HFS

HFS REPORT

Junior Chief Electronics

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PREFACE

In this report the activities of the sub deliverables ¨Electronic Throttle Control¨ and ¨Communication System¨ in the Electronics PMP are described. The aim of this report is to provide insight on the mentioned system in a concise manner where all the information needed is found in a single document. In addition to an update on the final state of the electrical system and recommendations for the Electronics Department of HFS-06. Finally, I would like to thank all the team members who have helped us get where we are today. Good Job!

I am grateful for the opportunity to lead the Electronics Department and for their support throughout the year!

EXECUTIVE SUMMARY

To achieve our goal in the Electronics Department in designing and producing a reliable electrical system I have been working on the Electronic throttle control and driver communication systems.

After investigating the theory behind the systems and going through HFS-05 design choices the current status of the ETC system was validated. Then, it was clear what still needs to be designed or redesigned. The competition legal requirements were theoretically satisfied by implementing the safety features of the ETC. However, we still need to confirm that in real-life setting.

By working closely with the HFS-05 driver Sydney Labrie, I was able to understand the driver needs. Then we came up with a simple method with high-cost benefit efficiency. The chosen system was driver earphones and a What's App call.

Evaluation assessment was concluded after FSN and it was deduced that the Electronic Throttle Control Design had failed to meet the total system requirements. Even though the TPS implausibility test was working as expected, the inability of the EMU Black to account for error tolerances of around 0.3 V meant that the throttle body could not function with 2 APPS sensors.

1 - PROBLEM DEFINITION

1.1 - TECHNICAL REVIEW

Our goal in the Electronics Department is to have

Our goal in Electronics Department HFS- 2.0 is to continue the work of the HFS-05 electronics. While the main goal for the electronics department is designing and producing a reliable electrical system which is completely rule compliant, developing an electrical system that would help improve the next generation of the HFS car and providing a stable ground to improve upon.

Therefore, this year, HFS-05 2.0 electronics department has to be able to implement the datalogging capabilities of the ADU. This will allow the next team to continue and improve the next generation car. Proper documentation is also key for the success of the team in the student competitions.

In this report I will describe the work assigned to me as a member of this department. My responsibilities include the driver communication system and the Electronic Throttle Control.

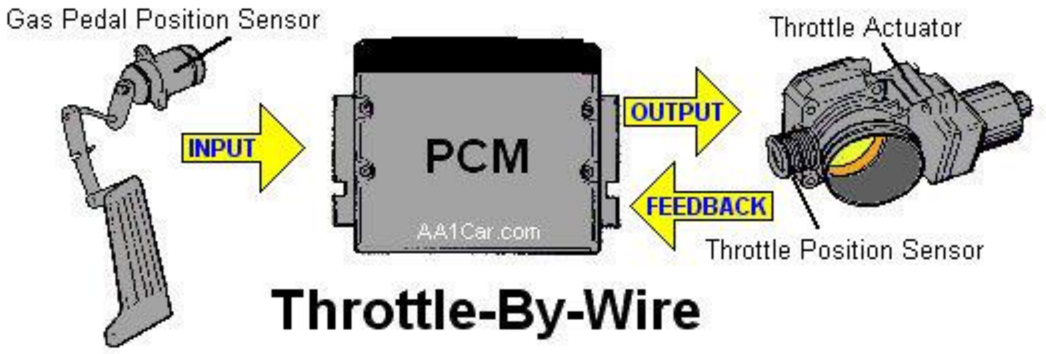
1.2 - DESIGN RULES & SOR

The design rules & SOR are derived from the FSG Rule book. FSG (2020).

Refer to Appendix A & B.

1.3 - SUMMARY RESEARCH

1. ETC



Electronic throttle control is a closed loop system that controls the position of the throttle body using APPS as input, Throttle Actuator as output, and TPS sensors for feedback. F1 Technical (2005). The Throttle Actuator is Bosch Throttle Body (Refer to Appendix C). It includes a DC motor controlled via an H-bridge implemented in the EMU Black ECU and 2 built in TPS sensors. The components found in our ETC system are shown identified below.

Type	Manufacturer	Manufacturer Part Number	Measurement Principle	T11.9.2 (a;b;c;d)
APPS 1	BOSCH	0 280 122 001	Resistive (analog)	a, b, c
APPS 2	BOSCH	0 280 122 001	Resistive (analog)	a, b, c
TPS 1	BOSCH	0 280 750 148	Resistive (analog)	a, b, c
TPS 2	BOSCH	0 280 750 148	Resistive (analog)	a, b, c

2. Communication System

The communication system between the driver and the team is important both for safety of the driver and his performance. The system has three functions:

1. Issue instructions to the driver, this takes the form of advising the driver while he is on the track.

2. Used by driver to inform team of desired set-up changes.

3. In extreme circumstances, it’s important to warn of a racing incident or system failure.

DriveSpark. (2018)

2.1 - CONCEPT PHASE

2.1.1 – Design Choice

HFS04: ¨ By using an ETC system we can implement electronic features like Traction Control and Launch Control. This technology would self-regulate throttle position to maintain maximum traction and boost performance at events like acceleration and skid pad during the FSG¨

	Implementing the BOSCH 0 280 750 148	Designing our own throttle body	Weight
Price	80	50	25%
Time - consumption	80	40	15%
Complexity	70	35	10%
Suitability	30/80	100	35%
Mating with the intake manifold	70	70	15%
TOTAL SCORE	77.5/60	67.5	100%

Therefore, by using Electronic Throttle control (Bosch 0 280 750 148) the car can implement traction control at perform at it's full potential.

