UNIT-5

Smart sensor are defined as those sensors in which the signal conditioning is carried out with in the transducer housing and provide standardized output signals in digital form and suited for transmission via communication bus to the central control room.

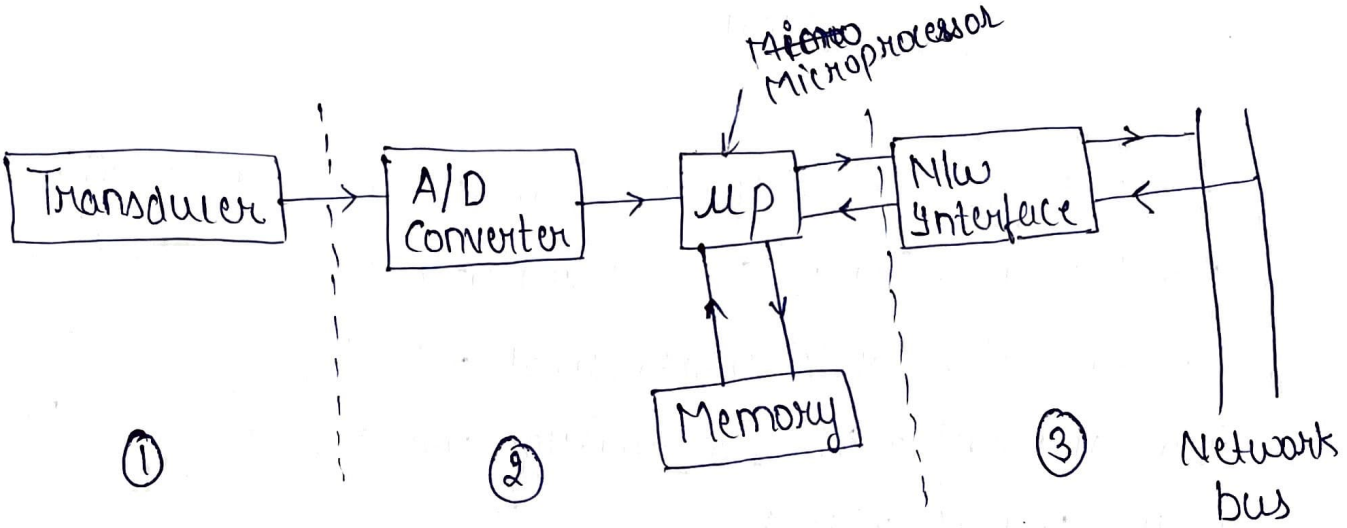
They will linearize their own output, compensate for environmental changes, and include self calibration and diagenostic functions, both for themselves and for the systems to which they are applied.

General structure of Smart Sensor

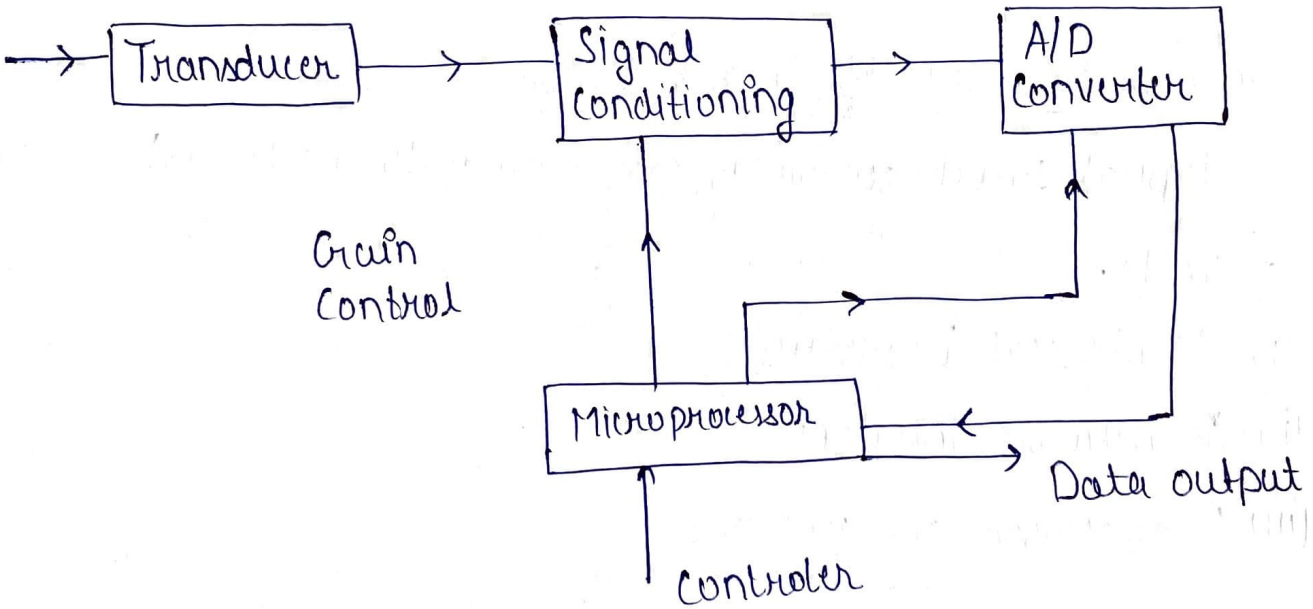
A typical smart sensor is configured with the there following elements-

