**CAN frames controlling the operation of an autonomous field robot**

Warsaw University of Technology controller -> PIMR controller

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 1 | 8 | 0-1 | 0-1 | 0-1 | 0-255 | 0-1 | 0-1 | 0-100 | 0-1 |

B0 - drives STOP; 0 - inactive; 1 - STOP of all drives active

B1 - engine STOP; 0 - the internal combustion engine can work; 1 - engine shutdown

B2 - COMMISSIONING; 0 - inactive; 1 - ignition of the internal combustion engine

B3 - Idle engine speed; 0 - 255 (255 means 2550 rpm)

B4 - Brake off; 0 - brake active; 1 - brake off

B5 - Turning on the distributors (valves arming); 0 - manifolds not active; 1 - manifolds

ready to go

B6 - Robot speed from GPS; 0 - the robot is not moving; 100 - robot speed = 10 km / h

B7 - Safe mode; 0 - inactive; 1 - emergency mode active

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| …… .. |

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Information parameter - control parameter

The following frame is included when the automatic operating mode is activated: (ID 100 B2 -> 1)

The frame should be sent on a different CAN bus than the other frames

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 12 | 8 | 0-2 | 0-2 | 0-1 | 0-1 | 0-1 | 0-1 | 0-1 | 0-1 |

B0 - Section 1 of a foliar sprayer ; 0 - closed; 1 - open

B1 - Section 2 of a foliar sprayer ; 0 - closed; 1 - open

B2 - Section 3 of a foliar sprayer ; 0 - closed; 1 - open

B3 - Section 4 of a foliar sprayer ; 0 - closed; 1 - open

B4 - Section 1 of the arable sprayer; 0 - closed; 1 - open

B5 - Section 2 of the arable sprayer; 0 - closed; 1 - open

B6 - Section 3 of the arable sprayer; 0 - closed; 1 - open

B7 - Section 4 of the arable sprayer; 0 - closed; 1 - open

The following frame is included when the turn mode is activated: 1 ( ID 25)

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 21 | 8 | 0-2 | 0-100 | 0-2 | 0-100 | 0-180 | 0-180 | 0-180 | 0-180 |

B0 - Direction of wheels rotation on the LEFT side; 0 - STOP wheels; 1 - forward; 2 - backwards

B1 - Wheel speed setting on the LEFT side; 0 - STOP wheels; 100 - maximum speed

B2 - Direction of rotation of the wheels on the RIGHT side; 0 - STOP wheels; 1 - forward; 2 - backwards

B3 - Wheel speed setting on the RIGHT side; 0 - STOP wheels; 100 - maximum speed

B4 - Turn PL (left front wheel turn); 0 - max turn left (-90 degrees); 90 - circle on

straight (0 degrees); 180 - max turn right (90 degrees)

B5 - PP turn (right front wheel turn); 0 - max turn left (-90 degrees); 90 - circle on

straight (0 degrees); 180 - max turn right (90 degrees)

B6 - TL turn (left-hand rear wheel turn); 0 - max turn left (-90 degrees); 90 - circle on

straight (0 degrees); 180 - max turn right (90 degrees)

B7 - TP turn (right-hand rear wheel turn); 0 - max turn left (-90 degrees); 90 - circle on

straight (0 degrees); 180 - max turn right (90 degrees)

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 22 | 8 | 0-2 | 0-100 | 0-1 | 0-100 | 0-2 | 0-2 | 0-1 | 0-1 |

B0 - Vertical tool correction; 0 - disabled; 1 - manual correction; 2 - automatic correction

(dependent on tool level sensors)

B1 - Setting the position of the vertical actuator (correcting the vertical position of the tools);

0 - maximum lowering of tools; 100 - maximum lifting of tools

B2 - Horizontal tool correction; 0 - disabled; 1 - manual correction

B3 - Setting the position of the horizontal actuator (correcting the horizontal position of the tools);

0 - maximum shift to the left side; 100 - maximum shift to the right

B4 - Rotary cultivator conversion; 0 - no reaction; 1 - move to the left; 2 - move to the right

B5 - Tiller drive; 0 - disabled; 1 - anti-clockwise rotation; 2 - clockwise rotation

B6 - Manual drive of the hydraulic oil cooler; 0 - disabled; 1 - radiator engine on

