USER AND INSTALLER MANUAL FOR OCTOPUS KDS-2, OCTOPUS KDS-2 MINI AND OCTOPUS KDS-2 NANO CONTROLLERS

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GENERAL CLAUSE

Octopus KDS-2, KDS-2 Mini and KDS-2 Nano controllers are electronic control devices and are designed for stabilized control of electrochromic glass, ensuring the maximum speed of optical switching from one state to another while maximizing the durability of electrochromic devices. The KDS-2, KDS-2 Mini and KDS-2 Nano controllers are designed for use in vehicles powered by an on-board DC network with a voltage of 12 V. It is allowed to use the controllers in other conditions if the general technical operating conditions are observed.

The design of the controller, the algorithms used, the firmware code, as well as the means and methods for preparing parameters for the controllers are protected by copyright laws and patents.

TECHNICAL CHARACTERISTICS OF CONTROLLERS

- Supply voltage: 6 - 14.5 (some versions up to 24) V DC
- Typical output power per channel: 2 A
- Peak output power per channel: 3 A
- Output Channel Voltage: 0 to 4 VDC
- Controller idle consumption: <100mA
- Ambient temperature during use: from - 50° C to + 50° C
- Number of glass tinting and shading cycles: not less than 50 000

BASIC CONTROLLER FUNCTIONS

The controllers KDS-2, KDS-2 Mini and KDS-2 Nano are able to control electrochromic glass with DC voltage from 0 to 4 V, both with direct and reverse polarity, with current up to 2 A for unlimited time, with current up to 3 A with duration no more than 30 seconds every 10 minutes. The KDS-2 controller is equipped with two independent channels, each of which can be controlled separately. The controller KDS-2 Mini and KDS-2 Nano have only one channel on board for connecting single electrochromic glass. For normal operation of electrochromic glass, it is always necessary to connect only one electrochromic glass to one channel of the controller.

Each controller supports firmware update via SWD interface and parameter configuration via USART interface.

Controllers can be controlled through the available interfaces: push (tact) buttons, latching buttons, switches, rotary incremental encoders (half and full step), including those with a push button, USART interface, standardized CAN interface.

Each of the controllers is equipped with the following set of monitoring sensors and systems:

- Internal thermometer to control the temperature of the controller. Used to stabilize the voltage supplied to the load.
- Outputs for connection of temperature sensors integrated into electrochromic glass. It is used to stabilize the voltage supplied to the load and control the temperature range of the electrochromic glass.
- External voltmeter sensors, used to minimize the effect of voltage drop when using long wires with small cross-section, used to connect electrochromic glass.
- Built-in wire breakage protection for load connection.
- Built-in protection against incorrect connection of external voltmeter sensors.
- Built-in hardware protection against short circuits at the load outputs.
- Built-in protection against reverse polarity when connecting power to the controller.
- Built-in hardware protection against overvoltage applied to electrochromic glass.
- Built-in system of obligatory relaxation and safe removal of "charge" from electrochromic glass.

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- Internal voltmeter to monitor the controller supply voltage.

INSTALLATION RECOMMENDATIONS

Controllers KDS-2, KDS-2 Mini and KDS-2 Nano are individually adjusted at the factory for specific pieces of electrochromic glass. With each specific unit of electrochromic glass, only the corresponding controller can be used. In the KDS-2 controller, when connecting, it is necessary to take into account which of the two channels of the device is individually configured for a specific electrochromic glass.

When connecting electrochromic glass to the controllers, observe the polarity of the connection. Failure to observe the polarity leads to accelerated obsolescence of the electrochromic glass.

The controllers KDS-2, KDS-2 Mini and KDS-2 Nano are manufactured in accordance with the standards of electronics used on vehicles; printed circuit boards are additionally coated with a protective varnish to avoid corrosion. However, the controllers are not supplied in a waterproof case and cannot be installed in places where moisture or any other liquid gets on the device case. It is recommended to install the controllers in a place protected from moisture ingress, away from heat sources, air conditioning systems[1].

When choosing a place for installing two-channel KDS-2 controllers, it is recommended to place them in such a way as to minimize the length of cables from the controller to the electrochromic glass. Single-channel controllers KDS-2 Mini and KDS-2 Nano are designed for installation directly into the car door, which avoids the time-consuming operation of pulling cables through the cabin.

To connect the controller to the power supply, it is recommended to use a flexible copper cable with a cross section from 0.75 mm^2 to 1.5 mm^2. To protect the power line from short circuits, when using a cable with a cross section of 0.75 mm^2, it is recommended to use a fuse with a rating of no more than 7.5 A, when using a cable with a cross section of 1 mm^2 or more, it is recommended to use a fuse of no more than 10 A.

For any electrical connections, it is recommended to use a flexible, oil and petrol resistant copper cable that retains its characteristics over the entire operating temperature range. These cables include cables of the KGVVA (CYKY-J) series and similar ones in characteristics.

The cables are connected to the KDS-2 controller through a spring-loaded latch, which ensures a reliable electrical connection, including in vibration conditions. The cables should be connected to the KDS-2 Mini controller by soldering using neutral fluxes and then protecting them with an insulating sleeve, for example, a heat shrink tube. Any connection is not allowed to strain any of the cables.

To connect control elements, buttons or encoders, it is recommended to use wires with a cross section of at least 0.12 mm2, for example, KGVVA or KSPVG (CQR). If it is necessary to use a control line longer than 2.5 meters, it is recommended to use cables with a large cross section.

Since electrochromic glass has a photovoltaic effect, it generates a negligible potential at the power terminals when exposed to light. Therefore, the glass must always be connected to the controller (KDS-2, KDS-2 Mini, KDS-2 Nano) providing a short circuit of the power terminals of the glass, or it is necessary to forcibly short-circuit the power terminals of the glass power supply.

CONNECTING ELECTROCHROMIC GLASS TO THE CONTROLLER

Electrochromic glass operates at ultra-low DC voltages; therefore, it is important to use a high-quality connection of the electrochromic glass to the controller using conductors that provide a minimum voltage drop between the controller and the electrochromic glass.

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[1] Despite the fact that the KDS-2 Nano controller is manufactured in a housing with improved moisture protection properties, nevertheless, the controller does not have moisture protection classes and cannot be used with full or partial immersion in liquid.

If the controller and the electrochromic glass are equipped with connectors (set depending on the order), then usually a sealed connector is used 06R-JWPF-VSLE-S and 06T-JWPF-VSLE-S from JST or similar.

The KDS-2, KDS-2 Mini and KDS-2 Nano controllers allow connecting electrochromic glass using 4 and 6-wire circuits. The choice of the connection scheme is carried out depending on the used cable cross-section and the length of the supply conductor.

In general, it is always recommended to use a 6-wire connection using a 0.75 mm^2 cable. When using a 6-wire connection scheme and a cable with a cross section of 0.75 mm^2 and more, the most accurate control of electrochromic glass with maximum performance is ensured. The minimum permissible cross-section of the used cable for connecting electrochromic glass is 0.12 mm^2.

APPLICATION OF 6-WIRE CONNECTION SYSTEM

This connection method must be used when using a cable with a cross section of less than 0.75 mm^2 and a length of over 1.2 meters, or when using a cable with a cross section of 0.75 mm^2 and a conductor length over 2.5 meters.

APPLICATION OF 4-WIRE CONNECTION SYSTEM

This method is allowed when using a cable with a cross section of 0.75 mm^2 or more with a cable length of up to 2.5 meters. This connection is also allowed when using cables with a cross section of at least 0.12 mm^2 with cable lengths up to 1.2 meters.

In all cases, with a cable length of up to 2.5 meters, it is allowed to use a mixed connection, when a cable with a larger cross-section is used for the power supply of the glass, and a cable with a smaller cross-section is used for the sensor outputs.

By default, the electrochromic glass and controllers are supplied with 6-wire sealed connectors installed.

CUSTOM CONFIGURATION

The KDS-2, KDS-2 Mini and KDS-2 Nano controllers allow updating the software microcode, and also some of the controller's functions can be configured to ensure full compliance with the wishes of the end user. The firmware update procedure and the required hardware for the configuration procedure are described in the document "Instructions for updating the microcode and configuration method for Octopus controllers".

The main functions of the controller, such as voltage and current parameters, time frames of execution units, algorithms for powering electrochromic glass, are set at the factory for each specific electrochromic glass and are not available for modification by the user.

To carry out the configuration procedure, you need to connect to the controller via USART-UART connection. When loading the controller, brief information about the controller is displayed, namely the firmware version, the version of the user settings, the version of the factory settings and the array with configuration data. In addition, the serial number of the controller, the applied electrochromic glass control algorithm and other statistical information are displayed on the screen.

