

Manual for Orbitron CANPowerControl v2.0



Automotive Power Supply
9-30V DC
ESD and power-surge protected

CAN Interface

Config & Full use over CAN !

v2.0B(Extended ID)
Configurable speed and IDs
Termination DIP-Switch on PCB

Mode-Select

Ground sensing input, used as
hardware write protection



Automotive grade
8-bit

CPU

ATMega328P
@8Mhz for low EMC

Optional available as
Automotive Arduino:
Write your own software
over the Arduino IDE

1 x Relay

10A 30V DC
(Single Pole Double Throw)

2 x Low-Side Switches PWM

10A Power Mosfet with fly-off diodes
0-100% duty cycle in 16-bit resolution
1Hz - 1000Hz base frequency

2 x Voltmeter

0-30V DC non-isolated
10-bit resolution
100Hz sampling

Contents

| | |
|--|----|
| Summary | 3 |
| Absolute maximum ratings..... | 5 |
| Features and technical data..... | 6 |
| Intended use..... | 7 |
| Housing mechanics | 8 |
| Electrical installation | 9 |
| Relay connection..... | 10 |
| Connecting the Low Side switched (MOSFET) Channels | 11 |
| Software configuration..... | 13 |
| Broadcasted status messages | 13 |
| Sending a command message..... | 16 |
| Changing the configuration | 18 |

Summary

CANPowerControl is a CAN controlled, license free, general purpose control- and measurement device. Enabling Pulse-Width-Modulation, Relay switching and voltage measurements over CAN.

When connected the first time to a 9-30V DC power supply it will turn on and directly output two CAN frames, on ID 1 and ID 2. These are called the „Broadcasted Messages“, since they broadcast the status and readings from the device.

The message on ID 1 will broadcast the readings from all input channels. As there are the two voltmeters and the digital input, that can sense if it is connected to ground or left unconnected. The message on ID 2 will broadcast the status and values of the output channels. As there are PWM duty cycle for CH1 and CH2, the base frequency, the status of the relay and in which PWM mode the device is currently working, independent or inverted.

The CANPowerControl will accept a „Command message“ on ID B (or 11 in decimal). This message is a twin to ID 2 Broadcasting message, with the same signals and exact same formatting. The difference is that this message will let you control the output channels. Whenever a value is successful changed, the new value will be broadcasted directly on ID 2.

The CANPowerControl can be configured with a „Configuration message“ on the highest ID on extended CAN: 1FFFFFFF. If the digital input is connected to ground the message will be accepted and the following can be changed: Broadcasting on/off, Broadcasting ID, Command ID, CAN Speed, Relay state at power on, PWM output active at power on. To ensure that the configuration is not changed by accident, simply disconnect the digital input from ground and the device will ignore any message on the Configuration ID.

The relay and the two mosfet powered PWM channels can be driven with up to 10A DC each. There are two PWM modes available: independent or inverted. In the later, CH2 always inverts the duty cycle of CH1.

In independent mode the duty cycles of CH1 and CH2 can be selected individually. They will though always share the same base frequency.

CANPowerControl accepts CAN V2.0B with the following speeds: 1Mb/s, 500kb/s, 250kb/s, 200kb/s, 125kb/s, 100kb/s, 50 kb/s, 31,25kb/s.

It is designed for extended (29 bit) data and remote frames, it is robust against 11-bit frames sent on the same bus.

Since the power circuits are unfused, make sure to use properly dimensioned fuses for your use-case (max 10A!). Also use fuses for the devices own power supply (1.6A Slow blow).

Both mosfet powered PWM channels also contain a fly-off diode each. Make sure to properly connect this diode. It will cancel the re-induced current from the switched load when the mosfet opens the circuit. If you are unsure if your load is inducing any current, connect the diode in every case. It will not harm your circuits but protect your CANPowerControl device.

Depending on the use case you may want to consider appropriate LC or RC filters when PWM switching loads.

