Formula Student Electric
Rules 2011

Version 1.1.0
Release Date: 26. Apr. 2011

1 Introduction

Since 2010 Formula Student Germany is organizing 2 Events, Formula Student Combustion (FSC) and Formula Student Electric (FSE). Both Events take place at the same dates and the same event site.

This rules document contains the Formula Student Germany rules for the Formula Student Electric Competition.

2 Important Dates

2.1 Competition Dates and Place

August 02, 2011 to August 07, 2011
Formula Student Electric (FSE) will take place in Hockenheim/Germany.

2.2 Registration

January 24, 2011 1200 CET

Registration forms will be accepted in the order in which they are received, starting January 24, 2011 at 1200 CET and ending on February 28, 2011 1200 CET or when the 30 cars registration limit is reached. Registration will be online at the FSE Website.

2.3 Structural Equivalency Form

April 04, 2011 at 1200 CEST

IMPORTANT: ALL TEAMS MUST SUBMIT A STRUCTURAL EQUIVALENCY FORM. A blank copy of this form is supplied on the Formula Student Germany Electric Website

http://www.formulastudentelectric.de/events/event-2011/rules-important-documents/

The Structural Equivalency Form must be uploaded to the 'My Team' area on the FSE website no later than April 04, 2011 at **1200 CEST**.

Late submissions will be penalized with -10 (minus ten) points per day, up to a maximum of -70 points, which will be taken off the team's Total Score.

Teams, which missed the SEF deadline by more than 7 days will be removed from the FSE 2011 competition.

In the event that the FSG Technical Committee requests additional information or calculations, teams have **10 days** from the date of the request to submit the requested information. Late submissions will be penalized with -5 (minus five) points per day, up to a maximum of -50 points, which will be deducted from the team's Total Score.

2.4 Impact Attenuator Data

April 04, 2011 at 1200 CEST

IMPORTANT: ALL TEAMS MUST SUBMIT AN FSG IMPACT ATTENUATOR DATA FORM. A blank copy of this form is supplied on the Formula Student Germany Website

http://www.formulastudentelectric.de/events/event-2011/rules-important-documents/

Impact Attenuator Data must be uploaded to the 'My Team' area on the FSE website no later than April 04, 2011 at **1200 CEST**.

Late submissions will be penalized with -10 (minus ten) points per day, up to a maximum of -70 points, which will be deducted from the team's Total Score.

Teams, which miss the IAD deadlines by more than 7 days will be removed from the FSE 2010 competition.

In the event that the FSG Technical Committee requests additional information or calculations, teams have **10 days** from the date of the request to submit the requested information. Late submissions will be penalized with -5 (minus five) points per day, up to a maximum of -50 points, which will be deducted from the team's Total Score.

2.5 Electrical Safety Form

May 02, 2011 1200 CEST

IMPORTANT: ALL TEAMS MUST SUBMIT AN ELECTRICAL SAFETY FORM. A TEMPLATE WILL BE PROVIDED ON THE FSG WEBSITE AND HAS TO BE USED, SEE RULE 7.1.

The Electrical Safety Form must be uploaded to the 'My Team' area on the FSE website no later than May 02, 2011 till **1200 CEST**.

Late submissions will be penalized with -10 (ten) points per day, up to a maximum of 70 points, which will be taken off the team's Total Score.

Teams which missed the ESF deadline by more than 7 days will be de-registered from the FSE 2011 competition.

In the event that the FSG Technical Committee requests additional information or calculations, teams have **7 days** from the date of the request to submit the requested information. Late submissions will be penalized with -5 (five) points per day, up to a maximum of 50 points, which will be taken off the team's Total Score.

2.6 Failure Modes and Effects Analysis

March 7, 2011 1200 CET

IMPORTANT: ALL TEAMS MUST SUBMIT A FAILURE MODES AND EFFECTS ANALYSIS. A TEMPLATE WILL BE PROVIDED ON THE FSG WEBSITE AND HAS TO BE USED, SEE RULE 7.2.

The Failure Modes and Effects Analysis must be uploaded to the 'My Team' area on the FSE website no later than March 7, 2011 till **1200 CET**.

Late submissions will be penalized with -10 (ten) points per day, up to a maximum of 70 points, which will be taken off the team's Total Score.

Teams, which missed the FMEA deadline by more than 7 days will be de-registered from the FSE 2011 competition.

In the event that the FSG Technical Committee requests additional information or calculations, teams have **7 days** from the date of the request to submit the requested information. Late submissions will be penalized with -5 (five) points per day, up to a maximum of 50 points, which will be taken off the team's Total Score.

2.7 Engineering Design Report and Design Spec Sheet

June 13, 2011 1200 CEST

The FSE Engineering Design Report must be uploaded to the 'My Team' area and the FSE Engineering Design Spec Sheet must be filled out online in the 'My Team' area on the FSE website no later than June 13, 2011 **1200 CEST**. The Formula Student Electric Engineering Design Spec Sheet Form can be found on the FSE website in the 'My Team' area prior the deadline.

Late submissions will be penalized with -10 (ten) points per day, up to a maximum of -100 points, which will be taken off the team's Engineering Design Event Score. No report submitted will result in a score of zero for the Engineering Design Event.

2.8 Cost Report

June 13, 2011 1200 CEST

The Cost Report consists of 2 parts, the Written Report and the Electronic Copy. The electronic Cost Report must be submitted as a Microsoft Excel® file. The file must be uploaded to the 'My Team' Area on the FSE Website no later than June 13, 2011 at 1200 CEST. The electronic Copy has to consist of a full vehicle BOM with cost data derived from the Cost Tables and supporting documentation (e.g. calculations, drawing or photos)

The written Report must be present during Cost Event judging.

Late submissions will be penalized with -10 (ten) points per day, up to a maximum of – 80 points, which will be taken off the team's Cost Event Score. No report submitted will result in a score of zero for the Cost Event.

2.9 Business Plan Executive Summary

June 13, 2011 1200 CEST

The Business Plan Executive Summary must be uploaded to the 'My Team' area on the FSE website no later than June 13, 2011 till **1200 CEST**.

Late submission or non submission will be penalized at the discretion of the judges with up to -5 (five) points. These penalty points will be taken from the Presentation Judging Form.

2.10 Charging Type and Power

May 02, 2011

Teams must inform FSG whether their accumulators are charged inside or outside the car and what the drawn peak power during charging is no later than May 02, 2011. The charging type and peak power can be entered after registration in the 'My Team' area.

2.11 Safety Responsible(s) Qualification Upload

June 27, 2011 at 1200 CEST

Several steps have to be completed to be accepted as a qualified SR for the event.

1) Each team member that wants to be accepted as SR must upload a document describing his/her qualification in the “My Account” area on the FSE Website. see also 3.7. This should be done in the form of an Adobe Acrobat® file (*.pdf).
2) The team captains are able to designate this team member as an SR at the event in the “My team area” after the upload of the qualification document, see 2.12.
3) After the team member has been designated as an SR at the event his/her qualification document will be reviewed by FSG officials.
4) If the qualification was determined to be sufficient for being an SR, the team member will be approved to be an SR at the event.

2.12 Team Member Designation

June 27, 2011 at 1200 CEST

Participating team members must be designated prior to the event. Additionally team members who should be an SR during the event must be designated as such. To designate a team member, please visit the “My team area” on the FSE Website.

Team members can only be designated as FSE participants if they have entered the following personal information in their user profiles:

- Personal Address (required for insurance purposes)
- ZIP code (required for insurance purposes)
- City (required for insurance purposes)
- Clothing size (required for Event T-Shirts)
- Emergency contact person (parents e.g.)
- Emergency contact phone (parents e.g.)
- FISITA organisation you belong to
- FISITA organisation member number
- JPG Copy of their Health Insurance Certificate
- Name of the Health Insurance Company
- Health Insurance Certificate period of validity

In case the health insurance data of one or more team members is missing or incorrect, FSG will decline the designation of the team member(s) in question. Only designation of team members with complete and correct health insurance information will be accepted.

Team members that were declined can be registered again after their health insurance data has been corrected for an additional processing fee of 50 Euro.

2.13 Scrutineering Quiz

May 09 2011 at 1200 CEST

Participating teams have to complete the Scrutineering Quiz. The scrutineering order at the event will be based on the time a team needs to complete the quiz. The fastest team will receive the first slot, the slowest team will receive the last slot. Teams that do not participate in the quiz will be sorted by registration order and will be placed at the very end of the scrutineering queue behind the slowest team to complete the quiz.

FSG has the right to reorder the scrutineering queue, in case the scrutineering slot of a team coincides with a time slot of the team for a static event.