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Figure 1 Displaying the controller on the screen after rebooting.

Normal controller operation is signaled by a control LED installed on the controller board and blinking at a frequency of 1 Hz.

The user has two contexts for controlling the controller via USART (standard connection speed 115200): the general context and the context of user settings. All commands are sent to the controllers in Latin letters and in upper case (if other is not clearly stated). The command is completed by pressing the Enter key.

GENERAL CONTEXT

In a general context, general purpose commands are available.

STAT - a command to display extended information about the current state of the controller the state of voltage generation, and sensor data.

REBOOT - command to reboot the controller.

INFO - a summary of the number of errors that occurred during the operation of the controller and the accumulated statistics, the command can be useful in diagnosing faults in the controller its connection.

DEMO - start demo mode.

ECHO x - disabling and enabling character escaping in terminal mode. If x is 0, then instant escaping of characters entered through the terminal to the screen is turned off, escaping is performed only on line feed, otherwise escaping is performed after each entered character.

TEST - the procedure for checking the hardware of the controller, connected buttons, encoders. For the test, it is recommended to use a 4 Ohm resistor with a power of 2 W or more as a load. It is not recommended to carry out the test procedure with the electrochromic glass connected. When the TEST command is called, the connections of buttons, encoders, the operability of the controller's relay switches, voltage generation, flash and EEPROM memory of the controller, CAN bus, buzzer, voltage and temperature sensors are sequentially checked. In general, pressing Enter skips the current test block, and pressing Esc exits the test procedure. After completing the test procedure, it is advisable to reboot the controller using the REBOOT command. The LED test verifies the performance of the LEDs with forward polarity, reverse polarity, and off. When testing the relay switches, you should hear the clicks of the electromechanical relays installed on the controller board. When testing the voltage generating ability of the controller, the generation of voltage equal to 0.25 V, 0.5 V and 1 V DC is sequentially tested. If you find any malfunctions during the test procedure, you should contact the supplier for clarification and do not connect the electrochromic glass to the controller.

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USER PREFERENCES CONTEXT

In this context, settings of controls, user characteristics of the controller are available. All changes made have an immediate effect and are saved until the controller is rebooted, if they were not previously saved. Basic custom context commands:

CONFIG - enter the user settings context mode. After entering this mode, the screen stimulus changes to CONFIG.

EXIT - exit from the context of user settings.

SAVECONFIG - saves all custom context settings.

LISTCONFIG - Display custom context settings on the screen.

PRINTCONFIG - carries out the output of all current user settings in the form of commands for subsequent loading into the controller.

SETPWD - sets a password to access the user configuration. After setting the password, you must save the user configuration.

DELETEPWD - delete the password from the user configuration. After deleting the password, you must save the user configuration.

When in custom context mode, the following commands can be used:

ALWAYSMAX 1/0 - changes the voltage generation mode by the controller. When using the ALWAYSMAX 1 command, the controller will switch the states of the electrochromic glass only between the "Maximum darkening" - "Maximum lightness" modes (binary mode). When using the ALWAYSMAX 0 command, the controller will sequentially switch between the following modes "Maximum shade" - "Medium shade" - "Minimum shade" - "Maximum lightness".

LEDINVERSE 1/0 - Changes the operating mode of the normal status control LEDs. When using parameter 0, the indication of the normal state corresponds to the on state of the control LED, the switching of modes is accompanied by a short off of the LED. When using parameter 1, the logic of operation of the normal state indication is inverted: during operation, the LED is off, when switching modes, the LED is briefly turned on.

ONELED 1/0 - this parameter enables the use of displaying the alarm state of one of the channels on the LEDs of two channels at once. It makes sense when installing only one LED and controlling only one button or encoder on a two-channel controller. By default, the value is 0, the function is disabled. Using this function is not recommended because it does not provide identification of the channel on which the alarm occurred, for example, a wire break. Disabling an emergency on one of the channels, if it happened on two channels at once, for example, glass overcooling below the limits of the operating range, will not be indicated by the LED indicator.

DARKLED 1/0 - this parameter controls the LED illumination mode. The default value is 0. When the parameter is equal to one, the green LEDs do not light up without generating voltage, otherwise they are always on when the controller is powered.

MINFEEDINGVOLTAGE x - sets the minimum threshold of the voltage supplying the controller to turn off the power on the electrochromic glass, set in volts. When the controller supply voltage is below the set value for 30 seconds or more, an emergency power off of the electrochromic glass occurs to preserve the car's battery charge. Switching between control modes of electrochromic glass is blocked. When the voltage is restored, further control of the electrochromic glass is possible.

ZUMMER 1/0 w x y z - Sets the confirmation buzzer signals. Parameter 1 - enables the buzzer mode, 0 - disables it. Parameter w defines the frequency in Hz of a single confirmation signal (double confirmation

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signal has a frequency of 250 Hz higher), x - duration of a single confirmation signal in ms (double confirmation signal is shorter by 5 ms, but not less than 10 ms). Parameter y - defines the frequency of the error signal in Hz, and z - the duration of the error signal in ms. Default values: 1 5000 15 1400 500.

EXTENDEDOUTPUT 1/0 - setting the long statistics output, analogous to the STAT command when the controller is restarted (1), by default the short output (0) is used.

AUTOREBOOTTIME x - sets automatic mode of controller reboot, x - value in minutes. The maximum possible value for the setting is 43200, which means 30 days from the start of the controller. The reboot procedure is required for the controller's internal timers to work correctly. If, at the time of the reset timer, the controller maintains the tinted state of the electrochromic glass, or performs any other procedure for generating voltage, then the restart process will be postponed until all procedures are completed, but for no more than 1 hour. After this period, the controller will be rebooted in any case.

AUTOTINT 1/0 - the setting is responsible for automatically enabling the first rendering mode when the controller is turned on (1), the default state (0) is waiting for a command from the user to start the rendering process. This feature should be used with caution as it may interfere with the automatic start of demo mode.

USECOLOR 1/0 - the setting is responsible for outputting (1) messages, warnings, errors to the serial port of the controller. By default, color output is enabled. It is recommended to disable this function in order to simplify communication if data exchange is used between two controllers via a serial port or with external devices.

DEMO MODE SETTINGS

Demo mode can be configured within the context of custom settings. The demo mode can be started in three ways: by long pressing of two control buttons (only for KDS-2), by means of the DEMO command, when the controller is started automatically. The performance of the demo mode is also affected by other controller settings for example ALWAYSMAX. Exit from the demo mode is carried out by pressing the control button, or upon expiration of the number of demo mode cycles.

DEMOSTARTUP 1/0 - start demo mode when loading the controller (value 1), waiting for commands (value 0).

DEMOMODECYCLE xxx, yyy - where xxx is the duration of one demo mode cycle in seconds (the first press of the virtual button), and yyy is the delay in seconds until the next press of the virtual button. If you use intermediate degrees of fade, there will be gradual switching over all of these stages. If the yyy parameter is not specified, both values become the same.

DEMOMODEMAXCYCLES xxx - maximum number of demo mode cycles. After passing all the cycles, the controller goes into the waiting mode for user commands.

DEMOMODEMIX 1/0 - variable switching of controller channels (only for KDS-2).

CONTROLS SETTINGS

Since the controller can be controlled in various ways, the appropriate setting must be made for the controls to work correctly.

Button control is configured with the following commands:

BUTTON y z - parameter y defines the time in ms of the duration of the long press of the button, the default value is 900 ms. The z parameter defines the duration of the debouncing procedure in ms. The default is 30 ms. If when the button is pressed, the controller operating modes "jump", it is recommended to increase the z value.

ONEBUTTON 1/0 - a command that determines the ability to control any button with two channels at once (only for KDS-2). By pressing the channel 1 button, you can measure the operation mode of channel

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1 and channel 2. Similarly, the channel 2 button can be used to control two channels at once. In this case, the indication, including the emergency one, is divided by channel LEDs.

BUTTONONRELEASE 1/0 is a command that determines how to determine when a button is pressed. With a value of 1, pressing is fixed directly when the button is pressed, with a value of 0 - when it is released.

USEROCKERSWITCH 1/0 is a command that enables (1) or disables (0) the use of latch buttons or switches. In the case of using this mode (1), all other modes of control by buttons and encoders are disabled, the ALWAYSMAX 1 mode is also automatically applied. When the use of switches is disabled, the previous ALWAYSMAX setting is not restored. If, when the switch is on, the controller starts the relaxation mode, then the automatic activation of the toning mode after starting the relaxation mode does not occur, you must turn the switch off and on. When using the two-channel controller control mode using latching buttons or switches, it is possible to additionally adjust the amount of light transmission of the electrochromic glass using an encoder. In this case, a latching button or switch must be connected to one channel, and the encoder to another. Additionally, it is necessary to activate the control modes with one button and one encoder.

