SAE J1772

SAE J1772 is a North American standard for electrical connectors for electric vehicles maintained by the Society of Automotive Engineers and has the formal title “SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler”.[1] It covers the general physical, electrical, communication protocol, and performance requirements for the electric vehicle conductive charge system and coupler. The intent is to define a common electric vehicle conductive charging system architecture including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector.

1 History

The older Avcon connector, featured here on a Ford Ranger EV

The main stimulus for the development of SAE J1772 came from the California Air Resources Board. Formerly electric vehicles like the General Motors EV1 had used inductive charger couplers. These were ruled out in favor of conductive coupling to supply electricity for recharging with the California Air Resources Board settling upon the **SAE J1772-2001 standard**[2] as the charging interface for electric vehicles in California in June 2001.[3] Avcon manufactured a rectangular connector compliant with that **SAE J1772 REV NOV 2001 specification** that was capable of delivering up to 6.6 kW of electrical power.[4] (Photos and description of this old-revision rectangular “AVCon connector” and “AVCon inlet” are at [5])

The CARB regulation of 2001 mandated the usage of SAE J1772-2001 beginning with the 2006 model year. Later requirements asked for higher currents to be used than the Avcon connector could provide. This process led to the proposal of a new round connector design by Yazaki which allows for an increased power delivery of up to 19.2 kW delivered via single phase 120–240 V AC at up to 80 amperes. In 2008 the CARB published a draft amendment to section 1962.2 Title 13 that mandated the usage of the oncoming SAE J1772 standard beginning with the 2010 model year.[6]

The Yazaki plug that was built to the new SAE J1772 plug standard successfully completed certification at UL. The standard specification was subsequently voted upon by the SAE committee in July 2009.[7] On January 14, 2010 the SAE J1772 REV 2009 was adopted by the SAE Motor Vehicle Council.[8] The companies participating in or supporting the revised −2009 standard include Smart, Chrysler, GM, Ford, Toyota, Honda, Nissan, and Tesla.

The **SAE J1772-2009 connector specification** has been added to the **international IEC 62196-2 standard** (“Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories”) with voting on the final specification to close in May 2011.[9] The SAE J1772 connector is considered a “Type 1” implementation providing a single phase coupler.[10]

1.1 Vehicle equipment

The SAE J1772-2009 was adopted by the car manufacturers of post-2000 electric vehicles like the third generation of the Chevrolet Volt and Nissan Leaf as the early models. The connector became standard equipment on the US-market due to the availability of charging stations with that plug type in the nation’s electric vehicle network (with the help of funding such as ChargePoint America program drawing grants from provisions of the American Recovery and Reinvestment Act).

The European versions were equipped with a SAE J1772-2009 inlet as well until the automotive industry settled on the IEC Type 2 “Mennekes” connector as the standard inlet - since all IEC connectors use the same SAE J1772 signaling protocol the car manufacturers are selling cars with either a SAE J1772-2009 inlet or an IEC Type 2 inlet depending on the market. There are also (passive) adapters available that can convert J1772-2009 to IEC Type 2 and vice versa. The only difference is that most European versions have an on-board charger that can take advantage of three-phase electric power with higher voltage and current limits even for the same basic electric vehicle model (such as Chevrolet Volt / Opel Ampera or the BMW i3).

1.2 Combined charging system

SAE is developing a Combo Coupler variant of the J1772-2009 connector with additional pins to accommodate fast DC charging at 200–450 Volts DC and up to 90 kW. This will also use Power Line Carrier technology to communicate between the vehicle, off-board charger, and smart grid.[11] Seven car makers (Audi, BMW, Daimler, Ford, General Motors, Porsche and Volkswagen) had agreed to introduce the “Combined Charging System” in mid-2012.[12] As of Spring 2013, there were not yet any production cars using the J1772 Combo plug. But by 2014, the first two vehicles were released using the SAE Combo plug: the BMW i3 was released in late 2013, and the Chevrolet Spark EV was released in 2014.[13] In Europe, the combo coupler is based on the Type 2 (VDE) AC charging connector maintaining full compatibility with the SAE specification for DC charging and the GreenPHY PLC protocol.[14]

2 Properties

2.1 Connector

The J1772-2009 connector is designed for single phase electrical systems with 120 V or 240 V such as those used in North America and Japan.