3 General

3.1 FSE 2011 Rules

The principle of Formula Student Electric is to allow the development of fully electric vehicles within the Formula Student framework. The competition for Formula Student Electric cars will be the same as Formula Student with some slight modifications due the special needs of fully electric vehicles.

The Formula Student Electric (FSE) competition will comply with the Formula SAE® 2011 rules.
The Formula Student Electric Rules include some specific rule changes and additions to allow the development of safe, fully electric vehicles with electro-chemical energy storage.

Those changes and additions are located within this document, which supersedes the specific sections of the published Formula SAE® rules for 2011.

3.2 Rules Questions

Any questions or ambiguities concerning the rules for Formula Student Electric will be resolved by the Formula Student Electric Rules Committee (FSE-Rules@FormulaStudent.de).

Any question must use following format in the subject line:

UNINAME_RULESNUMBER

Each Request must give following informations in the end

Name / Surname / University

Attachments must be in *.jpg or Adobe ® *.pdf format. Any other file format will not be accepted. The maximum Email size limit is 5 MB.

3.3 Official Language

The Formula Student Germany Official Language is English.

3.4 Official time

The Formula Student Germany official time:

From	Till	Time
31.10.10	26.03.11	CET
27.03.11	29.10.11	CEST

To convert CET or CEST to your local time you may use following website:

http://www.timeanddate.com/worldclock/converter.html

3.5 FSE Registration

3.5.1 Registration deadline

The registration deadline for Formula Student Electric is listed in the Important Dates section of this document. (Please refer to FSE Rules, section 2.2)

3.5.2 Registration Capacity Limit

Registrations will be given out, in the order in which they are received. The 2011 Formula Student Electric competition will be limited to 30 teams.

3.5.3 Registration Fee

The registration fee of 750 Euros is for a 20-person team. More team members can be registered for 20 Euros per additional team member. There is no limit to team size.

The registration fee must be paid on-line by PayPal within 72 hours of registration. Registration fees may not be paid by any other means. Registration fees are not refundable for any reason. There is no late registration and there are no exceptions to this registration policy.

3.5.4 Registration required information

Once the team has officially been registered for FSE, each team member and faculty advisor is required to add his/her identifying information online. All participants must provide their name and individual emergency contact information.

Participants may only be added (registered) by the team's official contact person (the person who registered the team for the event) until June 27, 2011 at 1200 CEST.

3.5.5 Independent teams

In case a university takes part in FSG2011 with two cars, one in FSC and one in FSE, then these teams may not share team members or faculty advisors at the event. This means that no team member can be part of both teams, work on both cars or take part in any static or dynamic event for both teams.

3.6 Society Membership

Every participating team member must be a member of one of the FISITA (www.fisita.org) engineering societies.

3.7 Safety Responsible

Every participating team has to appoint at least one safety responsible (SR) for the event. This person is responsible for all electrical operations of the vehicle during the event. The SR is also responsible for every kind of work at the car during the event. The SR is the only person in the team that is allowed to declare the car electrically safe, so that work on any system of the car may be performed by the team.
The SR must be a valid team member, which means that he/she has to have student status, see FSAE Rules 2011 A4.2.
The SR must be reachable by phone at all times during the event.
The SR must accompany the car whenever it shall be operated or is moved around at the event site.
The SR is not allowed to be a driver, if no second SR is named by the team who is not a driver.

The SR must be properly qualified. The minimum qualification which may be accepted is being a student of electrical engineering and being deeply involved with the design of the current FSE car. In order to register as an SR for the event, the respective team member must prove this by uploading a document describing his/her qualification in his/her “My Account”-area on the FSE Website, see 2.11 for details on how to become a qualified SR at the event.
It is recommended that the SR is certified for working with high voltage systems in automotive vehicles.

3.8 Extension of the Rules

Due to continuous development of the FSE rules, extensions or additions may be integrated at any time.
Any significant rule changes or additions will occur only once a year and will be published before the 30th of November.
Small rule changes, additions or rules for event specific operations will be published on the FSG Homepage.

3.9 Faculty Advisor

FSG recommends that all participating teams have a Faculty Advisor present with them at the competition. In the event that no Faculty Advisor is present during the competition, the Team Captain will take over all responsibilities of the Faculty Advisor.

3.10 Event Handbook

The event handbook may contain special event procedures and restrictions for example regarding working on the car etc. It has to be read and understood by all event participants.

3.11 Testing and Work Safety

All teams are advised to always follow common practices and common sense when working on the vehicle and when operating the vehicle, also before and after the event. Participating in events not suitable for Formula Student vehicles like hillclimbs, drag races, etc. is strongly not recommended!

4 Vehicle Requirements and Restrictions

4.1 Alternative Frame Rules (Specific FSG change of Formula SAE® 2011 Rule B 3.0)

Alternative Frame Rules are still under development. Therefore FSG will not offer the possibility to review any request for Alternative Frame Rules for 2011.

Teams for which the Alternative Frame request already has been granted by any other of the FSAE organizing bodies are allowed to use the frame build to the Alternative Frame Rules for the FSG 2011 competition.

4.2 Impact Attenuator

4.2.1 Anti Intrusion Plate (Specific FSG change of Formula SAE® 2011 Rule B 3.20.6)

On all cars, a 1.5 mm (0.060 in) solid steel or 4.0 mm (0.157 in) solid aluminium “anti-intrusion-plate” must be integrated into the Impact Attenuator. Alternative materials are prohibited.

4.3 Brake System

4.3.1 Brake System Master cylinder actuation

The brake system master cylinder must be direct actuated or by a mechanical connection. The use of bowden cables or push-pull bowden cables is not allowed.

The first 50% of the brake pedal travel may be used to regenerate brake energy. The remaining brake pedal travel must actuate the hydraulic brake system, but brake energy regeneration may remain active.

It is allowed to apply a low amount of brake torque to the driven wheels, if the throttle is not actuated. Low means that the applied brake torque is comparable to the brake torque of a combustion engine.

4.3.2 Brake light (Specific FSG change of Formula SAE® 2011 Rule B 7.4.1)

The car must be equipped with one red brake light. The brake light itself has to have a black background and a rectangular, triangular or near round shape with a minimum shining surface of at least 15cm². Each brake light must be clearly visible from the rear in very bright sunlight.
The brake light must turn on when the driver actuates the brake pedal.

4.3.3 Brake Over-Travel Switch Type(Specific FSG change of Formula SAE® 2011 Rule B 7.3.3)

The Brake Over-Travel switch must be a mechanical single pole, single throw (commonly known as a two-position) switch (push-pull or flip type) as shown in Figure 1.

Figure 1: example of allowed switch types for the brake over-travel switch

4.3.4 Brake Over-Travel Switch Function(Specific FSE change of Formula SAE® 2011 Rule B 7.3.1)

Instead of switching off the ignition and fuel pumps the brake pedal over-travel switch must shut down the Tractive System by opening the safety circuit, see also 7.16.

4.4 Driver Egress (Specific FSG change of Formula SAE® 2011 Rule B 4.8)

The driver egress, required by Formula SAE® 2011 Rule B 4.8 must be possible in all steering wheel positions.

4.5 Fire Extinguishers (Specific FSG change of Formula SAE® 2011 Rule B 17.14)

Aqueous Film Forming Foam (AFFF) fire extinguishers are prohibited.

4.6 Vehicle Identification

4.6.1 School Name (Specific FSG change of Formula SAE® 2011 Part B Rule 16.2)

Following school type abbreviations are accepted. The city name must be written fully.

Technical University - TU + City
University of Applied Sciences – UAS + City
University - Uni + City
Berufsakademie - BA + City

If the university uses a shortcut in their proper name, this shortcut is acceptable + city.

Example:
real name: Rheinisch-Westfälische Technische Hochschule Aachen -
proper name: RWTH Aachen

4.6.2 Technical Inspection Sticker Space (Specific FSG change of Formula SAE® 2011 Part B Rule 16.4)

The technical inspection sticker will be placed on the nose of the car directly in front of the cockpit opening. A space 75 mm tall x 150 mm wide (3” tall x 6” wide) must be made available for this sticker.

4.6.3 Transponders (Specific FSG change of Formula SAE® 2011 Part B Rule 15.2 and 15.3)

Transponders will be provided by FSG. Only provided transponders will be accepted. The allowed mounting position and orientation will be published in the event handbook.

4.7 Driver’s Underclothing (Specific FSG change of Formula SAE® 2011 Rule B 17.6)

All drivers have to wear underwear (long pants and long sleeve t-shirt) certified to SFI 3.3 or FIA 8856-2000

4.8 Chassis

The used chassis has to comply to the FSAE2011 rules. An old chassis design, which was not entered in an FSE event before, may be used only if it complies to the FSAE2011 rules. In this case the chassis has to be rebuild.
The requirements for the IAD and the Anti-Intrusion Plate are not affected by using an old chassis. Therefore both have to comply to the FSAE Rules 2011 and the FSG/FSE additions.