The setting of rotary encoders as control elements is carried out by the following commands:

ENCODER w x y z - the w parameter determines the number of "clicks" of the encoder per click. The default is 1. When using small encoder knobs, it is recommended to increase this value. When using large encoder knobs, it is recommended to leave this value at 1. Parameter x - the type of encoder used. A value of 0 implies the use of a half-step encoder, a value of 1 implies a use of a full-step encoder. The y parameter defines the duration of the anti-bounce procedure in ms for the encoder contacts, the default value is 10 ms. The **z** parameter defines the minimum threshold in ms for determining the duration of the fast encoder rotation, the default value is 50 ms.

ONEENCODER 1/0 - is a parameter that determines the possibility of using two channels to control by an encoder connected to any of the channels. Value 1 enables the function, value 0 disables it.

INFINITYTINT z - is a parameter that determines the order in which the encoders are used to obtain smooth switching between the degrees of glass tint from the largest to the smallest. The z parameter determines the number of encoder clicks to change the shading value in the range from the darkest to the lightest, it can take values from 1 to 254, the default value is 12. When using on a two-channel controller and using encoders, it is recommended either not to enable one-button control (ONEBUTTON) or use also control of one encoder (ONEENCODER) to avoid desynchronization of the channels.

SEPONOFF x y - separate control mode for turning on and off the toning mode using the outputs intended for connecting the encoder. Parameter x means the channel number, if parameter y is equal to 1, then when one of the encoder terminals A and B is closed to ground, a command will be given to turn on and off the controller toning mode. This function can be used to connect external control modules with unreliable communication to the controller, for example, control units over a radio channel. Encoder pin C is used to connect buttons and switches using conventional control circuitry.

Configuring controller control modes via CAN bus

Controllers of the KDS-2 family are equipped with the ability to connect directly to the CAN bus (ISO 11898 standard). Performance with tires other than the standard and incompatible with it is not guaranteed. The following operating speeds are supported: 10, 20, 50, 83, 100, 125, 250, 500, 800 and 1000 kb / s. As a rule, cars use several CAN buses at different speeds, and each bus is responsible for servicing a particular segment of the car.

Different segments of the same CAN bus or different CAN buses in a car can be connected by a repeater, which translates some parameters from one bus segment to another. Before connecting the controller to the car's CAN bus, it is necessary to first carry out diagnostics using external software and hardware tools, for example CanHacker or similar, to select the correct segment / bus / connection point and ensure the

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translation of the required packets. When connected to the OBDII diagnostic connector, on some cars, it is possible to access only the main diagnostic parameters transmitted via the car's CAN buses.

When connecting the controller to the CAN bus, make sure that the controller is also powered from the on-board circuit of the same vehicle, and not from an external power source. If it is impossible to send or receive messages by the controller via the CAN bus, it is necessary to make sure that the wires are connected correctly and the connection speed is selected in accordance with the speed in the used CAN bus. In some cases, it may be necessary to turn on the CAN bus end-of-line resistors on the controller, for which it is necessary to set jumpers on the paired pins near the CAN bus connection pins on the controller board.

A feature of working with the CAN bus is the constant transmission of messages over the bus from all connected devices. Each of the devices sends a status message to the bus with a certain regularity. The device state is encoded as a set of 8 bytes. In a case of a certain event, for example, pressing a button connected to the comfort unit, one or more bits of the corresponding device status byte are changed. Car manufacturers do not publicly publish information about the meaning of bits and bytes in messages on the CAN bus, therefore, the search and determination of the desired event and the desired message is carried out through a reverse study using CAN bus analyzers (for example, CanHacker or similar).

Device addressing in the CAN standard can be implemented in standard mode (11 bits per identifier) and in extended mode (29 bits per identifier). When configuring the controller to work with the CAN bus, it is necessary to use the identifier standard that is used in a specific CAN bus. When choosing addresses (identifiers) of the controller, you must make sure that any addresses intended for transmitting data to the CAN bus are unique. If the addresses match, interruptions in the operation of other devices using the CAN bus are possible. The frequency of sending messages about the status of the controller to the CAN bus is configurable. However, you should not set too frequent sending, as this can lead to excessive loading of the CAN bus and interruptions in the operation of the controller and other devices connected to the same bus. When choosing a translation address, you must adhere to the address selection rule. The lower the address (identifier) number, the higher its priority in transmission. In order to prevent interruptions in the operation of the standard equipment of the car, it is recommended to use the highest possible addresses from the available address space. In general, it is advisable to connect controllers to the least critical segments or CAN buses in order to avoid interference in the operation of the main systems of the car. When connecting the controller to the CAN bus, it is necessary to use a twisted conductor in order to minimize noise pickup on the CAN bus.

Since a large amount of data is transmitted via the CAN bus in real conditions, hardware filtering by sender addresses (identifiers) is used to receive control sequences in controllers. Do not completely disable filtering of incoming messages unless absolutely necessary.

Below is a list of commands for controlling the CAN bus settings in the controller. All manipulations are performed in the context of user settings.

CANSETMODE xxxxx - quick installation of controller settings in relation to the CAN bus. As a parameter, the command takes a bit mask, where each bit takes 0 (the function is disabled) or 1 (the function is enabled), with the following value (numbering from left to right):

> 4 - Using extended address identifier: 1 - extended, 0 - normal;
> 3 - type of command mode: 1 - "Leading (Master)", 0 - "Driven (Slave)";
> 2 - enable command mode: 1 - enabled, 0 – disabled;
> 1 - sending messages to the CAN bus: 1 - enabled, 0 - disabled;
> 0 - enabling work on the CAN bus: 1 - enabled, 0 - disabled.

These parameters can be changed by separate commands.

CANSTART and **CANSTOP** - commands, respectively, enable and disable work with the CAN bus.

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CANUSEEXTID 1/0 - if the parameter is 1, then the use of the extended 29-bit address identifier is enabled, if the parameter is 0, then the 11-bit identifier is used.

CANSETBITRATE x - the speed of data exchange with the CAN bus is set in kbit/s, the permissible values are 10, 20, 50, 83, 100, 125, 250, 500, 800 and 1000.

CANSETSTATTIMER x - the period for sending messages to the CAN bus about the controller state is set, this parameter also affects the command mode via the CAN bus. The value is set in milliseconds. The default is 1000, which means 1 second. If it is impossible to send messages for a certain number of messages, the CAN controller unit is reinitialized.

CANSETINFOTIMER x - the period for sending messages to the CAN bus about the controller's operating time and accumulated errors is set. The value is set in seconds. The default is 60 seconds. If it is impossible to send messages for a certain number of messages, the CAN controller unit is reinitialized.

CANSENDSTATUS 1/0 - enabling (parameter 1) or disabling (parameter 0) data transmission to the CAN bus about the controller state and information about the controller's operating time.

CANSETTXID x - initial identifier of the controller address for sending messages to the CAN bus. 17 consecutive addresses are used, starting with x. The entire range of addresses must be free in the address space of the used CAN bus; no other devices must be registered/connected at these addresses. Parameter x must be entered in hexadecimal notation and in accordance with the dimension of the addressing of the used CAN bus (11 or 29 bits).

The structures of messages about the status and operating time of the controller are given in Appendix 2.

Configuring message analysis modes on the CAN bus
When connected to the CAN bus, the controller is able to receive messages not only from other controllers or specialized devices (Command mode), but also to analyze messages from standard devices on the vehicle's CAN bus. Under certain conditions, the analysis data can be used to control the controller. Thus, the function of controlling the controller with standard buttons or switches of the vehicle can be realized.

CANSETFILTER x y - a command that sets filters for listening to the CAN bus. A total of 5 filters can be set sequentially. The **y** parameter can take the value 0 (using an 11-bit, short address) or 1 (using a 19-bit, long address), the **x** parameter accepts an address (identifier) for receiving messages.

CANCLEARFILTERS - a command that clears the filters specified with the **CANSETFILTER** command.

CANPRINTMESSAGES 1/0 1/0 - a command enabling (1) or disabling (0) the display of CAN bus messages received by the controller (first parameter) and transmitted by the controller (second parameter). Only messages from identifiers entered with **CANSETFILTER** and **CANEVENT** are accepted. This command can be used to debug the controller's operation with the CAN bus, if there is no separate CAN bus analyzer.

