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Electronic control unit for a vehicle with galvanically isolated supply voltages on a single printed circuit board

Abstract

The disclosure relates to an electronic control unit (ECU) for a vehicle. The ECU includes a 12V-domain controlling an electric load supplied with a first supply voltage and a 48V-domain controlling an electric load supplied with a second supply voltage. Both domains are arranged on a single printed circuit board (PCB) and are galvanically isolated from each other and connected with each other by a galvanically isolated data interface that transfers data between the domains according to a half-duplex or a full-duplex communication protocol. The 48V-domain includes a 48V-microcontroller and a 48V-power supply supplying the 48V-microcontroller, where the 48V-power supply is powered by the first supply voltage from the 12V-domain via a galvanically isolated supply interface.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application claims the benefit of International Application PCT/EP2020/071607, filed Jul. 30, 2020, which claims priority to European Application 19465542.9, filed Aug. 6, 2019. The disclosures of the above applications are incorporated herein by reference.

TECHNICAL FIELD

(2) The disclosure relates to an electronic control unit for a vehicle with galvanically isolated supply voltages on a single printed circuit board.

BACKGROUND

(3) Electrical systems of hybrid cars are powered by a plurality of supply voltages, e.g., by a first supply voltage of 12 Volts and a second supply voltage of 48 Volts. In order to control electric loads supplied with different voltages, such as motors driving actuators, valves or heaters, and in order to verify and control each of the supply voltages, according to the state of the art, a plurality of electronic control units (ECUs) are provided for a hybrid car, where each ECU is dedicated to a single supply voltage.

(4) Also, ECUs that include subsystems or domains dedicated to different supply voltages are known, where these subsystems are coupled for a transfer of digital and/or analog signals.

SUMMARY

(5) The disclosure provides an improved ECU for verifying and/or controlling different supply voltages and for verifying and/or controlling electric loads powered by different supply voltages.

(6) An electronic control unit (ECU) for a vehicle includes a 12V-domain and a 48V-domain. The 12V-domain is designed to control at least one electric load that is supplied with a first supply voltage. Also, the 12V-domain itself is at least in part supplied with the first supply voltage. The 48V-domain is designed to control at least one electric load that is supplied with a second supply voltage. Also, the 48V-domain itself is at least in part supplied with the second supply voltage.

(7) Implementations of the disclosure may include one or more of the following optional features. In some implementations, the first supply voltage is chosen as 12 Volts and the second supply voltage is chosen as 48 Volts.

(8) Both the 12V-domain and the 48V-domain are arranged on a single printed circuit board (PCB). They are galvanically isolated from each other. In some examples, they are galvanically isolated such that they withstand a voltage difference of at least 1 Kilovolt.

(9) Both domains are connected by a data interface that is galvanically isolated and configured for a data transfer according to a half-duplex or a full-duplex communication protocol.

(10) In some examples, the 48V-domain includes a 48V-microcontroller and a 48V-power supply supplying the 48V-microcontroller. The 48V-power supply is powered by the first supply voltage from the 12V-domain via a galvanically isolated supply interface.

(11) Thereby, the 48V-microcontroller may be operated even if the second supply voltage is off. Thus, it is possible to perform diagnostic tests with the 48V-microcontroller to detect failures in the 48V-domain, including failures in the 48V-microcontroller itself, before the second supply voltage is switched on.

(12) Also, the galvanic separation provided by the supply interface is extended onto the 48V-power

