## Reference Documents

<table>
<thead>
<tr>
<th>No.</th>
<th>Source</th>
<th>Title</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>[7]</td>
<td>VDV</td>
<td>VDV 261 specification</td>
<td>2018</td>
</tr>
<tr>
<td>[8]</td>
<td>IEC</td>
<td>Electric vehicle conductive charging system - Part 1: General requirements (IEC 61851-1:2010); German version EN 61851-1:2011</td>
<td>2010</td>
</tr>
<tr>
<td>[11]</td>
<td>ISO</td>
<td>ISO 16750 (see QLV VV_24V for version details)</td>
<td>-</td>
</tr>
<tr>
<td>[16]</td>
<td>ISO</td>
<td>ISO 7637-3 Road vehicles - Electrical disturbances from conduction and coupling - Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines</td>
<td>2007-07</td>
</tr>
<tr>
<td>[18]</td>
<td>Vector</td>
<td>QLV VV_24V VC_Platform_HD</td>
<td>1.0</td>
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</tbody>
</table>
## Safety Instructions

**Caution**
To avoid personal injuries and damage to property, you have to read and understand the following safety instructions and hazard warnings, prior to installation and use of this ECU, keep this documentation always near the ECU.

## Proper Use and Intended Purpose

**Caution**
The ECU may only be operated according to the instructions and descriptions of this manual; The ECU is exclusively designed for use by skilled personnel as its operation may result in serious personal injuries and damage to property. Therefore, only those persons may operate the ECU who have understood the possible effects of the actions which may be caused by the ECU; are specifically trained in the handling (e.g. calibration) with the ECU, the applied embedded software, and the system intended to be influenced; and have sufficient experience in using the ECU safely.

## Hazard Warnings

**Caution**
The ECU may control and/or otherwise influence the behavior of control systems and electronic control units, serious hazards for life, body and property may arise, in particular, without limitation, by interventions, in safety relevant systems (e.g. by deactivation or otherwise manipulating the engine management, steering, airbag and/or braking system) and/or if the ECU is operated in public areas (public traffic). Therefore, you must always ensure that the ECU is used in a safe manner. This includes, inter alia the ability to put the system in which the ECU is used into a safe state at any time (e.g. by “emergency shutdown”), in particular without limitation, in the event of errors or hazards. Furthermore, all technical safety and public law directives which are relevant for the system in which the ECU is used must apply. Provided that serious hazards for life, body and property may occur and before the use in public areas the system in which the ECU is used must be tested according to recognized rules of engineering in a non-public area.
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1 General

The Vector Controller – Vehicle Charge Control Unit (VC-VCCU) is a generic ECU for 24V environments. It realizes electrical charging according to DIN SPEC 70121 see [1] and ISO15118 see [6] for power line communication (PLC) with the infrastructure.

The Hardware basis is the VC36PLC-24 with an integrated flash bootloader. The VC-VCCU also includes an AUTOSAR 4 stack with a charging application flashed on the hardware.

The following parts are included in the delivery:

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC-VCCU</td>
<td>ECU with integrated software</td>
</tr>
<tr>
<td>Documentation</td>
<td>Customer receives a Technical Reference (this document) as well as a User Manual and Charging Sequence Diagrams</td>
</tr>
<tr>
<td>Remaining Bus Simulation</td>
<td>CANoe bus simulation for the VC-VCCU for bus test and evaluation purposes  &lt;br&gt;  ▶ CAN Database description (dbc)  &lt;br&gt;  ▶ Diagnostic description File (cdd)</td>
</tr>
</tbody>
</table>
2 System Architecture

The VC-VCCU is designed to be integrated into the vehicle with the following system architecture.

Figure 2-1 System Overview

2.1 Supported Peripherals

The supported peripherals depend on the VC-VCCU variant:

> VC-VCCU CCS-2 (Combo 2 Inlet): Phoenix CCS Type 2 Inlet EV-T2GBIE12...
> VC-VCCU CCS-1 (Combo 1 Inlet): Phoenix CCS Type 1 Inlet EV-T1GBIE12...