Read this manual carefully and please ask us in case of any uncertainties.

mail@orbitron.se

Absolute maximum ratings

| Value | Maximum rating | Comments |
|-------------------------------|---|--|
| Supply voltage | 30V DC | Circuit protection will engage from 33V |
| Supply current | 1,1A | Use a 1.6A slow blow Fuse |
| Switched current | 10A @ < 80°C | For both Mosfet Channels and Relay lines |
| Switched voltage | 30V | PWM with common ground to Power supply |
| Switched frequency | 1 kHz | Option for non-power switching: 30kHz |
| Measured voltage | 30V | Circuit protection will engage from 33V |
| Temperature upper limit | 80°C | |
| Temperature lower limit | -40°C | |
| Housing insulation resistance | >1000MΩ | |
| ESD on CAN lines | ±21kV, 50A(5/50ns), Lightning 3A (8/20μs) | Protection of automotive Controller Area Network (CAN) lines from damage due to electrostatic discharge (ESD), electrical fast transient (EFT), and other overvoltage transients |
| ESD on input and mosfet lines | 30kV, 600W (10/1000μs) Peak Surge Current 60A, 8.3ms (single half sine) | Protection against voltage transients induced by load dump and other transient voltage events. Relay lines are unprotected. |
| ESD on power input | 30kV, 7kW(10/1000μs), 2.2kW(10ms x 150ms), Peak surge 1000A for 8.3ms (single half sine) | Protection against lightning and inductive load switching voltage transient events for severe Automotive Load Dump applications. |
| Environmental exponation | IP67, Salt Spray: 96 hours, 320Hrs Temperature Humidity cycling | Proper use of sealed MX150 1.5 USCAR automotive contact strongly advised |

Features and technical data

- Generate PWM signals, 0-100% duty cycle in 16-bit resolution
- Enables control of PWM base frequency from 1Hz to 1000Hz in 1Hz steps
- Independent PWM duty cycles or inverted-PWM output on CH2
- Integrated Fly-off diodes for inductive loads on PWM channels
- 1 SPDT Relay (Single Pole Double Throw)
- 2 x Voltage measurement inputs, 0-30V DC, 10-bit resolution
- Up to 10A switching current per channel (< 80°C)
- 9-30V DC supply voltage
- Control, configure and use the device completely over CAN-Bus
- CAN v2.0B @: 31.25, 50, 100, 125, 200, 250, 500 or 1000kb/s
- Configurable sending and receiving adress (CAN ID)
- Configurable default Relay and PWM state at power-on
- Configurable broadcasting / silent mode
- Fixed configuration CAN adress: 1FFF FFF F (with Hardware Write Protection)
- Build-in CAN-Termination (manual switchable)
- Molex MX-150 1,5mm standard Automotive connector
- Water- and Dust-proof IP67 housing (130x100x40mm)

Intended use

CANPowerControl is designed to be used within automotive development in lab- or vehicle environment on closed tracks. It is a handy tool for test, research and development purposes. It should be operated by professionals. It is intended to connect to non-vehicle CAN networks like data-loggers or PC interfaces.

CANPowerControl can switch electric DC circuits, measure voltage and communicate via CAN-bus. Switching can be digital switching via the onboard relay or ,soft-switching' with two Pulse-Width-Modulation (PWM) channels.

By setting duty-cycle and base frequency, electric loads in the external circuit can be controlled with high accuracy. As for example electric pumps, electric engines, fans, LED's or lamps. For connection of **inductive loads** fly-off Diodes are integrated and can easily be connected to the external circuit.

When PWM switching loads a proper designed filter circuit (RC / LC) is strongly recommended. Since the design of such filter is dependent on the actual load conditions of your application, it is no integral part of CANPowerControl.

The two voltage inputs are intended to measure DC voltage from 0-30V.

We suggest a risk-assessment by the customer regarding the environment this product is used in.