After interviewing previous generation HFS driver to hear his perspective on driver communication. We came up with the following:

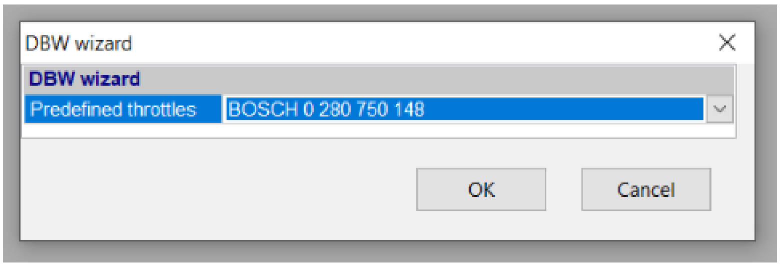
	Racing Radio Headset	Earphones	Weight
Price	30	100	50%
Suitability	100	40	25%

Necessity	20	60	25%
Total Score	45	75	100%

I believe that the driver should have the final say, this choice will be directly affecting him and taking his needs in account will positively influence his performance.

2.1.2 – Throttle Body & Communication System Selection

The throttle body was selected based on the compatibility with the EMU Black ECU and the recommended throttle body size for our engine. The Throttle Body size is a responsibility of the PT department.



Based on the choice table we have decided that for highest cost benefit efficiency we will communicate via whats app using the driver's earphones.

2.2 -VALIDATION & DESIGN

2.2.1 – Validation of HFS-05 Design

It is unusual to start validating before designing. However, since we are continuing the work of HFS-05 we had to know the current status of the system. After we understand that, then we can determine what needs still needs to be designed and what needs to be redesigned for improvements. In general, most of the wiring loom was reproduced this year. In my report, I will focus on what I had to design for the ETC.

Validating System Requirements

ETC:

System Requirement	Requirement Description	Validation
CV.1.6.4	The ETC must have at least the following sensors: APPS and 2 TPS,	Bosch Electronic Throttle Body contains 2 TPSs. As deduced from the specs in Appendix.
CV.1.6.6	When power is removed throttle must return to idle position in 1 second. If this doesn't happen, power to ignition, injectors and fuel pump must be disabled until throttle is in correct position for 1 s	Results in Evaluation
C.V.1.6.6-CV.1.6.7-CV.1.6.10	If plausibility does not occur between the values of at least two TPSs and this persists for more than 100 ms, the power to the ETC must be disabled.	Results in Evaluation
CV1.6.8	The ETC system must use at least 2 sources of energy to return the throttle to position.	The ETC uses a DC motor to move the throttle in normal cases, however when power is disabled a spring must return the throttle to it's initial position. We deduced that the ETC has a spring when we tried applying a force on the butterfly valve but we could not cause any motion. Therefore, we conclude there must be another source of energy exerting a resistive force to maintain equilibrium since the power to ETC was off.
CV.1.6.9	Springs in the TPS are not acceptable as return springs.	The unit has a built-in return spring. This spring is not part of any TPS sensors as stated in the rules

T.11.8.2	The APPS must be actuated by a foot pedal.	Check foot pedal component and how it's mounted relative to the sensor.
T.11.8.4	The foot pedal must return to the 0 % position when not actuated. The foot pedal must have a positive stop preventing the mounted sensors from being damaged or overstressed. Two springs must be used to return the foot pedal to the 0 % position and each spring must work when the other is disconnected. Springs in the APPS are not accepted as return springs.	Validated
T.11.8.5	At least two separate sensors must be used as APPSs.	The ETC includes 2 APPS by Bosch (0 280 122 001) not sharing any supply or signal lines.
T.11.8.6	When analog sensors are used, they must have a different, non-intersecting transfer functions.	Results in Evaluation
T.11.8.8	If an implausibility occurs between the values of the APPS for more than 100 ms, the power to ECT must be disabled.	Results in Evaluation
T.11.8.9	If three APPS sensors are used, then in case of An implausibility, any 2 sensors that are plausible may be used to define torque target.	We only use 2 APPS this does not apply for us.
T.11.8.11	It must be possible to separately disconnect each APPS signal wire to check functionalities.	Validated.
T.11.8.12	A fully released accelerator pedal must result in an idle position or lower throttle set-point. This may be exceeded only during a gear-shift for a max of 500 ms.	Results in Evaluation

2.2.2 – Design Phase

The designs I am responsible for are to implement safety features and make sure that if things go wrong the car will behave in a predictable manner such that both the car, driver and people around the car remain harmless.

Design Requirements:

Design Requirement 1: CV.1.6.10 If plausibility does not occur between the values of at least two TPSs and this persists for more than 100 ms, the power to the ETC must be disabled.

Design Requirement 2: T.11.8.6 When analog sensors are used, they must have a different, non-intersecting transfer functions.

Design Requirement 3: T.11.8.8 If an implausibility occurs between the values of the APPS for more than 100 ms, the power to ECT must be disabled.

Plausibility is defined as a deviation of less than ten percentage points between the TPS sensor values or pedal travel between APPS.

