Evolved MBSE Mini Project – BCM Module

LTTS Global Engineering Academy

L&T Technology Services

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Team No: 5
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Document History

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1.2	22/03/2021	Shiva Kumar Naga Vankadhara	Kopparapu Jyothi Swaroopa Rani	Dr.Prithvi Sekhar	Individual report- Hatch Control
1.3	22/03/2021	Patamsetti Sai Kalki	Pushkar Antony	Dr.Prithvi Sekhar	Individual report- AC Control
1.4	22/03/2021	Rama Subba Reddy	Shiva Kumar Naga Vankadhara	Dr.Prithvi Sekhar	Individual report- Sunroof Control
1.5	22/03/2021	Kopparapu Jyothi Swaroopa Rani	Rama Subba Reddy	Dr.Prithvi Sekhar	Individual report- Wiper control
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2.1	24/03/2021	Kopparapu Jyothi Swaroopa Rani	Pushkar Antony	Dr.Prithvi Sekhar	Maab guidelines for Wiper control
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1. INTRODUCTION:

1.1 FEATURES:

1.1.1 CRUISE CONTROL:

Cruise control is a system that automatically controls the speed of a motor vehicle. The system is a servomechanism that takes over the throttle of the car to maintain a steady speed as set by the driver. The model selected for this project is 2020 GMC Sierra Denali.

Cruise control system provides automatic speed incrementation and decrementation of vehicle without the usage of gas pedal. Vehicles with wire drive systems use the same actuator to operate the cruise control. The actuator unit is connected to the throttle valve and controls the throttle butterfly position under the command of the cruise control ECU. Actuator mechanisms normally use either a permanent magnet DC motor assembly or a vacuum diaphragm powered by a motor-driven pneumatic pump and controlled by solenoid valves or, in many cases, a vacuum operated diaphragm controlled by three simple valves.

Figure 1: One wire from actuator and another from gas pedal.

Figure 2: Cruise control Actuator

1.1.2 HATCH CONTROL:

In automotive electronics, **body control module** or 'body computer' is a generic term for an electronic control unit responsible for monitoring and controlling various electronic accessories in a vehicle's body. Typically, in a car the BCM controls the power windows, power mirrors, air conditioning, immobilizer system, central locking, etc. The BCM communicates with other on-board computers via the car's vehicle bus, and its main application is controlling load drivers – actuating relays that in turn perform actions in the vehicle such as locking the doors or dimming the interior lighting. The distinguishing feature of a hatchback is a rear door that opens upwards and is hinged at roof level (as opposed to the boot/trunk lid of a saloon/sedan, which is hinged below the rear window). Most hatchbacks use a two-box design body style, where the cargo area (trunk/boot) and passenger areas are a single volume. The rear seats can often be folded down to increase the available cargo area. Hatchbacks may have a removable rigid parcel shelf, or flexible roll-up cover to cover the cargo space behind the rear seats

1.1.3 AC CONTROL:

Air conditioning is the technology for indoor and automotive ambient comfort. AC facilitates in managing the pleasant climate inside the cabin by controlling the degree of coolness. To understand this just consider the one model of car and go into how it works. I'm taking GMC sierra to explain how the AC system works.

1.1.4 SUNROOF CONTROL:

A sunroof is a movable panel that opens to uncover a window in an automobile roof, allowing light and/or fresh air to enter the passenger compartment. Sunroofs can be manually operated or motor driven, and are available in many shapes, sizes and styles. While the term sunroof is now used generically to describe any glass panel in the roof, the term "moonroof" was historically used to describe stationary glass panes rigidly mounted in the roof panel over the passenger

compartment. A moonroof has a glass panel that is transparent and usually tinted. Previous terms include Sunshine Roof, Sliding Head and Sliding Roof

Figure 3: Sunroof image

1.1.5 WIPER CONTROL:

In today's automotive industry, the issue of driver safety and comfort is of great importance. An automatic windshield wiper system is of great aid in such cases. It betters the driving experience and improvises the safety factor of a vehicle by converting the manual windshield wiper system into an automatic system. By taking care of the attentions drivers would have to devote to control a manual system, an automatic wiper system helps them to concentrate more on driving safely. Although, few automated windshield wiper systems are available in the automotive market, they are very costly and not very effective. This project a cost effective and high performance automatic windshield wiper system developed using an Arduino Uno microcontroller and a rain intensity detection sensor. The system was programmed to use fuzzy logic to manipulate the analog data collected from the sensor, and the microcontroller controlled the wiper motor using pulse width modulation (PWM). The use of fuzzy logic allows the system to be easily reconfigurable. Such feature can be utilized to design different wiper system for different vehicles and weather conditions without any hardware modification.

Figure 4:Wiper Image

2. REASEARCH & LITERATURE SURVEY:

2.1 LITERATURE SURVEY:

CRUISE CONTROL:

- GMC SIERRA DENALI Owner's manual 2020
  PDF link:
  https://cdn.dealereprocess.org/cdn/servicemanuals/gmc/2020-sierra1500.pdf
- "Cruise Control Operation from Zero to Preset Speed-Simulation and Implementation" by F. A. Arvind Raj R., S. B. Sandhiya Kumar, Member IACSIT, IEEE and T. C. Karthik S.
  Paper Link: http://www.ijiet.org/papers/2-W13.pdf

HATCH CONTROL:

- Car brand chosen Mercedes BENZ
- Interface of the feature has a button on the door and 2 buttons on the back door.

Working:

It opens or closes if the user presses the button on the driver door and can hold the position of it by pressing the pause kind of button on the back of door and can resume the operation by pressing the stop button on the door which is present down the door and works with the sensor when the user places his leg near the sensor.

AC CONTROL:

When AC switch is on then fan will be on and ac will be on based on the temperature that given by the user. Temperature sensor senses the temperature and humidity sensor senses humidity if they are not greater than the desired level then only fan will be on and compressor will be off. If not both will on. we can also control the speed of the fan also and the direction of the airflow and recirculation of air also.

2.2 MY FEATURE:

CRUISE CONTROL:

In the cruise control feature I am building, I have taken a Level 1 cruise control. Here, there are 4 inputs and 1 output. The model I am taking for reference is the GMC SIERRA DENALI 2020 model.

HATCH CONTROL:

In hatch control, 4 inputs in which 1 is a sensor. The driver can open the hatch and there is a button to close the hatch too.

AC CONTROL:

In ac control, there is AC on/off switch with ambient car temperature, temperature control knob as well as switches to direct the airflow. Based on the given temperature, if the user temperature is less than ambient temperature then compressor will turn on.

SUNROOF CONTROL:

There are 2 inputs controlling the sunroof. One is manual input when pressed, the sunroof opens and the other is sensor based when there is any obstacle in between, the sunroof automatically closes.

WIPER CONTROL:

There are 5 modes of control of wiper system.

Low Speed wiper for low intensity of rain drops. High Speed Wiper for high intensity of rain drops. Mist wiper for one time forward and backward. Off Condition when there is no rain.

2.3 INPUTS:

2.3.1 CRUISE CONTROL:

2.3.1.1 USER INPUT:

- Cruise control on/off: Press to turn cruise control on or off.
- +RES: If there is a set speed in memory, press the control up briefly to resume to that speed or press and hold to accelerate. If cruise control is already engaged, use to increase vehicle speed.
- SET-: Press the control down briefly to set the speed and activate cruise control. If cruise control is already engaged, use to decrease the vehicle speed.
- Disengage cruise with set memory: It disengages the cruise control without erasing the set speed from memory.

This user input is achieved using push buttons.

Full Datasheet Link: [https://cdn.dealereprocess.org/cdn/servicemanuals/gmc/2020-sierra1500.pdf

Ex: Waytek round push button switch 44102

Characteristics:

- Supply voltage: 14VDC
- Supply current: 20A
- IP65

2.3.1.2 SENSOR INPUT:

Throttle Position sensor(TPS): The throttle is a valve mechanism allowing to modify the amount of gas flow into the cylinders of a gasoline internal combustion engine. The throttle is actuated directly by the driver through the gas pedal, and accordingly there was a mechanical connection between the two. The throttle position is mapped with the speed of the vehicle.

Input to the Sensor: Voltage (typically <25V, varies from sensor to sensor).

Sensor Output: Voltage (the peak voltage varies based on the sensor type and is proportional to the speed).

There are 3 types of TPS:

- Potentiometric TPS Measurement: Potentiometers are widely used as a cheap means for measuring rotational positions.

Example: PC-PTN

Figure 5: Potentiometric TPS

Full Datasheet Link: https://www.position-control.de/wpcontent/uploads/2016/09/Datasheet_PC_PTN.pdf

Characteristics:

- Supply Voltage: 24VDC
- Output Voltage: 0-10VDC
- Output Current: 4-20mA
- Temperature range: -30°C to +100°C
- Life: 100 million movements

- Inductive TPS Measurement: One way of measuring a rotational position in a contactless way is by using an inductive principle. Transmit coils send a signal, which is coupled back through a rotor into receiver coils.

  Example: LX3302

  Full Datasheet Link: http://static6.arrow.com/aropdfconversion/b3010cd8c0c5ab0b28a10c4470af4a9918099493/7527135720-lx3302-datasheet.pdf

  Characteristics:

  - Supply Voltage: 20V
  - Operating Temperature: -40°C to +150°C
  - Supply Current: 10mA
  - Operating humidity: 0-95
  - Frequency: 8.4 MHz

- Magnetic TPS measurement: Hall-effect based magnetic sensors, fully integrated on silicon, have since achieved a considerable share in this application.

  Example: 981 HE

Figure 6: Hall-effect TPS

Full Datasheet Link: https://docs.rs-online.com/68d1/0900766b80fe81c1.pdf

Characteristics:

- Supply Voltage: 5VDC
- Supply Current: 10mA
- Weight: 19g
- Linearity: 1%
- Mechanical travel: 360°

2.3.2 HATCH CONTROL:

2.3.2.1 USER INPUT:

- Hatch opening on/off: Press to open/close Hatch control on or off.
- Lock Key: To stop or resume the operation of the Hatch opening on the back-door bottom.
- Back door handle button: Hatch can be opened even by pressing this button.

This user input is achieved using push buttons.

Datasheet for push button: https://cdn.dealereprocess.org/cdn/servicemanuals/gmc/2020-sierra1500.pdf

Ex: Waytek push button switch 44102

Characteristics:

- Supply voltage: 14VDC
- Supply current: 20A
- IP65

2.3.2.2 SENSOR INPUT:

For the sensor input we will place the proximity sensor under the car backside which will be accessible for a person with his leg when he places his leg the sensor sends the information to the ECU to open the Hatch the below table give the information about the sensors which are feasible for the detection and working.

