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# Instead of Plugging in for V2G

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## Abstract

A safe, vandal-proof, inexpensive, inconspicuous, user-friendly, low-maintenance system requiring no effort by the driver, beyond that of parking his vehicle, consists of a concrete curb with embedded metal contacts to engage with corresponding contacts underneath the front end of a car driven against it. There are no cables or connectors, only *contacts* that, unlike those within a connector, need no protective covering to make them safe. The curb contacts become hot only after a series of checks, made by the interaction of small computer-logic systems in the curb and the car, ensure it *is completely safe to energize them*. The system is optimal for diagonal parking against a saw-tooth curb but perpendicular or parallel parking will work, too. Metering within the vehicle can keep account of electricity bought from or sold to the grid at any parking bay suitably equipped. Thus a large population of electric vehicles can be grid-connected whenever parked and their batteries provide the grid with its sorely needed capacity to store electricity. Wider use of wind and tidal power, which, unlike a generator cannot be turned on when needed, makes energy storage even more important. Vehicles that lack a home garage or carport can recharge wherever they find a parking space, without the need to use dedicated parking.

*Keywords: conductive charger, infrastructure, energy storage, standardization, V2G (vehicle to grid).*

## 1 Introduction

President Obama, in his first address to the full US Congress, listed first on his agenda of four topics reduction of the need to import oil. The easiest way to do this is to convert to electricity as a source of energy for automobiles and put batteries in them large enough to contain it. This massive collective storage capacity can become one huge battery for the electricity grid if the electric cars are connected to it when they are parked. Proponents of this "V2G" system point out that the average car is parked 95 percent of the time—plenty of time for it to serve as a useful storage unit. This idea has a weak point if it has to rely on the driver, especially if he or she has to cope with a heavy cable and connector, perhaps in the rain, whenever parking or driving away. Inescapably, the connection must be automatic. Because connections are usually made with connectors, it seems obvious that connectors must be used, or "plugged in." A connector consists of contacts surrounded by a protective shell that is not be needed if exposed contacts are never hot. This is easy to arrange, to any desired degree of reliability, using inexpensive logic elements. Instead of plugging a connector into a receptacle, connecting an electric vehicle to the grid reduces to bringing conducting surfaces into contact—a less exacting task. The charging station reduces to a *docking bay* (Fig.1) consisting simply of a concrete curb with embedded metal contacts. These engage with corresponding contacts underneath the front end of the car when it is driven against it. There are no connectors, only *contacts* that, unlike those within a connector, need no protective covering to make them safe. They

become hot only after a series of checks ensure it is completely safe to energize them. These checks are made by the interaction of small computer-logic systems in the curb and the car.

## 2 Details of implementation

The vehicle and docking bay exchange radio-frequency (R/F) signals to establish the vehicle's authenticity and that various safety conditions are met. In the vehicle, a shunt temporarily joins the contacts together for an important safety check *before transfer of electrical energy takes place*. Computer logic within the docking bay then confirms that the resistance between its hot contact and ground is low. Having thus satisfied that the contacts are well made and that the neutral contact is at ground potential, it instructs the vehicle to open the shunt. Computer logic within the vehicle confirms that the shunt is open and the docking bay then confirms that the resistance is now high and, therefore, that any leakage currents will be low. It is now safe for the "hot" contact to be energized. Flow charts appended to this paper describe the above logic in more detail.

A conventional domestic three-pin connector provides a pathway to ground that is separate from the neutral return path so that any exposed conducting surfaces will not pose a hazard even if the hot and neutral connections are miss-wired or faulty, or if a long extension cord is used. Although there could be a similar redundant grounding pathway between the docking bay and the vehicle via a third set of contacts, the testing carried out before the power is turned on makes this unnecessary in a system intended for energy transfer rates comparable to those of present-day plug-in systems (5-10 kW). It is safer than any in which such pre-testing is not carried out and power is left on all the time and contacts are hot even when not in use. Facing the car's front wheels, the curb would be raised into the low wall of a docking bay. This is a few inches high and substantial enough not to be damaged by the wheels coming to rest against it. Sealed flush into the top of the wall, instead of a connector, there would be two metal charging contacts facing obliquely upward (Fig. 1).

