Audi Autonomous Driving Cup 2017

Hardware Description

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Contents

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Abbreviations

AADC	Audi Autonomous Driving Cup
LiPo	Lithium-Polymer-Accumulator
IMU	Inertial Measurement Unit

1 Hardware

Figure 1: The AADC2017 car with AUDI Q2 cover

Figure 2: The AADC2017 car

1.1 Schematic diagram

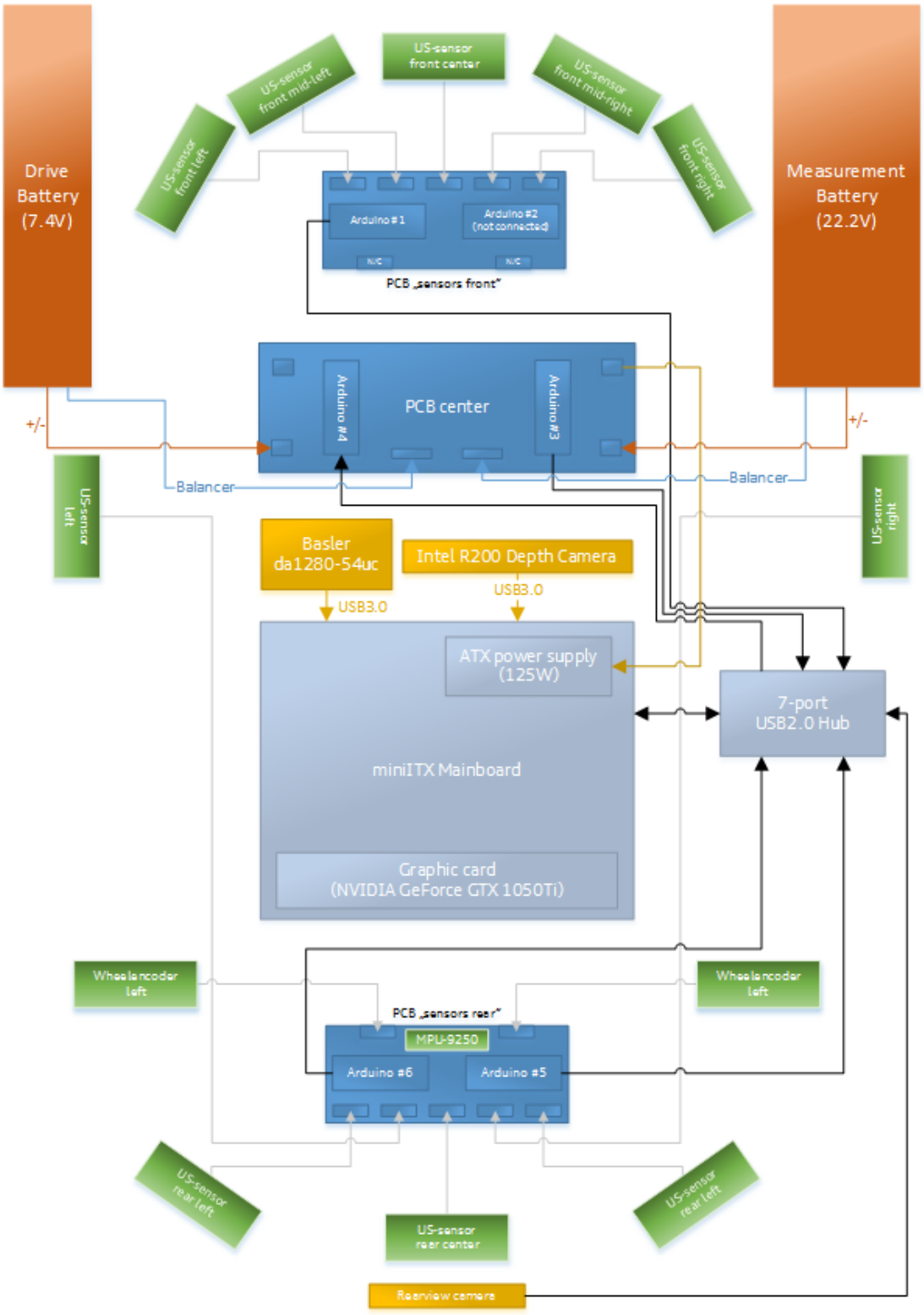


Figure 3: Schematic diagram

1.2 Computer

Built on a GIGABYTE GA-Z170N-WIFI miniITX mainboard, we can offer a wide range of PC configurations.

Figure 4: Mainboard GIGABYTE GA-Z170N-WIFI[1]

- Format: Mini-ITX
- Chipset: Intel® Z170
- Socket: 1151 for 6th generation Intel® CPUs ("Skylake")
- RAM: 2× DDR4 in Dual-Channel
- Slots (physical):
  - 1× PCIe 3.0 x16
  - 1× WiFi-/Bluetooth Module (incl. 802.11ac)
- Internal Connectors:
  - 6× SATA 6G
  - 1× M.2 (PCIe 3.0 x4)
  - 2× USB 3.0 (one header)
  - 2× USB 2.0 (one header)
  - 1× Fan (4-Pin PWM)

[1] http://www.gigabyte.de/Motherboard/GA-Z170N-WIFI-rev-10%23ov

    - Power/Reset/LED/Front-Audio
- External Connectors:
    - 1× PS/2 Keyboard/Mouse
    - 4× USB 3.0
    - 2 x Intel® GbE LAN chips (10/100/1000 Mbit)
    - Wi-Fi 802.11 a/b/g/n/ac, supporting 2.4/5 GHz Dual-Band
    - 2× WiFi Antenna (in bundle)
    - 2× HDMI 1.4b
    - 1× DVI
    - 1× S/PDIF (optical)
    - 5× Audio (7.1 Realtek ALC1150)

For this year's competition, the mainboard is equipped with an Intel® Core i3-6100T CPU (3.2 GHz), a single 8 GB DDR4 PC-2133 RAM and a 128GB M.2 2280 SSD disk drive. In addition, there is a NVIDIA GeForce GTX1050Ti graphics card mounted.

1.2.1 Graphics Card

The NVIDIA GeForce GTX 1050Ti graphics card specifications:

GPU Engine Specs:

- Base Clock (MHz) 1290
- Boost Clock (MHz) 1392
- NVIDIA CUDA® Cores 768

Memory Specs:

- Memory Speed 7 Gbps
- Standard Memory Config 4 GB GDDR5
- Memory Interface Width 128-Bit
- Memory Bandwidth 112 GB/sec

Technology Support:

- NVIDIA GPU Boost™ 3.0
- Microsoft DirectX 12 API with feature level 12_1
- OpenGL 4.5
- Bus Support PCIe 3.0

Display Support:

- Maximum Digital Resolution[2] 7680x4320 @ 60Hz

[2] 7680x4320 at 60Hz RGB 8-bit with dual DisplayPort connectors or 7680x4320 at 60 Hz YUV420 8-bit with DisplayPort 1.3 connector.

