# Remote controllers skidsteer

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**As a result of the 2 world wars, every year there are still approximately 300 ton[1] of bombs found on Belgian soil. To uncover these explosives on a safe manner the use of a remote controlled vehicle can reduce the possible threat of human casualties.**
**The Belgian Army has given us, VIVES University College, the task to convert an existing skidsteer so that it can be remote controlled. The skidsteer is fitted with a custom shovel arm so it's possible to reach a reasonable depth to uncover the bomb. The body of the skidsteer is also reinforced to withstand a possible bomb blast.**

The presented project is a combination of different fields. Electronics, hydraulics, mobile automation and CAN communication are combined in this off-road vehicle. 3 automotive bachelor students have realized this project in the school year 2016-17. Under the guidance of In-Vehicle Networks research group of the VIVES university College.

In 2015-16 a study has been done of the feasibility of the project. In the theoretical study all needed components were looked up. The different types of actuators (electrical, hydraulic) were compared.

*Figure 1: Remote controlled Skidsteer*

## Objectives

The primary objective of the project was to modify a mechanical controlled skidsteer so that it can be remote controlled. The mechanical connections were reengineered and are now hydraulically driven. So the drive, lift and tilt function can now be done remotely.

The existing wiring had to be adjusted and the complete CAN network wiring had to be added.

The skidsteer is fitted with a custom shovel arm so it's possible to reach a reasonable depth to uncover the found bomb.

Also the cabin is adjusted so that all components are protected against possible bomb blasts

## Network

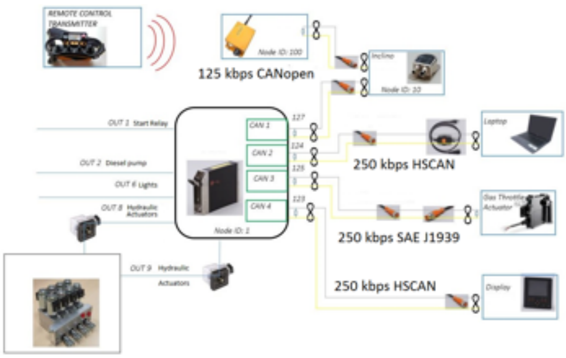



*Figure 2: Network schematic*

The skidsteer has 4 different CAN networks. Each has his specific function.

Network 1 is a CANopen network. The safety controller is the CANopen master and there're currently 2 CANopen slaves connected. The first CANopen slave is de remote module and the second slave module is an X-Y-inclinosensor. The used baudrate is 125 kbps.

Network 2 is a CANlayer 2 network mainly used for programming the safety controller. The used baudrate is 250 kbps.

Network 3 is a typical SAE J1939 network. There is one node connected. It is the gas throttle actuator. The used baudrate is 250 kbps.

The last network, network 4, is also a CANlayer 2 network. A display is connected to visualize the basic parameters of the skidsteer.

## Components

*Safety controller*

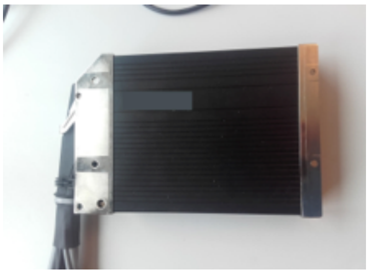


*Figure 3: Safety controller[2]*

The safety controller is the brain of the skidsteer.

It is equipped with 4 separated CAN busses that are freely configurable.

8 of the 16 outputs are usable as PWM-I outputs. These are used to control the current controlled hydraulic actuators.
Furthermore there are also digital I/O used for switching on the diesel pump, glow plugs, horn, the auxiliary hydraulic control, fuel shut-off valve,…

*Remote control*

*Figure 4: Remote control (transmitter and receiver)[3]*

With the remote control the skidsteer can be controlled from a distance.
The remote control exist out of 2 components the transmitter and the receiver.

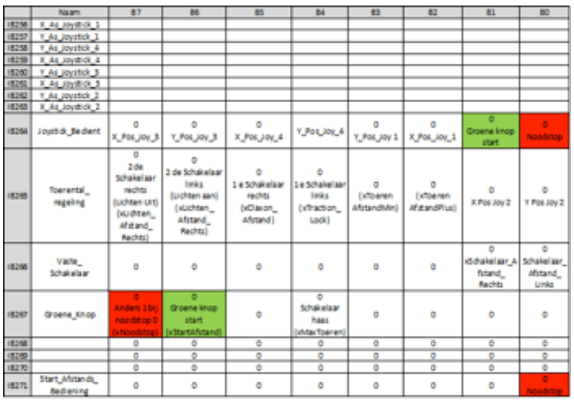
On the used transmitter there are 4 X-Y joysticks, 4 digital switches, 1 start/stop push button, 2 buttons to alter the rpm and 1 emergency stop available.