Considerable failure possibilities could be:

- Loss of CAN communication
- PWM channel shorted to ground due to overload
- Relay switching without command due to power failure
- Thermal event due to overload (>>10A)

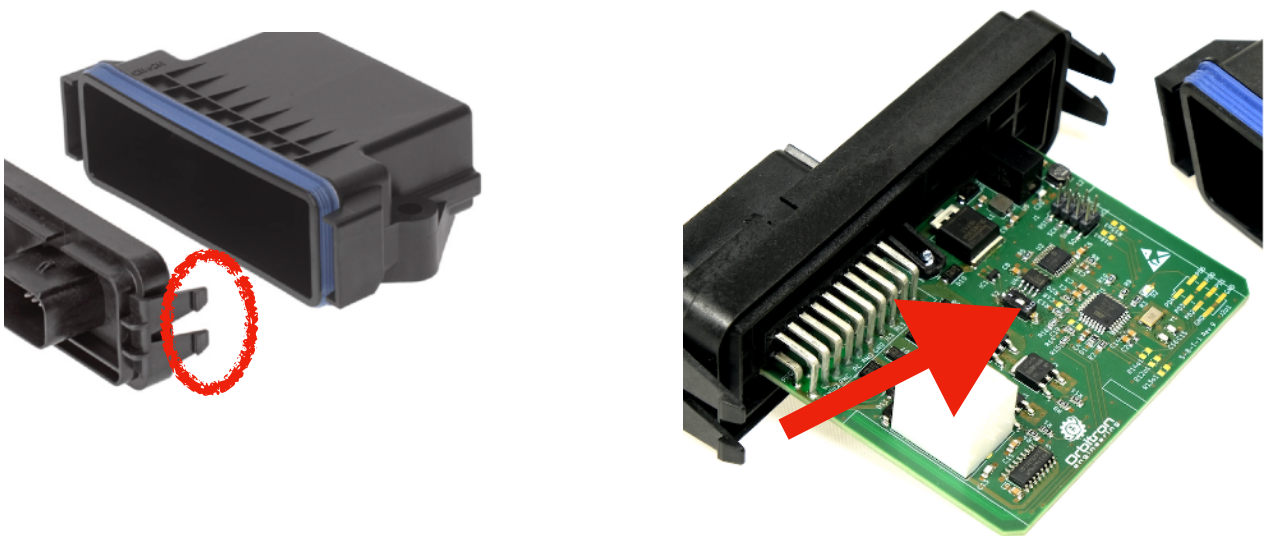
Possible mitigation strategies:

- Use fuses on all external circuits
- Do not exceed the maximum ratings
- Design a safe state under power loss
- Install an emergency power breaker
- Do not run it without its housing - to avoid shortcutting.

Housing mechanics

CANPowerControl will reach you ready assembled with its software installed. The termination of CAN lines is by default activated.

If you may wish to turn CAN Termination off or if you want to load any own developed firmware you need to open the housing. Press down the two snaps (red circle) with a small flathead screwdriver while gently pulling the top contact header.



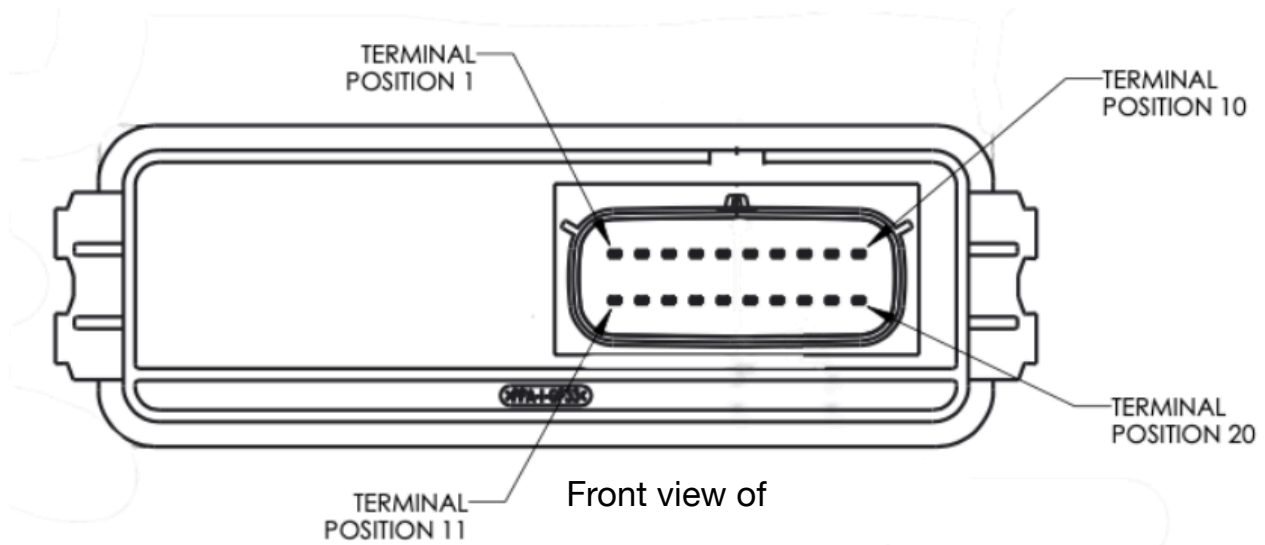
You will find a switch (red arrow) in the very middle of the circuit board. With a simple toggle CAN termination can be turned off.