supply and the 48V-microcontroller and protects these components.
(13) Due to the arrangement of both domains on a single PCB, the footprint and the installation space may be reduced. Also, costs for design, manufacturing and service may be reduced compared to solutions from the state of the art with multiple separate ECUs.
(14) In some examples, the 48V-domain includes a 48V-load control which is designed to verify the status of the second supply voltage and/or a 48V-motor control which is designed to control at least one electric load supplied by the second supply voltage. In this example, the 48V-microcontroller is arranged and configured such as to control the 48V-load control and/or the 48V-motor control.
(15) The control loops for electric loads supplied by the second supply voltage may be advantageously implemented with a particularly low latency, as measurement values and commands need not be transferred between the 12V-domain and the 48V-domain. The same advantage holds true for control loops that verify and/or control the second supply voltage. For example, more stable control loops for electric loads powered by the second supply voltage can be implemented.
(16) In some implementation, the data interface transfers digital data. In this case, all analog signals acquired from or sent to electric loads supplied by the second supply voltage are digitized by the 48V-microcontroller. The digitized values may then be processed by the 48V-microcontroller and/or transferred via the digital data interface between the 48V-microcontroller and the 12V-microcontroller.
(17) Digital data may be transferred by serial busses or protocols which require less wires or lines, thereby relieving the technical burden for the isolation of the data interface. Furthermore, digital data is less sensitive against electromagnetic interferences and does not require precise reference voltages for analog-to-digital conversion (ADC). This improves the robustness and the accuracy of data transferred along the data interface and prevents data loss as no conversion of analog signals is necessary.
(18) In some examples, the data interface is configured to support a controller area network (CAN) protocol and/or a serial peripheral interface (SPI) protocol and/or an inter-integrated circuit (I2C) protocol. Such protocols are well-known and may be implemented by available components and circuitry, thereby reducing the design and manufacturing burden.
(19) In some implementations, the supply interface includes a flyback converter. Flyback converters are well-known and readily available components for directed-current (DC/DC) conversion of voltages, that provide a good galvanic separation between the input and the output.
(20) In some implementations, the first supply voltage is 12 Volts and the second supply voltage is 48 Volts, where electric loads with relatively high power consumption, such as heaters or high power pump motors, are supplied with 48 Volts, and electric loads with relatively low power consumption, such as valves or gear selection motors, are supplied with 12 Volts. Thereby, the overall power consumption can be optimised.
(21) In some examples, the 48V-microcontroller is configured to perform a power-on-test of the 48V-domain upon switching on the first supply voltage. By an external switching regime it is possible to switch on the first supply voltage before the second supply voltage is switched on. When a failure is detected by the 48V-microcontroller during the power-on-test, the switching of the second supply voltage can be prevented and the ECU can be brought into a failsafe state. Thereby, safety and protection of the ECU and of components controlled by the ECU can be improved.
(22) In some examples, the 12V-domain includes a 12V-microcontroller which is connected via the data interface with the 48V-microcontroller. The 12V-microcontroller is configured as a master and the 48V-microcontroller is configured as a slave. When the first supply voltage is powered on, the 12V-microcontroller can perform a power-on-test of the 12V-domain. As it operates as a master, the 12V-microcontroller can be configured such as to enable the second supply voltage and/or to pass control to the 48V-microcontroller only when the power-on-test of the 12V-domain shows no

failure. Thereby, safety and protection of the ECU and of components controlled by the ECU can be improved.

(23) In some implementations, the 12V-domain includes a 12V-load control designed to verify the status of the first supply voltage and/or a 12V-motor control designed to control at least one electric load supplied by the first supply voltage. The 12V-microcontroller is arranged and configured such as to control the 12V-load control and/or the 48V-motor control.

(24) The control loops for electric loads supplied by the first supply voltage may be advantageously implemented with a low latency, as measurement values and commands need not be transferred between the 12V-domain and the 48V-domain. The same advantage holds true for control loops that verify and/or control the first supply voltage. For example, more stable control loops for electric loads powered by the first supply voltage can be implemented by this example of the disclosure.

(25) In some examples, the 12V-domain includes a 12V-CAN controller designed to transfer data via a CAN bus and connected with the 12V-microcontroller. Thereby, the 12V-domain can be controlled via the CAN bus and can exchange data and commands with other control units of the vehicle connected with the CAN bus. Also, via the data interface, the 48V-domain may communicate over the CAN bus. As the CAN bus is a frequently used communication standard in vehicles, this example improves the compatibility of the ECU.