Input types: Sensor input

Characteristics:

Proximity Sensors	range	I/P range	O/P response	O/P current
Capacitive	7.2mm-8.8mm(<1cm)	<=200mA	<35ms	<0.3mA
Optical	50mm-100mm(1cm-10cm)	(2.3 V to 3.6 V) Response(200ms)	<35ms	<0.3mA
Inductive	30mm	<10ms&(10v-36v)	<=0.3mss	<0.3mA

Table 1: Sensors Comparison

References:

- https://www.onsemi.cn/pdf/datasheet/noa3302-d.pdf
- https://www.gavazzionline.com/pdf/CA12CLC0.pdf
- https://docs.rs-online.com/e8de/0900766b80274a6e.pdf

Sensor chosen is Optical proximity sensor NOA3302 because the other sensors do need metal objects to get detection and the other sensors work only for short range of distance.
A servo motor is used to open the door and works with 3 different pulse widths to 3 different ranges 0to90degrees, 90to180degrees, in between 0 to 180 with milliseconds duration.

2.3.3 AC CONTROL:

2.3.3.1 USER INPUT:

- AC on/off: Press to turn cruise control on or off.
- AC temperature control switch: To change the temperature values
- Fan speed control switch to change the speed of the blower
- Recirculation to select the air to be recirculate or to get the outer air to enter the car inner cabin.
- Air flow direction control switches to change the direction of the air flow.

Full Datasheet Link: https://cdn.dealereprocess.org/cdn/servicemanuals/gmc/2020-sierra1500.pdf

For temperature control:
Characteristics:

- Supply voltage: 12V DC
- Supply current: 10A

To on ac and recirculation:

- Supply voltage :12 VDC
- Supply current: 3A

2.3.3.2 SENSOR INPUT:

2.3.3.2.1 Temperature Sensors:

2.3.3.2.1.1 LM20:

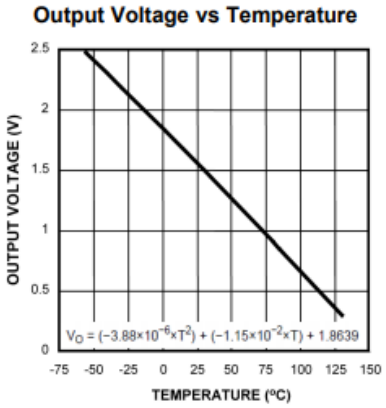


Figure 7:LM20

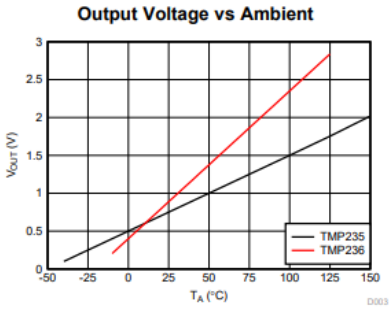
Characteristics:

- Power Supply Voltage Range - 2.4 V to 5.5 V
- Temperature ranges −55°C to 130°C

Datasheet: LM20 2.4-V, 10-µA, SC70, DSBGA Temperature Sensor datasheet (Rev. Q) (ti.com)

2.3.3.2.1.2 TM236:

Characteristics:



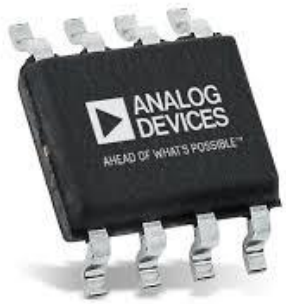


Figure 8: LM236

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Pressure	P_a	300		1200	hPa
Temperature	T_a	-40		85	°C
Supply voltage	V_{DD}	1.7		3.6	V
Supply voltage IO	V_{DDIO}	1.2		3.6	V

Table 2:TMP23x datasheet

Datasheet: TMP23x Low-Power, High-Accuracy Analog Output Temperature Sensors datasheet (Rev. E) (ti.com)

2.3.3.2.1.3 LMT87:

Characteristics:

	MIN	MAX	UNIT
Supply voltage	–0.3	6	V
Voltage at output pin	–0.3	(V_{DD} + 0.5)	V
Output current	–7	7	mA

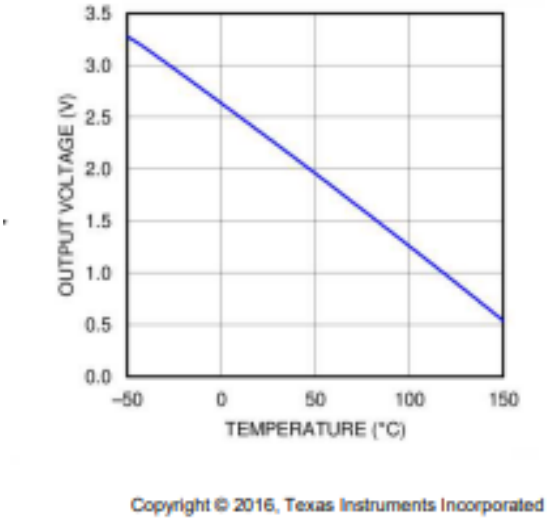


Figure 9: LMT87 Characteristic curve

Datasheet: LMT87 2.7-V, SC70/TO-92/TO-92S, Analog Temperature Sensors With Class-AB Output datasheet (Rev. E) (ti.com)

2.3.3.2.2 Humidity Sensors:

2.3.3.2.2.1 HTS2010SMD:

Characteristics

Ratings	Symbol	Value	Unit
Storage Temperature	Tstg	- 40 to 100	°C
Supply Voltage on humidity cell	Vs	10	Vac
Humidity Operating Range	RH	0 to 100	% RH
Temperature Operating Range	Ta	- 40 to 100	°C
Maximum Electric Power to be supplied (continuous) @ 25°C	P25	2	mW

Table 3: HTS2010SMD characteristics

Datasheet:
https://pdf1.alldatasheet.com/datasheetpdf/view/119967/HUMIREL/HTS2010SMD.html

2.3.3.2.2.2 HTU31:

Characteristics:

Voltage supply range from 3V to 5.5V

Storage Temperature[5]	Tstg	-40 to 150	°C
Supply Voltage (Peak)	Vcc	6V	Vdc
Humidity Operating Range	RH	0 to 100	%RH
Temperature Operating Range	Ta	-40 to +125	°C
VDD to GND		-0.3 to 6V	V
Digital I/O pins (DATA/SCK) to VDD		-0.3 to VDD+0.3	V
ESD HBM (human body model)[6]		±2	kV
ESD Charged device model[7]		750	V
ESD Machine model[8]		±200	V

Table 4: HTU31 Characteristics

2.3.3.2.2.3 DHT11:

Characteristics:

- to 5V power and I/O.
- 2.5mA max current use during conversion (while requesting data)
- Good for 20-80% humidity readings with 5% accuracy.

- Good for 0-50°C temperature readings ±2°C accuracy

Datasheet:https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf

2.3.3.2.3 High and Low pressure sensors:

2.3.3.2.3.1 BPS125:

Characteristics:

- Supply voltage range 3.0 V minimum
- 3.3 V typical
- 3.6 V maximum
- Pressure Range - 250 to 500 Pa, 0.15 to 1.0 PSI

Datasheet: https://datasheetspdf.com/pdf-file/1425473/BOURNS/BPS125/1

2.3.3.2.3.2 DPS368:

Characteristics:

Operation range: Pressure: 300 –1200 hPa and Temperature: -40 – 85 °C

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Pressure	P_a	300		1200	hPa
Temperature	T_a	-40		85	°C
Supply voltage	V_{DD}	1.7		3.6	V
Supply voltage IO	V_{DDIO}	1.2		3.6	V

Table 5: DPS368 Characteristics

Datasheet: https://www.infineon.com/dgdl/Infineon-DPS368-DataSheet-v01_01-EN.pdf?fileId=5546d46269e1c019016a0c45105d4b40

2.3.3.2.3.3 KP234:

- High precision pressure sensing (± 1.5 kPa)
- Large temperature range (-40 °C to 125 °C)

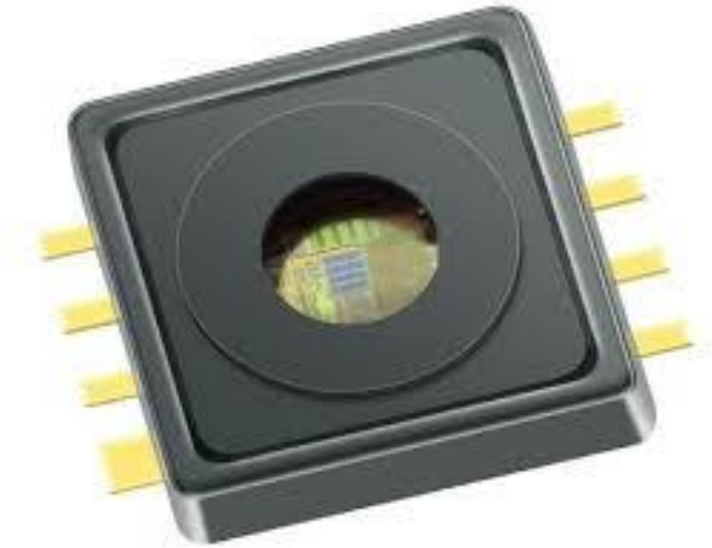


Figure 10: KP234

Datasheet: https://www.infineon.com/dgdl/Infineon-KP234-DS-v01_00-en.pdf?fileId=db3a30432ad629a6012af66bbf030b08

2.3.4 SUNROOF CONTROL:

2.3.4.1 USER INPUT:

- Sunroof open/close: Press push buttons open or close.
- Open: If open push button is pressed sunroof open.
- Close: If close push button is pressed sunroof close.
- Two Input buttons:
- Voltage 16v

2.3.4.2 SENSOR INPUT:

2.3.4.2.1 Hall effect Position sensor

Figure 11:Hall effect Sensor

DRV5023 Sensor

Operating voltage	2.5-38v
Operating Temperature	-40 - 125 ‘c
Operating Current	2.7 – 3.5 mA

Table 6:Sensor data table

Full Datasheet Link:
https://www.ti.com/lit/ds/symlink/drv5023.pdf?ts=1616321980928&ref_url=https%253A%252F%252Fwww.google.com%252F .