4.9 Firewall

A firewall must separate the driver compartment from all tractive system components and any oil or liquid cooling systems.
In case of using a non-metal material for the firewall (i.e. carbon fibre, fibreglass, etc.) a fire resistant heat protection shield with a metal surface must be fitted to that side of the firewall on which the tractive system components are. Aluminium tape or foil will not be accepted as a metal surface. It is only allowed to seal small gaps.
This metal material used as the firewall must have a minimum thickness of 0.3mm.
The metal surface part of the firewall must have a low resistance connection to control system ground.

4.10 Brake Test

During the brake test the car must be accelerated on a short straight with a standing start. After accelerating the tractive system has to be switched off by the driver and the driver has to lock all four wheels of the vehicle by braking. The brake test is successful if all four wheels lock while the tractive system is shut down.
NOTE: It is acceptable if the Tractive System Active Light switches off shortly after the vehicle has come to a complete stop as the reduction of the system voltage may take up to 5 seconds, see 7.13

4.11 Tractive System

4.11.1 Replacement of FSAE Rules 2011

Articles B8.1 until B8.9, B9 except B9.9, B10 and B11except B11.4 of the FSAE 2011 rules are superseded by the following FSE rules. Articles B8.10 and B8.11 are only valid if a cooling system is in use.

4.11.2 Power Limitation

The maximum power drawn from the battery must not exceed 100kW. This will be checked by evaluating the Energy Meter data.
Violating this value will lead to a DNF for the entire dynamic event in which the violation occurred e.g. If more than 100kW are drawn during one single acceleration run, the team will receive no points for the complete acceleration event.

4.11.3 Motors

Only electrical motors are allowed.
Any type of electrical motors is allowed. The number of motors is not limited.

4.11.4 Torque Encoder (throttle pedal position sensor)

Drive by wire is permitted.
The torque encoder must be actuated by a foot pedal.
The foot pedal must return to its original position when not actuated.
At least two sensors have to be used as torque encoder.
If an implausibility occurs between the values of these two sensors the power to the motor(s) has to be shut down completely. It is not necessary to completely deactivate the Tractive System, the motor controller(s) shutting down the power to the motor(s) is sufficient.
Motor power is allowed to be restored after the driver has selected the sensor that works correctly.
Each sensor has to have a separate detachable connector that enables a check of these functions by unplugging it during E-Scrutineering.

5 Pit Rules

5.1 Electrical Power during pushing

It must be possible to push the car around with all electrical systems deactivated.

5.2 Push Bar (Specific FSG/FSE change of Formula SAE® 2011 Part B Rule 17.15)

The push bar must be a separate, detachable device. Rear wings will not be accepted as push bar. The push bar must be located behind the rear axle when the car is moved.
One fire extinguisher has to be attached to the push bar by a quick release fastener in an easily accessible position.
Additionally a pair of high-voltage insulating gloves and a multimeter have to be attached to the push bar.
If a tool is needed to open the HVD, see 7.24, this tool has also to be attached to the push bar.

5.3 Activating the tractive system

The Event Handbook will define where and under which conditions the tractive system may be activated.

5.4 Quick Jack

Each team must present a quick jack to lift up the car by using the jacking point during Technical Inspection.
The quick jack must be able to lift up the car, so that the driven wheels are at least 10.2 cm (4 in) off the ground.

6 SEF and IAD Documents

6.1 Structural Equivalency and Structural Equivalency Form

All teams must submit the FSG Structural Equivalency Form. A blank copy of this form is supplied on the Formula Student Germany Electric Website http://www.formulastudentelectric.de/events/event-2011/rules-important-documents/

The use of alternative materials or tubing sizes to those specified in Formula SAE® 2011 Rule B 3.3.1 “Baseline Steel Material” is allowed, provided they have been judged by a technical review to have equal or superior properties to those specified in Formula SAE® 2011 Rule B 3.3.1 “Baseline Steel Material”.

Structural equivalency must be demonstrated by providing calculations and/or tests results. All calculations must compare the alternative material with S235Jr (Material number 1.0037). Tensile strength and yield stress properties (at a minimum) of the alternative material must be compared with the same attributes of S235Jr.

All formula symbols and abbreviations, used in the SEF, must be defined.

6.2 Impact Attenuator Data

All teams must submit the FSG Impact Attenuator Data Form, along their test results, description of the test setup, the used test equipment and photo documentation of the IAD before and after the test. The Impact Attenuator Data must be submitted no later than the specified date.

A blank copy of this form is supplied on the Formula Student Germany Electric Website http://www.formulastudentelectric.de/events/event-2011/rules-important-documents/

7 Electrical Rules

7.1 Electrical Safety Form (ESF)

Prior to the event all teams must submit clearly structured documentation of their entire electrical system (including control and tractive system) similar to the SEF called electrical safety form (ESF).
The ESF must visualize the interconnection of all electric components including the voltage level, the topology, the wiring in the car and the construction and build of the accumulator(s).
Teams must present data sheets with rated specifications for all tractive system parts used and show that none of these ratings are exceeded (including wiring components). This includes stress caused by the environment e.g. high temperatures, vibration, etc.
A template including the required structure for the ESF will be made available on the FSE website.
The ESF must be submitted as Adobe PDF-File.
The minimum allowed font size is 11pts. The font used must be Arial. Small pictures and small schematics should be put inside the text for easy reference, not in the appendix.
Data sheets and large schematics should be put in the appendix. Alternatively links to data sheets may be provided.
NOTE: Passing the ESF does not mean that you automatically pass E-Scrutineering with the described items / parts.

7.2 Failure Modes and Effects Analysis (FMEA)

Teams must submit a complete failure modes and effects analysis (FMEA) of the tractive system prior to the event.
A template including required failures to be described will be available on the FSE website. Do not change the format of the template. Pictures, schematics and data sheets to be referenced in the FMEA have to be included in the ESF.

7.3 Control and Tractive System

The tractive system of the car is defined as every part that is electrically connected to the motor(s) from the system's point of view.
The control system of the car is defined as every electrical part that is not part of the tractive system.
The tractive system must be completely insulated from the chassis and any other conductive parts of the car.
The tractive-system is a high-voltage system by definition, see 7.4.
The control system must be a low-voltage-system, see 7.4. The control system must be grounded to the chassis.
The entire tractive and control system must be completely galvanically separated.
The border between tractive and control system is the galvanic insulation between both systems. Therefore some components may be part of both systems.
Bypassing the control system and connecting the tractive batteries directly to the motor(s) is prohibited.

The control system must have been powered up properly before it is possible to activate the tractive system. This also means that a failure causing the control system to shut down must immediately deactivate the tractive system as well.

7.4 High-Voltage (HV) and Low-Voltage (LV)

Whenever a circuit carries more than a nominal operation voltage of 40V DC or 25V AC RMS it is defined as part of the High Voltage system. 600V DC or AC RMS is the maximum permitted nominal operation voltage that may occur between any two electrical connections.
Low voltage is defined as any voltage below 40V DC or 25V AC RMS.

The electrical layout of self developed devices must be documented accurately, see 7.1.

The LV and HV systems of the car must be separated.

- Using the same cable channel(s) for both systems is prohibited except for pilot or interlock circuits at the accumulator connector(s).
- If a housing contains parts of the HV and LV system, an insulation boundary made of non conductive material must separate both systems.
- If a printed circuit board (PCB) contains both HV and LV systems, they must be separated by sufficient space to avoid accidental flashover and they must be galvanically separated. Furthermore the HV and LV areas have to be clearly marked on the PCB. All self developed PCBs containing HV must be easily accessible during E-Scrutineering.

7.5 Positioning of tractive-system parts

All parts belonging to the tractive-system have to be positioned within the surface defined by the top of the roll bar and the outside edge of the four tires (See Figure 13 in the FSAE rules).
In side view no part of the tractive-system can project below the lower surface of the frame or the monocoque, whichever is applicable.
Additional regulations apply for accumulators, see 7.21.3.

7.6 Grounding

All electrically conductive parts of the vehicle (e.g. pedalbox, steering wheel, suspension, firewalls) which are prone to contact a damaged wire or electrical part, no matter if HV or LV, must have a resistance below 300 mOhm (measured with a current of 1A) to control system ground.

7.7 Insulation Monitoring Device (IMD)

Every car must have an insulation monitoring device (IMD) installed in the tractive system. For information regarding FSE approved IMD(s) please refer to the corresponding document in the “Rules & Important Documents” section of the FSG website.
The response value of the IMD needs to be set to 500 Ohm / Volt, related to the maximum tractive system operation voltage.
In case of an insulation failure or an IMD failure, the IMD must break the holding current flow of the accumulator insulation relay(s) to shut down the tractive system.