- Standard Display Connectors DP 1.4[3], HDMI 2.0b, DL-DVI
- Multi Monitor yes
- HDCP 2.2

Dimensions:

- Height 4.38
- Length 5.7
- Width 2 Slot

Thermal Power Specs:

- Maximum GPU Temperature 97 °C
- Graphics Card Power 75 W
- Recommended System Power[4] 300W

Figure 5[5]: NVIDIA GeForce GTX 1050Ti

[3] DisplayPort 1.2 Certified, DisplayPort 1.3/1.4 Ready
[4] Recommendation is made based on PC configured with an Intel Core i7 3.2 GHz processor. Pre-built system may require less power depending on system configuration.
[5] http://www.nvidia.de/graphics-cards/geforce/pascal/gtx-1050/

1.3 Arduino Micro

“The Arduino Micro is a microcontroller board based on the ATmega32u4 (datasheet), developed in conjunction with Adafruit. It has 20 digital input/output pins (of which 7 can be used as PWM outputs and 12 as analog inputs), a 16 MHz crystal oscillator, a micro USB connection, an ICSP header, and a reset button. It contains everything that is needed to support the microcontroller - getting started simply by connecting it to a computer via a micro USB cable. It has a form factor that enables it to be easily placed on a breadboard.

The Micro is like the Arduino Leonardo in that the ATmega32u4 has a built-in USB communication, eliminating the need for a secondary processor. This allows the Micro to appear to a connected computer as a mouse and keyboard, in addition to a virtual (CDC) serial / COM port.” [6]

Figure 6: Arduino Micro[7]

- Microcontroller: ATmega32u4
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V (limits 6 - 20 V)
- Digital I/O Pins: 20
- PWM Channels: 7
- Analog Input Channels: 12
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega32u4) (4 KB bootloader)
- SRAM: 2.5 KB (ATmega32u4)
- EEPROM: 1 KB (ATmega32u4)
- Clock Speed: 16 MHz
- Dimensions (LxW): 48 mm x 18 mm
- Weight: 13g

[6] http://arduino.cc/en/uploads/Main/ArduinoMicroFront_450px.jpg
[7] http://arduino.cc/en/uploads/Main/ArduinoMicroFront_450px.jpg

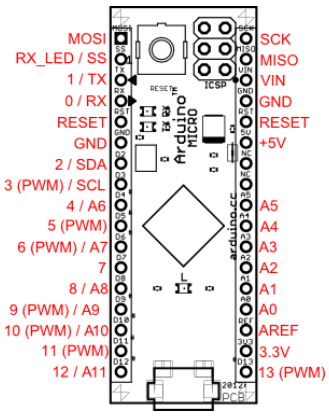


Figure 7: HC-SR04 Ultrasonic Sensor Arduino Micro Pinout[8]

[8] http://arduino.cc/en/uploads/Main/ArduinoMicro_Pinout3.png

1.4 Sensors

1.4.1 HC-SR04 Ultrasonic Sensor

Figure 8: HC-SR04 Ultrasonic Sensor[9]

HC-SR04 Ultrasonic Sensor

- Operating Voltage: 4.5V to 5.5V
- Quiescent Current: 1.5mA to 2.5mA
- Working Current: 10mA to 20mA
- Ultrasonic Frequency: 40Hz
- Range: 2cm to 400cm
- Resolution: 0.3cm
- Measuring Angle: 30°
- Effectual Angle: <15°
- Dimension (mm): 45 x 20 x 15

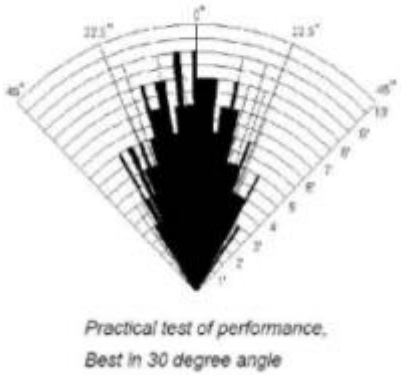


Figure 9: Measuring Angle HC-SR04 (1)

[9] HC-SR04 User's_Manual

1.4.2 9-axis MotionTracking Device

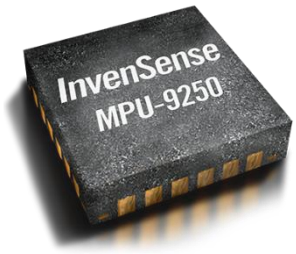


Figure 10: MPU-9250 9-axis Gyro, Accelerometer and Compass[10]

MPU-9250 MotionTracking Device

- Digital-output X-, Y-, and Z-axis angular rate sensors (gyroscopes) with a user-programmable full-scale range of ±250, ±500, ±1,000 and ±2,000°/sec and integrated 16-bit ADCs
- Digital-output triple-axis accelerometer with a programmable full-scale range of ±2g, ±4g, ±8g and ±16g and integrated 16-bit ADCs
- 3-axis silicon monolithic Hall-effect magnetic sensor with magnetic concentrator
- Digitally programmable low-pass Gyroscope filter

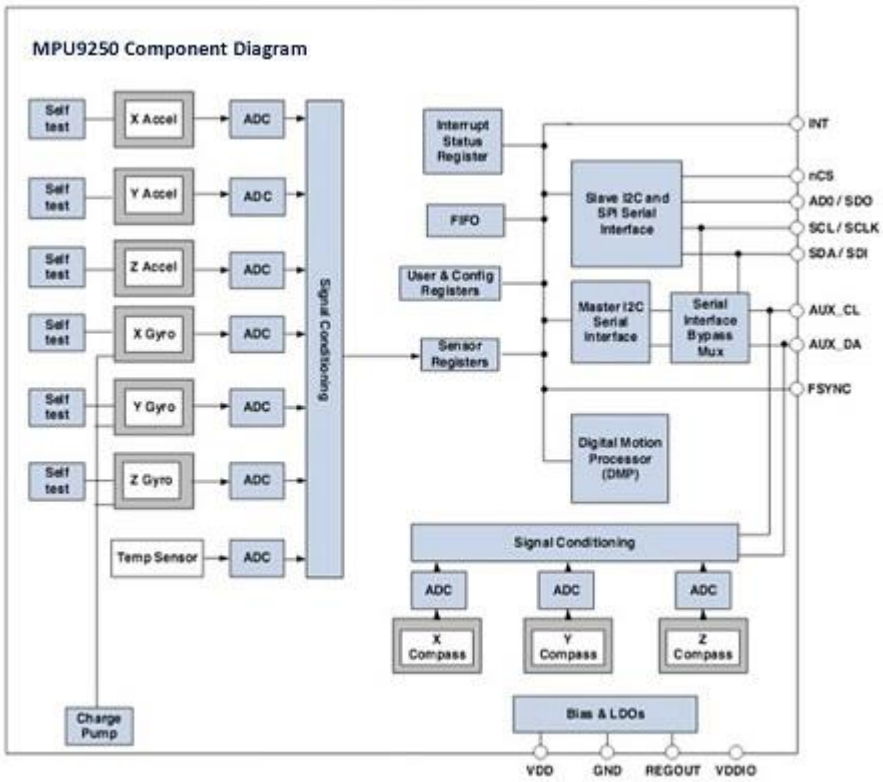


Figure 11: Block Diagram MPU-9250

[10] Invensense MPU-9250

1.4.3 HOA0902-11 – Encoder

Figure 12: HOA0902-11 Transmissive Encoder Sensor (2)