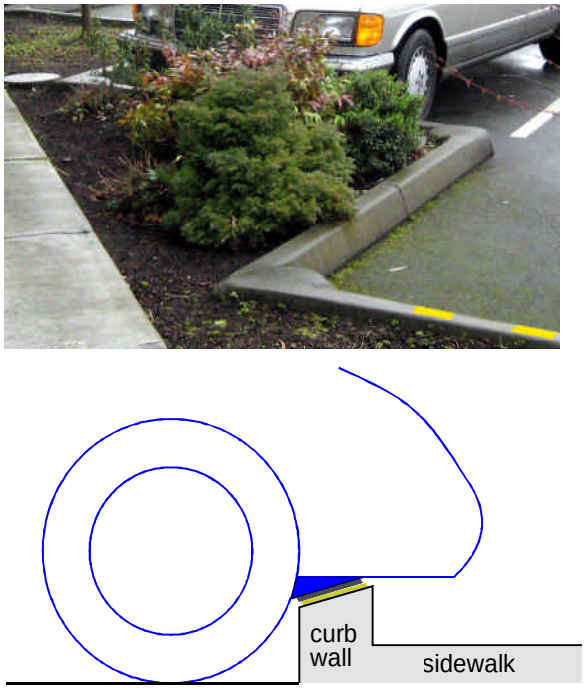


Fig. 1. A typical docking bay with low walls or curbs against which a car's front wheels would rest, arranged for angled parking. Note that the metal contacts embedded in the curb (right foreground) are unobtrusive and minimize cost, maintenance, and vandalism. There are no special needs for the elderly or disabled. There is no heavy (and possibly wet) cable to plug in, and no perceived, or actual, danger of electric shock.

Positioning the vehicle relative to the curb contacts is much less critical than opposing the two halves of a connector because the nature of the contacts allows considerable displacement, especially laterally. The vehicle's front wheels touching the curb fix its axial or longitudinal position while the driver determines its lateral position. This is easy and accurate if lateral alignment of the vehicle contacts is made relative to the driver rather than the vehicle: a line painted or taped on the hood aligned with the driver (assumed to be sitting in the left seat) extends forward and points directly to a vertical stick (or antenna) at the docking bay. It is a simple matter for the driver to bring his vehicle into position using this reference.[•] The antenna indicates that a parking slot allows connection to the grid and the stripe on the vehicle indicates that it is electric and rigged for curb contact.

[•] A similar system is used for aligning the trailer hitch ball at the rear of a vehicle with the receiving hitch at the front of trailer. In this case, as the driver backs up, he brings vertical antennae over the hitches on the vehicle and the trailer into alignment using the rear view mirror above the center of the windshield.

Figure 2 shows a variety of means for applying the vehicle contacts to those on the docking bay curb: a swinging arm, scissors, and a flexible mat. The flexible mat is the simplest and probably the best. Of thick rubber, hinged at its forward end so that it can flap down and bring mating contacts, set into its undersurface, onto the docking bay contacts. With the curb contacts completely covered by the mat beneath the vehicle and safety checks made, the docking bay turns on the power. Before leaving the docking bay, the mat's trailing edge retracts to a horizontal position. Figure 3 gives more detail.

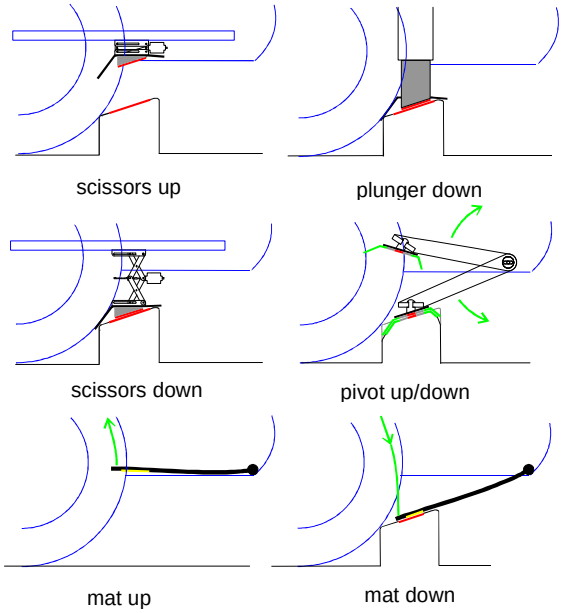


Fig.2. Various means for making contact with the docking bay. The mat system is shown in more detail in Fig. 3.