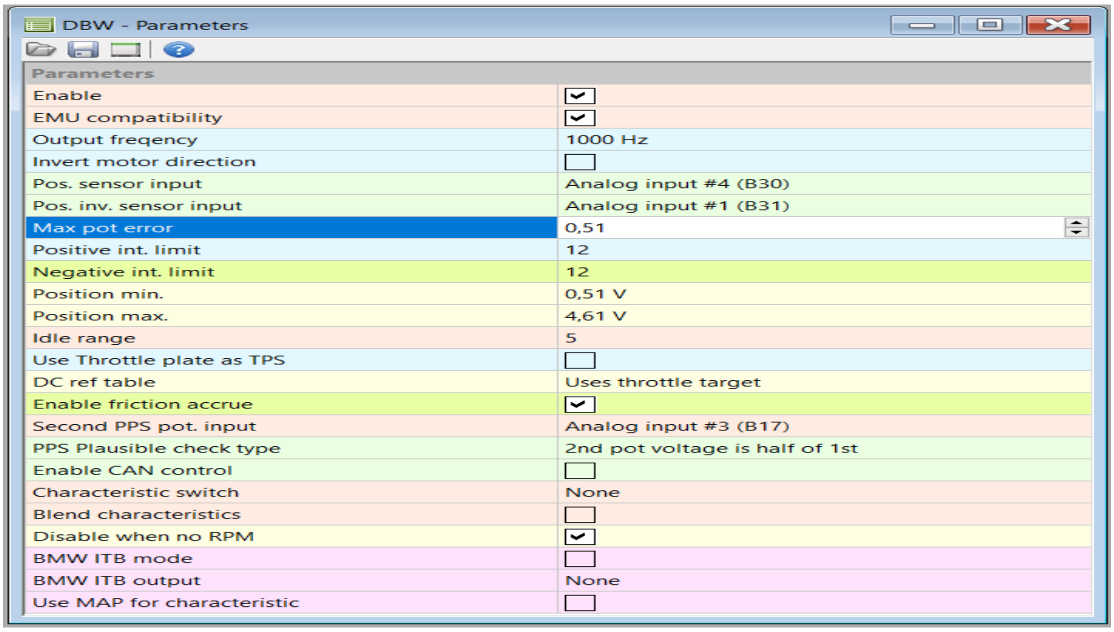
2.2.2 - Detailed description

Requirement 1 Design: To control the plausibility of TPS values we define the signal input for the ECU (Analog Input 4 & Analog Input 1) which are the throttle position signals. Then we can set the maximum error between the 2 values to be less than 10% points between the 2 TPS signals. If this value is exceeded the ECU will shut down the power to ETC as shown in EMU Black Documentation.

Max. pot. error	The sum of the voltage from both potentiometers should give 5V. *Max. pot error* parameter defines maximum deviation from 5V not to cause DBW error. If the voltage difference is greater EMU enters fails safe mode and closes the throttle. If the *Pos. inv. sensor input* is not assigned this safety function is not active

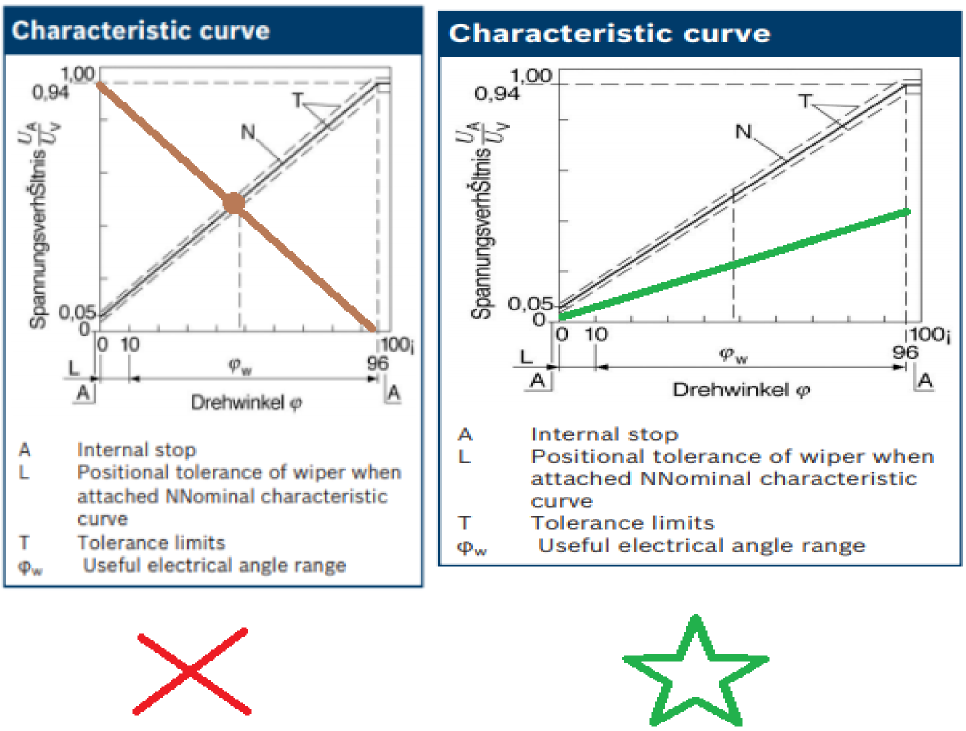
$$Max\ Error\ [Volts] = Voltage\ Operating\ Range * 10\% = 5 * 10\% = 0.5\ V$$

This value can be fine tuned when testing to find the optimal performance. It can be much less for example, less error is of course better, but we need to find the limit between accuracy and performance.



Requirement 2 & 3 Design:

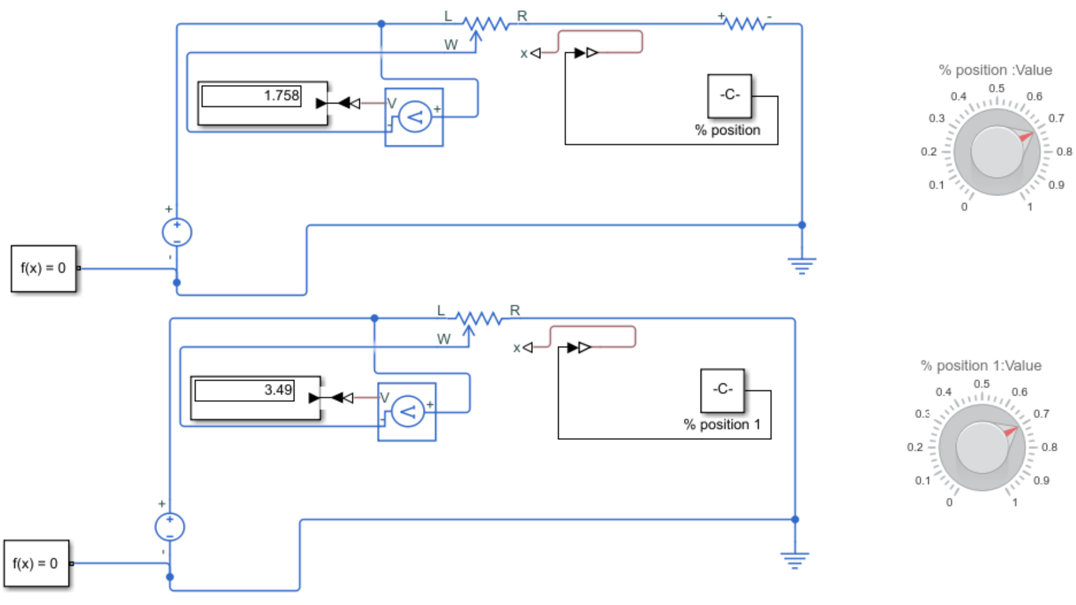
There are 2 ways to make identical sensors have different transfer functions. Either we reverse the polarity of power and ground (left pic), or we use a voltage divider to change the slope of the line (right pic). However, by using the 1st method we notice that the 2 lines are intersecting, this is not rule compliant. Therefore, we will use a voltage divider to decrease the slope of the line. To investigate what the resistor for the voltage divider should be we simulate the scenario in Matlab using Simscape. We also take in account the plausibility check types in EMU Black ECU.