Caution
The VC-VCCU CCS-1 variant has restriction due to hardware modifications:

> No over voltage protection on PP (pin 2K) in 24V systems (short-circuit)
> No open load detection on PP (pin 2K) possible
> Wake up on PP is unfailing

Once other inlets are used than mentioned above, please contact the Vector support in order to check the compatibility with the VC-VCCU.
3 ECU

This chapter contains an overview about the VC-VCCU. A detailed description of the electronics and housing can be found in the User Manual of the VC-VCCU[4].

3.1 ECU Overview

The following diagram and tables give an abstract overview of the interfaces of the hardware.

**Note**

There are many different configuration options for the hardware of the VC-VCCU. The following figure shows the configuration of the VC-VCCU.

---

**Figure 3-1  VC-VCCU Interfaces**
3.2 Key ECU Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Single Core µC with 120MHz</td>
</tr>
<tr>
<td>Memory</td>
<td>3,0 MB Code-Flash, 4x16 kB Data-Flash, 192 kB RAM</td>
</tr>
<tr>
<td>Voltage range</td>
<td>10V … 32V (ISO 16750, Code E)</td>
</tr>
<tr>
<td>Connector PINs</td>
<td>36 Pin</td>
</tr>
<tr>
<td>Communication</td>
<td>3x CAN 2.0B (incl. shielding)</td>
</tr>
<tr>
<td></td>
<td>1x PLC – Power Line Communication based on IEC61851, ISO 15118 and DIN 70121</td>
</tr>
<tr>
<td></td>
<td>with PP, PE and CP</td>
</tr>
<tr>
<td>I/O</td>
<td>Extensive Inputs and Outputs typically needed for in vehicle powerline charging systems</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-35°C … +85°C (ISO16750, Code H)</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>994µA / 114µA (with / without inlet)</td>
</tr>
<tr>
<td>Functional Safety</td>
<td>Not considered, development based on QM process</td>
</tr>
</tbody>
</table>

Table 3-1 VC-VCCU Key Characteristics
4 Functional Overview

4.1 Power Line Communication

4.1.1 Low Level communication with EVSE

According to [2] and [3] a low-level communication via PWM on the CP pin is supported. The following PWM duty cycles are valid:

<table>
<thead>
<tr>
<th>Duty Cycle of CP PWM</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% &lt;= DC &lt; 3%</td>
<td>No charging allowed</td>
</tr>
<tr>
<td>3% &lt;= DC &lt;= 7%</td>
<td>Usage of high-level protocol according to ISO15118 and DIN70121. Charging without this high-level protocol is not possible.</td>
</tr>
<tr>
<td>7% &lt; DC &lt; 8%</td>
<td>No charging allowed</td>
</tr>
<tr>
<td>8% &lt; DC &lt; 10%</td>
<td>Max current consumption is 6A</td>
</tr>
<tr>
<td>10% &lt;= DC &lt;= 85%</td>
<td>Available current = Duty Cycle * 0,6A</td>
</tr>
<tr>
<td>85% &lt; DC &lt;= 96%</td>
<td>Available current = (Duty Cycle – 64) * 2,5A</td>
</tr>
<tr>
<td>96% &lt; DC &lt;= 97%</td>
<td>Max current consumption is 80A</td>
</tr>
<tr>
<td>97% &lt; DC &lt;= 100%</td>
<td>No charging allowed</td>
</tr>
</tbody>
</table>

Table 4-1 Low Level Communication – Duty Cycle of CP PWM

4.1.2 AC Charging with low level communication

With the low-level communication, AC charging can be performed in the following sequence:

- Lock coupler after plugged into inlet
- Establish communication to EVSE via CP
- Get charging clearance from vehicle
- Start charging
- Continuous monitoring of charging progress
  - Vehicle state monitoring; Stop button monitoring; Temperature monitoring; EVSE communication; Self-diagnostic of actuators/sensors
- Stop charging
- Release coupler after a pressed stop button or a CAN signal

Note

For detailed information, please refer to the AC Charging diagram.
4.1.3 DC charging with High Level communication

According to see [1] and [6], high level communication for DC charging is supported. The supported charging profile is EIM (External Identification Means).

