, wiring, connectors and even some electronics. The boxes, which must be accessible to service personnel so fuses and relays can be replaced, help to make the wire harness modular so it can be broken into easy-to-install sub-harnesses. Since Tyco makes almost everything in the box except for fuses, resistors and other commodity components, it can price the box competitively.

Most of Tyco’s experience with distribution boxes comes from the former AMP with contributions also from these acquired businesses: Siemens Electromechanical Components, Raychem, Thomas & Betts and Proner Comatel.

According to the company, the growing use of distributed network wiring topologies has led carmakers to employ many more distribution boxes than in the past. For example, Mercedes C and E-class vehicles use both front- and rear-mounted distribution boxes. The boxes need to be small and easy to mount in a variety of locations. Experienced in making small, complex boxes, Tyco says it can meet those requirements. For box wiring it can apply whatever technology—PC boards, lead frames or hard-wiring—makes the most sense for a particular application. Tyco can also reduce the size of the boxes by incorporating its line of Micro Power relays and smaller, denser connectors.

Tyco expects its distribution box business to grow dramatically. In North America the company has won numerous programs to supply boxes for light and commercial duty trucks. In Europe, major projects are underway with three large OEMs, and in Korea, according to Tyco, several projects have been won or are in the works.

Mechatronics

Tyco’s second most promising growth area is mechatronic products, which integrate mechanical components with electronics components into single assemblies. Mechatronics is an answer to the growing need in the automotive industry for greater integration, fewer connections, higher reliability, smaller size, less weight and better economics. Tyco primarily supplies the electromechanical part of mechatronics. Tyco got into mechatronics several years ago, but the acquisition of Pretema GmbH in March 2001 gave Tyco greater capability to deliver complex assemblies incorporating plastic moldings, sensors, lead frames and contacts. This, plus Tyco’s existing capabilities in plating and bonding, laminating, gluing and sealing, gives the company the expertise it needs to excel in mechatronics.

The highest unit-volume automotive product so far from the Pretema connection is a hydraulic solenoid module, which Tyco now makes to fit into some Bosch ABS applications for light vehicles. The Bosch ABS solenoid unit includes the housing, relays, connectors and hydraulic solenoid coils. Some of the coils are manufactured by Tyco. Bosch supplies the hydraulic parts and the low-temperature co-fired ceramic device, which includes the semiconductor chips that control the ABS.

Another Tyco special mechatronic assembly is made to survive immersion in gearbox oil. The sealed gearbox assembly housing, which includes Tyco sealed connectors and seven Hall position sensors, is installed in a German carmaker’s continuously variable transmission. In addition to the ABS solenoid housing and the gearbox sensor assembly, Tyco makes brush holders for generators, dc-motor components, airflow meters, door-locking actuators and other engine control subassemblies. Many new applications are also in the works.

Tyco Electronics’ Mechatronics Competence Center (formerly Pretema in Niefern, Germany) provides all the necessary technologies, engineering services and production under one roof. Current mechatronics customers include Bosch, WA BCO, Valeo, TRW, Siemens VDO, Denso, ContiTech and Magneti Marelli.

PLCD Position Sensors

A nother promising growth area is linear and angular position sensors made using Tyco’s permanent-magnet linear contactless displacement technology. The PLCD process was introduced by Siemens Electromechanical Components, according to Tyco Electronics, and first used in automotive applications in the late 1990s. A PLCD sensor uses a special soft-magnetic core, which is wound over its entire length by a primary coil as well as short secondary coils at each end. A permanent magnet brought close to the sensor results in local magnetic saturation of the core. The resulting voltages vary according to the position of the permanent magnet.

Tyco’s most promising PLCD application so far is in automatic manual transmissions. Tyco’s PLCD sensors are currently in production on Mercedes E
and C-class vehicles ordered with Mercedes’ Sequentronic automatic manual option. Tyco expects this application to grow quickly since several other European carmakers are expected to soon make automatic manual transmissions available. Three to four sensors are needed in each automatic gearbox to measure gear, shift and clutch position. Each sensor, depending on the application, can cost as much as €5 ($5.85). Other potential applications include brake systems, pedal position sensing, seat position sensing and shock absorber travel sensing for chassis load leveling systems.

PLCD sensors, which can inductively measure both angular and linear displacement, compete against potentiometer sensors, which can wear out, and against Hall sensors. Since the Hall device is a semiconductor, Hall sensors can withstand only a limited range of temperatures. When in situ signal-conditioning is not required, Tyco’s PLCD sensors will handle temperatures as high as 180 degrees C. Otherwise the sensors can handle up to 140 degrees C. While typical automotive applications run from 20 mm to 80 mm, Tyco’s PLCD sensors can measure up to 250 mm of linear displacement and 270 degrees of rotational displacement. They are accurate to within +/- 1%, with repeatability of +/- 0.2%. The permanent magnet, which moves with the part being measured, can be read reliably from as far away as 20 mm, even through nonmagnetic walls made from aluminum or brass. Tyco makes the entire assembly housing including sealed connectors and the sensing element.