By selecting what PPS plausibility check type we make sure that in case of implausibility the power to throttle is shut down. We also narrow down the design possibilities for the voltage divider.

Second PPS pot. input	Analog input #3 (B17)
PPS Plausible check type	2nd pot voltage is half of 1st
Enable CAN control	2nd pot voltage is half of 1st
Characteristic switch	2nd pot voltage follows pot 1st
Blend characteristics	Sum of 2nd and 1st pot is 5V

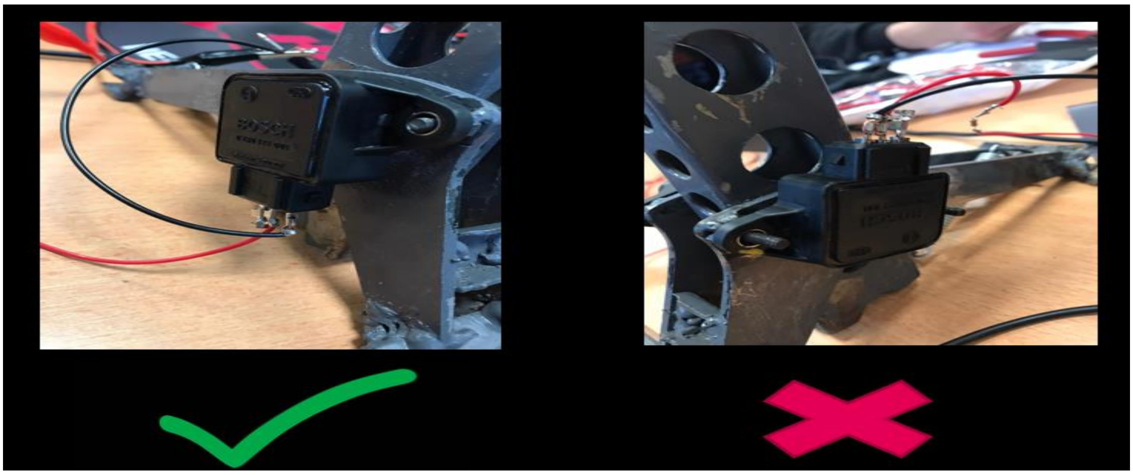
By using Simscape Electrical Library Toolbox we can build the circuit in Simulink using the Variable Resistor that represent our sensors. Using the total resistance of the APPS sensor we can determine the value of the resistor in voltage divider circuit. In the simulation we can see two circuits, each representing the wiring for an APPS. The first circuit has a resistor in series with the sensor to divide the voltage. Since we want one APPS voltage to be half of the other, we need the operating voltage to be 2.5 and not 5 V. Therefore, we add a resistor with resistance of 2kOhms which equals the resistance of APPS (Appendix D). The simulation confirms that one APPS voltage is half the other while both being at 70% travel position.



2.2.3 - Production

- 2k Ohm resistor soldered in series with 5V line.

- The mounting orientation of the sensor has been determined after testing.



2.3 - IMPROVEMENT PHASE

2.3.1 - Design feedback

Semester 1:

My designs were immediately approved with no feedback. However, I have got a lot of feedback for the production of the wiring loom. Some of the comments I have got were concerning the reliability of the wiring. I do not consider myself a hands-on type of person, therefore I have been learning crimping, soldering, wire routing,etc.. This has been my biggest obstacle during the year and by working with my teammates I am being taught how things should be done.

Semester 2:

The TPS implausibility test using ECU Master worked fine, however the calculation for error tolerance in part 2.2.2. was inaccurate.

2.3.2 - Improved design

Semester 1:

After the comments on my unreliable work, I have decided to let someone else from my team do the work that requires hands-on experience while I try to practice on the side. I do not want to risk my unreliable work affecting the final product.

Semester 2:

$U_{\text{Throttle Position}=95\%} = 3.5\ \text{V}$

$U_{\text{Throttle Position}=5\%} = 1.25\ \text{V}$

The function representing the voltage as a function of throttle position can be obtained using the 2 points shown above.

Pt 1(0.95,3.5)

Pt 1(0.05,1.25)

$$\text{Slope} = \frac{3.5\text{-}1.25}{0.95\text{-}0.05} = 2.5\ \text{V}/1\%\text{Throttle Position}$$

$$U_{\text{Throttle Position}} = 2.5*\text{Throttle Position} + \text{Offset}$$

$$3.5 = 2.5*0.95 + \text{Offset}$$

$$Offset = 3.5 - 2.4 = 1.1\ V$$

$$U_{\text{Throttle Position}} = 2.5*\text{Throttle Position} + 1.1$$

$$\rightarrow Throttle\ Position = \frac{U_{\text{Throttle Position}}\text{-}1.1}{2.5}$$

$$\Delta\text{Throttle Postion} = \frac{U_{\text{Final}}\text{-}1.1}{2.5} - \frac{U_{\text{Initial}}\text{-}1.1}{2.5} = \frac{\Delta U}{2.5}$$

Plausibility is defined as a deviation of less than ten percentage points between the sensor values as defined in CV 1.4.3 and no detected failures as defined in T 11.9.

$$\rightarrow 0.1 = \frac{\Delta U}{2.5};\ \Delta U = 0.25\ \text{V}$$

3 – EVALUATION

The system requirements could be seen as a binary state, that is either true or false. Therefore, testing was done by setting the right conditions and then observing the behavior.