(i) A physical transducer
(ii) A network interface
(iii) A processor and memory

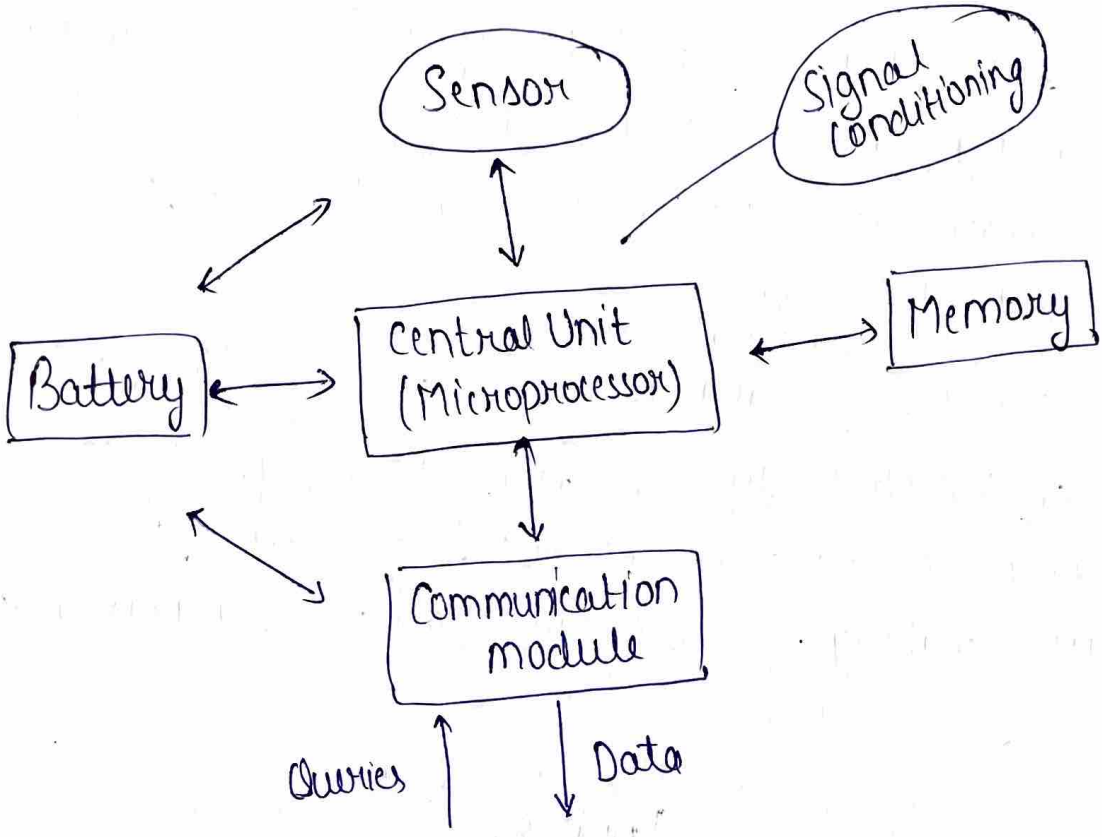
These is also a data socket is connected to the smart sensors to connect with the data bus. With the help of internet, the data can be transferred.



