System

Melex is equipped with a Raspberry Pi 4, on which Raspberry PI OS lite 64 bit version is installed. In addition, ROS Noetic was installed to connect the devices with each other.

Device data:

- Login: pi
- Password: raspberry
- WiFi ip: 172.16.7.250
- Ethernet ip: 172.16.8.250

When RPi is started, ROSMASTER starts automatically. In order to connect to it, the ROS environment variables must be set as follows:

- ROS_MASTER_URI = http: // ip_address_RPi: 11311 /
- ROS_HOSTNAME = PC_ip_address
- ROS_IP = PC_ip_address

Threads

After connecting, the PC user will get access to the following ROS topics:

- trailer_angle_module module - responsible for tracking the steering angle of the trailer
  - / trailer / marker_visible - returns Bool - true if the camera sees the marker, false otherwise
  - / trailer / angle - returns the value of Float32 - trailer turning angle based on the Z axis of the marker
- motor_switch module - responsible for returning the state of the autonomous driving switch
  - / motor_switch - returns Bool - true if the autonomous driving switch is on and the steering motor controller is powered
- analog module - responsible for inputs and outputs of the analog module
  - / analog / in / 0 - returns UInt8 - digital value of the signal from the potentiometer of the braking control system
  - / analog / out - takes UInt8 - digital value of the signal emulating the acceleration pedal transmitted to the multiplexer

• brake_motor module - responsible for servomechanism of the braking system

- / set_brake - takes Int16 - the set value for the braking control system from the minPos - maxPos range of the node parameters

• direction module - responsible for switching relays with signals determining the direction of travel

- / set_direction - Takes Int8
  - value <1> corresponds to driving forward
  - value <-1> reverse driving
  - value <0> neutral position of the drive switch on the panel
- / direction - returns Int8 - direction value as above.

• mode module - responsible for the operation of the multiplexer and the automatic mode logic

- / set_mode - accepts UInt8
  - value <0> corresponds to manual mode (direction signals and accelerator pedal levels are transmitted from physical instruments)
  - value <1> stop mode (no signals transmitted, vehicle is stationary)
  - value <2> automatic mode (emulated signals are transmitted)
- / mode - returns uint8 - mode value as above.

• speed module - responsible for speed measurement from the Hall sensor

- / speed_module / rpm - returns Int16 - wheel speed in revolutions per minute
- / speed_module / km_per_hour - returns Float32 - vehicle speed expressed in kilometers per hour, taking into account the radius of the wheel preserved in the node parameter / speed_module / r_cm

• turn_motor module - is responsible for servo servo steering

- / set_turn_angle - takes Int16 - the value of steering wheel rotation in the range +/- of the node parameter / turn_motor_module / turnRange

• main_launch module - responsible for the parameterized launch of all nodes

Parameters

In order to parameterize the work of nodes, each module has a launch file in which the most important parameters that define the operation have been defined.

• trailer_angle_module

- / angle / marker_id - marker identifier
- / angle / marker_size - marker size

• analog_module

- / analog_module / broadcast_input - takes bool - true value corresponds to publishing digital signals on threads

• brake_motor_module

- / brake_motor_module / minPos - minimum position of the servo-braking potentiometer signal
- / brake_motor_module / maxPos - maximum position of the brake servo potentiometer signal

• direction_module

- / direction_module / direction - the default direction set after starting the node

• mode_module

- / mode_module / default_mode - the default mode of operation after starting the node

• speed_module

- / speed_module / r_cm - the radius of the wheel used to calculate the speed, expressed in centimeters

• turn_module

- / turn_motor_module / k_p - gain of the proportional part of the PID controller
- / turn_motor_module / k_i - gain of the integral part of the PID controller
- / turn_motor_module / k_d - gain of the derivative part of the PID controller
- / turn_motor_module / rawCenter - angular position of the encoder when the steering wheel is set to zero
- / turn_motor_module / rawRange range of operation +/- of the torsion system in relation to the zero position expressed in degrees on the encoder shaft
- / turn_motor_module / turnRange - range of allowed steering wheel turn expressed in degrees
- / turn_motor_module / startup_calibration - a conditional parameter that triggers the steering wheel calibration after startup. If the calibration is not performed, the value / turn_motor_module / rawCenter will be taken as the zero point

A common parameter for many nodes is:

• / modulename / frequency - frequency of publishing data on the thread

Commissioning

In order to start the system:

1. Set the steering wheel to the zero position with respect to which the steering angle will be set.
2. Turn on the power to the control board by turning the ignition key.
3. Wait 90 seconds for the system to start up, the ROS server and the calibration torsion system vibration (depending on the parameter / turn_motor_module / startup_calibration).
4. Turn the switch on the panel responsible for:
    - Supplying power to the steering motor controller.
    - Connecting the steering motor to the controller.
    - Autonomous mode signal forwarding to the ROS server.
5. Check the position of the brake motor piston (it should go back to the minimum position during initialization).

Troubleshooting

Incorrect trailer steering angle or marker visibility

- The marker may get dirty, wiping it will improve the quality of detection.
- The lamp attached to the camera must be turned on, guaranteeing constant lighting conditions.
- If the marker has been unscrewed, make sure to screw it in the same orientation or recalibrate the initial value of the twist in the marker axis.

The camera module cannot open the data stream

- Check the connection in order: HDMI cable at the trailer, HDMI cable at the PCB, tape against the plate, tape at the camera.
- Check that two instances of the node using the camera are not running.

Modbus encoder not responding

- Check the cable connection at the encoder.
- Check the cable connection at the RS485 module.
- Remove and reinstall the RS485 module.

The analog module cannot establish an I2C connection

The problem may appear as applying the maximum value to the accelerator pedal output. This is due to the I2C communication error and the last set value being stored in the register.

- Remove and reinstall the analog module.

Premature braking of the servo system

Due to the strong non-linearity of the potentiometer, recalibration of the minimum and maximum values may be required. To do this, you need to:

- Change the minPos and maxPos values to the full range, ie 255 and 0 respectively.
- Empirically check the settings for which braking is most effective by entering values on the thread / set_brake.
- Save new minPos and maxPos values in the module startup file.

There is a lot of resistance when turning the steering wheel or the steering wheel bounces

- Steering wheel returns to position when the auto tuning program is running and the controller has power. This is to maintain the desired position. In order to switch to the manual mode, turn the switch on the panel.
- When the system is turned off and the controller has no power, the steering wheel may still be stiff if the auto mode switch is turned on due to a short circuit in the winding. Disconnect them by turning off the switch on the panel.