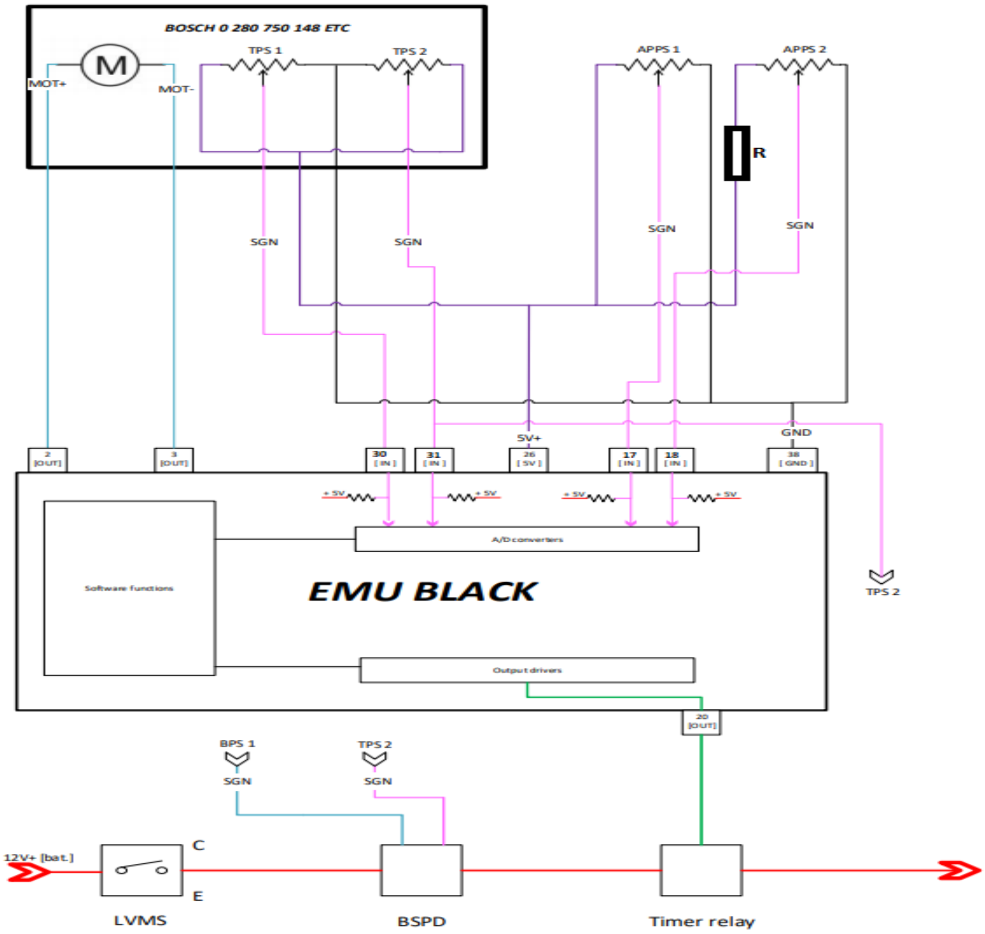
3.1 - OVERVIEW

System Requirement	Requirement Description
CV.1.6.6	When power is removed throttle must return to idle position in 1 second. If this doesn't happen, power to ignition, injectors and fuel pump must be disabled until throttle is in correct position for 1 s
C.V.1.6.6-CV.1.6.7-CV.1.6.10	If plausibility does not occur between the values of at least two TPSs and this persists for more than 100 ms, the power to the ETC must be disabled.
T.11.8.6	When analog sensors are used, they must have a different, non-intersecting transfer functions.

T.11.8.8	If an implausibility occurs between the values of the APPS for more than 100 ms, the power to ECT must be disabled.
T.11.8.12	A fully released accelerator pedal must result in an idle position or lower throttle set-point. This may be exceeded only during a gear-shift for a max of 500 ms.

3.2 – PROTOTYPE

The prototype is part of the wiring loom and includes the throttle body and APPS wiring. The inputs to the ECU are shown below:



Communication System.

The communication system was tested at our test drives at IPKW and the driver could communicate hands free. It also didn’t cost anything since the earphones were available already.

3.3 - TESTING AND RESULTS

Requirement	Test Method	Test Result
CV.1.6.6 When power is removed throttle must return to idle position in 1 second. If this doesn't happen, power to ignition, injectors and fuel pump must be disabled until throttle is in correct position for 1 s	Shutdown circuit button is pressed.	Throttle Body closes instantly.
CV.1.6.10 If plausibility does not occur between the values of at least two TPSs and this persists for more than 100 ms, the power to the ETC must be disabled.	Tested by unplugging one sensor signal.	Throttle Body closes instantly.
T.11.8.6 When analog sensors are used, they must have a different, non-intersecting transfer functions.	Measure Voltage at Pedal Position of 0 and 100%. Then calculate the equations of the line. (Similar to Equations in Improved Design Semester 2)	APPS 1 Pt 1 (0,2); Pt 2 (1,4) $U = 2x + 2$ APPS 2 Pt 1 (0,1.8); Pt 2 (1,2.1) $U = 0.3x + 1.8$ Lines not intersecting
T.11.8.8 If an implausibility occurs between the values of the APPS for more than 100 ms, the power to ECT must be disabled.	Test Throttle Body with 2 APPS Sensors. Then	Test could not be performed since the 2ND APPS input was

	unplug one of the sensor inputs and twist it to simulate an incorrect sensor voltage.	not exactly half of the first. It was off by +-0.3 V. Therefore the throttle body wouldn't open since the implausibility check is on.
T.11.8.12 A fully released accelerator pedal must result in an idle position or lower throttle set-point. This may be exceeded only during a gear-shift for a max of 500 ms.	This is tested by checking the TPS position when accelerator is not pressed. It can also be configured using a lookup table in ECU Masters.	A fully released pedal results in 3-5% Throttle Position.