Characteristics:

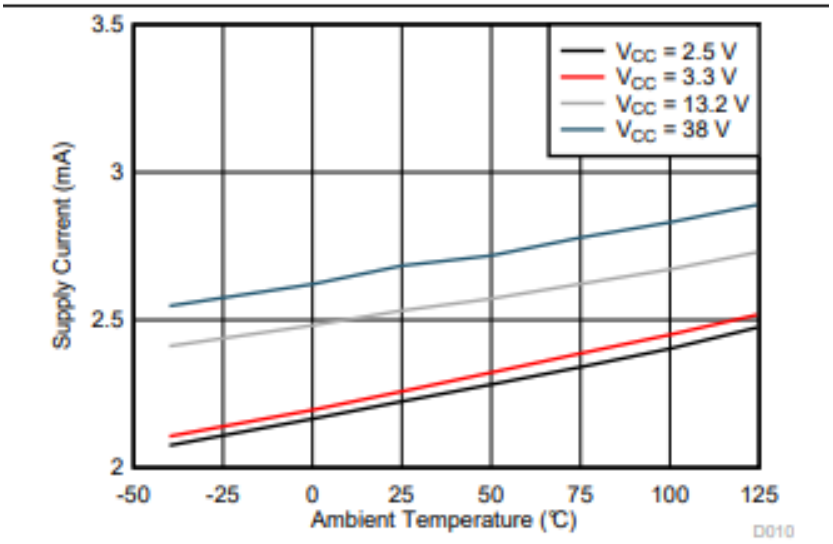


Table 7: DRV5023 characteristics curve

Two different sensor links:

- Refer for DVR5055 Sensor: https://www.ti.com/lit/ds/symlink/drv5055.pdf?ts=1616109475973&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FDRV5055
- Refer for A1321, A1322, and A1323 Sensors: https://datasheetspdf.com/pdf/157105/AllegroMicroSystems/A1321/1

2.3.5 WIPER CONTROL:

2.3.5.1 USER INPUT:

- We're using Rotary switch for wiper control System.
- LO: If we press LO, then the wiper will wipe for low intensity of rain drops with low speed.
- HI: If we press HI, then the wiper will wipe for high intensity of rain drops with high speed.
- 1X: If we press 1X, then the wiper will wipe for one time forward and backward.
- Off: If we press Off, then the wiper will Off.
- Input Voltage: 3.3V
- Input Current: 5A

2.3.5.2 SENSOR INPUT:

2.3.5.2.1 Rain sensor:

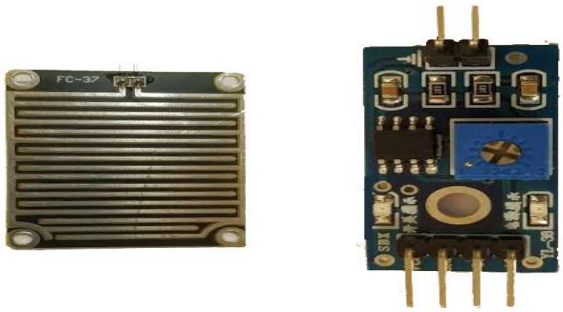


Figure 12:Rain Sensor

- Working voltage 5V
- Output format: Digital switching output (0 and 1), and analog voltage output AO
- Potentiometer adjust the sensitivity
- Uses a wide voltage LM393 comparator
- Comparator output signal clean waveform is good, driving ability, over 15mA
- Anti-oxidation, anti-conductivity, with long use time
- With bolt holes for easy installation
- Small board PCB size: 3.2cm x 1.4cm

Operating voltage	12 VDC ±10 %
Average power consumption	0.30 W at 12 V
Maximum power consumption with sensor plate heating on	3.12 W at 12 V 1)
Analog output	1 to 3 V (wet to dry)
Operating temperature	-15 … +55 °C (+5 … +131 °F)

Table 8: Rain sensor characteristics

2.3.5.2.2 Wiper control switch:

The RW200 series Rotary Wiper has four wiper control positions via a rotating knob: Off, Intermittent, Continuous Low Speed and Continuous High Speed. The device has a washer function that operates the washer pump and wiper while the knob is depressed.