CANEVENT a b c d e f - a command that sets an event on the CAN bus to which the controller responds. If messages were received via the CAN bus in the order and mode specified by this command, the controller reacts by virtual "pressing" the control button (switches the glass control modes in accordance with the control settings). Command parameters:

 a - event type:

1. Repeated message from one address (identifier), for example, pressing and releasing a button in a car.
2. Messages from different addresses (identifiers) in a specific order. For example, successive pressing of the button, turning on the lighting devices, changing the setting of the electric drive of the seats.
3. A set of messages from different addresses (identifiers).

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b - identifier (address) of the source of messages. This identifier does not need to be added to the list of addresses provided by the **CANSETFILTER** command.

c - the number of the byte in the message to which the reaction occurs. Typical numbering in analysis programs is from 7 (leftmost byte) to 0 (rightmost).

d - is a bit mask. Consists of 8 positions each of which can contain **0**, **1** or *****. If **0** or **1** is set at a specific position, then the event is considered "caught" only if exactly such values are set at these positions in the message. The ***** symbol in the position value means that this position is not controlled and absolutely any value can be in this position in the message. For event types 1 and 2 (parameter **a**) to trigger the event it is necessary not only to "catch" the event (the button is pressed) but also the subsequent receipt of a message from the same identifier (address) that does not match the mask (the button is released).

e - event type modifier (parameter **a**):

> a = 1 - **e** sets the number of messages "button released", after this value, a virtual "pressing" on the control button is generated.

> a = 2 - **e** specifies the sequence number of this message in the sequence.

> a = 3 - **e** sets the status of the "button" (event), if **e** = 1, then the message should not change until all other messages are tracked (the pressed button is not released), if **e**> 1, then a message that does not match should be followed under the event filter (the pressed button was released).

f - an optional parameter that allows you to set a channel (1 or 2) on the multichannel controller and thus control each channel separately. If the parameter is not specified then the value 1 is used.

Examples of **CANEVENT** command:

CANEVENT 1 7ff 5 * 01 * 1 *** 3 - 3 events are set ("pressing" the button) from the address 7ff and in byte 5 there should be 0 in 6 bits and 1 in 5 and 3 bits (counted from 0).

The following example sets a sequence of 3 events ("pressing" a button followed by its "releasing") from addresses 123, 124, 125 and, accordingly, significant byte 5 (counted from 0):

CANEVENT 2 0x123 5 * 0101 *** 1

CANEVENT 2 0x124 5 * 0101 *** 2

CANEVENT 2 0x125 5 * 0101 *** 3

This example displays the setting to be triggered by pressing and holding one "button" and pressing and releasing another "button" (messages from the first address are the same, from the second they change):

CANEVENT 3 0x123 5 * 0101 *** 1

CANEVENT 3 0x124 5 * 0101 *** 2

Addresses can be specified either as 0x123 or simply 123. In addresses that use letters (hexadecimal notation), you can use both lowercase and uppercase letters.

CANSETTIMEOUT x - the command sets the timeout in seconds for executing the sequences of "catching" events and means the time from the first event in the sequence to the last. The default is 10 seconds.

CANPRINTEVENTS - the command displays the values of the specified events with the **CANEVENT** command.

CANCLEAREVENTS x - the command clears the specified events with the **CANEVENT** command on the channel specified by x. If the x parameter is omitted, then channel 1 is used.

Command mode

In addition to the usual control mode by means of buttons or encoders, the command mode allows the controller to be controlled by an external device by transmitting commands via the serial port or CAN bus.

The command mode can be activated both in the "Leading" and "Driven" modes. In the "Leading" mode, the controller sends commands to switch between modes. And in the "Driven" mode, the controller receives commands for switching between modes.

When the controllers operate in the "Leading" and "Driven" modes, it is necessary to ensure that the settings of the operating modes of all controllers are identical in order to avoid desynchronization.

Command mode via serial port

In this mode only two controllers can be connected. One of the controllers should work in the "Leading" mode, the second controller is switched to the "Driven" mode. The controller which is in the "Leading" mode receives control actions either from the control elements connected to it (buttons, encoders, switches), or via the CAN bus. The controller in the "Driven" mode will execute the commands received from the "Leading" controller through the USART-UART connection. When a command is received, which is a symbolic code for pressing a control element on the "Leading" controller, the "Driven" controller executes this command to the same extent if it received such a control signal from a control element connected directly to it. For this reason, if the "Driven" controller is equipped with control elements (buttons, encoders, switches), then pressing them can lead to desynchronization of the operation of the two controllers.

To connect two controllers, it is necessary to connect their standard USART-UART connectors with a crosshair of RX and TX contacts. 3.3 V pins, if present should not be connected. It is compulsory to connect GND contacts.
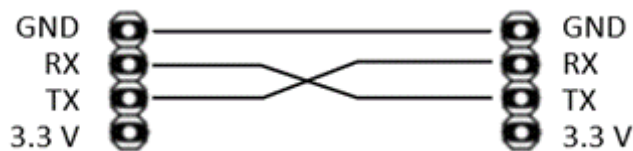

Figure 2. Cross-connect UART of two controllers

When connecting controllers using the serial port command mode use a reliable connection, use a shielded cable and keep it away from sources of interference. If there is an instability in the operation of two controllers connected in the command mode via the serial port then it is necessary to check the quality of the conductor used for the connection, reduce the total length of the USART-UART cable or switch to another type of connection for the command mode.

Enabling, toggling, and disabling command mode via the serial port is done from the user settings context. The mode setting is carried out using the SETCOMMANDMODE command. Switching to the "Leading" mode is carried out by the **SETCOMMANDMODE 2** command, to the "Driven" mode by the **SETCOMMANDMODE 3** command, the mode is turned off by the **SETCOMMANDMODE 0** command.

If a command pulse occurs on the "Leading" controllers it sends the corresponding control sequence to the serial port. The sequence consists of 10 bits, where each bit can be 1 or 0. Numbering starts from the left. Sequence Bits Assignment:

       09 – switch on button is released;
       08 – switch off button is released;
       07 – the button is hold;
       06 – the switch is off;
       05 – the switch is on;

04 – turn the encoder to the right;
03 – turn the encoder to the left;
02 – the button is released;
01 – button pressed;
00 – channel number (0 - channel 1, 1 - channel 2).

All bits from 1 to 9 take on a value equal to 1 only in the event of an event. Otherwise, the corresponding bits remain zero. Examples of command mode triggering on the "Leading (Master)" controller:

0000001001 - turn the encoder to the left on channel 2;
0000010001 - turn the encoder to the right on channel 2;
0000000011 - button pressed on channel 2;
0000000101 - button released on channel 2;
0000000010 - button pressed on channel 1;
0000000100 - the button on channel 1 is released;
0010000000 - button pressed on channel 1.

Command mode using CAN bus

The command mode using the CAN bus allows you to control more controllers and is more reliable than using the command mode via the serial port. When connected via the CAN bus, the controller can act as a "Leading", in this case it will broadcast its state to the CAN bus as well as "Driven" when it listens on the bus waiting for a change in control packets from the "Leading" device. As in the case of the command mode via the serial port an external device can also act as a "Leading" device, sending control messages in the event of certain events.

Enabling the command mode using the CAN bus is carried out in the user settings context using the **CANSETCOMMANDMODE** command. As parameters, the command is passed the mode parameter and the identifier (address) of the device on the CAN bus. When the mode is enabled, it is necessary to specify the correct device identifier in abbreviated or extended addressing (depending on the selected addressing mode in the CAN bus of a particular vehicle), this identifier must be unique in the space of the used CAN bus. Examples of using the command:

CANSETCOMMANDMODE 0 - disable command mode using the CAN bus;
CANSETCOMMANDMODE 2 111 - enabling the "Leading" mode with identifier 111 (short addressing mode);
CANSETCOMMANDMODE 3 111 - enabling the "Driven" mode with identifier 111 (short addressing mode).

When switching on the "Driven" mode, it is necessary to indicate the identifier (address) of the "Leading" device.

The first parameter for CANSETCOMMANDMODE is the command mode operation mode via the CAN bus:

0 - the mode is disabled;
1 - reserved;
2 - "Leading" mode, transfers its state to the bus;
3 – "Driven" mode, listens to the bus.

The second parameter is identifier (address). In the case of the "Leading", this is the address from which the broadcast will be conducted. When choosing an address, it must be unoccupied in the bus of a particular vehicle. In the case of "Driven", this is the address from which messages (packets) of the command mode will be expected to be received.

