

Annex A (normative)

Pilot function through a control pilot circuit using PWM modulation and a control pilot wire

A.1 General

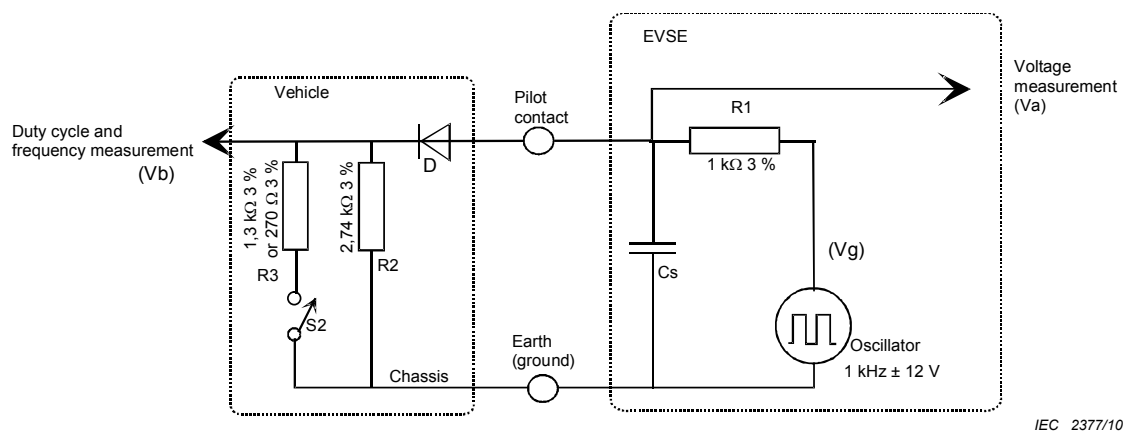
This annex concerns all charging systems that ensure the pilot function with a pilot wire circuit with PWM modulation in order to define the available current level for mode 2 and mode 3 charging. This annex describes the functions and sequencing of events for this circuit based on the recommended typical implementation circuit parameters. The parameters indicated in this annex have been chosen in order to ensure the interoperability of systems with those designed according to the standard SAE J1772.

NOTE This annex is not applicable to vehicles using pilot functions that are not based on a PWM signal and a pilot wire.

A.2 Control pilot circuit

Figure A.1 and A.2 show the basic principle of operation of the control pilot circuit.

Parameters of the circuits are defined in Table A.1, Table A.2, Table A.3, Table A.5, Table A.6, and Table A.7.



NOTE Stray capacities (Cv and Cc) between pilot and earth are not shown on figure (see Tables A.1 and A.2).

Figure A.1 – Typical control pilot circuit

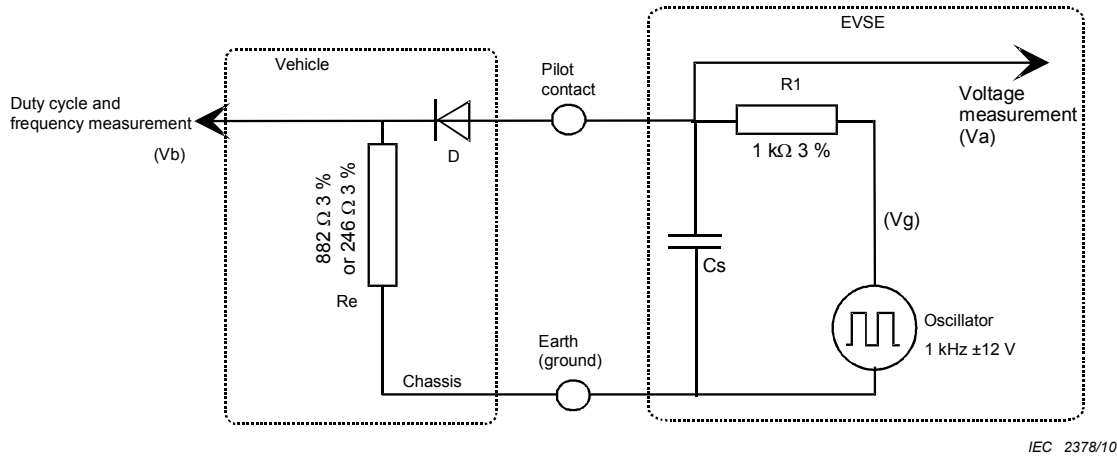


Figure A.2 – Simplified control pilot circuit

The simplified circuit shall not be used for vehicles drawing more than 16 A single phase. It shall not be used with 3-phase supply.

