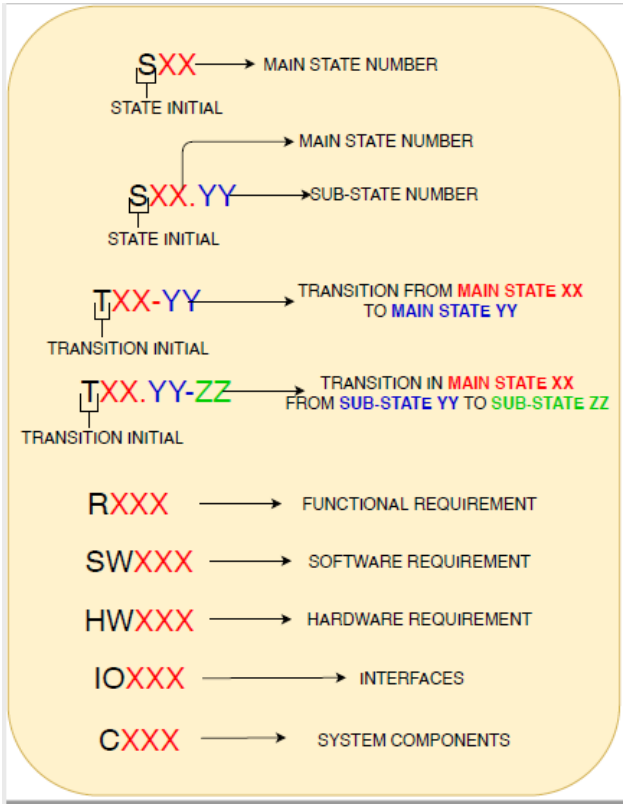
Politecnico di Torino

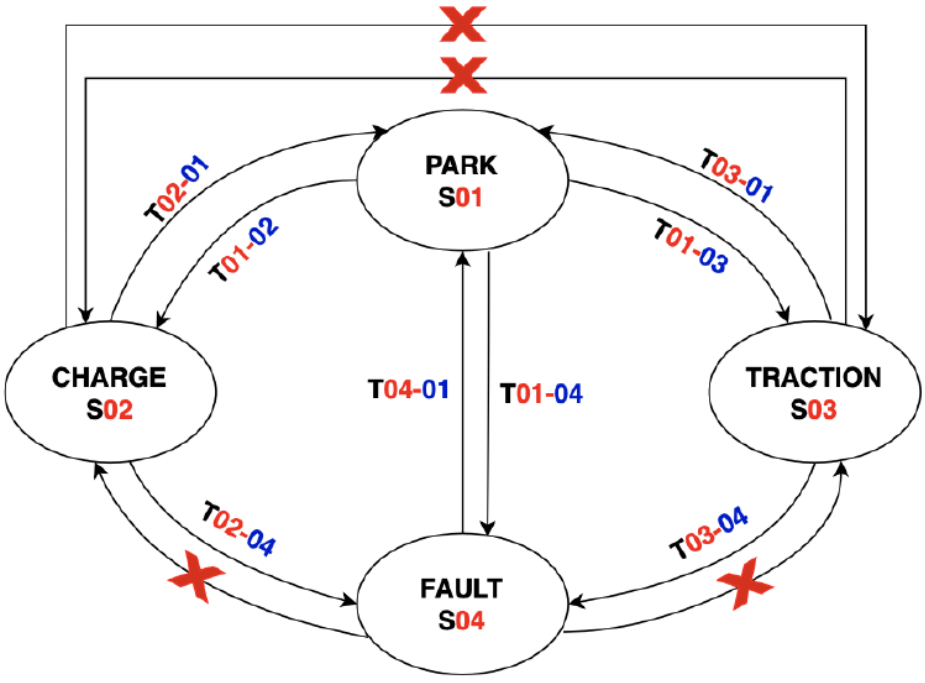
Technical Specifications

Version	Date	Author	Change Description
V2.1	18/05/2022	Sebastiano Ungolo	First release of the technical specifications

Legend



Main states and main transmissions diagram



Main state description table

ID State	Name	Definition
S01	**Park**	In park state the vehicle is still, if the key lock is rotated to the ON position the preliminary procedure to go in traction are executed.
S02	**Charge**	In charge state the vehicle is still and the battery is on charge
S03	**Traction**	In traction state the vehicle can move if a direction is correctly chosen.
S04	**Fault**	In fault state, the vehicle can be still or in movement. In any case, the HV devices are switched off.