Compared with other magnet/inductive-based contactless sensors, Tyco Electronics says its PLCD sensors are more robust against vibration and temperature and offer greater flexibility in design.

Radar Sensors

M/A-COM first started making vehicular radar sensors in 1994, when it began supplying sensors to Eaton Vorad for heavy duty trucks. In 1996, M/A-COM started working with Mercedes on what would become the world’s first radar-assisted adaptive cruise control (ACC) system. Now called Distronic, the Mercedes ACC system was first offered as an option on the 1999 S class in Europe. The sensor measures the distance to the vehicle ahead in the same lane. A daptive cruise control varies the speed of the car to maintain a safe following distance. M/A-COM’s direct customer on the Mercedes Distronic system is Automotive Distance Control Systems, now part of Continental. Mercedes currently offers ACC as an option in most global markets on the S, SL and E class as well as the CLK and CL coupes.

M/A-COM ships approximately 15,000 radar sensors per year— for Mercedes cars, as well as DaimlerChrysler trucks and Nissan vehicles. A ccording to a source outside of M/A-COM, the company will supply radar sensors to General Motors for installation in a model year 2004 vehicle.

One problem with today’s ACC systems is that they automatically shut down when the vehicle slows to less than 40 mph, because the 77 MHz sensors can’t measure accurately enough at short range. In order to make cruise control work in stop-and-go traffic, M/A-COM will soon come out with a second, nearer-range sensor that operates at 24 GHz.

Demand for a second sensor would expand the market for radar and ACC components, but until the price of radar sensors comes down significantly, the feature will remain limited to high-end vehicles. According to M/A-COM, stop-and-go ACC will be brought to consumers starting in 2006, on a German luxury sedan. With two radar sensors needed, stop-and-go ACC systems will be even more expensive than Distronic— currently priced at about $3,000 to the consumer— despite the fact that short-range sensors are less expensive than long-range sensors. Radar has come down in cost by half since it was first introduced, and as volumes increase and the price is further reduced, M/A-COM sees near-range applications beyond ACC, such as blind spot warning, side impact pre-crash warning and park distance control.

Multiband Antennas

M/A-COM is GM’s sole source for multiband antennas, which are required by OnStar-equipped vehicles to pick up location data from GPS satellites and to handle cell-phone transmissions between the vehicle and the OnStar service center. OnStar GPS antennas are tuned to 1,575 MHz, while the analog cell phone antennas are tuned to 800 MHz. M/A-COM recently began shipping GM tri-band antennas, which can pick up GPS, transmit and receive analog cell phone signals as well as PCS (Personal Communications Service) cell phones, which operate at 1,900 MHz. GM currently supports about two million OnStar subscribers.

Fiber-Optic Bus Components

Tyco Electronics claims to be the first company in the world to bring fiber-optic connectors and cable assemblies to the automotive market. The company makes all the passive connecting components necessary to build D2B, MOST and byteflight fiber-optic networks. D2B networks will no longer be required as Mercedes, BMW, Audi and other carmakers opt for the MOST bus standard, which handles higher bit rates. MOST is used to connect multimedia and information systems together. Currently there are 14 vehicles in production that use MOST, with another four expected by the end of this year. Other suppliers besides Tyco provide MOST network components. Tyco has built prototype IEEE 1394 network components, which Ford and other carmakers believe will eventually become the fiber-optic network standard of the future.
the flexibility of EHPS, TRW cites one of its production applications where the power pack is installed right behind a headlamp. The modularity of the system also makes it easier to install, saving time and labor costs in the assembly process.

A nother edge that electro-hydraulic power steering has on EPS, according to TRW’s Mr. Badawy, is that it doesn’t much different from hydraulic power steering. “We have made tremendous gains in the steering feel issues that go with the transition to EPS systems. However, some OEMs are not willing to go with EPS because they like the hydraulic feel.” TRW is a world leader in sales of electro-hydraulic power steering systems, with contracts in Europe with three Carmakers for 11 platforms; and with two OEMs in the Asia/Pacific region, for three platforms. TRW also makes EPS systems.

In time, other vehicle control systems such as automatic lane-keeping and electronic stability control will be integrated with EPS, and the perceived value of electric power steering will improve. Dick Angelo, power steering sales manager for Koyo U.S.A., the exclusive supplier of EPS for GM’s Saturn vehicles, commented, “One of the things that EPS allows you to do is integrate the electronics with the other pieces of the system. Sooner or later—this is not too far off—there is going to be steer-by-wire and dynamic stability control. All these features, including ABS, are going to be controlled by one controller.” EPS offers somewhat more flexibility than EHPS in electronics integration, since it eliminates the need to deal with fluids in the system.

