special report

By making standardized charging stations as common and as safe as gas stations, the electric-vehicle industry hopes to drive itself into transportation's mainstream

Charge! EVs power up for the long haul

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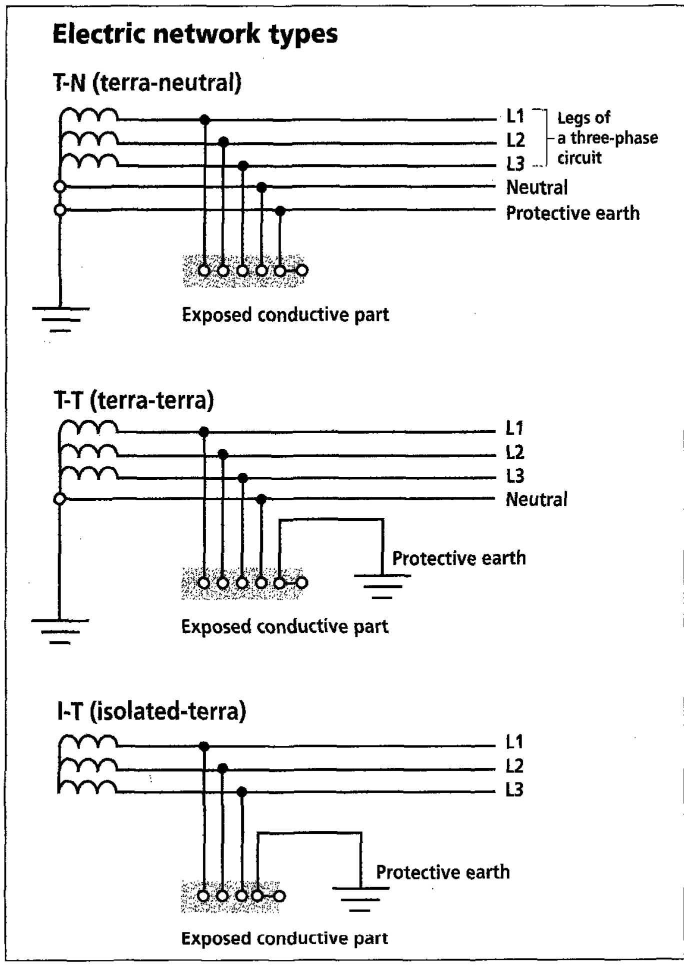

[1] Three types of electrical networks exist around the world. The T-N and T-T systems, which are grounded (initial T for terra or earth indicates this), are most prevalent. The isolated I-T (ungrounded) system is rarely encountered. The second letter indicates that the exposed conductive part (prongs on a plug, for example) is independently grounded (T) or grounded through the system (N). A system-level approach to charger design begins with these networks and considers electricity generation and dispersal and wiring systems in all types of buildings, as well as the electric vehicle (EV).

When smog kept suffocating three sprawling cities—Los Angeles, Paris, and Tokyo—in the early 1990s, a standardized infrastructure for charging electric vehicles (EVs) was at last seen as a worthwhile goal. The superiority of clean EVs to dirty gas-powered transportation was borne in on everyone as never before. But EVs stood no chance of success without a refueling infrastructure that matched the corner gas pump for availability and ease of use. The ultimate in convenience would be an infrastructure that let EVs charge up at home.

In France, the government in concert with the national electric utility, Electricité de France, and the domestic auto manufacturers, began an aggressive EV test and development program. In Japan, the Eco-Station demonstration project was established by the Japan Electric Vehicle Association (JEVA). JEVA had been established by the Ministry of International Trade and Industry in 1976 to coordinate EV development among government, universities, research laboratories, and the auto industry. The Eco-Station project offered environmentally friendly vehicles—electric, natural gas, methanol, and others—a familiar, gas-station refueling environment. Part of this project resulted in a proposed connector configuration and plans for "fast" charging an EV, that is, charging at least 50 percent of the battery in 15 minutes or less.

In the United States, two events jump-started the domestic EV industry—the push in 1990 by the California Air Resources Board for EV mandates to take effect as early as 1998, and the bold declaration by General

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Motors Corp., Detroit, at the 1991 North American Auto Show to be the first to market with an EV. In response, the Electric Power Research Institute (EPRI), Palo Alto, Calif., organized the Infrastructure Working Council (IWC) in 1991 to rally experts from the electric utility, automobile, and electrical equipment industries to address the issues of EV infrastructure for battery charging—charging system architecture, couplers, and technical and societal impacts.

Every major new technology from radio to TV (black and white, color, and high-definition) and VCRs, from computers to EVs relies on basic technical standards to make the transition from invention to commercial success. In the early 1990s, the groundwork for an EV industry was laid by a carefully coordinated, international effort to establish a common means of charging EVs and to develop standards to ease their commercialization.