Main transition description table

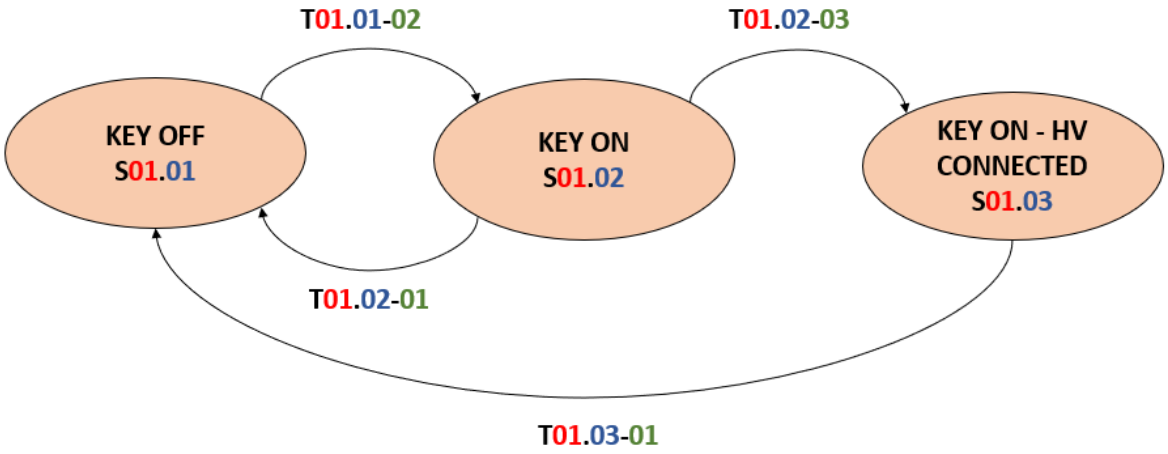
ID Tran. States	Name	Conditions	Hardware Requirements	Software Requirements
T01-03	**Park2Traction**	1. The pre-charge procedure is correctly completed. 2. The driver full presses the brake in order to toggle the both switches. 3. Key lock position: CRANK. - 1 and 2 can be reversed. In case the procedure is not respect, it needs to be restarted from KEY OFF	HW001: Key lock HW006: Brake switch HW008: HV Battery	SW001: Key signal acquisition SW002: Brake signal acquisition SW012: HV Battery status acquisition
T03-01	**Traction2Park**	Key lock turned to OFF position.	HW001: Key lock	SW001: Key signal acquisition
T01-02	**Park2Charge**	- Pull up the handbrake. - the plug is inserted	HW013: Plug HW016: AC charger HW020: Handbrake	SW007:Charger status acquisition SW003: Handbrake signal acquisition
T02-01	**Charge2Park**	The plug is disconnected.	HW013: Plug HW016: AC charger	SW007:Charger status acquisition

T03-04	**Traction2Fault**	A major traction fault is detected and the system moves into the fault state: - When the plug is inserted - When Emergency is pressed - When a fault is detected on the battery - When a fault is detected on the inverter - When a fault is detected on the Accelerator pedal	HW016: AC charger HW008: HV Battery HW005: Accelerator pedal HW010: Inverter HW024: Emergency button	SW007: Charger status acquistion SW012: HV Battery status acquistion SW014: Inverter status acquisition SW004: Accelerator pedal acquisition SW017: Emergency signal acquisition
T02-04	**Charge2Fault**	A major traction fault is detected and the system moves into the fault state: - When a fault is detected on the AC charger - When Emergency is pressed - When a fault is detected on the battery - When a fault is detected on the inverter	HW016: AC charger HW008: HV Battery HW010: Inverter HW024: Emergency button	SW007: Charger status acquistion SW012: HV Battery status acquistion SW014: Inverter status acquisition SW017: Emergency signal acquisition
T01-04	**Park2Fault**	A major traction fault is detected and the system moves into the fault state: - When Emergency is pressed - When a fault is detected on the battery - When a fault is detected on the inverter - When a fault is detected on the Accelerator pedal - When the VMU sense a voltage level lower than a threshold	HW016: AC charger HW008: HV Battery HW005: Accelerator pedal HW010: Inverter HW024: Emergency button HW002: VMU	SW012: HV Battery status acquistion SW014: Inverter status acquisition SW004: Accelerator pedal acquisition SW017: Emergency signal acquisition SW021: 12V battery voltage check