This has to be done without the influence of any logic e.g. a micro-controller. See also 7.16 regarding the re-activation of the tractive-system after an insulation fault.
The status of the IMD has to be shown to the driver by a red indicator light in the cockpit that is easily visible even in bright sunlight. This indicator has to light up, if the IMD detects an insulation failure or if the IMD detects a failure in its own operation e.g. when it looses reference ground.
The IMD indicator light has to be clearly marked with the lettering “IMD” or “GFD” (Ground Fault Detector).

7.8 Insulation Monitoring Device Test (IMDT)

The insulation monitoring device will be tested during E-Scrutineering. This is done by connecting a resistor between the measuring points, see 7.10, of the tractive system and several electrically conductive vehicle parts while the tractive system is active. (See example in Figure 2)
The test is passed if the IMD shuts down the tractive system within 30 seconds at a fault resistance of 50% below the response value corresponding to 250 Ohm / Volt.
The IMDT may be repeated at any time during the event. After the car passes the test for the first time, critical parts of the tractive system will be sealed. The vehicle is not allowed to take part in any dynamic event if any of the seals are broken until the IMDT is successfully passed again.

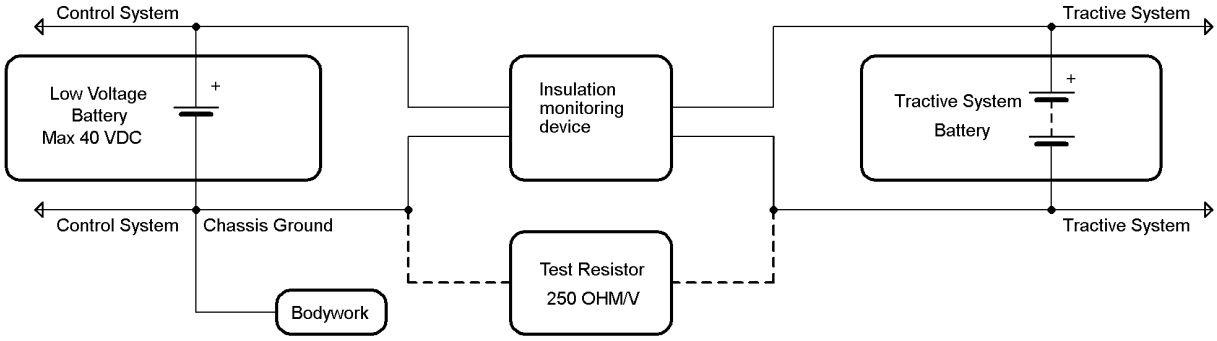

Figure 2: insulation monitoring device test example

7.9 Rain test

Teams have to pass a rain test during Scrutineering to be allowed to move the car under its own power on the event. The car has to pass the IMDT, see rule 7.8, before the rain test can be performed.
During the rain test the tractive system has to be active and none of the driven wheels may touch the ground. It is not allowed to have a driver seated in the car during the rain test.
Water will then be sprayed at the car from any possible direction for 120 seconds. The water spray will be rain like. Therefore there will be no direct high-pressure water jet shot at the car.
The test is passed if the insulation monitoring device does not react while water is sprayed at the car and 120 seconds after the water spray has stopped. Therefore the total time of the rain test is 240 seconds, 120 seconds with water-spray and 120 seconds without.
Teams have to make sure that water cannot aggregate anywhere in the chassis.

If any of the seals that were applied during E-Scrutineering is broken, the rain test must be redone after the IMDT was successfully passed again.

7.10 No exposed tractive system connections except for measuring points (HVMP)

All parts, especially live wires, contacts, etc. of the tractive system need to be isolated by non-conductive material or covers to be protected from being touched. A protection degree of IP65 is recommended for the rain test.

Two tractive system voltage measuring points must be installed directly next to the master switches, see rule 7.15.
The measuring points must be protected by a non-conductive housing that can be opened without tools. The measuring points must be protected from being touched with the bare hand / fingers, once the housing is opened. 4mm banana jacks rated to an appropriate voltage level have to be used, see Figure 3 for an example.
The measuring points must be connected to the positive and negative motor controller/inverter supply lines.

Figure 3: HVMP 4mm banana jack example

These measuring points will be used to check during E-Scrutineering that the tractive system is shut down properly in the given time, see rule 7.15. They are also needed to ensure the safety of the vehicle for possible rescue operations after an accident or when work on the vehicle is to be done.

7.11 Insulation, wiring and conduit

Only insulation material that is appropriate for the expected surrounding temperatures may be used. Using only insulating tape or rubber-like paint for insulation is prohibited.
All wires and terminals used in the tractive system must be reasonably sized and the wires must be marked with wire gauge, temperature rating and insulation voltage rating. Alternatively a serial number or a norm printed on the wire is sufficient if this serial number or norm is clearly bound to the wire characteristics for example by a data sheet.
The complete tractive system wiring harness must be professionally built and secured against loosening and/or mechanical stress.
All HV wires that are not protected by housings or enclosures must be orange.
If HV wires run through an area in which mechanical damage to the wire is likely then the wiring has to run in orange non-conductive cable channels. Shielded cables may be accepted as alternative to cable channels but have to be especially mentioned and approved in the ESF.
Wiring and Cable channels must be securely attached.
The tractive system wiring must be shielded against damage by rotating and / or moving parts.

Mounting wires lower than the lowest point of the chassis is prohibited.
The use of shielded wires is recommended for the tractive system.
If external, uninsulated heat sinks are used, they must be properly grounded to the Control System ground.

7.12 Insulation Measurement Test (IMT)

The insulation resistance between the tractive system and control system ground will be measured during E-Scrutineering. The available measurement voltages are 250V and 500V. All cars with a maximum nominal operation voltage below 500V will be measured with the next available voltage level e.g. a 175V system will be measured with 250V, a 300V system will be measured with 500V etc. All teams with a system voltage of 500V or more will be measured with 500V.
To pass the IMT the measured insulation resistance has to be at least 500 Ohm/Volt related to the maximum nominal tractive system operation voltage.

7.13 Tractive-system-active light (TSAL)

It must be clearly visible when the tractive system is set to active. The car is defined as active whenever the accumulator insulation relay is closed or the voltage outside the accumulator containers exceeds 40V DC or 25V AC RMS. For this the car must be equipped with a light mounted under the highest point of the main roll hoop which lights if the car's tractive system is active and which is off when the tractive system is not active, see definition above.
The TSAL must be red.
The TSAL has to flash continuously with a frequency between 2Hz and 5Hz.
The TSAL has to be clearly visible from every horizontal direction, except small angles which are covered by the main roll hoop, even in very bright sunlight.
NOTE: If any offical e.g. track marshal, scrutineer, etc. considers the TSAL to not be easily visible during track operations the team may not be allowed to compete in any dynamic event before the problem is solved.
It is prohibited to mount other lights in proximity to the TSAL.

7.14 Shut Down Buttons

A system of three shut-down buttons must be installed on the vehicle.
Pressing one of the shut-down buttons must separate the tractive system from the accumulator block by opening the accumulator insulation relays, AIRs, see also Rule 7.16.
After separating the system, the voltage in the tractive system must drop to under 40V DC or 25V AC RMS in less than **five** seconds.
Each shut-down button must be a push-pull or push-rotate emergency switch where pushing the button opens the circuit of the holding current of the accumulator insulation relays. The shut-down buttons must not act through logic, e.g. a micro-controller.
One button must be located on each side of the vehicle behind the driver’s compartment at approximately the level of the driver’s head. The minimum allowed diameter of the shut down buttons on both sides of the car is 40 mm.
One shut-down button is equivalent to the cockpit-mounted Master Switch and must be easily accessible by the driver in any steering wheel position. The minimum allowed diameter of the shut down button in the cockpit is 24 mm.

The shutdown buttons are not allowed to be easily removable, e.g. mounted onto a removable body work.

7.15 Master Switches

Each vehicle has to have two Master Switches, the Control System Master Switch, CSMS, and the Tractive System Master Switch, TSMS.
The CSMS must completely disable power to the Control System and must be direct acting, i.e. it cannot act through a relay or logic.
The CSMS must be located on the right side of the vehicle, in proximity to the Main Hoop, at shoulder height and be easily actuated from outside the car.
The TSMS must be located next to the CSMS and break the current flow holding the accumulator insulation relays. The TSMS must be direct acting, i.e. it cannot act through a relay or logic.
After separating the system, the voltage in the tractive system must drop to under 40V DC or 25V AC RMS in less than **five** seconds, see also Rule 7.16.
Both master switches have to be of the rotary type, with a red, removable key, similar to the one shown in Figure 4.
The master switches are not allowed to be easily removable, e.g. mounted onto a removable body work.
The function of both switches must be clearly marked with “LV” and “HV”. A sticker with a red or black lightning bolt on a yellow background or red lightning bolt on a white background must additionally mark the Tractive System Master Switch.
The “ON” position of both switches must be in the horizontal position.