The experts worked in various forums to understand the challenges, set boundary conditions, and negotiate the standards development process. The result has been the timely creation of standards, so that EVs may be produced and sold just as the auto industry is moving from demonstration and development to production.

Starting from scratch

A standard electrical charging connection is analogous to the familiar gas pump nozzle, but it presented unique challenges to these experts. After all, spilling a few drops of gasoline at the pump is not inherently dangerous to the klutz, but spilling a few coulombs onto the human body is. Unlike fuel, which must be vaporized or ignited to create a hazardous condition, electric power flows in an energized state that must be handled carefully.

In fact, connecting an EV to the electrical network for charging presents an unprecedented set of conditions. For the first time in history, consumers, members of the general public of all ages, would be asked to make a high-power electrical connection—typically between 5 and 150 kW—perhaps once or twice a day, and outdoors in all types of weather.

Consumer safety was of the essence. Thus, the top priority requirements of a standard EV charging system and associated "plug" were that it first and foremost be not only safe, but perceived as safe; that it be intuitive and easy for consumers to use; and that it be cost-effective. Ideally, too, a standard charge coupler between the vehicle and power source would be compatible with electric networks around the world.

Safety first!

This set of conditions mandated a double-fault safety management system to circumvent or mitigate potential shock hazards from the standard EV charging system. In other words, a consumer would still be protected while connecting the vehicle to the power source despite one or even two failures in the safety systems.

Classical electrical safety management techniques, which serve as the basis for electrical safety standards around the world, require the systematic layering of basic (insulation), fault (fuse), and additional (ground-fault circuit interrupters) protective measures. The exact measures used vary with the nature of the product involved (in this case, electric-vehicle chargers); its electrical characteristics (voltage, current, frequency, and network configuration); type of user (general public or qualified persons); and conditions of use. The perception of safety is slightly less well defined, but most would grant that seeing exposed conductive elements could discomfit the casual user, and touching them could be even more upsetting.

Standard household and industrial wiring devices prompted the criterion that the plug be easy for consumers to use. However, the electrical connectors under consideration were not. Instead, they were very large and heavy to accommodate the power levels under consideration, required a certain orientation for proper use, and needed significant insertion force. To compound matters, most standardized wiring devices had not been designed for high-durability applications where the connection must be made as often as daily (possibly more frequently) and in all types of weather.

The cost impact of the EV charging infrastructure on vehicle, electric utility, consumer, and society had to be carefully considered. In the absence of an installation designed for the purpose, the relative costs could only be evaluated by establishing a basic charging system architecture—location of charging apparatus, inlet, and charging control, and the speed and size of the charger. In turn, this would drive the allocation of cost between the vehicle and the supply network and determine the interface or coupler cost.

In an ideal world, a single coupler design would be developed that was compatible with the different electrical characteristics of networks used in every country. Over and above their well-known differences in voltage and frequency, these networks have three basic configurations. The International Electrotechnical Commission (IEC) denotes them by two-letter designations as follows: T-N, T-T, and I-T [Fig. 1].

The first letter, T or I, describes the relationship of the system to earth. T, for terra or earth, indicates that the system is earthed or grounded and this is by far the most widely used network. The I designation indicates that the system is isolated from earth or in some cases connected to earth by a controlled impedance.

The second letter designation identifies the relationship of exposed conductive parts (the prongs on a plug or the slots on the receptacle—for example, to the installation of earth. In this case, T signifies that the utilization equipment is directly earthed independent of the system earth and N, *neutre* or neutral, signifies that the protective earth of the utilization equipment is connected to or common with the system earthing conductor.

The T-N system is the most popular and can be found in North, Central, and South America, many areas in Europe, most of Asia, Australia, and much of Africa. The T-T system is used primarily in France, Southern Europe, and Northern Africa.

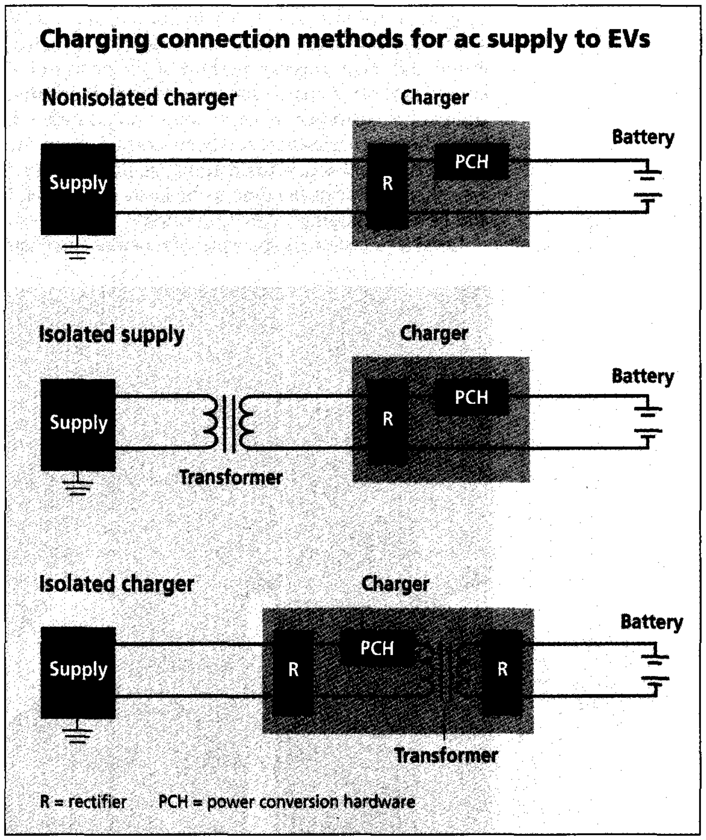
In developing an appropriate EV charging infrastructure, a system-level approach had to consider all aspects—the generation, transmission, and distribution of electricity; the wiring systems in homes, commercial buildings, and industrial facilities; the special equipment for charging; and the EV.