T04-01	**Fault2Park**	The key lock is in OFF position	HW001: Key lock	SW001: Key signal acquisition
T04-03	**Fault2Traction**	This transition is not possible.	/	/
T04-02	**Fault2Charge**	This transition is not possible.	/	/
T02-03	**Charge2Traction**	This transition is not possible. The interlock is activated to disable traction state.	HW015: Interlock	/
T03-02	**Traction2Charge**	This transition is not possible.	/	/

Park state

Park sub-states diagram



Park sub-states description table

ID Substate	Name	Functional Requirements	Hardware Requirements	Software Requirements
		S01.R001 - Any direction selection is ignored in this state.	HW007: Directional selector	/
S01.01	KEY OFF	**S01.01.R001:** - VMU is always supplied by 12V battery. - No other electric devices has to be supplied by 12V battery.	HW002: VMU	/
		S01.01.R002: When this state is reached: - VMU remains active for a defined time and then enter in the Sleep Mode.	HW002: VMU	SW010: VMU status management
S01.02	KEYON	**S01.02.R001:** - VMU exits from the Sleep Mode	HW002: VMU	SW010: VMU status management
		S01.02.R002: - VMU turns on the HV battery and triggers the pre-charge procedure	HW008: HV battery HW002: VMU	SW013: HV Battery status management
		S01.02.R003: - The display lights up. All leds lights up.	HW004: display HW021: Led BWD HW022: Led FWD HW023: Led fault HW029: Led InTraction HW009: Led HV bus HW008: HV battery	SW012: HV Battery status acquisition
		S01.02.R004: - VMU receives messages from the body computer. - VMU sends messages to the body computer to accomplish the diagnostic phase.	HW002: VMU HW005: Body Computer	SW006: Body Computer management
		S01.02.R005: - The original components and the retrofit one are powered up adapting to the original routine.	HW005: Accelerator pedal HW006: Brake switch HW007: Directional selector HW020: Handbrake	/
		S01.02.R006: - The Vacum pump is activated by VMU	HW002: VMU HW011: Vacum pump	SW009:Vacum pump status management
		S01.02.R007: - VMU senses if the 12V battery voltage is above a minimun level.	HW002: VMU	SW021: 12V battery voltage check

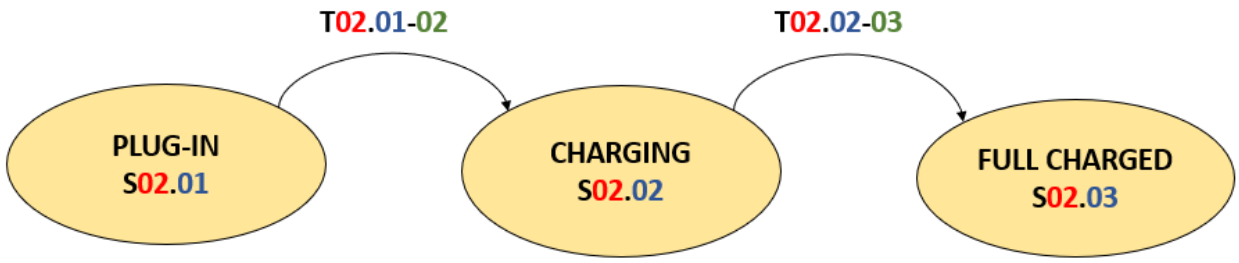
S01.03	**KEYON - HV CONNECTED**	**S01.03.R001** - When the battery is connected on the HV bus all leds turn off except for the led battery status.	HW021: Led BWD HW022: Led FWD HW023: Led fault HW029: Led InTraction HW009: Led HV bus HW008: HV battery	/
		S01.03.R002: - The VMU turns on the inverter.	HW002: VMU HW010: Inverter	SW008: Inverter status management
		S01.03.R003: - The DC/DC converter is enabled	HW012: DC/DC converter	SW019: DC/DC converter status management
		S01.03.R004: - if the heater selector is pressed, the heater system is powered on and the led behind the selector lights up	HW031: Led heater HW034: heater selector HW029: heater	SW020: heater selector acquisition