In cities having much winter snow, the docking bays could be under cover or an arrangement such as that illustrated in Figure 4 could be used, following the same safety precautions. This also shows a forward-sloping windshield to increase roof area for solar panels sufficient to power an air conditioner.

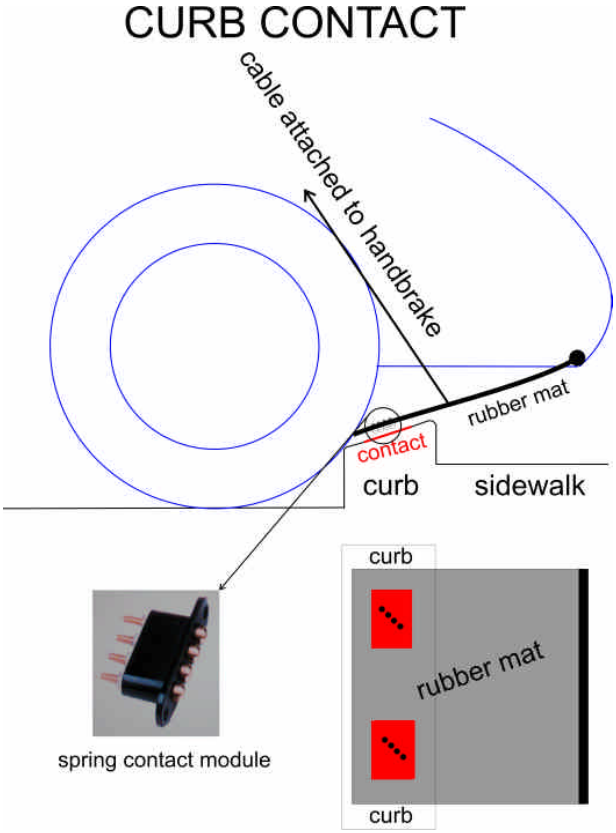


Fig.3 Preferred Curb Contact system. When the car comes to rest against the curb, the handbrake is applied. This lowers the mat so that its contacts touch the brass plates set into the curb.

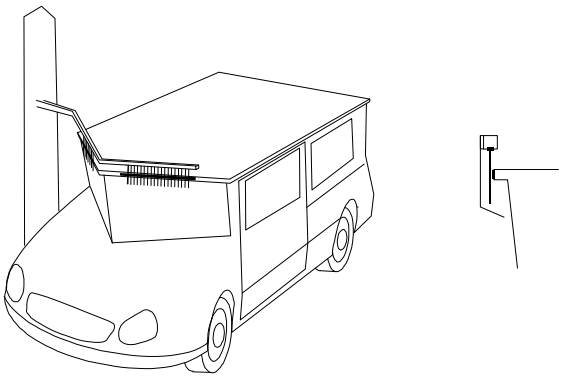

Fig.4 Preferred Charging gantry. The leading edges of the V front of the roof are carbon contacts. Descending from the gantry arm are metal rods which form the charging contacts. These are fairly stiff. They are firmly set into the underside of the arm. The arm is made of non-conducting material. Wires inside pass through the gantry to receive energy from cables beneath the ground. Because the gantry rods are in full view of the driver, very accurate positioning of the vehicle is easy, however restraints against the front wheels will prevent the vehicle from moving too far forward. The figure on the right shows a protective boot to cover the rods when they are activated.

# 3 Conclusion

At least five problems are solved by the docking bay parking-charging-grid-buffering system: the limited range of the BEV, the limited energy storing capacity of the utility company, susceptibility of charging facilities to vandalism, forgetting to plug in at night, and having to cope with heavy and possibly wet cables and connectors.


## Acknowledgements

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## Authors


Gordon Dower MD FACC is a retired scientist with many publications including 7 patents awarded or pending, 6 related to transportation. The one not related is the EASI lead system, widely used in heart monitoring. It funds the development of Ridek modularity (ridek.com), currently focused on electric taxis in Lima and London.



