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# Electric Power Assisted Steering

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ABSTRACT
Electric Power-Assisted Steering (Epas) Is A New Power Steering Technology That Will Define The Future Of Vehicle Steering. The Assist Of Epas Is The Function Of The Steering Wheel Torque And Vehicle Velocity. The Assist Characteristic Of Epas Is Set By Control Software, Which Is One Of The Key Issues Of Epas. The Straight-Line Type Assist Characteristic Has Been Used In Some Current Epas Products, But Its Influence On The Steering Maneuverability And Road Feel Hasn't Been Explicitly Studied In Theory.

In This Paper, The Straight-Line Type Assist Characteristic Is Analyzed Theoretically. Then A Whole Vehicle Dynamic Model Used To Study The Straight-Line Type Assist Characteristic Is Built With Adams/Car And Validated With Dcf (Driver Control Files) Mode Of Adams/Car. Based On The Whole Vehicle Dynamic Model, The Straight-Line Type Assist Characteristic's Influence On The Steering Maneuverability And Road Feel Is Investigated. Based On The Driver's Request For The Ideal Relationship Between Steering Wheel Torque And Vehicle Velocity, The Vehicle Speed Proportional Coefficient Of The Assist Characteristic Can Be Determined By Making Steering Wheel Torque At Different Vehicle Lateral Acceleration Agree With The Request Of The Driver At A Certain Velocity. The Target Of This Paper Is Analyzing The Influence Of The Straight-Line Type Assist Characteristic On The Steering Maneuverability And Road Feel, And Studying How To Apply Simulation Method To Determine The Straight-Line Type Assist Characteristic Of Epas, Which Will Direct And Benefit The Adjustment Of The Assist Characteristic During The Road Test.

## I. INTRODUCTION

Steering and braking are the most critical safety factors in vehicular control. Safe operation of the vehicle demands that the operator be able to maintain absolute control of the vehicle's critical operating dynamics:

(1) Control of the direction of motion of the vehicle (steering)

(2) Control of the velocity of the vehicle, i.e. the ability to slow and fully stop the vehicle (braking)

Electric power steering (EPS or EPAS) uses an electric motor to assist the driver of a vehicle. Sensors detect the position and torque of the steering column, and a computer module applies assistive torque via the motor, which connects to either the steering gear or steering column. This allows varying amounts of assistance to be applied depending on driving conditions. Engineers can therefore tailor steering-gear response to variable-rate and variable-damping suspension systems, optimizing ride, handling, and steering for each vehicle. On Fiat group cars the amount of assistance can be regulated using a button named "CITY" that switches between two different assist curves, while most other EPS systems have variable assist. These give more assistance as the vehicle slows down, and less at faster speeds. In the event of component failure that fails to provide assistance, a mechanical linkage such as a rack and pinion serves as a back-up in a manner similar to that of hydraulic systems.

Electric systems have an advantage in fuel efficiency because there is no belt-driven hydraulic pump constantly running, whether assistance is required or not, and this is a major reason for their introduction. Another major advantage is the elimination of a belt-driven engine accessory, and several high-pressure hydraulic hoses between the hydraulic pump, mounted on the engine, and the steering gear, mounted on the chassis. This greatly simplifies manufacturing and maintenance. By incorporating electronic stability control electric power steering systems can instantly vary torque assist levels to aid the driver in corrective maneuvers. The first electric power steering system appeared on the Suzuki Cervo in 1988. [1]

## II. BASIC STEERING MECHANISM

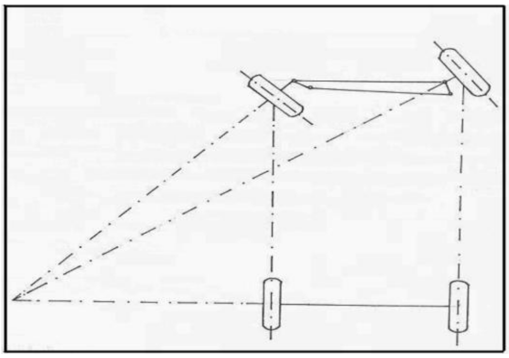

**Fig.1 Basic steering principle**

The primary function of steering systems is to achieve angular motion of the front wheels to negotiate a turn. This is done through linkage and steering gear which convert rotary motion of the steering wheel into angular motion of the front road wheels. [2, 3]