Caution
Plug and Charge is not supported by the VC-VCCU.

The DC charging is done in the following sequence:

- Lock coupler after plugged into inlet
- Get charging clearance from vehicle
- Session setup with EVSE
- Parameter exchange with EVSE (charging mechanism, schedule tables…)
- Isolation measurement with EVSE
- Start pre-charge
- Start charging
- Continuously monitoring of charging progress
  - Vehicle state monitoring; Stop button monitoring; Temperature monitoring; EVSE communication; Self-diagnostic of actuators/sensors
- Stop charging
- Release coupler after a pressed stop button or a CAN-signal

Note
For detailed information, please refer to the DC Charging diagram.

The first schedule table from EVSE will always be accepted on the protocol layer but ignored in the application (charging will start immediately, independent from the received schedule table).

4.2 Stop Button

The button is monitored continuously when the VC-VCCU is active. If the button is pressed, the charging is stopped, the coupler will be unlocked.

Caution
The voltage levels at the inlet power supply pins are not checked by the VC-VCCU prior to unlocking the coupler. This must be done by the other system components and controlled by the CAN signal which sets the signal VCVCCU_Vehicle_PlugUnlockPermission.
4.3 StopCharge CAN Signal
The StopCharge CAN Signal is monitored continuously when the VC-VCCU is active and the feature is activated. If the StopCharge CAN Signal is set to pressed, the charging is stopped, the coupler will be unlocked.

4.4 Generic switch input
An additional digital input to connect an additional button. Besides, the generic input is used for the charging arbitration.

4.5 Terminal 15 signal input
If there is the need for a discrete wakeup of the ECU instead of a CAN network wakeup, the Terminal 15 signal input may be used to wake the ECU and keep it awake.

4.6 Status LEDs
The charging status can be displayed via three LED which can be controlled via CAN messages by an external ECU. For more details, please refer to the User Manual of the VC-VCCU[4].

4.7 High Side Outputs
Three High Side Outputs are available for general purposes which can be controlled via CAN signals by an external ECU. For more details, please refer to the User Manual of the VC-VCCU[4].

4.8 Reprogramming of the ECU software
Reprogramming will be done via diagnostic CAN (CAN0). Therefore, the UDS protocol will be used. The following reprogramming features are supported:
- Download of one logic block of application and basic software
- Download of one logic block of Ethernet transceiver firmware
- Pipelined programming
- Pipelined verification
- Security via CRC (no signature)
- Updater for the flash bootloader itself is not supported

4.9 Self-diagnostics and fault memory
The VC-VCCU continuously monitors all relevant inputs and outputs. The information is available in the self-diagnostic messages of the outputs.
In addition to that, the self-diagnostic also includes faults during charging or in case of internal faults.
Furthermore, the VC-VCCU includes a fault memory which is able to store several DTCs.
4.10 ECU state handling
An ECU wakeup is performed due to following reasons:

- Terminal 15 signal
- CAN wakeup
- Stop button pressed
- Vehicle coupler connected
- Control Pilot Pin active
- Wake up from real time clock

If the ECU is active there are the following awake reasons possible to stay active:

- Terminal 15 signal
- Control Pilot activity
- CAN active
- Active Diagnostic Session

In all other cases, the VC-VCCU will go to sleep.

4.11 Coupler present detection
For the coupler present detection, the proximity pin (PP) or the PWM signal of the control pilot line (CP) is used.

4.12 Locking / unlocking the Combo2 and Combo1 coupler
The locking / unlocking of the Combo2 and Combo1 coupler is done with a motor, controlled by an H-Bridge.

The coupler will be locked when:

- A vehicle coupler is detected and
- A CAN lock signal is received
- If the coupler was unlocked but not removed after a certain time

The locking is performed after a specified time the coupler was detected.