There is also a header soldered which allows to upload new firmware. Once the original firmware is overwritten, it can't be restored other than by an Orbitron engineering service partner.

You will also find I2C- bus, solder pads for termination resistors and solder pads from unused ports on the PCB. These may be incorporated for customer developments or future updates.

When closing the housing, be cautious of the blue sealing! It should form a constant thick insulation and keep itself in place.

Electrical installation



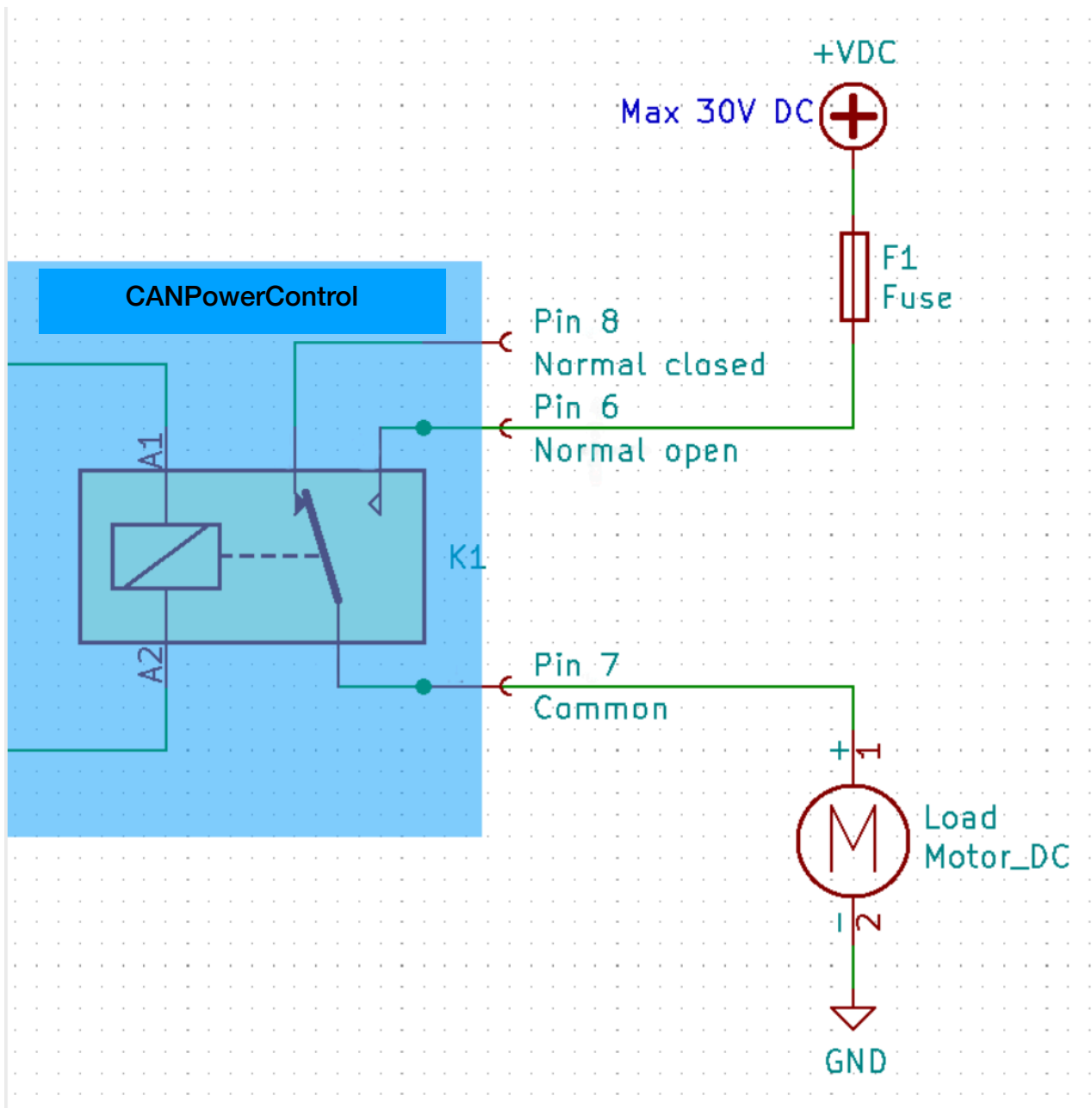
Connector: Molex MX150 1.5, 20 Pos, Pol A