The round 43 millimetres (1.7 in) diameter connector has five pins, with three different pin sizes

- AC Line 1, AC Line 2 - same sized, larger power pins
- Ground Pin
- Proximity Detection, Control Pilot - same sized, smaller control pins

Proximity Detection - Prevents movement of the car while connected to the charger.

Control Pilot - Communication line used to coordinate charging level between the car and the charger as well as other information.

The connector uses a 1 kHz square wave at ±12 volts generated by the Electric Vehicle Supply Equipment (EVSE), i.e. the charging station, on the pilot pin to detect the presence of the vehicle, communicate the maximum allowable charging current, and control charging.[15] The connector is designed to withstand up to 10,000 connection/disconnection cycles and exposure to the elements. Approximating one connection/disconnection cycle daily, the average connector’s lifespan should be just over 27 years.

2.2 Charging

The J1772 standard defines two charging levels:[8]

The SAE J1772 committee has also proposed a DC connector based on the SAE J1772-2009 AC connector shape with additional DC and ground pins to support charging at 200–450 V DC and 80 A (36 kW) for **DC Level 1** and up to 200 A (90 kW) for **DC Level 2**[16] after evaluating the J1772-2009 connector against other designs including the JARI/TEPCO connector used by the CHAdeMO DC fast charge protocol.[17] The SAE **DC Level 3** charging levels have not been determined, but the standard as it exists as of 2009 has the potential to charge at 200–600 V DC at a maximum of 400 A (240 kW).

For example, a 240 kW charger that charges a plug-in vehicle, such as the BMW i3 with range extender that gets 100 miles per 21.7 kWh (155 MPGe, 217 Wh per mile), would get approximately 18 miles of range per minute that a driver spends charging throughout the life of the car. To put this into perspective, the Ford Taurus FWD 3.5L, which the EPA compares as an average new gasoline only car, gets 23 MPG, meaning that a gasoline pump that pumps at 7 gallons per minute gives 161 miles of range per every minute that a driver spends pumping gas throughout the life of the car.[18]

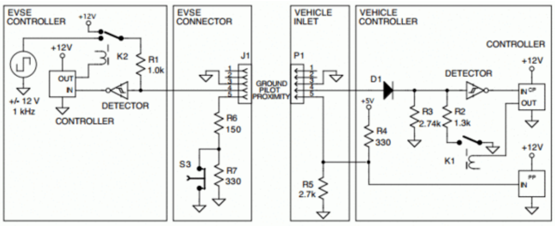
2.3 Safety

The J1772 standard includes several levels of shock protection, ensuring the safety of charging even in wet conditions. Physically, the connection pins are isolated on the interior of the connector when mated, ensuring no physical access to those pins. When not mated, J1772 connectors have no voltage at the pins,[19] and charging power does not flow until commanded by the vehicle.[17]

The power pins are of the first-make, last-break variety. If the plug is in the charging port of the vehicle and charging, and it is removed, the control pilot and proximity detection pin will break first causing the power relay in the charging station to open, cutting all current flow to the J1772 plug. This prevents any arcing on the power pins, prolonging their lifespan. The proximity detection pin is also connected to a switch that is triggered upon pressing the physical disconnect button when removing the connector from the vehicle. This causes the resistance to change on the proximity pin which commands the vehicle's onboard charger to stop drawing current immediately before the connector is pulled out.

3 Signaling

The signaling protocol has been designed so that[17]



J1772 signaling circuit

- supply equipment signals presence of AC input power
- vehicle detects plug via proximity circuit (thus the vehicle can prevent driving away while connected)
- control pilot functions begin
    - supply equipment detects plug-in electric vehicle
    - supply equipment indicates to PEV readiness to supply energy
    - PEV ventilation requirements are determined
    - supply equipment current capacity provided to PEV
- PEV commands energy flow
- PEV and supply equipment continuously monitor continuity of safety ground
- charge continues as determined by PEV
- charge may be interrupted by disconnecting the plug from the vehicle

The technical specification was described first in the 2001 version of SAE J1772 and subsequently the IEC 61851-1 and IEC TS 62763:2013. The charging station puts 12 volts on the contact pilot (CP) and the proximity pilot (PP) (also "Plug Present") measuring the voltage differences. This protocol allows it to skip integrated circuit electronics as they are required for other charging protocols like the CAN bus used with Chademo or EnergyBus – the SAE J1772 is considered robust enough for a range of −40 °C to +85 °C.