General Structure/Configuration of the Smart Sensor



I-C chip of a Smart Sensor

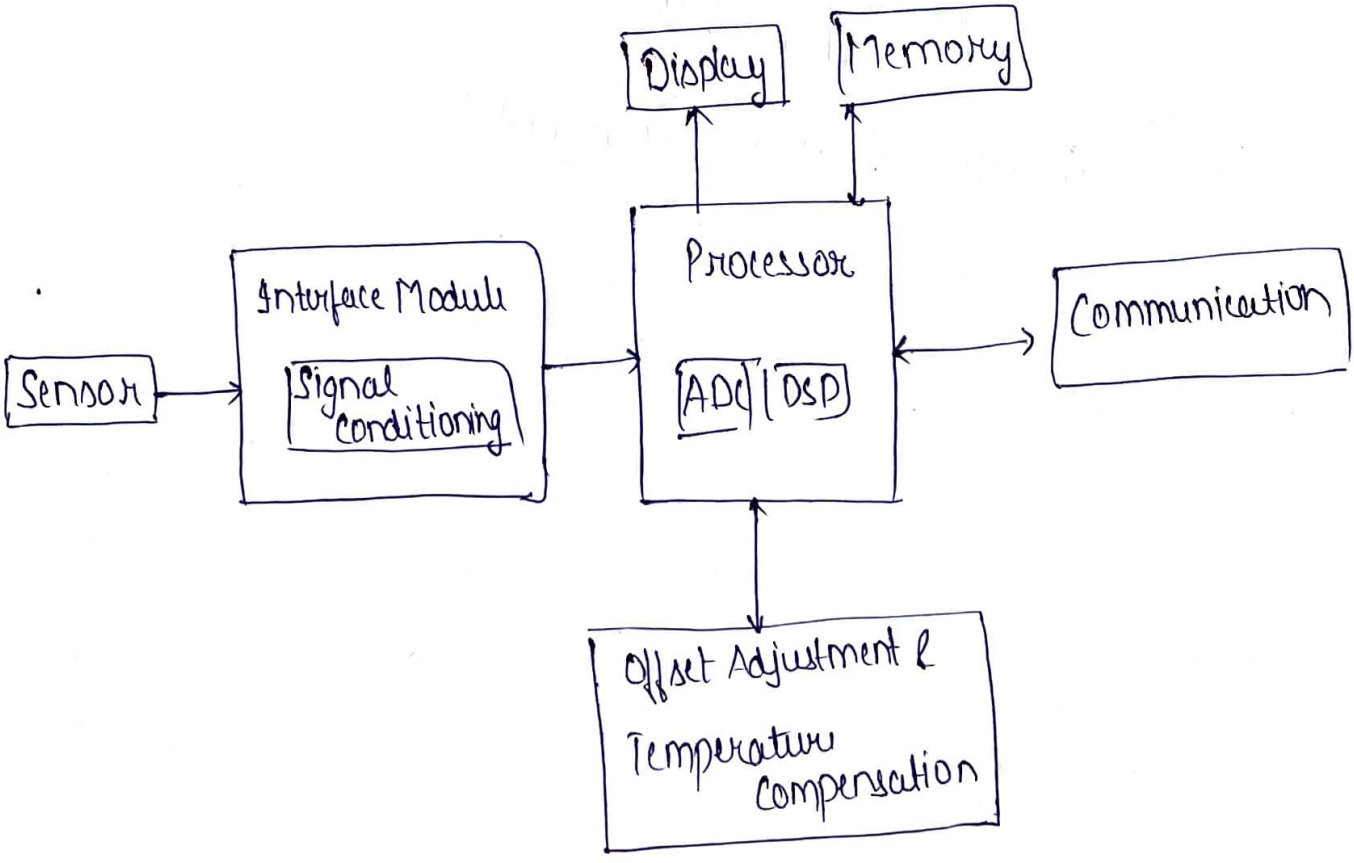


Architecture of a Sensor node

A sensor producing an electrical output, when combined with some interfacing hardware is termed to be an intelligent sensor. The intelligent sensors are also called smart sensor, which is a more acceptable term now.

Sensor + Interfacing hardwares = Smart Sensors

This type of sensor is different from other types of sensors as because it carries out functions like ranging, calibration and decision making for communication and utilization of data.



Components of Smart Sensors

The initial motivation behind the development of Smart Sensors include-

1. Compensation for non-ideal behaviour of the sensors
2. Provision for communication of the process, data with the host system.

An intelligent field device or sensor possesses the following properties:-

(i) Automatic ranging and calibration through a built-in digital system.

(ii) Auto aquisition and storage of caliberation constants in local memory of the device.

(iii) Auto-configuration and verification of hardware for correct operation.

(iv) Auto-correction of offset, time and temperature drifts

(v) Auto linearization of non-linear transfer characteristics

(vi) Self-tuning control algorithms (fuzzy logic based)

(vii) Controlled programs

(viii) Control through signal bus and host system.

(ix) Condition monitoring is also used for fault diagnosis

(x) Communication through a serial bus.

The Smart sensor should also integrated with complimentary trends such as:

(i) New sensing methods

(ii) Improved computing capability

(iii) Digital communication.

Digital correction in such new techniques improves performance by

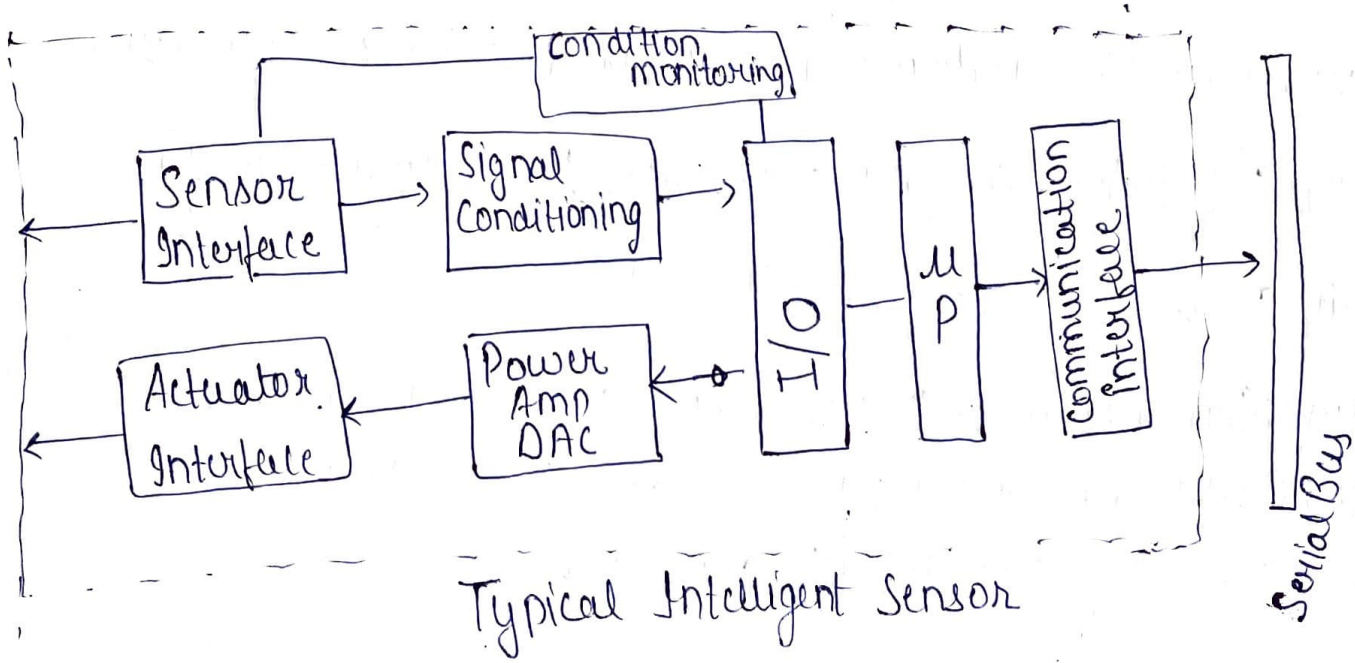
(i) Compensating for sensor non-linearity

(ii) Permitting a larger portion of sensors and meet specification.

(iii) Incorporating programmable gain.

(iv) Changing Sampling rate

(v) Changing interliasing filter frequency.



