Vehicle Control Unit (VCU)

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Contents

Chapter 1

FastChargeSAE VCU firmware

Vehicle Control Unit (VCU) firmware is based upon 4 states:

- STAND: stato 0, accensione della vettura, si ritorna qui ogni volta che casca l'SC
- HVON: stato 1, alta tensione attiva si accede solo da STAND tramite AIRbutton e SC$>$3V
- DRIVE: stato 2, lo stato di guida sicura, accedibile tramite procedura RTD ma anche con lo scatto delle plausibilità tramite procedura di rientro

Chapter 2

CAN Networks

Two CAN networks have been designed to be inserted into the vehicle: a first CAN network between the VCU and the inverter (CAN funzionale) and a second CAN network between the VCU, TCU and SCUs (CAN servizi).

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3.1 Modules

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Module Documentation

6.1 CAN_module_group

Modules

- CAN_funzionale_group
- CAN_servizi_group

Macros

- #define VCU_NODE_ID 2
  VCU Node ID.

Functions

- bool can_init ()
  This function initializes both CAN funzionale and CAN servizi networks.

6.1.1 Detailed Description

6.1.2 Function Documentation

6.1.2.1 can_init()

```
bool can_init ( )
```

This function initializes both CAN funzionale and CAN servizi networks.

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Return values

true	CAN networks initialized successfully
false	CAN networks initialization failed

Definition at line 26 of file CO_can.cpp.

6.2 CAN_funzionale_group

Macros

- #define INVERTER_NODE_ID 1

  Inverter Node ID.

Functions

- volatile bool can_funzionale_initialized ()

  This function returns CAN funzionale initialization status.
- void can_funzionale_send_sync ()

  This function sends a periodic CANOpen sync message to inverter slave node.
- void CAN_FUNZ_BOOTUP_CB (CAN_FRAME *frame)

  This function manage boot-up message sent over CAN funzionale network by inverter slave node. Upon boot-up message reception the VCU send a SDO client request for check inverter vendor ID; then inverter is considered online over CAN funzionale network.
- void CAN_FUNZ_VENDOR_ID_CB (CAN_FRAME *frame)

  This function manage SDO server response with inverter Vendor ID. VCU sends NMT operational and PDOs to enable PWM; then inverter is considered correctly configured and a timer is started for sending periodic sync messages.
- void CAN_FUNZ_GENERAL_CB (CAN_FRAME *frame)

  This function manage TPDO from inverter and deserializes data:
- bool can_funzionale_init ()

  This function initialize CAN funzionale hardware port with baudrate CAN_FUNZ_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from inverter slave node (filter = 0x00000700 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); mailbox 1 is configured for receiving vendorID SDO response from inverter (filter = 0x00000580 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); remaining mailboxes are configured for receiving TPDOs from inverter slave node (filter = 0x00000080, mask = 0x1FFFFCFF).
- volatile bool can_funzionale_online ()

  This function returns if inverter is online and active over CAN funzionale.
- void inverter_torque_request (uint16_t torque)

  This function send torque request to inverter. If inverter is active over CAN funzionale network then the request is done via RPDO1 viceversa it's done via analog signal.
- void inverter_regen_request (uint16_t regen)

  This function send regen request to inverter.
- volatile uint16_t get_torque_actual_value ()

  This function return the torque value requested by inverter to motor retrieved from TPDO1 from inverter over CAN funzionale network.

Variables

- volatile bool can_funz_initialized = false

  CAN funzionale initialization status flag (true if initialized)
- volatile bool inverter_online = false

  Inverter online status flag (true if online)
- volatile bool inverter_configured = false

  Inverter configured status flag (true if configured)
- volatile uint16_t torque_actual_value = 0

  Torque requested by inverter to motor.

6.2.1 Detailed Description

6.2.2 Function Documentation

6.2.2.1 CAN_FUNZ_BOOTUP_CB()

```
void CAN_FUNZ_BOOTUP_CB (
            CAN_FRAME * frame )
```

This function manage boot-up message sent over CAN funzionale network by inverter slave node. Upon boot-up message reception the VCU send a SDO client request for check inverter vendor ID; then inverter is considered online over CAN funzionale network.

Author

Arella Matteo
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Parameters

in	*frame*	CAN frame received from CAN funzionale port

Definition at line 77 of file can_funzionale.cpp.