7.16 Safety Circuit

Setting any of the 2 master switches or the 3 shut-down buttons to the “Off”-Position, activating the brake-over-travel-switch, an insulation failure detected by the IMD or critical values of the accumulators detected by the battery management system, BMS, must open all accumulator insulation relay(s) and, as stated before, the voltage in the tractive system must drop to under 40V DC or 25V AC RMS in less than **five** seconds after such event.
An exemplary schematic of the required safety circuit, excluding possibly needed interlock circuitry, is shown in Figure 4.
If the tractive system is shut down by the BMS or the IMD an acknowledgement by the driver is required, before the tractive system can be set active again. For example: Applying an IMD test resistor between HV+ and control system ground must deactivate the system. Disconnecting the test resistor must not re-activate the system.
All circuits that are part of the safety circuit have to be designed in such a way, that in de-energized state they are open with respect to the current controlling the AIRs.

7.17 Independent Activation of the Tractive System

The driver has to be able to (re-)activate or reset the Tractive System from within the cockpit without the assistance of any other person. Resetting or re-activating the Tractive System by operating shut-down buttons or switches which cannot be reached by the driver is considered as working on the car.

7.18 Ready-To-Drive-Sound

The car has to make a characteristic sound, once not continuous, when it is ready to drive. The car is ready to drive as soon as the motor(s) will respond to the input of the torque encoder / acceleration pedal.
The sound level has to be a minimum of 70dBA, fast weighing, for at least 1 second in a radius of 2m around the car.
The used sound has to be easily recognizable. No animal voices, song parts or sounds that can be interpreted as offensive will be accepted.
An example for an acceptable sound can be found in the "Rules & Important Documents" section of the website. If you want to make sure that your sound is accepted during E-Scrutineering send it to fse-rules@formulastudent.de prior the event for approval.

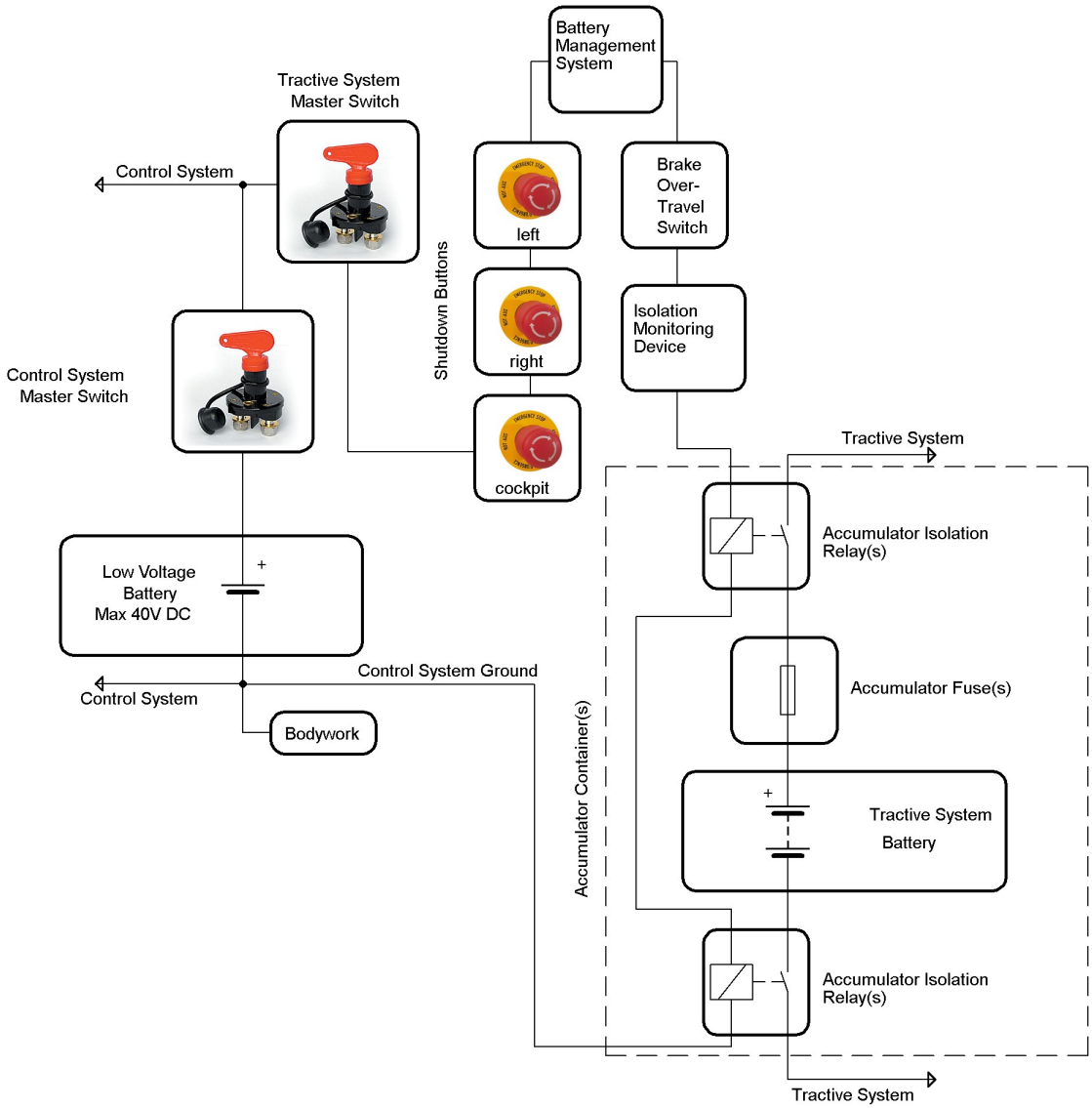

Figure 4: Schematic overview of the car's shutdown system

7.19 Fusing

The tractive system must be appropriately fused. Fusing of the control system is recommended.

7.20 Energy Storage

All types of accumulators except molten salt and thermal batteries are allowed. E.g.: Batteries, Supercaps, etc.
Fuel cells are prohibited.
The data sheets with rated specifications of the used accumulator cell(s) must be part of the ESF.
If the used accumulator cells are not intrinsically safe, which has to be proven by according documentation in the ESF, special regulations may apply, see Rule 7.25 .

7.21 Accumulator Container

7.21.1 General

The used accumulator stack(s) must be enclosed in (an) accumulator container(s).
If multiple accumulators are to be used as spare parts than they all have to be of the same size, weight and type.
Spare accumulator packs have to be presented at E-Scrutineering.
If the accumulator container(s) is not easily accessible during E-Scrutineering, detailed pictures of the internals during assembly have to be provided.

If several accumulator containers which are interconnected should be treated as one single container e.g. to avoid several AIRs, all electrical connections between these containers have to be protected according to 7.21.3. That way one big accumulator container is built with respect to the mechanical and electrical configuration.

7.21.2 Electrical Configuration

The poles of the accumulator stack(s) and/or cells must be insulated against the inner wall of the accumulator container, if the container is made of electrically conductive material. In this case the outer side of the container must have a low-resistance connection to control system ground.
Every accumulator container must contain at least one fuse and at least two accumulator insulation relays, see rule 7.22, as shown in Figure 4.
If the HV-connectors of the accumulator containers can be removed without the use of tools, a pilot contact/interlock line has to be implemented which breaks the current through the AIRs whenever the connector is removed.
Contacting / interconnecting the single cells by soldering in the high current path is prohibited. Soldering wires to cells for the voltage monitoring input of the BMS is allowed, since these wires are not part of the high current path.
Each accumulator container must have a prominent indicator, such as an LED that will illuminate whenever a voltage greater than 40VDC is present at the outer connector. Alternatively an analogue voltmeter may be used. Whichever solution is used, it must be clearly visible from outside of the car in ready-to-race condition.
Indirectly measuring the voltage at the connectors by only activating the indicator when the AIRs are closed is not sufficient.
The indicator must always work, e.g. even if the container is removed from the car and carried around.

