Formula Student Electric
Rules 2012

Version 1.0.1
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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

July 31, 2012 to August 05, 2012
Formula Student Germany (FSG) will take place in Hockenheim/Germany.

2.2 Registration

2.2.1 Registration FSE

January 16, 2012 at 1200 CET

Registration forms will be accepted in the order in which they are received, starting January 16, 2012 at 1200 CET and ending on February 27 2012 1200 CET or when the 32 cars registration limit is reached. Registration will be online at the FSG Website.

2.2.2 Early Registration

January 9, 2012 at 1200 CET

Early registrations will be accepted in the order in which they are received, starting January 9, 2012 at 1200 CET and ending on January 15, 2012 at 1200 CET, or when all FSE2011 Top5 teams are registered, whatever occurs first.

All remaining slots that are not used during early registration will then become available for all teams when Official Registration opens on January 16, 2012.

2.3 Structural Equivalency Form

April 02, 2012 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 Website

http://www.formulastudent.de/fse/2012/rules/

The Structural Equivalency Form must be uploaded to the 'My Team' area on the FSG website no later than April 02, 2012 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 FSG 2012 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 02, 2012 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.formulastudent.de/fse/2012/rules/

Impact Attenuator Data must be uploaded to the 'My Team' area on the FSG website no later than April 02, 2012 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 FSG 2012 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 07, 2012 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 FSG website no later than May 07, 2012 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 2012 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 5, 2012 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 5, 2012 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 2012 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 11, 2012 at 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 FSG website no later than June 11, 2012 1200 CEST.

The FSE Engineering Design Spec Sheet Form can be found on the FSG website in the 'My Team' area prior the deadline. Late submissions will be penalized with -10 (minus ten) points per day, up to a maximum of -100 points, which will be deducted from 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 11, 2012 at 1200 CEST

The Cost Report consists of two parts, a written report and an electronic report. The electronic Cost Report must be submitted as a Microsoft Excel® file. The file must be uploaded to the 'My Team' Area on the FSG Website no later than June 11, 2012 at 1200 CEST. The electronic report 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 at the competition during the Cost Event.

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

Note: FSG is currently working on a different solution. It may happen that the upload format will be changed during the year. FSG will announce a possible change via www.formulastudent.de

2.9 Business Plan Executive Summary

June 11, 2012 at 1200 CEST

The Business Plan Executive Summary must be uploaded to the 'My Team' area on the FSG website no later than June 11, 2012 at **1200 CEST**.

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

2.10 Charging Type and Power

April 30, 2012

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 April 30, 2012. The charging type and peak power can be entered after registration in the 'My Team' area.

2.11 Safety Responsible(s) Qualification Upload

June 25, 2012 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 FSG 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 25, 2012 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 FSG 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 or copy of insurance confirmation letter (not older than one year)
- Name of the Health Insurance Company
- Health Insurance Certificate period of validity
- Current Target Degree of Study

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 07 2012 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. The Quiz will include questions about the 2012 Rules and the 2012 FSG Event Handbook.

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.

2.14 Vehicle Status Video and Vehicle Status Report

July 09, 2012 at 1200 CEST

All teams must upload a video showing the car running under his own power prior the competition.

The Vehicle Status Video and Vehicle Status Report must be uploaded to the ‘My Team’ area on the FSG website no later than July 09, 2012 at **1200 CEST**.

The video must be between 15 seconds and 30 seconds long, showing the car from a 3rd person view. During the video the car must be viewable in side view. Running the car with bodywork is not necessary, but strongly recommended.

Teams which are not able to upload a video of the running car must hand in a Vehicle Status Report. This report must include:

- Written status of the car
- Photos of the car in the actual assembly status
- List of all major components of the car, status of the components and photos of the components

- Reason for delay and project plan to finish the car prior the competition

FSG organizers will check each of the Vehicle Status Videos and Vehicle Status Reports.