6.2.2.2 CAN_FUNZ_GENERAL_CB()

```
void CAN_FUNZ_GENERAL_CB (
            CAN_FRAME * frame )
```

This function manage TPDO from inverter and deserializes data:

TPDO num	NODE-ID	Data
1	INVERTER_NODE_ID	Torque Actual Val

Author

Arella Matteo
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Parameters

in	*frame*	CAN frame received from CAN servizi port

Definition at line 170 of file can_funzionale.cpp.

6.2.2.3 CAN_FUNZ_VENDOR_ID_CB()

```
void CAN_FUNZ_VENDOR_ID_CB (
            CAN_FRAME * frame )
```

This function manage SDO server response with inverter Vendor ID. VCU sends NMT operational and PDOs to enable PWM; then inverter is considered correctly configured and a timer is started for sending periodic sync messages.

Author

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Parameters

in	*frame*	CAN frame received from CAN servizi port

Definition at line 108 of file can_funzionale.cpp.

6.2.2.4 can_funzionale_init()

```
bool can_funzionale_init ( )
```

This function initialize CAN funzionale hardware port with baudrate CAN_FUNZ_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from inverter slave node (filter = 0x00000700 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); mailbox 1 is configured for receiving vendorID SDO response from inverter (filter = 0x00000580 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); remaining mailboxes are configured for receiving TPDOs from inverter slave node (filter = 0x00000080, mask = 0x1FFFFCFF).

This function initializes CAN funzionale network with inverter.

Author

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Return values

true	CAN servizi initialized
false	CAN servizi not initialized

Author

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Return values

true	CAN funzionale network initialized successfully
false	CAN funzionale network initialization failed

Definition at line 192 of file can_funzionale.cpp.

6.2.2.5 can_funzionale_initialized()

```
volatile bool can_funzionale_initialized ( )
```

This function returns CAN funzionale initialization status.

Author

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Return values

true	CAN funzionale network initialized
false	CAN funzionale network not initialized

Definition at line 44 of file can_funzionale.cpp.

6.2.2.6 can_funzionale_online()

```
volatile bool can_funzionale_online ( )
```

This function returns if inverter is online and active over CAN funzionale.

This function returns if CAN funzionale network is online.

Author

Arella Matteo
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Return values

true	CAN funzionale initialized, inverter online and inverter configured successfully
false	CAN funzionale not initialized or inverter not online or configured.

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Return values

true	CAN funzionale network online
false	CAN funzionale network offline

Definition at line 226 of file can_funzionale.cpp.

6.2.2.7 can_funzionale_send_sync()

```
void can_funzionale_send_sync ( )
```

This function sends a periodic CANOpen sync message to inverter slave node.

Author

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Definition at line 55 of file can_funzionale.cpp.

6.2.2.8 get_torque_actual_value()

```
volatile uint16_t get_torque_actual_value ( )
```

This function return the torque value requested by inverter to motor retrieved from TPDO1 from inverter over CAN funzionale network.

This function return the torque value requested by inverter to motor.

Author

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Returns

Torque requested by inverter to motor

Definition at line 276 of file can_funzionale.cpp.

6.2.2.9 inverter_regen_request()

```
void inverter_regen_request (
            uint16_t regen )
```

This function send regen request to inverter.

Author

Arella Matteo
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Parameters

in	*regen*	Regen request value

Definition at line 258 of file can_funzionale.cpp.

6.2.2.10 inverter_torque_request()

```
void inverter_torque_request (
            uint16_t torque )
```

This function send torque request to inverter. If inverter is active over CAN funzionale network then the request is done via RPDO1 viceversa it's done via analog signal.

This function send torque request to inverter.

Author

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Parameters

in	*torque*	Torque value in percentage multiplied per tcs torque limiter coefficient

Definition at line 241 of file can_funzionale.cpp.

6.3 CAN_servizi_group

Macros

- #define SCU_FRONTAL_NODE_ID 1

  Frontal SCU Node ID.
- #define TCU_NODE_ID 4

  TCU Node ID.

Functions

- void timeout ()

  This function is executed periodically after CAN servizi 'go Operational' NMT request is sent. When timeout occurs if next_pedals_seq_num is greater than curr_pedals_seq_num then frontal SCU is considered active, viceversa it is considered offline.
- volatile bool can_servizi_initialized ()

  This function returns CAN servizi initialization status.
- void CAN_SERV_BOOTUP_CB (CAN_FRAME *frame)

  This function manage boot-up messages sent over CAN servizi network by slave nodes.
- void CAN_SERV_GENERAL_CB (CAN_FRAME *frame)

  This function manage PDOs received over CAN servizi network and deserializes data:
- bool can_servizi_init ()