Figure 13: Encoder Wheel

Honeywell HOA0902-11 – Transmissive Encoder Sensor

- Operating voltage: 4.5V to 5.5V (Detector)
- Operating voltage: 1.6V (Emitter)
- Revers Leakage Current: 10uA (Emitter)
- Supply Current: 12mA
- Slot width: 3.2 mm
- Resolution: up to 0.457mm
- Tach Pulse Width: 3…20 us

Encoder Wheel

The encoder wheel is a 3D printed BFFT in-house development. It fits exactly onto the rear wheels and has 30 slots that result in 60 edges (rising and falling).

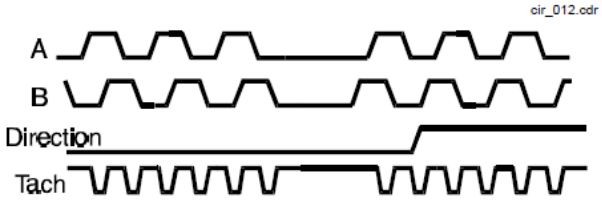


Figure 14: Output Timing Diagram HOA0902-11 (2)

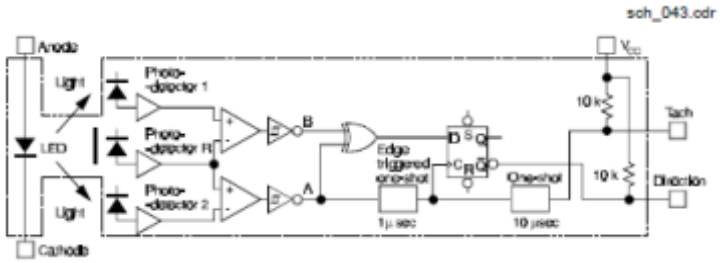


Figure 15: Functional Block Diagram HOA0902 (2)

1.5 Actuators

1.5.1 Absima "ACS1615SG" Steering Servo

Figure 16: Absima "ACS1615SG" Combat Series[11]

Absima "ACS1615SG" Combat Series

- Operating voltage: 4 .8V to 6.0V
- Pulling Force: 13kg to 15kg
- Regulating time: 0,11s to 0,09s
- Angle: 60°
- Weight: 77 g

1.5.2 Robitronic Speedstar Brushless Speed Controller

Figure 17: Robitronic Speedstar Brushless Crawler[12]

Robitronic Speedstar Brushless Regler 8,5T

- LiPo Cells: 2-3s
- B.E.C. Voltage: 5V
- B.E.C. Current: 3,0A
- Ampacity: 260A / phase (brushless)
- Motor Turn Limit: 8,5 Turn (brushless)
- Internal Resistance: 0,005 Ohm / phase (brushless)
- Dimensions (mm): 40 x 41 x 28.7
- Weight: 43g

[11] Absima "ACS1615SG" Combat Series
[12] Robitronic Speedstar Brushless Crawler

1.5.3 Motor Hacker Skalar 10

Figure 18: Hacker SKALAR 10 21.5 Brushless Motor[13]

Hacker SKALAR 10 21.5 Brushless Motor 1/10

- Technology: Sensored, brushless
- Scale: 1/10
- Voltage: 3,2 - 11,1V
- Length: 52.3mm
- Diameter: 35.7mm
- R/min per Volt: 2.100
- Max. power: 149W
- Turns: 21,5T
- Weight: 162g

1.5.4 Absima CR2s V.2 Radio System

You can use the radio system to control the car manually. Please see chapter 2.4 Use Remote Radio Controller for a detailed description.

[13] Hacker SKALAR 10 21.5T Brushless Motor

Figure 19: Absima CR2S V.2 Radio Transmitter

Absima CR2S V.2 Radio Transmitter

- Channels: 2
- RF power: less than 20 dbm
- Modulation: GFSK
- Code type: digital
- Sensitivity: 1024
- Low voltage warning: yes (less than 4,5 V)
- Power: 6 V (1.5V AA *4)
- ANT length: 26 mm
- Dimensions (mm): 220 x 150 x 100
- Weight: 328 g

Figure 20: Absima CR2S V.2 Radio Receiver

Absima CR2S V.2 Radio Receiver

- Channels: 3
- Frequency band: 2.4 GHz
- Modulation: GFSK
- Sensitivity: 1024
- RF receiver sensitivity: -100 dbm
- Power: 4.5–7.2 V
- ANT length: 26 mm
- Dimensions (mm): 37.6 x 22.3 x 13
- Weight: 5 g

1.6 Cameras

1.6.1 Depth Camera Intel R200

Figure 21: Intel® RealSense™ R200 Depth Camera[14]

Intel® RealSense™ R200 Depth Camera

- Streams: RGB, Depth, 2x Infrared
- RGB Stream
  - Resolution (H x V pixels): 1920x1080, 640x480
  - FOV (V x H x D): 43° x 70° x 77°
  - FPS: 15, 30, 60
- Infrared Stream
  - Resolution (H x V pixels): 640x480, 492x372, 332x252
  - FOV (V x H x D): 46° x 59° x 70°
  - 30, 60

[14] https://click.intel.com/intel-realsense-developer-kit-r200.html

	• Depth Stream
	  ○ Resolution (H x V pixels): 628x468, 480x360, 320x240
	  ○ FPS: 30, 60
	• Infrared Projector
	  ○ FOV (V x H x D): 60° x 60° x 80°

1.6.2 Front Camera Basler daA1280-54uc

Especially for road sign and lane detection, the car is equipped with an additional front camera.