Figure 13:Rotary Wiper

2.4 ALGORITHM (Flow Chart):

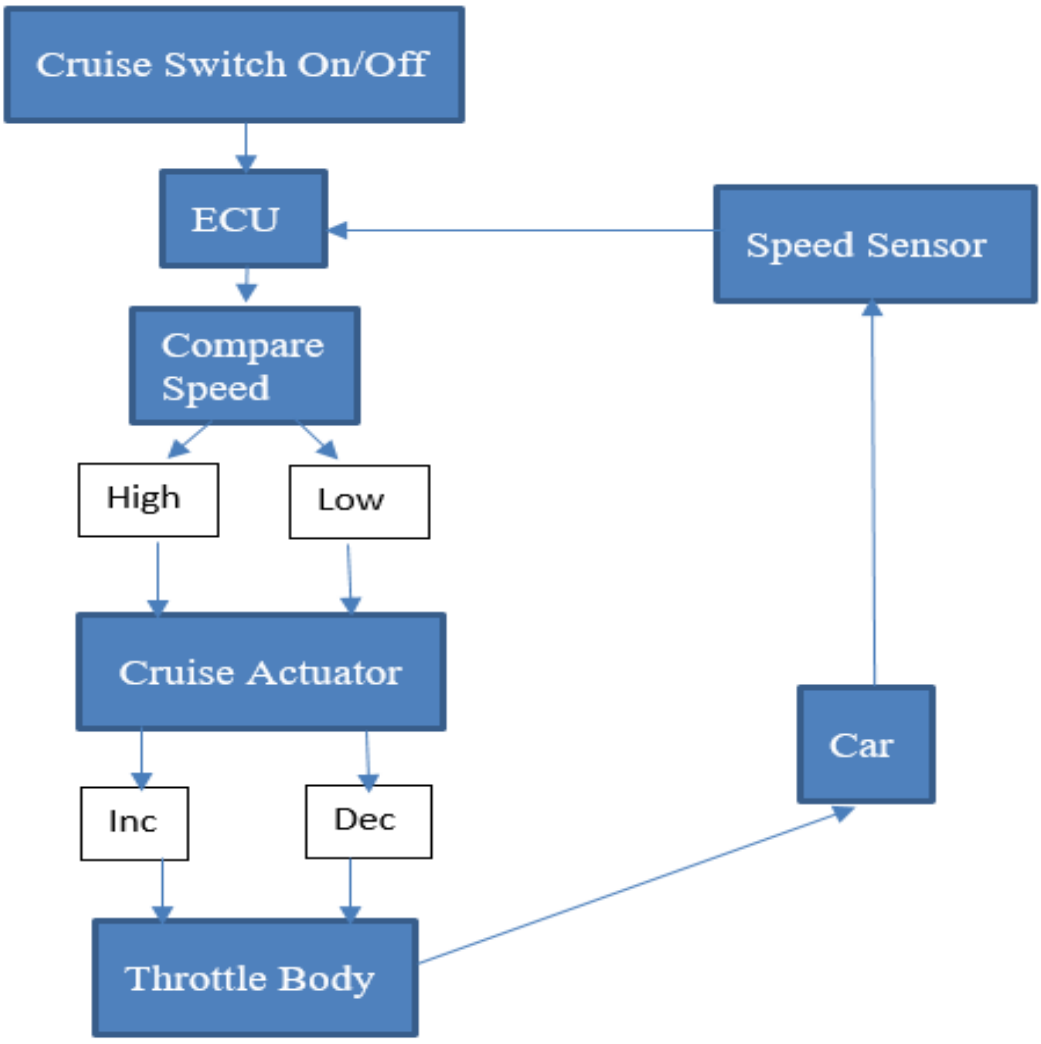


Figure 14:algorithm for cruise control

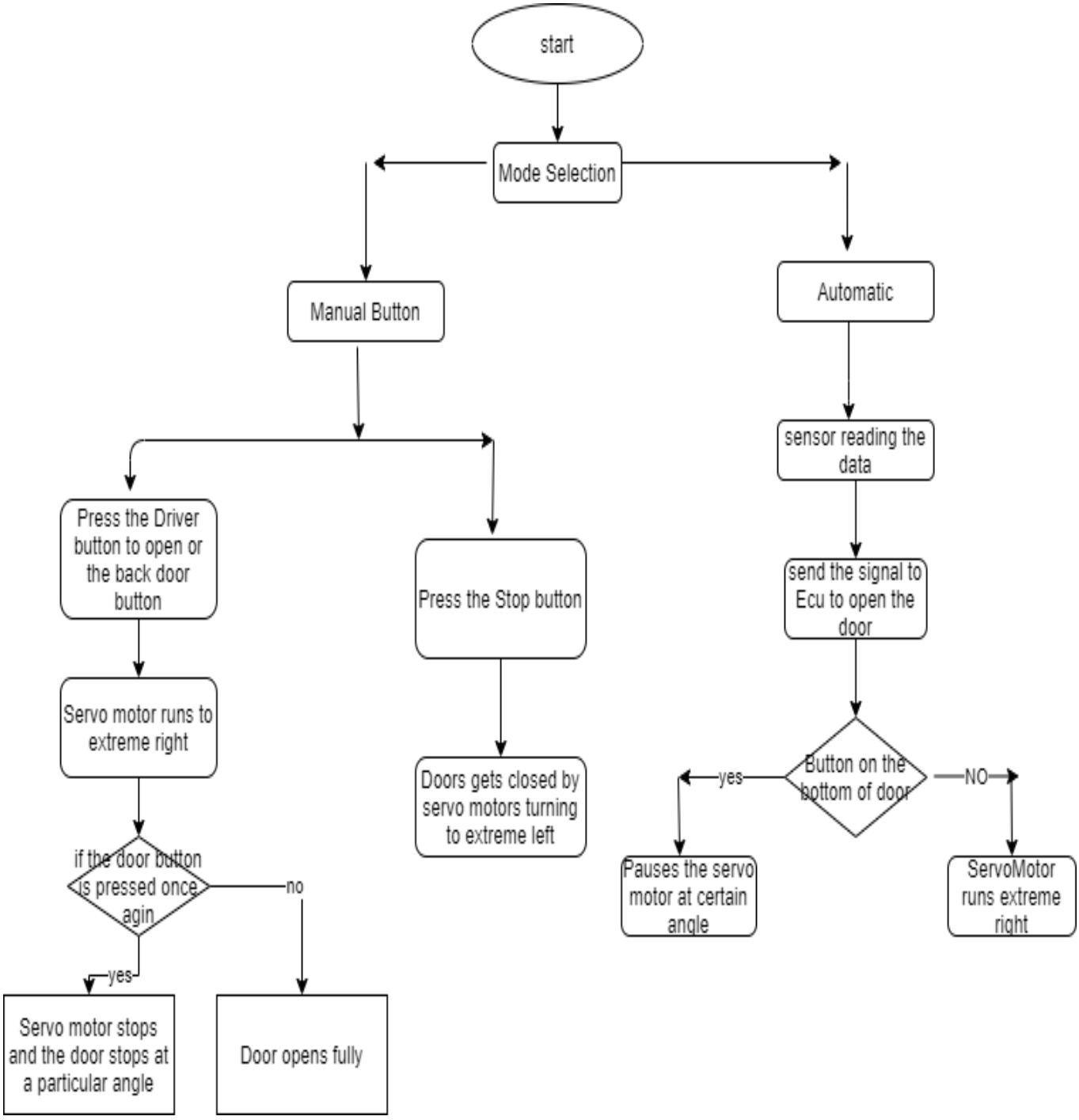


Figure 15:Algorithm for Hatch opening

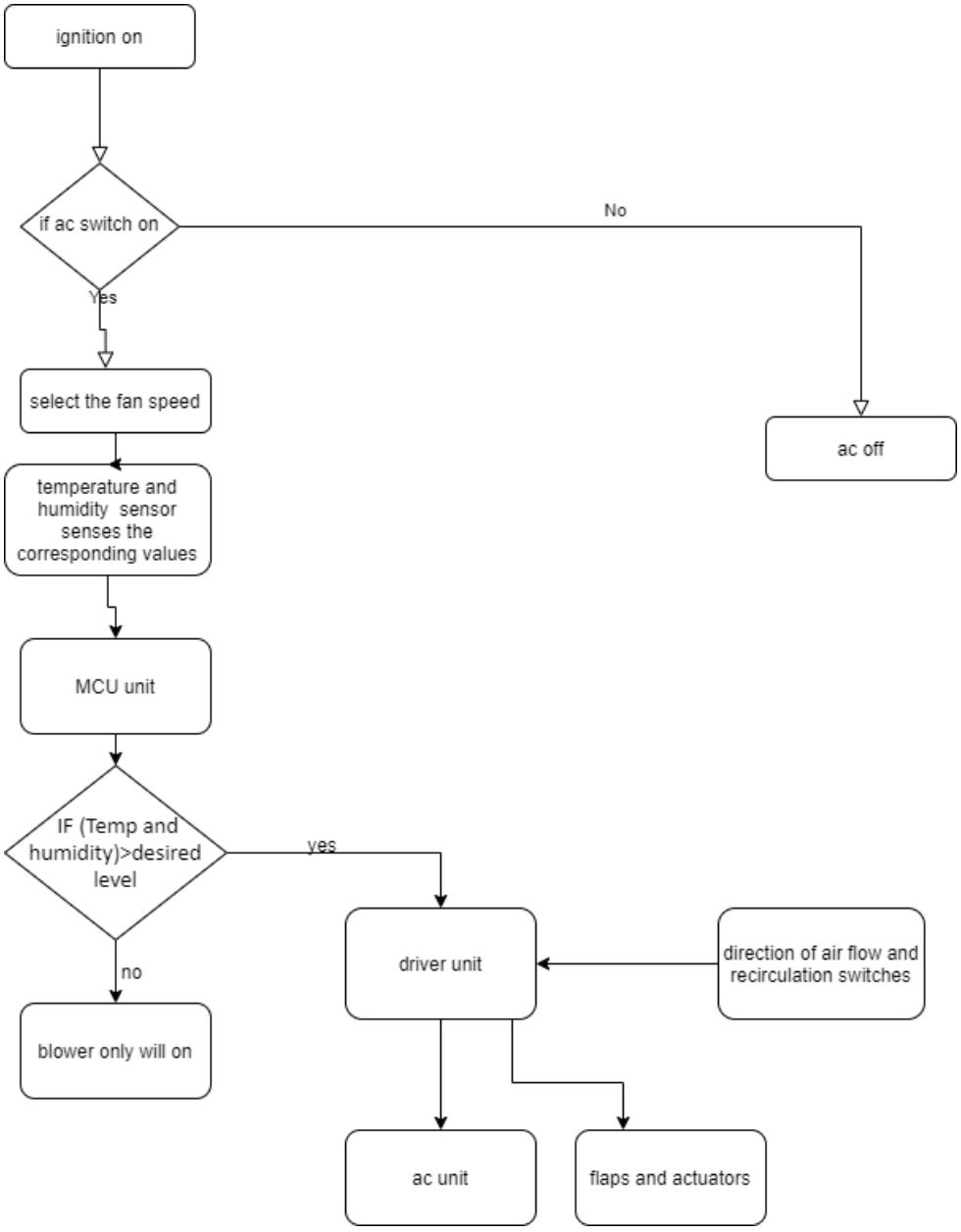


Figure 16:Algorithm for AC control

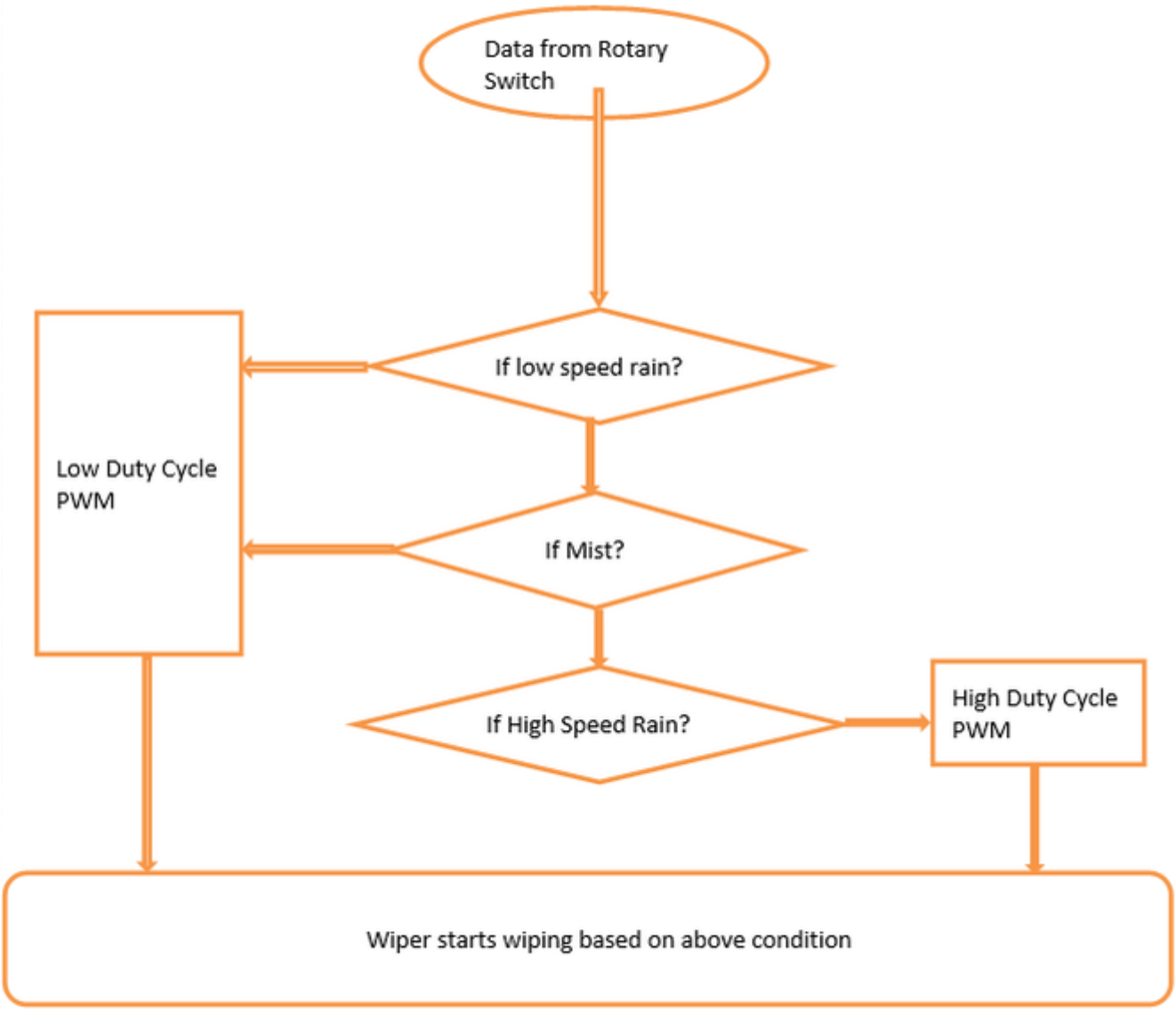


Figure 17:Algorithm for Wiper control

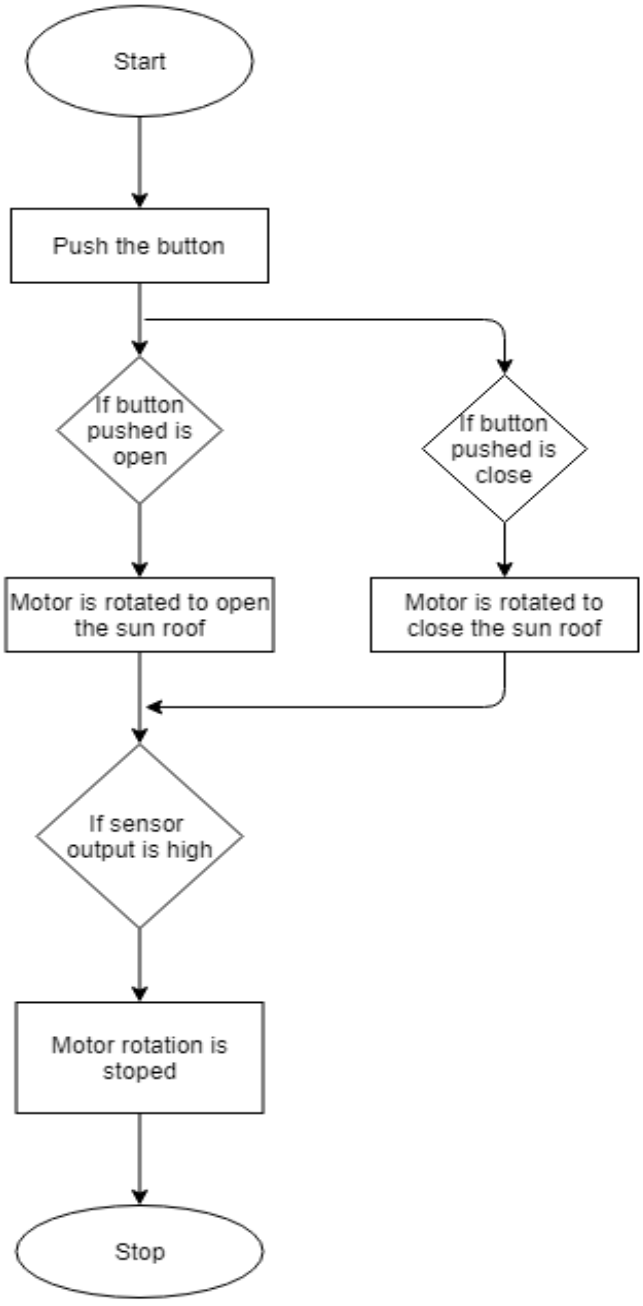


Figure 18:Algorithm for Sunroof control

2.5 SWOT ANALYSIS:

STRENGTHS

Cruise Control:
1.Ease for Driver
2.Comfort of not needed to press the pedal
Hatch Control:
1.Can be opened automatically with sensor
2.Can be opened at some angle
3.Can be closed easily and can stop closing if object is not fit into it.
AC Control:
1.Provide comfortable ambient atmosphere.
2.Make user not to effect his drive to the outside atmosphere.
3.Cost Effective
Sun roof Control:
1.Better lighting in car
2.Better air permeability in traffic.
Wiper Control:
1.Safe driving when it is raining
2.Increases Visibility
3.Low Cost to implement.

WEAKNESSES

Cruise Control:
1. Inefficient in high traffic areas as it is not designed for that purpose.
2.Can be used only in high ways/long lanes with less traffic
Hatch Control:
1.Slow opening of the backdoor
2.Wear and tear of the sensor can happen
AC Control:
1.Fuel Consumption increases
2.Direction of airflow is not there
Sun roof Control:
1.Too Expensive
2.High Maintainence
Wiper Control:
1.High Maintainence

OPPORTUNITIES

Cruise Control:
1. Can go into adaptive cruise control
2. Stepping stone for fully autonomous cars.
Hatch Control:
1.Easy access to backdoor opening
2.Need not to worry about handle doors
AC Control:
1.Can be manual
2.Can be automated
Sun roof Control:
1. Used in different type of weather conditions
Wiper Control:
1.Used in different types of weather conditions and improves visibility.