B7 - Suction fan drive; 0 - off; 1 - enabled

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 23 | 8 | 0-2 | 0-50 | 0-1 | 0-1 | 0-1 | 0-1 | 0-255 | 0-255 |

B0 - Seeding shaft drive; 0 - shaft does not rotate; 1 - automatic settings according to the algorithm;

2 - manual seeding control;

B1 - Rotation of the sowing shaft in manual mode; 0-32 - value specifying the quantity of rpm

B2 - Sprayer hydraulic drive; 0 - off; 1 - drive enabled

B3 - Electric drive of the sprayer; 0 - off; 1 - drive enabled

B4 - Lights 1; 0 - disabled; 1 - enabled

B5 - Lights 2; 0 - disabled; 1 - enabled

B6 - Additional tool 1 (optional element); 0 - disabled; 255 - maximum value of the setting

B7 - Additional tool 2 (optional element); 0 - disabled; 255 - maximum value of the setting

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 24 | 8 | LSB | MSB | LSB | MSB | LSB | MSB | LSB | MSB |

B0 and B1 - Turn PL (turn of the front wheel on the left side); 0 - max turn left (-90 degrees);

900 - wheel straight ahead (0 degrees); 1800 - max turn right (90 degrees); a double-byte variable

WORD type; B0 - LSB (low byte); B1 - MSB (high byte)

B2 and B3 - PP turn (right front wheel turn); 0 - max turn left (-90 degrees);

900 - wheel straight ahead (0 degrees); 1800 - max turn to the right (90 degrees); a double-byte variable

WORD type; B2 - LSB (low byte); B3 - MSB (high byte)

B4 and B5 - TL turn (left-hand rear wheel turn); 0 - max turn left (-90 degrees);

900 - wheel straight ahead (0 degrees); 1800 - max turn to the right (90 degrees); a double-byte variable

WORD type; B4 - LSB (low byte); B5 - MSB (high byte)

B6 and B7 - TP turn (right rear wheel turn); 0 - max turn left (-90 degrees);

900 - wheel straight ahead (0 degrees); 1800 - max turn right (90 degrees); a double-byte variable

WORD type; B6 - LSB (low byte); B7 - MSB (high byte)

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 25 | 8 | 0-5 | 0-180 | 0-2 | 0-100 | 1-250 | 1-30 | 124-188 | 0 |

B0 - Wheels turning mode; 0 - inactive; 1 - each wheel turns independently; 2 - car mode

(front swivel wheels); 3 - machine mode (swivel front and rear wheels to the opposite

page); 4 - parallel mode (all wheels turn in parallel); 5 - winding mode w

place (the wheels adjust automatically, allowing the robot to rotate in place) (fig. 1)

B1 - Steering angle of the wheels (works in the following steering modes: 2, 3 and 4); 0 - max turn left (-90 degrees); 90 - circle on  
 straight (0 degrees); 180 - maximal turn to the right (90 degrees) (in mode 2 the angle is limited   
in the range of 40-140 degrees, and in mode 3 in the range of 50-130 degrees)

B2 - Driving direction (works in modes 2, 3, 4, 5); 0 - the robot is not moving; 1 - forward drive (or

around to the right in 5); 2 - driving backwards (or around to the left in mode 5)

B3 - Robot speed setting; 0 - the robot is not moving; 100 - the maximum speed of the wheels

B4 - Distance between seeds; 1-250 - a value that determines the distance between seeds during

seeding (mm)

B5 - Number of holes in the shield; 1-30 - a value specifying the number of holes in the seeder's disc

B6 - Robot wheel track; 124-188 - track width range (cm)