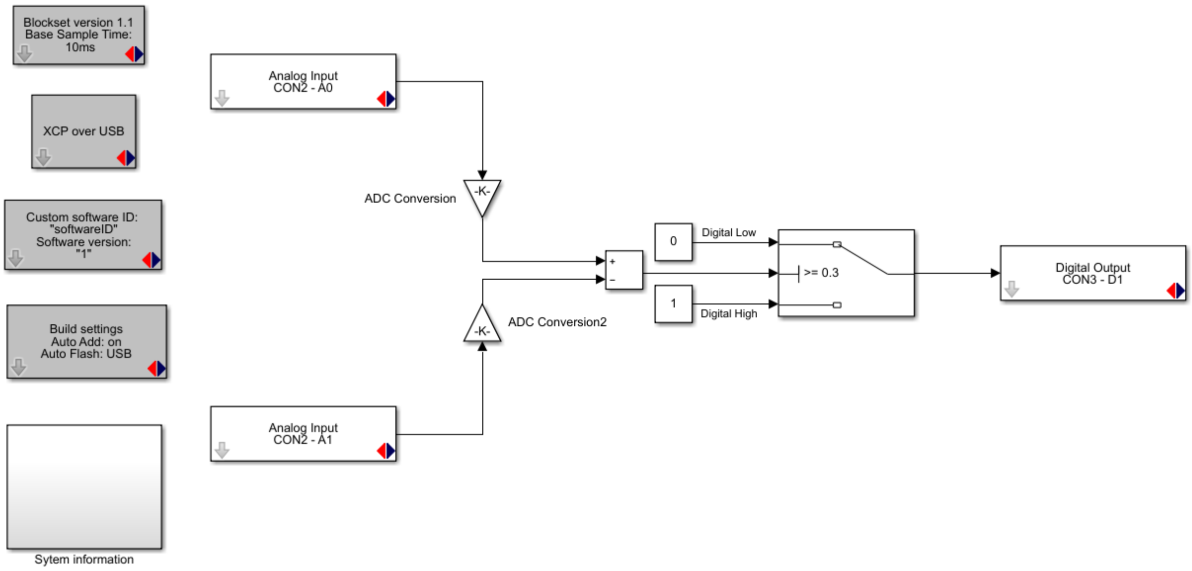
3.4 – ASSESSMENT

The TPS implausibility test using the ECU masters function was successful in closing the throttle body. However, the design choice of the APPS wiring circuit did not meet requirement T.11.8.8. The ECU expected APPS2 to be exactly half APPS1, but the signal had +-0.3V error, then ECU assumed implausibility and shut down the throttle body. Then it wasn't possible to start the engine with 2 APPS like the regulations required. This error is due to the resistor tolerances as well as the reliability issues we were facing. To fix this issue, we can use a microcontroller to activate a relay/transistor that switches the DC motor of the throttle body on and off. This is shown in the following section. This method is inspired by the approach of other combustion engine teams at FSN.

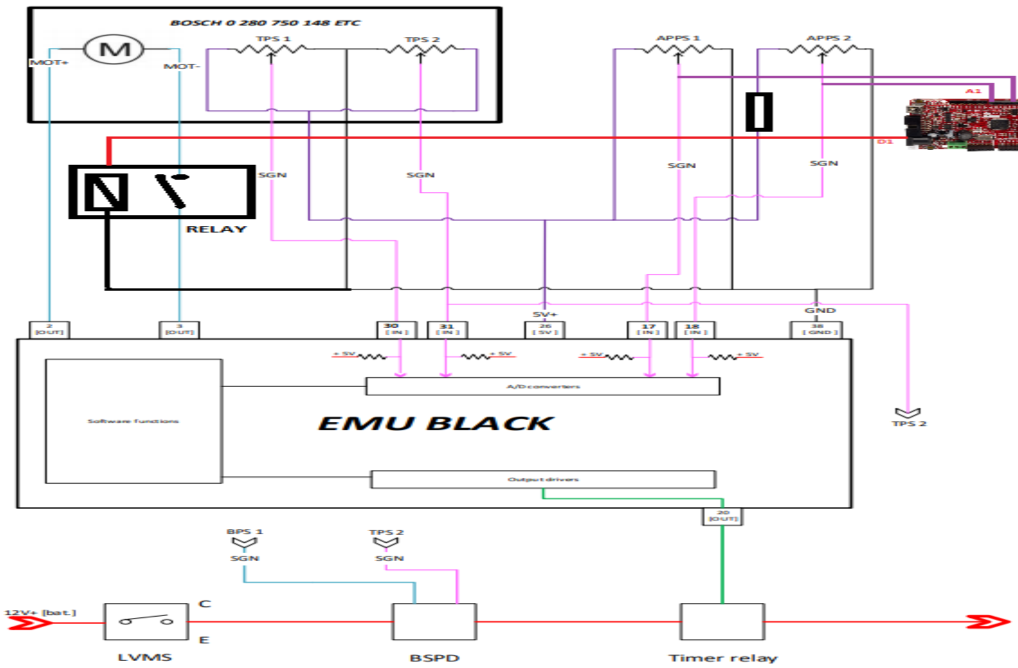
3.5 – FUTURE WORK

Recommended APPS Design Choice:

Since HAN uses the STM32 Olimexino and has a dedicated Matlab toolbox, we can implement the implausibility test using a Simulink model. The sensor inputs are connected to the analog inputs which are converted to a voltage using the ADC. If the difference in voltage is less than 0.3 V than the system is plausible. Therefore, the controller will output a digital High (3.3V) that will energize the relay and thus the motor will be grounded. If the voltage is greater than 0.3 voltage than there is implausibility in the system and the relay will switch off the DC motor ad shut the throttle body.