 Figure 22: Front Camera Basler daA1280-54uc [15]	Front Camera Basler daA1280-54uc • Resolution (H x V pixels): 1280 x 960px • Pixel Size horizontal/vertical: 3.75 µm x 3.75 µm • FPS: 45 in Car (54 max.)
	Lens • Evetar M13B02118W • Iris: F1.8 • Focal length: 2.1mm • FOV (V x H x D): 96° x 130° x 170°

1.6.3 RearView Camera Delock 96368

 Figure 23: RearView Camera Delock 96368[16]	RearView Camera Delock 96368 • Resolution (H x V pixels): max. 2592 x 1944, min. 160 x 144 • FPS: max. 30, min. 7 • 80° fix focus

[15] http://www.baslerweb.com/en/products/cameras/area-scan-cameras/dart/daa1280-54uc
[16] http://www.delock.de/produkte/G_96368/merkmale.html?setLanguage=en

1.7 Power supply

1.7.1 External power supply unit

Figure 24: Mean Well GST160A24-R7B[17]

(3-pin IEC plug is included in scope of delivery)

Mean Well GST160A24-R7B

- Input Voltage: 85~264VAC
- Input AC Current: 1.85A / 115VAC
  1A / 230VAC
- Output DC Voltage: 24V
- Output Rated Current: 6,67A
- Output Rated Power (max.): 160W
- Connection cable: UL2464 18AWGx4C
  1200+-50mm for 15V~48V
- Connection: R7B (male)
- Dimensions (mm): 175x72x35

DC Output Plug:

R7B	Pin Assignment	
	 -V connected to AC FG	PIN NO. / OUTPUT

PIN NO.	OUTPUT
1	+Vo
2	-Vo
3	-Vo
4	+Vo

Figure 25[18]: Pin Assignment of external power supply unit

[17] https://www.conrad.de/de/tischnetzteil-festspannung-mean-well-gst160a24-r7b-24-vdc-667-a-160-w-1439251.html
[18] http://www.meanwell.com/scripts/resource/pdfJS/web/viewer.html?f=GST160A&pdf=GST160A-SPEC.PDF

Mechanical Specification:

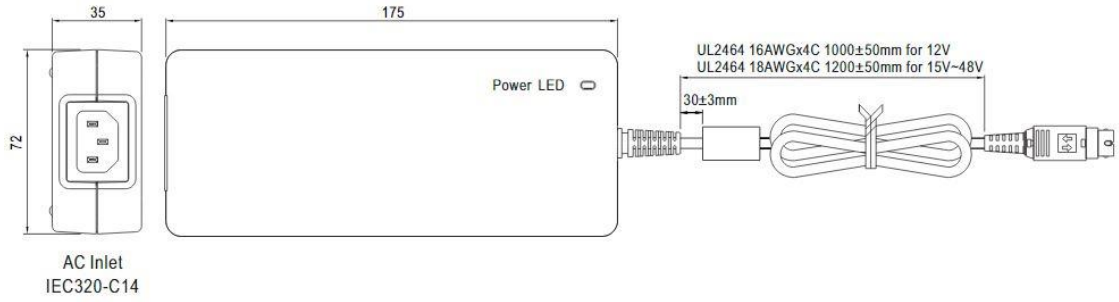


Figure 26[19]: Mechanical Specification of external power supply unit

1.7.2 Battery for powertrain units

Figure 27: Yuki Model 2S (7.4V) battery

Yuki Model 2S (7.4V) battery

- Configuration: 2s1p
- Nominal voltage: 7.4V
- Rated capacity: 5.200mAh
- Max. charge rate: 2C (10.4 A)
- Cont. discharge rate: 45C (234 A)
- Connection cable: silicon
- Connection: Deans T-Plug
- Balancer cable: PVC (JST XH)
- Dimensions (mm): 137.5 x 46 x 25
- Weight: 280g

1.7.3 Battery for measurement units

Figure 28: Yuki Model 6S (22.2 V) battery

Yuki Model 6S (22.2 V) battery

- Configuration: 6s1p
- Nominal voltage: 22.2 V
- Rated capacity: 5.200mAh
- Max. charge rate: 2C (10.4 A)
- Cont. discharge rate: 45C (234 A)
- Connection cable: silicon
- Connection: Deans T-Plug
- Balancer cable: PVC (JST XH)
- Dimensions (mm): 137 x 43 x 60

[19] http://www.produktinfo.conrad.com/datenblaetter/1400000-1499999/001439251-da-01-en-MEAN_WELL_GST160A24_R7B_SNT_EXTERN_160W.pdf

	• Weight: 715 g

1.7.4 Charger

 Figure 29: Absima APC-1[20]	Charger Absima APC-1 • Operating Voltage: DC 11.0 ~18.0 V • Input Voltage: AC 100 ~ 240 V • Circuit Power (charge): max. 80 W • Circuit Power (discharge): max. 5 W • Charge Current Range: 0.1 ~ 10.0 A • Discharge Current Range: 0.1 ~ 2.0 A • Lithium battery cell count: 1–6 cells • Dimensions (mm): 130×115×61 • Weight: 380g

1.7.5 Charging Batteries

For 2S LiPo – accumulators: For 6S LiPo – accumulators:

Figure 30: Batteries (2S & 6S) connected to the charger

First, connect the battery to the charger as shown in Figure 30. Connect the charger to the power socket and conjunct the balancer cable and the power cable from battery pack to the charge.

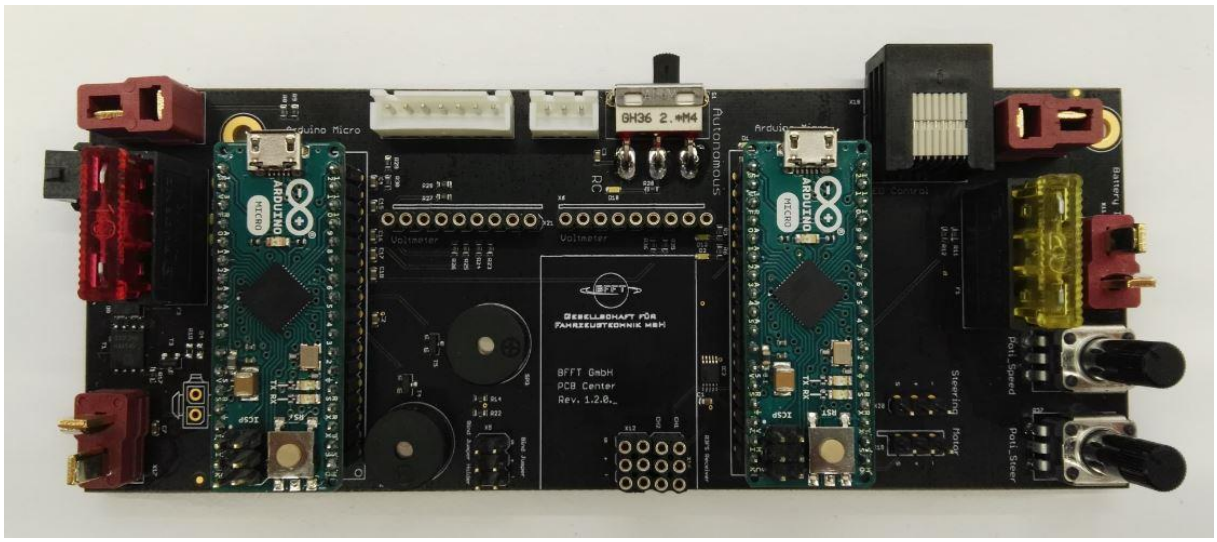
Always charge the batteries in balance mode. During this mode, the internal processor thereby controls the charging current in order to normalize the voltage monitors each cell of the pack. You may not use a different mode than balance mode to avoid a damage of the batteries.