B7 - Inactive

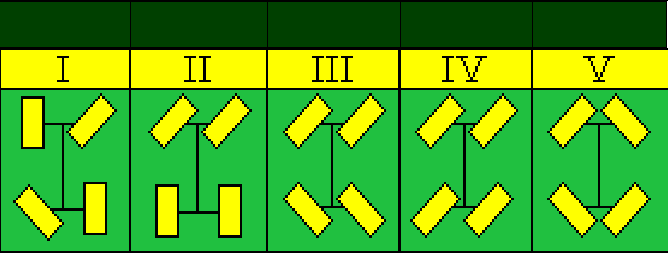


Fig . Steering modes for the ID 25 B0

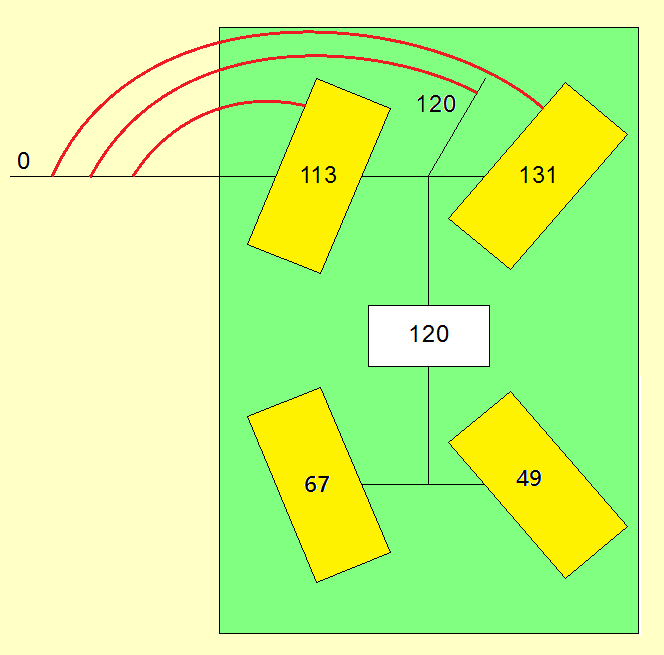


Fig . Turn mode 3; angle setting of 120 degrees

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| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 26 | 8 | 0-1 | 0-1 | 0-1 | 0-1 | 0 | 0 | 0 | 0 |

B0 - Mixing solenoid valve in the arable system of the sprayer; 0 - off; 1 - enabled

B1 - Solenoid valve for opening the arable system of the sprayer; 0 - off; 1 - enabled

B2 - Solenoid valve for venting in the soil system of the sprayer;

0 - off; 1 - enabled

B3 - Solenoid valve for venting in the foliar system of the sprayer; 0 - off; 1 - enabled

B4 - Inactive

B5 - Inactive

B6 - Inactive

B7 - Inactive

**MASTER CAN frame that controls the operation of an autonomous field robot**

CONTROL REMOTE -> other controllers

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 100 | 8 | 0-1 | 0-1 | 0-1 | 0 | 0 | 0 | 0 | 0 |

B0 - drives STOP; 0 - inactive; 1 - STOP of all drives active

B1 - engine STOP; 0 - the internal combustion engine can work; 1 - engine shutdown

B2 - MAN / AUTO; 0 - manual mode; 1 - automatic mode

B3 - Inactive

B4 - Inactive

B5 - Inactive

B6 - Inactive

B7 - Inactive

**CAN frames with information from measuring sensors**

PIMR driver -> control drivers

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 31 | 8 | LSB | MSB | LSB | MSB | LSB | MSB | LSB | MSB |

Time interval: 220 ms;

B0 i B1 - Rotational speed PL; a two-byte variable of the WORD type that specifies the speed value

left front rotating wheel ( imp / s) \* 100; B0 - LSB (low byte); B1 - MSB

(high byte)

B2 and B3 - Rotational speed of the PP; a two-byte variable of the WORD type that specifies the speed value

right-hand front wheel rotating ( imp / s) \* 100; B0 - LSB (low byte); B1 - MSB

(high byte)

B4 and B5 - Rotational speed TL; a two-byte variable of the WORD type that specifies the speed value

left-hand rear wheel rotating ( imp / s) \* 100; B0 - LSB (low byte); B1 - MSB

(high byte)

B6 and B7 - Rotational speed TP; a two-byte variable of the WORD type that specifies the speed value

right-hand rear wheel rotating ( imp / s) \* 100; B0 - LSB (low byte); B1 - MSB

(high byte)

**1 revolution of the wheel equals 54 pulses**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 32 | 8 | 0-180 | 0-180 | 0-180 | 0-180 | 0-60 | 0-60 | 0-60 | 0-60 |

Time interval: 125 ms;

B0 - Turn PL (left front wheel turn); 0 - max turn left (-90 degrees); 90 - circle on  
 straight (0 degrees); 180 - max turn right (90 degrees);

B1 - PP turn (right front wheel turn); 0 - max turn left (-90 degrees); 90 - circle on  
 straight (0 degrees); 180 - max turn right (90 degrees);