Park internal transition description table

ID Tran. Park	Name	Conditions	Hardware requirements	Software requirements
T01.01-02	**KEY OFF --> KEY ON**	The key is turned ON.	HW001: Key lock	SW001: Key signal acquisition
T01.02-01	**KEY ON --> KEY OFF**	The key is turned OFF.	HW001: Key lock	SW001: Key signal acquisition
T01.02-03	**KEYON --> KEYON - HV CONNECTED**	The procedure concerning the connection of the HV battery the HV bus is completed	HW008: HV battery	SW012: HV Battery status acquistion
T01.03-01	**KEYON - HV CONNECTED --> KEYOFF**	The key is turned OFF.	HW001: Key lock	SW001: Key signal acquisition

Charge state

Charge sub-states diagram



Charge sub-states description table

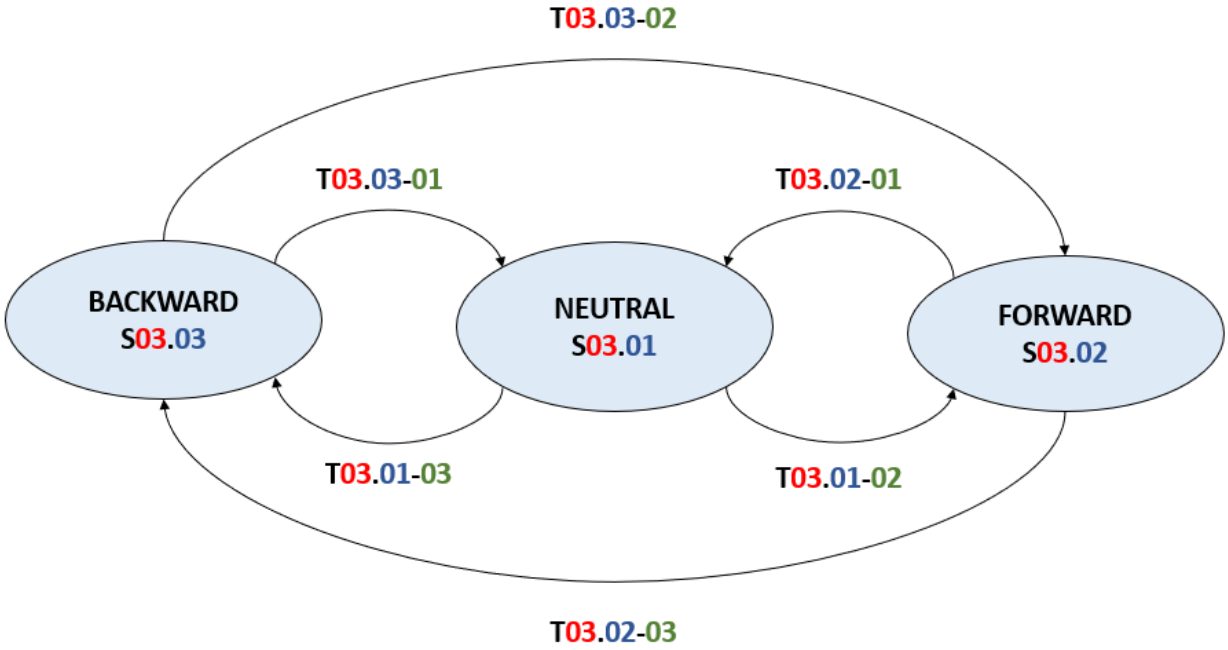
S02.01	**PLUG-IN**	**S02.01.R001:** - The VMU wakes up. - A led notifies that the plug is inserted. - The display lightes up.	HW013: Plug HW014: Led plug connected HW004: Display	SW007:Charger status acquisition
		S02.01.R002: - The VMU wakes up as soon as the plug is connected.	HW002: VMU	SW010: VMU status management
		S02.01.R003: - The plug triggers the interlock mechanism to disable the power on of the inverter (HW).	HW015: Interlock	/
		S02.01.R004: - The VMU triggers the HV battery charging procedure	HW008: HV battery	SW013: HV Battery status management
		S02.01.R005: - If the temperature is too low for charging, wait untill the battery heat up enough.	HW008: HV battery	SW013: HV Battery status management
S02.02	**CHARGING**	**S02.02.R001:** - The VMU enables the AC charger output	HW016: AC charger HW002: VMU	SW013: Charger status management
		S02.02.R002: - The VMU enables the DC/DC converter	HW012: DC/DC converter HW002: VMU	SW019: DC/DC converter status management
		S02.02.R003: - Blink of a led [period=500 ms] to indicate that the charge process is going on	HW017: Led charge status HW002: VMU	SW007: Charger status acquisition
		S02.02.R004: - Display the state of charge of the HV battery.	HW004: display	SW007: Charger status acquisition
S02.03	**FULL CHARGED**	**S02.03.R001:** - A led is turned on always to notify the end of the charge. - The VMU disable HV battery, DC/DC converter and AC charger output	HW004: display HW017: Led on charge/full charged HW002: VMU	SW012: HV Battery status acquisition SW013: Charger status management SW019: DC/DC converter status management SW013: HV Battery status management