Typical Intelligent Sensor

Typically Intelligent Sensor

Components -

(i) Primary elements

(ii) Excitation devices

(iii) Amplification

(iv) Filters

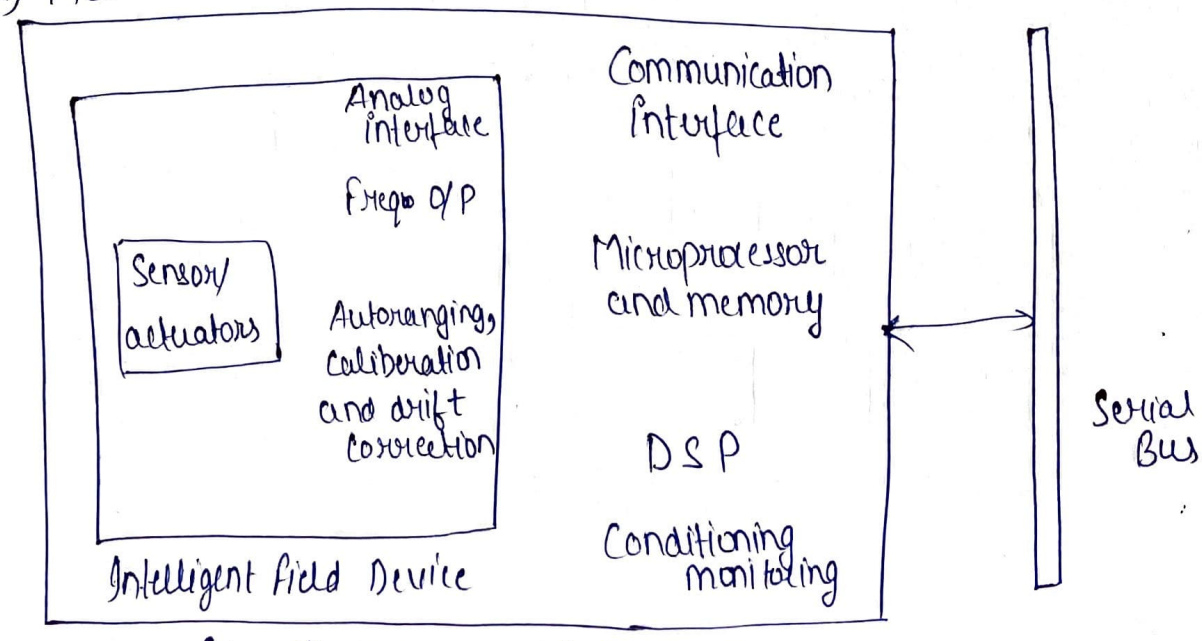
(v) Converters

(vi) Compensation ⟶ Non linearity
⟶ Noise
⟶ Response Time
⟶ Drift
⟶ Sensitivity
⟶ Interface

(vii) Information processing

(viii) Data communication

(ix) Automation



Simplified Version of Smart Sensor

Characteristics of Smart Sensor

- Self Calibration
- Self Testing
- Self Communication

Self Calibration - Calibration is finding out how far a measured value lies from the value that is defined as being the true one by a method that is traceable an accepted standard.

It is only possible to conduct calibration without reference to the agreed standard in two situations:-

(i) Where the sensor itself is inherantly calibrated in traceable manner.

(ii) Where the sensor can, from past experience, refer to replacement transfer standard for a sufficient time of operation before internal calibration is needed again.

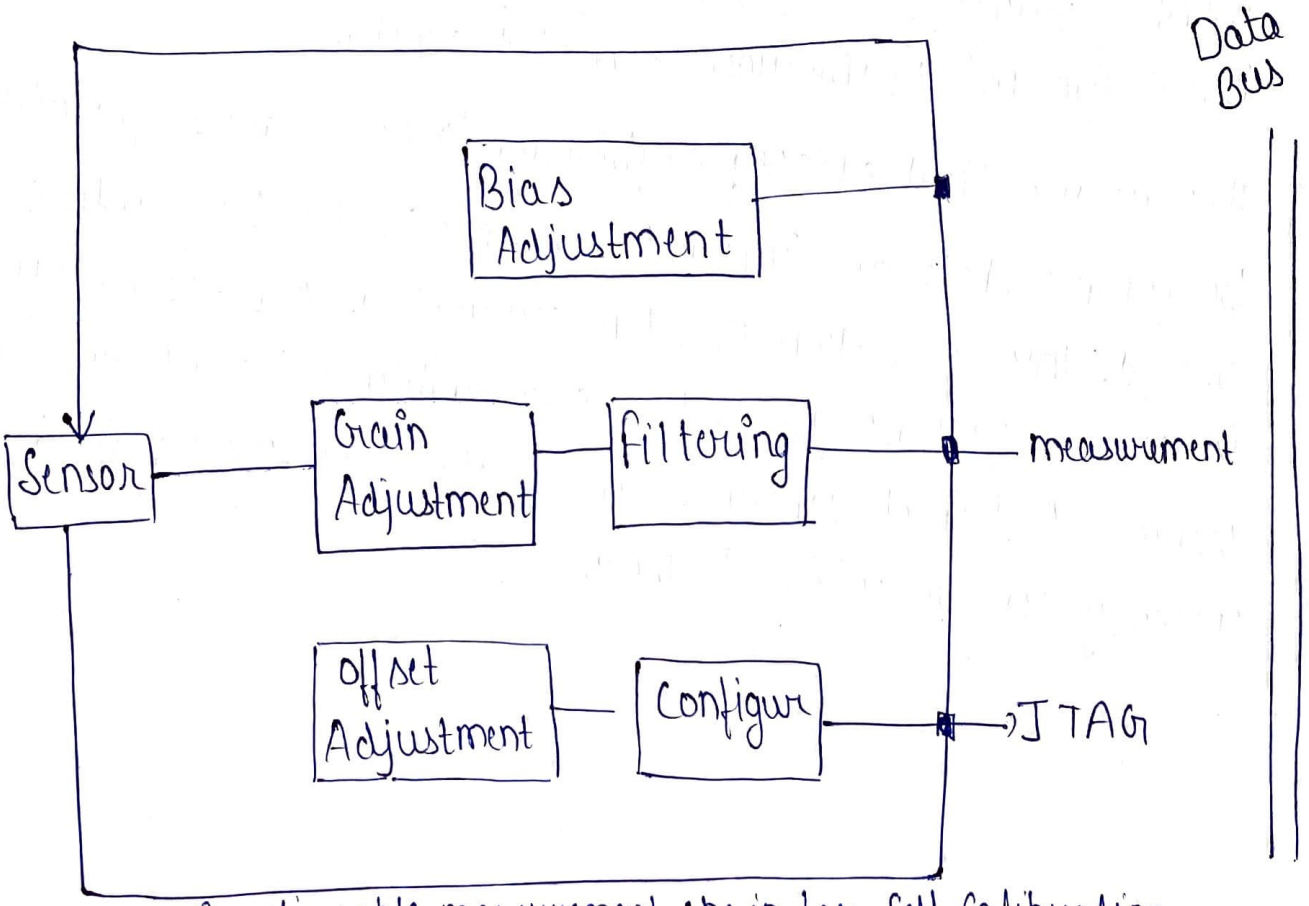
This means that all self calibration sensors must periodically be compared to an internal reference to be traceable calibrated. This situation is often overlooked. Auto-calibration is sensor systems needs the availability of small reference source. A list of likely transfer standard source used with memory sensor is as follows:-