Teams which hand in a Vehicle Status Report must answer all questions from the organizers within 72 hours. Teams, which missed the Vehicle Status Video / Vehicle Status Report deadline will be removed from the FSG 2012 competition. Missing the 72 hour deadline for answering questions of the organizers is comparable to non submission.

Video File format: mp4 / h.264, in a .zip folder / up to 1080p / max file size 20MB

Report File format: pdf / max. file size 5MB

3 General

3.1 FSE 2012 Rules

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

The Formula Student Electric (FSE) competition will comply with the Formula SAE® 2012 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 2012.

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

Do not ask about more than one rule per mail. Divide your questions in several mails, if you have questions with respect to more than one rule.

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 only**.

3.4 Official time

The Formula Student Germany official time:

From	Till	Time
30.10.11	24.03.12	CET
25.03.12	27.10.12	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.

3.5.2 Registration Capacity Limit

Registrations will be given out, in the order in which they are received. The 2012 Formula Student Electric competition will be limited to 32 teams.

3.5.3 FSE Early Registration for Formula Student Germany Top5 Overall Finishers

5 registration slots will be available for the FSE 2011 Top5 overall finishers.

Place	Team
1	Delft TU
2	Zürich ETH
3	Ravensburg DHBW
4	München TU
5	Karlsruhe KIT

3.5.4 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.

3.5.5 FSG Registration Required Contact 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 25, 2012 at 1200 CEST.

3.5.6 Independent teams

In case a university takes part in FSG2012 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 and Safety Advisor

3.7.1 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 2012 A4.2 and 3.8.
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 FSG Website.
It is recommended that the SR is certified for working with high voltage systems in automotive vehicles. In case a non-electrical engineering student should become an SR, this certificate is mandatory.

3.7.2 Safety Advisor

FSG recommends that the safety of an FSE vehicle is ensured by using a professionally competent person(s) nominated by the team who can advise on the safety systems during the design phase of the vehicle. This person(s) will be designated the Safety Advisor.
The Safety Advisor may be changed from being a recommendation to being a requirement in future FSE rules sets.

3.8 Student Status

Students seeking a PhD degree/PhD Students or equal are not allowed to participate at FSG.

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

Alternative Frame Rules are allowed for FSE 2012. Teams must submit their Request by December 31st 2011 to following Email address AF-Rules@Formulastudent.de . Teams must follow the Formula SAE® AF Rules.

4.2 CFRP space frame chassis

Using CRFP tubes in the Primary Structure is not permitted.

4.3 Impact Attenuator

4.3.1 Impact Attenuator Design (Specific FSG change of Formula SAE® 2012 Rule B3.20.1)

Additional to the Formula SAE® 2012 Rule B 3.20.1 requirements Impact Attenuators must have a closed front section

Quasi-static testing is not allowed. Only dynamic tests (drop down, sledge or pendulum test) are allowed.

4.3.2 Anti Intrusion Plate (Specific FSG change of Formula SAE® 2012 Rule B3.20.6)

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. The anti intrusion plate must be installed at the test and must show that the maximum deflection is not more than 25,4mm. A simulation of the deflection is not sufficient.

4.4 Brake System

4.4.1 Brake System Master cylinder actuation

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

The first 90% of the brake pedal travel may be used to regenerate brake energy without actuating the hydraulic brake system.
The remaining brake pedal travel must directly 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.

4.4.2 Brake light (Specific FSG change of Formula SAE® 2012 Rule B7.4.1)

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. The 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.

4.4.3 Brake Over-Travel Switch (Specific FSG change of Formula SAE® 2012 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

4.4.4 Brake Over-Travel Switch Function(Specific FSE change of Formula SAE® 2012 Rule B7.3.1)

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 7.17.

4.5 Driver Egress (Specific FSG change of Formula SAE® 2012 Rule B4.8)

The driver egress, required by Formula SAE® 2012 Rule B 4.8 must be possible in all steering wheel positions.