GM Out Front in North America

Among the Big Three in North America, GM has been the most aggressive about electric power steering. Despite the low fuel prices in the States and Canada, General Motors has been placing EPS into series production. The industry’s first North American application came in 2002 when EPS was provided as a standard feature on the GM Saturn Vue (SUV), followed by the Saturn Ion (sedan) in 2003. The Saturn EPS systems are supplied by Koyo U.S.A. As mentioned above, GM will bring out EPS on the 2004 Chevrolet Malibu, also as a standard feature. Supplied by Delphi, the Malibu system will couple electric power steering with speed sensitive steering, a feature that shares components with EPS. Since it is all algorithm, speed sensitive steering comes nearly for free, once EPS is installed. Speed sensitive steering varies the amount of power assist provided, according to the speed of the vehicle. As the vehicle slows, more power is delivered and vice versa.

According to GM’s Ebram Handy, 20 or 30 years from now as the industry makes the transition to hybrid and fuel-cell vehicles, all GM light vehicles will come equipped with by-wire steering systems driven by electric motors: “The by-wire systems are basically all EPS-based. If you back track from that time, there have to be interim steps. The way I see it, gradually we’ll phase into EPS. That gives us an edge on combining the different chassis functions, starting with the integration of steering and braking,” he said.

GM is getting plenty of experience with by-wire steering with trucks that boast the Delphi Quadrasteer four-wheel steering feature. The first Quadrasteer system was installed in the 2002 GMC Sierra Denali. In the 2003 model year, Quadrasteer is also offered on the GMC Sierra and Chevrolet Silverado half-ton Extended Cab and Crew Cab pickups, the GMC Yukon XL and the Chevy suburban. In Europe, General Motors provided EPS standard on the 1997 Opel Corsa. In the 2003 model year, Delphi supplied a four-wheel four-wheel steering system for the 2004 Chevrolet Malibu, also as a standard feature. Supplied by Delphi, the Malibu system will couple electric power steering with speed sensitive steering, a feature that shares components with EPS. Since it is all algorithm, speed sensitive steering comes nearly for free, once EPS is installed. Speed sensitive steering varies the amount of power assist provided, according to the speed of the vehicle. As the vehicle slows, more power is delivered and vice versa.

A recent development in EPS is the Delphi Quadrasteer four-wheel steering system. This system uses a single controller to control both the steering and braking system. This allows for better stability and handling of the vehicle. The system is currently used in the 2004 Chevrolet Malibu, and is expected to be available in future GM vehicles.

Bishop & Associates’ 2002 World Automotive Connector Market

The graphs below are based on data from Bishop & Associates’ (St. Charles, Illinois) report 2002 World Automotive Connector Market. For more information on this report or other market research on the world connector markets, contact Ron Bishop at (1) 630-443-2702; bishop@bishopinc.com.

### Worldwide Automotive Connector Market 2002 and 2007, by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>2002</th>
<th>2007</th>
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</thead>
<tbody>
<tr>
<td>North America</td>
<td>2,214</td>
<td>2,921</td>
</tr>
<tr>
<td>Europe</td>
<td>1,327</td>
<td>1,483</td>
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<tr>
<td>Japan</td>
<td>826</td>
<td>850</td>
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<tr>
<td>A/PW</td>
<td>477</td>
<td>1,401</td>
</tr>
<tr>
<td>ROW</td>
<td>2,977</td>
<td>2,977</td>
</tr>
</tbody>
</table>

### Automotive Connector Content by Vehicle System, 2007

- **2007 Total Market:** $9,243.4 Million
- **Body Wiring & Power Dist.:** $1,747.6 million
- **Nav. & Instrumentation:** $493.7 million
- **Safety & Security:** $1,887.3 million
- **Powertrain:** $2,417.8 million
- **Comfort, Convenience, Entertainment:** $2,696.9 million

### Average Automotive Connector Content per Vehicle 2002 and 2007

<table>
<thead>
<tr>
<th>Region</th>
<th>2002</th>
<th>2007</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>$134.41</td>
<td>$155.82</td>
<td>3.0%</td>
</tr>
<tr>
<td>Europe</td>
<td>$131.62</td>
<td>$168.63</td>
<td>5.1%</td>
</tr>
<tr>
<td>Japan</td>
<td>$140.96</td>
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<tr>
<td>Asia Pacific</td>
<td>$109.90</td>
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</tr>
<tr>
<td>ROW</td>
<td>$84.38</td>
<td>$104.15</td>
<td>3.6%</td>
</tr>
<tr>
<td><strong>Total Average</strong></td>
<td>$126.25</td>
<td>$150.81</td>
<td>3.6%</td>
</tr>
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</table>