B2 - TL turn (left-hand rear wheel turn); 0 - max turn left (-90 degrees); 90 - circle on  
 straight (0 degrees); 180 - max turn right (90 degrees);

B3 - TP turn (right-hand rear wheel turn); 0 - max turn left (-90 degrees); 90 - circle on  
 straight (0 degrees); 180 - max turn right (90 degrees);

B4 - Rotational speed PL; value representing the rotational speed of the left front wheel   
( rpm );

B5 - PP rotational speed; value representing the rotational speed of the front wheel on the right   
( rpm );

B6 - TL rotational speed; value representing the rotational speed of the left rear wheel   
( rpm );

B7 - TP rotational speed; value representing the rotational speed of the rear right wheel   
( rpm );

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 33 | 8 | 0-100 | 0-100 | 0-1 | 0-1 | 0-50 | 0-100 | 0-100 | 0 |

Time Interval: 425 ms;

B0 - Position of the vertical actuator (corrects the vertical position of the tools);

0 - maximum lowering of tools; 100 - maximum lifting of tools

B1 - Position of the horizontal actuator (corrects the horizontal position of the tools);

0 - maximum shift to the left side; 100 - maximum shift to the right

B2 - LEFT end of the tiller; 0 - limit switch is not enabled; 1 - the tiller is located from

left side

B3 - RIGHT end stop of the tiller; 0 - limit switch is not enabled; 1 - the tiller is located from

right side

B4 - Rotation speed of the sowing shaft; 0 - shaft does not rotate; 0-50 - value specifying

shaft rotational speed in rpm

B5 - Level of fertilizer filling in 1 tank; 0-100 - value specifying% of tank filling

B6 - Level of fertilizer filling in the 2nd hopper; 0-100 - value specifying% of tank filling

B7 - Inactive

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 34 | 8 | 0-120 | 0 | 0-100 | 0-250 | 0-1 | 0-1 | 0-60 | 0 |

Time Interval: 1050 ms;

B0 - Tool level sensor; value specifying the tool level in degrees minus 60

(e.g. 65 means 65-60 = 5 degrees)

B1 - Inactive

B2 - hydraulic oil temperature at the selected point; 0-100 - value specifying

temperature ( o C )

B3 - hydraulic oil pressure at the selected point; 0-250 - value determining pressure (bar)

B4 - minimum condition of hydraulic oil; 0 - more than min; 1 - minimum condition

B5 - maximum level of hydraulic oil; 0 - below max; 1 - maximum state

B6 - average rotational speed of the wheels; value representing the average rotational speed of the wheels

( rpm );

B7 - Inactive

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 99 | 8 | 0-1 | 0-1 | 0-1 | 0-1 | 0 | 0 | 0 | 0 |

Time interval: 1540 ms;

B0 - Failure of turning a wheel PL; 0 - correct operation; 1 - faulty sensor or connection

B1 - PP wheel turning failure; 0 - correct operation; 1 - faulty sensor or connection

B2 - TL wheel turning failure; 0 - correct operation; 1 - faulty sensor or connection

B3 - TP wheel turning failure; 0 - correct operation; 1 - faulty sensor or connection

B4 - Failure of the vertical actuator; 0 - correct operation; 1 - faulty sensor or connection

B5 - Horizontal actuator failure; 0 - correct operation; 1 - faulty sensor or connection

B6 - Tool level sensor failure; 0 - correct operation; 1 - faulty sensor or

connection

B7 - Inactive

**CAN frame sent by the internal combustion engine controller**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **bits** | **B0** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** |
| 51 | 8 | LSB | MSB | 0-1 | 0-100 | 0 | 0-100 | 0 | 0-100 |

B0 and B1 - Rotational speed of the combustion engine; a two-byte variable of the WORD type that determines  
 the value of the rotational speed of the combustion engine ( rpm ); B0 - LSB (low byte);   
B1 - MSB (high byte)

B2 - Internal combustion engine operation; 0 - off; 1 - the engine is running

B3 - Coolant temperature; 0 - 100 - value determining the temperature ( o C )

B4 - Inactive

B5 - Fuel level in the tank; 0-100 - value specifying% of tank filling

B6 - Inactive

B7 - Oil pressure in the internal combustion engine; 0 - 100 (100 means 10 bar)