- Voltage - 20 per diode,
- radiation - Black body at ~~comm~~ controlled Temperature
- temperature - standard temperature points boiling, freezing etc.
- Length - Gauge block, interferometers
- Resistance - Calibrated stable resistor

For self calibration of smart sensors the two steps are-

1. Auto-test step :- This step consists of the evolution of offset error and varifying is amplification gain.

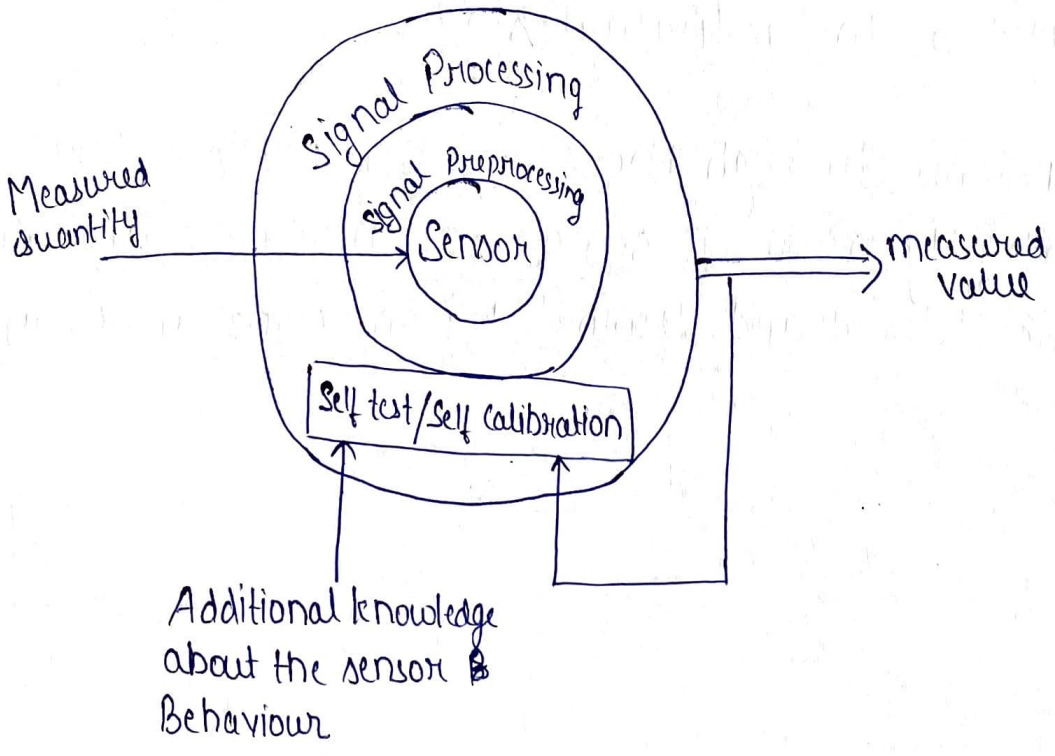
2. Auto adjustment step :- The offset and gain errors estimated in the auto test step are connected in this step, as per the figure below.



Reconfigurable measurement chain for Self Calibration

Self Testing

It is a common practice for measuring systems. When started up, to run a suite of tests that test for many fault conditions. This is called self test. This process identifies area where a system is already out of specification or, perhaps, trending toward it. The general principles and practices of self test and auto-correction are described.



Self-Test and Calibration Structure

The state of the art system can be inspected by a comparison of the real output to the expected value due to the previous known relationship.