Charge internal transition description table

ID Tran. Charge	Name	Conditions	Hardware requirements	Software requirements
T02.01-02	**PLUG-IN --> CHARGING**	HV battery is ready to charge	HW008: HV battery	SW012: HV Battery status acquistion
T02.02-03	**CHARGING --> FULL CHARGED**	HV battery is full charged	HW008: HV battery	SW012: HV Battery status acquisition

Traction state

Traction sub-states diagram



Traction sub-states description table

		S03.R001: - The VMU sends the signal/message to close the main contact from the inverter to the HV battery. - The traction state enter is communicated to to the user by a dedicated led	HW010: Inverter HW002: VMU HW019: Relè Inverter HW029: Led InTraction	SW015: Inverter status management
		S03.R002: The regenerative brake procedure has 2 level of action: - when the accelerator pedal is released - when the brake pedal is pressed In both cases the original brake lights have to light up	HW006: Brake switch HW0ac: Original brake lights HW00d: Accelerator pedal acquisition	SW016: Torque resquest
		S03.R003: - If the boost mode is selected, the strategy to control to control the inverter and/ or provide the torque change	HW010: Inverter HW025: Driving profile selector	SW015: Inverter status management SW016: Torque resquest SW018: Driving profile acquisition
		S03.R004: - When the brake is pressed, the torque request is set to 0	HW006: Brake switch	SW016: Torque resquest
		S03.R005: - if the heater selector is pressed, the heater system is powered on and the led behind the selector lights up	HW031: Led heater HW034: heater selector HW030: heater	SW020: heater selector acquisition
S03.01	**NEUTRAL**	**S03.01.R001:** - The vehicle could move if the handbrake is not pulled. Neither forward or reverese direction are selected. - The torque request is set to zero	/	SW011: Direction status management SW016: Torque resquest
S03.03	**BACKWARD**	**S03.02.R001:** - The BWD selection is showen to the user using both a led and the display. - When the accelerator pedal is pressed the vehicle moves in back direction.	HW021: Led BWD HW005: Accelerator pedal HW010: Inverter	SW011: Direction status management SW016: Torque request SW004: Accelerator pedal acquisition
S03.02	**FORWARD**	**S03.02.R001:** - The FWD selection is showen to the user using both a led and the display. - When the accelerator pedal is pressed the vehicle moves in forward direction.	HW022: Led FWD HW005: Accelerator pedal HW010: Inverter	SW011: Direction status management SW016 Torque request SW004: Accelerator pedal acquisition