The coupler will be unlocked when:

- An unlock message is received on CAN and
- The charging stop button is pressed or
- [in case of Combo1] the S3Switch is pressed or
- The StopCharge CAN Signal is pressed
4.13 Temperature monitoring
The supported Combo2 and Combo1 vehicle inlet has 2 temperature sensors:
- One sensor is used for AC charging
- One sensor is used for DC charging
The VC-VCCU has a third temperature sensor Input which might be used for individual purposes. The read temperature is not used for the control of the charging.

4.14 Configuration of Software
The VC-VCCU allows configurations of the firmware on the diagnostic channel:
- Baudrate adjustment between 250 kBaud, 500 kBaud and 1 MBaud on the J1939 CAN
- Automatic switch of high side output to wakeup other ECUs
- Configurable message cycle times of several messages
- Transport Layer Security (TLS) for V2G communication and VAS
- Configurable Security Key Constant

4.15 Value Added Services (VAS)
Value added service are additional service which are not part of the V2G communication and not mandatory for charging. The VC-VCCU supports VAS according to ISO 15118-2 [6] and VDV 261 [7].

4.16 Charging Arbitration
The charging arbitration enables the operation of two VC-VCCUs on the same CAN channel. It targets use cases which require two charging inlets (two VC-VCCUs) per vehicle but only one charging inlet is used for charging at a time.
For charging arbitration, the VC-VCCU provides the following configurations on the diagnostic channel:
- Configuration of Primary Source Address
- Configuration of Secondary Source Address
- Activation/Deactivation of Charging Arbitration
For more details, please refer to the User Manual of the VC-VCCU [4].
5 Qualification

This section describes the qualification of the VC-VCCU. The qualification of Vector ECUs is executed by accredited test labs, according to international standards. Documents with detailed test specification and test results are not provided. Further details on the performed tests could be available on individual request.

5.1 Configuration

The qualification of the VC-VCCU design has been performed in the following configuration of the hardware.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-speed CAN</td>
<td></td>
</tr>
<tr>
<td>Channel</td>
<td>Termination</td>
</tr>
<tr>
<td>CAN0</td>
<td>not populated</td>
</tr>
<tr>
<td>CAN1</td>
<td>120Ω</td>
</tr>
<tr>
<td>CAN2</td>
<td>120Ω</td>
</tr>
<tr>
<td>20mA LED Output</td>
<td>&gt; PWM dimming</td>
</tr>
<tr>
<td>200mA High-Side Output</td>
<td>&gt; Static digital</td>
</tr>
<tr>
<td>5A High-Side Output</td>
<td>&gt; Freewheeling diode</td>
</tr>
<tr>
<td></td>
<td>&gt; Static digital</td>
</tr>
<tr>
<td>5A H-Bridge</td>
<td>&gt; Static digital</td>
</tr>
<tr>
<td>IP Protection Class</td>
<td>&gt; Housing sealed</td>
</tr>
</tbody>
</table>

Table 5-1 Qualification configuration

5.2 Electrical tests

The following electrical tests have been performed:

- E-01 Overvoltage
- E-05 Load dump
- E-06 Superimposed alternating voltage
- E-07 Slow decrease and increase of supply voltage
- E-08 Slow decrease, quick increase of the supply voltage
- E-08 Reset behavior at voltage drop
- E-10 Short interruptions
- E-11 Starting profile
E-12 Voltage curve with interactive generator regulation
E-13 Single line interruption
E-14 Multiple line interruption
E-15 Reversed voltage
E-16 Ground reference and supply offset
E-17 Short circuit protection
E-19 Quiescent current
E-22 Overcurrent
E-23 Direct current supply voltage
E-24 Voltage transient to engine rpm steps
E-25 Momentary drop in supply voltage

5.3  EMC Test

The following tests have been performed:

- EMC1 - RF-emissions - Measurements at the artificial network (AN-Test, CISPR 25:2008-03)
- EMC2 - RF-emissions – Measurements with antennas (RE-Test, CISPR 25: 2008-03)
- EMC7 - Transient emissions on supply cables (CTE-Test, ISO 7637-2: 2011-03)
- EMC9 - RF-immunity to interference – Bulk current injection (BCI-Test, ISO/DIS 11452-4: 2010-01)
- EMC14 - Transients on supply lines (TSUP-Test, ISO 11452-2: 2004-11)
- EMC15 - Transients on lines except supply lines (TOL-Test, ISO 7637-3: 2007-07)
- EMC16 - Electrostatic discharge – Handling Test (ESDH, ISO 10605: 2008-07)
- EMC17 - Electrostatic discharge – Direct discharge (ESDD, ISO 10605: 2008-07)
- EMC18 - Electrostatic discharge – Indirect discharge (ESDI, ISO 10605: 2008-07)

5.4  Climatic tests

The following climatic tests have been performed:

- K-01 High / Low temperature storage test
- K-02 Temperature step test
- K-03 High / Low temperature operation test
- K-05 Rapid change of temperature with specified transition duration
5.5 Mechanical tests
The following mechanical tests have been performed:
- M-01 Free fall
- M-03 Dust test
- M-04 Vibration test (Profile D)
- M-06 Mechanical shock (Severity II, Drivers door)

5.6 Life tests
The following life tests have been performed:
- L-02 High temperature endurance test
- L-03 Alternating temperature endurance test

Assumed Life time: 50000h / 15 Years

5.7 Chemical Tests
The following chemical tests have been performed:
- AA - Diesel fuel
- BA - Engine oil
- BE - Greases
- BF - Silicone oil
- CC - Antifreeze fluid
- CD - Urea
- CG - Protective lacquer remover
- CA - Battery fluid
- CE - Cavity protection
- CF - Protective lacquer
- DF - Cold cleaning agent
- DJ - Ammonium containing cleaner
- EB - Transpiration
- ED - Refreshment containing caffeine and sugar
- EF - Cream, coffee whitener
- DB - Vehicle washing chemicals
- DC - Interior cleaner
- DD - Glass cleaner
- DE - Wheel cleaner
- EE - Runway de-icer
- AE - Methanol
- DG - Acetone
- DH - Cleaning solvent
- DK - Denatured alcohol
## 6 Glossary and Abbreviations

### 6.1 Abbreviations & Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>AUTOSAR</td>
<td>AUTomotive Open System ARchitecture</td>
</tr>
<tr>
<td>BMS</td>
<td>Battery Management System</td>
</tr>
<tr>
<td>CAN</td>
<td>Controller Area Network</td>
</tr>
<tr>
<td>CCS</td>
<td>Combined Charging Standard</td>
</tr>
<tr>
<td>.cdd</td>
<td>CANdela Diagnostic Description File</td>
</tr>
<tr>
<td>CP</td>
<td>Control Pilot</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclic Redundancy Check</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DCB</td>
<td>Disconnecting Circuit Breaker</td>
</tr>
<tr>
<td>ECU</td>
<td>Electronic Control Unit</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>EVSE</td>
<td>Electric Vehicle Supply Equipment</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>PLC</td>
<td>Power Line Communication</td>
</tr>
<tr>
<td>PE</td>
<td>Physical Earth</td>
</tr>
<tr>
<td>PP</td>
<td>Proximity Pin / Plug Present</td>
</tr>
<tr>
<td>PWM</td>
<td>Pulse-Width Modulation</td>
</tr>
<tr>
<td>QM</td>
<td>Quality Management</td>
</tr>
<tr>
<td>RAM</td>
<td>Random Access Memory</td>
</tr>
<tr>
<td>RESS</td>
<td>Rechargeable Energy Storage System</td>
</tr>
<tr>
<td>UDS</td>
<td>Unified Diagnostic Services</td>
</tr>
<tr>
<td>V2G</td>
<td>Vehicle-to-Grid</td>
</tr>
<tr>
<td>VAS</td>
<td>Value Added Services</td>
</tr>
<tr>
<td>VCU</td>
<td>Vehicle Control Unit</td>
</tr>
<tr>
<td>VC-VCCU</td>
<td>Vector Controller – Vehicle Charge Control Unit</td>
</tr>
<tr>
<td>VDV</td>
<td>Verband Deutscher Verkehrsunternehmen</td>
</tr>
</tbody>
</table>