Secondary functions of the steering system are:

1. To provide directional stability of the vehicle while going straight ahead.
2. To provide perfect steering condition, i.e. perfect rolling motion of the wheels at all times.
3. To facilitate straight ahead recovery after completing turn.
4. To reduce the effort required by the driver to steer.
5. To minimize tire-wear.

## 2.1 STEERING LINKAGE

2.1.1 Linkage for Vehicle with Rigid Axle Front Suspension

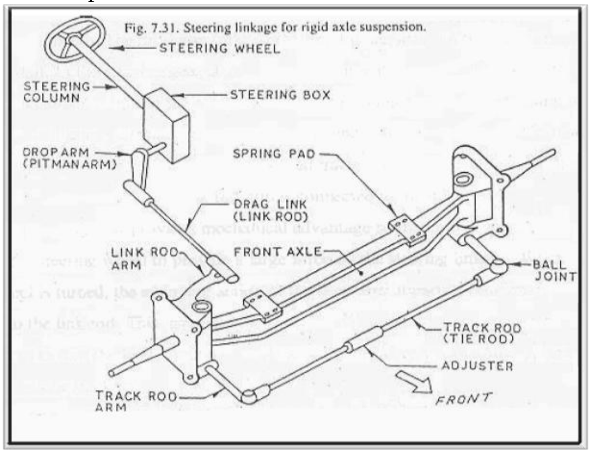


**Fig 2. Steering Linkages**

2.1.2 Linkage For Vehicle With Independent Front Suspension

Here the two stub axel move up down independent of each other due to which distance between balls joint ends of the two track rod is continuously varying. Hence conventional track rod cannot be used. Here three piece track rod is used, the centre portion being called the relay rod, which is connected to the idler arm and drum arm. The relay rod is restricted to move in horizontal plane only.

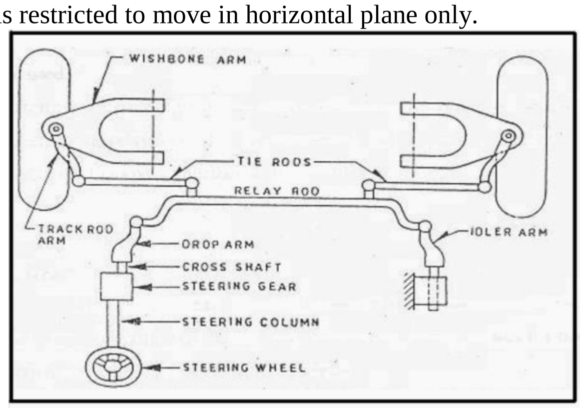


**Fig 3. Steering Linkage for Vehicle with Axel Front Suspension**

## 2.2. STEERING GEAR

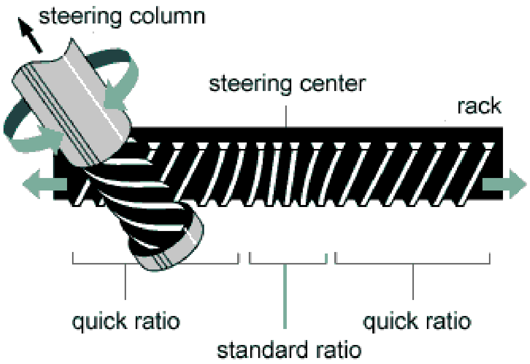


**Fig 4. Steering gear**

The steering gear converts the rotary turning motion of the steering wheel into the To and Fro motion of the link rod. Moreover it also provides the necessary leverage so that driver is able to steer without fatigue. There are many types and makes of steering gears in use in automobiles. The important ones are below: [4]

(1). Worm and worm wheel steering gear.
(2). Cam and double roller steering gear.
(3). Re-circulating ball type steering gear.
(4). Rack and pinion steering gear.