7.21.3 Mechanical Configuration

All accumulator containers must be rugged and rigidly mounted to the chassis to prevent the containers from loosening during the dynamic events or possible

accidents. If fasteners are used for mounting an accumulator container, they have to comply to Article B14 of the FSAE rules.
All accumulator containers must lie within the surface defined by the top of the roll bar and the outside edge of the four tires (See Figure 13 in the FSAE rules).
All accumulator containers must be protected from side or rear impact collisions.
If an accumulator container or parts of it are mounted outside of the primary structure (B.3.2) an additional impact structure according to FSAE rules B3.24 or B3.26 must be build to protect the accumulator.
The accumulator container must be built of mechanically robust and fireproof material. If the container is made of CFRP, GFRP or similar a resin system has to be used that is self-extinguishing, or appropriate measures have to be taken to protect the inner side of the accumulator containers against fire.
The data sheet of the used resin system has to be presented at scrutineering, if a self-extinguishing resin system is used.
The cells and/or stacks must be appropriately secured against loosening inside the container.
Breakthroughs or holes in the container are only allowed for the wiring-harness, ventilation, cooling or fasteners. These holes must be sealed according to article 7.10.
The container has to be completely closed at all times, when mounted to the car and also when dismounted from the car without the need to install extra protective covers. Openings for ventilation should be of a reasonable size, e.g. completely open sidepods containing accumulators are not allowed.

A sticker with an area of at least 750mm² and a red or black lightning bolt on yellow background or red lightning bolt on white background must be applied on every accumulator container. The sticker must also contain the text “High Voltage” or something similar if the battery voltage is greater than 40VDC e.g. Figure 5.

Figure 5 : High Voltage Sticker

All kinds of accumulators that may vent an explosive gas must have a ventilation system or pressure relief valve to prevent the vented gas from reaching an explosive concentration.
Every accumulator container which is completely sealed must also have a pressure relief valve to prevent high-pressure in the container.

7.21.4 Working on Accumulator Containers

Opening of or working on accumulator containers is only allowed in the charging area, see rule 7.29. This also applies to interconnected containers as described in 7.21.1.

7.22 Accumulator Insulation Relay(s) (AIR)

In every accumulator container at least two insulation relays must be installed.
The accumulator insulation relays must cut both(!) poles of the accumulator.
If these relays are open, no HV may be present outside of the accumulator container.
The insulation relays must be of a “normally open” type.
The maximum switch-off-current of the used accumulator insulation relay must be higher than the used accumulator fuse value.

7.23 Pre-Charge and Discharge Circuits

A circuit that is able to pre-charge the intermediate circuit to at least 90% of the current accumulator voltage before closing the second AIR has to be implemented.
This circuit has to be blocked by a de-activated safety circuit, see rule 7.16.
Therefore the pre-charge circuit must not be able to pre-charge the system, if the safety circuit is open.
It is allowed to pre-charge the intermediate circuit for a conservatively calculated time, before closing the second AIR. A feedback via measuring the current intermediate circuit voltage is not required.
If a discharge circuit is needed to meet the “below five seconds under 40VDC”-bound, it has to be designed to handle the maximum discharge current for at least 15 seconds. The calculation proving this has to be part of the ESF.
The discharge circuit has to be wired in a way that it is always active whenever the safety circuit is open. Furthermore the discharge circuit has to be fail-safe.

7.24 HV Disconnect (HVD)

At least one pole of the HV system has to be able to be interrupted by quickly removing an accessible element, fuse or connector to be able to disconnect the HV-system from the car in case of (a) stuck accumulator insulation relay(s) for example.
Rule 7.10 remains valid, therefore a dummy connector or similar may be needed to restore the system's insulation.
The HV Disconnect has to be clearly marked with "HVD".
Being able to quickly disconnect the accumulator(s) from the rest of the HV system by its connector(s) will satisfy this rule.
If a tool is needed to open the HVD this tool has also to be attached to the push bar, see also rule 5.2.

7.25 Battery Management System (BMS)

Each accumulator must be monitored by a battery management system whenever the tractive system is active or the accumulator is connected to a charger.
The BMS must continuously measure the cell voltage of every cell in order to keep the cells inside the allowed minimum and maximum cell voltage bound stated in the cell data sheet. If single cells are directly connected in parallel, only one voltage measurement is needed.

The BMS must continuously measure the temperatures of critical points of the accumulator to keep the cells below the allowed maximum cell temperature bound stated in the cell data sheet.
The temperature of at least 35% of the cells has to be monitored by the BMS, if the used accumulator cells are not intrinsically safe, which has to be proven by corresponding documentation in the ESF. The monitored cells have to be equally distributed over the accumulator container(s).
Cells are only considered intrinsically safe, if they are not prone to thermal runaway if they are overcharged, undercharged, overheated or mechanically damaged.
The BMS must be capable of shutting down the tractive system, if critical values are detected.
FSE recommends to monitor every cell voltage and every cell temperature.

7.26 Wiring of the tractive system supply

All accumulator containers must be wired to a single point. It does not matter if they are wired in series or parallel but all the energy supplying the tractive system must flow through this single point and must pass the energy meter position, see article 7.27.

7.27 Energy meter

In the tractive system supply wires, see article 7.26, a calibrated energy meter provided by the FSE organization must be inserted at the event. The type and size of the connector(s) and the energy meter will be published on the FSE website. The energy meter is used to calculate the efficiency score by measuring the total energy being sourced by the accumulator(s).
The energy meter is sealed by the officials before the dynamic events. Any manipulation or broken seals of the energy meter result in a DNF for the efficiency scoring.
The recorded data is downloaded by the officials after the Endurance Event to calculate the efficiency score.

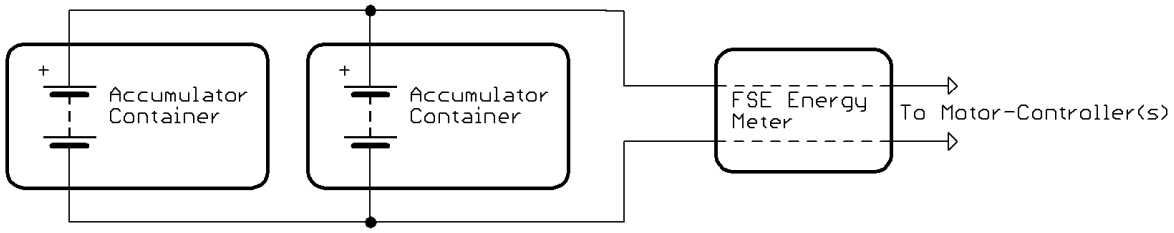

Figure 6: Exemplary Energy Meter Wiring

7.28 High-Voltage Enclosures

Every housing or enclosure containing parts of the high-voltage system except motor housings must be labelled with (a) reasonably sized sticker(s) with a red or black lightning bolt on yellow background or red lightning bolt on white background. The sticker must also contain the text “High Voltage” or something similar if the voltage is more than 40VDC, see Figure 5.
If the housing material is electrically conductive, it must have a low-resistance connection to control system ground.

7.29 Charging

There will be a separated charging area on the event site. Charging tractive system accumulators is only allowed inside this area.
Accumulators may be charged inside the car.
It is also possible to charge the accumulators outside the car with a removable accumulator container.
The accumulator containers or the car itself, depending on whether the accumulators are charged externally or internally, must have a label with the following data during charging: Team name and Safety Responsible phone number(s).
Only chargers presented and sealed at E-Scrutineering are allowed. All connections of the charger(s) must be isolated and covered. No open connections are allowed.
Charging accumulators is allowed at all times during the event in the charging area, but there may be assigned time slots for charging accumulators inside the car due to the limited space on the event site. The time slots will be team specific.
Charging accumulators in a removable accumulator container will not be restricted by time slots.
NO WORK IS ALLOWED ON ANY OF THE CAR'S SYSTEMS DURING CHARGING, IF THE ACCUMULATORS ARE CHARGED INSIDE THE CAR.
No grinding, drilling, etc. is allowed in the charging area!
At least one team member has to stay with the accumulator(s) / car during charging.
Moving accumulator cells and/or stack(s) around at the event site is only allowed inside a closed accumulator container.
The provided electrical connection will be one 3P+N+PE, 6h, 400V/16A 50Hz socket according to IEC 60309 per team.
NOTE: The available charging power may be lower than the maximum power usually provided by the electrical connection.

7.30 Accumulator Container Hand Cart

In case removable accumulator containers are used in order to accomodate charging, a hand cart to transport the accumulators has to be presented at Scrutineering.
The brake of the hand cart must be designed such that it can only be released using a dead man's switch, i.e. the brake is always on except when someone releases it by pushing a handle for example.
The brake must be capable to stop the fully loaded accumulator container hand cart.
The hand cart must be able to carry the load of the accumulator container(s).
The hand cart(s) must be used whenever the accumulator container(s) are transported on the event site.

8 Technical Inspection

8.1 Inspection & Testing Requirement

The Technical Inspection will be divided in an electrical inspection and a mechanical inspection.
The electrical inspection will declare the car as electrically safe and must be the first inspection. Before passing E-Scrutineering the car may only be moved around on the event site, if both detachable keys of the Master Switches have been removed and are kept safe by a Safety Responsible.

