



A Review on Design of Seat Control Module

¹ Ganesh C L, ² Venkatesh S

¹Student, ²Associate Professor

¹Department of Electronics and Instrumentation,
¹RV College of Engineering, Bengaluru, India

Abstract: The Car Seat Control Module (SCM) is a vital system in automotive seating controls that utilizes a motor to control and manage various seat movements. This paper deals with the existing technologies which are used in SCMs and the technology gap between mainstream cars and Premium cars. It discusses about the use of old technologies in SCMs of mainstream car and automatic features available in Premium Cars. It finally explains about the Market demand for the advanced features of SCMs.

IndexTerms - Save and Recall Function, Easy Entry-Exit function, Ergonomics & Comfort, Mechanical Seat Assembly, Electronic System

INTRODUCTION

1.1 What is an SCM?

A Seat Control Module (SCM) is an electronic control unit, typically found in modern cars, that is designed and programmed for managing and controlling various functions and movements of the car seat. It acts as the central control unit [1] for the adjustment of the seat, such as seat positioning, backrest angle, lumbar support, and seat height. The SCM receives input signals from seat control switches or buttons, which are then processed and translated into commands that control the corresponding motors or actuators responsible for adjusting the seat. These motors are usually the brushed DC motors and occasionally other electric motors are utilized. Mainstream cars typically offer basic features and technology that cater to the mass market, while premium/high-end cars provide advanced and cutting-edge features. This includes advanced safety systems, state-of-the-art infotainment systems, high-performance engines, advanced suspension systems, and innovative driver assistance technologies. The superior technology and features in premium cars enhance comfort, convenience, performance, and overall driving experience. The SCM is a computer that controls the operation of the seats, including the adjustment, memory settings, and heating and ventilation.

1.2 History

The history of Seat Control Modules [2] can be traced back to the advancements in automotive technology and the increasing demand for driver's comfort and convenience features in vehicles. In the early days of automobiles, seat adjustments were manual and required physical effort from the occupants. However, as automotive technology progressed, electrically controlled seats started to emerge in luxury and high-end vehicles. These early electric seat controls utilized basic switches and relays to operate the seat movements. During the 1980s and 1990s, electronic control units (ECUs) began to play a more prominent role in automotive systems. This led to the development of more sophisticated and integrated seat control systems. These systems incorporated microcontrollers and sensors to enable more precise seat adjustments and added functionalities like memory presets. In the early 2000s, with the rise of multiplexing and advanced vehicle networks, SCMs became more complex and capable. The integration of digital communication protocols [3] such as LIN (Local Interconnect Network) and CAN (Controller Area Network) enabled seamless communication between various vehicle modules and allowed for more sophisticated seat control features. Figure 1.1 shows the Power Seat Control Module of front left driver for Mercedes W and E.

2 A Review of Existing Technologies

This section deals with existing car seat control technologies in mainstream automobile cars.



Figure 1.1. Power Seat Control Module Front Left Driver Side for Mercedes W and E series
(Source: Google Images)

Motors can be classified based on their power type (AC or DC) and the mechanism they employ to generate rotation. Brushless DC motors in Figure 3.1, as their name suggests, operate without the use of brushes. Unlike brushed motors, where current is delivered to the rotor coils through brushes and a commutator, brushless motors have a different configuration.

2.1 Mechanical Seat Assembly

Mechanical seat assemblies [4] in mainstream cars offer a wide range of adjustability options to accommodate the varying preferences and body types of passengers. These include seat height adjustment, seatback recline, lumbar support adjustment, and fore-aft positioning. The mechanisms responsible for these adjustments are engineered for smooth operation, precise control, and long-term durability. By allowing users to manually customize their seating position, the mechanical seat assembly promotes optimal driving posture and comfort, reducing fatigue during long drives. Some of the current features included in mechanical seat assemblies in mainstream cars include:

1. Manual Lumbar Support Adjustment
2. Manual Seat Height adjustment
3. Manual Seat Back-Rest Reclining adjustment
4. Manual Seat Forward-Backward Sliding Adjustment
5. Manual Head-Rest Adjustment

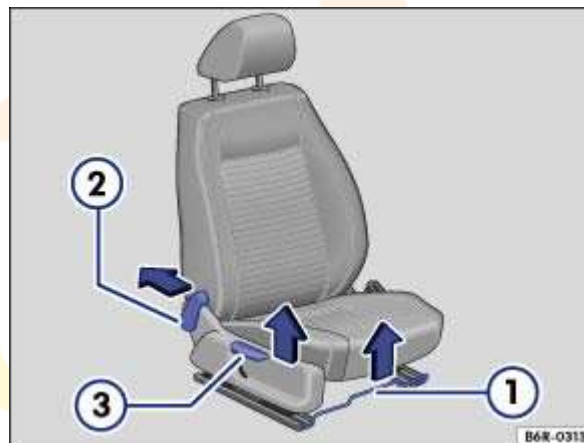


Figure 0.2. Mechanical Seat Assembly
(Source: Volkswagen)

2.2 Ergonomics & Comfort

Ergonomics plays a crucial role in the design of car seat assemblies, ensuring comfort, safety, and user-friendly operation. However, while advanced seat features are becoming more prevalent in high-end and luxury vehicles, mainstream cars often lag in offering advanced ergonomic capabilities.

1. Seating Adjustability

Mainstream car seat assemblies typically provide basic adjustability options, such as seat height, seatback recline, and fore-aft positioning. However, they may lack finer adjustments, such as adjustable lumbar support or adjustable side bolsters. These advanced features are designed to provide optimal support for different body types and preferences, reducing discomfort and fatigue during long drives. The limited adjustability in mainstream car seats can result in a compromise in achieving the most comfortable and ergonomically sound seating position for the driver and passengers.

2. Material and Cushioning

Mainstream car seat assemblies often prioritize cost-effectiveness, which can lead to compromises in material quality and cushioning. While they may offer adequate support and comfort, the quality and durability of materials, as well as the overall cushioning technology, may not match the standards found in higher-end vehicles. Advanced seats often incorporate advanced cushioning materials, such as memory foam or gel-infused foams, which provide enhanced comfort and pressure distribution. These materials can reduce fatigue and improve long-term comfort during extended periods of driving.

3. Intelligent Seat Controls and Integration

Another area where mainstream car seat assemblies may fall behind is in the integration of intelligent seat controls and advanced connectivity features. Higher-end vehicles often feature sophisticated seat control systems that allow personalized settings, automatic adjustments based on driver profiles, and connectivity with other vehicle systems. These advanced features enhance user convenience, adaptability, and ergonomic customization. In mainstream cars, the seat controls may be more basic and lack the seamless integration and advanced connectivity found in advanced seat assemblies.

2.3 Seat Electronic System

Electronic systems [5] play a vital role in modern car seat assemblies, offering advanced automatic and manual features, comfort customization, and user-friendly controls. However, while high-end cars incorporate sophisticated electronic seat systems, mainstream cars often lack these advanced capabilities. Figure 2.2 shows a full featured seat control module by *Texas Instruments*.

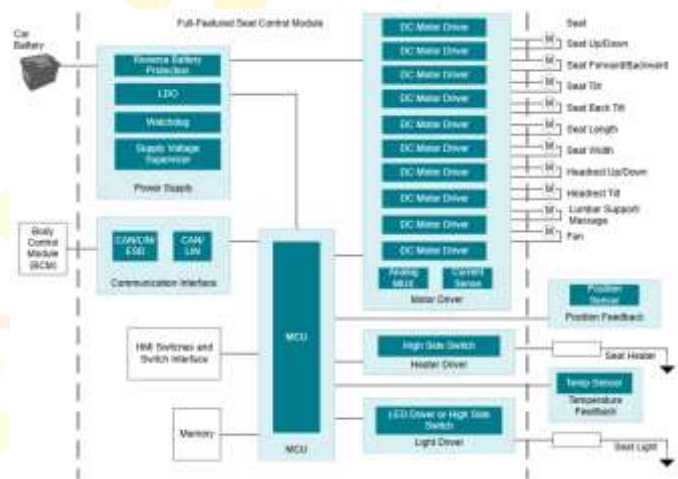


Figure 0.3. Full featured Seat Control Module
(Source: Texas Instruments)