4.6 Fire Extinguishers (Specific FSG change of Formula SAE® 2012 Rule B17.14)

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

4.7 Vehicle Identification

4.7.1 School Name (Specific FSG change of Formula SAE® 2012 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

4.7.2 Technical Inspection Sticker Space (Specific FSG change of Formula SAE® 2012 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.

4.7.3 Transponders (Specific FSG change of Formula SAE® 2012 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.

4.8 Driver’s Underclothing (Specific FSG change of Formula SAE® 2012 Rule B17.6)

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

4.9 Chassis

The used chassis has to comply to the FSAE2012 rules. An old chassis design, which was not entered in an FSE event before, may be used only if it complies to the FSAE2012 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 2012 and the FSG/FSE additions.

4.10 Firewall (Specific FSE addition to Formula SAE® 2012 Rule B4.3 and B4.5)

A firewall must separate the driver compartment from all tractive system components and any oil or liquid cooling systems.
The firewall must be made from or coated with an electrically insulating material.
The firewall must be fire resistant according to UL94-V0 or equivalent.
The firewall must be puncture and scratch resistant.
Rule 7.6 applies, if a coated material is used, which is or may become conductive.

4.11 Brake Test (Specific FSE change to Formula SAE® 2012 Rule B7.2)

During the brake test the car must be accelerated on a short straight from 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 passed if all four wheels simultaneously 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

4.12 Tractive System

4.12.1 Replacement of FSAE Rules 2012

Articles B8.1 until B8.9, B9 except B9.9, B10 and B11 except B11.4 of the FSAE 2012 rules are superseded by the following FSE rules. Articles B8.10 and B8.11 are only valid if a cooling system is in use.

4.12.2 Power Limitation

The maximum power drawn from the battery must not exceed 85kW. This will be checked by evaluating the Energy Meter data.
Violating this value will lead to disqualification for the entire dynamic event in which the violation occurred e.g. if a violation occurs during one single acceleration run, the team will be disqualified for the complete acceleration event.

A violation is defined as using more than 85kW for more than 100ms continuously or using more than 85kW, after a moving average over the last prevailing 500ms of the respective data point was applied.

The respective data of each run in which a team has drawn more than 85kW from the battery and the resulting decision will be made public.
Regenerating energy is not restricted by this rule.

4.12.3 Motors

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

4.12.4 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.
The foot pedal must have a positive stop preventing the mounted sensors from being damaged or overstressed.
At least two separate sensors have to be used as torque encoder. Separate is defined as not sharing supply or signal lines.
If an implausibility occurs between the values of these two sensors the power to the motor(s) has to be immediately 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.
Implausibility is defined as a deviation of more than 10% pedal travel between the sensors.
If three sensors are used at least two sensors have to be within 10% pedal travel.
Each sensor has to have a separate detachable connector that enables a check of these functions by unplugging it during E-Scrutineering.

4.12.5 Torque Encoder Plausibility Check

The power to the motors has to be immediately shut down completely, if the brake pedal is actuated and the torque encoder signals more than 25% pedal travel at the same time.
The motor power shut down has to remain active until the torque encoder signals less than 5% pedal travel, no matter whether the brake pedal is still actuated or not.

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® 2012 Part D13.2)

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 7.25, 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.

5.5 Tire and Rim Combination

During Scrutineering each team needs to present a tires for dry condition and tires for wet conditions. All dry tires have to have the same manufacturer, size and compound as all other sets.

All wet tires have to have the same manufacturer, size and compound as all other sets.

Running different tire sizes, manufacturer and compounds for each wheel in a set is acceptable.

The tire type/rim type combination presented during Scrutineering must be the same during the whole event. The rims for dry tires and wet tires can be different.

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 Website

http://www.formulastudent.de/fse/2012/rules/

The use of alternative materials or tubing sizes to those specified in Formula SAE® 2012 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® 2012 Rule B 3.3.1 “Baseline Steel Material”.

