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1 Control Pilot

1.1 Purpose

The Control Pilot (former called Safety Pilot) is an additional means to increase safety and reliability of the charging process of an EV.

1.2 Functions

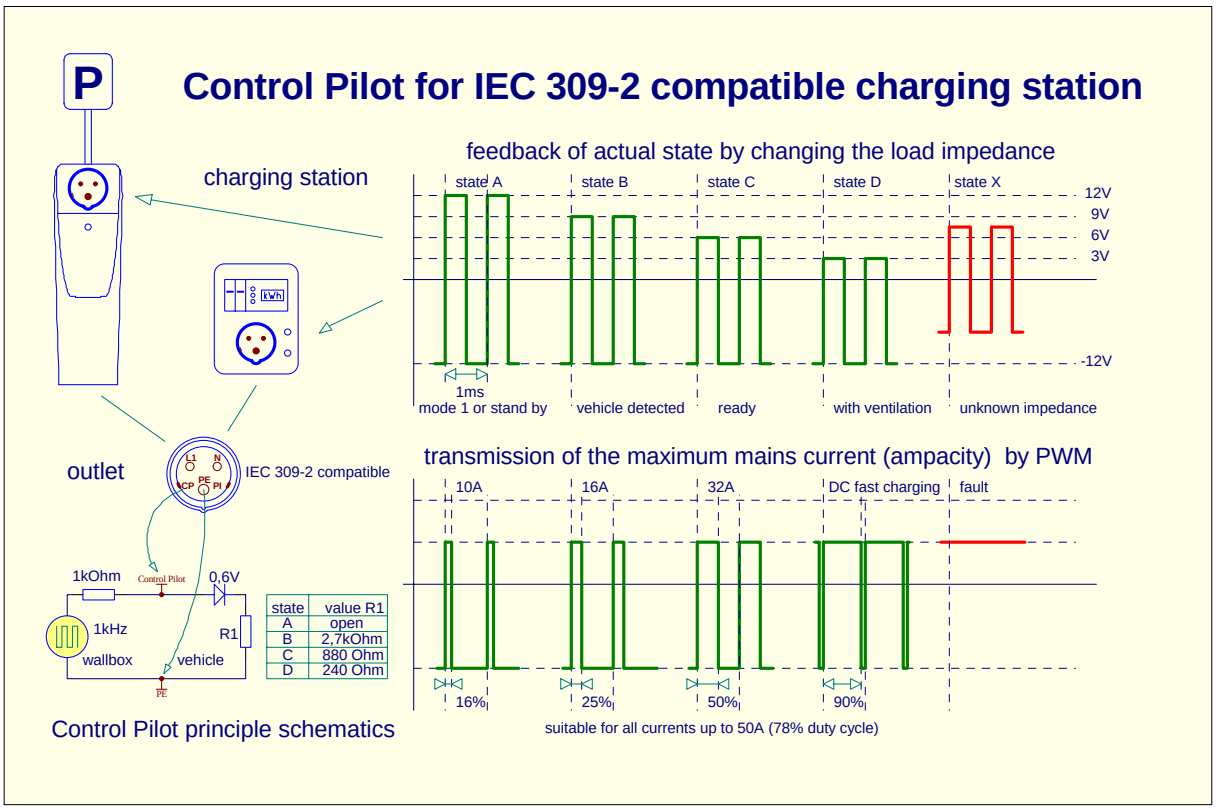
Mandatory funktions

- Verification that the vehicle is properly connected
- Continuous protective earth conductor integrity checking
- Energization of the system
- De-energization of the system

Optional Funktions

- Determination of ventilation requirements of the charging area
- Transmission of the current rating of EV supply equipment
- Start/Stop of charging
- Retaining / releasing of the coupling

1.3 Specifications of the Control Pilot circuitry (compatible to SAE 1772)



Vehicle detection

The load impedance on the vehicle side consists of a resistor, connected in series with a diode. The negative half wave of the control pilot signal remains unloaded. Therefore the wall box can distinguish between the presence of a vehicle and an unintended turn on request e.g. caused by a wet finger.

Information from the vehicle to the wallbox

Communication from the on board charger to the wallbox is provided by changing of the load impedance. Totally four operating states (A, B, C and D) one idle state (I) and one error state (X) are possible:

State definition by load impedance at the vehicle side (source resistance of the control pilot signal is constant at 1kOhm