A tremendous advantage of EVs is that they are the ultimate alternative fuel vehicle. They shift reliance from a single fuel—gasoline—to the broad range of primary feedstock used for electric power generation—coal, natural gas, oil, nuclear, hydro, and renewables. Subsequently, an improvement in electric-utility generation efficiency can be realized by charging EVs during periods of low (off-peak) demand—overnight. This allows increased use of larger, more efficient baseload generating facilities.

The exploitation of off-peak capacity establishes the first boundary condition for EV charging—that the charge process take no longer than 8 to 10 hours. Simple mathematics provides nominal charging requirements. Representative values, such as 4.5–8 km/kWh and a desired customer driving range of 160–240 km, yield battery capacities around the 20–50-kWh range and charge rates of 3–9 kW, or 6 kW nominal, when charger and battery charge efficiencies are factored in.

In North America, where 240-V single-phase is the most common electrical supply, this yields a 30-A circuit, on a par with an electric clothes dryer. That value is well within reach of the transmission, distribution, and installed-service capabilities in use everywhere. This is particularly true when charging overnight, when electricity usage is lowest and most economical, is considered. In a nutshell, the compatibility of EV charging with the existing network neatly sidesteps the costs of upgrading transmission, distribution, and electrical services.

The next step in establishing standards is to set boundary conditions for the EV charging system architecture. A battery charger in essence performs two basic functions: it converts alternating into direct current, and it regulates the voltage in a manner consistent with the ability of a battery to accept current. There are three recognized methods of connecting a battery to the network through a charger. They rely variously on an isolated supply, an isolated charger, or a nonisolated charger [Fig. 2]. All of these methods have unique merits and should be accommodated in a general architecture scheme.



[2] Chargers can connect batteries to electric-supply networks in three ways, either not isolating the charger or isolating it from the supply, or from the supply and battery. The end result is the same: a fully charged battery.

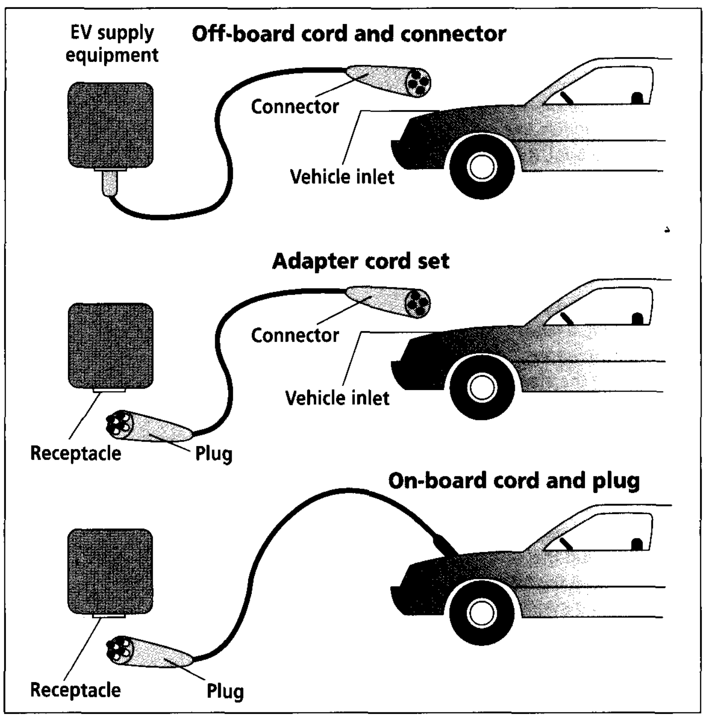
Plugging in, turning on

A second key consideration in EV charging is the vehicle's physical connection to the supply network. The three available methods are cord with a plug end, cord with a connector end, and cord set [Fig. 3]. The most popular and familiar method of connecting equipment is to attach a cord and plug to the appliance and connect it to a receptacle or electrical outlet. (Typically, plugs have prongs that fit into a receptacle; connectors do not.)