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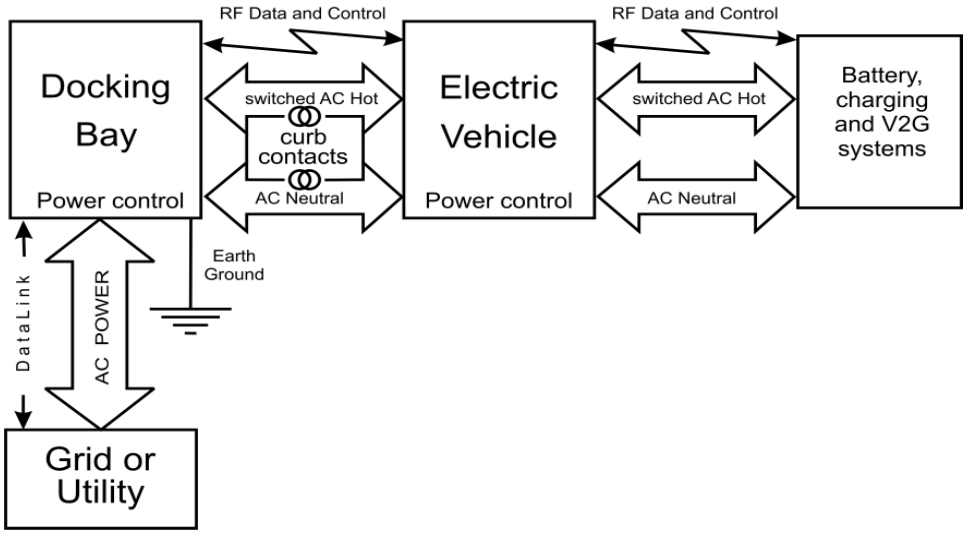
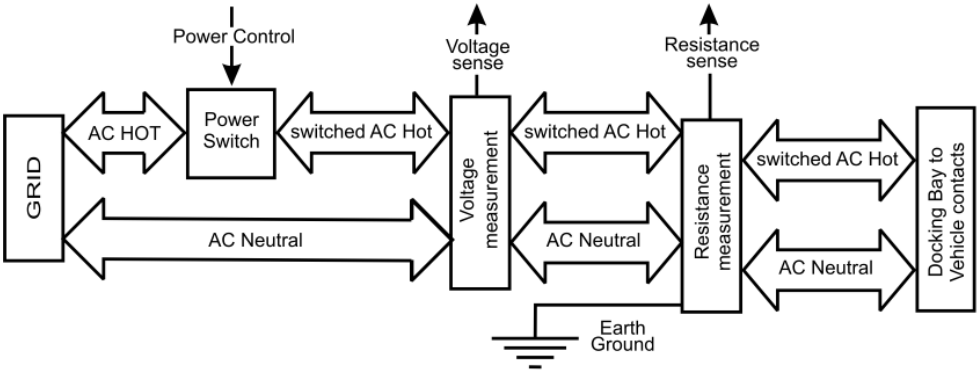
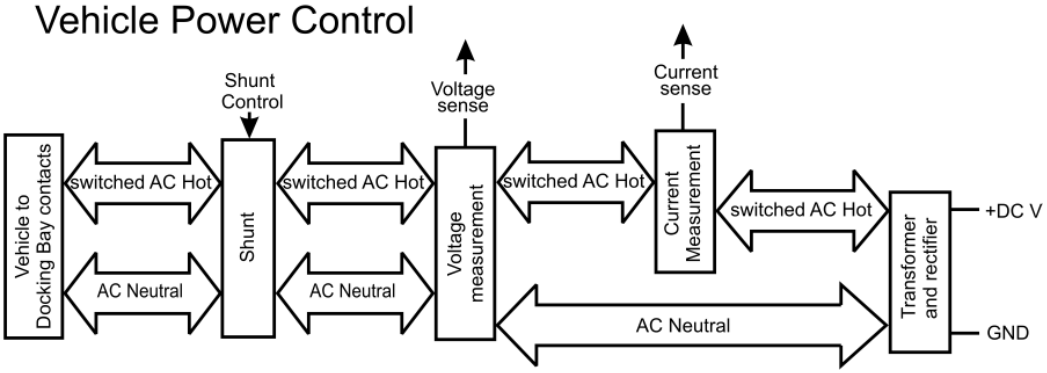
Docking Bay / Electric Vehicle
Two Way Energy Exchange