The charging station sends a 1000 Hz square wave on the contact pilot that is connected back to the protected earth on the side of the vehicle by means of a resistor and a diode (voltage range ±12 V ±0.4 V). The live wires of public charging stations are always dead if the CP-PE (protective earth) circuit is open, although the standard allows a charging current as in Mode 1 (maximum 16 A). If the circuit is closed then the charging station can also test the protective earth to be functional. The vehicle can request a charging state by setting a resistor - using 2700 Ω a Mode 3 compatible vehicle is announced ("vehicle detected") which does not require charging. Switching to 880 Ω the vehicle is "ready" to be charged and switching to 240 Ω the vehicle requests "with ventilation" charging which does not have an effect outdoors but the charging current will be switched off indoors if no ventilation is available. The charging station can use the wave signal to describe the maximum current that is available from the charging station with the help of pulse width modulation: a 16% PWM is a 10 A maximum, a 25% PWM is a 16 A maximum, a 50% PWM is a 32 A maximum and a 90% PWM flags a fast charge option.[20]

The pilot line circuitry examples in SAE J1772:2001 show that the current loop CP-PE is connected permanently via a 2740 Ω resistor making for a voltage drop to from +12 V to +9 V when a cable is hooked up to the charging station which activates the wave generator. The charging is activated by the car by adding parallel 1300 Ω resistor resulting in a voltage drop to +6 V or by adding a parallel 270 Ω resistor for a required ventilation resulting in a voltage drop to +3 V. Hence the charging station can react by only checking the voltage range present on the CP-PE loop.[21] Note that the diode will only make for a voltage drop in the positive range - any negative voltage on the CP-PE loop will shut off the current as being considered a fatal error (like touching the pins).

The PWM duty cycle of the 1 kHz CP signal indicates the maximum allowed mains current. According to the SAE it includes socket outlet, cable and vehicle inlet. In the US the definition of the "ampacity" (ampere capacity) is split for continuous and short term operation.[20] The SAE defines the ampacity value to be derived by a formula based on the 1000 µs full cycle (of the 1 kHz signal) with the maximum continuous ampere rating being 0,6 A per 10 µs (with lowest 100 µs = 6 A and highest 800 µs = 48 A).[21]

The pin PP is also named "Plug Present" as the SAE J1772 example pinout describes the switch S3 as being mechanically linked to the connector latch release actuator. During charging the EVSE side connects the PP-PE loop via S3 and a 150 Ω R6 - when opening the release actuator a 330 Ω R7 is added in the PP-PE loop on the EVSE side which gives a voltage shift on the line to allow the electric vehicle to initiate a controlled shutoff prior to actual disconnection of the charge power pins. However many low power adapter cables do not offer that locking actuator state detection on the PP pin.

3.1 P1901 powerline communication

In an updated standard due in 2012, SAE proposes to use power line communication, specifically IEEE P1901, between the vehicle, off-board charging station, and the smart grid, without requiring an additional pin; SAE and the IEEE Standards Association are sharing their draft standards related to the smart grid and vehicle electrification.[22]

P1901 communication is compatible with other 802.x standards via the IEEE P1905 standard, allowing arbitrary IP-based communications with the vehicle, meter or distributor, and the building where chargers are located. P1905 includes wireless communications. In at least one implementation, communication between the off-board DC EVSE and PEV occurs on the pilot wire of the SAE J1772 connector via HomePlug Green PHY power line communication (PLC).[23][24][25]

4 Compatible charging stations

In North America and Japan, the Chevrolet Volt,[26] Nissan Leaf,[27] Mitsubishi i-MiEV, Toyota Prius Plug-in Hybrid and Smart electric drive all come with 120 V portable charging leads that couple a 120 V mains plug to the car's J1772 receptacle; in the countries where 220-230V domestic mains electricity is common, the portable EVSE leads commonly supplied with the vehicle can perform a level 2 charge from a domestic mains plug, albeit at a lower current than a dedicated high-current charging station.