NOTE This circuit gives an equivalent result to the circuit shown in Figure A.1 when the switch S2 is closed. The simplified control pilot circuit cannot create vehicle states A and B as defined in Table A.3.

Table A.1 – EVSE control pilot circuit parameters (see Figures A.1 and A.2)

| Parameter ^a | Symbol | Value | Units |
|---|---------|-------------------------|-------|
| Generator open circuit positive voltage ^c | Voch | 12,00 (± 0,6) | V |
| Generator open circuit negative voltage ^c | Vocl | – 12,00 (± 0,6) | V |
| Frequency | Fo | 1 000 (± 0,5 %) | Hz |
| Pulse width ^{b, c} | Pwo | Per Table A.4 (± 25 µs) | µs |
| Maximum rise time (10 % to 90 %) ^c | Trg | 2 | µs |
| Maximum fall time (90 % to 10 %) ^c | Tfg | 2 | µs |
| Minimum settling time to 95 % steady state ^c | Tsg | 3 | µs |
| Equivalent source resistance ^c | R1 | 1 000 ± 3 % | Ω |
| Recommended EMI suppression | Cs | 300 | pF |
| Maximum total cable ^d capacity + Cs | Cs + Cc | 3 100 | pF |

^a Tolerances to be maintained over the full useful life and under environmental conditions as specified by the manufacturer.

^b Measured at 0 V crossing of the ± 12 V signal.

^c Measured at point Vg as indicated on Figure A.1.

^d Typical vehicle cord capacities (Cc) should be minimized and less than 2 000 pF.

Table A.2 – Vehicle control pilot circuit values and parameters (see Figures A.1, A.2)

| Parameter | Symbol | Value | Units |
|--|--------|----------------------|----------|
| Permanent resistor value | R2 | 2,74 k ($\pm 3\%$) | Ω |
| Switched resistor value for vehicles not requiring ventilation | R3 | 1,3 k ($\pm 3\%$) | Ω |
| Switched resistor value for vehicles requiring ventilation | R3 | 270 ($\pm 3\%$) | Ω |
| Equivalent total resistor value no ventilation (Figure A.2) | Re | 882 ($\pm 3\%$) | Ω |
| Equivalent total resistor ventilation required (Figure A.2) | Re | 246 ($\pm 3\%$) | Ω |
| Diode voltage drop (2,75 – 10 mA, -40 °C to + 85 °C) | Vd | 0,7 ($\pm 0,15$) | V |
| Maximum total equivalent input capacity | Cv | 2 400 | pF |

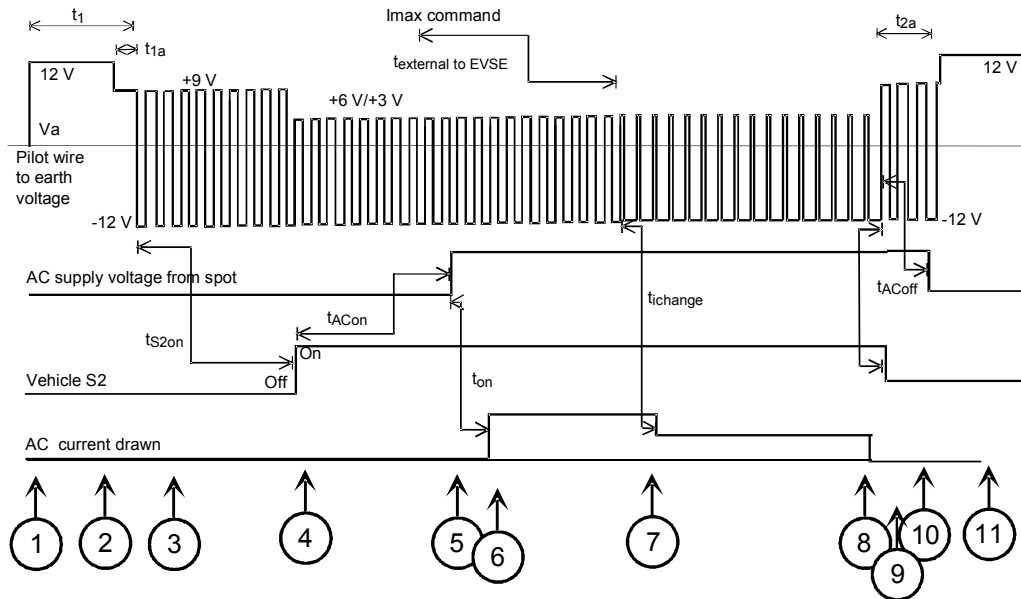
Tolerances are to be maintained over full useful life and under design environmental conditions.