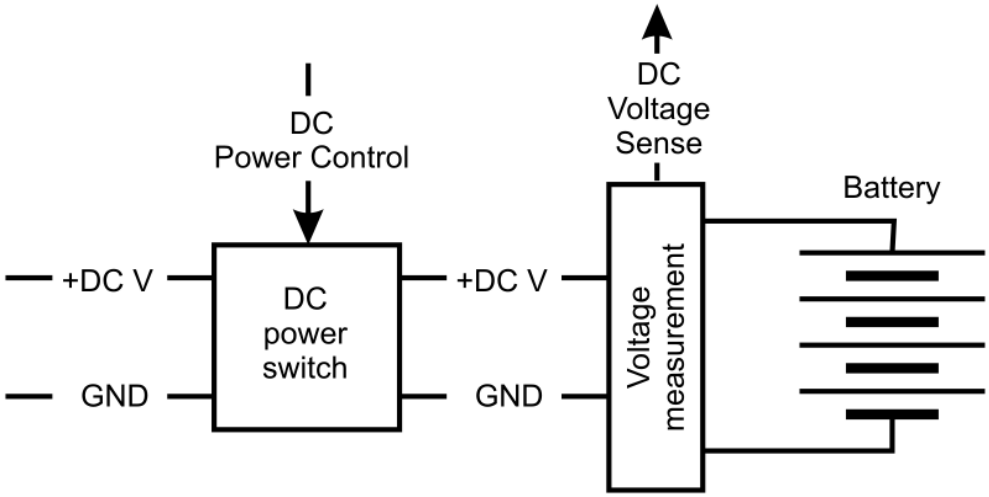

Docking Bay Power Control



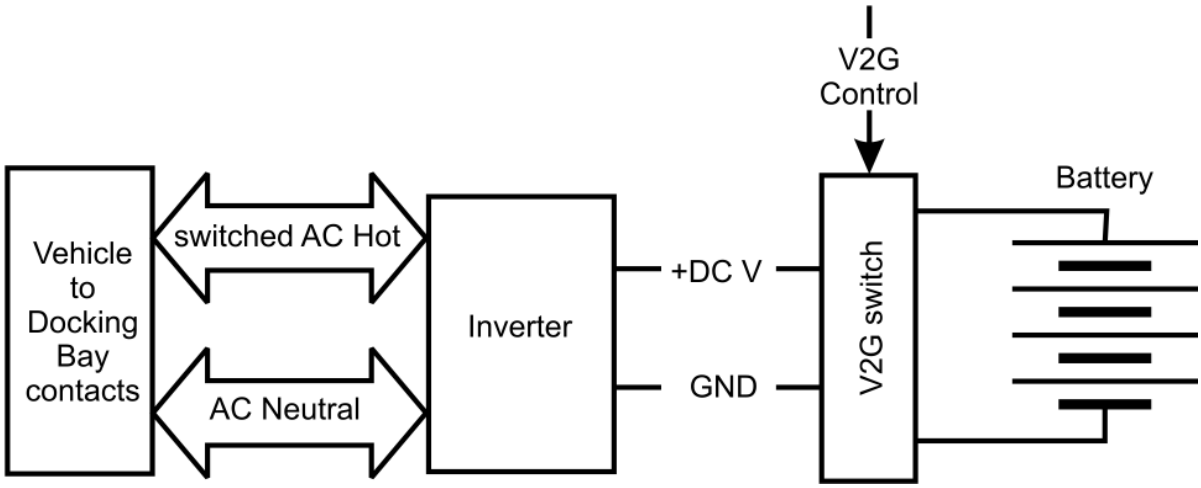

Vehicle Power Control

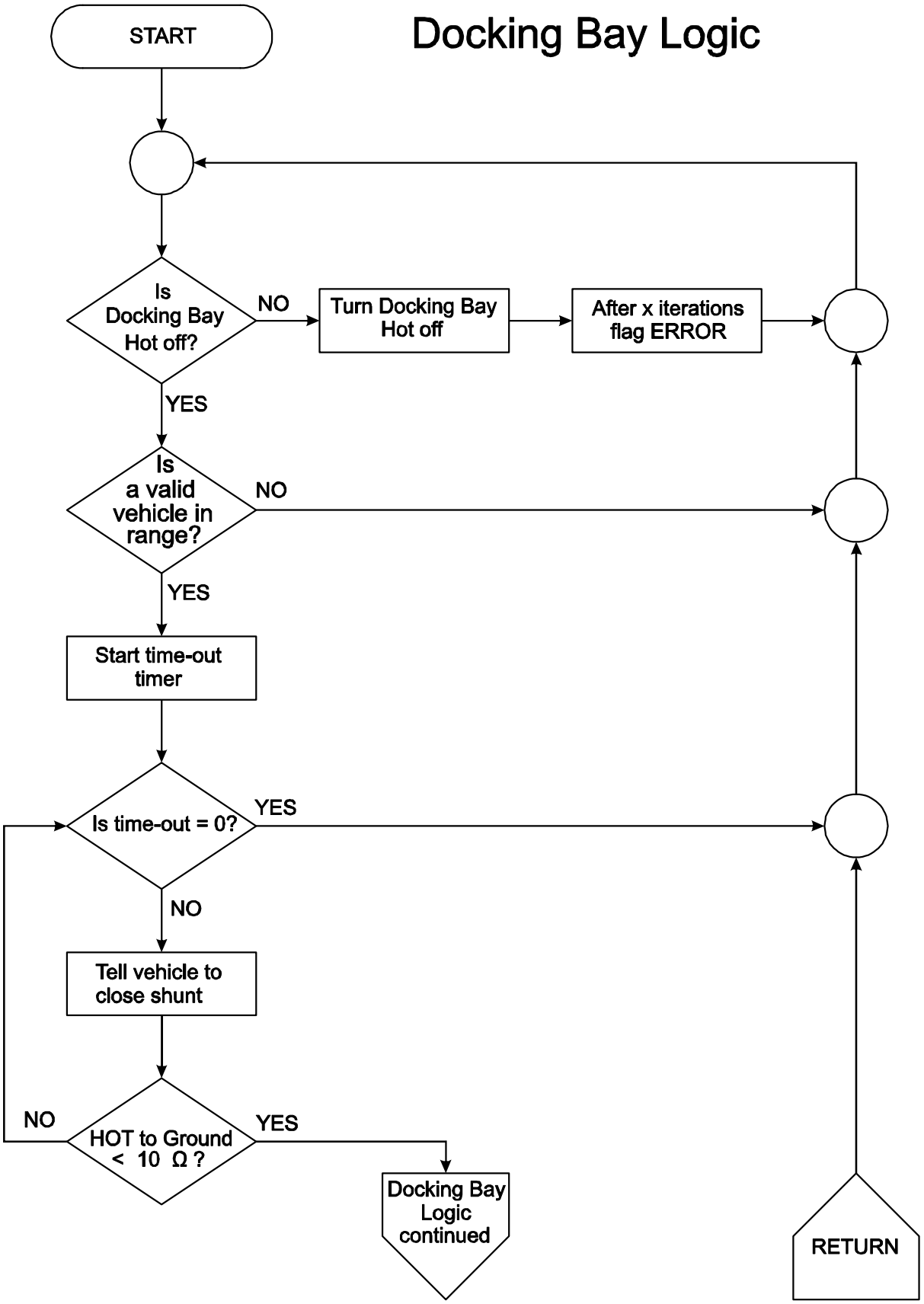


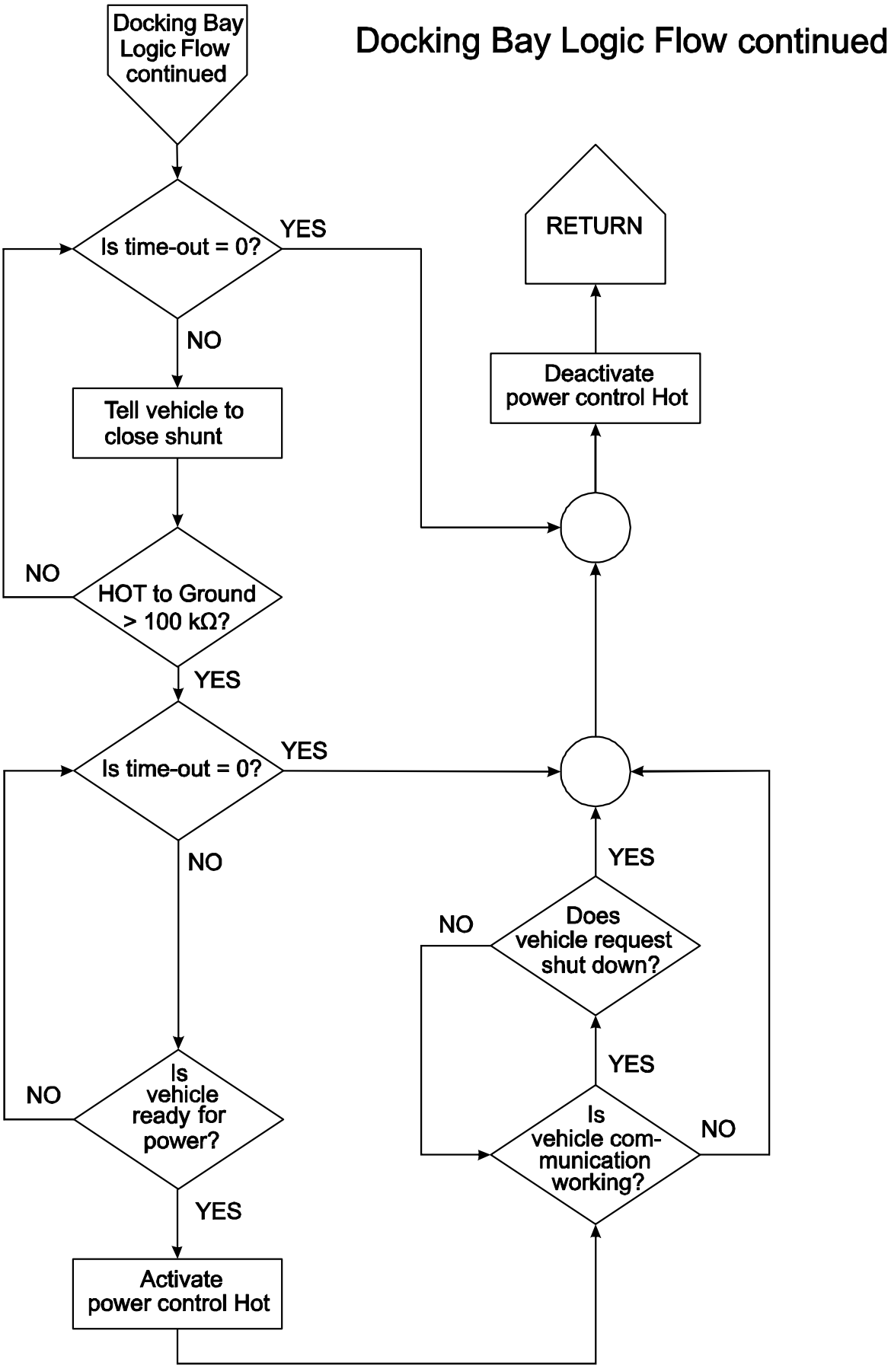
## Vehicle Charging System

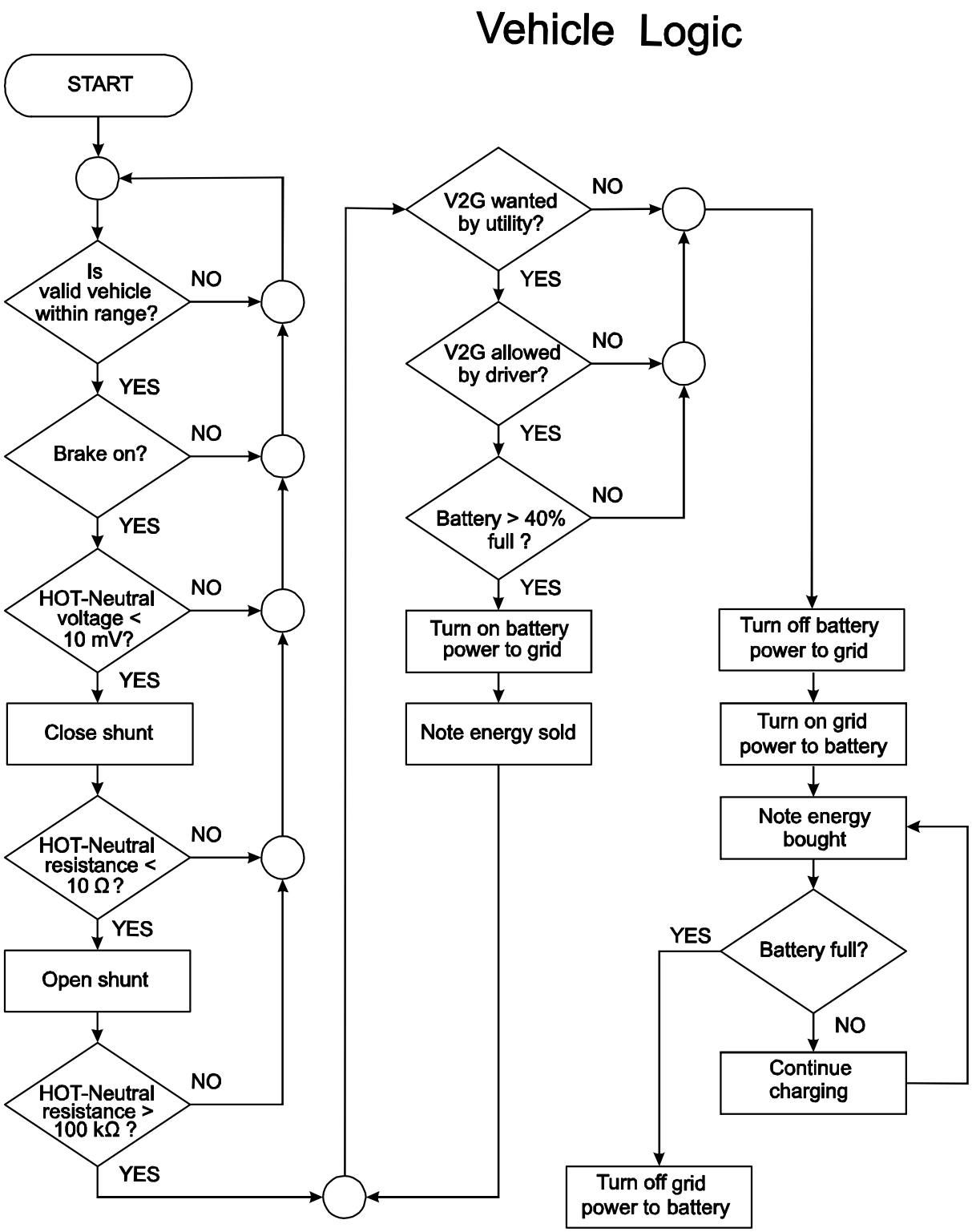



## Vehicle Discharging to Grid (V2G) System




Docking Bay Logic
START