(26) In some examples, the 12V-microcontroller is configured to perform operations that are relevant for the safety of the vehicle and the 48V-microcontroller is configured to perform operations that are not relevant for the safety of the vehicle. Thereby, the overall effort for risk-control measures can be reduced and the reliability of the ECU can be improved.

(27) The details of one or more implementations of the disclosure are set forth in the accompanying drawings and the description below. Other aspects, features, and advantages will be apparent from the description and drawings, and from the claims.

Description

DESCRIPTION OF DRAWINGS

(1) FIG. **1** shows an electronic schematic design of a hybrid electronic control unit with an isolated CAN node according to the state of the art.

(2) FIG. **2** shows an electronic schematic design of a hybrid electronic control unit with an isolated microcontroller according to the state of the art.

(3) FIG. **3** shows an exemplary electronic schematic design of a hybrid electronic control unit with a 48 Volts domain galvanically isolated from and partly powered by a 12 Volts domain.

(4) Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

(5) FIG. **1** shows an electronic schematic design of a hybrid electronic control unit (ECU) **10** being used in hybrid cars according to the state of the art. The ECU **10** is implemented on a single printed circuit board (PCB) that includes a 12V-domain **20** and a 48V-domain **30** which are galvanically isolated from each other.

(6) The 12V-domain **20** is electrically supplied by a 12V-supply voltage V**12** of 12 Volts and by a 12V-ground G**12**. The 48V-domain **30** is electrically supplied by a 48V-supply voltage V**48** of 48 Volts and by a 48V-ground G**48**. According to the state of the art, the 12V-supply voltage V**12** is switched on before the 48V-supply voltage V**48**.

(7) The 12V-domain **20** is formed as a Controller Area Network (CAN) node. It provides a first CAN pin CANH and a second CAN pin CANL that are connectable with an external two-wire CAN bus. CAN busses are well-known for data transfer between control units of a vehicle.

(8) The ECU **10** includes a data interface **11** that is designed to transfer data between the CAN pins CANL, CANH of the 12V-domain **20** and the 48V-domain **30**. The data interface **11** has a 12 Volts

side **11**.**12**V connected with the 12V-domain **20** and a 48 Volts side **11**.**48**V connected with the 48V-domain **30**. Both sides **11**.**12**V, **11**.**48**V of the data interface **11** are galvanically isolated from each other. In the example shown in FIG. **1**, both sides **11**.**12**V, **11**.**48**V of the data interface **11** are designed and configured to support the CAN protocol, thus forming a serial CAN interface between the 12V-domain **20** and the 48V-domain **30**.

(9) The 12V-domain **20** includes a 12V-power supply **21** that electrically supplies the 12 Volts side **11**.**12**V of the data interface **11**. The 12V-power supply **21** is powered by the 12V-supply voltage V**12**.

(10) The 48V-domain **30** includes a 48V-power supply **31** that electrically supplies the 48 Volts side **11**.**48**V of the data interface **11**. The 48V-power supply **31** is powered by the 48V-supply voltage V**48**. The 48V-power supply **31** has a 48V-power status pin **31**.S that indicates the status of the 48V-power supply **31**.

(11) The power supplies **21**, **31** provide a voltage of 5 Volts to power each side **11**.**12**V, **11**.**48**V of the data interface **11**.

(12) The 48V-domain **30** further includes a 48V-microcontroller **32**, a 48V-load control **33** and a 48V-motor control **34**.

(13) The 48V-load control **33** is powered by the 48V-supply voltage V**48** and is designed to control and/or verify the load status of the externally provided voltage of 48 Volts via a first and a second probe pin V**48**H, V**48**L. The probe pins V**48**H, V**48**L are connected with the 48V-supply voltage V**48** and the 48V-ground G**48**, respectively, via external measurement resistors.

(14) The 48V-motor control **34** is powered by the 48V-supply voltage V**48** and is designed to control an external brushless directed current (BLDC) motor **40**. The BLDC motor **40** may be formed as an actuator, such as a high-power pump motor.