Please refer to the manual of the charger for a detailed description of charging lithium batteries.

[20] http://shop.absima.com/LADETECHNIK/Ladegeraete/Ladegeraet-APC-1.htm?shop=absima&SessionId=&a=article&ProdNr=4000013&t=25&c=218&p=218

1.8 Printed Circuit Boards (PCBs)

1.8.1 PCB_Center



On this PCB there are plugged in two Arduino micros. The red circle marks the Arduino, which is used for voltage measurement the blue one controls the lights, speed control and servo.

The yellow fuse is dimensioned with 20A and is used to protect the motor and speed controller. On the left side, there is a red 10A fuse, which protects the ATX-power supply and the mainboard.

The tw0 9 pin connectors (green circle) are used for the two LiPo-Checkers.

In addition, there is a connector for the Bind-Jumper with an included holder for it.(yellow circle)

The connector on the right side of it is used for the R3FS-Reciever.

The two white connectors on the top of the board are used for the two different balancer cables. The left one is for the 6S-battery the right one for the 2S-battery.

The switch next to them is for choosing between the two operation modes “radio-controlled” (left) or “autonomous” (right).

The RJ45 socket is for the connection between the PCB_Center and the LED_Control.

The two red 2-pin plugs are for the 2 different batteries. The left one is used for the 22,2V battery the right one for the smaller one 7,4V battery.

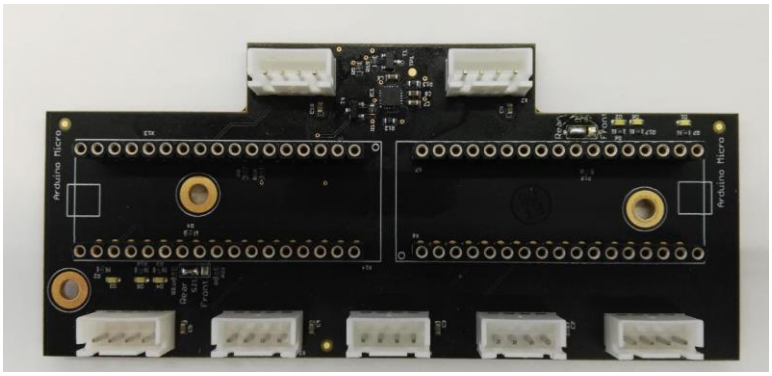
On the two red pin sockets you are able to connect the ATX power supply on the left side which is plugged in at the mainboard and on the other side there is also a connector for the speed controller.

The black 4-pin socket is for the external power supply.

At the bottom on the right there are two 3-pin headers. The upper one is used for the steering and the lower ne is used for the speed controller.

You can adjust the steering and speed with the two potentiometer on the right side.

1.8.2 Sensor PCB



The Sensor PCB is used in the front and in the rear of the car.

These two printed circuit boards are almost identical. They differ from that only in that small detail that one is jumpered for usage in the front and the other one is jumpered for usage in the rear.

1.8.2.1 Sensor PCB front

At this PCB there is connected one Arduino micro on the headers on the right side and five ultrasonic sensors from the front spoiler are plugged in at the five 4-pin connector.

1.8.2.2 Sensor PCB rear

At this PCB there are connected five ultrasonic sensor and two wheel encoders.

There is one ultrasonic sensor on each side of the car and three of them are installed in the rear. The wheel encoders are located in the inside of the tires.

There are also two Arduino micros on the PCB, which are connected on the USB Hub on the right side of the car.

1.8.3 LED_Control

This PCB is placed in the back of the covering.

There are only three connectors on this PCB. The one RJ-45 socket, where you can plug in the cable that is also connected to the PCB_Center.

The other two black headers are used to plug in the two different cable sets for the lights. The 10-pin connector is used for the cable set to the LEDs in the back of the covering and the 8-pin connector is used for the cable set to the LEDs in the front of the car.

2 Starting the Car

2.1 Connecting the batteries

The car has two batteries:

- The first one (2S LiPo, 7.4V) for power supply of the actuators (the speed-controller/motor and the steering servo)
- The second one (6S, 22.2V) for power supply of the PC, the Arduinos and the measurement technology.

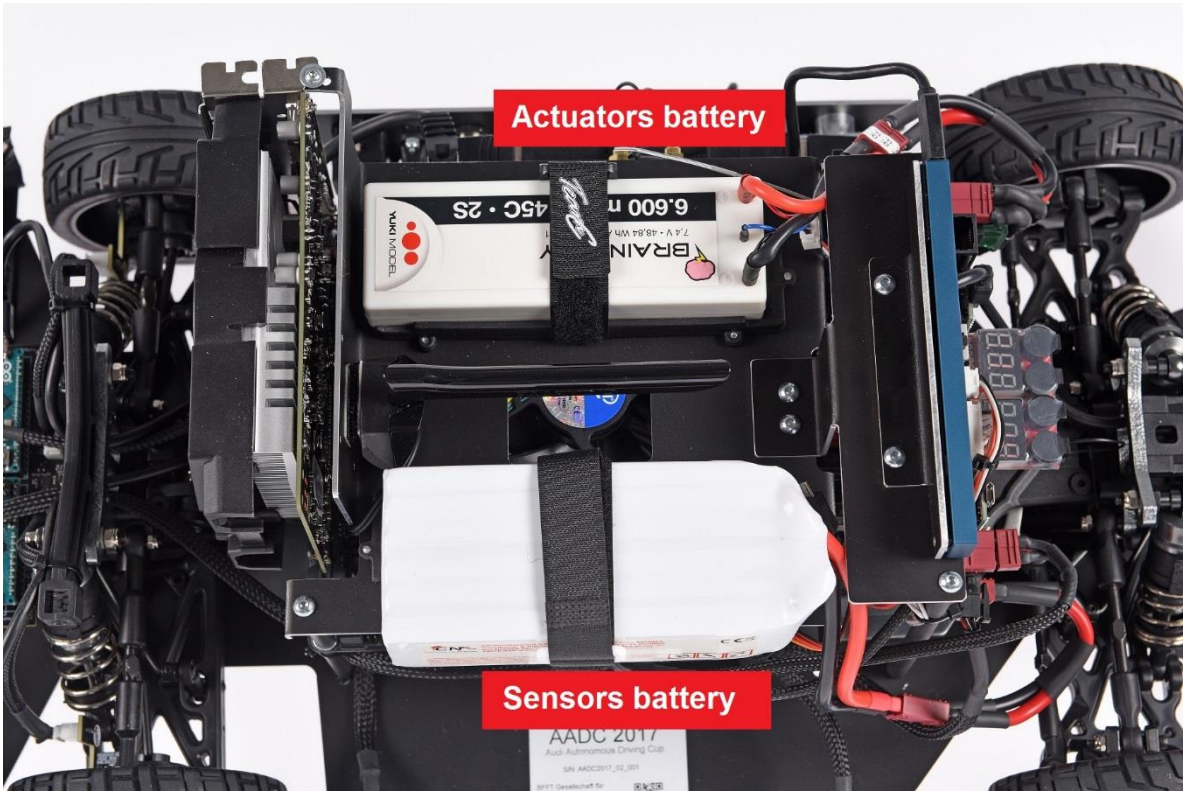


Figure 31: Top view batteries

You need to charge these two batteries, place them in the vehicle as shown in Figure 31: Top view batteriesFigure 31 and connect thme to the board as shown in Figure 32.

