RES-D3-CS20 ELECTRIC VEHICLE DC FAST CHARGER REMOTE DISPENSER APPLICATION BRIEF

The Next Generation of DC Fast Charging Remote Dispenser

The RES-D3-CS20 EV remote dispenser is the most recent addition to the Rhombus Energy Solutions DC fast charger product lineup. The D3 remote dispenser is our first DC fast charger dispenser incorporating Rhombus’ proprietary Sequential Power Switching (SPS) capability. The SPS feature enables one Rhombus PCS (Smart Inverter) to sequentially connect with up to 5 dispensers with a single power feed. This approach reduces the amount of trenching required to install the dispensers, and eliminates the need for an external switching box which many competitive designs require.

Rhombus also simplifies the sequential charging process through automation. As each EV reaches its target charge level, the dispenser disconnects and connects to the next dispenser until all connected vehicles reach their target charge level. Sequential charging priorities can be configured both locally &/or via the cloud. The dispenser is compatible with both “Charge Only” and “Bi-Directional / V2G” products and applications.

Key Features

- The RES-D3-CS20 design supports up to five (5) remote dispensers/PCS
- Our Sequential Power Switching (SPS) feature allows dispensers to be connected without dedicated wiring per dispenser
- The dispenser’s extremely small (~0.67 ft²) footprint simplifies vehicle yard layout, clearances
- The dispenser can be mounted on a wall or column to simplify indoor vehicle garage layouts

Five RES-D3-CS20 remote dispensers pictured with a Rhombus 125kW DC fast charger and a 60kW fast charger
Remote Dispensers – The Right Answer for Medium- and Heavy-Duty Vehicle Fleets

For medium- and heavy-duty (M/HD) EVs (public transit buses, school buses, and municipal vehicles), maximizing parking density in vehicle yards is critical. Even though these yards often have one hundred over a couple of acres, it is typical to see vehicles parked end-to-end with only a foot of space on the sides. Integrated high-power AC/DC dispensers have fairly large footprints, and putting them next to M/HD vehicles negatively impacts vehicle parking density. This is especially true when the need to protect the integrated chargers with bollards or similar barriers is considered.

In contrast, the typical remote dispenser has a footprint of roughly 1 to 2 ft² (with many less than this), allowing them to be placed in the space on the side of the buses. This eliminates any impact on vehicle lot parking density.

When Does It Make Sense to Connect Multiple Remote Dispensers to A Single PCS?

Sharing a single PCS across multiple dispensers can make sense in many instances. If the energy that can be provided by a PCS over a charging window is significantly more than what a single vehicle requires. In these cases, it can make sense to charge multiple vehicles from a single PCS. To do this without moving vehicles around in the vehicle lot requires multiple dispensers to be connected to the PCS.

Several factors impact when the sharing a PCS makes sense. These include the battery capacity of the vehicle, the energy used on the vehicle’s route, the length of the charging window, and the size of the PCS. If sharing makes sense, there are two methods for achieving this: parallel connection of the dispensers, or serial connection of the dispensers (see the diagram below). The parallel method requires DC switches to connect the dispensers to the PCS, as well as a power line from the DC switch to each dispenser.
Sequential Power Switching (SPS) Capability
With One Cable, NO EXTERNAL SWITCH BOX

Rhombus’ SPS feature in the D3 remote dispenser simplifies the connection of multiple dispensers to a single PCS. The SPS feature of the serially-connected D3 remote dispensers enables one Rhombus PCS (Smart Inverter) to sequentially connect with up to 5 EV’s with a single power feed. This approach eliminates the need for an external switching box which competitive parallel designs require. The sericonnection also significantly reduces the amount of trenching required to install power cables between the PCS and dispensers. At $10,000-$20,000 per 1000 feet of trench, this can be a big savings in a multi-acre vehicle yard.

Rhombus also simplifies the sequential charging process through automation. As each EV reaches its target charge level, the dispenser disconnects and connects to the next dispenser until all connected vehicles reach their target charge level. Sequential charging priorities can be configured both locally &/or via the cloud.

Case Study #1a: V1G School Bus Charging

Electrification of school buses is of critical interest, and creating the right charging infrastructure has a huge impact on vehicle availability. The average electric school bus has a 150kWh battery, and uses 1/3 of that energy (50kWh) on each of two runs per day (morning and afternoon). The daytime charging window tends to be 5 hours (9am-2pm), while the night window is 9 hours (9pm-6am, avoiding the 5pm-9pm peak load hours). During charging, each bus can “sink” a little over 7kW of power (100kWh ÷ 14 hours). For this use case, let’s assume that charging is unidirectional (V1G) only.

In this case, sharing a Rhombus 60kW charger across five buses makes considerable sense. The PCS can source 540 kWh of power over the nighttime 9-hour charging window, and 300kW over the daytime charging window. Even if only the daytime window and the nighttime super off-peak charging window were used (1am-6am), a total of 600kWh could still be sourced, allowing five (5) buses to charge with 100kWh to spare if a bus is late getting into the bus yard. This is an ideal situation for a shared PCS across five (5) dispensers.

Case Study #1b: V2G School Bus Charging

This use case is like use case #1, except the buses will put their excess energy (50 kWh per bus) back into the grid during the four (4) peak load hours of 5pm-9pm. There are two impacts to this change in the scenario:

- A 60kW PCS can sink 240 kWh of energy back to the grid during peak hours (60kW x 4 hrs).
- The buses will need to be fully recharged during the charging window, requiring 150kW each.

If five (5) dispensers are shared across one Rhombus 60kW PCS, nearly all of the excess energy of the five buses (250kW = 5 buses x 50 kWh per bus) can be sunk by the single 60kW PCS. For charging, the PCS would have to put out a total of 750kWh of energy (150kWh per bus x five buses). This would take 12.5 hours of charging to accomplish (750 kWh ÷ 60 kW). This can be supported across the afternoon and night charging windows, again represents a near-ideal situation.