(15) In some examples, the 48V-domain **30** may include further controllers powered by the 48V-supply voltage V**48** and designed to control external electrical loads, such as heaters. Also, controllers that control more than one external electrical load are known from the state of the art.

(16) The 48V-microcontroller **32** is powered by the 48V-power supply **31**. As an example, the 48V-microcontroller **32** is supplied with a voltage of 5 Volts provided by the 48V-power supply **31**.

(17) The 48V-microcontroller **32** is connected with the 48 Volts side **11**.**48**V of the data interface **11**, with the 48V-power status pin **31**.S of the 48V-power supply **31**, with the 48V-load control **33** and with the 48V-motor control **34** such that it may transfer data, for example status information, acquired measurements or control signals, with the data interface **11**, the 48V-power supply **31**, the 48V-load control **33** and the 48V-motor control **34**. Said connections may be formed as multi-wire connections.

(18) In particularity, the 48V-microcontroller **32** is configured to receive instructions via the data interface **11** and translate such instructions into control signals controlling the 48V-motor control **34**. The 48V-microcontroller **32** is furthermore configured to retrieve diagnostic data, such a status data from the 48V-power supply **31**, from the 48V-load control **33** and/or from the 48V-motor control **34**, and to transfer such diagnostic data via the data interface **11** to the CAN pins CANL, CANH and thus to the external CAN bus. The 48V-microcontroller **32** may also be configured to run software that implements a control loop controlling peripheral components such as one or more BLDC motors **40**, heaters or other actuators supplied by the 48V-supply voltage V**48**.

(19) From the state of the art, examples are known where the 12V-domain **20** includes a CAN controller arranged in between the CAN pins CANL, CANH and the 12V-side **11**.**12**V of the data interface **11**.

(20) Also, examples are known, where the 12V-domain **20** includes a 12V-microcontroller **22**, yet where the 48V-domain **30** does not include the 48V-microcontroller **32**, as shown in FIG. **2**. In such an example, data such as status information, acquired measurements or control signals is transferred between the 12V-microcontroller **22** and various components of the 48V-domain **30**, such as the 48V-power supply **31**, the 48V-load control **33** and the 48V-motor control **34**, via the

data interface **11**. To provide access to an external CAN bus for the 12V-microcontroller **22**, such an example may also include a 12V-CAN controller **25** arranged in between the CAN pins CANH, CANL and the 12V-microcontroller **22**.

(21) Therefore, it is not sufficient in those examples to form the data interface **11** as serial interface such as a CAN interface. Rather, the data interface **11** is designed for the parallel transfer of multiple digital and/or analog signals. Of course, in order to maintain the galvanic isolation of the domains **20**, **30**, each of the signal lines of the data interface **11** has to be designed for galvanic separation.

(22) In yet a further example known from the state of the art, the 48V-motor control **34** is substituted by a controller that is implemented in the 12V-domain **20** and a power circuitry having power transistors that is implemented in the 48V-domain **30**. Such an example requires additional signal lines along the data interface **11** controlling the gate voltages of the power transistors. In such an example, the controlling of the gate voltages precisely and the conformance of electromagnetic compatibility raise an additional technical burden.

(23) Also, examples are known from the state of the art, where a 12V-load control **23** is implemented in the 12V-domain **20**, which is configured to control and/or verify the status of the 12V-supply voltage V**12**.

(24) FIG. **3** schematically shows an exemplary ECU with a 12V-domain **20** and a 48V-domain **30** that are arranged on the same PCB.

(25) The 12V-domain **20** is electrically supplied by a 12V-supply voltage V**12** of 12 Volts and by a 12V-ground G**12**. The 48V-domain **30** is electrically supplied by a 48V-supply voltage V**48** of 48 Volts and by a 48V-ground G**48**.

(26) The 12V-domain **20** is formed as a Controller Area Network (CAN) node. It provides a first CAN pin CANH and a second CAN pin CANL that are connectable with an external two-wire CAN bus.