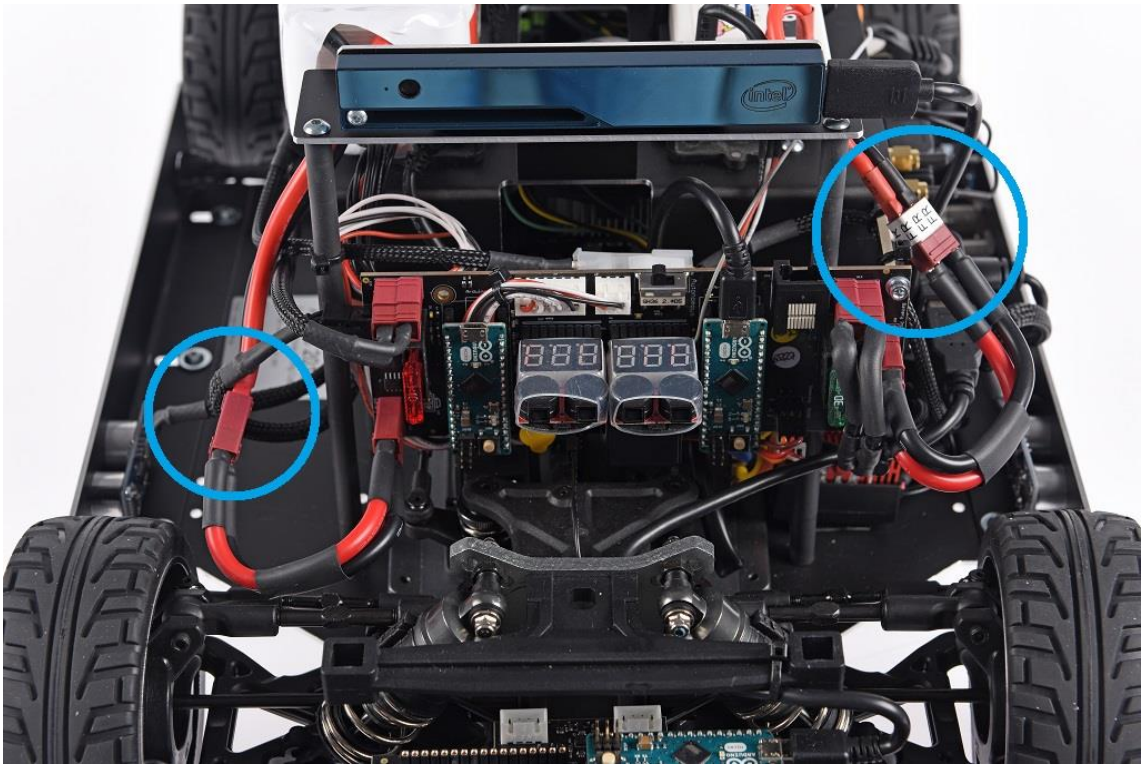


Figure 32: Connecting the batteries

For connecting the batteries, make sure to connect the power cables (thick ones with red and black cable, see blue circles above). Please always connect/disconnect these cables. Never unplug any cable on the PCB, except balancer and USB-cables, otherwise might damage the PCB.
Afterwards connect the balancer cable (thin wires, black, white and red) and make sure that the battery voltmeters are plugged into the connector. If you have everything connected properly, the voltmeters will show the voltages of the batteries in big red letters.

YOU MUST USE THE BATTERY VOLTMETERS DURING USING THE CAR. OTHERWISE THE BATTERIES COULD BE IRREVERSIBLE DAMAGED, OR COULD CATCH FIRE AND DAMAGE THE CAR. EVERYTIME THE CAR IS USED THE VOLTMETER MUST SHOW A VOLTAGE AND IF THEY START TO BEEP, DISCONNECT THE ACCORDING BATTERY AND CHARGE IT.

2.2 Connecting the external power supply

You can also power the car externally by using the external power supply (24V/160W). In this case, you can only remove the sensor battery. You still need the actuators battery for controlling the actuators.

The external power supply and the Sensors battery, respectively, are hot pluggable. Therefore, you are able to connect the external power supply while the battery is still connected and vice versa. That enables you to change the Sensors battery without shutting down the PC.