The command mode message is 8 bytes in size with the following byte allocation, numbered to the right:

6 + 7 - state of the encoder on channel 2;
5 - state of the algorithm on channel 2;
4 - channel number = 2, second channel;
2 + 3 - state of the encoder on channel 1;
1 - state of the algorithm on channel 1;
0 - channel number = 1, first channel.

In the case of using a single channel controller, bytes 4 and 7 are zero. Examples of command mode messages on the CAN bus:

00 00 00 02 00 00 00 01 - channels 1 and 2 are disabled;
00 00 03 02 00 00 06 01 - channel 1 is at the 6th stage of the control algorithm, channel 2 is at the 3rd stage of the control algorithm;
00 02 06 02 00 00 06 01 - channel 1 is in the 6th stage of the control algorithm, channel 2 is in the 6th stage of the control algorithm and the encoder is in position 2.

In the case of using a single-channel controller, for example, KDS-2 Mini or KDS-2 Nano, bytes 4–7 remain zero. The frequency of publication of a command mode message by the "Leading" controller is set by the frequency of sending messages about the controller status (command **CANSETSTATTIMER**).

DIFFERENCES BETWEEN USED CONTROL ALGORITHMS

Several control algorithms for electrochromic glass are implemented in the controllers of the KDS-2 family. The choice of the algorithm and its adjustment is carried out by the manufacturer of the electrochromic glass and is made in accordance with the characteristics of the load at the manufacturer's plant. The current used algorithm for managing the glass is displayed when the controller boots up or when the STAT command is called. The following algorithms are available:

Simple is the simplest algorithm that provides the smallest possible set of tools for controlling electrochromic glass and is intended for use in stationary conditions, for example, in a laboratory.

SmartSimple is a further development of the Simple algorithm using temperature correction (increasing and decreasing) of the load supply voltage[2].

BlackJack is an advanced electrochromic glass control algorithm that provides the highest performance due to an insignificant, about 20%, reduction in the controller lifetime resource[3].

Since each controller is equipped with several electromechanical relays, it is normal to have slight clicks when switching between some modes.

CONTROL ELEMENTS

Switching the operating modes of the controller can be carried out by buttons, switches, encoders, as well as by means of USART and CAN interfaces. On a two-channel controller it is possible to control one button or an encoder for two channels simultaneously (**ONEBUTTON** and **ONEENCODER** settings, respectively). In this case, a button or an encoder can be connected to any of the channels. Parallel connection of a button and an encoder to one channel is allowed, or use of an encoder with a push button.

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[2] Actual voltage at the load depends on a number of facts and not only on the measured temperature.
[3] The life of the controller is determined by the life of the electromechanical relays used. Normal algorithms switch the relays twice per a tinting/bleaching cycle. Automotive grade relays used in the controllers have a MTBF of at least 100,000 cycles, so the minimum number of tinting/tinting cycles of a controller is no less than 50,000 cycles. And even a 20% reduction in life leaves at least 40,000 cycles, which is more than enough for daily operation over a long period of time.

The buttons connected to the controller can be either push (tact switch), that is, without fixation, or with fixation in the pressed position. The **USEROCKERSWITCH** setting must be configured to use the lock buttons or switches. When using a latching button or a switch it is advisable to use the **ALWAYSMAX** setting with position 1. In this case, the controller is switched to the operating mode without intermediate states between the maximum and minimum shading of the electrochromic glass.

Complete with the controller, at the request of the consumer, PS001-N11NAWURUG buttons produced by Well Buying or similar are supplied. These buttons are tactful, i.e., without latching, and are equipped with a built-in two-color LED indicator. It is allowed to use other types of buttons with the controller. Before installing the button in the car, you should first check the clarity of the operation of pressing the button. When jumping over the mode by pressing the button, you should increase the anti-bounce interval using the z parameter of the **BUTTON** command of the settings. The y parameter of this command is used to determine the period of pressing the button, which is recognized by the system as a long press. A long press on the two channel buttons activates the demo mode (only for the two-channel controller).

When using encoders, as a rule, the type of encoder should be adjusted. It can be either full step or half step. Full-step encoders send two pulses to the controller in one click of the rotary knob, half-step only one pulse. When using an encoder with a type different from the setting in the parameters, it is possible either to skip over the steps of the algorithms, or there is a need for a larger number of rotations of the encoder shaft to trigger the transition of the algorithm to the next step. If the setting is correct, it may be necessary to additionally set the number of rotations of the encoder shaft required for the transition of the controller control algorithm to the next step. When using a small encoder knob, it is recommended to set an increased value, and when using a large one, on the contrary, a reduced one. At the customer's request, PEC12R-4220F-S0024 encoders manufactured by Bourns or similar can be supplied with the controller.

In addition to buttons and encoders, movement between stages of the control algorithm can be carried out using signals from an external remote-control unit. Such a control unit can be a conventional system for controlling garage doors, barriers and other automatics, with a 12 V DC power supply (for example, Apollo RX-Multi with Apollo TOM 2 or Apollo RX-Fix units). The external remote power supply unit can be equipped with both impulse relays (simulation of pressing a button) and stable relays (simulation of switch operation). The relay outputs are connected in the same way as the buttons. Parallel connection of buttons, encoders and remote-control units is allowed.

When connecting buttons, it is necessary to connect them to the GND and "Encoder C" outputs of the controllers (see Appendix 1). When connecting encoders, the connection is made to the outputs GND, "Encoder C" (for encoders with a push button), "Encoder B", "Encoder A".

Figure 3 Connection diagram of indicator LEDs

To indicate the status of the controller, it is possible to use LEDs with a current consumption of up to 20 mA. As a rule, green and red LEDs are used, connected opposite.

The LEDs are connected to the controller outputs "LED".

CONTROLLER MANAGEMENT PROCEDURE

Under the influence of external control, for example, by pressing buttons, or after the expiration of internal timers, the controller performs the transition procedures through the internal stages of the electrochromic glass control algorithm. The number of steps may vary depending on the algorithm used. The current state of the controller pins, as well as the stage of the glass control algorithm, can be obtained by calling the STAT command.

Stage zero means maximum glass transparency. At this time, no voltage is applied to it. When you press the control button or when you turn the encoder shaft, the controller goes to the stage of maximum glass darkening. When controlling the buttons, press the button once, when using the encoder, rotate by a specified number of clicks in the direction of increasing the degree of shading (the side of rotation to increase the degree of shading is determined by how the encoder leads are connected to the controller's outputs "Encoder B" and "Encoder A").

Each push of a button is accompanied by a visual confirmation by a per channel LED indicator and a signal from the built-in buzzer. If the operation requested by the user is currently unacceptable, a sound confirmation of the impossibility of performing the operation occurs. The change in state when you turn the encoder is accompanied only by sound. When the maximum or minimum state is reached when using the encoder a double confirmation signal is given in other cases if the voltage supply mode is turned on to the electrochromic glass, a single confirmation sound is given, in other cases the rotation of the encoder shaft does not cause a change in the state and, accordingly, there is no confirmation indication.

When using several degrees of glass tinting, subsequent pressing of the control button will transfer the controller algorithm to the stage that provides an average state in terms of the degree of tinting of electrochromic glass. Another press will switch the controller to the lowest shading stage. The next press will switch the controller algorithm to the accelerated uncollaring mode. During accelerated bleaching, the controller cannot be switched to any other mode until the procedure is complete. The LED flashes during the fast-bleaching procedure.

When changing the degree of tinting of glass, it is necessary to take into account that the actual change in the state of the degree of tinting of the glass does not occur instantly, it takes some time to change the state of the degree of tinting.

When the binary controller control mode is enabled, when only the maximum transparency and maximum shading modes are available the controller algorithm can only switch between these two modes sequentially (also including the accelerated bleaching mode).

If the controller is not energized then it is transferred to the mode of smooth glass bleaching.

InfinityTint

InfinityTint is a proprietary Octoglass technology for smooth and precise adjustment of the required level of light transmission of electrochromic glass. This technology is used when using encoders in conjunction with buttons or using encoders with an additional button function.

When using InfinityTint, push buttons, including a button on the encoder, are used to toggle the glass tint modes on and off. Encoders are used to change the depth of glass tinting within the limits possible for a given product.

When using the InfinityTint function, you should pay attention to the correct settings for the type of encoder used, as well as adjusting the accuracy of the toning degree adjustment with the **INFINITYTINT** command. The higher the value of the parameter, the more accurate you can adjust the shading depth. However, it should be borne in mind that the procedure for changing the shading depth takes some time and only after its expiration the selected glass shading depth set.

The rotations of the encoder affect the degree of shading depth only in the modes of accelerated shading or maintaining the glass shading level. In these modes, when the encoder is rotated, an audible confirmation of the encoder shaft rotation is performed. When the minimum or maximum setting of the shading levels is reached, a double audible confirmation is used.