| Pin | Function | Pin | Function |
|-----------|--|-----|--|
| 1 | Resistive loads MOSFET Channel 2 | 11 | Ground |
| 2 | Inductive loads MOSFET Channel 2 | 12 | Voltage Supply 9-30V DC, use a 1,6A Fuse! |
| 3 | Resistive loads MOSFET Channel 1 | 13 | CAN High use twisted pair with Pin 4 |
| 4 | Inductive loads MOSFET Channel 1 | 14 | CAN Low use twisted pair with Pin 3 |
| 5 | Additional Ground for MOSFETS with Pin 15 + 11 | 15 | Additional Ground for MOSFETS with Pin 5 + 11 |
| 6 | Relay Normal Open | 16 | Not connected |
| 7 | Relay Common | 17 | Not connected |
| 8 | Relay Normal Closed | 18 | Not connected |
| 9 | Voltmeter Channel 2, 0-30V DC | 19 | Not connected |
| 10 | Voltmeter Channel 1, 0-30V DC | 20 | Program ON, connect to GND to write a new configuration via CAN. Leave open / not-connected for write protection |

Relay connection

CANPowerControl contains one Single Pole Double Throw relay which can be used for DC Voltages up to 30V.

The picture below shows an example on how the relay could be used. Make sure to always fuse the circuits connected to CANPowerControl!



Connecting the Low Side switched (MOSFET) Channels

CANPowerControl contains two Low-Side switched (MOSFET) Channels. Since these MOSFETS are N-channel MOSFETS they need to be inserted „behind“ the load, on the low side, conducting towards ground!

The MOSFET channels can be operated in two different modes:

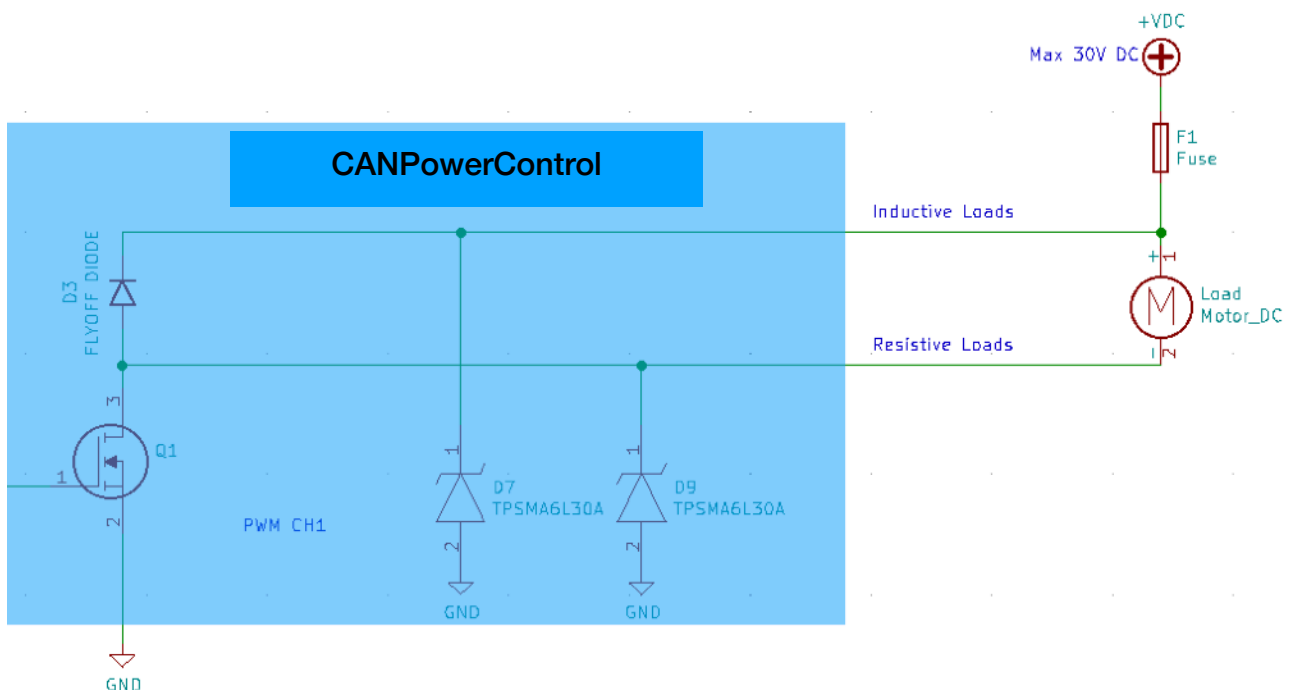
In **independent mode** it is possible to set different duty cycles for each Channel. They will both share the same base frequency.

In **inverted mode** Channel 2 will always output the inverted signal from Channel 1 as long as PWM output is activated. Any PWM duty input for CH2 will be ignored.

| Duty Cycle CH1 | Duty Cycle CH2 |
|----------------|----------------|
| 0 % | 100 % |
| 100 % | 0 % |
| 40 % | 60 % |
| 70 % | 30 % |

When inductive loads are switched off, they will induce a reverse current which can **destroy the MOSFET inside the device!** To avoid that CANPowerControl has built in fly-off Diodes.

Please study the below picture thoroughly before using the MOSFET channels.



When using the MOSFET Channels, make sure PIN 5 and PIN15 are also connected to Ground. These Pins will lower the thermal stress on the PCB (Printed Circuit Board) when switching high currents on MOSFET channels.

Always Fuse the connected circuits! D7 and D9 are voltage suppressor diodes that will short to ground if any voltages higher than 30V are detected.

What are inductive loads?

Depending on the frequency, almost every load will have some inductance. It is therefore highly recommended to **always connect the fly-off diode**, it will not harm your connected circuit. But it will remove a lot of thermal load from the MOSFETS - which will make your CANPowerControl live longer!

Controlling lamps with filaments (wounded)

When cold, the filament has a very low resistance, allowing for a lot of current. When the filament begins to glow the resistance increases and stabilizes. Be very aware that you do not exceed the maximum rating of 10A DC(!) when dimming high loads on filaments. Also rising base frequency will add AC components to the equation. Same advise applies for inductances (coils, speakers, motors).

Proper designed Filter circuits are highly recommended (RC/LC) !