(27) The ECU **10** includes a data interface **11** that is designed to transfer data between the 12V-domain **20** and the 48V-domain **30**. The data interface **11** has a 12 Volts side **11**.**12**V connected with the 12V-domain **20** and a 48 Volts side **11**.**48**V connected with the 48V-domain **30**. Both sides **11**.**12**V, **11**.**48**V of the data interface **11** are galvanically isolated from each other such that this isolation withstands a voltage of at least 1 Kilovolt.

(28) In an example, the data interface **11** is configured according to standardized full or half duplex communication protocols for digital data such as CAN or serial peripheral interface (SPI). In an example, the data interface **11** and the domains **20**, **30** are configured such that the 12V-domain **20** acts as a master whereas the 48V-domain **30** acts as a slave.

(29) The data interface **11** includes a plurality of data lines designed to transmit digitized data between the 12V-domain **20** and the 48V-domain **30**. Each of the data lines is galvanically isolated in order to maintain the galvanic separation between both sides **11**.**12**V, **11**.**48**V of the data interface **11**.

(30) The 12V-domain **20** includes a 12V-power supply **21** that electrically supplies the 12 Volts side **11**.**12**V of the data interface **11**. The 12V-power supply **21** is powered by the 12V-supply voltage V**12**.

(31) The 48V-domain **30** includes a 48V-power supply **31** that electrically supplies the 48 Volts side **11**.**48**V of the data interface **11**. According to the disclosure, the 48V-power supply **31** is powered via a supply interface **12** arranged in between the 12V-domain **20** and the 48V-domain **30**.

(32) The supply interface **12** has a 12 Volts side **12**.**12**V connected with the 12V-domain **20** and a 48 Volts side **12**.**48**V connected with the 48V-domain **30**. Both sides **12**.**12**V, **12**.**48**V of the supply interface **12** are galvanically isolated from each other.

(33) On its 12 Volts side **12**.**12**V, the supply interface **12** is connected with the 12 Volts power line and thus with the 12V-supply voltage of 12 Volts.

(34) On its 48 Volts side **12**.**48**V, the supply interface **12** is connected with and supplying the 48V-