This works fine with stationary devices that are connected and generally left alone such as a lamp, range, dryer, stereo, TV, and so on. It works less well for EVs where daily or more frequent connection in all weather conditions and safely managing and storing a large cord on the vehicle, especially for high-power fast charging, becomes technically unreasonable and a potential consumer inconvenience.

Because a dedicated circuit with special equipment will probably have to be installed to charge an EV, the auto manufacturers unanimously agreed that the familiar gasoline pump configuration where the hose (cord) and nozzle (plug or connector) are fixed to the pump (charging equipment) is the preferred method. This solution combines convenience with flexibility in coping with special conditions, such as long distances between charging equipment and the vehicle inlet. The third method of using a cord set fitted with a plug and connector was considered as acceptable for limited situations such as charging from a common existing receptacle.

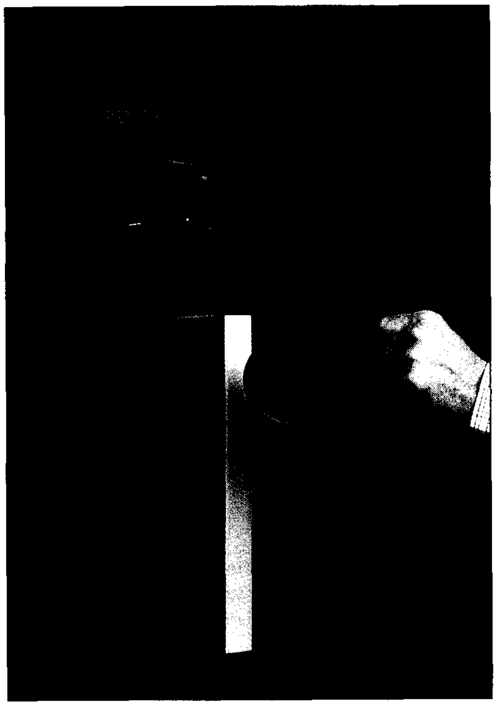
Given the above scenario where equipment oper-



[3] Other considerations aside, the car and electric-supply network must be connected. The cord can be permanently attached to either the car or supply receptacle, leaving only one end to connect, or it can require connections at both ends.

ating at 200 V in Japan, 230 V in Europe, and 240 V in the United States and 40 A nominal, is the preferred and most popular method of EV charging—known as Level 2 charging—two other methods that address EV customer concerns were also considered. From the start, customers had been worried about the charge time and access to charging facilities. To reassure them, what have come to be known as Level 3 and Level 1 charging were established.

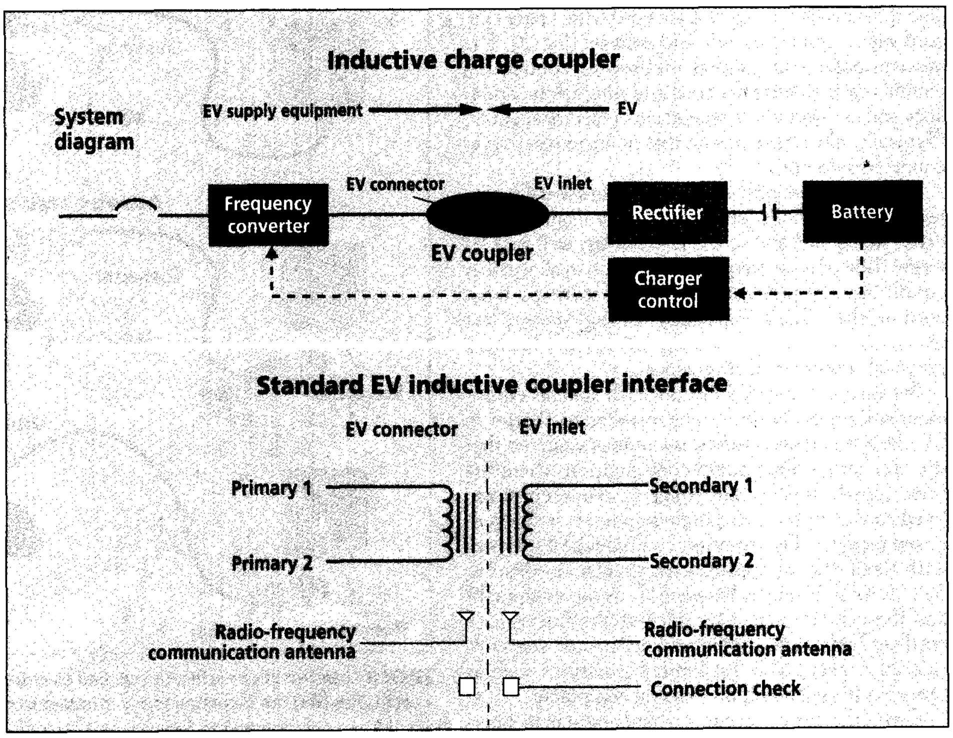
Level 3 or fast charging replenishes more than half of the battery capacity in approximately 10–15 minutes at a commercial public facility. (Note that the IWC set the levels and their basic criteria.) Level 3 charging is particularly suited to fleet applications where a 15-minute opportunistic charge during a lunch break can significantly extend a vehicle's daily range and use.