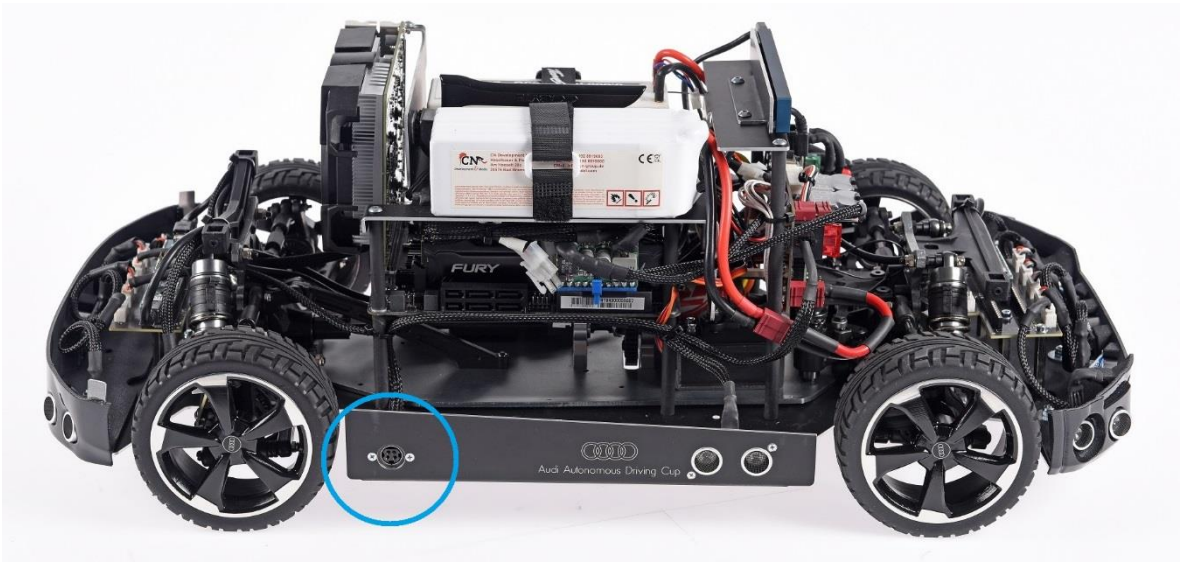


Figure 33: Connector for external power supply

2.3 Switching on

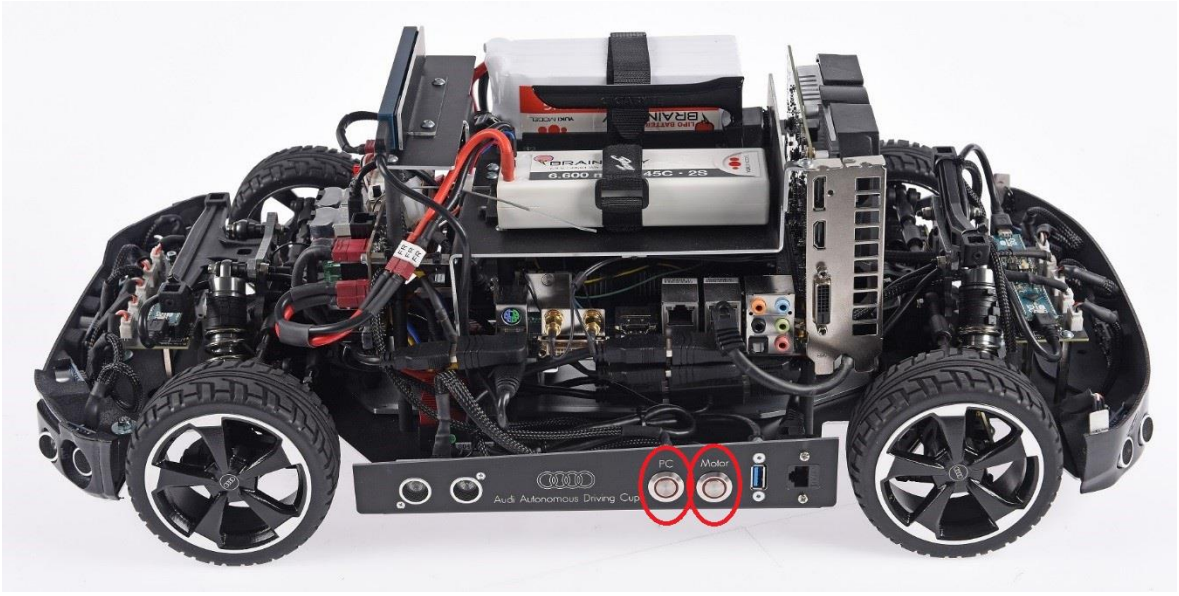


Figure 34: Switches on the car

The car has two switches to start the car. The switch labeled *PC* turns on the ATX power supply. It will take 2 seconds after pressing the switch until the PC starts. Afterwards the USB ports are supplied and the Arduinos consequently.

The other switch labeled *Motor* turns on the actuators. You need to press the switch in order to control the actuators. We recommend turning off the actuators if you use the car on your desk to prevent unexpected acceleration of the car.

2.4 Connecting other devices

An USB3.0 and a CAT5 RJ45 slot are also on the left side. To connect a monitor to the car, please use the according slots of the graphic card. Note, the slots on the mainboard will not work if the gpu is present.

2.5 Use Remote Radio Controller

To use the controller described in 1.5.4, you need to activate the remote receiver on the PCB center by switching the RC/autonomous mode switch.

2.5.1 Activate Remote Radio Controller

Please follow the instructions below to use the radio controller.

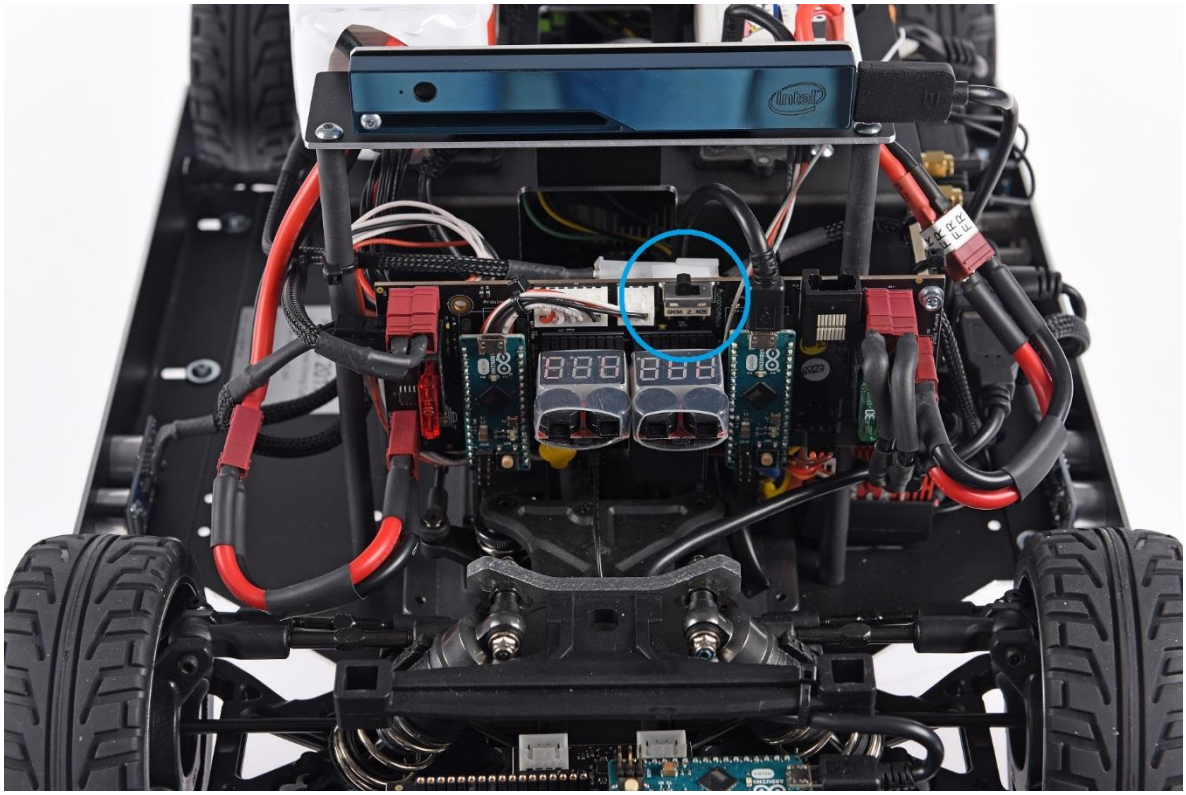


Figure 35: Switch for RC/autonomous mode

1. First make the sure that the *Bind Jumper* is placed in the *Bind Jumper Holder* position and not in the *Bind Jumper* position (i.e. the position next the remote radio receiver).
2. Then the mode switch has to be set to the *RC* position as shown in Figure 30. Afterwards a LED right below the switch will turn on.
3. After setting the switch correctly, you need to reset the Arduino next to the switch by pressing the *Arduino Reset* button. After this reset, the speed controller will initialize.