power supply **31**.
(35) In an example, the supply interface **12** may be formed as a flyback converter. But also other examples of DC/DC converters known from the state of the art that provide galvanic separation of the input from the output may be used.
(36) The 48V-power supply **31** has a 48V-power status pin **31**.S that indicates the status of the 48V-power supply **31**.
(37) The power supplies **21**, **31** provide a voltage of 5 Volts to power each side **11**.**12**V, **11**.**48**V of the data interface **11**.
(38) The 48V-domain **30** further includes a 48V-microcontroller **32**, a 48V-load control **33** and a 48V-motor control **34**.
(39) The 48V-load control **33** is powered by the 48V-supply voltage V**48** and is designed to control and/or verify the load status of the externally provided voltage of 48 Volts via a first and a second probe pin V**48**H, V**48**L. The probe pins V**48**H, V**48**L are connected with the 48V-supply voltage V**48** and the 48V-ground G**48**, respectively, via external measurement resistors.
(40) The 48V-motor control **34** is powered by the 48V-supply voltage V**48** and is designed to control an external brushless directed current (BLDC) motor **40**. The BLDC motor **40** may be formed as an actuator, such as a high-power pump motor.
(41) In some implementations, the 48V-domain **30** may include further controllers powered by the 48V-supply voltage V**48** and designed to control external electrical loads, such as heaters. Also, controllers that control more than one external electrical load are known from the state of the art.
(42) The 48V-microcontroller **32** is powered by the 48V-power supply **31**. As an example, the 48V-microcontroller **32** is supplied with a voltage of 5 Volts provided by the 48V-power supply **31**.
(43) The 48V-microcontroller **32** is connected with the 48 Volts side **11**.**48**V of the data interface **11**, with the 48V-power status pin **31**.S of the 48V-power supply **31**, with the 48V-load control **33** and with the 48V-motor control **34** such that it may transfer data, for example status information, acquired measurements or control signals, with the data interface **11**, the 48V-power supply **31**, the 48V-load control **33** and the 48V-motor control **34**. The connections may be formed as multi-wire connections and may be designed to carry digital and/or analog signals.
(44) The 48V-microcontroller **32** is configured to receive instructions via the data interface **11** and translate such instructions into control signals controlling the 48V-motor control **34**. The 48V-microcontroller **32** also retrieves diagnostic data, such as status data from the 48V-power supply **31**, from the 48V-load control **33** and/or from the 48V-motor control **34**, and to transfer such diagnostic data via the data interface **11** to the 12V-domain **20**. The 48V-microcontroller **32** may also be configured to run software that implements a control loop controlling peripheral components such as one or more BLDC motors **40**, heaters or other actuators supplied by the 48V-supply voltage V**48**.
(45) The 12V-domain **20** includes 12V-microcontroller **22** that is supplied by the 12V-power supply **21** as known from the state of the art. Furthermore, the 12V-domain **20** includes a 12V-load control **23**, a 12V-motor control **24** and a 12V-CAN controller **25**.
(46) The 12V-CAN controller **25** is supplied with a 5 Volts output voltage of the 12V-power supply **21** and is connected with the CAN pins CANH, CANL. The 12V-CAN controller **25** is further connected with the 12V-microcontroller **22**. The 12V-CAN controller **25** is configured to drive an external CAN bus if connected with the CAN pins CANH, CANL and to transfer data between such CAN bus and the 12V-microcontroller **22**.
(47) The 12V-load control **23** is powered by the 12V-supply voltage V**12** and is designed to control and/or verify the load status of the externally provided voltage of 12 Volts via a first and a second probe pin V**12**H, V**12**L. The probe pins V**12**H, V**12**L are connected with the 12V-supply voltage V**12** and the 12V-ground G**12**, respectively, via external measurement resistors.
(48) The 12V-motor control **24** is powered by the 12V-supply voltage V**12** and is designed to control an external load such as a low-power brushless directed current (BLDC) motor **50**. The