Products compatible with SAE J1772-2009 include:

- AeroVironment home charging station for the Nissan Leaf[28]
- BTCPower (Broadband TelCom Power, Inc.)[29]
- Bosch Power Max home charging stations
- ClipperCreek products include CS-40,[30] LCS-25[31] and LCS-25p,[32] HCS-40.[33] The product with highest charging amperage is CS-100.[34]
- ChargePoint CT4000 newest intelligent charger,cable management,driver services CT500, CT2000, CT2100, and CT2020 families of ChargePoint Networked Charging Stations[35]
- EATON Pow-R-Station Family of Electric Vehicle Charging Stations [36]
- ECOtality Blink home wall-mount and commercial stand-alone charging stations[37][38]
- Electric Motor Werks JuiceBox Open Source 15 kW 60 A EVSE
- EVSEadapters EVSE240V16A 240V 16A Portable Level 2 EVSE
- EVoCharge – Retractable Reel EVSE's designed to support Residential, Commercial and Industrial Markets.
- GE Wattstation available in 2011[39]
- GoSmart Technologies ChargeSPOT line of charging stations
- GRIDbot's "UP" family of charging stations
- Hubbell PEP Stations - http://www.hubbell-wiring.com/press/pdfs/WLDEE001.pdf
- Leviton evr-green home charging stations at a range of power levels, with separate pre-wire kit that allows one to plug into a NEMA 6 240 V receptacle[40]
- Schneider Electric / Square D EVLink Charging Solutions for residential, commercial, and fleet charging solutions.
- Siemens VersiCharge for cost effective residential, semi-public, and fleet level 2 EV charging.
- SemaConnect ChargePro Charging Stations
- Shorepower Technologies ePump line of fully customizable EVSE; indoor and outdoor solutions for cars and trucks.
- TucsonEV - J1772 Adapter Boxes, Inlets and Plugs with and without cord, 70 A and 30 A. We will soon have a J1772 Compatible EVSE for up to 240 V/30 A
- CIRCONTROL CIRCARLIFE product range includes EV charging infrastructure with post and wall mount units with J1772 standard
- OpenEVSE Project - Open Source Design for EVSE.
- eStation Level-2 Charger by Vega. Part of chargeNET network in Sri Lanka

5 Competing standards

The proposal of the Mennekes connector initiated by RWE and Daimler has been added as a "Type 2" implementation to IEC 62196 providing a single and three phase coupler.[10][41] The connector was specified in the VDE-AR-E 2623-2-2 standard - this connector specifies up to 63 A three-phase (at 400 V in Central Europe) which makes for a maximum of 63 A × 400 V × $\sqrt{3}$ = 43.6 kW. Additionally the IEC 62196-2 standard specifies a "Type 3" connector providing a single and three phase coupler with shutters which takes up the proposal of the EV Plug Alliance (Scame, Schneider, Legrand).[10]

All plug types - including Type 1 (SAE), Type 2 (VDE) and Type 3 (EVPlug) - share the same specifications for the pilot pin taken from the IEC 61851-1 standard.

Tokyo Electric Power Company has developed a specification solely for level 3 high-voltage DC automotive fast charging using a different connector (JARI Level 3 DC), and formed the CHAdeMO (abbreviation of “CHArge de MOve”, equivalent to “charge for moving”) association with Japanese automakers Mitsubishi, Nissan and Subaru to promote it.[42]

6 References

[1] Society of Automotive Engineers; Craig B. Toepfer (2001-09-27). “SAE Electric Vehicle Conductive Charge Coupler, SAE J1772, REV. MONTH01” (DOC). California Air Resources Board. Retrieved 2009-10-23.

[2] “Rulemaking: 2001-06-26 Updated and Informative Digest ZEV Infrastructure and Standardization” (PDF). *title 13, California Code of Regulations*. California Air Resources Board. 2002-05-13. Retrieved 2010-05-23. Standardization of Charging Systems

[3] “ARB Amends ZEV Rule: Standardizes Chargers & Addresses Automaker Mergers” (Press release). California Air Resources Board. 2001-06-28. Retrieved 2010-05-23. the ARB approved the staff proposal to select the conductive charging system used by Ford, Honda and several other manufacturers

[4] California Air Resources Board; Alexa Malik. “Rulemaking: 2001-06-28 15 DAY NOTICE ZEV Infra 15day Ntc2-28.doc” (PDF). Retrieved 2009-10-23.

[5] “SAE J1772-2001(older AVCON) Electric Vehicle Chargers”. CarStations. 2013-01-24. Retrieved 2014-01-25.