Scrutineers will mark or seal various different approved parts (i.e. insulation monitoring device, accumulator containers, energy meter, tires, rims etc.). The car can be disqualified from any dynamic event by using unmarked parts or substituting marked parts. Parts with broken seals are equivalent to being unmarked.
Broken seals can only be replaced by a scrutineer.

After passing E-Scrutineering the car can be presented for the normal mechanical scrutineering.

8.2 Insulation test

The insulation test is composed of the insulation monitoring device test, see article 7.8, the insulation measurement test, see article 7.12 and the rain test, see article 7.9.

8.3 Equipment

For the electric part of the technical inspection each team must present the following equipment:

- accumulator charger to be used during the event
- all accumulator containers to be used during the event
- data sheets for all used parts in the tractive system
- Copy of the ESF
- Copy of the FMEA
- Accumulator Container Hand Cart, if needed

Tools:

- Insulated cable shear
- Insulated screw drivers
- Multimeter with protected probe tips
- Insulated spanners, if screwed connections are used in the tractive system
- Face Shield
- HV isolating gloves
- HV isolating blanket of at least 1,5m²

8.4 Car weighing

All cars will be weighed prior to Engineering Design Judging. All cars are to be weighed in ready to race condition. All fluids and coolant must be in the car. This weight will be the car's Official Technical Inspection weight. There will be a penalty if the car weight changes during Dynamic Competition. The allowable weight tolerance is ± 5.0 kg. In the case of overweight or underweight in comparison to the Technical Inspection weight, the team will be penalized -20 (twenty) points for each kg (or portion of a kg) of additional or missing weight. This point penalty will be deducted from the Engineering Design Event score. (Each 0.1 to 1.0 kg = -20 points)
Example:
If the car is 5.3 kg underweight: 5.3 kg minus the 5.0 kg tolerance = 0.3 kg equals -20 Points
If the car is 7.8 kg overweight: 7.8 kg minus the 5.0 kg tolerance = 2.8 kg equals -60 Points
If the car weight changes due to replacement of broken parts, the car must be presented for tech inspection and then re-weighed. It is the team's responsibility to have the car re-weighed before entering a dynamic event after changing parts.

9 Static Events

9.1 Business Plan Presentation (75 Points)

9.1.1 Executive Summary

Judging will start with an Executive Summary before the FSE Competition. The principal document submitted prior to the Business Plan Presentation is an Executive Summary. The Executive Summary must not exceed one (1) page, team name and car number must be written on the Executive Summary. The Executive Summary should contain a brief description of the team's Business Plan. Included in the Summary the two most outstanding technical features of the car have to be listed. The Summary has to include the anticipated production cost, per vehicle, in a production run of 1000 cars per year.

The Executive Summary must relate to the specific prototype car entered in the FSE competition. The costs of the prototype car entered will not be considered as part of the Business Plan judging.

Even though the Executive Summary is only judged by the presentation judges, all Engineering Design and Cost judges will have access to the file and may refer to it.
The Executive Summary must be submitted in Adobe Acrobat® format (*.pdf file) online, no later than the specified date.

Late submission and non submission will be penalized. It is at the discretion of the judges to deduct between -5 (five) points from the Presentation Judging score.

Note: Consider your Executive Summary to be the first impression of your Business Plan to the Executive Board of a major auto manufacturing company.

9.1.2 Deep dive topic

After submission of the Executive Summary the teams will receive a specific deep dive topic from the presentation judges prior the competition. The task will be sent via email on the date specified in the Action Deadlines, to the team's responsible person's email address.

Every team has to present this special deep dive topic in a detailed way as a part of the team's business plan presentation to the judges.

NOTE: A team must not describe only this deep dive topic in the business plan presentation. It's important that a team presents the business plan.

9.1.3 Data Projection Equipment

Video Projectors will be provided by Formula Student Electric. These Projectors will have VGA Input Connectors.

The organizers will not provide any other presentation equipment needed. Teams planning to use other presentation equipment, as a part of their presentation, are responsible for bringing, or otherwise arranging for their own equipment.

9.1.4 Judging Sequence

Tbd.

9.1.5 Scoring Formula

The scoring of the event is based on the average of the two or three presentation judging forms. There is a maximum of seventy-five (75) points from the FSG Presentation Judging Form.

Non finalist:

PRESENTATION SCORE = 70 x (Pyour/Pmax)
Where:
“Pmax``” is the highest score awarded to any team not participating in the finals
“Pyour” is the score awarded to your team

Finalists:

1st Place 75 points
2nd Place 74 points
3rd Place 73 points
4th Place 72 points
5th Place 71 points

It is intended that the scores will range from near zero (0) to seventy-five (75) to provide good separation. The Presentation Event Captain may at his/her discretion; normalize the scores of different judging teams.

9.2 Engineering Design Event (150 Points)

9.2.1 Judging Sequence

At Formula Student Germany Engineering Design Judging will consist of two parts:

I. Initial judging of all vehicles
II. Final judging ranking

9.2.2 Engineering Design Report Files File Format and Size

The FSE Engineering Design Report must be submitted in Adobe Acrobat® format (*.pdf file) online, no later than the specified date. The size of the document must not exceed 5MB. A responsibly sized document will be much smaller than 5MB in file size. Please ensure that photos within the Acrobat file are of an appropriate resolution.

9.2.3 Engineering Design Spec Sheet File Format and Units

The FSE Engineering Design Spec Sheet must be filled out online, no later than the specified date, see 2.7. The Formula Student Electric Engineering Design Spec Sheet Form can be found on the FSE website in the 'My Team' area prior the deadline.

The form is for metric units only.

9.2.4 Penalty for late submission

Penalties for late/non submission of the Engineering Design Reports and/or Engineering Design Spec Sheets is as follows:

Late arrival of one or both documents: -10 (ten) points for each day, up to a maximum

penalty of -100 points.

Failure to submit one or both documents will automatically result in zero points for the Engineering Design Event.

The penalty points will be deducted from your final Engineering Design Scores. The minimum allowable Engineering Design Score will be 0 Points. (Points will not go negative.)

9.3 Cost Event (100 Points)

9.3.1 Cost Event Scoring (Specific FSG/FSE change of Formula SAE® 2011 Part C Rule 3.7)

The points for the Cost and Manufacturing Event will be broken down as follows

$20x\frac{(P_{max}/P_{your})-1}{((P_{max}/P_{min})-1)x\left(P_{your(Visual\_Inspection)}/40\right)}$	20 Points	20 Points lowest cost - each of the participating schools will be ranked by total retail cost from the BOM multiplied with a quotient of $P_{your\ (visual\ inspection)}$ and 40 (maximum points for visual inspection) and given 0-20 points based on the formula on the left. P_{your} is the cost of your car and P_{min} is the cost of the cheapest car. P_{max} is the cost of the most expensive car. $P_{your\ (visual\ inspection)}$ are your points for the visual inspection.40 points are the maximum score for visual inspection
	40 Points	Real Case Situation – Teams will receive a task covered a “Real Case in Industry”
	40 Points	Event Day/Visual Inspection - The cars will be reviewed for part content and manufacturing feasibility. The submitted process descriptions will be discussed.
Total	**100 Points**	

9.3.2 Late submission of Cost Report (Specific FSG/FSE change of Formula SAE® 2011 Part C Rule 5.15)

Teams that submit reports later than the specified date will be penalized -10 (ten) points per day, up to a maximum penalty of -80 points. Teams that do not submit a Cost Report will receive 0 (zero) points for the Cost & Manufacturing Analysis score. Minimum Event score is 0 (zero) points.

9.3.3 Addenda (Specific FSG/FSE change of Formula SAE® 2011 Part C Rule 5.15)

For changes in your corrections made after the submission of the cost report please use the FSE cost addendum form given in the FSAE Rules Appendix C-5. For all new parts, which are manufactured, a drawing must be attached to the addendum form.

9.3.4 Cost Report Penalties Process (Specific FSG/FSE change of Formula SAE® 2011 Part C Rule 5.17)

Only penalty method A will be used for FSE, described in Part C Rule 3.18 “Penalty Method A- Fixed Point Deductions” of the Formula SAE® 2011 Rules. The Formula SAE® 2011 Rules 3.19 “Penalty Method B – Adjusted Cost Deductions” is not valid for the FSG competition.