low-power BLDC motor **50** may be formed as an actuator, for example a gear selection motor or a valve.
(49) In general, first loads with relatively low power consumption are driven by the 12V-domain **20**, whereas actuators with relatively (in comparison to said first loads) high power consumption are driven by the 48V-domain **30** in order to optimize the power consumption.
(50) In some examples, the 12V-domain **20** may include further controllers powered by the 12V-supply voltage V**12** and designed to control external electrical loads, such as heaters. Also, controllers that control more than one external electrical load are known from the state of the art.
(51) The 12V-microcontroller **22** is connected with the 12 Volts side **11**.**12**V of the data interface **11**, with the 48V-power status pin **31**.S of the 12V-power supply **21**, with the 12V-load control **23** and with the 12V-motor control **24** such that it may transfer data, for example status information, acquired measurements or control signals, with the data interface **11**, the 12V-power supply **21**, the 12V-load control **23** and the 12V-motor control **24**. The connections may be formed as multi-wire connections and may be designed to carry digital and/or analog signals.
(52) In particularity, the 12V-microcontroller **22** is configured to receive instructions via the 12V-CAN controller **25** from an external CAN bus, if connected, and to translate such instructions into control signals controlling the 12V-motor control **24**.
(53) The 12V-microcontroller **22** furthermore translates instructions received from the 12V-CAN controller **25** into signals, such as digital signals, that are passed to the data interface **11** and further on to the 48V-microcontroller **32**. Thus, it is possible to control, via the 12V-CAN controller **25**, the 12V-microcontroller **22** and the data interface **11**, the 48V-microcontroller **32** from the external CAN bus connected to the CAN pins CANH, CANL.
(54) The 12V-microcontroller **22** is furthermore configured to receive signals, preferably digital signals, sent from the 48V-microcontroller **32** via the data interface **11**. Thus it is possible to run a software program on the 48V-microcontroller **32** that retrieves data, such as diagnostic load control data or diagnostic motor control data from controls **33**, **34** of the 48V-domain **30**, pre-process and evaluate such data and transfer the result of such pre-processing or evaluation via the data interface **11** to the 12V-microcontroller **22** and further on to the external CAN bus.
(55) As an advantage, it is possible to implement control loops controlling controls **33**, **34** and other peripherals of the 48V-domain **30** with tight timing restrictions in the software running on the 48V-microcontroller **32**, whereas less time sensitive operations can be programmed into the software running on the 12V-microcontroller **22** or on an external processing device connected with the ECU **10** via a CAN bus. This enables a lower latency and thus an improved stability for control loops controlling periphery of the 48V-domain **30**
(56) Whereas in general it is thus possible to assign software functionality to either of the microcontrollers **22**, **32** arbitrarily, in some examples all safety relevant functions are assigned to the 12V-microcontroller **22** and the microcontrollers **22**, **32** are configured such that the 12V-microcontroller **22** acts as a leading system (master) and the 48V-microcontroller **32** acts as a following system (slave) in the communication along the data interface **11**.
(57) As a further advantage, it is possible to digitize data such as measurement data in the 48V-domain **30**, for example a voltage probed by the 48V-load control **33**, by the 48V-microcontroller **32**. In addition or alternatively, it is possible to convert digital data passed via the data interface **11** into analog values by the 48V-microcontroller **32**. Thereby, the data interface **11** can be relieved of the requirement of transferring analog signals. This improves the accuracy and robustness of the transfer of values between the domains **20**, **30**. This can also improve the electromagnetic compatibility (EMC) of the ECU **10** or relieve technical measure to fulfil EMC requirements.
(58) The 12V-microcontroller **22** is furthermore configured to retrieve diagnostic data, such as status data from the 12V-power supply **21**, from the 12V-load control **23** and/or from the 12V-motor control **24**, and to transfer such diagnostic data via the 12V-CAN controller **25** to the outside CAN bus. The 12V-microcontroller **22** may also be configured to run software that implements a

control loop controlling peripheral components such as one or more low-power BLDC motors **50** or other actuators supplied by the 12V-supply voltage V**12**.
(59) As yet a further advantage of the ECU **10** according to FIG. **3**, the 48V-power supply **31** and the 48V-microcontroller **32** are powered on as soon as the 12V-supply voltage V**12** is available. Thereby, diagnostic tests such as a power-on self-test (POST) of the 48V-microcontroller **32** can be run before the 48V-supply voltage V**48** is switched on and, in case of a failure detected by a test, the switching on of the 48V-supply voltage V**48** can be prevented and the entire ECU **10** can be brought into a failsafe state. Thereby the reliability of the ECU **10** is improved.
(60) A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the disclosure. Accordingly, other implementations are within the scope of the following claims.
LIST OF REFERENCE SIGNS
(61) **10** electronic control unit (ECU) **11** data interface **11**.**12**V12 Volts side **11**.**48**V48 Volts side **12** supply interface **12**.**12**V12 Volts side **12**.**48**V48 Volts side **20** 12V-domain **21** 12V-power supply **22** 12V-microcontroller **23** 12V-load control **24** 12V-motor control **25** 12V-CAN controller **30** 48V-domain **31** 48V-power supply **31**.S 48V-power status pin **32** 48V-microcontroller **33** 48V-load control **34** 48V-motor control **40** brushless directed current (BLDC) motor **50** low-power BLDC motor CANH first CAN pin CANL second CAN pin G**12** 12V-ground G**48** 48V-ground V**12** 12V-supply voltage, first supply voltage V**48** 48V-supply voltage, second supply voltage V**48**H first probe pin V**48**L second probe pin V**12**H first probe pin V**12**L second probe pin