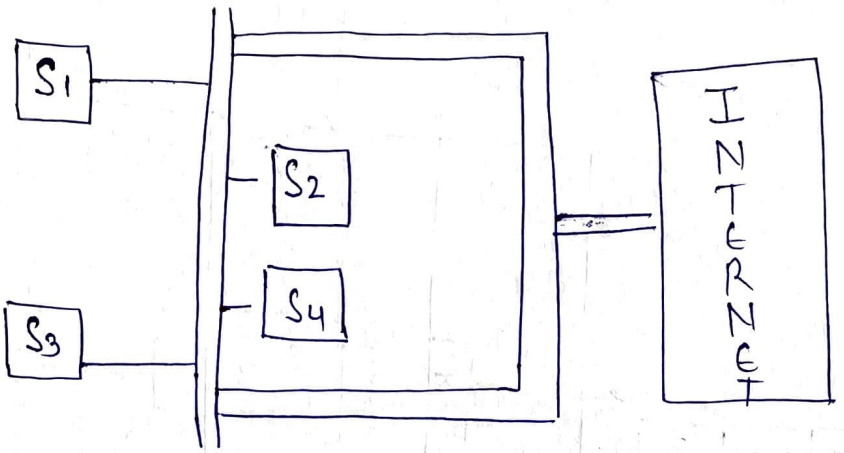
The functioning of this process is possible in a closed loop structure, where the output value is fed back to the signed being measured. The offset is now calculated and adjusted to remove the errors.

A further potential of built-in self test is possible in multi-sensor system, making use of more information provided by the individual sensors.

For instance, through the comparison of the outputs redundantly available sensors, strongly deviating sensors can be detected and eliminated from signal processing.

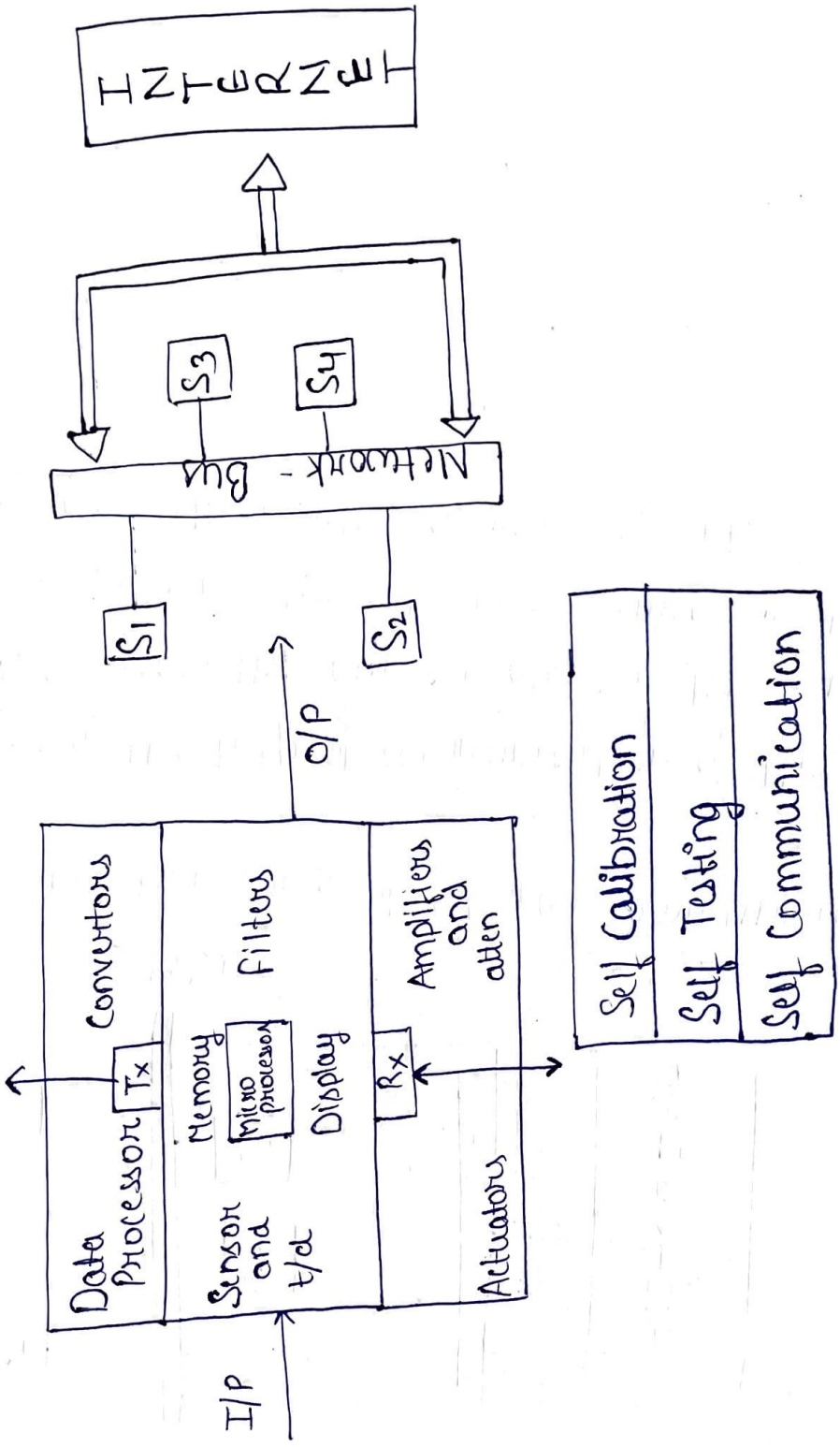
Self Computing / Communicating

The smart sensor connected through a processor via data sockets and ports with data bus through internet.



Bus transfer protocol for communication

Hence by the help of communication of the sensors the data from the one sensor. can be transferred to another sensor where the measurement is done by the help of some other reference measurement.