# III. NEED OF EPAS

Design options are one of the biggest advantages to the electric power steering. With no pump, mounting bracket, hose or pulley or belt, a lot of under-hood space is liberated for other uses, especially when the servo motor is mounted on the column inside the car. The control unit can be, mounted anywhere on the vehicle, and it can vary the boost level infinitely over a wider range of conditions. Boost level can even become a driver-adjustable feature, and of course boost is available even when engine isn't running,

Needs a lot of data though, and the power requirement have an impact on the battery and charging system design. Also, the steering wheel torque sensor is a very sophisticated new device which means it's relatively early in its development and therefore, expensive. But when u think about all the hydraulic stuff you don't need for steering, the trade-off is quite acceptable from the engineering, service and environmental point of view. Eliminating power steering fluid from a vehicle provides obvious environmental advantages, along with the fuel saved by not having to drive a hydraulic pump with the engine. On the production line, the time requirement for installation and adjustment is significantly shorter. In the development lab, tuning the system to work in different vehicles takes a few hours of computer type, instead of several days needed to install and different hydraulic valve combinations.

The column-mounted motor is (so far) the least expensive design, so it will probably be the most common in this generation of electric power steering. But a column-mounted motor is not well suited for use on larger, heavier vehicles. This creates an interesting difference from the way most other new automotive technologies have been introduced. With almost every other new automotive feature, such as air conditioning or automatic transmission, the larger, more expensive cars always had it first. As development continue and cost, size and complexity came down, the new features made their way down to the smaller, less expensive cars. Aside from the Acura NSX, electric power steering technology most likely will start from the bottom a move up to the larger, more expensive cars. Two basic reasons are cited for this.

First, larger, heavier cars require more power to turn the steering wheel, and more expensive rack-mounted-motor design are more suitable for the smaller application.

Second, according to an SAE paper written by Dominique Peter and Ruck Gerhard of ZF Len system (Steering system) in Germany, the present generation of electric steering boost can't deliver the feel and handling that sriver's expect in larger, heavier cars, which in their country mean expensive cars.

A good answer to both these problem lies in another "new" technology that Delphi and others say is just around the corner: the 42-volt electrical system. Regardless of how an electric steering is configured, current draw would be very high, more than most of today's electrical systems can provide for any length of time.

## IV. SYSTEM MODELING AND WORKING

### 4.1 CONSTRUCTION AND CONFIGURATION

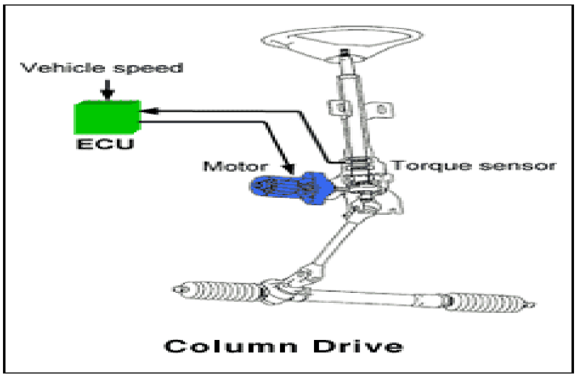


**Fig 5. Column Drive Electric Power Steering**

Currently there are four different types of electric power steering system, all based on rack and pinion steering. Each is differentiated by the placement of the motor, which defines certain application advantages as well as having a big influence on the price. In the first type figure 3.3 the motor is built into the steering rack housing, making it the most sophisticated and expensive type of electric power steering system. This type uses permanent magnet direct current (DC) motor, with the armature mounted so that it actually rotates around the rack. At one end of the motor, a gear meshes with another gear to turn a ball screw that is parallel to the rack. A clamp connects a re-circulating ball unit to the rack, so as the unit moves along the length of the ball screw; its motion is transferred directly to the rack. The steering wheel torque sensor is built into the pinion housing. This motor-in-rack layout has the advantage of being extremely compact and can be installed in almost the same space as a hydraulic boosted rack.