Structural equivalency must be demonstrated by providing calculations and/or tests results

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 Website http://www.formulastudent.de/fse/2012/rules/

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 FSG website at http://www.formulastudent.de/fse/2012/rules/
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 made available on the FSG website at http://www.formulastudent.de/fse/2012/rules/
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 be 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 must be contained within the frame to be protected against being damaged in case of a crash or roll-over situation.
If these parts are mounted in a position where damage is likely, for example motors at the rear of the car, they have to be protected by a fully triangulated structure with tubes of a minimum outer diameter of 20mm and a minimum wall thickness of 1mm or equivalent.
Outboard wheel motors are allowed where the motor is outside of the frame but only if an interlock is added such that the Safety Circuit, 7.17, is opened if the wheel assembly is damaged or knocked off the car.
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 7.22.3.

7.6 Grounding

All electrically conductive parts of the vehicle (e.g. parts made of steel, (anodized) aluminium, any other metal parts, etc.) and all parts of the vehicle which may become electrically conductive(e.g. completely coated metal parts, carbon fibre parts,etc.) 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.
This may be tested by checking any point which is likely to be conductive, for example the driver's harness attachment bolt, but where no convenient conductive point is available then an area of coating may be removed.

NOTE: Carbon fibre parts may need special measures such as using copper mesh or similar to keep the ground resistance below 300mOhm.

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 7.17 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.

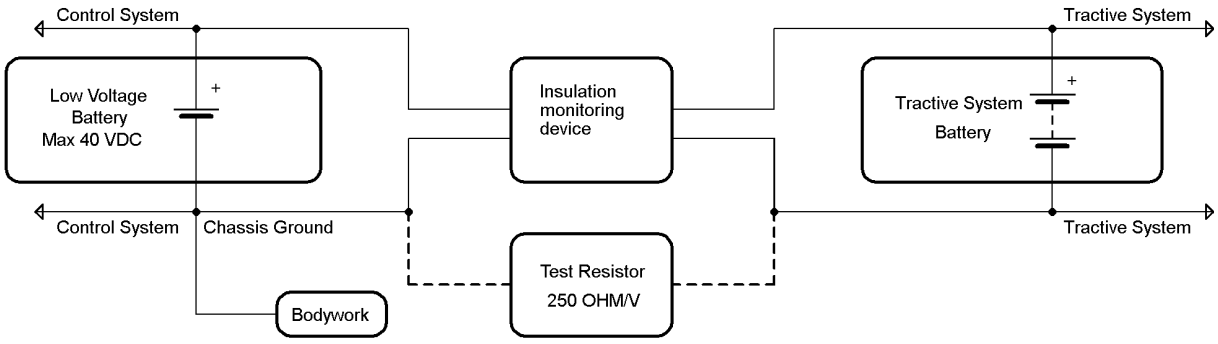

Figure 2: insulation monitoring device test example

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.

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 voltage being present within the tractive system must directly control the TSAL using hard wired electronics (no software control is permitted).
It must not be possible for the driver's helmet to contact the TSAL.
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 7.17

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 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 7.17.
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 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 Inertia Switch

All vehicles must be equipped with an inertia switch. This must be a Sensata Resettable Crash Sensor or equivalent approved by FSE.
The inertia switch must be part of the Safety Circuit and must be wired in series with the shutdown buttons such that an impact will result in the Safety Circuit being opened. The inertia switch must latch until manually reset.
The device must trigger due to an impact load which decelerates the vehicle at between 6g and 11g depending on the duration of the deceleration (see spec sheet of the Sensata device).
This may be reset by the driver from within the driver's cell.
It must be possible to demount the device so that its functionality can be tested by shaking it.