1. Power Seat Adjustments

High-end car seat assemblies often feature electronic power seat adjustments, offering precise control over various seat parameters, including seat position, seatback angle, lumbar support, and headrest position. These adjustments are typically motor-driven and controlled by electronic systems, allowing users to find their preferred seating position with ease. In contrast, mainstream cars commonly rely on manual seat adjustments, which are less convenient and lack the precise customization offered by electronic power seat controls.

2. Memory Functionality

Advanced electronic seat systems in high-end cars often incorporate memory functionality, allowing users to store and recall their preferred seat settings. Multiple driver profiles can be saved, enabling seamless transitions between different drivers and their personalized seating configurations. This feature is absent in mainstream cars, where users are required to manually readjust the seat each time, resulting in inconvenience and a lack of customization.

3. Heating, Ventilation, and Massage

High-end car seat assemblies often integrate electronic systems to provide additional comfort features such as seat heating, ventilation, and massage functions. These systems allow passengers to adjust seat temperature, airflow, and experience massage therapy while driving, enhancing overall comfort and relaxation. In contrast, mainstream car seat assemblies typically lack these advanced electronic comfort features, limiting the options for enhancing passenger comfort and relaxation during journeys.

4. Integration with Vehicle Systems

High-end car seat assemblies often have seamless integration with other vehicle systems, such as infotainment and driver-assist systems. This integration enables synchronized operation and customization options. For example, seat adjustments can be linked to driver profiles, allowing the seat to automatically adjust based on individual preferences upon recognizing the driver. In

mainstream cars, the electronic seat systems may be less integrated and lack connectivity with other vehicle systems, limiting the convenience and automation options available to passengers.

3. A Case Study

Feature	Hyundai Santro Xing	Hyundai Tucson
Seat Adjustment	Manual	Electric
Number of adjustable positions	4	10
Memory settings	None	2
Heated seats	None	Available
Ventilated seats	None	Available
Seat control module	Absent	Present

Table 0.1. Comparison between Hyundai's Santro Xing & Tucson

As a case study, and for the purpose of discussion, comparison of two car models manufactured by Hyundai is shown in the table 3.1. The Hyundai Santro Xing (Mainstream Model) has manual seat adjustment, where the driver and the passenger must manually adjust the seats to their desired position. The Hyundai Tucson (Premium Model) has electric seat adjustments, which allows the driver and passenger to adjust the seats using buttons or a control knob. The Hyundai Tucson also has more adjustable positions than the Hyundai Santro Xing, with as many as 10 axes adjustments, compared to the Santro Xing's only 4 axes adjustment. The Hyundai Tucson also has memory settings, which allow the driver and passenger to save and recall their preferred seat positions. The Hyundai Tucson also has heated seats and ventilated seats, which are not available in the Hyundai Santro Xing. The seat control module is a computer that controls the operation of the seats, including the adjustment, memory settings, and heating and ventilation.

4. Technology Gap

1. Use of Mechanical Relays

A significant Technology Gap in some seat control modules (SCMs) is the use of mechanical relays for switching and control purposes. Mechanical relays have limitations in terms of their lifespan, switching speed, and susceptibility to mechanical wear and tear. Solid-state MOSFETs, on the other hand, offer numerous advantages, including faster switching times, longer lifespan, higher efficiency, and smaller form factor. By transitioning to solid-state MOSFETs, SCMs could improve reliability, reduce maintenance needs, and enhance overall performance.