On two-channel controllers KDS-2, it is allowed to use a latching button or a switch and an encoder together. In this case, for correct operation, the encoder is connected to one channel and the switch to another. Additionally, one button control, one encoder control and switch control are included. On single-channel controllers KDS-2 Mini it is not possible to use a latching button or a switch and an encoder together.

RELAXATION PROCEDURE

With prolonged and continuous use of the tinting mode of the connected electrochromic glass, after the expiration of the time set by the manufacturer, the glass will be forcibly turned off to avoid damage to it (relaxation procedure). This operation is required and does not constitute an error or malfunction. Information about the maximum operating time of electrochromic glass is indicated in the passport for the glass, and it is also displayed in the output of the STAT command. When the relaxation procedure occurs, it is allowed to re-switch the electrochromic glass to the toning mode.

ERRORS AND EMERGENCIES

KDS-2, KDS-2 Mini and KDS-2 Nano controllers are complex electronic devices designed for safe control of electrochromic glass. Safety is ensured not only through the use of specialized algorithms, but also through a variety of sensors that minimize the occurrence of dangerous situations.

The device constantly monitors its supply voltage. If the supply voltage drops below the value set by the **MINFEEDINGVOLTAGE** command for 30 seconds the controller stops any voltage generation and blocks its activation. The mode is confirmed by the LED indicator. When the supply voltage is restored to the normal level the emergency mode is turned off and the ability to switch the control algorithms of the controller is unlocked. This condition is not erroneous or abnormal and is intended to protect the vehicle battery from discharge.

The controller is made on an element base intended for use in road transport, so it has a wide range of operating temperatures. Note, however, that the internal temperature of the controller may be at least 10 degrees higher than the ambient temperature. If the temperature of the controller goes beyond the set temperature regime, both along the lower limit and along the upper one, then voltage generation is stopped and its activation is blocked until the temperature returns to normal. Being in this state is confirmed by the LED indicator. When the temperature regime is restored, the controller will be unlocked. Therefore, when choosing a place for installing the controller it is necessary to exclude the proximity of heating devices as well as flows of hot or cold air entering the controller.

Electrochromic glass is a complex technical product, long-term and trouble-free operation of which depends on many factors one of which is the permissible operating temperature. Since the controller is adjusted for a specific electrochromic glass, the temperature limits at which the glass can be used are also set by the manufacturer. If the temperature of the glass goes beyond the set limits m then the generation of voltage for the glass is blocked, and the glass itself is turned to the transparent state. The blocking is confirmed by the LED indicator. When the glass temperature is restored to the permitted range, the lock is released. The temperature limits of the electrochromic glass performance are indicated in the product passport.

KDS-2, KDS-2 Mini and KDS-2 Nano controllers are equipped with hardware protection (ATAS) against overvoltage supply to the electrochromic glass, as well as against overcurrent at the load outputs (for example, in the event of a short circuit that can lead to a fire). When any of these events occur, voltage generation is disabled and does not resume until the controller is rebooted. A hardware protection event

is an abnormal situation for the controller and it is recommended that you visit your dealer to correct the potential problem.

A precursor to a short circuit can be an open contact to the glass. In this case, even before a short circuit occurs an error associated with an unconnected electrochromic glass may occur. The error is confirmed by the LED and the voltage generation on the affected channel is disabled until the controller is rebooted.

If the external sensors of the voltmeter are incorrectly connected (for example, polarity is not observed), it is impossible to correct the generated voltage correctly. Under any generation conditions, the controller will receive incorrect actual voltage readings. If a similar situation is detected, generation on the affected channel is disabled until the controller is rebooted.

The controller firmware is designed with the vehicle industry best practices in mind and is tested multiple times before being installed in the controllers. However, in some situations, for example, with degradation of the controller microchips, the presence of previously undetected latent manufacturing defects in the chips errors in the hardware platform, etc., the controller may behave incorrectly leading to its "freezing". In this case, in order to avoid possible damage to the connected electrochromic glass, the controller is rebooted with disconnection of voltage generation, if such occurred at the time of "freezing".

If a non-fatal error occurs, the effect of which extends until the factor that caused the error is eliminated, the contrast LED turns on and 5 error signals are generated. When an error occurs, which can only be disabled when the controller is rebooted, the contrast LED turns on and 10 error signals are signaled. The controller can be rebooted both by means of the REBOOT command sent through the USART, and by turning off and on the controller's power supply. Information about accumulated errors can be obtained using INFO command.