Disadvantages are higher price, complexity and need to replace the whole rack assembly if the motor, sensor or any mechanical component fails. Electric power steering (EPS) in the Acura NSX has the armature rotating around the rack itself. It turns the ball screw which moves a re-circulating ball screw that is clamped to the rack. The torque sensor is built into the pinion housing.(Figure1.1)Three other configurations are subscribed. On the double pinion type system, the motor is mounted to the rack in separate housing and drives the rack through a second opinion. Since the motor is a separate unit, the rack is less expensive to manufacture than the first type and easier to repair in the field. Also it operates through a separate opinion; It is well suited on use on heavier vehicles. [5]

A third basic layout has the motor mounted to the normal pinion housing on the rack, so it acts directly on the existing pinion shaft through an appropriate transmission. Again all components can be serviced or replaced separately, and different Gear ratio can be used to tune the same basic component for duty in several different chassis. This system probably will cost less to a op and manufacture, and it take up less space than the double-pinion type. A fourth version is used on flat pinion. The rack-and-pinion steering assembly is a standard configuration, and an electric motor simply is attached to the steering column, the motors torque is added to the driver's steering wheel efforts through a worm gear transmission. The motor can be mounted anywhere along the column, leaving the design engineers lots of options. [5]

### 4.2 BASIC COMPONENT'S AND WORKING

The system itself comprises main components: An electric control unit (E.C.U.) , a torque sensor, an electric motor and an intermediate gear with clutch. All these components are integrated into one unit which can be placed on any part of steering column. A database is used to communicate the vehicle speed and engine speed to the EPAS system and the torque sensor detects the force the driver is using to turn the steering wheel. All this information is passed to the ECU.

The ECU uses this information to calculate the additional force required by the EPAS system to achieve the pre-programmed steering feel. The steering power is then transmitted by engine to the steering gear by means of an intermediate gear system. The ratio between manual steering torque and electric power controlled in relation to vehicle speed, offering the relevant assistance at varying speeds.

At low speed the system offers maximum power, making the steering easy to operate, and at increased speed, when little or no assistance is required reduces amount of power supplied. [6]

Throughout this operation the ECU monitors the system constantly to detect malfunctions and, if necessary, disengages the power assistance with the aid of a built clutch. This ensures that the car still steerable if a fault occurs. [6]

### 4.3 CONTROL STRATEGY

The steering control unit needs a lot of information to get the boost level and timing just right. Along with vehicle speed and charging system output level, most of the other data is already available from several onboard-computers.

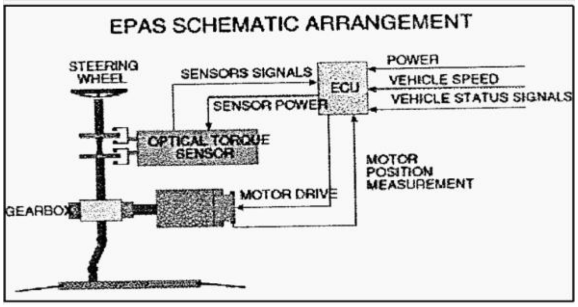


**Fig 6. EPAS Schematic Arrangement**

There is one new sensor required, a steering wheel torque sensor that tell the control unit how much effort the driver will applying to the steering wheel. A frequent complaint made of HYPAS system is their tendency to over assist the driver at higher speeds in poorly designed unit it can result in the vehicle oscillating or "yawing" around the central line as the driver attains to correct the over steer.[7]

In the new EPAS system, software allows precise control over steering behavior. Algorithms programmed in to the system defined speed sensitivity, yaw damping, and steering self-cantering a sports feel or offer light load setting. A safety relay incorporated in to the design improves fault tolerance, while the electronic control unit, Includes diagnostic function's for fault detection in management. If the system fails its fail stop design cuts the torque assistance and returns the driver to manual steering.[7]