  This function initialize CAN servizi hardware port with baudrate CAN_SERV_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from CAN servizi slave nodes (filter = 0x00000700, mask = 0x1FFFFF80); remaining mailboxes are configured for receiving TPDOs from CAN servizi slave nodes (filter = 0x00000080, mask = 0x1FFF↩ FC80).
- void can_servizi_go_operational ()

  This function send a CANOpen master NMT message for request 'go to Operational' state to CAN servizi slave nodes (SCUs and TCU).
- volatile bool can_servizi_online ()

  This function returns if CAN servizi network is online.
- volatile bool tcs_online ()

  This function returns if TCU node is active and online on the CAN servizi network.
- volatile uint8_t get_servizi_tps1 ()

  This function returns the value of the first APPS in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_servizi_tps2 ()

  This function returns the value of the second APPS in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_servizi_brake ()

  This function returns the value of brake pedal position sensor in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile bool get_servizi_apps_plausibility ()

  This function returns the value of APPS plausibility retrieved by frontal SCU node over CAN servizi network.
- volatile bool get_servizi_brake_plausibility ()

  This function returns the value of brake plausibility retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_tcs_torque_coefficient ()

  This function returns the value of torque limiter percentage retrieved by TCU node over CAN servizi network.

Variables

- volatile bool can_serv_initialized = false

  CAN servizi initialization status flag (true if initialized)
- volatile bool SCU_F_online = false

  Frontal SCU online status flag (true if online)
- volatile bool TCS_online = false

  TCS online status flag (true if online)
- volatile uint32_t curr_pedals_seq_num = 0

  Frontal SCU PDOtx1 current sequence number.
- volatile uint32_t next_pedals_seq_num = 0

  Frontal SCU PDOtx1 next sequence number.
- volatile uint8_t tps1_percentage = 0

  First APPS percentage value retrieved by frontal SCU node.
- volatile uint8_t tps2_percentage = 0

  Second APPS percentage value retrieved by frontal SCU node.
- volatile uint8_t brake_percentage = 0

  Brake pedal position sensor percentage value retrieved by frontal SCU node.
- volatile bool apps_plausibility = true

  APPS plausibility status retrieved by frontal SCU node.
- volatile bool brake_plausibility = true

  Brake plausibility status retrieved by frontal SCU node.
- volatile uint8_t tcs_coefficient = 0

  torque limiter percentage retrieved by TCU node

6.3.1 Detailed Description

6.3.2 Function Documentation

6.3.2.1 CAN_SERV_BOOTUP_CB()

```
void CAN_SERV_BOOTUP_CB (
            CAN_FRAME * frame )
```

This function manage boot-up messages sent over CAN servizi network by slave nodes.

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Parameters

in	*frame*	CAN frame received from CAN servizi port

Definition at line 115 of file can_servizi.cpp.

6.3.2.2 CAN_SERV_GENERAL_CB()

```
void CAN_SERV_GENERAL_CB (
            CAN_FRAME * frame )
```

This function manage PDOs received over CAN servizi network and deserializes data:

TPDO num	NODE-ID	Length	Data
1	SCU_FRONTAL_NODE_ID	4	APPS1 percentage
			APPS2 percentage
			Brake percentage
			APPS plausibility
			BRAKE plausibility
1	TCU_NODE_ID	1	TCU torque limiter

When PDOtx1 message is received from frontal SCU node then next_pedals_seq_num is incremented for keep track of last pedals message received.

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Parameters

in	*frame*	CAN frame received from CAN servizi port

Definition at line 149 of file can_servizi.cpp.

6.3.2.3 can_servizi_go_operational()

```
void can_servizi_go_operational ( )
```

This function send a CANOpen master NMT message for request 'go to Operational' state to CAN servizi slave nodes (SCUs and TCU).

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Definition at line 206 of file can_servizi.cpp.

6.3.2.4 can_servizi_init()

```
bool can_servizi_init ( )
```

This function initialize CAN servizi hardware port with baudrate CAN_SERV_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from CAN servizi slave nodes (filter = 0x00000700, mask = 0x1FFFFF80); remaining mailboxes are configured for receiving TPDOs from CAN servizi slave nodes (filter = 0x00000080, mask = 0x1FFFFC80).

This function initializes CAN servizi network.

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Return values

true	CAN servizi initialized
false	CAN servizi not initialized

Author

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Return values

true	CAN servizi network initialized successfully
false	CAN servizi network initialization failed

Definition at line 182 of file can_servizi.cpp.

6.3.2.5 can_servizi_initialized()

```
volatile bool can_servizi_initialized ( )
```

This function returns CAN servizi initialization status.