7.17 Safety Circuit

Setting any of the 2 master switches or of the 3 shut-down buttons to the “Off”-Position, activating the brake-over-travel-switch, an insulation failure detected by the IMD, a tripped inertia switch or critical values of the accumulators detected by the battery management system, BMS, must open all accumulator insulation relay(s) and 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 the tractive system must remain disabled until being manually reset by a person directly at the car which is not driver.
It must not be possible for the driver to re-activate the tractive system from within the car in case of an BMS or IMD fault.
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. The tractive system must remain inactive until it was manually reset.
All circuits that are part of the safety circuit have to be designed in a way, that in de-energized state they are open with respect to the current controlling the AIRs.
If the tractive system is de-activated while driving, the motor(s) has/have to spin free e.g. no brake torque must be applied to the motor(s).

7.18 Activating 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 except for situations in which the BMS or IMD have shut down the tractive system, see 7.17.
Resetting or re-activating the Tractive System by operating controls which cannot be reached by the driver is considered as working on the car.
Only closing the Safety Circuit/AIRs must not set the car to ready-to-drive mode. The car is ready to drive as soon as the motor(s) will respond to the input of the torque encoder / acceleration pedal. Therefore additional actions are required by the driver to set the car to ready-to-drive-mode e.g. pressing a dedicated start button, after the tractive system has been activated.

7.19 Ready-To-Drive-Sound

The car has to make a characteristic sound, once not continuous for at least 1 second and a maximum of 3 seconds , 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 / accelerator pedal.
The sound level has to be a minimum of 70dBA, fast weighing, 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.

7.20 Fusing

The tractive system must be appropriately fused meaning that each wire must be fused lower than the continuous current which it is able to carry
Fusing of the control system is recommended.