Traction internal transition description table

ID Tran. Traction	Name	Conditions	Hardware requirements	Software requirements
T03.01-02	**Neutral --> Fwd selection**	- The brake pedal is pressed - The handbrake is released - Speed lower than a threshold - FWD is selected on the direction selector for more than 500 ms	HW007: Directional selector HW006: Brake switch HW020: Handbrake	SW005: Direction selector acquisition. SW002: Brake signal acquisition SW003: Handbrake signal acquisition SW014: Inverter status acquisition
T03.01-03	**Neutral --> Bwd selection**	- The brake pedal is pressed - The handbrake is released - Speed lower than a threshold - BWD is selected on the direction selector for more than 500 ms	HW007: Directional selector HW006: Brake switch HW020: Handbrake	SW005: Direction selector acquisition. SW002: Brake signal acquisition SW003: Handbrake signal acquisition SW014: Inverter status acquisition
T03.02-03	**Fwd --> Bwd**	- The brake pedal is pressed - The handbrake is released - Speed lower than a threshold - BWD is selected on the direction selector for more than 500 ms	HW007: Directional selector HW006: Brake switch HW020: Handbrake	SW005: Direction selector acquisition. SW002: Brake signal acquisition SW003: Handbrake signal acquisition SW014: Inverter status acquisition
T03.03-02	**Bwd --> Fwd**	- The brake pedal is pressed - The handbrake is released - Speed lower than a threshold - FWD is selected on the direction selector for more than 500 ms	HW007: Directional selector HW006: Brake switch HW020: Handbrake	SW005: Direction selector acquisition. SW002: Brake signal acquisition SW003: Handbrake signal acquisition SW014: Inverter status acquisition
T03.03-01	**Bwd --> Neutral**	The handbrake is pulled	HW020: Handbrake	SW003: Handbrake acqusition
T03.02-01	**Fwd --> Neutral**	The handbrake is pulled	HW020: Handbrake	SW003: Handbrake acqusition

Fault

Fault sub-states description table

	S04.R001: - Disconnect the HV battery and Inverter - Turn on the fault led - Display the fault message - The torque resquest is set to zero	HW010: Inverter HW008: HV battery HW012: DC/DC Converter HW016: AC charger HW023: Led Fault	SW022: Fault management

Warning

State	Description	Hardware Requirements	Software Requirements	Warning code	Message
Park	The plug is inserted but the handbrake is not pulled	HW020: Handbrake HW013: Plug HW016: AC charger HW027: Led warning HW026: Buzzer	SW007: Charger status acquisiton SW003: Handbrake signal acquistion SW00A: Warning	W01	"Pull up the handbrake to start to charge"
	The key is in crank while the pre-charge procedure is not ended	HW026: Buzzer HW027: Led warning HW001: Key lock HW008: HV battery	SW012: HV Battery status acquisition SW001: Key signal acquisition SW00A: Warning	W02	"Start procedure not correct: wait the connection of the HV battery before to go in crank. Move to key off and restart the procedure"
	The key is in crank while the brake is not pressed	HW026: Buzzer HW027: Led warning HW001: Key lock HW006: Brake switch	SW012: HV Battery status acquisition SW001: Key signal acquisition SW00A: Warning SW002: Brake signal acquisition	W03	"Start procedure not correct: full press the brake before to go in crank. Move to key off and restart the procedure"

Charge	The velocity of the vehicle is upper than a threshold	HW013: Plug HW016: AC charger HW026: Buzzer HW027: Led warning HW010: Inverter	SW014: Inverter status acquisition SW007: Charger status acquisiton SW00A: Warning	W04	"Vehicle is moving! Stop the vehicle for continuing to charge"
	The key is moved from the OFF position	HW013: Plug HW016: AC charger HW026: Buzzer HW027: Led warning HW001: Key lock	SW007: Charger status acquisiton SW001: Key signal acquisition SW00A: Warning	W05	"The vehicle is in charge. Disconnect the plug if want to drive"

