Automotive Sensors & Actuators

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Evolution in Automotive Industry
What is the first step you do while starting the car??
Remote Keyless Entry
Electrical Actuators - Central Locking Actuators

Wiring Diagram

1. White
2. Brown
3. White
4. Brown
5. Green
6. Blue
7. Black
8. Red

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Now, Doors are unlocked.  
What next??
Hand Brake Position sensor:
What next??
Electric Actuator Application in Starting System

Criteria for starting the engine:

To run the engine at 250 rpm for definite time.

Solenoid-Electrical Linear Actuator:

1. Ignition switch
2. EMS ECU
3. Crank relay
4. Solenoid
   - Pinion gear engagement
   - Supply to starter motor
5. Challenges
Typical Engine Compartment:
Electric Actuator Application in Injection System

Merits:
1. Highest precision-control positioning
2. Electric actuators can be reprogrammed quickly.
3. They offer immediate feedback for diagnostics and maintenance.
4. In terms of noise, they are quieter than pneumatic and hydraulic actuators
5. Because there are no fluids leaks, environmental hazards are eliminated.

Demerits:
1. Cost
2. Performance depends on environmental condition
Now, Engine has started
What next??
Hall Effect GSL Position Sensor Application

Nano AMT case

GSL Unit

Logic Table

- Open circuit / short to battery
- "1" Not Switched
- Signal Inter-short
- "0" Switched
- Short circuit to Ground

Sensor Output Waveform
Hall Effect Speed Sensor

Key Features:-
- It work at zero engine speed
- Many operate up to 15,000 rpm
- The air gap tolerances are very large; up to 5 mm
- The sensor has 3 wires: power, ground and signal.
- They are powered with low voltage (4.75 to 24 volts) and have very little current draw (20 mA).
Hydraulic Actuator Application in Transmission System

This Part – Gear Selection
Getting automated in AMT

Synchroniser

Main Shaft

Layshaft

Slave Cylinder

Clutch Plate

Flywheel

Engine

Master Cylinder

Clutch Pedal

Clutch & flywheel

Gear Box

Master Cylinder actuation done by Hydraulic Clutch actuator AMT system
Hydraulic Actuator Application in Transmission System

- Clutch position detection
- Gear position detection
- Shift position detection
- Hydraulic pressure sensing
- Clutch speed detection
- Door switch status
- Brake switch status
- Crank request switch status
- Levers position status
- Clutch Actuator
- Gear Actuators
- Shift Actuator
- DC motor for hydraulic pump control
- Cranking Relay

TCU
Hydraulic Actuator Application in Transmission System

System Block Diagram:

- Gear Shift Lever With Sensor
- AMT Kit
- Transaxle

AMT Kit Components:
- Hydraulic Reservoir
- Motor & Pump assembly
- Accumulator
- Hydraulic Baseplate
- Clutch Actuator
- TCU

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Hydraulic Actuator Application in Transmission System

**Types of Hydraulic Actuator:**

1. Single acting
2. Double acting
Hydraulic Actuator Application in Transmission System

- **Selection EV**
- **Gear 2 EV**
- **Clutch EV**
- **Gear 1 EV**
- **EV0 = Clutch EV**
- **EV1 = Gear 1**
- **EV2 = Gear 2**
- **EV3 = Selection EV**

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Hydraulic Actuator Application in Transmission System

Control Strategy:-

[Diagram showing gear selection and shift gates with labels for different gears and gates.]
Merits:

- Hydraulic actuators are rugged and suited for high-force applications.
- A hydraulic actuator can hold the force.

Demerits:

- Hydraulics will leak fluid. Loss of fluid leads to less efficiency.
- Hydraulic fluid leaks lead to cleanliness problems and potential damage to surrounding components and areas.
- Hydraulic actuators require many companion parts, including a fluid reservoir, motors, pumps, release valves, and heat exchangers, along with noise-reduction equipment.
- Overall weight of the system is very high.
Pneumatic Actuator

**Merits:**
- Simple Construction.
- Better accuracy.
- Can work in extreme temperature areas.
- Pneumatic actuators are also lightweight, require minimal maintenance,
- Cost-effective method of linear motion.