Self Communication put its advantages in

→ Handling through portable devices
→ Self calibration and testing
→ Reduced wired complexity
→ Loss of data etc.

Application of Smart Sensors

Industrial - In industries machines and equipments are monitored and controlled for pressure, temperature, humidity level and also for vibrations.

Automotives - Communication between engine, transmission, suspension, breaking and other control has long been anticipated.

Finger Print Recognition - A fingerprint sensor is an electronic device used to capture a digital image of the fingerprint pattern. The captured image is called a live scan. The live scan digitally processed to create a biometric template which is stored and used for matching.

Pattrin Recognisition :- The sensor used insident light or backlight to detect the controvers of an object and compares them with the controles of one or severals models in a reference image

Smart Toys :-

These days the trend in toys is to make them as life like as possible which move or change directions after sensing objects around them.

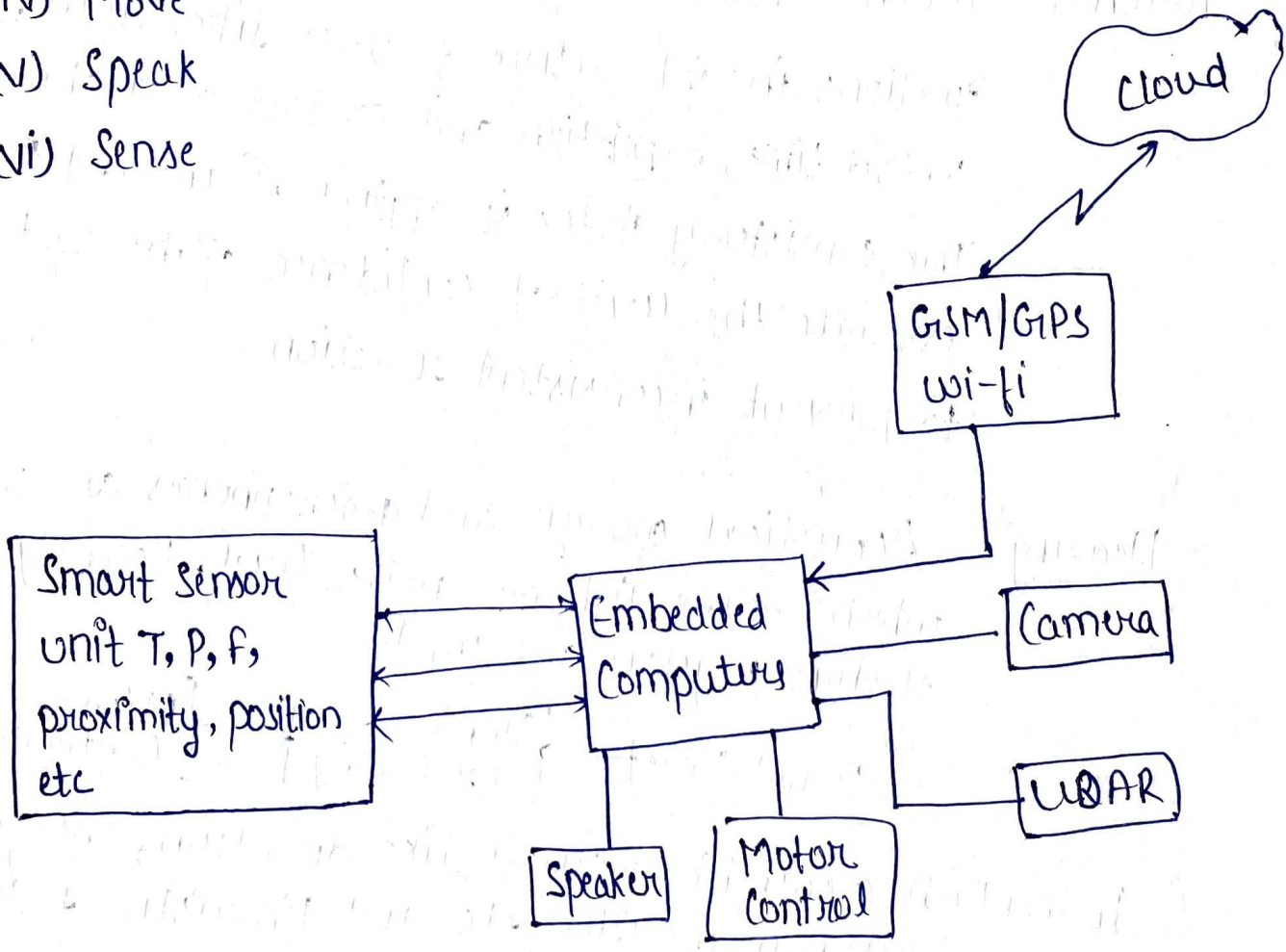
Biomedical Applications :-

A number of smart sensors for biomedical applications have also been developed by using chip technology eg biochips cyto-sensor micro-physio-meter : biological applications of silicon technology.

Automatic Robot Control

Robot sensing is a subarea of robotics science intended to give robots sensing cababilities, so that robot are more human like. Robotic sensing mainly give robotics the ability to -

(i) Vision
(ii) Touch
(iii) Hear
(iv) Move
(v) Speak
(vi) Sense

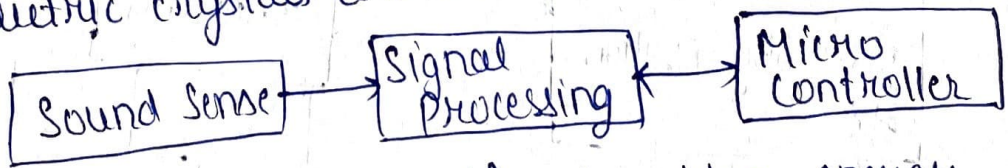


Generalized block Diagram

Vision- The visual sensing system can be based on anything from the traditional camera, Sonar and laser to the new technology of radio frequency identification(RFID), which transmit radio signals to a tag on an object that emits back an identification.