Level 1 charging allows a vehicle to access the most popular grounded standard outlet. Since most garages in the United States have a 120-V/15-A duplex outlet, and similar receptacles abound in other countries, being able to hook up for EV charging is handled by an adapter cord set (a cord with one plug end and one connector end). However, the limited power capability of this outlet and regulations governing circuit sharing and continuous loads (steady demand for 3 hours or more) restrict Level 1 charging to emergency or limited convenience use in North America.

The long-term vision of EV charging includes a mix of facilities. The highest-priority charging points are points of access at home and workplace. Public access charging at such facilities as malls, airports, and park and ride mass transit stations, compliment these primary points. Commercial, public fast-charge stations further encourage EV use by solving range limitations and consumer concerns over long charge times.

A standard connector or plug for charging must support the basic charging system architecture. Whatever the charging system configuration and battery type or size, and regardless of customers' conviction that it is the auto makers' job to service the battery, the auto makers concurred that control of the charge process would reside on the vehicle—regardless of where the charger is located—to optimize the performance of the battery. Subsequently, two coupler technologies, inductive and conductive, have been the focus of technical and standards development.



[4] The typical inductive coupler used in the United States has a paddle-like connector [above]. It is easy for consumers to use and similar to a gas pump where a nozzle is inserted into the gas tank for fill-up. To get electric power from the distribution network into the battery in the car [right], a high-frequency converter, connected to the electricity network and off-board the EV, sends energy to a rectifier and charger control on the vehicle. It does this via a two-piece, take-apart transformer: the paddle-like connector holds the primary and the secondary is on the EV at the connector-inlet interface. The frequency converter and control communicate via an RF link to ensure charging does not begin until all connections are properly made, and ends when the battery is charged.

The great debate: inductive ...

Shortly after announcing its intention to be the first to market with an EV, General Motors indicated it would be using a unique inductive coupler technology for connecting its vehicle to the network for charging. The core element is based on the concept of a take-apart transformer. The system architecture basically consists of a high-frequency converter connected to the power supply off-board the vehicle, a high frequency take-apart transformer at the vehicle interface, and an on-board rectifier and charge controller [Fig. 4].

The system is fundamentally an isolated-charger type with the off-board power electronics serving as a current source as commanded by the on-board charge controller. In regulating charge rate, the charge controller communicates with the frequency converter over a close-coupled radio-frequency media link using a standard J1850 Class B Data Communications Network Interface and the recently developed J2293 protocol for EV charging, both from the Society of Automotive Engineers (SAE).

Increasing the frequency from the line to the 100-kHz-plus range reduces the size of the plug to allow ease of use for the consumer. Functionality and interoperability are ensured by strict control of both the off- and on-board equipment, yielding a system standard as opposed to just a coupler standard.

The inductive system is presently being used with the GM EV1 and Nissan Altra EV. High-power versions, up to 120 kW, have been demonstrated. A second generation of the inductive system is currently being jointly developed by GM and Toyota Motor Corp., Tokyo.

... versus conductive

Other auto manufacturers opted to develop a more traditional approach based on simple contact technology. The conductive ac/dc-coupled system is based on a standard coupler interface and an open system architecture that supports the use of either on- or off-board chargers, all of the three possible connection schemes, and voltage, current, and voltage/current source chargers [Fig. 5].