APPENDIX 1. SCHEMES
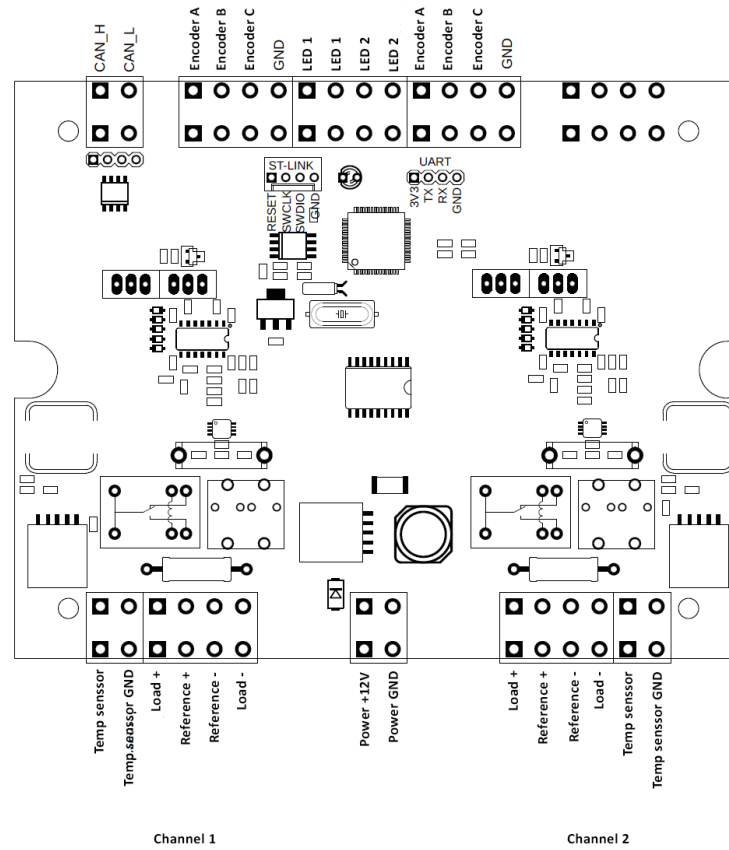

Figure 4 Scheme of controller KDS-2 outputs
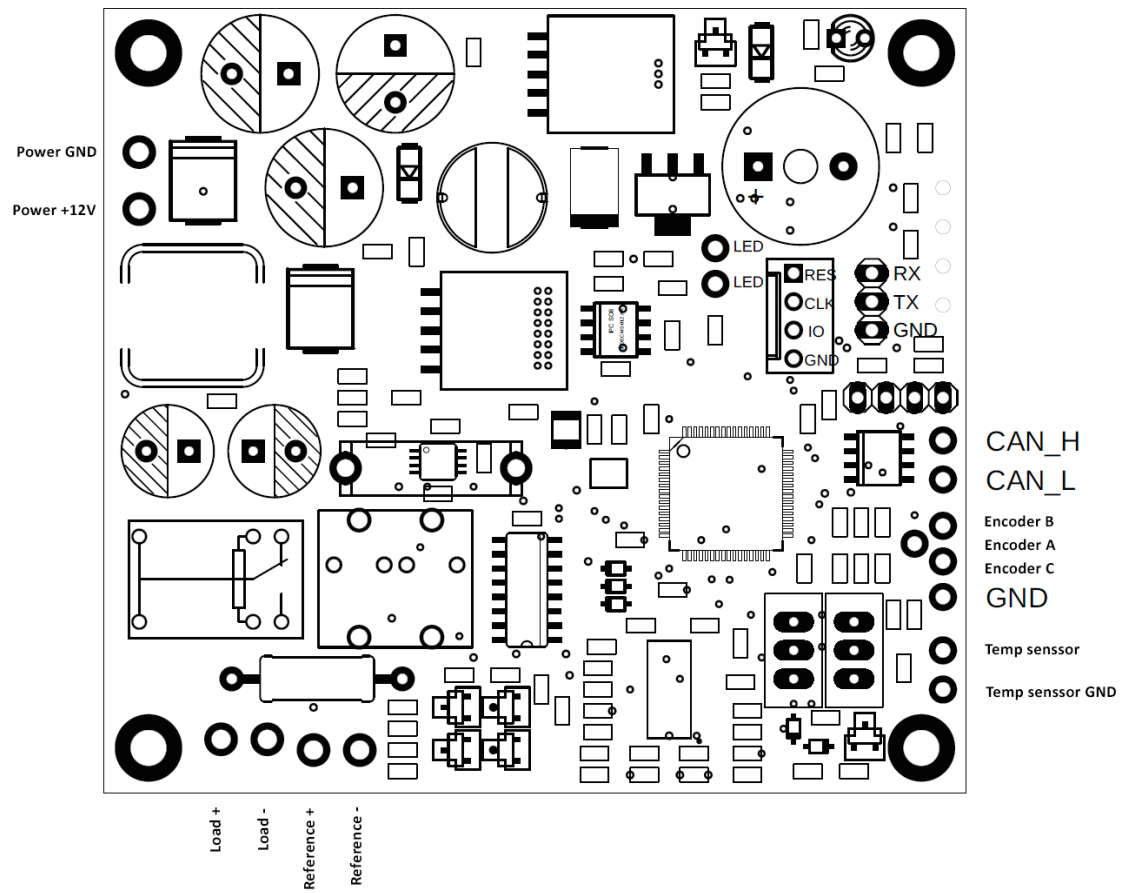
Figure 5 Scheme of controller KDS-2 mini revision 2.1 outputs
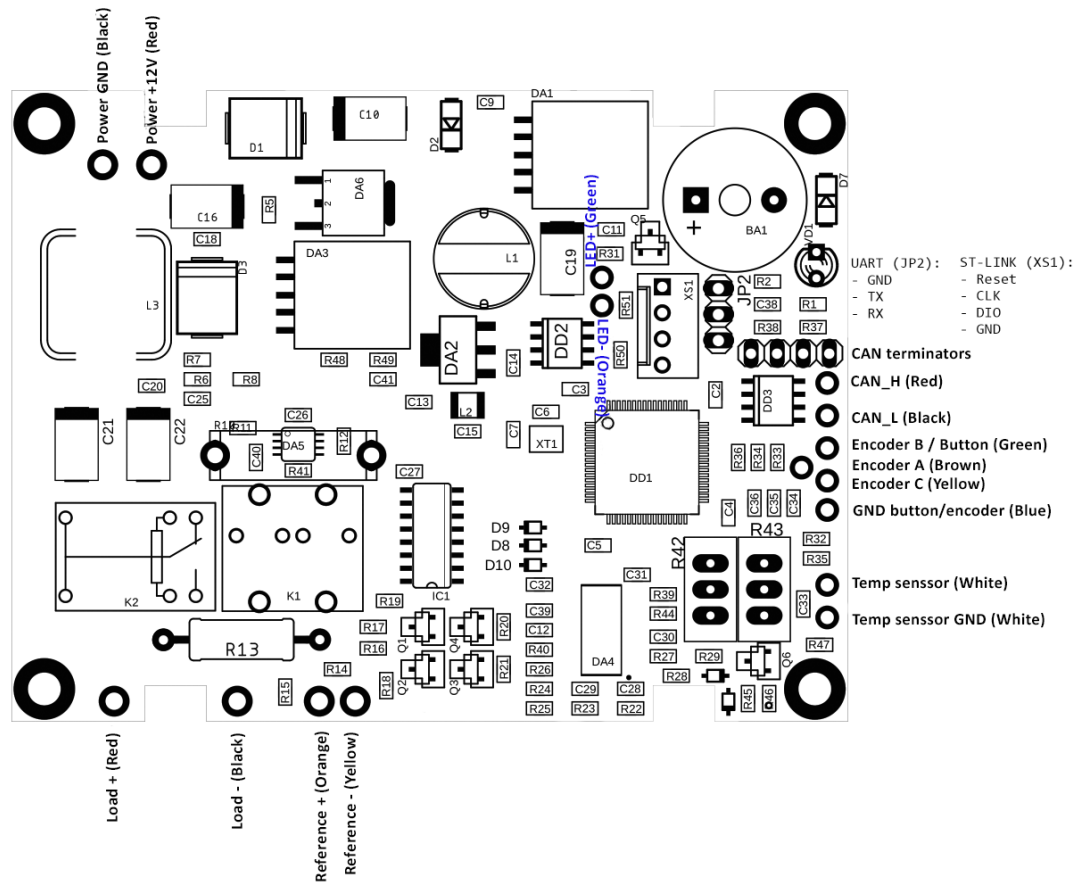
Figure 6 Scheme of controller KDS-2 mini revision 2.2 outputs
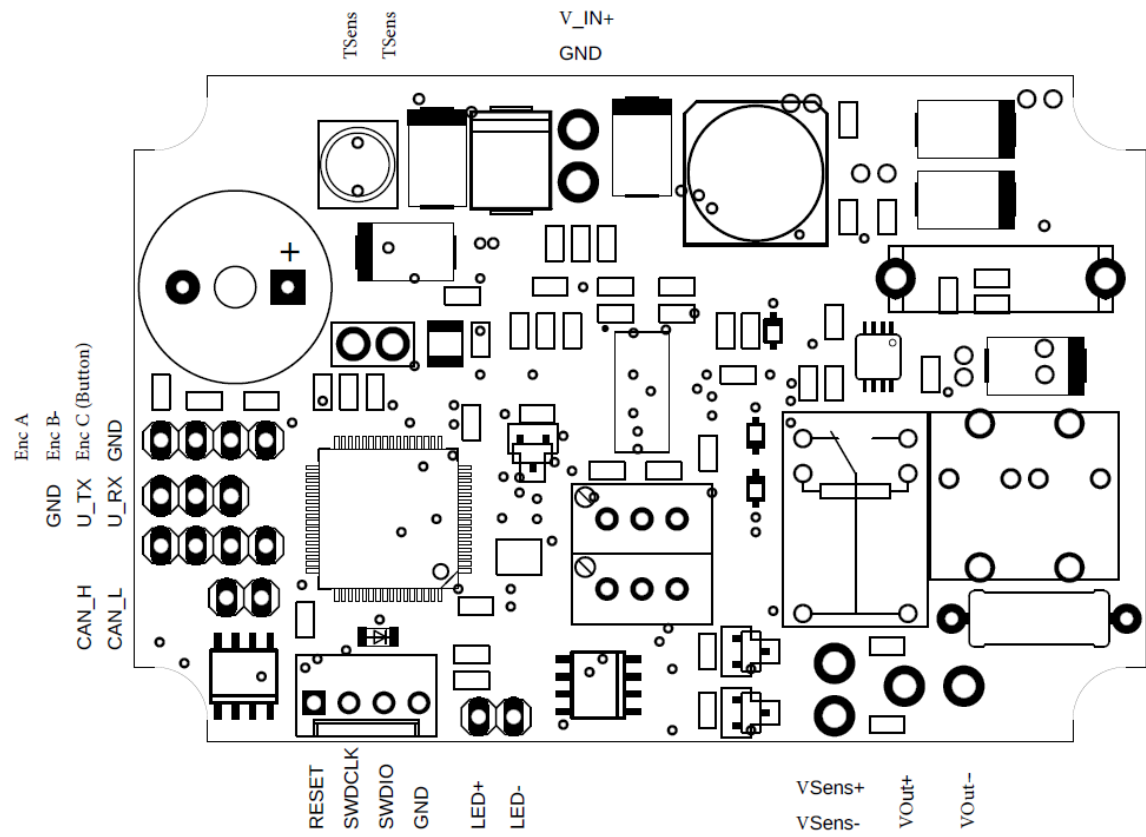
Figure 7 Scheme of controller KDS-2 Nano outputs