Prototype Improved Version



TE Connectivity, 12V dc Coil Automotive Relay SPDT Plug In Single Pole, 1432785-1 :

ELECTRICAL CHARACTERISTICS: (ALL DATA APPLIES @ 23°C UNLESS OTHERWISE SPECIFIED)

COIL DATA:

NOMINAL VOLTAGE:	12 VDC
OPERATE VOLTAGE:	7.8 VDC MAXIMUM
RELEASE VOLTAGE:	1.2 VDC MINIMUM
COIL RESISTANCE:	90 OHMS +/− 10%
OPERATE TIME:	8 mSEC. MAXIMUM EXCLUDING BOUNCE
RELEASE TIME:	5 mSEC. MAXIMUM EXCLUDING BOUNCE
TEMPERATURE RANGE:	OPERATING −40°C TO +85°C

Olimexino Digital Output= 3.3 V > Release voltage of relay. Which means the olimexino can energize the coil in the relay. Note: A transistor can be used instead of the relay depending on the DC Motor current.

Current Status of Vehicle Electronic System:

As junior chief I think Its important to provide an update on the current state of the electronic system. Since the APPS implausibility test caused the throttle body to shut down, the team had to work around that to get to FS Czech. They installed a throttle by cable to avoid any electronic implausibility tests. In addition to that, the wheel speed signal was not being shared over CAN. Since the CAN network between ECU and ADU is working, I suspect that the Wheel Speed to CAN module is not setup properly. Therefore, it was not possible to shift electronically without a wheel speed signal. Hence, the team installed a manual transmission system.

3.6 – REFLECTION

Preparing the car for FSN the last couple of weeks was tough. However, participating in the event was a very valuable experience. Seeing formula student teams from all over Europe exchanging knowledge and helping each other while competing at the events was amazing!!

Unfortunately the Electronics was not ready for technical inspection. It is my personal opinion that as an Electronics Department we were late to start prototyping, the first 3-4 months we were busy researching and working on the wiring from previous generation. For example, the ECU was not turned on before the 6th month, while we had it since the first day. Working with the ECU from the beginning would have allowed us to understand the relationship between every sensor/component and the ECU. Which caused that some components were not tested on a mini circuit before being included in the main system (like the Wheel Speed to CAN Module).

3.7 – RECOMMENDATIONS FOR HFS-06

- *Last year the BSPD was tested at HAN using a power supply and a wave generator to simulate sensor input. The BSPD is a fancy switch, it switches when the input from the sensors are above a threshold which you can set by screwing a potentiometer on the PCB (must be powered and grounded ofcourse). We use a multimeter to test continuity to see if switch is open or not. The mistake we did was that we assumed the current from the power supply we tested with and the current from the electrical system would be the same. It was not and we damaged the BSPD. What I recommend is checking the components of the PCB and checking the specs (max current) on the input pins then Measure the current before connecting it.*
- *The ADU connector is horrible to work with. Once the pin is inside connector it's almost impossible to take it out again without breaking the connector. Which is not ideal for rapid prototyping and testing. Therefore, it's a possibility to connect the pins straight to the ADU, however the metallic pins (shown below) MUST be shielded with a shrink tube to avoid*

any contact between the pins on the ADU side. (Same goes for ECU)

- *Avoid using the buck converter shown below. According to our experience it was a component that is damaged quickly. Try to go for Automotive Certified components.*

Adjustable Step-down Module 3-40VDC to 1.5-35VDC LM2596

4 - REFERENCES

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5 – APPENDICES

Appendix A: Communication System SOR

Communication system											
Must Have			Should Have			Could Have			Won't Have		
Technical	Functional	Regulatory	Technical	Functional	Regulatory	Technical	Functional	Regulatory	Technical	Functional	Regulatory
	The driver must communicate hands free with pit crew.			Range and battery must be sufficient to complete the events while communicating with pit crew.			Earphones or a headset could be used to call the pit crew.				
	The selected method of communication must come at a very low for cost benefit efficiency.										

Appendix B: ETC SOR

ETC											
Must Have			Should Have			Could Have			Won't Have		
Technical	Functional	Regulatory	Technical	Functional	Regulatory	Technical	Functional	Regulatory	Technical	Functional	Regulatory
CV 1.6.7 When power is removed, the electronic throttle must immediately close at least to idle position ±5 %. An interval of one second is allowed for the throttle to close to idle, failure to achieve this within the required interval must result in immediate disabling of power to ignition, fuel injectors and fuel pump. This action must remain active until the TPS signals indicate the throttle has returned to the requested position for at least one second.	CV 1.6.5 The ETC system must be equipped with at least the following sensors: APPS, TPS, BSE					T 10.3.10 If three sensors are used, then in the case of an APPS implausibility, any two sensors that are plausible may be used to define the torque target and the 3rd APPS may be ignored.		CV 1.6.3 (could) An ETC system that is commercially available, but does not comply with CV 1.6, may be used, only if it does comply with the intent of the rules and is approved by the officials.			CV 1.6.10 Springs in the TPSs are not acceptable as return springs.
CV 1.6.8 If plausibility does not occur between the values of at least two TPSs and this persists for more than 100 ms, the power to the electronic throttle must be immediately shut down.	CV 1.6.9 The electronic throttle must use at least two sources of energy capable of returning the throttle to the closed position. (DC MOTOR + SPRING)										Springs in the APPS are not accepted as return springs.
CV 1.6.11 The power to the electronic throttle must be immediately shut down, as defined in CV 1.6.7, if the throttle position differs by more than 10 % from the expected target TPS position for more than one second.	T 10.3.5 At least two separate sensors must be used as APPSs. Separate is defined as not sharing supply or signal lines.	T 10.3.11 Each APPS must have a separate detachable connector that enables a check of these functions by unplugging it. If not, an inline switchable break-out box must be made available during technical inspection that allows disconnection of each APPS signal.									
BSPD AND ETC CV 1.6.13 ,CV 4.1,											
T 10.3.4 The foot pedal must return to the 0 % position when not actuated. The foot pedal must have a positive stop preventing the mounted sensors from being damaged or overstressed. Two springs must be used to return the foot pedal to the 0 % position and each spring must work when the other is disconnected. Springs in the APPS are not accepted as return springs.											
T 10.3.6 If analog sensors are used, they must have different transfer functions, each having a positive slope sense with either different gradients and/or offsets to the other(s).											
T 10.3.8 If an implausibility occurs between the values of the APPSs and persists for more than 100 ms • [CV ONLY] The power to the electronic throttle must be immediately shut down											
T 10.3.12 A fully released accelerator pedal must result in: • [CV ONLY] An idle position or lower throttle set-point. This may only be exceeded during a gearshift for a maximum of 500 ms.											