THREATS

Cruise Control:
1. If driver is not careful, it may lead to accidents
2. Can lead to drowsy driving
Hatch Control:
1.Can be opened easily by anyone
2. Distance of sensor input might become a problem
AC Control:
1.May another company will come with airflow with same cost
Sun roof Control:
1. Creates noise and disturbance to the driver
Wiper Control:
1.Damages wiper blades leads to damage in glass and visibility

Figure 19: SWOT Analysis

3. DETAILED REQUIREMENTS:

3.1 HIGH LEVEL REQUIREMENTS:

ID	Description
H_CC_01	Cruise control subsystem- The Cruise system was introduced to reduce the driver fatigue for long drives. It is a closed loop control systems.
H_HD_02	Opening of the back door through physical switch and proximity sensor
H_SUN_03	Opening & closing Sun roof
H_FW_04	Enabling front wind shield wiper
H_RW_05	Enabling rear wind shield wiper
H_AC_06	Main requirement is to provide comfort for the people on the vehicle cabin. This feature includes the process of controlling the temperature based on the user comfortable

3.2 LOW LEVEL REQUIREMENTS:

ID	Description
L_CC_01	Cruise control should turn on only if vehicle speed is >40kmph.
L_CC_02	It should hold the vehicle speed at the selected value.
L_CC_03	Hold the speed with minimum surging.
L_CC_04	Allow the vehicle to change speed.
L_CC_05	Deactivate the control immediately after the brakes are applied.
L_CC_06	Store the last set speed.
L_HD_07	Stopping of the door through a button located on the bottom such that the servo motor stops at certain angle with the pulse width.
L_HD_08	Servo motor should go extreme right when there is no handle door button pressed.
L_HD_09	Servo motor should go extreme left when the user presses the stop button on the bottom of the door.
L_HD_10	Driver can close and open the back door from the door switch which is next to him.
L_AC_11	AC should turn on whenever the user turns on the switch
L_AC_12	Based on the temperature set sensor should sense and maintain according to that.
L_AC_13	User can change the speed of the based on his requirement
L_AC_14	If the temperature is set then fan only will work.
L_AC_15	User can change the direction of airflow.

L_AC_16	User can turn off the AC.
L_SUN_17	Operating motor used for sunroof panels
L_LS_18	Enabling low speed wiper
L_HS_19	Enabling High speed wiper
L_MW_20	Enabling mist condition wiper

4. DESIGN & IMPLEMENTATION:

4.1 HIGH LEVEL DESIGN & IMPLEMENTATION:

Figure 2.1: HLR of our design

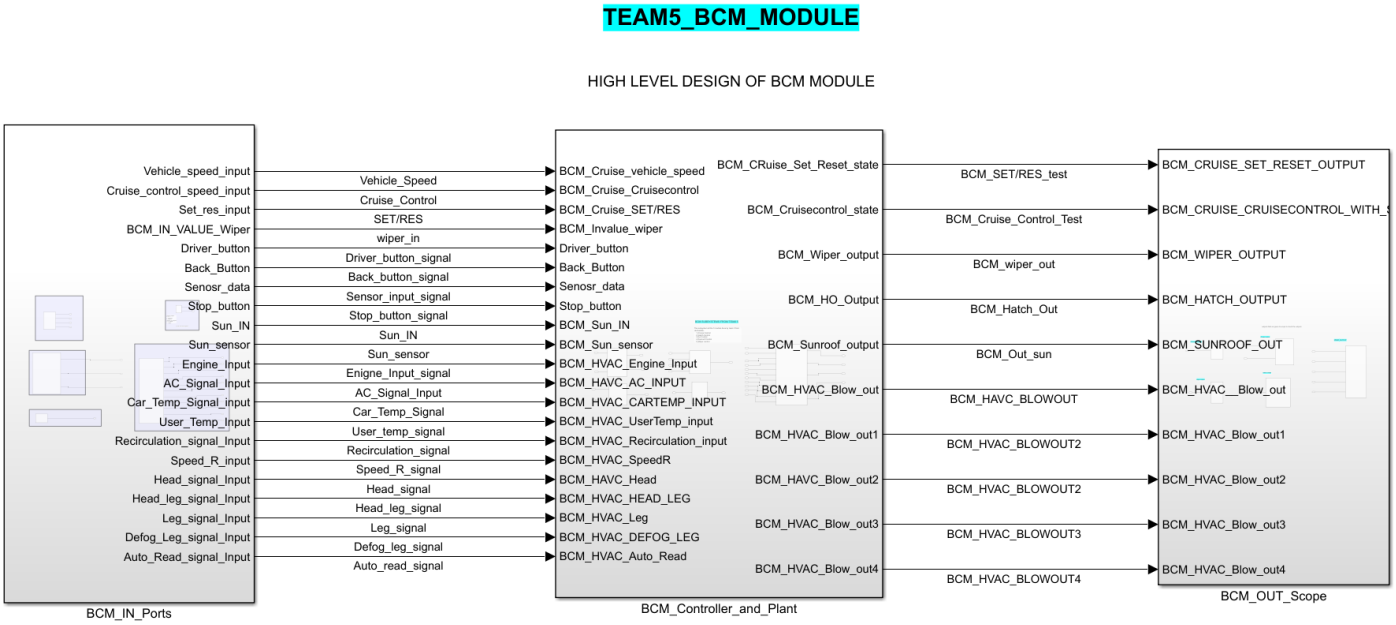


Figure 20: High Level BCM

4.2 LOW LEVEL DSEIGN & IMPLEMENTATION:

Cruise Control:

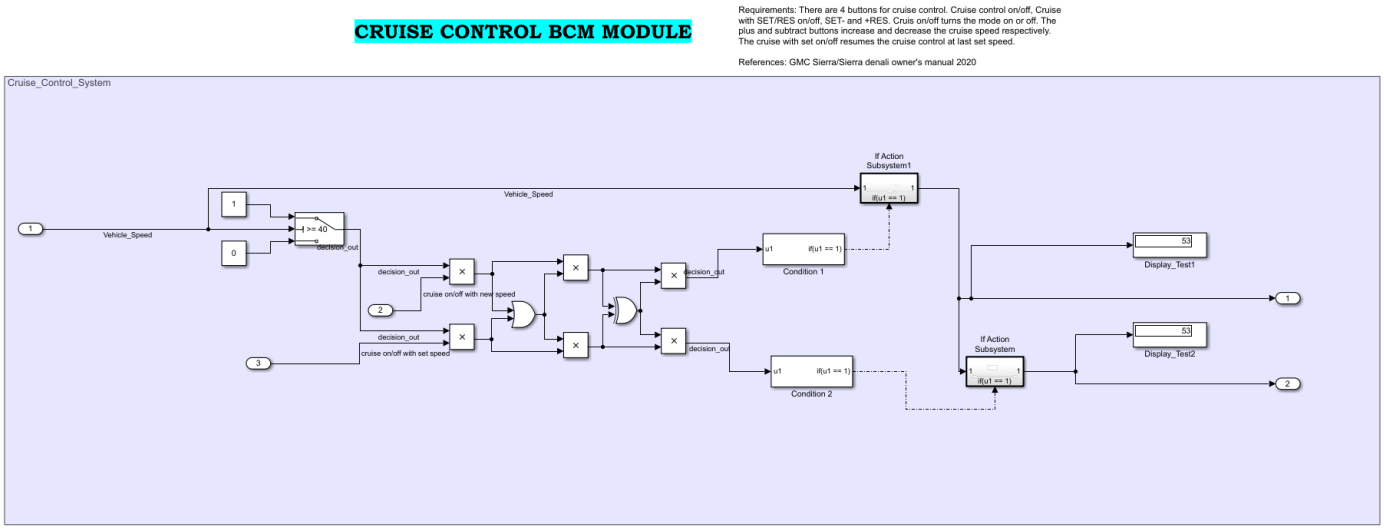


Figure 21: Cruise Control design

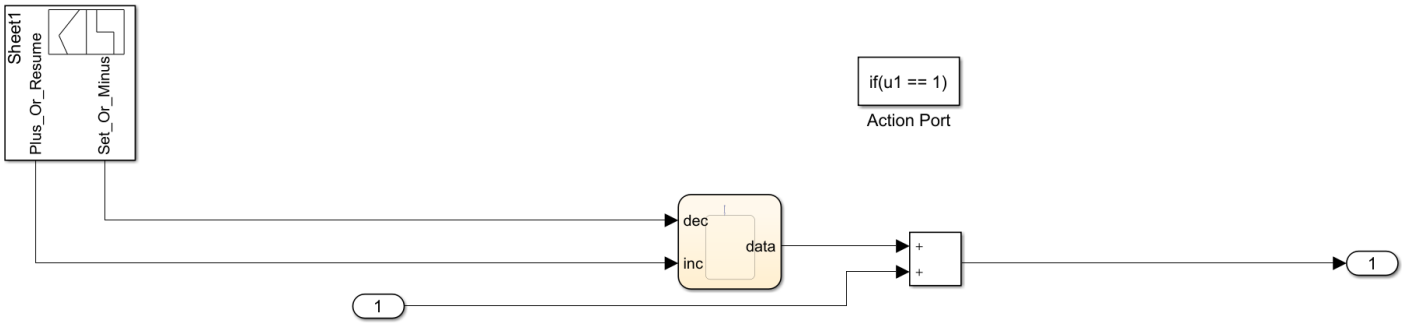


Figure 22: SET- and +RES block

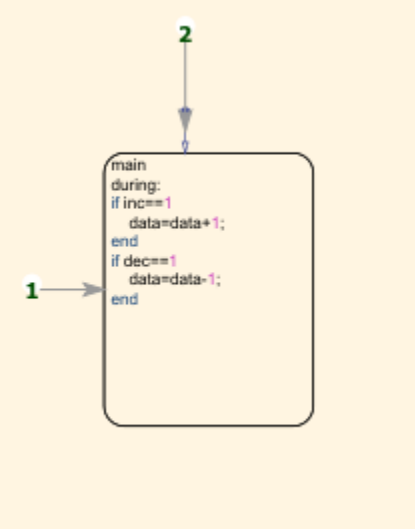


Figure 23: Inside the chart of Fig8

HATCH CONTROL:

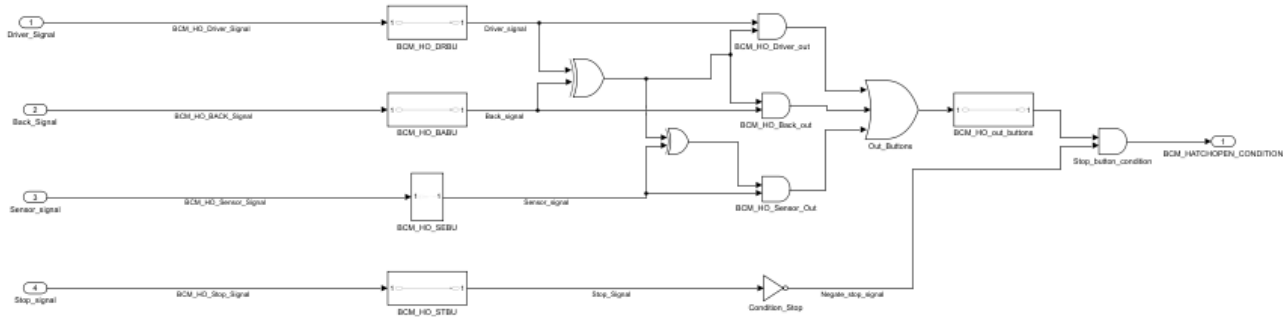


Figure 24: Hatch opening low level

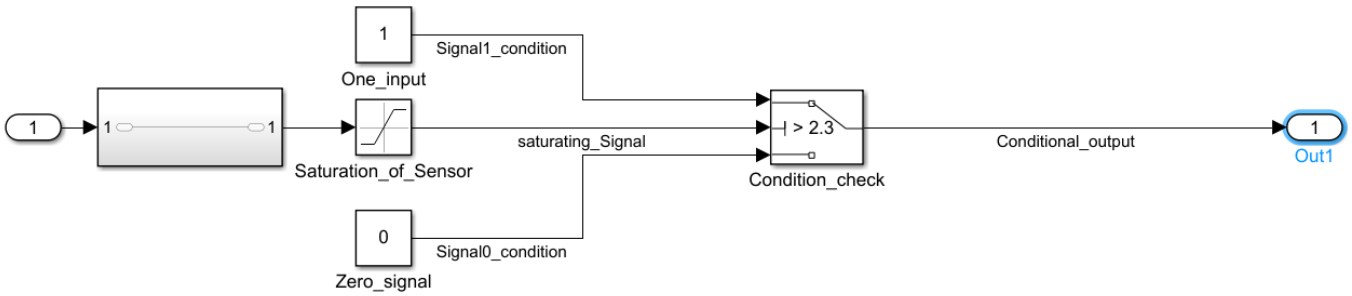


Figure 25: Hatch opening sensor conversion to digital

HVAC CONTROL:

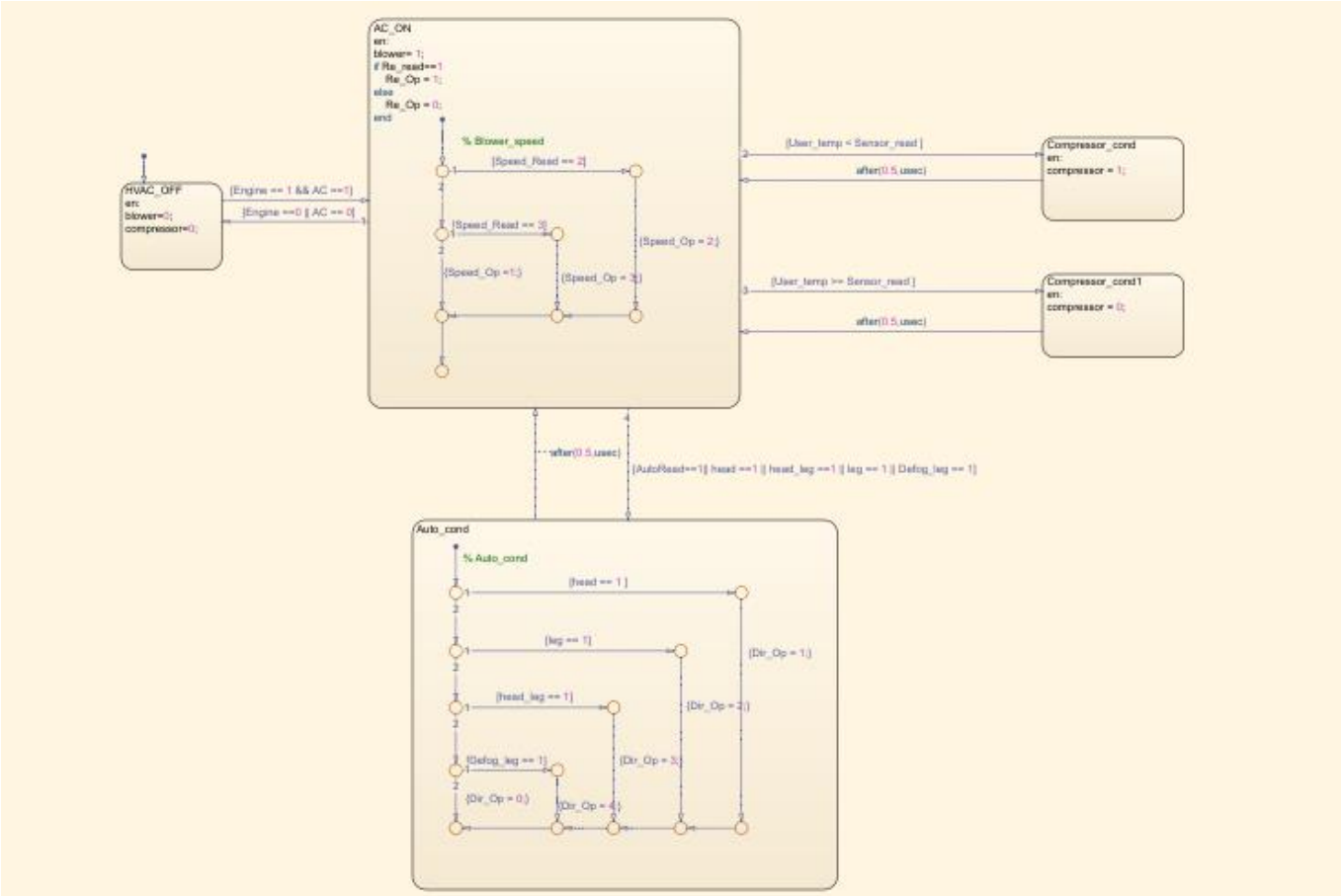


Figure 26: BCM HVAC low level

SUNROOF CONTROL:

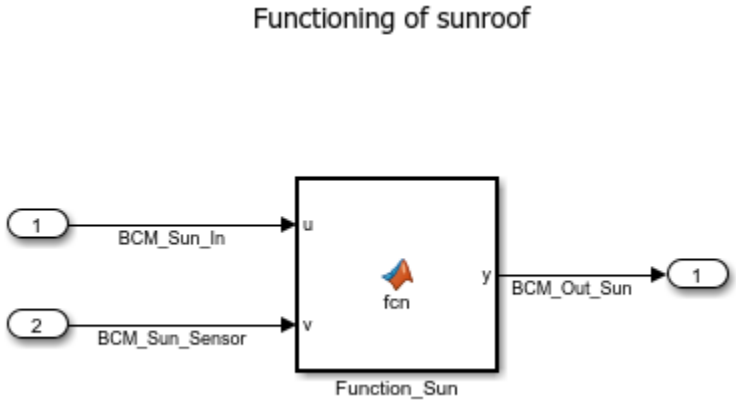


Figure 27: BCM sunroof low level

WIPER CONTROL:

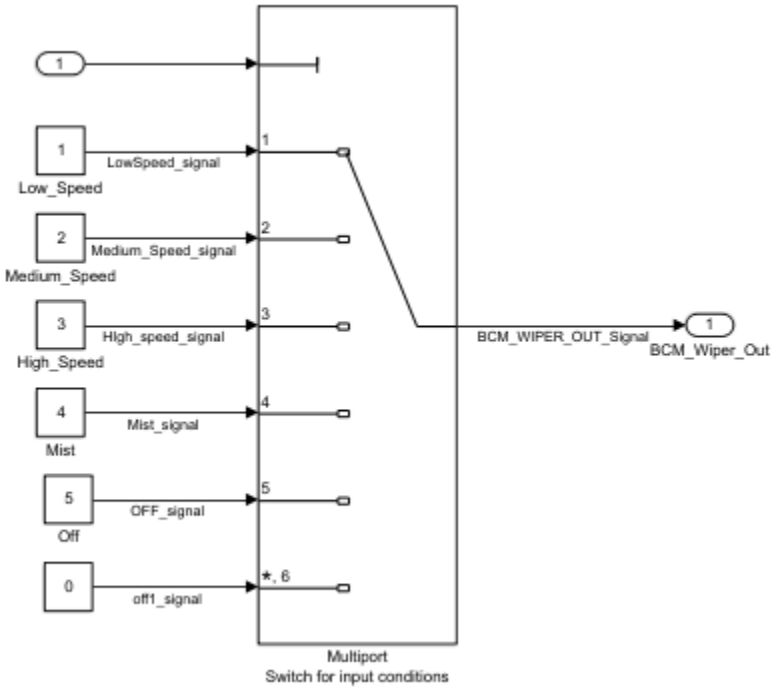


Figure 28: BCM wiper low level

5. TEST PLAN:

5.1 HIGH LEVEL TEST PLAN:

Test ID	Description	Input given	Output expected	Actual output	Type of Test	Result
HLT_CR_01	A speed of 50kmph with cruise control	50, Cruise On	50	50	Requirement based	Pass

	switch in On state is given as input.					
HLT_SUN_02	Open push button pressed	16v	Sunroof open	Sunroof open	Requirement based	Pass
HLT_SUN_03	Close push button pressed	16v	Sunroof close	Sunroof close	Requirement based	Pass
HLT_FW_04	Enabling front wind shield wiper	Front Wiper should be on	Front Wiper On	Front Wiper On	Requirement based	Pass
HLT_RW_05	Enabling rear wind shield wiper	Rear Wiper should be on	Rear Wiper On	Rear Wiper On	Requirement based	Pass
HLT_AC_06	To check whether ignition condition	Ign =0 Ac on =0	Ac off	Ac off	Scenario based	Pass
HLT_AC__02	When ignition on To check the ac button condition	Ign = 0 Ac on =0	Ac off	Ac off	Scenario based	Pass
HLT_AC_03	When ignition on To check the ac button condition	Ign =0 Ac on =1	Ac on	Ac on	Scenario based	Pass
HLT_HD_1	A Button in the driver door and the sensor input should open the hatch at the back	DriverButton=0, Sensordata=1	Hatch open	Hatch open	Scenario based	Pass