Claims

1. An electronic control unit (ECU) for a vehicle, the electronic control unit comprising: a 12V-domain designed to control an electric load supplied with a first supply voltage; a 48V-domain designed to control an electric load supplied with a second supply voltage, the 12V-domain and the 48V-domain are arranged on a single printed circuit board (PCB), the 48V-domain comprises: a 48V-microcontroller; and a 48V-power supply supplying the 48V-microcontroller; and a galvanically isolated data interface designed to transfer data between the domains according to a half-duplex or a full-duplex communication protocol, the galvanically isolated data interface galvanically isolates the 12V-domain and the 48V-domain from each other and connects the 12V-domain and the 48V-domain with each other; wherein the 48V-power supply is powered by the first supply voltage from the 12V-domain via a galvanically isolated supply interface, and wherein the 48V-domain comprises a 48V-load control designed to verify a status of the second supply voltage and/or a 48V-motor control designed to control at least one electric load supplied by the second supply voltage, wherein the 48V-microcontroller is arranged and configured such as to control the 48V-load control and/or the 48V-motor control.
2. The electronic control unit of claim 1, wherein the data interface transfers digital data.
3. The electronic control unit of claim 1, wherein the supply interface comprises a flyback converter.
4. The electronic control unit of claim 3, wherein the data interface supports a controller area network (CAN) protocol and/or a serial peripheral interface (SPI) protocol and/or an inter-integrated circuit (I2C) protocol.
5. The electronic control unit of claim 1, wherein the first supply voltage is 12 Volts and the second supply voltage is 48 Volts.
6. An electronic control unit (ECU) for a vehicle, the electronic control unit comprising: a 12V-domain designed to control an electric load supplied with a first supply voltage; a 48V-domain designed to control an electric load supplied with a second supply voltage, the 12V-domain and the 48V-domain are arranged on a single printed circuit board (PCB), the 48V-domain comprises: a 48V-microcontroller; and a 48V-power supply supplying the 48V-microcontroller; and a

galvanically isolated data interface designed to transfer data between the domains according to a half-duplex or a full-duplex communication protocol, the galvanically isolated data interface galvanically isolates the 12V-domain and the 48V-domain from each other and connects the 12V-domain and the 48V-domain with each other; wherein the 48V-power supply is powered by the first supply voltage from the 12V-domain via a galvanically isolated supply interface, and wherein the 48V-microcontroller performs a power-on-test of the 48V-domain upon switching on the first supply voltage.

7. An electronic control unit (ECU) for a vehicle, the electronic control unit comprising: a 12V-domain designed to control an electric load supplied with a first supply voltage; a 48V-domain designed to control an electric load supplied with a second supply voltage, the 12V-domain and the 48V-domain are arranged on a single printed circuit board (PCB), the 48V-domain comprises: a 48V-microcontroller; and a 48V-power supply supplying the 48V-microcontroller; and a galvanically isolated data interface designed to transfer data between the domains according to a half-duplex or a full-duplex communication protocol, isolates the 12V-domain and the 48V-domain from each other and connects the 12V-domain and the 48V-domain with each other; wherein the 48V-power supply is powered by the first supply voltage from the 12V-domain via a galvanically isolated supply interface, and wherein the 12V-domain comprises a 12V-microcontroller connected via the data interface with the 48V-microcontroller, wherein the 12V-microcontroller is configured as a master and the 48V-microcontroller is configured as a slave.

8. The electronic control unit of claim 7, wherein the 12V-domain comprises a 12V-load control designed to verify a status of the first supply voltage and/or a 12V-motor control designed to control at least one electric load supplied by the first supply voltage, wherein the 12V-microcontroller is arranged and configured such as to control the 12V-load control and/or the 12V-motor control.

9. The electronic control unit of claim 7, wherein the 12V-domain comprises a 12V-CAN controller connected with the 12V-microcontroller.

10. The electronic control unit of claim 7, wherein the 12V-microcontroller performs operations that are relevant for the safety of the vehicle and the 48V-microcontroller performs operations that are not relevant for the safety of the vehicle.