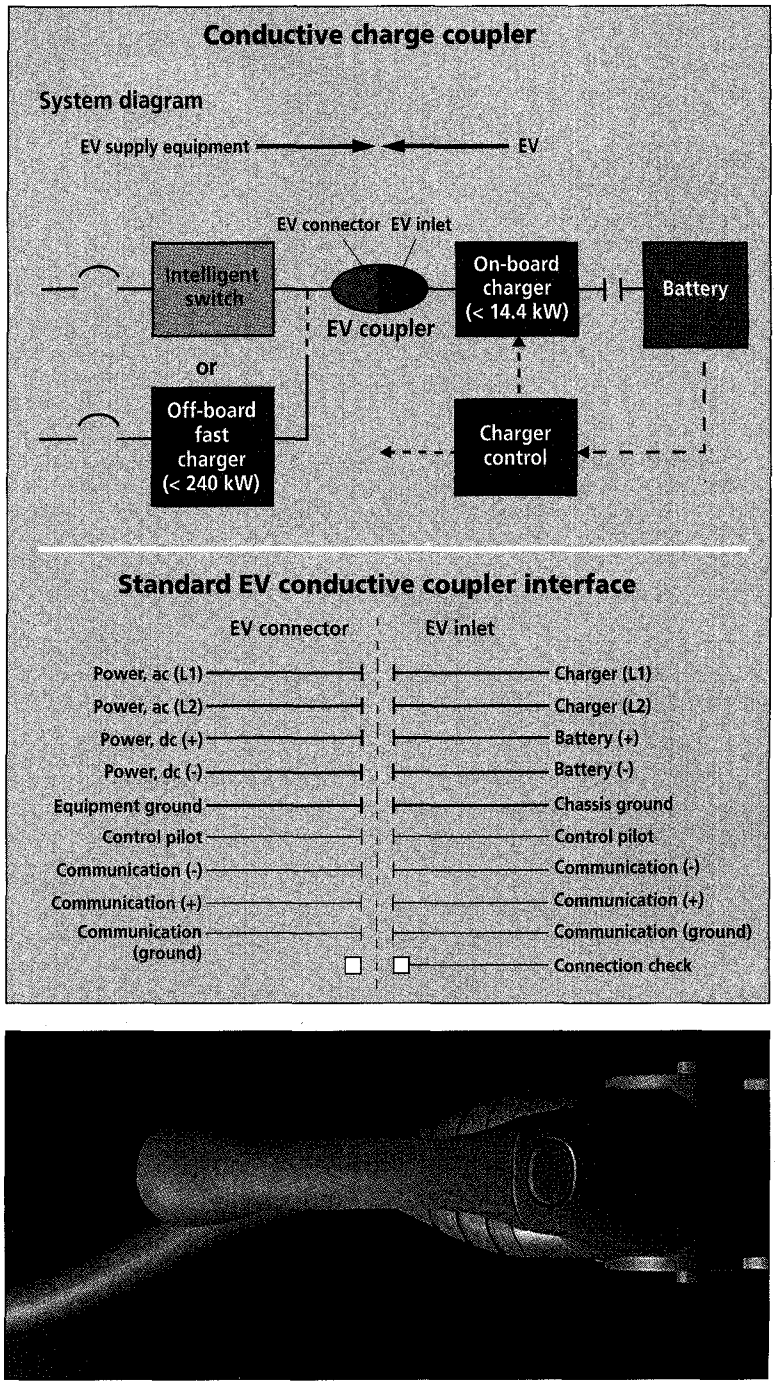
For primary Level 2 charging, most OEMs prefer an on-board charger where ac power is supplied to the vehicle over an intelligent switch, and the network protective earth is connected to the vehicle chassis during charging. In these circumstances, the charger design can be optimized for the vehicle and the infrastructure costs can be minimized to include only the contactor, enclosure, and supervisory electronics to ensure safe operation.

For Level 3 fast charging, the size and weight of the charger mandated that it be an off-board device, with dc power being transferred to the vehicle [see "Effective fast-charging infrastructure for EVs," pp. 46–47]. But the system also accepts lower-rate off-board chargers. In this case, hardwire communication media is used by the vehicle controller to regulate charging using the same SAE J1850 and J2293 standards as the inductive system.

The interface to support an ac/dc conductive coupled system [Fig. 5, again] is a nine-pin configuration for North America consisting of:

- Two single-phase ac contacts rated 240 V ac, 60 A, and 14.4 kVA.
- Two dc contacts rated 600 V dc, 400 A, and 240 kW.
- One equipment ground, sized for fault clearing.
- One control pilot signal contact for the control, interlock, ground monitoring, and ampacity marking functions.
- Three signal contacts for the hardwire communication media.

The mated coupler components, connector, and vehicle inlet can be populated with whatever power and communication contacts are required by the sup-



[5] Resembling a long snout, the conductive coupler [photo] offers an elegant solution to charging under the three possible connection schemes, with on- or off-board chargers and voltage and/or current sources. Because it handles so many variations, the connector/inlet interface looks complicated, but really is not [diagram, top]. Each of the nine pins handles a specific duty, be it control, power, ground, or communication. A keyed connection ensures proper insertion, just as in the inductive set-up.

Effective fast-charging infrastructure for EVs

EDWARD MOORE

Fast-charge stations with public access become an ever more obvious need as electric vehicles (EVs) make inroads into the marketplace. The core issue is how far the EV can travel without recharging, and without a range extended by fast charge, the average EV owner will not be able to completely relinquish a conventional car.

The situation will be felt all the more intensely as newer battery technology finds its way into EVs. The high-capacity batteries will increase not just the range (a good thing) but also the charge time (a bad thing). Standard EV charging at home, using 6-kW Level 2 charging systems, could double to 6 hours. An elegant solution to the problem outside the home would be the ability to fast-charge, known as opportunity charging. The output power of fast-charging systems, also known as Level 3, currently runs from 22 kW to a high of 120 kW.

Yet, the charging infrastructure must meet criteria beyond speed. It should offer billing, say, and wheelchair access for disabled drivers. The EV industry must determine what is needed and satisfy those needs with its products.