Case Study #2: V21G Refuse Truck Charging

Refuse truck electrification is also a big initiative today. Electric refuse trucks have battery capacities that range from 221 kWh (BYD6R) to 400kWh (Peterbilt 520). We will assume that the vehicles use 90% of this capacity (199kW – 360kW) on their route between 6am and 5pm. This leaves a charging window is 9 hours (9pm-6am, avoiding the 5pm-9pm peak load hours), during which each truck can sink between 22kW and 40kW of power.

In this case, a 125 kW unidirectional charger could support five (5) BYD6R refuse trucks, or three (3) Peterbilt 520 refuse trucks across the charging window. V2G operations would also be supported without changing the number of dispensers shared – the 22 kWh to 40kW of unused capacity per vehicle could easily be “sunk” during one hour of the peak load period (22kWh x 5 trucks = 110 kWh; 40kW x 3 trucks = 120kWh). During the charging period, the five (5) BYD6R trucks would consume 1,105 kWh of energy, which the 125kW charger could source during the 9-hour charging window. The three Peterbilt 520 trucks would consume 1200 kWh during charging, which would take 9.6 hours.

The results of these case studies are shown in the following table.
<table>
<thead>
<tr>
<th>Scenario/ Vehicle</th>
<th>Battery Cap (kWh)</th>
<th>% Used Daily</th>
<th>Unused Cap (kWh)</th>
<th>PCS Sizing (kW)</th>
<th>Dispensers per PCS</th>
<th>Charge Window (hrs)</th>
<th>Charge Time (hrs)</th>
<th>V2G: PCS Sink Cap (kWh)</th>
<th>V2G: Veh Cap Avail (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1a: Electric School Bus (V1G)</td>
<td>150</td>
<td>67%</td>
<td>50</td>
<td>60</td>
<td>5</td>
<td>14</td>
<td>8.33</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>#1b: Electric School Bus (V1G)</td>
<td>150</td>
<td>67%</td>
<td>50</td>
<td>60</td>
<td>5</td>
<td>14</td>
<td>12.50</td>
<td>240</td>
<td>250</td>
</tr>
<tr>
<td>#2: Refuse Truck (BYD6R; V1G)</td>
<td>221</td>
<td>90%</td>
<td>22.1</td>
<td>125</td>
<td>5</td>
<td>9</td>
<td>7.96</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>#2: Refuse Truck (Peterbilt 540; V1G)</td>
<td>400</td>
<td>90%</td>
<td>40</td>
<td>125</td>
<td>3</td>
<td>9</td>
<td>8.64</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>#2: Refuse Truck (BYD6R; V2G)</td>
<td>221</td>
<td>90%</td>
<td>22.1</td>
<td>125</td>
<td>5</td>
<td>9</td>
<td>8.84</td>
<td>500</td>
<td>110.5</td>
</tr>
<tr>
<td>#2: Refuse Truck (Peterbilt 540; V2G)</td>
<td>400</td>
<td>90%</td>
<td>40</td>
<td>125</td>
<td>3</td>
<td>9</td>
<td>9.60</td>
<td>500</td>
<td>120</td>
</tr>
</tbody>
</table>

### Dispenser Dimensions

<table>
<thead>
<tr>
<th>V2G/Bi-Directional Model #</th>
<th>Rhombus RES-D3-CS20-V2G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatible Rhombus Inverters</td>
<td>RES-DCVC60-480-V2G (60kW)</td>
</tr>
<tr>
<td>Charge Only Model #</td>
<td>Rhombus RES-D3-CS20</td>
</tr>
<tr>
<td>Compatible Rhombus Inverters</td>
<td>RES-DCVC60-480 (60kW)</td>
</tr>
</tbody>
</table>

**DC Output/Input (Dispenser)**

- Rated Power (kW): 60kW, 125kW
- Rated Operating Voltage Range: Vdc: 270 - 870, 530 - 920
- Rated Current: (Adc): +200Adc (Charging Only), +/-200ADC (V2G)
- Sequential Power Switching Capable: Yes
- Max Dispenser to Inverter Ratio: 5:1
- Connector and Cable: CCS 1, Up to 20ft (standard)

**Mechanical**

- Dispenser Envelope Dimensions: ~8"D x ~12"W x 50" H (Wall Mount) or 69" H (Pedestal Mount)
- Dispenser Weight: ~150 lbs. (configuration dependent)

**Environmental**

- Environmental Rating: NEMA 3R
- Operating Ambient Temp.: -30 °C to 50 °C (-22 to 122°F)
- Storage Temperature Range: -30 °C to 60 °C (-22 to 140°F)
- Humidity: 0 to 95% (non-condensing)
- Altitude: De-rated over 2,000m above sea level

**Communication & Control**

- EV Communication: SAE J1772 & ISO 15118-2
- External Control & Management: OCPP1.6 J, Rhombus VectorStat® for enhanced diagnostics and energy management.

**Certification, Safety, Compliance**

- Dispenser Certifications: UL 2202 and UL 2231 w/ compatible Rhombus PCS.

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1. One power inverter can support multiple dispenser/vehicle connections sequentially. Only one dispenser is actively charging/discharging at a time. The system automatically switches between active dispensers as required. Sequential switching dispenser option is required to enable this capability.
2. ISO 15118-2 EV to EVSE communication standard is limited to "Charge Only". Pending updates to the ISO 15118 standard are expected to expand support for V2G communication and capabilities. Early V2G demonstrations require custom communication and control development. Please talk with your sales representative to discuss your application.