Traction	The brake switch is broken	HW026: Buzzer HW027: Led warning HW006: Brake switch	SW014: Inverer status acquisition SW00A: Warning	W06	"The regenerative brake is not more working"
	the direction selector is moved but: - the brake is not pressed	HW026: Buzzer HW027: Led warning HW006: Brake switch	SW002: Brake signal acquisition SW00A: Warning	W07	"Press the brake to select the direction"
	the direction selector is moved but: - the handbrake is pulled	HW026: Buzzer HW027: Led warning HW020: Handbrake	SW003: Handbrake signal acquistion SW00A: Warning	W08	"Release the handbrake to select the direction"
	the direction selector is moved but: - the speed is above a given threshold	HW026: Buzzer HW027: Led warning HW010: Inverter	SW014: Inverter status acquisition SW00A: Warning	W09	"The direction cannot be selected if you are moving"

Hardware requirements

Legend
Indicators
Original HMI components
Retrofit HMI components
Retrofit plant components

Specification	Title	Comments
HW004	Display	Location: dashboard
HW021	Led BWD	2 pins: 1 GND, 1 signal 12V Location: dashboard
HW022	Led FWD	2 pins: 1 GND, 1 signal 12V Location: dashboard
HW009	Led HV bus	2 pin: 1 GND, 1 signal 12V Location: dashboard
HW014	Led plug connected	2 pins: 1 GND, 1 signal 12V Location: near the socket of the AC charger
HW017	Led charge status	2 pins: 1 GND, 1 signal 12V Location: near the socket of the AC charger
HW023	Led Fault	2 pin: 1 GND, 1 signal 12V Location: dashboard
HW029	Led InTraction	2 pins: 1 GND, 1 signal 12V Location: dashboard
HW026	Buzzer	Location: dashboard
HW031	led heater	2 pins: 1 GND, 1 signal 12V Location: dashboard Correlation with HW034: heater selector
HW032	Led driving profile	2 pins: 1 GND, 1 signal: 12V Location: dashboard Correlation with HW025: driving profile selector

HW001	Key lock	5 pins: 1 source 12V, 4 signals 12 V Signals: - INT - INT/A - 50 - 15/54 Available signals in the engine hood that are going to be used: - INT - 50 (https://www.dropbox.com/home/Attivit%C3%A0/Vehicles/Panda%20169/Impianto_elettrico/Analisi%20impianto%20elettrico%20nativo?preview=20210927+EVERGRIN+-+Vehicle+-+Impianto+Elettrico+-+Tabelle+segnali+V2.pdf)
HW005	Accelerator pedal	6 pins: 2 sources 12V, 2 GND, 2 signals 12V
HW006	Brake switch	4 pins: 2 NC contact, 2 NO contact
HW020	Handbrake	2 pins: NC contact
HW033	Original brake lights	They are connected to the body computer. They must light up (by the body computer) when the brake switch is pressed. They must light uo (by the VMU) when the accelerator pedal is released.
HW007	Direction selector	4 pins: 2 GND, 2 signals 12V Location: ?
HW024	Emergency button	2 pins: 1 GND, 1 signal 12V Location: dashboard
HW025	Driving profile selector	2 pins: 1 GND, 1 signal 12V Location: dashboard Correlation with HW032
HW013	Plug	External component
HW034	heater selector	2 pins: 1 GND, 1 signal 12V Location: dashboard Correlation with HW031

HW002	Vehicle management unit	https://www.dropbox.com/home/Attivit%C3%A0/Retrofit%20Kit/Subsystems/VMU%20-%20Vehicle%20Management%20Unit
HW008	HV Battery	https://www.dropbox.com/home/Attivit%C3%A0/Retrofit%20Kit/Suppliers/SHENZHEN%20AUG%20ENERGY%20-%20Battery%20Pack
HW010	Inverter	/
HW011	Vacum pump	/
HW012	DC/DC converter	/
HW015	Interlock	It's a mechanism made by a relè: when the plug is inserted, the AC charger pilot the relè disconnect the inveter from the 12V source
HW016	AC charger	https://www.dropbox.com/home/Attivit%C3%A0/Retrofit%20Kit/Suppliers/TC%20Charger%20-%20AC-DC%20charger
HW019	Relè Inverter	2 pins: 1 source 12V from AC charger, 1 GND, 2 inputs HV, 2 outputs 12V
HW030	heater	https://www.dropbox.com/home/Attivit%C3%A0/Retrofit%20Kit/Suppliers/VVKB%20-%20Liquid%20heater