10 Dynamic Events

10.1 Dynamic Events and Maximum score (Specific FSE change of Formula SAE® 2011 Part D Article 1)

Skid Pad	75
Acceleration	75
Autocross	100
Efficiency	100
Endurance	325
Total	**675**

10.2 Skid Pad Scoring (Specific FSE change of Formula SAE® 2011 Part D Rule 6.8.2)

The following equation is used to determine the scores for the skid-pad event:

$$SkidPadScore = 71{,}5x\frac{(6.184/T_{your})^2 - 1}{(6.184/T_{\min})^2 - 1} + 3{,}5$$

Where:
"**Tyour**" is the average of the left and the right timed laps on your best run including penalties.
"**Tmin**" is the elapsed time of the fastest car

10.3 Autocross Scoring (Specific FSE change of Formula SAE® 2011 Part D Rule 7.8.1)

The following equation is used to determine the scores for the autocross event:

$$AutocrossScore = 95{,}5x\frac{(T_{\max}/T_{your}) - 1}{(T_{\max}/T_{\min}) - 1} + 4{,}5$$

Where:
"**Tmin**" is the lowest corrected elapsed time recorded for any competitor in either heat
"**Tmax**" is 125% of Tmin
"**Tyour**" is the lowest corrected elapsed time in either heat for the team being scored.

10.4 Endurance Scoring (Specific FSE change of Formula SAE® 2011 Part D 8.19.2 and D 8.18.3)

The following equation is used to determine the scores for the endurance event:

$$EnduranceScore = 275x\frac{(T_{\max}/T_{your}) - 1}{(T_{\max}/T_{\min}) - 1} + 50$$

Where:
"**Tmin**" will be the lowest corrected time of the fastest team of the event.
"**Tyour**" will be the combined corrected times of both of your team's drivers in the heat.
"**Tmax**" will be 1.333 times "**Tmin**".

The Minimum Endurance Score is 25 (twenty five) Points, even if the corrected time of the team (Tyour) is higher than 133% of the fastest corrected time (Tmin)

10.5 Efficiency Scoring (Specific FSE change of Formula SAE® 2011 Part D 8.22 and D 8.23)

The following equation is used to determine the scores for the endurance event

$$Efficiency = 100x\frac{\left(EfficiencyFactor_{\min} / EfficiencyFactor_{your}\right) - 1}{\left(EfficiencyFactor_{\min} / EfficiencyFactor_{\max}\right) - 1}$$

$$EfficiencyFactor = \left(\frac{T_{\min/laptotal}}{T_{yours/lapyours}}\right)x\left(\frac{E_{\min/laptotal}}{E_{yours/lapyours}}\right)$$

Where:
"**T_{min}**" will be the lowest corrected time of the fastest team of the event.
"**T_{yours}**" will be the combined corrected times of the drivers in your heat. Vehicles whose corrected time exceeds 1.333 times the corrected time of the fastest team, will receive zero (0) points for efficiency.

"**E_{min}**" per Lap is the lowest consumed endurance energy by any competitor
"**E_{yours}**" is the consumed endurance energy of the team being scored.

Lapyours will be the number of driven laps, at least 50% of the total endurance distance.

Laptotal will be the number of the full endurance distance.

The energy is calculated as the time integrated value of the measured voltage multiplied by the measured current logged by the energy meter. Only energy flowing from the accumulator to the motor(s) will be taken into account.

Efficiency factor min is the minimum factor reached by a team.
Efficiency factor max is the maximum factor reached by a team.

Before the endurance event, every energy meter memory storage may be cleared by an official. The energy meter data is read out when the car is in Parce Fermé.

11 Changelog

V1.1.0:

2.11:
June 27, 2011 at 1200 CEST

Several steps have to be completed to be accepted as a qualified SR for the event.

1. Each team member that wants to be accepted as SR must upload a document describing his/her qualification in the “My Account” area on the FSE Website. see also 3.7. This should be done in the form of an Adobe Acrobat® file (*.pdf).
2. The team captains are able to designate this team member as an SR at the event in the “My team area” after the upload of the qualification document, see 2.12.
3. After the team member has been designated as an SR at the event his/her qualification document will be reviewed by FSG officials.
4. If the qualification was determined to be sufficient for being an SR, the team member will be approved to be an SR at the event.

2.12:
Additionally team members who should be an SR during the event must be designated as such.

New Rule 3.5.5 Independent teams

In case a university takes part in FSG2011 with two cars, one in FSC and one in FSE, then these teams may not share team members or faculty advisors at the event. This means that no team member can be part of both teams, work on both cars or take part in any static or dynamic event for both teams.

3.7:

The SR must be a valid team member, which means that he/she has to have student status, see FSAE Rules 2011 A4.2.

In order to register as an SR for the event, the respective team member must prove this by uploading a document describing his/her qualification in his/her “My Account”-area on the FSE Website, see 2.11 for details on how to become a qualified SR at the event.

4.11.4:
It is not necessary to completely deactivate the Tractive System, the motor controller(s) shutting down the power to the motor(s) is sufficient.
Motor power is allowed to be restored after the driver has selected the sensor that works correctly.
Each sensor has to have a separate detachable connector that enables a check of these functions by unplugging it during E-Scrutineering.

5.2:
If a tool is needed to open the HVD, see 7.24, this tool has also to be attached to the push bar.

7.18:
The car is ready to drive as soon as the motor(s) will respond to the input of the torque encoder / acceleration pedal.

7.21.1:
If several accumulator containers which are interconnected should be treated as one single container e.g. to avoid several AIRs, all electrical connections between these containers have to be protected according to 7.21.3. That way one big accumulator container is built with respect to the mechanical and electrical configuration.

7.21.2:
Contacting / interconnecting the single cells by soldering in the high current path is prohibited. Soldering wires to cells for the voltage monitoring input of the BMS is allowed, since these wires are not part of the high current path.

Indirectly measuring the voltage at the connectors by only activating the indicator when the AIRs are closed is not sufficient.
The indicator must always work, e.g. even if the container is removed from the car and carried around.

7.21.3:
The accumulator container must be built of mechanically robust and fireproof material. If the container is made of CFRP, GFRP or similar a resin system has to be used that is self-extinguishing, or appropriate measures have to be taken to protect the inner side of the accumulator containers against fire.
The data sheet of the used resin system has to be presented at scrutineering, if a self-extinguishing resin system is used.
The cells and/or stacks must be appropriately secured against loosening inside the container.
Breakthroughs or holes in the container are only allowed for the wiring-harness, ventilation, cooling or fasteners. These holes must be sealed according to article 7.10.

All kinds of accumulators that may vent an explosive gas must have a ventilation system or pressure relief valve to prevent the vented gas from reaching an explosive concentration.
Every accumulator container which is completely sealed must also have a pressure relief valve to prevent high-pressure in the container.

New Rule 7.21.4 Working on Accumulator Containers
Opening of or working on accumulator containers is only allowed in the charging area, see rule 7.29. This also applies to interconnected containers as described in 7.21.1.

7.24:
If a tool is needed to open the HVD this tool has also to be attached to the push bar, see also rule 5.2.

7.25:
If single cells are directly connected in parallel, only one voltage measurement is needed.

Cells are only considered intrinsically safe, if they are not prone to thermal runaway if they are overcharged, undercharged, overheated or mechanically damaged.

V1.0.2:

Figure 2:
“Max 60 DC Volts” was changed to “Max 40VDC”

V1.0.1:

7.5:
In side view no part of the tractive-system can project below the lower surface of the frame or the monocoque, whichever is applicable.
Additional regulations apply for accumulators, see 7.21.3.

7.6:
All electrically conductive parts of the vehicle (e.g. pedalbox, steering wheel, suspension, firewalls) which are prone to contact a damaged wire or electrical part, no matter if HV or LV, must have a resistance below 300 mOhm (measured with a current of 1A) to control system ground.

7.13:
NOTE: If any offical e.g. track marshal, scrutineer, etc. considers the TSAL to not be easily visible during track operations the team may not be allowed to compete in any dynamic event before the problem is solved.

6.18:
The sound level has to be a minimum of 70dBA, fast weighing, for at least 1 second in a radius of 2m around the car.

7.21.3:
If an accumulator container or parts of it are mounted outside of the primary structure (B.3.2) an additional impact structure according to FSAE rules B3.24 or B3.26 must be build to protect the accumulator.

7.23:
A circuit that is able to pre-charge the intermediate circuit to at least 90% of the current accumulator voltage before closing the second AIR has to be implemented. This circuit has to be blocked by a de-activated safety circuit, see rule 7.16. Therefore the pre-charge circuit must not be able to pre-charge the system, if the safety circuit is open.

It is allowed to pre-charge the intermediate circuit for a conservatively calculated time, before closing the second AIR. A feedback via measuring the current intermediate circuit voltage is not required.
If a discharge circuit is needed to meet the “below five seconds under 40VDC”-bound, it has to be designed to handle the maximum discharge current for at least 15 seconds. The calculation proving this has to be part of the ESF.
The discharge circuit has to be wired in a way that it is always active whenever the safety circuit is open. Furthermore the discharge circuit has to be fail-safe.

V1.0.0:
Initial release