2. Use of Outdated 8-bit Microcontrollers

Another Technology Gap is the continued use of outdated 8-bit microcontrollers in some SCMs. These microcontrollers have limited processing capabilities, lower resolution for precise seat adjustments, and restricted motor driving capacities. Upgrading to newer 32-bit microcontrollers would provide higher processing power, improved resolution for smoother seat movements, increased motor driving capacities, and the potential for implementing advanced control algorithms. Additionally, newer microcontrollers often offer low power consumption, contributing to overall energy efficiency.

3. Stall Detection in Power Seat Control Module

The absence of stall detection is a Technology Gap that can impact user safety and seat functionality. Stall detection allows the SCM to identify instances where the seat motor is unable to complete a requested movement due to an obstruction or excessive load. By implementing stall detection mechanisms, the SCM can protect against motor damage, prevent excessive current draw, and improve safety by halting or adjusting the seat movement accordingly.

4. CAN Communication with BCU and ECU

CAN (Controller Area Network) communication is a widely used protocol for efficient and reliable communication between different electronic control units in a vehicle. However, some SCMs in mainstream cars may lack CAN communication capabilities, limiting their ability to seamlessly integrate and exchange data with other vehicle systems. By incorporating CAN communication, SCMs can enable enhanced functionalities, such as synchronized operation with other modules, centralized control, and improved diagnostics capabilities.

5. Power Saver Features

Many mainstream SCMs lack power saver features that optimize energy consumption. These features can include auto power-off when the seat is not in use for a certain period, sleep modes to minimize standby power consumption, or intelligent power management that adjusts power levels based on seat usage. Implementing power saver features can improve overall energy efficiency, extend battery life, and align with environmental sustainability goals.

6. Easy Entry and Exit Feature

An important Technology Gap is the absence of an easy entry and exit feature in some SCMs. This feature automatically adjusts the seat position to facilitate comfortable ingress and egress for the driver and passengers. By incorporating easy entry and exit functionality, SCMs can enhance convenience, especially in tight spaces, by minimizing the need for manual seat adjustments.

7. Memory Module for Seat Position Recall

The lack of a memory module is another significant Technology Gap in some SCMs. A memory module allows users to store and recall their preferred seat positions with ease. This feature is particularly beneficial when multiple drivers share a vehicle or when different seating preferences need to be accommodated. By integrating a memory module, SCMs can provide personalized seating experiences, **enhancing user comfort and convenience.**

5 Market Growth

The trend for market size for automotive seat control modules from 2022 to 2032 is shown in the below figure 4.1.

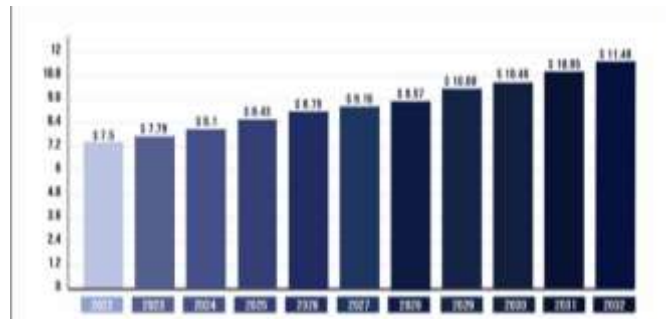


Figure 0.4. Automotive Seat Control Modules Market Size, 2022 to 2032 (USD Billion)

(Source: www.precedenceresearch.com)

Some driving factors accountable for Market Growth [6] for Seat Control Modules are:

1. Snowballing Body Electronic Functions in Current Vehicles

The increasing integration of advanced electronic functions in modern vehicles is a key factor driving the market growth for seat control modules. With the growing demand for comfort, convenience, and safety features, car manufacturers are incorporating an array of body electronic functions that require robust seat control modules to manage and control these functions effectively.