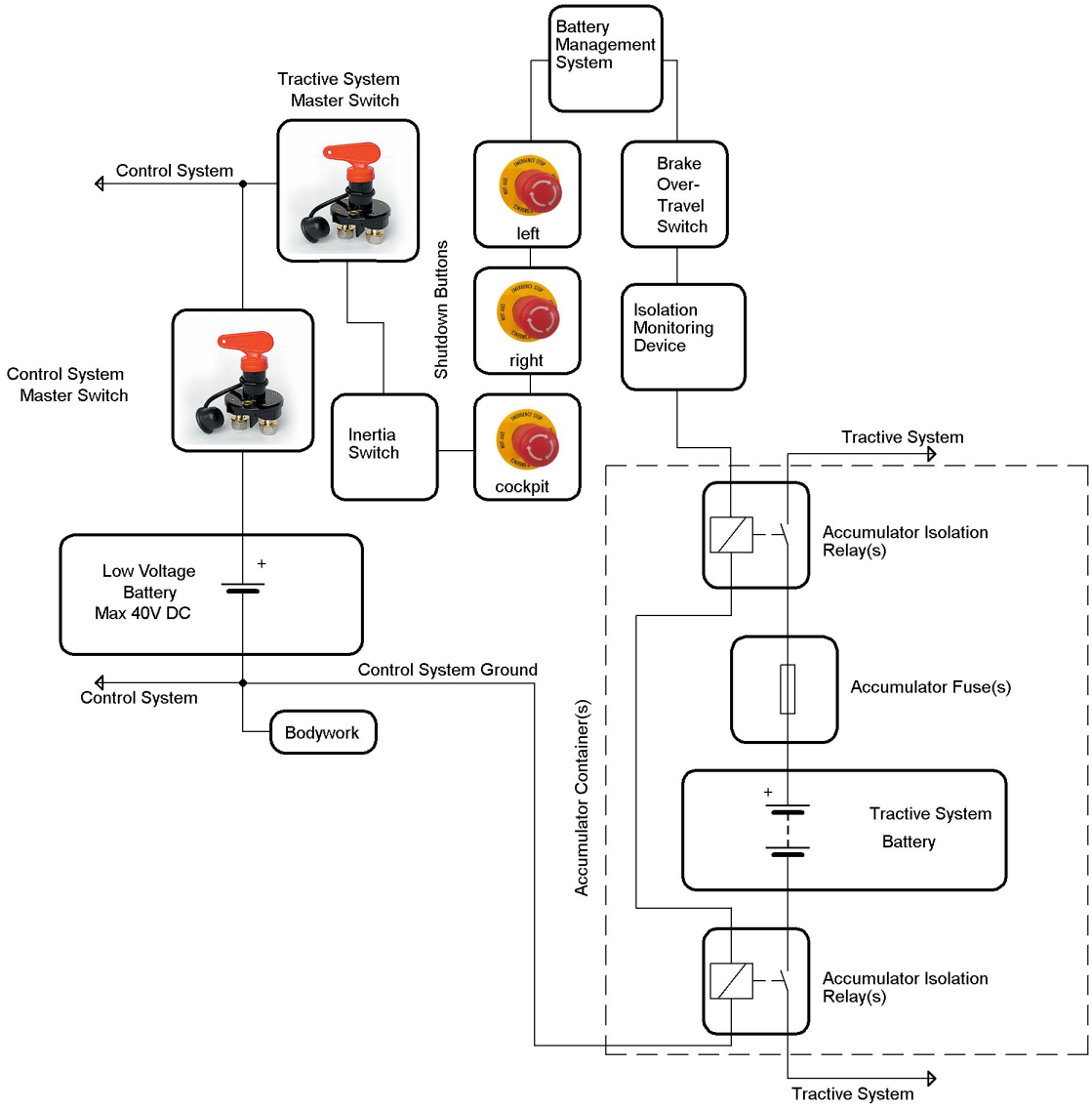

Figure 4: Schematic overview of the car's Safety Circuit

7.21 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 7.26 .

7.22 Accumulator Container

The following rules apply to tractive system accumulators, no matter if these are above or below the LV voltage limit.

7.22.1 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.

FSAE Rule B11.4.5 is not valid for FSE cars.

7.22.2 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 7.23, as shown in Figure 4.
Maintenance plugs or similar measures have to be taken to allow separating the internal cell stacks in a way, that the separated cell stacks carry a voltage of less than 120VDC. The separation has to affect both poles of the stack.
This separation measure has to be used whenever the accumulator containers are opened for maintenance and whenever cell stacks should be removed from the container. Maintenance plugs requiring tools to separate the stacks will not be accepted.
Each stack has to be electrically insulated by the use of suitable material towards other stacks in the container and on top of the stack to prevent arc flashes caused by inter stack contact or by parts/tools accidentally falling into the container during maintenance for example. Air is not considered to be a suitable insulation material in this case.
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.
The voltage being present at the connectors must directly control the indicator using hard wired electronics (no software control is permitted). 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.

7.22.3 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.
The mounting system must be designed to withstand forces from a 20g deceleration such that the accumulator container does not enter the driver's cell area and 10g deceleration in any other direction. The calculations/tests proving this must be part of the SES.
All accumulator containers must lie within the frame.
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 major structure (B.3.2) an additional impact structure according to FSAE rules B3.24 or B3.26 must be build to protect the accumulator. Alternative designs need an SEF and must be part of the SES of the vehicle structure.
The accumulator container must be built of mechanically robust material.
The used material must be fire resistant according to UL94-V0 or equivalent.
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.
The contained cell stacks must be separated by an insulating and fire resistant (according to UL94-V0 or equivalent) barrier in a way, that no single cell stack contains more than 5MJ energy, if fully charged. These barriers are only needed, if cells, which are not intrinsically safe, see 7.26, are used.
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.

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.

Figure 5 : High Voltage Sticker

7.22.4 Working on Accumulator Containers

Opening of or working on accumulator containers is only allowed in the charging area, see rule 7.30. This also applies to interconnected containers as described in 7.22.1.
Whenever the accumulator containers are opened the cell stacks have to be separated by using the maintenance plugs, see 7.22.2.