Software configuration

Broadcasted status messages

When CANPowerControl is connected the first time to power it will automatically start broadcasting its status at **1000kb/s** on Arbitration ID 1 and ID 2. The message on ID 1 will broadcast the readings from all input channels. The message on ID 2 will broadcast the status and values of the output channels.

The ID can be changed with the Setup message. You will specify a sending address for the first message. Please note that the second message always gets the ID directly after the first message. (Example: You specify Broadcasting on ID 4 the device will output on ID4 **and** ID5)

So lets take a look at the first Broadcasted message:

| Broadcasted CAN Message | | | ID: 1 | | Type: Unsigned | | Format: Intel | |
|-------------------------|----|----|-------|----|----------------|----|---------------|----|
| Byte \ bit | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| B0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| B1 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
| B2 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| B3 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| B4 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 |
| B5 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 |
| B6 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 |
| B7 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 |

This message contains three signals:

Voltmeter 1: bit 0 - 9 (Yellow): Shows the current measured voltage between ground and voltmeter channel 1 in Volt.

Voltmeter 2: bit 10 - 19 (Green): Shows the current measured voltage between ground and voltmeter channel 2 in Volt.

Scale factor for both is 0,0344 which allows for a total display range of 0-35V. This is **not** the total measurement range! CANPowerControl contains circuit

protection that will short the input to ground if any voltages over 30V are detected. Be aware not to exceed this maximum and use fuses if in any doubt about maximum voltage.

Calibration: By changing the scale factor and offset it is possible to calibrate the voltage measurement.

Program enable/on: bit 20 (Orange): Shows if the digital-in is connected to ground (1) or not (0). If the value is 1 the device will accept a Setup CAN Message on ID 1FFFFFFF (Highest CAN ARB ID). (Orange)

The second Broadcasted message:

| Broadcasted CAN Message | | | ID: 2 | | Type: Unsigned | | Format: Intel | |
|-------------------------|----|----|-------|----|----------------|----|---------------|----|
| Byte \ bit | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| B0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| B1 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
| B2 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| B3 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| B4 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 |
| B5 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 |
| B6 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 |
| B7 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 |

PWM duty cycle CH1: bit 0 - 15 (Green): Shows the current selected duty cycle for PWM channel 1. FFFF or 65535 is equal to 100% duty cycle, resulting in a full switched MOSFET. 0000 is equal to 0% duty cycle, resulting in a complete non-conducting or open MOSFET.

Base frequency: bit 16 - 31 (Yellow): Shows the current selected base frequency for the PWM channels in Hz. The Base frequency applies always to both PWM channels, regardless in which PWM mode CANPowerControl is running.

Relay: bit 32 (Red): Shows if the relay is activated (1) or deactivated (0)

PWM active: bit 33 (Blue): Shows if PWM output is activated (1) or deactivated (0). If deactivated both Channels will be open, meaning non-conducting towards ground.

PWM mode: bit 34 (Teal): Shows if the device operates in **independent mode (0)** where an individual duty-cycle for both channels can be chosen or if it operates in **inverted mode (1)**, where CH2 always outputs the inverted value of CH1. (In inverted mode all PWM duty-cycle commands for CH2 are ignored)

PWM duty cycle CH2: bit 40 - 55 (Pink): Shows the current selected duty cycle for PWM channel 2. FFFF or 65535 is equal to 100% duty cycle, resulting in a full switched MOSFET. 0000 is equal to 0% duty cycle, resulting in a complete non-conducting or open MOSFET.

Sending a command message

When CANPowerControl is connected the first time to power it will accept a command message at 1000kb/s on Arbitration ID B (Dec:11). This command message contains the same signals in the same format as the second Broadcasting message, shown in the previous chapter.

When CANPowerControl receives this message it will alter its status and keep it until the next message arrives or the device is power-cycled. It is even possible to disconnect the CAN lines, the device will keep its state.

To change Relay, PWM activation and mode on start up see next chapter about configuration.