5.2 LOW LEVEL TEST PLAN:

Test ID	Description	Input given	Output expected	Actual output	Type of Test	Result
LLT_CR_01	A speed of 37kmph given as input and cruise was turned on.	37	Cruise mode should not get activated	Cruise mode doesn't get activated	Boundary based	Pass
LLT_CR_02	A speed of 50kmph given and "+RES" button is pressed 5 times.	50, +RESx 3	55	55	Scenario based	Pass
LLT_CR_03	A speed of 55kmph given and "SET-" button is pressed 4 times	55, SET-x4	51	51	Scenario based	Pass
LLT_CR_04	Previous set cruise control is 51kmph, user turns on the cruise control and presses "Cruise set resume speed".	Cruise resume	51	51	Scenario based	Pass
LLT_HD_01	A Button on the back-door handle is pressed	Back Button =1	Hatch opens	Hatch open	Scenario based	Pass
LLT_HD_02	A Stop button on the bottom of the door should be pressed.	Stop Button =1	Hatch closes	Door opening should be closed	Scenario based	Pass
LLT_HD_03	A button on the back-door handle is pressed	Back door	Hatch opening	Can't be seen as	Scenario based	Failed

		button =1	Should pause	motor is required		
LLT_HD_04	A Button on the bottom of the door should be pressed after pressing the back-door handle button	Bottom Button =1	Hatch should close	Hatch closes	Scenario based	Pass
LLT_HD_05	Sensor should detect the object and hatch should open	Sensor input= 2.6	Hatch open	Hatch open	Scenario based	Pass
LLT_HD_06	Sensor should detect the object and hatch should open	Sensor input= 2.1	Hatch should not open	Hatch will not open	Boundary based	Pass
LLT_SUN_07	Open push button pressed	16v	Motor rotates forward	Motor rotates forward	Scenario based	Pass
LLT_SUN_08	Close push button pressed	16v	Motor rotates reverse	Motor rotates reverse	Scenario based	Pass
LLT_LS_09	Enabling Low Speed Wiper	Low Speed Wiper should be On	Low Speed Wiper On	Low Speed Wiper On	Scenario based	Pass
LLT_HS_10	Enabling High Speed Wiper	High Speed Wiper should be On	High Speed Wiper On	High Speed Wiper On	Scenario based	Pass
LLT_M_11	Enabling Mist condition Wiper	Mist Conditi on Wiper	Mist Conditio n Wiper On	Mist Condition Wiper On	Scenario based	Pass

		should be On				
LLT_AC_12	To give the desired temperature by switching on AC	Case 2	20degrees AC on Fan on high mode	20deg High mode	Boundary based	Pass
LLT_AC_13	To give desired temperature	Case 3	35 deg Heater on Fan on Medium mode	35 deg Medium mode	Boundary based	Pass
LLT_AC_14	To on ventilation	Case 4	To adjust knobs to change direction of air flow	Front ac inlets are closed	Boundary based	Pass

6. COMPLIANCE:

6.1 ASSUMPTIONS TAKEN:

Hatch control:

1. Thought of to show motor logic but couldn't do it due to time constraint.
2. Inserted the proximity sensor for the hatch opening and its working fine.
3. Gave the access to both driver and passenger for opening Hatch.
4. Gave the stop button to close the hatch.

Cruise control:

1. There are 4 inputs- Cruise on/off, Plus speed, Decrease speed and Resume at set speed. Wherein it should also have a feature where on pressing plus speed, it should get back to the set speed.
2. Due to time constraint, I couldn't implement that.

6.2 MAAB GUIDELINES FOLLOWED:

Cruise control:

- db_0081: Unconnected signals / blocks: None was there in my model. I followed this rule in my previous and current model.
- jc_0110: Direction of block:

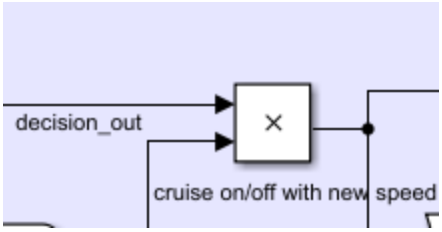


Figure 29: Direction of block

- jc_0792: Unused data: This rule was followed perfectly.
- jm_0002: Block resizing::

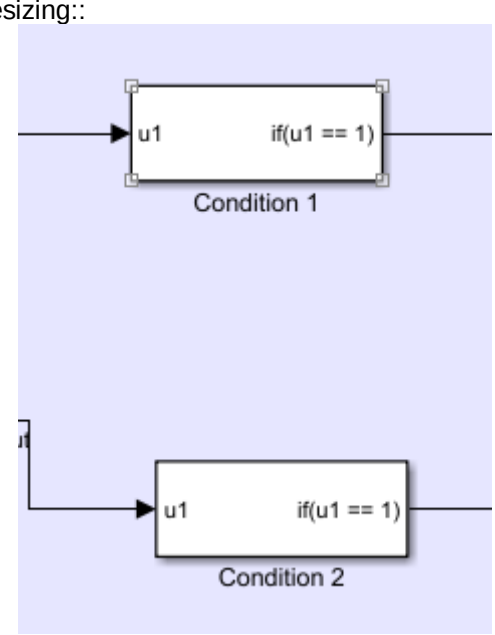


Figure 30: Blocks/subsystems have been sized equally

- na_0019: Restricted Variable Names: Didn't use any restricted names like TRUE,FALSE,etc

Hatch Control:

- na_0008: Display of labels on signals

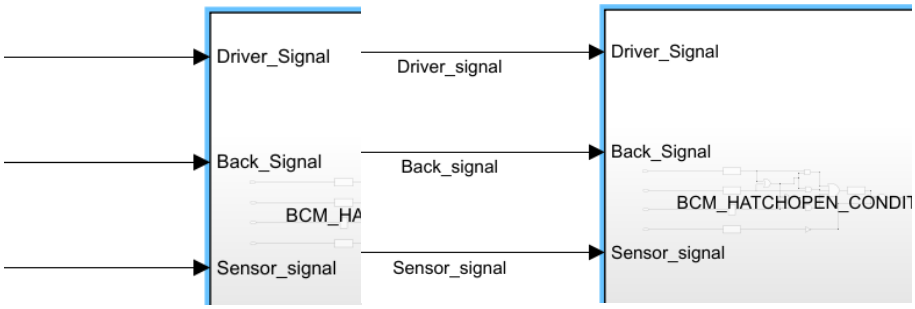


Figure 31: Display of signal labels Before and after

- na_0002: Appropriate implementation of fundamental logical and numerical operations

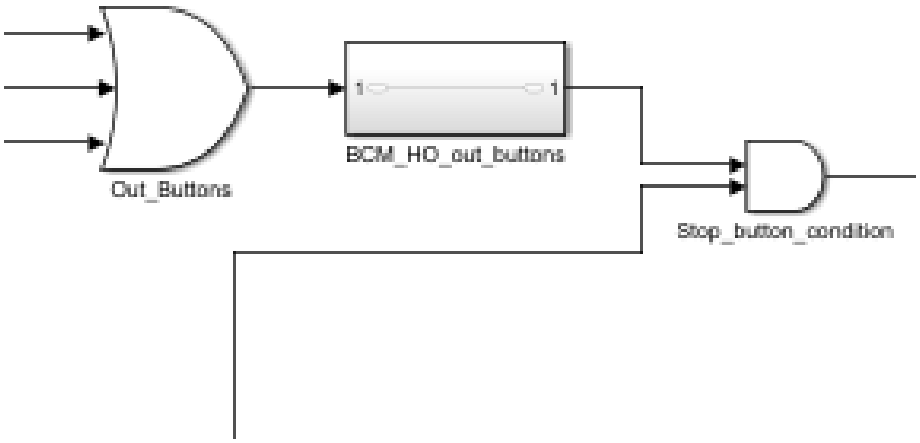


Figure 32: Implementation using logical blocks

- jc_0141: Use of the Switch block

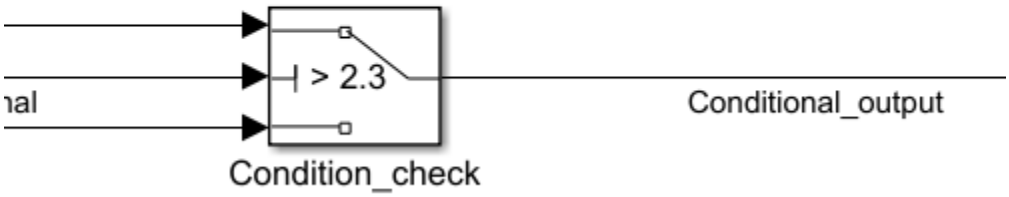


Figure 33: Switch block used in taking the sensor data

- db_0116: Simulink patterns for logical constructs with logical blocks

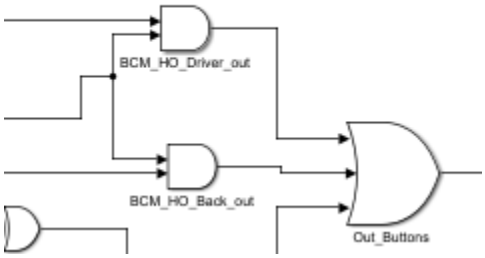


Figure 34: Logical construction

- jc_0201: Usable characters for Subsystem

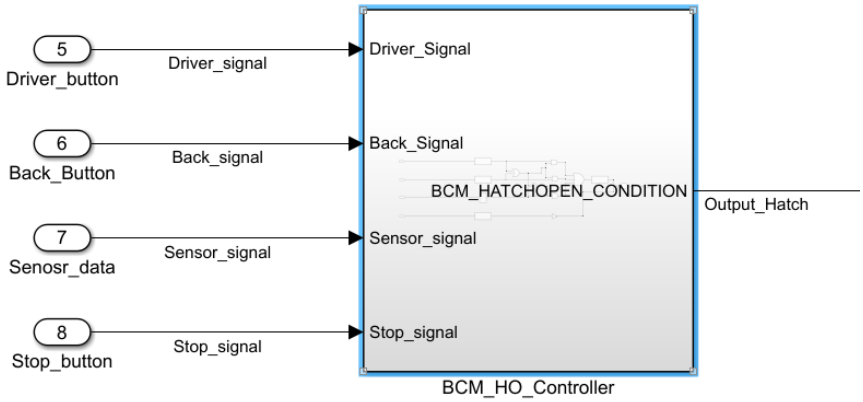


Figure 35: Subsystem name using the guideline

Wiper Control System:

- jc_0246: Length Restriction for parameter name

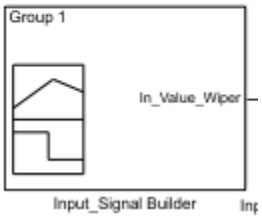


Figure 36: Length of restriction for parameter name

- ar_001: Usable characters for file names

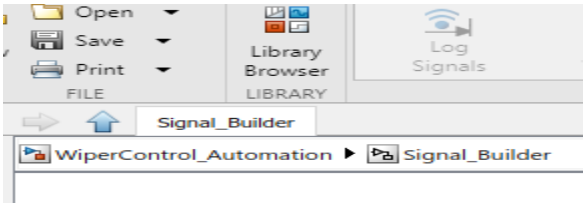


Figure 37: Usable characters for file names

- jc_0243: Length restriction for subsystem names

Figure 38: Length restriction for Subsystems

- jc_0231: Usable Characters for block names

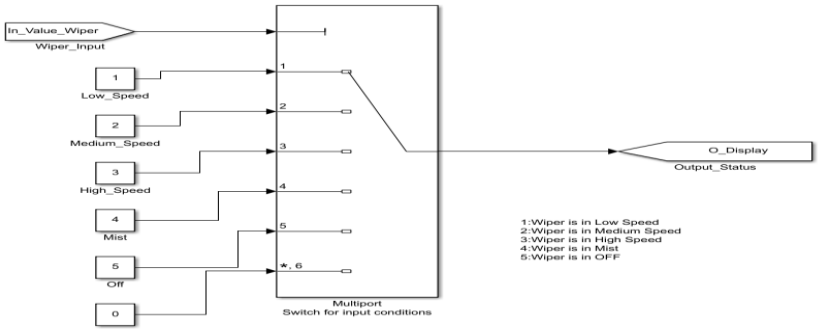


Figure 39: Usable characters for block names

- db_0142: Position of block names

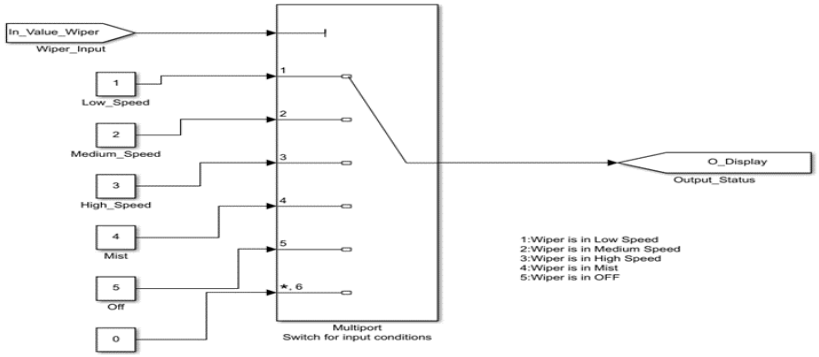


Figure 40: Position of block names

AC Control System:

- jc_0244

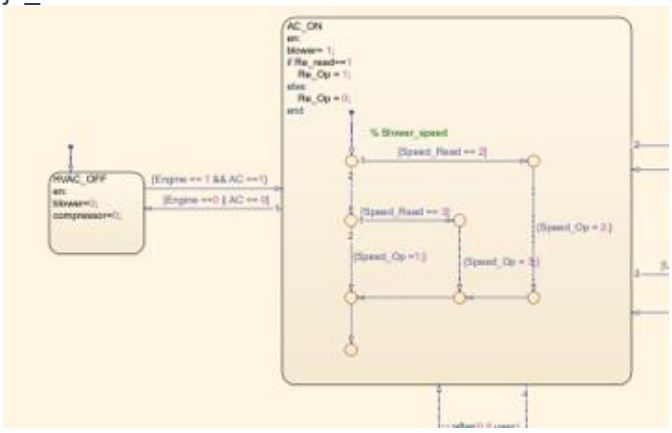


Figure 41: Length Restriction for inport and outport names

- jc_0795: Usable characters for stateflow datanames

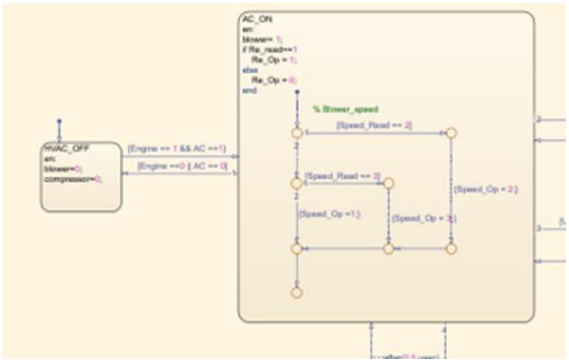


Figure 42: Usable Characters for stateflow data names

- *jc_0241: Length Restriction for model file names*

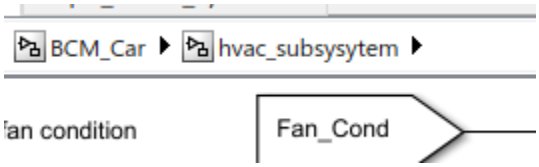


Figure 43: Length Restriction for model file names

- jc_211: Usable characters for inport and outport blocks

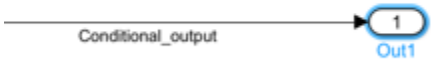


Figure 44:Usable characters for inport and outport blocks

- jc_0171: Classification of connections between structural subsystems

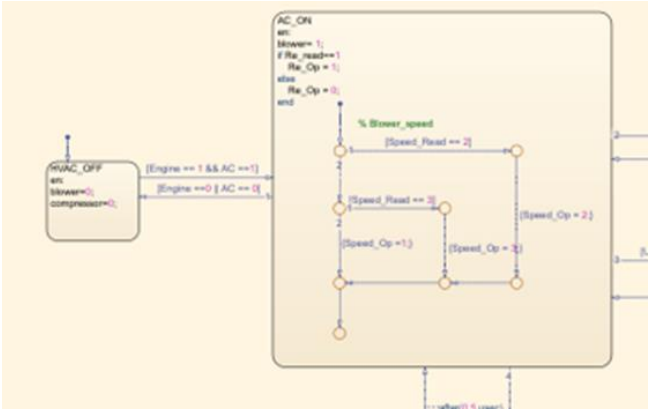


Figure 45: Classification of connections between structural subsystems

Sunroof System:

- jc_0201: Usable characters for subsystem names

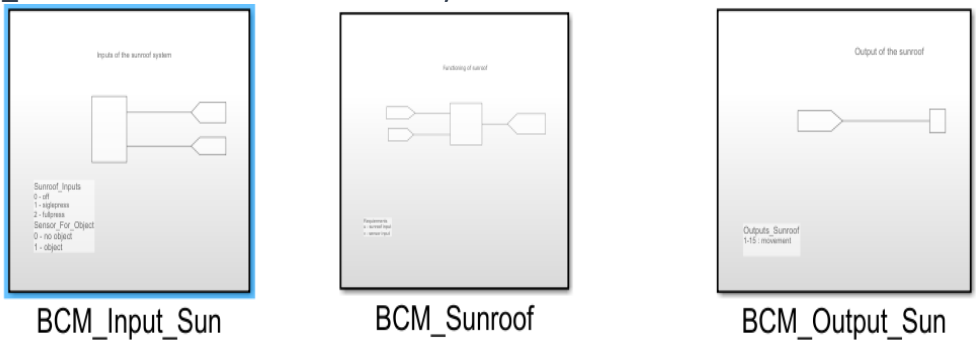


Figure 46: Usable Characters for subsystems names

- jc_0232: Usable characters for parameter names

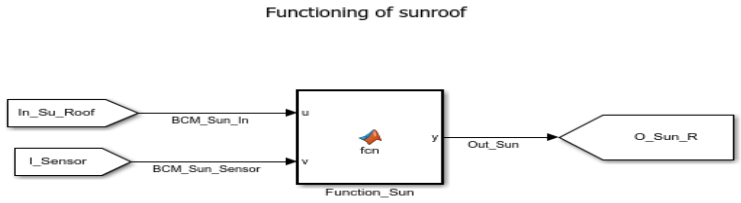


Figure 47:Usable characters for parameter names

- jc_247: Length restriction for block names

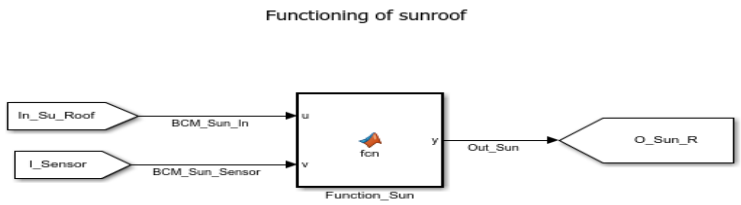


Figure 48: Length restriction for block names

- db_0144: Use of subsystems

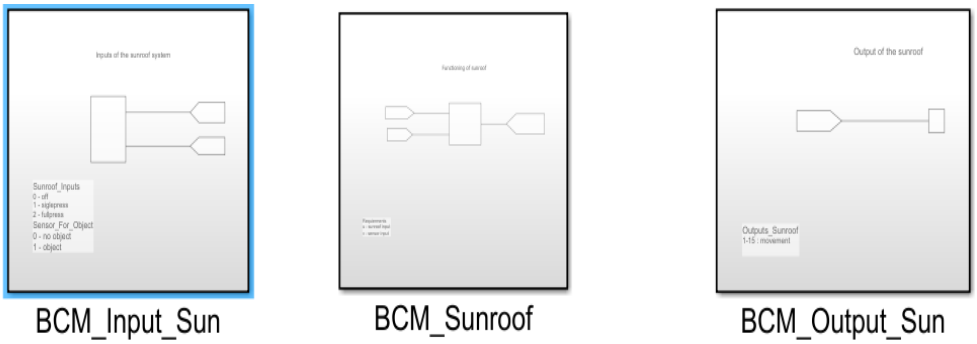


Figure 49:Use of Subsystems

- jc_0245: Length Restriction for signal and bus names

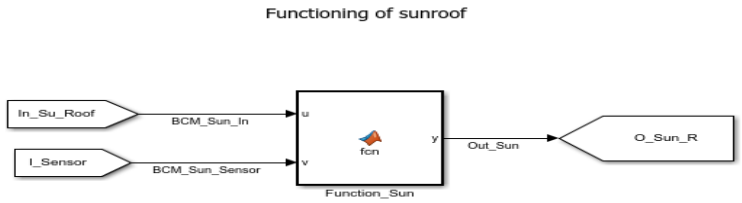


Figure 50:Length restriction for signal and bus names

6.3 MODEL ADVISOR RESULT:

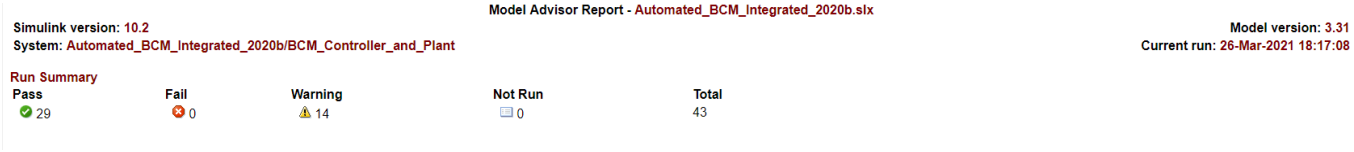


Figure 51: Model advisor result

6.4 MCDC COVERAGE REPORT:

Summary

Model Hierarchy/Complexity

		Decision	Condition	MCDC	Execution
1. Automated_BCM_Integrated_2020b	60	100%	100%	100%	100%
2. . . . BCM_Controller_and_Plant	59	100%	100%	100%	100%
3. . . . . BCM_Cruise_Control	6	100%	100%	100%	100%
4. . . . . If Action Subsystem1	3	100%	NA	NA	100%
5. . . . . Chart	3	100%	NA	NA	NA
6. . . . . SF: BCM_Controller_and_Plant/BCM_Cruise_Control/If Action Subsystem1/Chart	2	100%	NA	NA	NA
7. . . . . BCM_HO_Controller	3	100%	100%	100%	100%
8. . . . . BCM_HO_SEBU	3	100%	NA	NA	100%
9. . . . . BCM_Sunroof	10	100%	100%	100%	NA
10. . . . . Function_Sun	10	100%	100%	100%	NA
11. . . . . BCM_Wiper_Control_System	5	100%	NA	NA	100%
12. . . . . Subsystem	35	100%	100%	100%	NA
13. . . . . AC_control_chart	35	100%	100%	100%	NA
14. . . . . SF: BCM_Controller_and_Plant/Subsystem/AC_control_chart	34	100%	100%	100%	NA
15. . . . . SF: AC_ON	2	100%	NA	NA	NA
16. . . . . SF: Auto_cond	4	100%	NA	NA	NA

Figure 52: MCDC Result

KEY LEARNINGS:

- Usage of MAAB guidelines in the model.
- Industry standard report writing.
- Research work on each feature.
- MC/DC coverage.
- Modelling techniques.
- Using Model Advisor.
- Matlab Tools.