Table A.3 – Pilot functions

| Vehicle state | | Vehicle connected | S2 | Charging possible | | Va ^a | |
|--|---|-------------------|--------|-------------------|---|-------------------|--|
| A | | no | open | no | | 12 V ^d | Vb = 0 V |
| B | | yes | open | no | | 9 V ^b | R2 detected |
| C | } | yes | closed | Vehicle ready | { | 6 V ^c | R3 = 1,3 k Ω $\pm 3\%$ Charging area ventilation not required |
| D | | | | | | 3 V ^c | R3 = 270 Ω $\pm 3\%$ Charging area ventilation required |
| E | | yes | open | no | | 0 V | Vb = 0: EVSE, utility problem or utility power not available, pilot short to earth ... |
| F | | yes | open | no | | -12 V | EVSE not available |
| ^a All voltages are measured after stabilization period, tolerance ± 1 V. ^b The EVSE generator may apply a steady state DC voltage or a ± 12 V square wave during this period. The duty cycle indicates the available current as in Table A.5. ^c The voltage measured is function of the value of R3 in Figure A.1 (indicated as Re in Figure A.2). ^d 12 V static voltage. | | | | | | | |

Typical start-up and shut-down sequence:

The Figure A.3 shows the sequence of a typical charging cycle under normal operating conditions. The sequences are detailed in Table A.4.



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Figure A.3 – Typical charging cycle under normal operating conditions

Table A.4 – description of connecting sequences as shown on Figure A.3

| | State | Conditions |
|---|---------|--|
| 1 | A | Vehicle unconnected – the full generator voltage is measured by the EVSE at Va (see Figure A.1). The generator signal Vg is a +12 V DC voltage |
| 2 | B | The cable assembly is connected to the vehicle and to the EVSE. This condition is detected by the 9 V signal measured at Va. The voltage from the signal generator (Vg) may be either a steady state +12 V DC or a ±12 V, 1 kHz signal in conformity with Table A.1 if the EVSE is immediately available for the supply of energy. |
| 3 | B | The EVSE is now able to supply energy and indicated the available current to the vehicle by the duty cycle in conformity with Table A.5. The presence of the diode D (see Figure A.1) is detected by the – 12 V and gives added guarantee that the 9 V signal is a reliable indication of a vehicle connected. |
| 4 | B → C,D | S2 is closed by vehicle as a function of requirements to indicate that the vehicle can receive energy. There are no timing requirements for the closing of On. |
| 5 | C,D | EVSE closes circuit. The timing of switch closure may be subject other requirements (payment, data exchange). If state D is detected, the switch will close only if ventilation requirements are met. |
| 6 | C,D | Current drawn from the vehicle. The timing and current profile are determined by the vehicle. Current may not exceed that indicated by the duty cycle (Table A.5). |
| 7 | C,D | External demand for power reduction. Such a demand may originate from the grid or by manual setting on EVSE. The Vehicle adjusts the current demand to that indicated by the duty cycle. |
| 8 | C,D | End of charge, decided by the vehicle. |
| 9 | C,D → B | Vehicle asks for disconnect. This may be the result of the proximity contact being opened. |
| 10 | B | EVSE detects state B (created by opening of S2 on vehicle) and opens the contactor. |
| 11 | A | Complete removal of cable assembly from vehicle or EVSE is detected by the 12V signal. |
| NOTE The EVSE should allow removal of the plug if the end of the charging session is ended by entering state A. | | |