06T-JWPF-VSLE-D
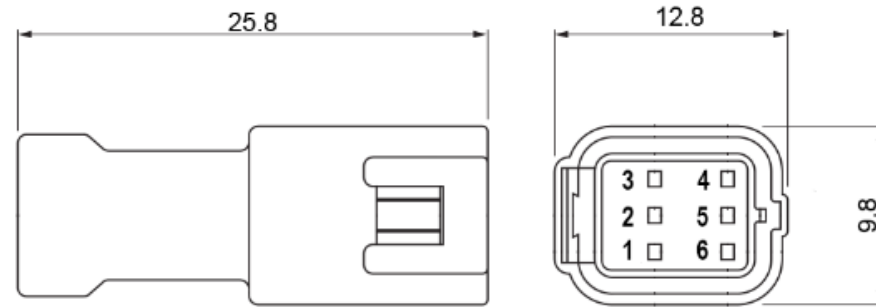
06R-JWPF-VSLE-D
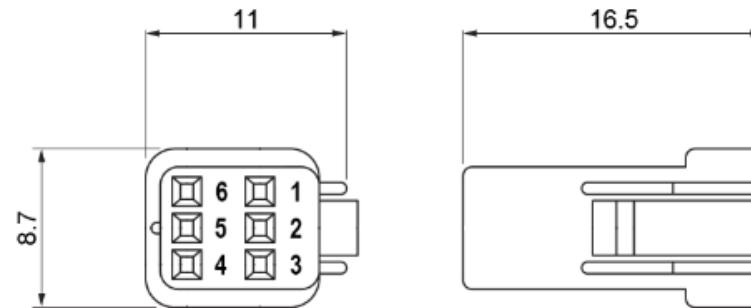
Figure 8 Pin assignment of connectors 06R-JWPF-VSLE-S and 06T-JWPF-VSLE-S

Pin number	Purpose	Wire color
1	load +	Pink
2	Voltmeter sensor +	Red
3	Thermal sensor	Green
4	Thermal sensor	White
5	Voltmeter sensor −	Black
6	load −	Brown

Table 1 Basic pin assignment diagram on JWPF-VSLE0D connectors

APPENDIX 1. CAN-BUS MESSAGES

Structure of the controller status message

The controller status message takes 9 messages, transmitted sequentially over the CAN bus. Messages are distinguished by the address identifier starting from the address set via **CANSETTXID**. Byte numbering starts from right to left; zero byte is rightmost.

ID address	Byte number	Meaning
CANSETTXID + 0	0	Elapsed time since controller start, s
	1	
	2	
	3	
	4	Supply voltage of the CPU controller, mV
	5	
	6	Controller supply voltage, mV
	7	
CANSETTXID + 1	0	Supply voltage error: 0 - no error, 1 - low voltage
	1	CPU controller temperature error: 0 - no error, 1 - CPU overheating, -1 - overcooling
	2	Temperature of the CPU controller in degrees Celsius
	3	
	4	Current demo mode: 0 - disabled, 1 - enabled
	5	Enabling demo mode at startup: 0 - disabled, 1 - enabled
	6	Bit mask (possibly a combination of bits) of command modes: 00000000 - all modes are disabled; 00000010 - "Leading" command mode is enabled via the serial port; 00000011 - "Driven" command mode is enabled via the serial port; 00010000 - "Leading" command mode is enabled via CAN-bus; 00011000 – "Driven" command mode via CAN bus is enabled; Example: 00100011 - "Leading" command mode via CAN bus and "Driven" via serial port is enabled.
	7	The used control algorithm: 0 - control is disabled, 1 – Simple, 2 – SmartSimple, 3 – BlackJack.
CANSETTXID + 2	Channel 2	
	0	Reserved
	1	Error byte mask: 00000000 - no errors; 00000001 - unknown error; 00000011 - glass overheating; 00000101 - glass overcooling; 00001001 - ATAS system triggered.
	2	Voltage and polarity byte mask: 00000000 - voltage generation disabled and negative polarity enabled; 00000001 - voltage generation is on and negative polarity is on; 00010000 - voltage generation disabled and positive polarity enabled; 00010001 - voltage generation is on and positive polarity is on.
	3	Power Algorithm Stage
	Channel 1	

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	4	Reserved
	5	Error byte mask: 00000000 - no errors; 00000001 - unknown error; 00000011 - glass overheating; 00000101 - glass overcooling; 00001001 - ATAS system triggered
	6	Voltage and polarity byte mask: 00000000 - voltage generation disabled and negative polarity enabled; 00000001 - voltage generation is on and negative polarity is on; 00010000 - voltage generation disabled and positive polarity enabled; 00010001 - voltage generation is on and positive polarity is on.
	7	Power Algorithm Stage
Channel 1		
CANSETTXID + 3	0	Time before relaxation procedure in minutes
	1	
	2	Glass temperature, in degrees Celsius
	3	
	4	Current, mA
	5	
	6	Voltage, mV
	7	
CANSETTXID + 4	0	The total charge received by the glass is pendants. The value is represented by fluctuating point number.
	1	
	2	
	3	
	4	The charge received by the glass during the accelerated painting mode, pendants. The value is represented by a floating point number.
	5	
	6	
	7	
CANSETTXID + 5	0	The negative charge received by the glass, pendants. The value is represented by a floating point number.
	1	
	2	
	3	
	4	The positive charge received by the glass, pendants. The value is represented by a floating point number.
	5	
	6	
	7	
Channel 2		
CANSETTXID + 6	0	Time before relaxation procedure in minutes
	1	
	2	Glass temperature, in degrees Celsius
	3	
	4	Current, mA
	5	
	6	Voltage, mV
	7	
CANSETTXID + 7	0	

ID address	Byte number	Meaning
	1	The total charge received by the glass is pendants. The value is represented by fluctuating point number.
	2	
	3	
	4	The charge received by the glass during the accelerated painting mode, pendants. The value is represented by a fluctuating point number.
	5	
	6	
	7	
CANSETTXID + 8	0	The negative charge received by the glass, pendants. The value is represented by a fluctuating point number.
	1	
	2	
	3	
	4	The positive charge received by the glass, pendants. The value is represented by a fluctuating point number.
	5	
	6	
	7	

Table 2 Description of the values of the bytes of messages about the controller status

Data in values that span more than one byte are calculated starting with the leftmost, least significant bit. For example, a message with data 3F 0A 00 00 C8 0C 58 2F sent from the address **CANSETTXID + 0** contains 3F 0A 00 00 as the time in seconds elapsed since the start of the controller. To correctly convert the value to decimal representation, you must change the byte order to 00 00 0A 3F and convert the resulting value from hexadecimal to decimal. Result: 2623 seconds. Similarly, the voltage supply to the microprocessor of the C8 controller 0C is first converted to 0C C8, and then to decimal form. Result: 3272 millivolts. And the remaining value 58 2F is responsible for displaying the supply voltage of the controller. Decimal 58 2F is 12120 millivolts. Another example, **CANSETTXID + 4** contains a data message 0A D7 63 3F B8 1E C5 3F, where 3F C5 1E B8 (bytes 0 - 3) means 1.54 coulombs and 3F 63 D7 0A (bytes 4–7) means 0.89 coulombs. Conversion to floating point number is performed based on the representation of the exponent and mantissa[4] (standard 4-byte float type).

In the case of using a single-channel microcontroller the messages C**ANSETTXID + 6, CANSETTXID + 7** and **CANSETTXID + 8** are not transmitted.

The structure of the message about the operating time of the controller
The controller status message takes 9 messages transmitted sequentially over the CAN bus. Messages are distinguished by the address identifier starting from the address set via **CANSETTXID + 10**. Byte numbering starts from right to left; zero byte is the rightmost.

ID address	Byte number	Meaning
CANSETTXID + 10	0	Controller runtime in 15 minute intervals
	1	
	2	
	3	
	4	Number of controller starts
	5	
	6	
	7	
CANSETTXID + 11	0	Number of automatic reboots
	1	

---

[4] For converting you can use an online calculator.

	2	
	3	
	4	
	5	Number of protection operations against controller freezing and
	6	erroneous states (Watchdog).
	7	
CANSETTXID + 12	0	
	1	The number of overheating of the CPU controller
	2	
	3	
	4	
	5	The number of overcooling of the CPU controller
	6	
	7	
Channel 1		
CANSETTXID + 13	0	
	1	Number of "Glass not connected" errors
	2	
	3	
	4	
	5	Number of ATAS errors
	6	
	7	
CANSETTXID + 14	0	
	1	Number of glass overheating errors
	2	
	3	
	4	
	5	Number of errors with incorrect glass connection
	6	
	7	
CANSETTXID + 15	0	
	1	Reserved
	2	
	3	
	4	
	5	The number of overcooling of the CPU controller
	6	
	7	
Channel 2		
CANSETTXID + 16	0	
	1	Number of "Glass not connected" errors
	2	
	3	
	4	
	5	Number of ATAS errors
	6	
	7	

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CANSETTXID + 17	0	Number of glass overheating errors
	1	
	2	
	3	
	4	Number of errors with incorrect glass connection
	5	
	6	
	7	
CANSETTXID + 18	0	Reserved
	1	
	2	
	3	
	4	The number of overcooling of the CPU controller
	5	
	6	
	7	

In the case of using a single-channel microcontroller the messages **CANSETTXID + 16, CANSETTXID + 17 and CANSETTXID + 18** are not transmitted.