Author

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Return values

true	CAN servizi network initialized
false	CAN servizi network not initialized

Definition at line 102 of file can_servizi.cpp.

6.3.2.6 can_servizi_online()

```
volatile bool can_servizi_online ( )
```

This function returns if CAN servizi network is online.

Author

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Return values

true	CAN servizi network online
false	CAN servizi network offline

Definition at line 220 of file can_servizi.cpp.

6.3.2.7 get_servizi_apps_plausibility()

```
volatile bool get_servizi_apps_plausibility ( )
```

This function returns the value of APPS plausibility retrieved by frontal SCU node over CAN servizi network.

Author

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Return values

true	APPS plausibility
false	APPS implausibility

Definition at line 245 of file can_servizi.cpp.

6.3.2.8 get_servizi_brake()

```
volatile uint8_t get_servizi_brake ( )
```

This function returns the value of brake pedal position sensor in percentage, retrieved by frontal SCU node over CAN servizi network.

Author

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Returns

Brake pedal position percentage value

Definition at line 240 of file can_servizi.cpp.

6.3.2.9 get_servizi_brake_plausibility()

```
volatile bool get_servizi_brake_plausibility ( )
```

This function returns the value of brake plausibility retrieved by frontal SCU node over CAN servizi network.

Author

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Return values

true	Brake plausibility
false	Brake implausibility

Definition at line 250 of file can_servizi.cpp.

6.3.2.10 get_servizi_tps1()

```
volatile uint8_t get_servizi_tps1 ( )
```

This function returns the value of the first APPS in percentage, retrieved by frontal SCU node over CAN servizi network.

Author

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Returns

First APPS percentage value

Definition at line 230 of file can_servizi.cpp.

6.3.2.11 get_servizi_tps2()

```
volatile uint8_t get_servizi_tps2 ( )
```

This function returns the value of the second APPS in percentage, retrieved by frontal SCU node over CAN servizi network.

Author

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Returns

Second APPS percentage value

Definition at line 235 of file can_servizi.cpp.

6.3.2.12 get_tcs_torque_coefficient()

```
volatile uint8_t get_tcs_torque_coefficient ( )
```

This function returns the value of torque limiter percentage retrieved by TCU node over CAN servizi network.

Author

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Returns

Torque limiter coefficient in percentage

Definition at line 255 of file can_servizi.cpp.

6.3.2.13 tcs_online()

```
volatile bool tcs_online ( )
```

This function returns if TCU node is active and online on the CAN servizi network.

Author

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Return values

true	TCS is online and active
false	TCS is offline

Definition at line 225 of file can_servizi.cpp.

6.3.2.14 timeout()

```
void timeout ( )
```

This function is executed periodically after CAN servizi 'go Operational' NMT request is sent. When timeout occurs if next_pedals_seq_num is greater than curr_pedals_seq_num then frontal SCU is considered active, viceversa it is considered offline.

Author

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Definition at line 93 of file can_servizi.cpp.

6.4 Board_model_group

Functions

- void model_init ()

  This function initializes hardware board.
- volatile uint8_t get_tps1_percentage ()

  This function returns the value of the first APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint8_t get_tps2_percentage ()

  This function returns the value of the second APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint8_t get_brake_percentage ()

  This function returns the value of the brake pedal position sensor in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile bool get_apps_plausibility ()

  This function returns the value of APPS plausibility retrieved by CAN servizi network, if online, or by analog signal.
- volatile bool get_brake_plausibility ()

  This function returns the value of brake plausibility retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint16_t get_SC_value ()

  This function returns the value of the SC.
- void **model_enable_calibrations** ()
- void **model_disable_calibrations** ()

6.4.1 Detailed Description

6.4.2 Function Documentation

6.4.2.1 get_apps_plausibility()

```
volatile bool get_apps_plausibility ( )
```

This function returns the value of APPS plausibility retrieved by CAN servizi network, if online, or by analog signal.

Author

Arella Matteo
(mail: arella.1646983@studenti.uniroma1.it)

Return values

true	APPS plausibility
false	APPS implausibility

Definition at line 203 of file model.cpp.

6.4.2.2 get_brake_percentage()

```
volatile uint8_t get_brake_percentage ( )
```

This function returns the value of the brake pedal position sensor in percentage, retrieved by CAN servizi network, if online, or by analog signal.

Author

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Returns

Brake pedal position sensor percentage value

Definition at line 199 of file model.cpp.

6.4.2.3 get_brake_plausibility()

```
volatile bool get_brake_plausibility ( )
```

This function returns the value of brake plausibility retrieved by CAN servizi network, if online, or by analog signal.