Safety may be assured with assorted systems that provide ac power isolation, a verified safety ground, and both ac and dc ground current testing. The system must also be able to detect open and short circuits in the high-power output circuit. Clearly, at power levels as high as 240 kW, even small percentages of the total current ought not to be felt on the charger or vehicle chassis. Any failures in these areas must shut off the system. System failure is acceptable, but only if it is fail safe.

Ease of use is subjective, but intuitive controls and coupler design should be obvious to everyone. How to turn the charger on and off, and connect the [illegible], should be pretty self-evident. The user ought also to be given good feedback on charge status, state of charge, and fault conditions. These kinds of features matter most in Level 3 chargers, since most of them will be installed to support large fleets of vehicles or the general public. Smaller chargers like the Level 2 units are most often installed in a home, giving their owners the chance to familiarize themselves with the ins-and-outs of their own charger.

Convenience is a name for how well a device satisfies the user's needs. The Level 3 charging system should be installable indoors or outdoors, in any public location. It should also provide point-of-sale billing and replenish at least 50 percent of the battery's capacity in less than 15 minutes. Of course, fast chargers are uniquely qualified to provide the short recharge time, since they are typically 10–20 times as powerful as their Level 2 counterparts.

So-called "universal" charge control algorithms should [illegible] damage the battery [illegible] of this kind are generally based on charge acceptance alone, even though, depending on the specific battery, many other factors may be important.

Better results are obtained with a vehicle-based battery management system, which monitors more parameters and which controls charging correctly for the battery involved. The system should not rely only on pack-level voltage and current for charge control—module-level voltage and temperature data, in conjunction with pack-level data, provide better feedback, hence more effective charge control. With charge current levels as high as 500 A, reliable temperature data is critical. The system should also be able to recognize open and short circuits as well as provide thermal management.

As new batteries are introduced, backward compatibility is eminently desirable. The EV charging infrastructure should not have to be changed, particularly in the case of a public access installation, as many Level 3 chargers will be. The system architecture is therefore forced to use an on-vehicle battery management system that sends control information to an off-board fast-charge station. The on-vehicle battery management system is programmed with the charge control algorithm appropriate

ply equipment or vehicle. The equipment ground and control pilot contacts are always required.

The coupler design uses a butt-type contact and is derived from the product developed for the EV test and demonstration program in France. This design was selected by SAE after extensive durability testing of the basic contacts and the prototype components. With this design, the contacts are shielded on the connector and inlet when disconnected. During the insertion and rotation involved in connection, the shields are automatically retracted. This method of connection and type of contact produced a design that was easy to use, even when configured for high-power dc transfer, and provided an additional safety measure.

Setting the standard

The recommendations of the EPRI-IWC Connector and Connecting Station Committee were published in December 1993, and codes and standards development for charging equipment proceeded apace through the next few years. In the United States, under the auspices of the EPRI-IWC Health and Safety Committee, a panel of experts was convened to develop an article (standard) on EV charging equipment for the 1996 National Electrical Code (NEC). The proposed revisions were to include Article 625, Electric Vehicle Charging System Equipment. The result was approved for publication in the 1996 NEC and has been updated for the 1999 NEC. Also during this period, the SAE EV Charging Systems Committee developed and approved SAE Recommended Practices for conductive (J1772) and inductive (J1773) charging systems.

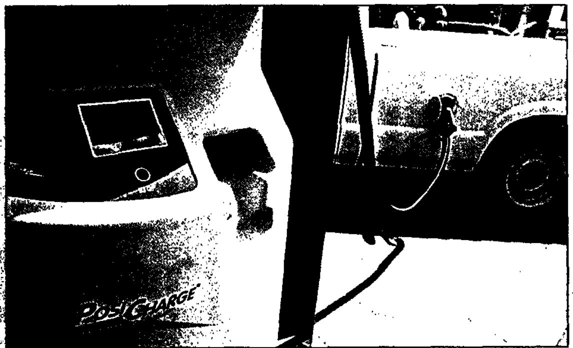
Development of a consensus on product standards was initiated by Underwriters Laboratories Inc., in step with activities of the SAE and NEC. Presently, outlines of investigations are under way to establish three EV-related product standards. They are UL 2202, UL 2231, and UL 2251. UL 2202 is the proposed standard for EV charging equipment and covers all nonvehicle electrical equipment for EV charging. UL 2231 is the proposed standard for personnel protection systems for EV supply circuits and covers the requirements for a layered system of double-fault protection for both grounded and isolated charging systems. UL 2251 is the proposed product standard for plugs, receptacles, and couplers for EVs.

Incidentally, UL 2231 came out of a comprehensive UL study funded by EPRI, Ford, GM, and Chrysler on personnel protection. Although it presently applies to EV charging systems, it is suitable for general electrical equipment and may be more broadly applied in the future.