*Figure 5: Push buttons of the remote control [3]*

The inputs of the transmitter can be sent through Bluetooth to the receiver. The actual maximum distance is 100 m

In our case the input data is actually been sent through a 50m copper wire (CAN) to the receiver. These distances might evolve in function of the requirements of BEL Defense.

The process data of the remote control is available in 2 RX-PDO's.



| | Naam | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |
|---|---|---|---|---|---|---|---|---|---|
| IB256 | X_As_Joystick_1 | | | | | | | | |
| IB257 | Y_As_Joystick_1 | | | | | | | | |
| IB258 | Y_As_Joystick_4 | | | | | | | | |
| IB259 | X_As_Joystick_4 | | | | | | | | |
| IB260 | Y_As_Joystick_3 | | | | | | | | |
| IB261 | X_As_Joystick_3 | | | | | | | | |
| IB262 | Y_As_Joystick_2 | | | | | | | | |
| IB263 | X_As_Joystick_2 | | | | | | | | |
| IB264 | Joystick_Bedient | 0 X_Pos_Joy_3 | 0 Y_Pos_Joy_3 | 0 X_Pos_Joy_4 | Y_Pos_Joy_4 | 0 Y_Pos_Joy 1 | 0 X_Pos_Joy_1 | 0 Groene knop start | 0 Noodstop |
| IB265 | Toerental_ regeling | 0 2 de Schakelaar rechts (Lichten Uit) (xLichten_ Afstand_ Rechts) | 0 2 de Schakelaar links (Lichten aan) (xLichten_ Afstand_ Rechts) | 0 1 e Schakelaar rechts (xClaxon_ Afstand) | 0 1 e Schakelaar links (xTraction_ Lock) | 0 (xToeren AfstandMin) | 0 (xToeren AfstandPlus) | 0 X Pos Joy 2 | 0 Y Pos Joy 2 |
| IB266 | Vaste_ Schakelaar | 0 | 0 | 0 | 0 | 0 | 0 | 0 xSchakelaar_A fstand_ Rechts | 0 Schakelaar_ Afstand_ Links |
| IB267 | Groene_Knop | 0 Anders 1 bij noodstop 0 (xNoodstop) | 0 Groene knop start (xStartAfstand) | 0 | 0 Schakelaar haas (xMaxToeren) | 0 | 0 | 0 | 0 |
| IB268 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IB269 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IB270 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IB271 | Start_Afstands_ Bediening | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 Noodstop |

*Figure 6: Data mapping of the RX-PDO's*

In the first RX-PDO message the 8 analog values of the joysticks (4 times X-Y) are available. When the joysticks are in neutral the value of the byte is between 7Fh-80h. When moved in positive direction the value will change to maximum D6h.
When moved in negative direction the value will change to minimum 29h.

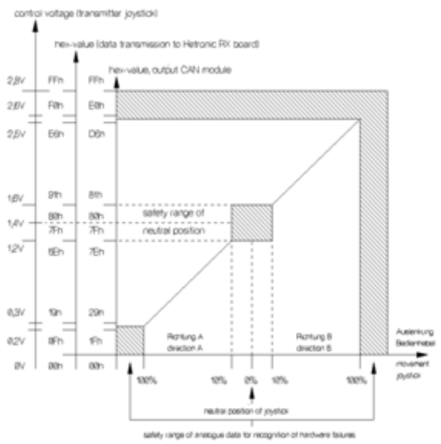


Figure 7: Analog value of one of the dimension of the joystick

The second RX-PDO message is filled with digital inputs of the different switches, pushbuttons and the emergency stop.

*Inclinosensor*

Figure 8: CANopen X-Y inclinosensor[4]

The inclinosensor is used as a CANopen slave and is connected to the safety controller. The sensor is place right in the middle of the machine.

| Byte 0 | Byte 1 | Byte 2 | Byte 3 |
|---|---|---|---|
| Inclination value longitudinal (X axis) OD index: 6010h | | Inclination value lateral (y axis) OD index: 6020h | |

| Byte 0 to byte 3 | Byte 4 to byte 7 |
|---|---|
| Inclination value longitudinal (X axis) OD index: 6110h | Inclination value lateral (y axis) OD index: 6120h |

Figure 9: the PDO's of the inclinosensor

The safety controller receives 2 PDO messages from the inclinosensor. Both have the same data but the resolution is different.