Author

Arella Matteo
(mail: arella.1646983@studenti.uniroma1.it)

Return values

true	Brake plausibility
false	Brake implausibility

Definition at line 207 of file model.cpp.

6.4.2.4 get_SC_value()

```
volatile uint16_t get_SC_value ( )
```

This function returns the value of the SC.

Author

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Returns

SC value

Definition at line 211 of file model.cpp.

6.4.2.5 get_tps1_percentage()

```
volatile uint8_t get_tps1_percentage ( )
```

This function returns the value of the first APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.

Author

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Returns

First APPS percentage value

Definition at line 191 of file model.cpp.

6.4.2.6 get_tps2_percentage()

```
volatile uint8_t get_tps2_percentage ( )
```

This function returns the value of the second APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.

Author

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Returns

Second APPS percentage value

Definition at line 195 of file model.cpp.

6.4.2.7 model_init()

```
void model_init ( )
```

This function initializes hardware board.

Author

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Definition at line 156 of file model.cpp.

Chapter 7

Class Documentation

7.1 pedals_ranges_s Struct Reference

Public Attributes

- volatile uint16_t **tps1_max**
- volatile uint16_t **tps1_low**
- volatile uint16_t **tps2_max**
- volatile uint16_t **tps2_low**
- volatile uint16_t **brake_max**
- volatile uint16_t **brake_low**

7.1.1 Detailed Description

Definition at line 56 of file model.cpp.

The documentation for this struct was generated from the following file:

- model.cpp

Chapter 8

File Documentation

8.1 can_funzionale.cpp File Reference

CAN funzionale module implementation.

```
#include "can_funzionale.h"
#include "def.h"
#include <due_can.h>
#include <DueTimer.h>
```

Functions

- volatile bool can_funzionale_initialized ()

  This function returns CAN funzionale initialization status.
- void can_funzionale_send_sync ()

  This function sends a periodic CANOpen sync message to inverter slave node.
- void CAN_FUNZ_BOOTUP_CB (CAN_FRAME *frame)

  This function manage boot-up message sent over CAN funzionale network by inverter slave node. Upon boot-up message reception the VCU send a SDO client request for check inverter vendor ID; then inverter is considered online over CAN funzionale network.
- void CAN_FUNZ_VENDOR_ID_CB (CAN_FRAME *frame)

  This function manage SDO server response with inverter Vendor ID. VCU sends NMT operational and PDOs to enable PWM; then inverter is considered correctly configured and a timer is started for sending periodic sync messages.
- void CAN_FUNZ_GENERAL_CB (CAN_FRAME *frame)

  This function manage TPDO from inverter and deserializes data:
- bool can_funzionale_init ()

  This function initialize CAN funzionale hardware port with baudrate CAN_FUNZ_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from inverter slave node (filter = 0x00000700 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); mailbox 1 is configured for receiving vendorID SDO response from inverter (filter = 0x00000580 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); remaining mailboxes are configured for receiving TPDOs from inverter slave node (filter = 0x00000080, mask = 0x1FFFFCFF).
- volatile bool can_funzionale_online ()

  This function returns if inverter is online and active over CAN funzionale.
- void inverter_torque_request (uint16_t torque)

  This function send torque request to inverter. If inverter is active over CAN funzionale network then the request is done via RPDO1 viceversa it's done via analog signal.
- void inverter_regen_request (uint16_t regen)

  This function send regen request to inverter.
- volatile uint16_t get_torque_actual_value ()

  This function return the torque value requested by inverter to motor retrieved from TPDO1 from inverter over CAN funzionale network.

Variables

- volatile bool can_funz_initialized = false

  CAN funzionale initialization status flag (true if initialized)
- volatile bool inverter_online = false

  Inverter online status flag (true if online)
- volatile bool inverter_configured = false

  Inverter configured status flag (true if configured)
- volatile uint16_t torque_actual_value = 0

  Torque requested by inverter to motor.

8.1.1 Detailed Description

CAN funzionale module implementation.