Is Docking Bay Hot off?
NO
Turn Docking Bay Hot off
After x iterations flag ERROR
YES
Is a valid vehicle in range?
NO
YES
Start time-out timer
Is time-out = 0?
YES
NO
Tell vehicle to close shunt
HOT to Ground < 10 Ω ?
NO
YES
Docking Bay Logic continued
RETURN


Docking Bay Logic Flow continued
Docking Bay Logic Flow continued
Is time-out = 0?
YES
NO
RETURN
Deactivate power control Hot
Tell vehicle to close shunt
NO
HOT to Ground > 100 kΩ?
YES
Is time-out = 0?
YES
NO
YES
NO
Does vehicle request shut down?
Is vehicle ready for power?
NO
YES
Is vehicle com-munication working?
NO
YES
Activate power control Hot


Vehicle Logic
START
Is valid vehicle within range?
NO
YES
Brake on?
NO
YES
HOT-Neutral voltage < 10 mV?
NO
YES
Close shunt
HOT-Neutral resistance < 10 Ω ?
NO
YES
Open shunt
HOT-Neutral resistance > 100 kΩ ?
NO
YES
V2G wanted by utility?
NO
YES
V2G allowed by driver?
NO
YES
Battery > 40% full ?
NO
YES
Turn on battery power to grid
Note energy sold
Turn off battery power to grid
Turn on grid power to battery
Note energy bought
Battery full?
YES
NO
Continue charging
Turn off grid power to battery