The received PDO data is primarily used to give the operator an indication of the possible risk of tipping. That is also why the data is visualize on the display.

If the inclination angle is higher than 75° the diesel pump of the skidsteer will deactivated.

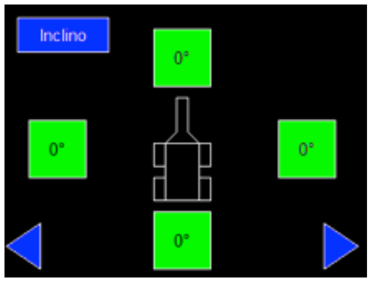



Figure 10: Visualization of the inclino values

*Gas throttle actuator*

Figure 11: Gas throttle actuator[5]

With the gas throttle actuator it is possible to adjust the existing mechanical gas throttle.

Figure 12: Mechanical gas throttle

The actuator can be controlled through J1939 specific messages. In the message TFAC (PGN 61466), the parameter 'Engine Throttle Actuator 1 Control Command' can be used to change the position of the actuator.

The feedback/actual position of the actuator can be found in message LFE1 (PGN 65266).

With 2 other J1939 proprietary messages a diagnose of the actuator can be done (current error, temperature error,…)

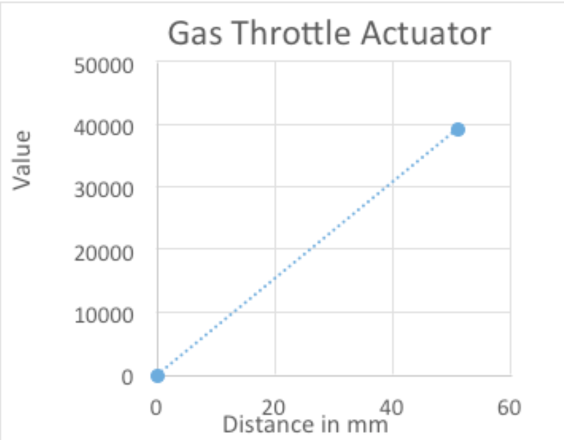



*Figure 13: Mechanical gas throttle*

The maximum stroke of the actuator is 50,8 mm. To get this stroke the J1939 parameter data value has to be 9999hex (39321dec).

To get a stroke in between the CAN data can be calculated with a lineair function.

*Display*


*Figure 14: Display*[6]

With the display all the basic parameters of the skidsteer are been visualized:

- Information of the lights
- Information of the inclinosensor
- The position of gas throttle actuator

**Mechanics**

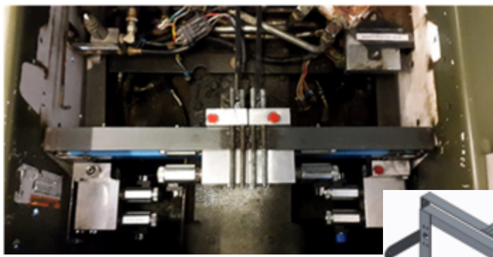


*Figure 15: Mounting bracket for hydraulic actuators*

The 4 hydraulic actuators are all mounted on one and the same mounting bracket. This bracket is easily removable. It is even possible to replace back the mechanical joysticks if needed.

*Figure 16: Adjusted cabin*

To protect all electronic components the cabin of the skidsteer is adjusted. So when a bomb should explode the electronics won't be damaged. And can possible be used in another skidsteer.

**Hydraulics**

*Hydraulic actuator*

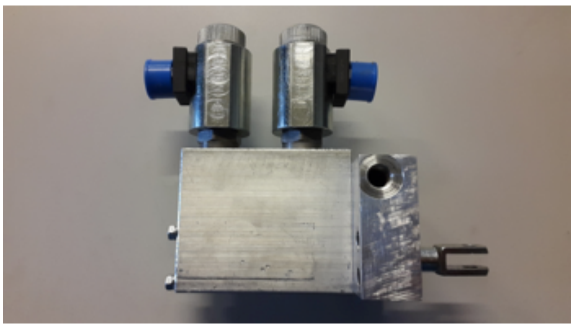


*Figure 17: Hydraulic actuator*[7]

The used hydraulic actuator can generate a force of 1300 N on 30 bar. The stroke is here +/- 13 mm. This is just enough to move all functions (drive, lift and tilt) correctly.