Author

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(mail: arella.1646983@studenti.uniroma1.it)

Date

2018

8.2 can_funzionale.h File Reference

CAN funzionale module header.

```
#include "common.h"
```

Functions

- bool can_funzionale_init ()

  This function initialize CAN funzionale hardware port with baudrate CAN_FUNZ_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from inverter slave node (filter = 0x00000700 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); mailbox 1 is configured for receiving vendorID SDO response from inverter (filter = 0x00000580 + INVERTER_NODE_ID, mask = 0x1FFFFFFF); remaining mailboxes are configured for receiving TPDOs from inverter slave node (filter = 0x00000080, mask = 0x1FFFFCFF).
- volatile bool can_funzionale_initialized ()

  This function returns CAN funzionale initialization status.
- volatile bool can_funzionale_online ()

  This function returns if inverter is online and active over CAN funzionale.
- void inverter_torque_request (uint16_t torque)

  This function send torque request to inverter. If inverter is active over CAN funzionale network then the request is done via RPDO1 viceversa it's done via analog signal.
- void inverter_regen_request (uint16_t regen)

  This function send regen request to inverter.
- volatile uint16_t get_torque_actual_value ()

  This function return the torque value requested by inverter to motor retrieved from TPDO1 from inverter over CAN funzionale network.

8.2.1 Detailed Description

CAN funzionale module header.

Author

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Date

2018

8.3 CAN_ID.h File Reference

CAN nodes ID definitions module.

Macros

- #define VCU_NODE_ID 2
  VCU Node ID.
- #define INVERTER_NODE_ID 1
  Inverter Node ID.
- #define SCU_FRONTAL_NODE_ID 1
  Frontal SCU Node ID.
- #define TCU_NODE_ID 4
  TCU Node ID.

8.3.1 Detailed Description

CAN nodes ID definitions module.

Author

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Date

2018

8.4 can_servizi.cpp File Reference

CAN servizi module implementation.

```
#include "can_servizi.h"
#include <due_can.h>
#include <DueTimer.h>
```

Functions

- void timeout ()

  This function is executed periodically after CAN servizi 'go Operational' NMT request is sent. When timeout occurs if next_pedals_seq_num is greater than curr_pedals_seq_num then frontal SCU is considered active, viceversa it is considered offline.
- volatile bool can_servizi_initialized ()

  This function returns CAN servizi initialization status.
- void CAN_SERV_BOOTUP_CB (CAN_FRAME *frame)

  This function manage boot-up messages sent over CAN servizi network by slave nodes.
- void CAN_SERV_GENERAL_CB (CAN_FRAME *frame)

  This function manage PDOs received over CAN servizi network and deserializes data:
- bool can_servizi_init ()

  This function initialize CAN servizi hardware port with baudrate CAN_SERV_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from CAN servizi slave nodes (filter = 0x00000700, mask = 0x1FFFFF80); remaining mailboxes are configured for receiving TPDOs from CAN servizi slave nodes (filter = 0x00000080, mask = 0x1FFF↩ FC80).
- void can_servizi_go_operational ()

  This function send a CANOpen master NMT message for request 'go to Operational' state to CAN servizi slave nodes (SCUs and TCU).
- volatile bool can_servizi_online ()

  This function returns if CAN servizi network is online.
- volatile bool tcs_online ()

  This function returns if TCU node is active and online on the CAN servizi network.
- volatile uint8_t get_servizi_tps1 ()

  This function returns the value of the first APPS in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_servizi_tps2 ()

  This function returns the value of the second APPS in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_servizi_brake ()

  This function returns the value of brake pedal position sensor in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile bool get_servizi_apps_plausibility ()

  This function returns the value of APPS plausibility retrieved by frontal SCU node over CAN servizi network.
- volatile bool get_servizi_brake_plausibility ()

  This function returns the value of brake plausibility retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_tcs_torque_coefficient ()

  This function returns the value of torque limiter percentage retrieved by TCU node over CAN servizi network.

Variables

- volatile bool can_serv_initialized = false

  CAN servizi initialization status flag (true if initialized)
- volatile bool SCU_F_online = false

  Frontal SCU online status flag (true if online)
- volatile bool TCS_online = false

  TCS online status flag (true if online)
- volatile uint32_t curr_pedals_seq_num = 0

  Frontal SCU PDOtx1 current sequence number.
- volatile uint32_t next_pedals_seq_num = 0

  Frontal SCU PDOtx1 next sequence number.

- volatile uint8_t tps1_percentage = 0

  First APPS percentage value retrieved by frontal SCU node.
- volatile uint8_t tps2_percentage = 0

  Second APPS percentage value retrieved by frontal SCU node.
- volatile uint8_t brake_percentage = 0

  Brake pedal position sensor percentage value retrieved by frontal SCU node.
- volatile bool apps_plausibility = true

  APPS plausibility status retrieved by frontal SCU node.
- volatile bool brake_plausibility = true

  Brake plausibility status retrieved by frontal SCU node.
- volatile uint8_t tcs_coefficient = 0

  torque limiter percentage retrieved by TCU node

8.4.1 Detailed Description

CAN servizi module implementation.