[6] “Report on the Current Situation and Future Direction of Electric Vehicle Charger Standardisation”, SMMT, July 2010

[7] Sam Abuelsamid (2009-06-29). “Underwriters Laboratories approves SAE J1772 charging plug”. Retrieved 2009-10-10. Underwriters Laboratories has completed its certification testing on the connector developed by Yazaki.

[8] “SAE standard on EV charging connector approved”. SAE International. 2010-01-15. Retrieved 2010-03-14.

[9] “Document: 23H/250/CDV - : IEC 62196-2 Ed. 1: Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories”, IEC, 13. December 2010

[10] “IEC International Standard for EV charging - A step forward for global EV roll-out”, IEC Newslog, 3. February 2011

[11] “New SAE International Quick-Charge EV Connector Standard Gaining Momentum” (Press release). SAE International. 2011-08-04. Retrieved 2011-08-11.

[12] “Universal charging for electric cars”. Auto123.com. 2011-11-15.

[13] Seabaugh, Christian (2013-09-13). “First Test: 2014 Chevrolet Spark EV 2LT SparkSS”. Motor Trend. Retrieved 18 February 2014.

[14] Dr. Heiko Doerr (2011-11-08). “Current Status of the Combined Charging System” (PDF). Coordination Office Charging Interface (Audi, VW, BMW, Daimler, Porsche.

[15] SAE EV Charging Systems Committee, SAE Electric Vehicle Conductive Charge Coupler

[16]

[17] Gery Kissel, SAE J1772 Task Force Lead (2010-02-18). “SAE J1772 Update For IEEE Standard 1809 Guide for Electric-Sourced Transportation Infrastructure Meeting” (PDF). SAE International. Retrieved 2010-09-03.

[18] U. S. Environmental Protection Agency and U.S. Department of Energy (2012-11-30). “Comparison Side-by-Side - 2013 Chrysler 200, 2013 Ford Taurus FWD, 2013 Toyota Venza, and 2013 Hyundai Santa Fe Sport 2WD”. Fueleconomy.gov. Retrieved 2012-12-09.

[19] “Charging the Chevy Volt web chat”. GM-Volt.com. 2009-08-20. Retrieved 2010-09-03. When a J1772 standard plug (like on the Volt) is disconnected from the vehicle, no voltage is present at the pins.

[20] Anro Mathoy (17 January 2008). “Definition and implementation of a global EV charging infrastructure” (PDF). BRUSA Elektronik. Retrieved 2012-04-08.

[21] “SAE J1772 - SAE Electric Vehicle Conductive Charger Coupler”. August 2001. Appendix A, Typical Pilot Line Circuitry. Retrieved 2012-04-09.

[22] Pokrzywa, Jack; Reidy, Mary (2011-08-12). “SAE’s J1772 'combo connector' for ac and dc charging advances with IEEE’s help”. SAE International. Retrieved 2011-08-12.

[23] “Development and Implementation of SAE DC Charging Digital Communication for Plug-in Electric Vehicle DC Charging”. Papers.sae.org. Retrieved 2014-01-25.

[24] “Smartgrid EV Communication module (SpEC) SAE DC Charging Digital Communication Controller - Energy Innovation Portal”. Techportal.eere.energy.gov. Retrieved 2014-01-25.

[25] “Smart Grid EV Communication Module | Argonne National Laboratory”. Anl.gov. Retrieved 2014-01-25.

[26] Sebastian Blanco (2009-08-11). “GM shows off 120V and 240V chargers for 2011 Chevy Volt”. Autoblog. Retrieved 2010-06-27.

[27] “Nissan LEAF Electric Car | Answers | Charging”. Nissan. Retrieved 2010-05-25.

[28] Patrick Ponticel (2010-01-15). "AeroVironment to supply Leaf home charging unit". *SAE Vehicle Engineering Online*. SAE International. Retrieved 2010-06-26.

[29] "EV Fast Charger - Products and Applications - BTCPower (Broadband TelCom Power, Inc.)". BTCPower. Retrieved 2014-03-02.

[30] "ClipperCreek Ships the Only UL Listed SAE Compatible Charging Station" (Press release). ClipperCreek. 2010-05-07. Retrieved 2010-06-26.

[31] "ClipperCreek Introduces the Smallest 240V Plug and Cord Connected EV Charge Station Available" (Press release). ClipperCreek. 2013-09-16. Retrieved 2014-01-05.