**Demerits:**
- Pressure losses and air’s compressibility make pneumatics less efficient than other linear-motion methods.
- A compressor must run continually operating pressure even if nothing is moving.
- Even though the air is easily available, it can be contaminated by oil or lubrication, leading to downtime and maintenance.
Sensors used in Transmission Control System

- Clutch position sensor
- Gear position sensor
- Shift position sensor
- Hydraulic pressure sensor
- Clutch speed sensor
- Door switch sensor
- Brake switch sensor
- Crank request switch sensor
- Levers position sensor

TCU

- Clutch Actuator
- Gear Actuators
- Shift Actuator
- DC motor for hydraulic pump control
- Cranking Relay
Magnetic Reluctance Clutch Speed Sensor

OSCILLOSCOPE PATTERNS

Creeping Issue:

RECECTANCE

32 Teeth

NORMAL

CRACKED

DAMAGED

MISSING

MISSING

DIGITAL

VOLTS

TIME

1.93V
1.29V
1.13V
0.97V
0.64V
Magnetic Reluctance Clutch Speed Sensor

- The magnitude & frequency of the voltage produced is directly proportional to how fast the magnetic field changes, therefore, the faster the engine spins the higher the peak voltage.

**Merits:**
- i) Low cost
- ii) Easy to package

**Demerits:**
- As the voltage increases, the potential for noise or interference (EMI) increases.
  - i) Use of twisted wires
  - ii) Use of filters
  - iii) Air gap increase
- Slow speed detection
- Difficult to diagnose
- Extra signal processing is required in TCU
- Pelican Issue
LVDT Clutch Position Sensor

Circuit Diagram

Output Waveform

Hall Type-PWM output Clutch Position Sensor
Hydraulic Pressure sensor

Potentiometric

Capacitive

Differential Transformer
Hydraulic Pressure sensor

Pressure Sensor Characteristics

- Diagnosis Setting range
- Max saturated Signal value
- Nominal characteristic
- Limit acceptable characteristics
- Measuring Range
- Min saturated Signal value
- Diagnosis Setting range

Diagram showing the relationship between sensor output signal and sensor output signal [% V_Supply].

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Sensors used in Engine Controller
Optical Crankshaft Speed Sensor

**Demerits:**

- Sensitive to Contamination
**Purpose:** Airflow rate is necessary for the engine control unit (ECU) to calculate load on the engine and deliver the correct fuel mass to the engine.

![Control Circuit Diagram](image)

**Output Performance**
Throttle angle sensor

Key Features:

- This potentiometer can be used to measure any angular rotation.
- In particular, it is well suited for measuring throttle angle.
- The only disadvantage to the potentiometer for automotive applications is its analog output.
- For digital engine control, the voltage $v(a)$ must be converted to digital format using an analog-to-digital converter.
**Purpose:** Engine coolant temperature information is used by engine control unit (ECU) to decide fuel injection rate and idle speed control during cold condition

**Operating Principle:**

1. Thermocouple
2. Thermistor (Negative temp coefficient of resistance)
Lambda Sensor

**Purpose:** This sensor gives the value of current air to fuel ratio.

This sensor measures the oxygen content in exhaust gas

\[
\lambda = \frac{(\text{air/fuel})}{(\text{air/fuel at stoichiometry})}
\]
Lambda Sensor

- Generated Voltage
- Air Fuel Ratio
- Control Module commands fuel system to "GO LEAN"
- Control Module commands fuel system to "GO RICH"
Now, Vehicle is running at 80 Kmph
What next??
ABS System: Sensors and Actuators
ABS System: Sensors and Actuators
Challenges in Automotive Industry

1. Cost - AMT Kit
2. Packaging issues
3. Time for new development
4. Opportunities for start-up
Thank you for listening. Any questions?

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