Author

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Date

2018

8.5 can_servizi.h File Reference

CAN servizi module header.

```
#include "common.h"
```

Functions

- bool can_servizi_init ()

  This function initialize CAN servizi hardware port with baudrate CAN_SERV_BAUDRATE. Mailbox 0 is configured for receiving boot-up messages from CAN servizi slave nodes (filter = 0x00000700, mask = 0x1FFFFF80); remaining mailboxes are configured for receiving TPDOs from CAN servizi slave nodes (filter = 0x00000080, mask = 0x1FFF↩ FC80).
- volatile bool can_servizi_initialized ()

  This function returns CAN servizi initialization status.
- void can_servizi_go_operational ()

  This function send a CANOpen master NMT message for request 'go to Operational' state to CAN servizi slave nodes (SCUs and TCU).
- volatile bool can_servizi_online ()

  This function returns if CAN servizi network is online.
- volatile bool tcs_online ()

  This function returns if TCU node is active and online on the CAN servizi network.

- volatile uint8_t get_servizi_tps1 ()

  This function returns the value of the first APPS in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_servizi_tps2 ()

  This function returns the value of the second APPS in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_servizi_brake ()

  This function returns the value of brake pedal position sensor in percentage, retrieved by frontal SCU node over CAN servizi network.
- volatile bool get_servizi_apps_plausibility ()

  This function returns the value of APPS plausibility retrieved by frontal SCU node over CAN servizi network.
- volatile bool get_servizi_brake_plausibility ()

  This function returns the value of brake plausibility retrieved by frontal SCU node over CAN servizi network.
- volatile uint8_t get_tcs_torque_coefficient ()

  This function returns the value of torque limiter percentage retrieved by TCU node over CAN servizi network.

8.5.1 Detailed Description

CAN servizi module header.

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Date

2018

8.6 CO_can.cpp File Reference

CAN setup module implementation.

```
#include "CO_can.h"
#include "can_servizi.h"
#include "can_funzionale.h"
```

Functions

- bool can_init ()

  This function initializes both CAN funzionale and CAN servizi networks.

8.6.1 Detailed Description

CAN setup module implementation.

Author

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Date

2018

8.7 CO_can.h File Reference

CAN setup header module.

```
#include "common.h"
#include "board_pinout.h"
```

Functions

- bool can_init ()

  This function initializes both CAN funzionale and CAN servizi networks.

8.7.1 Detailed Description

CAN setup header module.

Author

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Date

2018

8.8 common.h File Reference

common macro definitions module

```
#include <stdint.h>
#include "CAN_ID.h"
#include "board_pinout.h"
```

Macros

- #define CAN_FUNZ_BAUDRATE 1000000

  Defines CAN funzionale baudrate.
- #define CAN_SERV_BAUDRATE 1000000

  Defines CAN servizi baudrate.
- #define SERIAL_BAUDRATE 115200

  Defines serial baudrate.
- #define INVERTER_TORQUE_MIN 0

  Defines inverter torque request lower bound.
- #define INVERTER_TORQUE_MAX 32767

  Defines inverter torque request upper bound.
- #define CAN_FUNZ_SYNC_PERIOD 5000

  Defines CAN funzionale sync message trasmission period.
- #define CAN_SERVIZI_TIMEOUT_PERIOD 30000

  Defines CAN servizi timeout period for fault check.

8.8.1 Detailed Description

common macro definitions module

Author

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Date

2018

8.9 model.cpp File Reference

Board model implementation file.

```
#include "model.h"
#include "filter.h"
#include "can_servizi.h"
#include <DueFlashStorage.h>
```

Classes

- struct pedals_ranges_s

Macros

- #define **ADC_BUFFER_SIZE** 128
- #define **BUFFERS** 4
- #define **ADC_MIN** 0
- #define **ADC_MAX** 4095
- #define **APPS_PLAUS_RANGE** 10
- #define **ADC_CHANNELS_LIST** TPS1_ADC_CHAN_NUM | TPS2_ADC_CHAN_NUM | BRAKE_ADC_C↩ HAN_NUM | SC_ADC_CHAN_NUM
- #define **ADC_CHANNELS** 4
- #define **TPS1_ADC_OFFSET** 0
- #define **TPS2_ADC_OFFSET** 1
- #define **BRAKE_ADC_OFFSET** 2
- #define **SC_ADC_OFFSET** 3
- #define **BUFFER_LENGTH** ADC_BUFFER_SIZE ∗ ADC_CHANNELS
- #define **TPS1_UPPER_BOUND** 3723
- #define **TPS1_LOWER_BOUND** 993
- #define **TPS2_UPPER_BOUND** 1861
- #define **TPS2_LOWER_BOUND** 496
- #define **BRAKE_UPPER_BOUND** 0
- #define **BRAKE_LOWER_BOUND** ADC_MAX
- #define **FIRST_RUN_FLAG_ADDR** 0
- #define **PEDALS_RANGES_FLASH_ADDR** 4