The actuator is controlled with 2 solenoids each receiving a PWM-I signal. The current range varies between 800 to 1800mA.

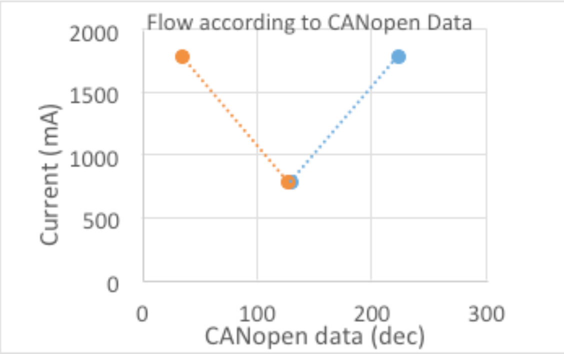



*Figure 18: The current of hydraulic actuator*

One of the main advantages of these hydraulic actuators is that when the current is interrupted the actuators will go to a neutral state (safe state). This results in the stopping of the skidsteer when driving and stopping of lifting and tilting function.

*Pressure reducing valve*

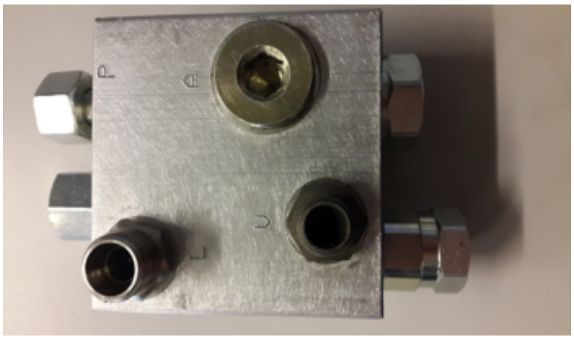


*Figure 19: Pressure reducing valve*[8]

The hydraulic actuators work on 30 bar pressure. Therefore a reducing valve is needed to lower the main pressure from 90 bar to 30 bar.

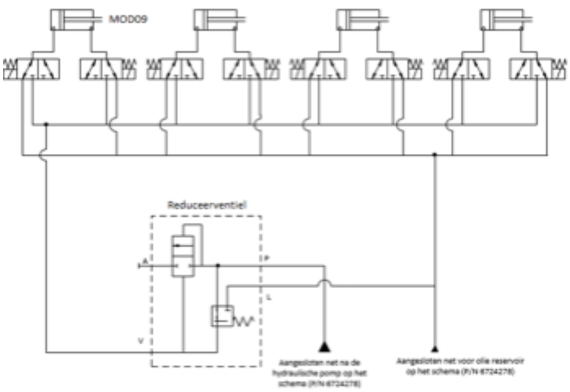



*Figure 20: Hydraulic schematic*

**Future**

*Figure 21: remote controlled skidsteer*

For the school year 2017-18 some adjustments will be made:

- The used safety controller will be replaced by another type. Mainly due to the limited amount of PWM-I outputs.

Also some additions will be added.

- Adding extra weight at the back of the skidsteer for a better balancing of the machine.
- Adding multiple camera's to control the skidsteer completely from a distance.
- Adding multiple pressure sensors to have the ability to diagnose the machine from a distance
- Adding an speed sensor to obtain the actual rpm

Further in the future other additions can be added:

- Adding GPS tracking and guidance system. This possible because of the low speed of the skidsteer. The GPS RTK could be used. For example to make an auto guidance drive possible to a pre-marked place.
- Adding 3D camera for detection of possible obstructions

## Conclusion

This project has been and will be a very interesting learn lesson for the bachelor students and myself as mentor.

In this project the different technical fields are combined as a whole.

A big thank you to the Belgian Army for making this project possible. Also I want to thank Vangaever the dealer of Bobcat in Belgium.

### References

[1] Belgian Newspaper De Morgen, http://www.demorgen.be/binnenland/elk-jaar-nog-300-ton-bommen-gevonden-in-westhoek-b0d776eb/
[2] IFM - Safety controller- CR7032
[3] Hetronic –remote control Nova XL
[4] IFM - Inclinosensor - JN2100
[5] Thomson – gas throttle actuator – ET12-174
[6] IFM - Display CR0451
[7] FaberCom - Hydraulic actuator - MOD09
[8] FaberCom - Hydraulic supply block– IT009

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