Appendix C: ETC Data Sheet

Bosch Motorsport | Electronic Throttle Body

Electronic Throttle Body

www.bosch-motorsport.com

BOSCH
Invented for life

- Many bore diameters available
- Throttle position sensor is redundant
- For flex-fuel, CNG, LPG
- Idle default position

The throttle body is designed to control the fresh air of spark ignition engines in combination with an electronic throttle control system. ETB applications with flex-fuel, CNG and LPG are permissible if injected in the air flow after the throttle body.
A typical ETC system includes the following components: electronic throttle body, accelerator pedal module and electronic control unit.
You will find the available bore diameters in the variations table.

Application

Temperature range	-40 to 140°C
Max. vibration	50 to 250 m/s² at 50 Hz to 2 kHz

Technical Specifications

Mechanical Data

Available bore diameters	32 mm 40 mm 46 mm 50 mm 52 mm 54 mm 60 mm 82 mm

Electrical Data

Supply voltage	6 to 16 V
Supply voltage sensor	5 ± 0.2 V
Max. allowed generator current	<10.0 A

Characteristic

Output signal I	0 to 5 V for 0 to 90°
Output signal II	5 to 0 V for 0 to 90°

Connectors and Wires

Various motorsport and automotive connectors are available on request.

Please specify the required wire length with your order.

Installation Notes

For correct mounting please respect the hints on the next page "Mounting position".

The ETB can be connected directly to control units with ETC functionality.

Please find further application hints in the offer drawing at our homepage.

Figure A: Bosch Electronic Throttle Body.

	Electronic Throttle Body 32 mm
Bore Diameter (mm)	32
Connector	D261.205.358-01
Pin 1 A	Motor -
Pin 2 B	Poti -
Pin 3 C	Poti +
Pin 4 D	Motor +
Pin 5 E	Poti 2
Pin 6 F	Poti 1
Flange diameter (mm)	40
Hole circle diameter (mm)	50 x 50
Weight (kg)	0.9
Max. air flow rate*	394 kg/h at 85° angle
Opening direction**	counterclockwise

Figure B: Bosch 0 280 750 148 32 mm Throttle Body Pinout.

Appendix D: APPS Sensors Data Sheet

Angle sensor

Measurement of angles up to 88°

Input quantity: φ
Output quantity: R

- Potentiometric angular-position sensors with linear characteristic curve.
- Sturdy design for exacting demands.
- Compact size.

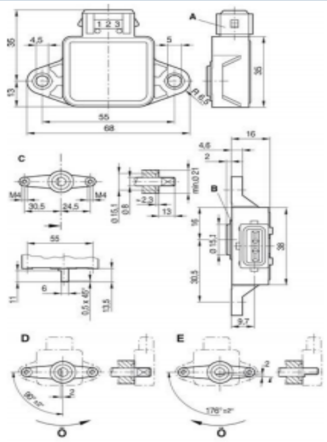
Part number 0 280 122 001

Technical data

Useful electrical angle range	degrees	≤ 86
Useful mechanical angle range	degrees	≤ 86
Angle between internal stops (must not be reached when fitted)	degrees	≥ 95
Direction of rotation		Any
Total resistance (term. 1-2)	kΩ	2 ± 20 %
Wiper protective resistor (wiper in zero position, term. 2-3)	Ω	710 ... 1380
Operating voltage U_V	V	5
Load		Ohmic resistance
Permissible wiper current	µA	≤ 18
Voltage ratio from stop to stop - characteristic curve 1		$0,04 \leq U_A/U_V \leq 0,96$
Slope of nominal characteristic curve	deg^{-1}	0,00927
Operating temperature		- 40 °C ...+ 130 °C
Approximate value for permissible vibration acceleration	m/s^2	≤ 700
Service life (rotary cycles)	Mill.	2

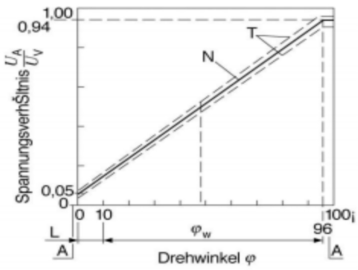
Accessories are not included in the scope of delivery of the sensor and are therefore to be ordered separately as required.

Dimensional drawing



A Plug connection
B O-ring 14.65 x 2 mm
C Attachment dimensions for throttle-valve housing
D Clockwise
E Anti-clockwise
Ö Throttle-valve opening direction

Characteristic curve



A Internal stop
L Positional tolerance of wiper when attached NNominal characteristic curve
T Tolerance limits
φ_w Useful electrical angle range