7.23 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.

7.24 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 7.17.
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.

7.25 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.
It must be possible to remove the HVD within 10 seconds in ready-to-race condition.
The team will have to demonstrate this during E-Scrutineering.

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.
If no tools are needed to open the HVD, an interlock is needed additionally.

7.26 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 30% 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 their cell chemistry is based on LiFePO4.
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.

7.27 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 power supplying the tractive system must flow through this single point and must pass the energy meter position, see article 7.28.
No further energy storages except for reasonably sized intermediate circuit capacitors are allowed beyond this point.

7.28 Energy meter

In the tractive system supply wires, see article 7.27, 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.

The energy is calculated as the time integrated value of the measured voltage multiplied by the measured current logged by the Energy Meter.
Energy flowing from the accumulator(s) to the motor(s) will be multiplied with a factor of 1 and added to the used energy. Energy flowing from the motor(s) to the accumulator(s) will be multiplied with a factor of 0.9 and subtracted from the used energy.

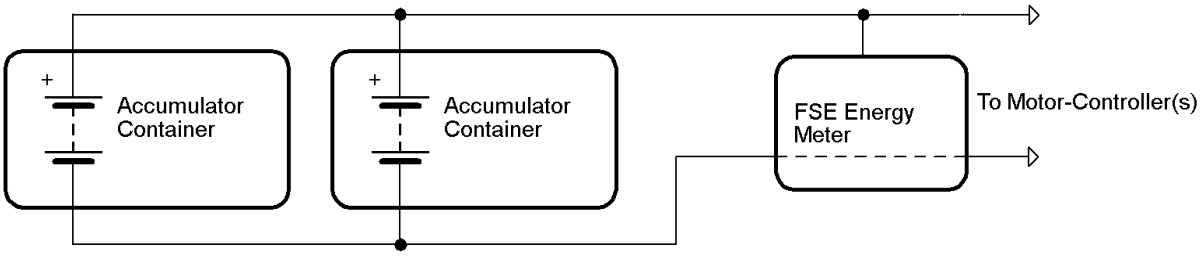

Figure 6: Exemplary Energy Meter Wiring

7.29 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 or possibly electrically conductive, it must have a low-resistance connection to control system ground, see rule 7.6.

7.30 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 completely closed accumulator container.

7.31 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.

The Scrutineering Inspection sheet will be made available on the FSG website at http://www.formulastudent.de/fse/2012/rules/

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
- 2 HV isolating blankets of at least 1.0m² each

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.

8.5 Inspection Holes

To allow the verification of tubing wall thickness, 4.5 mm (0.18 inch) inspection holes must be drilled in a non-critical location of both the Main Hoop and the Front Hoop. In addition, the Technical Inspectors may check the compliance of other tubes that have minimum dimensions specified. This may be done by the use of ultra sonic testing or by the drilling of additional inspection holes at the inspector's request. Inspection holes must be located so that the outside diameter can be measured ACROSS the inspection hole with a vernier caliper, i.e. there must be access for the vernier caliper to the inspection hole and to the outside of the tube one hundred eighty degrees (180°) from the inspection hole.

9 Dynamic Events

9.1 Dynamic Events and Maximum score (Specific FSG change of Formula SAE® 2012 Part D Article 1)

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

9.2 Skid Pad Scoring (Specific FSG change of Formula SAE® 2012 Part D Rule 6.8.3)

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

$$SkidPadScore = 71.5x\frac{(T_{max}/T_{your}) - 1}{(T_{max}/T_{min}) - 1} + 3.5$$

Where:
"**Tyour**" is the average of the left and the right timed laps on your best run including penalties.
"**Tmin**" is the lowest corrected elapsed time recorded for any competitor in either heat
"**Tmax**" is 125% of **Tmin**

Teams exceeding **Tmax** will receive 3.5 points.