2. Growing Awareness Associated with Vehicle Convenience and Safety

Consumers are becoming more aware of the benefits of vehicle convenience and safety features, leading to an increased demand for advanced seat control modules. As people prioritize comfort, ergonomics, and personalized settings, the market for seat control modules is expanding to meet these expectations, offering enhanced adjustability, memory functionality, and integration with other vehicle systems.

3. Augmented Production of Trucks and Economy Class Vehicles

The rising production of trucks and economy class vehicles is fuelling the growth of low-end body control modules, including seat control modules. As these vehicles aim to provide affordable and functional options to a broader customer base, the demand for cost-effective seat control modules with basic functionalities is on the rise.

4. Integration of Smartphones with Seating Systems

The integration of smartphones with seating systems is an emerging trend that is driving market growth for seat control modules. With the use of mobile applications and wireless connectivity, users can control various seat functions, such as temperature, massage settings, and seating positions, through their smartphones. This integration enhances convenience and personalization, leading to increased demand for advanced seat control modules.

5. Increasing Sale of Luxury Vehicles

The growing sales of luxury vehicles, which emphasize premium comfort and advanced features, are propelling the market for high-end seat control modules. Luxury vehicle owners expect advanced seat functionalities, including motorized adjustments, memory settings, and personalized comfort options, leading to increased demand for sophisticated seat control modules that cater to these requirements.

6. Growing After-Market Solutions for Seat Control

The availability of after-market solutions for seat control modules is contributing to market growth. After-market suppliers offer retrofit options, allowing consumers to upgrade their existing car seats with advanced control modules. This trend appeals to car owners who wish to enhance the comfort and functionality of their vehicles without purchasing new ones, driving the demand for seat control modules in the after-market sector.

7. Increasing Preference for Private Cars and Long-Distance Travel

The rising preference for private cars, coupled with the growing trend of long-distance travel in developing regions, is boosting the market for seat control modules. As road networks modernize and people opt for private vehicles for convenience and safety, the demand for comfortable and adjustable seating solutions increases, driving the growth of seat control modules.

6 Conclusion

In conclusion, the seat control module (SCM) plays a crucial role in the comfort, ergonomics, and functionality of car seats. However, there are several technology gaps in mainstream cars, compared to premium cars, that can be implemented to enhance the SCM's performance. These include transitioning from mechanical relays to solid-state MOSFETs for improved reliability, as well as upgrading from outdated 8-bit microcontrollers to 32-bit microcontrollers for higher processing capabilities, apart from incorporating stall detection for safety and motor protection, implementing CAN communication for seamless integration with other vehicle systems, adding power saver features for energy efficiency, integrating easy entry and exit functionality for convenience, and incorporating memory modules for personalized seat position recall. Addressing these technology gaps will result in more advanced and user-friendly SCMs, elevating the overall driving experience in mainstream cars.

REFERENCES

- [1] T. Instruments, "Seat position & comfort module," Texas Instruments, [Online]. Available: <https://www.ti.com/solution/automotive-seat-position-comfort-module>.
- [2] Wikipedia, "Power Seat," Wikipedia, 2022. [Online]. Available: https://en.wikipedia.org/wiki/Power_seat.
- [3] W. Bolton, "Communication: Protocols," in *Mechatronics: Electronic control systems in mechanical and electrical Engineering*, Pearson, 2015, pp. 381-394.
- [4] Volkswagen, "Volkswagen Polo Owners Manual: Mechanical controls on the front seats," Volkswagen, [Online]. Available: https://www.vwpolo.net/mechanical_controls_on_the_front_seats-82.html.
- [5] Infineon, "body electronics and lighting: Seat Control," Infineon, [Online]. Available: <https://www.infineon.com/cms/en/applications/automotive/body-electronics-and-lighting/seat-control/>.
- [6] P. Market, "Automotive Seat Control Modules Market," Precedence Market, April, 2023.