Table A.5 – Pilot duty cycle provided by EVSE

| Available line current | Nominal duty cycle provided by EVSE (Tolerance ± 1 percentage point) |
|--|--|
| Digital communication will be used to control an off-board DC charger or communicate available line current for an on-board charger. | 5 % Duty Cycle |
| Current from 6 A to 51 A: | $(\% \text{ duty cycle}) = \text{current[A]} / 0,6$ $10 \% \leq \text{duty cycle} \leq 85 \%$ |
| Current from 51 A to 80 A: | $(\% \text{ duty cycle}) = (\text{current[A]} / 2,5) + 64$ $85 \% < \text{duty cycle} \leq 96 \%$ |

Table A.6 – Maximum current to be drawn by vehicle

| Nominal duty cycle interpretation by vehicle | Maximum current to be drawn by vehicle |
|--|---|
| Duty cycle $< 3 \%$ | Charging not allowed |
| $3 \% \leq \text{duty cycle} \leq 7 \%$ | Indicates that digital communication will be used to control an off-board DC charger or communicate available line current for an on-board charger. Digital communication may also be used with other duty cycles. Charging is not allowed without digital communication. 5 % duty cycle shall be used if the pilot function wire is used for digital communication |
| $7 \% < \text{duty cycle} < 8 \%$ | Charging not allowed |
| $8 \% \leq \text{duty cycle} < 10 \%$ | 6 A |
| $10 \% \leq \text{duty cycle} \leq 85 \%$ | Available current = $(\% \text{ duty cycle}) \times 0,6 \text{ A}$ |
| $85 \% < \text{duty cycle} \leq 96 \%$ | Available current = $(\% \text{ duty cycle} - 64) \times 2,5 \text{ A}$ |
| $96 \% < \text{duty cycle} \leq 97 \%$ | 80 A |
| Duty cycle $> 97 \%$ | charging not allowed |
| If the PWM signal is between 8 % and 97 %, the maximum current may not exceed the values indicated by the PWM even if the digital signal indicates a higher current. | |

Table A.7 – EVSE timing (see Figure A.3)

| | | | |
|--|----------------|--|---|
| t_1 and t_{1a} | No maximum | Turn on of 1 kHz oscillator | The frequency and voltage shall always conform to the values indicated in Table A.1 |
| t_{ACon} | 3 s | Beginning of supply of AC power after detection of state C or state D (vehicle request for energy) This time can be extended if there is digital communication established within this time | If conditions cannot be met EVSE should send one of following: steady state voltage 5 % PWM, state E or F |
| $t_{external}$ | 10 s | Modification of pulse-width in response to an external command to EVSE | The external command may be a manual setting or command from grid managements systems |
| t_{ACoff1} | 100 ms maximum | Delay until contactor opens and terminates AC energy transfer in response to S2 opened | S2 will cause pilot voltage change which, when detected by EVSE causes opening of contactors |
| T_{2a} | No maximum | The state B is be maintained while the vehicle is connected provided the EVSE is capable of supplying further energy | The duty cycle shall indicate the current available as in Table A.5 |
| $t_{ventilation}$ (not shown on Figure A.3) | 3 s maximum | Delay for ventilation command turn on after transition from state C (6 V) to state D (3 V) | |
| Other conditions for termination of energy supply | | | |
| | 3 s maximum | Delay for opening of contacts to terminate energy supply if abnormal conditions are encountered | This typically includes out of spec voltages of pilot, ventilation, non respect of current drawn (if measured by EVSE) |
| | 3 s maximum | Delay for turning off the square wave oscillator after transition from state B,C or D to state A | |
| | 100 ms maximum | Delay for opening contact if local proximity switch is opened | This applies to connectors using the proximity contact defined in B.4 |
| | 2 s maximum | Delay for applying a static 12 V signal after transition from state B, C or D, to state A. | |
| EV timing (see Figure A.3) | | | |
| T_{S2} | No maximum | S2 turn - request for AC supply | Determined by EV requirements |
| t_{on} | No maximum | Beginning of charging | The charging profile and timing are controlled by the vehicle. Ramp-up of current should only be possible when voltage is detected. |
| t_{ACoff2} | 3 s maximum | Stop charger current draw, set S2 open if Pilot signal out of tolerance, state E or state F detected | Only applies to systems using complete pilot circuit described in Figure A.1 |
| $t_{ichange}$ | 5 s maximum | Change of current following change in PWM duty cycle | |
| | 100 ms | Delay for stopping charging current drawn by vehicle if proximity contact opened | Not shown on diagram |