### 4.4 TORQUE SENSOR

The torque sensor is the heart of the system and is one of the most innovative electronic devices. We have seen in recent years. The key to the success of EPAS is an accurate, reliable and low cost torque sensor. However torque measuring devices are complex and expensive. Although there are number of newly developed systems they are usually based on techniques that are require an intermediate compliant member in the steering shaft-usually a torsion bar- and an electrical connection between the steering shaft and the electronics. Non-contact sensors are also used but they are expensive. These being such a critical component of the system the main torque sensor have been briefly discussed here.[8]


**Fig 7. Optical Torque Sensor**

Lucas Varity incorporates a dual-channel optical device. Its non-contacting design and mechanical simplicity provides system reliability, while the use of optics offers immunity to EM interference. To operate, two patterned disks mounted on either end of the torsion bar separating the steering wheel and steering column.

Torque applied to the steering wheel creates a relative movement between the two disks. Light intensity reaching the photo detectors varies in proportion to torque. [8]

Because either detector can be used to measure the light intensity and thus torque, the system is redundant. Offset patterns on the two discs furthermore allow software to calculate the steering wheels relative position and velocity by comparing the two sensor signals. Researchers at the use department of energy Aams laboratory says a ¼ thing ring of material could be used in an electronic torque sensor regulate the steering power provided to a cars wheel by an electric motor (Figure 4.2.2), A sensor using a small ring of the cobalt-ferrite composites would be strategically placed on the steering column. As a driver turn the wheel, the magnetization of the cobalt-ferrite ring would change in proportion to the amount of force applied the driver. The change could be detected by nearby field sensor that would interpret how much force should be applied to turn the wheels and then relay the information to an electrical power-assist motor. Unlike the hydraulic system, the electrical system would consume minimum energy when the steering wheel was not being turned. What makes the cobalt-ferrite composite ideal for this application is a property known as magneto striction, Magneto strictive materials undergo slight length changes when magnetized. They take advantage of that property.

### 4.5 ELECTRONIC CONTROL UNIT

The electronic principle is simple, but it relies on to features developed just for this application. First is the very advanced algorithm in the computer program that calculates steering wheel position and torque, essentially giving the machine the ability to interpret the human driver's intensions? After that, the control unit simply chooses and appropriate output from a look-up table, similar to the way engine computers control ignition timing. Motor Design

Achieving a smooth, progressive feel at the steering wheel requires a motor with low levels of ripples and cogging torque. Lucas variety, therefore, uses a three phase inverter to control motor phase current, and hence torque. An array of MOSFETS makeup the circuitry; pulse with modulation (PWM) regulates switching time sequence for the MOSFETS stages. Since the power-switching stage encompasses the most complex dynamics of the whole EPAS system, optimization requires computer simulation. Lucas uses the saber simulator program from US software house analogy Inc. to analyze alternative PWM strategies, and to model the complex patterns of secondary currents induced when the MOSFETS stages are switched. The aim is to ensure smooth control of the switching stages and also reduce the ripple currents fed into the battery harness. These currents have to be filter out to protect the electronics in the EPAS control unit. Bye minimizing the ripple current, they are able to use filter currents with lower ripple specifications and, therefore, lower cost.[9]

## V. PERFORMANCE ANALYSIS

### 5.1 Hydraulic Power Steering V/S Electric Power Steering

Hydraulic power steering is a primitive technology used for decades and has improved a lot with time. Earlier, it did not have any difference in steering response with speed of the car, but the new-age of hydraulic power steering are speed sensitive and work better than the older hydraulic power steering