9.3 Autocross Scoring (Specific FSG change of Formula SAE® 2012 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.

9.4 Endurance Scoring (Specific FSG change of Formula SAE® 2012 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**".
If **Tyour** > **Tmax**: Endurance Score = 25 (twenty five) points.

9.5 Efficiency Scoring (Specific FSE change of Formula SAE® 2012 Part D 8.22 and D 8.25)

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. The car must re-enter the track after the driver change.

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. Regenerated energy will be multiplied with 0.9 and subtracted from the used energy.

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.

10 Static Events

10.1 Business Plan Presentation (75 Points)

10.1.1 Executive Summary

Judging will start with an Executive Summary before the FSG 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. In the Summary the two most outstanding technical features of the car should be listed. The Summary has to include the anticipated production cost, per vehicle, in a production run of 1000 cars per year (value from Cost Report).

The Executive Summary must relate to the specific prototype car entered in the FSG 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 (minus five) points from the Presentation Judging score. The penalty points will be deducted from your final Business Plan Presentation 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

10.1.2 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 as a part of the team's business plan presentation to the judges.

NOTE: A team should not describe only this Deep Dive Topic in the business plan presentation. It's important that a team presents a good business plan as well.

10.1.3 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.

10.1.4 Judging Sequence

At Formula Student Germany the Business Plan Presentation Judging will consist of two parts:

- Initial judging of all teams
- Final judging ranking the top 3-5 teams

10.1.5 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.

10.2 Engineering Design Event (150 Points)

10.2.1 Judging Sequence

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

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

10.2.2 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.

10.2.3 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. The Formula Student Electric Engineering Design Spec Sheet Form can be found on the FSG website in the 'My Team' area prior the deadline.

The form is for metric units only.

10.2.4 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.

10.3 Cost Event (100 Points)

10.3.1 Cost Event Scoring (Specific FSG change of Formula SAE® 2012 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**

10.3.2 Late submission of Cost Report (Specific FSG change of Formula SAE® 2012 Part C Rule 3.15)

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.

10.3.3 Addenda (Specific FSG change of Formula SAE® 2012 Part C Rule 3.16)

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 E. For all new parts, which are manufactured, a drawing must be attached to the addendum form.

10.3.4 Cost Report Penalties Process (Specific FSG/FSE change of Formula SAE® 2012 Part C Rule 3.17)

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® 2012 Rules. The Formula SAE® 2012 Rule C 3.19 “Penalty Method B – Adjusted Cost Deductions” is not valid for the FSG competition.

11 Changelog

V1.0.1

2.12:
Added:
Current Target Degree of Study

4.4.2:
Added:
The brake light must turn on when the driver actuates the brake pedal.

4.12.2:
Deleted:
A violation is defined as using more than 85kW for more than 2% of the uncorrected time (no cones etc. included) of the respective run. E.g. if a team sets a time of 3.81s in an acceleration run it may not use more than 85kw for more than 76.2ms in total. In the Endurance this will be evaluated lap-wise.

Added:
A violation is defined as using more than 85kW for more than 100ms continuously or using more than 85kW, after a moving average over the last prevailing 500ms of the respective data point was applied.

5.5:
Added:
Running different tire sizes, manufacturer and compounds for each wheel in a set is acceptable.

8.5:
Added:
To allow the verification of tubing wall thickness, 4.5 mm (0.18 inch) inspection holes must be drilled in a non-critical location of both the Main Hoop and the Front Hoop. In addition, the Technical Inspectors may check the compliance of other tubes that have minimum dimensions specified. This may be done by the use of ultra sonic testing or by the drilling of additional inspection holes at the inspector's request. Inspection holes must be located so that the outside diameter can be measured ACROSS the inspection hole with a vernier caliper, i.e. there must be access for the vernier caliper to the inspection hole and to the outside of the tube one hundred eighty degrees (180°) from the inspection hole.

V1.0.0:
Initial release