Touch :- Touch pattern enable robots to interpret human emotions in interactive features like, force, contact time, repitition and contact area change. The consistency index is applied at the end to evaluate the level of confidence of the system to prevent inconsistent reaction.

Hearing :- Acoustical arrays and microphones are used which reduce internal noise level.. Recently piezo-electric crystals are used.



It controls acoustic features like duration, energy, pitch, spectrum, wavelets etc and linguistic features like Bag of words, part of speech, Smantics and

Movement: It requires a guidance system with displacement and proximity sensors that are connected with the cloud.

Sense:- To sense environmental conditions like pressure force, temperature etc. It is need as an act of survival of the robotic system.

Moreover, it also have capability to learn and follow the environmental and genetic algorithms through machine learning.

Types of Sensors used:

1. Light Sensors → Photo resister, photovoltaic cell, photo tubes, photo transistors etc.
2. Sound Sensor → Microphones and RFID receivers
3. Contact Sensor → Capacitive touch sensor
4. Temperature Sensor → LCLM34, LM35, TMP35 etc
5. Proximity Sensor → Infrared transreceives (LED System)
   Ultrasonic
   Photo resistors
6. Distance Sensors → Ultrasonic, infrared, laser, encoders, stereo cameras
7. Pressure Sensors → Tactile pressure sensor (touch sensitive)
8. Tilt Sensor → Mercury bulb
9. Navigation and Positioning → GPS, Digital magnet compass
10. Acceleration Sensor → accelerometers

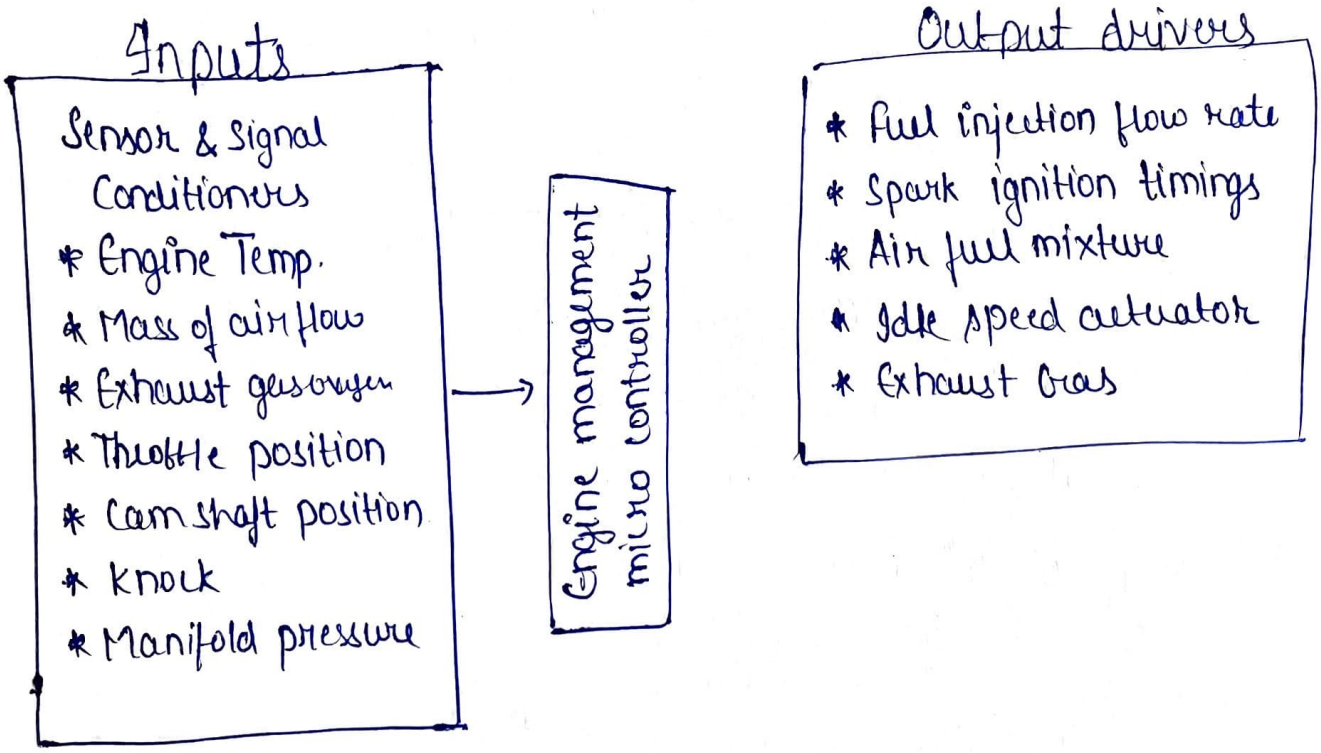
11. Gyroscope → to maintain the principle of angular momentum

12. Voltage Sensor →
13. Current Sensor →] → op-amp based

etc.

Automobile Engine Control

A modern automobile engine is invariably ~~fastened~~ fitted with an on board computer control system i.e a microcontroller with a high size RAM, which receives electrical signals from a number of engine sensors. then uses the stored data to for controlling combustion system in order to give optimal engine performance at various operating conditions like starting, normal running, cold start, accelerations.



Schematic diagram of key elements of Automobile Engine Management system.

EMS → Engine mgmt system

ECU → Engine control unit