**Table 1. Electromechanical Specification's Of a Typical Pinion EPAS System**

| ITEM | SPECIFICATION |
|---|---|
| Rack Force | 7747 |
| Rack Stroke | 144 mm |
| Stroke Ratio | 45.335 mm/rev. |
| Rack & Pinion | |
| module | 2.3 |
| number of teeth | 6 |
| Reducer | |
| Type | Worm & resin wheel |
| Reduction gear ratio | 15.1 |
| Motor | |
| Type | Brushed DC motor |
| Rated voltage | 12 V |
| rated current | 65A |
| Rated torque | 3.4 Nm |
| Rated rotational speed | 1,180 rev/min |

1. Hydraulic Power Steering System is complicated compared with Electric Power Steering.
2. Hydraulic Power Steering System usually weighs more than Electric Power Steering.
3. Hydraulic Power Steering uses hydraulic fluids for operation whereas there is no such fluid needed for Electric Power Steering, thus Electric Power Steering needs less maintenance compared to hydraulic power steering.
4. Electric Power Steering gives better response at different speeds as compared to Hydraulic Power Steering.
5. Eclectic Power Steering is less prone to problems and faults and are more durable as compared to Hydraulic power steering.
6. Hydraulic power steering extracts power from engine, so it reduces the fuel mileage of the engine. Electric power steering consumes power from battery which is also charged by engine, but it consumes less power compared to Hydraulic power steering. So a car having Electric power steering will give more mileage than one with Hydraulic power steering.

Here is the Graph showing the driver steering effort for the both sides steering of the vehicle

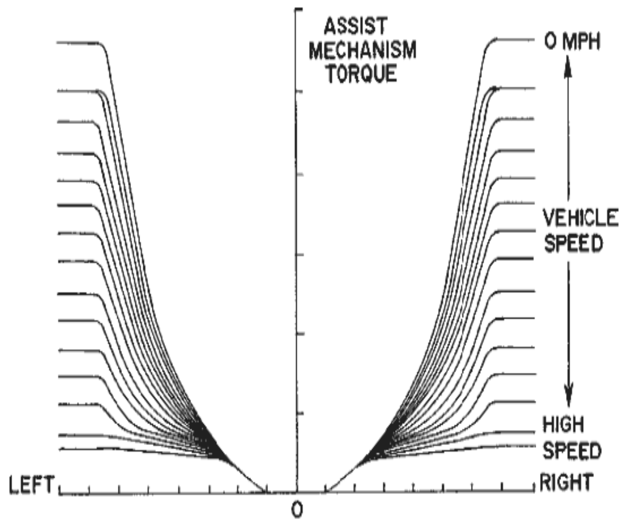


**Fig 8. Driver Steering Effort**

## VI. CONCLUSIONS AND FUTURE SCOPE

### 6.1 CONCLUSIONS

These drawbacks are however only temporary barriers for the large scale introduced of these systems in today's car's and it can be uniquely stated that EPAS is the future in power steering. The advantages far outweigh the disadvantages and as the system components get introduced at more economical prices, EPAS will become most efficient, safe and reliable power steering system.

### 6.2 Future Scope

To-date, technical and product liability concerns have precluded the introduction of such systems in the U.S. market through it is expected that niche application may be expected in the near-to-midterm mix of future vehicles. Such system designs have yet to prove themselves sufficiently reliable and safe to prevent dangerous auto steer event. Auto steer has crept into the lexicon as an adjunct to the development of EPS system. As the name implies Auto steer denote an uncontrolled steering event neither commanded nor stoppable by the vehicles driver due to catastrophic failure in the electron hardware or software. In truth, these systems are control servo systems, similar in function to aircraft control servo systems, and must have multiple redundancies.

Although these new EPAS systems are said to have multiple redundancy, their design and broad application within the automotive industry have been, and will continue to be, subject to economic pressure more extreme then found in the aircraft industry. For instance one obvious safety related item has been universally deleted from such system specifications: a clutch for physically disengaging the reduction gear box and drive motor assist assembly from the host steering system in the event of system failure. This means that a driver encountering an EPAS system failure will have to exert additional force to “Back drive” The systems reduction gear box and drive motor assist assembly while attempting to maintain control of the vehicle in the absence of normal power steering assist.

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