Software requirements

Specifications	Title	Description
SW001	Key signal acquisition	The key has 4 digital output signals, only 2 pins (INT and 50) are used to get the key position: - For each signal, after 3 consecutive samples at the same logic level the information is acquired. - 2 signals are combined to get the key position information
SW002	Brake signal acquisition	The brake has 2 digital output signals: - For each signal, after 3 consecutive samples at the same logic level, the information "brake pressed / brake released" is acquired correctly - When the slowest signal toggles, a check is performed with respect to the fastest one
SW003	Handbrake signal acquistion	The handbrake information is considered acquired if consecutive samples are at the same logic level for 500 ms
SW004	Accelerator pedal acquisition	The accelerator pedal has 2 analog output signals, one is the double of the other. One is used to determine the torque request, the other one is used for error detection. The relative error percentage must be lower than 3% for 500 ms
SW005	Direction selector acquisition	The direction selector has 2 digital output signals, FWD and BWD. The direction information is considered acquired if consecutive samples are at the same logic level for 500 ms
SW006	Body computer management	The VMU manages the body computer: - Receive/Send the messages that the body computer needs to complete the original start up procedure. - Receive tha status of the car through the CAN network.
SW007	Charger status acquisiton	VMU gets the status of the AC-Charger: - The charger is plugged in/unplugged - Monitor charge status - Errors
SW008	Charger status management	VMU manages the status of the AC-Charger - On/Off procedure
SW009	Vacum pump status management	VMU manages the on/off of the vacuum pump

SW010	VMU status management	Baseline software lets the VMU to: - enter into the Sleep mode after a given time when the key is moved to the OFF position. - Wake up when the key is in ON position. - Wake up when the plug is inserted.
SW011:	Direction status management	Manage the Forward, backwards and neutral state of the vehicle. Display the information throught 2 indicators (Led FWD and led BWD) and the display.
SW012	HV Battery status acquisition	The VMU gets the status of the battery: - SOC - Temperature - Status (off, ready, charging, error) - Voltage - Current
SW013	HV Battery status management	The VMU manages the status of the battery: - Send commands to manage the status (charge, discharge, on, off, fault, etc)
SW014	Inverter status acquisition	The VMU gets the status of the inverter: - Voltage - Current - Status (on, off, error) - Motor speed
SW015	Inverter status management	The VMU manage the status of the inverter: - status (on, off, power ready, stand by, error) - main contact
SW016	Torque request	Computes the commands given by the user and the status of the devices (state of charge, temperature, profile, speed, etc...) and according to the a set of parameters, generates a signed torque request The torque request according to the accelerator pedal must be tunable. The torque is set to zero if the brake pedal is pressed.
SW017	Emergency signal acquisition	The emergency has 1 digital output signal: after 3 consecutive samples at the same logic level the information "emergency pressed / emergency released" is acquired correctly
SW018	Driving profile acquisition	The driving profile selector has 1 digital output signal: after 3 consecutive samples at the same logic level the information "boost seleced / boost not selected" is acquired correctly
SW019	DC/DC converter status management	VMU manages the on/off of the DC/DC converter
SW020	Heater selector acquisition	The heater selector has 1 digital output signal: after 3 consecutive samples at the same logic level the information "heater seleced / heater not selected" is acquired correctly
SW021	12V battery voltage check	The VMU sense if the voltage level of the 12V battery is over a threshold
SW022	Fault management	Switch off the HV devices and set the torque request to zero when a fault is detected or the user press the emergency button
SW00A	Warning	the VMU inform the driver that using: - a buzzer - a message for details on the warning