[32] "ClipperCreek Announces the $549 LCS-25 with More Wall Plugs, Direct Replacement for ECOtality Residential Customers" (Press release). ClipperCreek. 2013-11-12. Retrieved 2014-01-05.

[33] "ClipperCreek Introduces HCS-40 Lowest Priced 30 Amp" (Press release). ClipperCreek. 2013-12-09. Retrieved 2014-01-05.

[34] "CS-100, 75A, 240V charging, 25′ cord". ClipperCreek. Retrieved 2014-01-05.

[35] "Coulomb Technologies Achieves UL Listing from Underwriters Laboratories for ChargePoint Networked Charging Stations for Electric Vehicles" (Press release). Coulomb Technologies. 2010-06-09. Retrieved 2010-06-26.

[36] "Electric Vehicle Solutions". Eaton.com. Retrieved 2014-01-25.

[37] Donald Melanson (2010-07-27). "ECOtality and Frog Design debut eye-catching Blink EV chargers". Engadget. Retrieved 2010-07-29.

[38] "ECOtality Introduces Blink The First Smart, Interactive, Iconic EV Chargers and Network" (PDF) (Press release). ECOtality. 2010-07-27. Retrieved 2010-07-29.

[39] Sebastian Blanco (2010-07-13). "GE unveils new electric car charger, the WattStation [w/video]". Autoblog Green. Retrieved 2010-07-13.

[40] "Leviton Announces Residential Charging Stations for Electric Vehicle Market" (Press release). Leviton. 2010-07-20. Retrieved 2010-07-29.

[41] Winfried Tröster (2009-01-29). "62196 Part 2-X: Dimensional interchangeability requirements for pin and contact-tube vehicle couplers" (PDF). International Electrotechnical Commission. Retrieved 2010-04-15.

[42] "Tokyo Electric Power Licenses Aker Wade to Build Level III Fast Chargers". Green Car Congress. 2010-01-15. Retrieved 2010-04-13.

7 External links

- SAE J1772 Committee

8 Text and image sources, contributors, and licenses

8.1 Text

- **SAE J1772** *Source:* https://en.wikipedia.org/wiki/SAE_J1772?oldid=679645350 *Contributors:* Emorog, Karn, Chowbok, D6, ArnoldReinhold, Alistair1978, Welshie, Guidod, Hooperbloob, Gene Nygaard, Woohookitty, Mbutts, DavideAndrea, Skierpage, Wavelength, Kc5kql, Bovineone, Voidxor, Pelegri~enwiki, Back ache, SmackBot, BenFranske, Monz, Taric25, Isnoop, Cybercobra, Daniel.Cardenas, Cargoudel, HUnger, Jac16888, Cydebot, Dirtyblueshirt, Billheller, Nintendo Maniac 64, Mwarren us, Alexrr123, Dougfal, Sovxx, GrandDrake, Gene93k, Cliff, Megiddo1013, Jax 0677, Addbot, Mortense, Darwin-rover, SolarElectricVehicle, Luckas-bot, Yobot, Pineapple fez, Reinraum, Ndsm, AnomieBOT, El Irlandés, MarkWarren, Anna Frodesiak, Thinker jones, Erik9bot, FrescoBot, Mcuzbek, JonathanBuck IEC, Hbmallin, Bobsutterfield, John of Reading, Love2scoot, JPnSD, Richardbdonnelly, Mrmacrae73, JamesCCamp, Kevinsmcintyre, Tholme, Gridbot, BG19bot, GSPII, MARKYORMARK, Asauers, Aisteco, BattyBot, Rushd37, Aremesz, Jcgam, Hmainsbot1, Guywhocares, Kachirulo, Blakness, Davisb21, Maguirecg, Bohnell, Monkbot and Anonymous: 83

8.2 Images

- **File:GSFRAvconConnected.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/4/44/GSFRAvconConnected.jpg *License:* CC SA 1.0 *Contributors:* Transferred from en.wikipedia to Commons. *Original artist:* The original uploader was Leonard G. at English Wikipedia *Geoff Shepherd released the image under the CC-SA license in personal correspondance to Leonard G.*
- **File:J1772_signaling_circuit.gif** *Source:* https://upload.wikimedia.org/wikipedia/commons/b/b6/J1772_signaling_circuit.gif *License:* CC BY-SA 3.0 *Contributors:* Using schematic capture software
Previously published: no *Original artist:* DavideAndrea

8.3 Content license