state	load	condition	reaction of the charging station	control pilot signal
I	any load	An IEC 309-2 connector was plugged in; detection by a microswitch	No energization before pressing the start button	-12V static
A	open end	no Control Pilot communication.	Energization after pressing the start button. Line current limited to 16A. **Mode 1 charging**	1kHz, duty cycle depends on ampacity positive 12V, pulse
Once a control pilot communication was established, state A will deenergize the system and not allow mode 1 charging. The charging process could proceed at any time by reestablishing one of the active states (C or D) of the control pilot circuit.				
B	2,7kΩ +diode	A mode 3 compatible vehicle has been connected but is not ready for energy delivery.	The vehicle is detected and the charging station waits for transition to C.	1kHz, PWM, 1kΩ internal resistance positive 9V, pulse
C	880Ω +diode	A mode 3 compatible vehicle is connected and ready for energy delivery. The direct transition from A to C without the intermediate step B is also allowed.	Mains will be delivered to the socket outlet protected by a 32A line fuse The continous current is equal to the ratet value	1kHz, PWM, 1kΩ internal resistance positive 6V, pulse negative -12V, any state
D	240Ω +diode	Same as C with the requirement that ventilation of the charging place must be switched on.	Outdoor same as C. If no sufficient vent. could be guaranteed, no energy delivery is allowed.	1kHz, PWM, 1kΩ internal resistance positive 3V, pulse
Releasing the mechanical switch causes immediate deenergization and produces a master reset. A new start pulse is necessary to reestablish charge again. **Interruption of the control pilot circuit causes deenergitation without a master reset. (transition to state A with immediate deenergization)**				
X	R between 200Ω and 5kΩ	The load impedance is in the range of valid values but the diode is missing.	No energization. The error is indicated by an optical signal. From any other state: deenergization without reset.	negative less than -12V, pulse

Information from the wallbox to the vehicle

The maximum allowed mains current is indicated by the duty cycle of the control pilot signal.

In the US the duty cycle of the control pilot signal indicates the rated current of the actual connection including socket outlet (if any), cable and vehicle inlet. It prevents the on board charging system from recharging at an insufficient source.

For domestic charging at common outlets the control pilot generating unit is attached with the charging cable (mode 2).

For Europe it is intended to use a modified IEC connector at the wall side both for domestic and public charging stations capable of delivering 32A. This connector has the same mechanical dimensions as the already existing single phase 16A device (coloured blue) but one of its 7 additional contacts is dedicated for the control pilot.

Although the same signal forms are implemented to provide control pilot functionality, the information of the maximum current is used to adjust the on board charging system according to the given limit.

However, a decrease of the default value of 32A will be an exception:

- for a short period, to avoid undesired peak loads (the vehicle is used to balance mains load)
- programmed by the user to gain low tariff facilities
- permanently if the supply is rated for a lower than the default current e.g. domestic places

Both approaches are compatible to each other. The US 60Hz 240V/208V source is basically compatible to the European single phase 50Hz 230V source.

A car designed for the US market could be operated in Europe without any major changes of the on board charging system.

Coding of the standard current values (IEC 38)

current [A]	6	10	16	25	32
duty cycle	25/256	5/32	1/4	25/64	1/2

By trying to relate simple duty cycles (8-bit system) to the IEC standard values a slight deviation to the US table occours:

duty cycle	USA	Europe
0,9	DC-quick charge	DC-quick charge
0,8	48A	presently not used
0,6	36A	presently not used
0,5	30A	32A
0,4	24A	25,5A
0,3	18A	19A
0,25	15A	16A

A car with an SAE1772 compatible on board charger will find the following values in Europe

duty cycle	USA	Europa
0,5	30A	32A
0,39	23,4A	25A
0,31	18.8A	20A
0,25	15A	16A
0,16	9,4A	10A

2 Power Indicator

The Power Indicator is important where the use of unspecific infrastructure with no control pilot facilities is desired. It is provided by an additional contact at the vehicle inlet.

By putting a load impedance to ground on this contact, a lower input current value is required. (The default value where no control pilot communication takes place is 16A) The whole system works still under mode 1.

3 Requirements of an on board charging system to be operated at a IEC 309-2-compatible charging infrastructure

3.1 Vehicle inlet

Besides the power contacts the vehicle inlet must at least provide one contact for the control pilot and should have another to enable the implementation of the power indicator.

3.2 On board charger

The on board charger should be able of a continuous variation of the input current. This would be a requirement if the control pilot is intended to be used adaptive.

Further, it should provide an additional digital input for reducing the input power to a lower value

common on board chargers designed for the european market with 3,6kW

Only the power indicator would be necessary, because the default maximum current without control pilot communication is 16A

However, a Control Pilot does provide additional safety and some countries may require this in the future

On board chargers designed for the US market with input power greater than 3,6kW

USA

These chargers are equipped with the SAE 1772 Control Pilot. They are operated at the 240V supply system (two phases 120V with 180° phase displacement) or the 208V industrial supply system (two phases of a three phase 208V/120V). In both cases the potential of any life contact against ground will always be 120V AC.

Europe

Utilizing an european single phase supply, one of the life will become the neutral while the other one will carry the whole potential of 230V against ground. Overvoltage protection measurements should be examined because switching transients could reach then 700V easily.

Utilizing the SAE 1772 Control Pilot in Europe

If possible, the control pilot transmission of the ampacity should be used in an adaptive way in order not to interrupt the charging process, when lower power consumption is requested.

Power Indicator

It is assumed that existing systems will not provide an additional input. But these chargers operate only under mode 3 environment. Therefore, when operated at an unspecific outlet, they require always the generator in the cable which is called mode 2.

If the charger is adaptive to the maximum current, the cable indicates the outlet for which it is designed for.