NOTE: When setting the Mode to *Radio Controlled* all the actuators commands from the Arduino and from ADTF are ignored.

NOTE: Probably, the zero position of the Radio Controller System has to be adjusted. Take care of the last point in Chapter 2.4.3.

2.5.2 Deactivate Remote Radio Controller

To deactivate the Radio Controller again and use the Arduino and ADTF commands, do the following steps:

1. Set the mode switch to *Autonomous*.
2. Press the Arduino Reset Button to restart the Arduino and use the control commands from the Arduino.

2.5.3 Bind Radio Controller to Radio Remote Receiver

If the Radio Remote Receiver (mounted on the board) needs to be bind to the Radio Controller again to join the devices. Therefore, every controller can be used with every receiver by binding the two devices. The binding also prevents receiving signals from the other controllers of the same model.

The binding was made for every car prior to the delivery, so it is not necessary to do the binding again. If the binding was lost, follow the instructions below to match the devices again:

1. Make sure that the *Mode Switch* is set to *Autonomous Mode*
2. Set the *Bind Jumper* to the *Bind Jumper* position and not to the *Bind Jumper Holder* position.
3. Set the *Mode Switch* to the *RC Mode*; the red LED of the receiver should blink now.
4. Take the Remote Controller and make sure charged batteries are in the controller.

Figure 36: Radio Controller Buttons

5. Press and hold the *Bind Button* with a pencil or something other useful. While pressing the *Bind Button* turn the *Power Switch* to ON. The red LED on the remote receiver on the car should stop blinking.
6. Now, remove set the *Mode Switch* back to *Autonomous Mode* and place the *Bind Jumper* back to the *Bind Jumper Holder* position again.

7. Set The *Mode* Switch back to *RC Mode.*
8. Now you can turn on the controller again.
9. Normally, you need to calibrate the speed controller to the output of the radio controller. This setup routine maps the maximum motor speed to the maximum PWM signal of the radio controller system and the minimum motor speed to the minimum PWM signal of the radio controller system. The PWM signals from the Arduino which are used in software driven mode are different from the signals from the radio system, so normally the speed controller has to be calibrated each time the mode is switched from Arduino to the Radio System and vice versa. You can use a little trick can be used to avoid this effort.
   When the speed controller is powered on (after pressing the Button *Motor* in the side sills), it waits for the zero position (PWM signal which corresponds to motor speed zero set during calibration procedure). During this time, the red LED of the speed controller is on. When the speed controller gets the zero position it does some more beeping and the green LED is also turned on and the speed controller works properly.
   You can adjust this zero position by the potentiometer *THROTTLE TRIM*. Therefore, after turning the power for the speed controller on (some first beeping from it) you can adjust this potentiometer to set the correct zero position. If you found the correct position the speed controller does some more beeping. Maybe you have to try this multiple times, each time switch the motor on and try another position of the potentiometer.

3 Calibration

3.1 Speed Controller Setup

Usually, you do not need to calibrate the Speed Controller because this is already done prior to the vehicle delivery. The Speed Controller Setup does a mapping from the received PWM Signal (from the Arduino or the Radio Remote Control) to the minimum and maximum range of the motor.

If for any reasons, it is necessary to do this again, please follow these instructions:

1. Start the Car, Switch Speed Controller on, load and start the SpeedControllerCalibrationConfiguration Project (Please see the "*AADC2017_Software_Description"*). Make sure the Property *Enable Speed Controller Fallback* of the Filter *Car Control* is turned to False.
2. Press the setup-button of the Speed Controller for more than a second. The green led will start to indicate the pressing will start to light continuously if the button is released now.
3. Now the full throttle has to be transmitted to the steering controller. The red light will confirm the full throttle position, then you have to release. The full throttle can be transmitted from ADTF from the Car Control Filter by moving the bar to topmost position.
4. Now the maximum Reverse has to be transmitted and will be confirmed by red and green light. Release to zero position again. The maximum reverse can be transmitted from ADTF from the Car Control Filter by moving the bar to lowermost position.
5. The Controller will proceed with some blinking and peeping to confirm the calibration.

For further details, refer to the manual of the controller:

http://www.robitronic.com/en/manual-robitronic.html?file=files/anleitungen/robitronic/Speedstar_Brushless_Crawler_Manual.pdf

NOTE: The speed controller needs the zero position at startup phase. When the speed controller is powered on it does some first beeping and the red LED is turned on and it waits for the zero position. After receiving it the green LED turns on and it does some beeping. This zero position is set during the described setup procedure.

3.2 Steering Calibration

The steering calibration consists mainly of a mapping from the servo angle to a valid curvature. You can do this by the Steering Calibration Filter and is described in the "*AADC2017_Software_Description"*.

3.3 Adjustment with Potentiometers

On the Actuator Board are two potentiometer mounted which can be used for fine adjustment of the steering servo and the speed controller.

Figure 37: Potentiometer in Zero Position

The potentiometer for the steering servo changes its zero position to make the car drive straight ahead. The potentiometer for the speed controller modifies the mapping over the complete scope as shown in Figure 33.

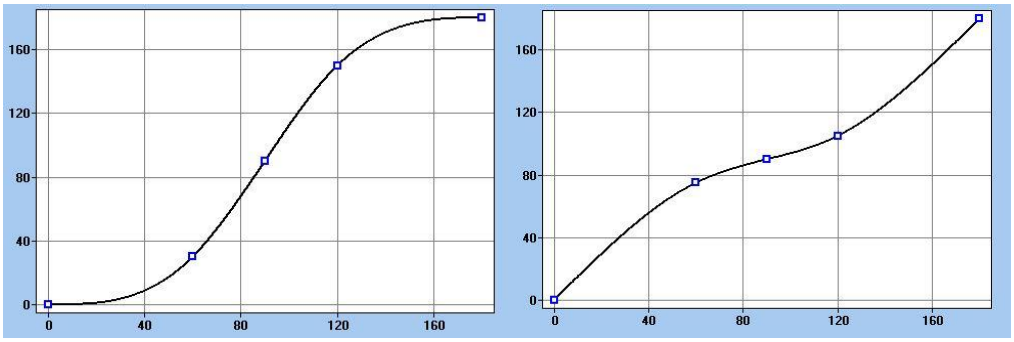


Figure 38: Modifications with speed controller potentiometer

4 Troubleshooting

If any errors during using the car occur, please refer to the support forum at https://www.audi-autonomous-driving-cup.com/ .

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