This is the Command message:

| Command CAN Message | | | ID: B (dec 11) | | Type: Unsigned | | Format: Intel | |
|---------------------|----|----|----------------|----|----------------|----|---------------|----|
| Byte \ bit | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| B0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| B1 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
| B2 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| B3 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| B4 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 |
| B5 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 |
| B6 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 |
| B7 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 |

PWM duty cycle CH1: bit 0 - 15 (Green): Sets the duty cycle for PWM channel 1. FFFF or 65535 is equal to 100% duty cycle, resulting in a full switched MOSFET. 0000 is equal to 0% duty cycle, resulting in a complete non-conducting or open MOSFET.

Base frequency: bit 16 - 31 (Yellow): Sets the current selected base frequency for the PWM channels in Hz. The Base frequency applies always to both PWM channels, regardless in which PWM mode CANPowerControl is running.

Relay: bit 32 (Red): Actuates the relay (1) or releases it (0).

PWM active: bit 33 (Blue): Activates the PWM outputs (1) or deactivates them(0). If deactivated both Channels will be open, meaning non-conducting towards ground.

Note that in PWM deactivated mode channel 2 is NOT inverting channel 1 any longer if the device is operated in inverted mode! Both channels remain non-conductive (not switched to ground).

PWM mode: bit 34 (Teal): Selects if the device operates in **independent mode (0)** where an individual duty-cycle for both channels can be chosen or if it operates in **inverted mode (1)**, where CH2 always outputs the inverted value of CH1. (In inverted mode all PWM duty-cycle commands for CH2 are ignored)

PWM duty cycle CH2: bit 40 - 55 (Pink): Sets the duty cycle for PWM channel 2. FFFF or 65535 is equal to 100% duty cycle, resulting in a full switched MOSFET. 0000 is equal to 0% duty cycle, resulting in a complete non-conducting or open MOSFET.

Changing the configuration

It is possible to configure CANPowerControl over CAN. This is done with a configuration CAN message that needs to be send on the highest Arbitration ID possible on extended CAN: 1FFFFFFF hex (536870911 dec).

CANPowerControl has a **hardware write protection** for this CAN ID. It will only accept a configuration message if **Program enable/on (PIN 20)** is connected to ground!

Pin 20 has an internal pull-up resistor that will activate the write protection as long as PIN20 is left unconnected. For mobile applications we suggest to properly isolate the cable connected to Pin 20 or to make sure the highest ArbID is not used on the CAN network.

The configuration message contains 6 signals:

| Configuration CAN Message | | | ID: 1FFFFFFF | | Type: Unsigned | | Format: Intel | |
|---------------------------|----|----|--------------|----|----------------|----|---------------|----|
| Byte \ bit | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| B0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| B1 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
| B2 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| B3 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| B4 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 |
| B5 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 |
| B6 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 |
| B7 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 |

SetCommandArbID: bit 0 - 28 (Green):

This defines the address commands to the device are sent to. The default is set to b in hex or 11 in decimal. Tipp: Do not get confused by decimal and hexadecimal notations.

Speed: bit 29 - 31 (Red):

This sets the CAN baud rate of CANPowerControl, default is 1000.

| Decimal | Binary | Speed [kB/s] |
|---------|--------|--------------|
| 7 | 111 | 1000 |
| 6 | 110 | 500 |
| 5 | 101 | 250 |
| 4 | 100 | 200 |
| 3 | 11 | 125 |
| 2 | 10 | 100 |
| 1 | 1 | 50 |
| 0 | 0 | 31,25 |

SetBroadcastingArbID: bit 32 - 60 (Yellow):

This defines the address CANPowerControl sends its first Broadcasted message. The default is set to 1. The second message will always follow on the next ID, which is 2 in the default setting.

SetDefaultRelay 1: bit 61 (Blue):

This defines whether the relay is unpowered (0) or powered (1) on startup of CANPowerControl. The default is 1.

SetDefaultPWM: bit 62 (Pink):

This defines whether the PWM output is activated (1) or deactivated (0) on startup of CANPowerControl. The default is 0.

SetBroadcastingActive: bit 63 (Teal):

This enables (1) or disables (0) the broadcasting message. Default is enabled (1).