Typedefs

- typedef struct pedals_ranges_s **pedals_ranges_t**

Functions

- void **ADC_Handler** ()
- void model_init ()

  This function initializes hardware board.
- volatile uint8_t get_tps1_percentage ()

  This function returns the value of the first APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint8_t get_tps2_percentage ()

  This function returns the value of the second APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint8_t get_brake_percentage ()

  This function returns the value of the brake pedal position sensor in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile bool get_apps_plausibility ()

  This function returns the value of APPS plausibility retrieved by CAN servizi network, if online, or by analog signal.
- volatile bool get_brake_plausibility ()

  This function returns the value of brake plausibility retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint16_t get_SC_value ()

  This function returns the value of the SC.
- void **model_enable_calibrations** ()
- void **model_disable_calibrations** ()

Variables

- volatile uint8_t **tps1_adc_percentage** = 0
- volatile uint8_t **tps2_adc_percentage** = 0
- volatile uint8_t **brake_adc_percentage** = 0
- volatile bool **apps_adc_plausibility** = false
- volatile bool **brake_adc_plausibility** = false
- volatile uint16_t **tps1_value** = 0
- volatile uint16_t **tps2_value** = 0
- volatile uint16_t **brake_value** = 0
- volatile uint16_t **SC_value** = 0
- DueFlashStorage **dueFlashStorage**
- volatile uint16_t **tps1_max** = 3723
- volatile uint16_t **tps1_low** = 993
- volatile uint16_t **tps2_max** = 1861
- volatile uint16_t **tps2_low** = 496
- volatile uint16_t **brake_max** = 0
- volatile uint16_t **brake_low** = 4095
- volatile int **bufn**
- volatile int **obufn**
- volatile uint16_t **buf** [4][128 ∗4]
- volatile bool **calibrate** = false

8.9.1 Detailed Description

Board model implementation file.

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Date

2018

8.10 model.h File Reference

Board model header file.

```
#include <Arduino.h>
```

Functions

- void model_init ()

  This function initializes hardware board.
- volatile uint8_t get_tps1_percentage ()

  This function returns the value of the first APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint8_t get_tps2_percentage ()

  This function returns the value of the second APPS in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint8_t get_brake_percentage ()

  This function returns the value of the brake pedal position sensor in percentage, retrieved by CAN servizi network, if online, or by analog signal.
- volatile bool get_apps_plausibility ()

  This function returns the value of APPS plausibility retrieved by CAN servizi network, if online, or by analog signal.
- volatile bool get_brake_plausibility ()

  This function returns the value of brake plausibility retrieved by CAN servizi network, if online, or by analog signal.
- volatile uint16_t get_SC_value ()

  This function returns the value of the SC.
- void **model_enable_calibrations** ()
- void **model_disable_calibrations** ()

8.10.1 Detailed Description

Board model header file.

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Date

2018

8.11 VCU.ino File Reference

Main module file.

```
#include "common.h"
#include "CO_can.h"
#include "can_servizi.h"
#include "model.h"
#include "states.h"
```

Functions

- void setup ()

  This function perform basic board setup.
- void loop ()

  This function is called into endless while main loop. It takes care of dispatching states of the finite state machine (TODO: see states)

8.11.1 Detailed Description

Main module file.

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8.11.2 Function Documentation

8.11.2.1 loop()

```
void loop ( )
```

This function is called into endless while main loop. It takes care of dispatching states of the finite state machine (TODO: see states)

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Definition at line 63 of file VCU.ino.

8.11.2.2 setup()

```
void setup ( )
```

This function perform basic board setup.

- It starts initializing both CAN funzionale (with inverter) and CAN servizi (with the two SCUs and TCS); if the comunication between inverter and VCU can't be established via CAN bus then the VCU is configured to request torque value to inverter by analog signal.
- It initializes board hardware (TODO: see model)
- If the configuration over CAN servizi with the frontal SCU was successful then VCU (master) send an NMT request to go in 'Operational' state (TODO: see later).

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Definition at line 43 of file VCU.ino.

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