With the selection of two charging technologies, conductive and inductive, and their means of coupling, codes and standards are in place or in development in the United States to support EV commercialization. Similar efforts are ongoing in Canada and Japan, and within the IEC.

Canada has revised Part 1 of its electrical code by for the installed battery type. If a new battery chemistry is adopted, the system can be reprogrammed with the correct charge parameters, without modifications to the charging station. With this approach, a standard charging station can charge any vehicle, regardless of variations in the battery chemistry or charge algorithm.

Poor power factor and harmonic distortion are to be avoided, too. They affect the quality of utility power to other customers on the same utility feed. They also drive up the utility bill for some industrial applications, where reactive power is a component of the utility rate. A power factor (cosine of phase shift voltage and current) greater than 0.95 pretty much indicates that the unit does not create high levels of reactive power. This type of power is basically lost and is not transferred to the battery pack.



A 10 percent loss at 6 kW is clearly not as significant an issue as a 10 percent loss at 120 kW. Utility companies are particularly concerned about the third harmonic, which contributes to heat in line transformers. Bearing all this in mind, total harmonic distortion should not exceed 5 percent, and no single harmonic, including the third, should exceed 3 percent.

The industry will never take off if it relies on subsidies from or cost sharing with the government. Instead, the EV infrastructure must make sound business sense to equipment manufacturers, dealers, and operators. In dollar terms, the cost of the charger, maintenance, and installation ought to be recoverable within a reasonable time-frame, and with a profit.

Further, the price paid to charge the EV must be acceptable to the EV owner. According to financial studies, the business case for installing and operating fast-charge stations becomes acceptable below US $0.70/W. That is, a 60-kW charger should sell for less than $42 000.

The EV industry has done a lot to develop and implement standards for EV charging. The Society of Automotive Engineers has issued three standards that specify the complete charging system architecture and implementation. J1772 and J1773 deal with the physical interface between charger and vehicle for conductive and inductive charging systems, respectively. J2293 describes the power transfer characteristics (Part 1) and the communications requirements (Part 2).

Underwriters Laboratories has in the meantime equipped the industry with documents for testing EV charging systems. UL 2202 and UL 2251 cover the charging station and the charge coupler, respectively. Other standards that need to be considered include the National Electrical Code and the Americans with Disabilities Act.

Both U.S. and non-U.S. manufacturers are not only building vehicles that comply with these standards, but are also working with charger manufacturers and other component suppliers to ensure that products meet performance standards, industry compatibility standards, and safety standards. This provides an important objective check for future owners and operators of EV charging stations.

Simply charging fast is not enough to popularize electric vehicles—the charging infrastructure must also be effective. AeroVironment's PosiCharge Fast Charge System makes this its goal [see photograph]. Given the commitment of the industry, the electric vehicle has a bright and healthy future.

Edward Moore is manager for electric infrastructure at AeroVironment Inc., in Mon-rovia, Calif.

adopting Section 86 for EV charging systems and is starting on Part 2, product standards, this year. These standards are or will be closely harmonized with their U.S. equivalents.

The Japan Electric Vehicle Association has published four standards governing conductive EV charging equipment, which from a system architecture standpoint, are closely akin to the U.S. and Canadian standards. An exception is the connecting means, which presently uses the product developed for the Eco-Station project described earlier.

As for the IEC's Technical Committee 69 for Electric Road Vehicles, its Working Group 4 for charging infrastructure is close to circulating a committee draft for voting. This document has received active input from representatives of the automotive industry around the world and is also harmonized to the extent possible with North American and Japanese activities. If approved, this document will set the requirements for the European community and other IEC member countries.

As the year 2000 approaches, EVs are rapidly moving from demonstration to volume production, thanks in large part to the technical community. In cooperation with standards development bodies, it has delivered a strong foundation for a safe, efficient, and high-value EV charging infrastructure that addresses the complexities of the supply network and vehicle interface with a harmonized solution. Only one question remains: will conductive or inductive charge-couplers prevail in the long-term marketplace? ●

To probe further

For more on standards development for the global EV charging infrastructure, visit the World Wide Web sites of the primary organizations responsible for those standards. The Society of Automotive Engineers, Warrendale, Pa., maintains an extensive directory of its standards and the group's standards development activities at www.sae.org. The International Electrotechnical Commission (www.iec.ch) currently has two working groups under its Technical Committee 69 for electric vehicles. The working groups are examining motors and motor control systems, and power supplies and chargers.

The Electric Power Research Institute, Palo Alto, Calif., provides logistical coordination for the U.S.'s National Electric Vehicle Infrastructure Working Council. The council's Web site (www.epri.com/csg/trans/iwc/index.html) contains back issues of its news briefs and published papers, amid other pertinent information.

For more about the PosiCharge fast-charging system from AeroVironment Inc., Monrovia, Calif., as well as the company's other products for electric vehicles, see the company's Web site located at www.aerovironment.com/area-electric/vehicles.html.

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