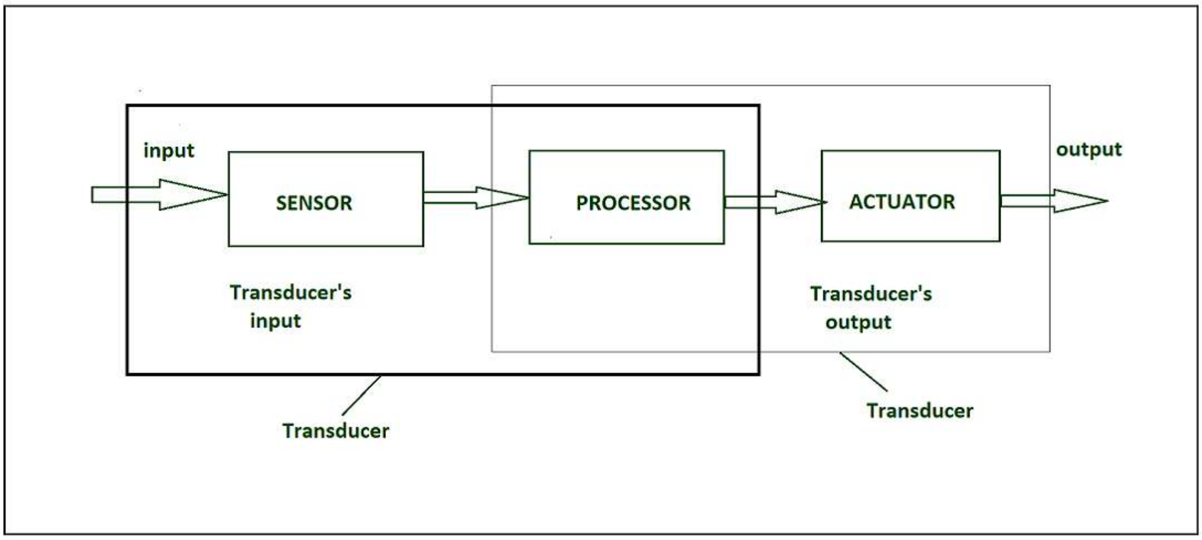
UNIT-3

1. **Explain about sensors and actuators in IOT?**

SENSORS

A device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity. The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance etc.



IOT HARDWARE

Transducer :

- A transducer converts a signal from one physical structure to another.
- It converts one type of energy into another type.
- It might be used as actuators in various systems.

Sensors characteristics :

1. Static
2. Dynamic

1.Static characteristics :

It is about how the output of a sensor changes in response to an input change after steady state condition.

- **Accuracy –**
  Accuracy is the capability of measuring instruments to give a result close to the true value of the measured quantity. It measures errors. It is measured by absolute and relative errors. Express the correctness of the output

compared to a higher prior system. Absolute error = Measured value – True value
Relative error = Measured value/True value

- **Range –**
  Gives the highest and the lowest value of the physical quantity within which the sensor can actually sense. Beyond these values, there is no sense or no kind of response.
  e.g. RTD for measurement of temperature has a range of -200`c to 800`c.
- **Resolution –**
  Resolution is an important specification towards selection of sensors. The higher the resolution, better the precision. When the accretion is zero to, it is called threshold.
  Provide the smallest changes in the input that a sensor is able to sense.
- **Precision –**
  It is the capacity of a measuring instrument to give the same reading when repetitively measuring the same quantity under the same prescribed conditions.
  It implies agreement between successive readings, NOT closeness to the true value.
  It is related to the variance of a set of measurements.
  It is a necessary but not sufficient condition for accuracy.
- **Sensitivity –**
  Sensitivity indicates the ratio of incremental change in the response of the system with respect to incremental change in input parameters. It can be found from the slope of the output characteristics curve of a sensor. It is the smallest amount of difference in quantity that will change the instrument’s reading.
- **Linearity –**
  The deviation of the sensor value curve from a particular straight line. Linearity is determined by the calibration curve. The static calibration curve plots the output amplitude versus the input amplitude under static conditions.
  A curve’s slope resemblance to a straight line describes the linearity.
- **Drift –**
  The difference in the measurement of the sensor from a specific reading when kept at that value for a long period of time.
- **Repeatability –**
  The deviation between measurements in a sequence under the same conditions. The measurements have to be made under a short enough time duration so as not to allow significant long-term drift.

Dynamic Characteristics :
Properties of the systems

- **Zero-order system –**
  The output shows a response to the input signal with no delay. It does not

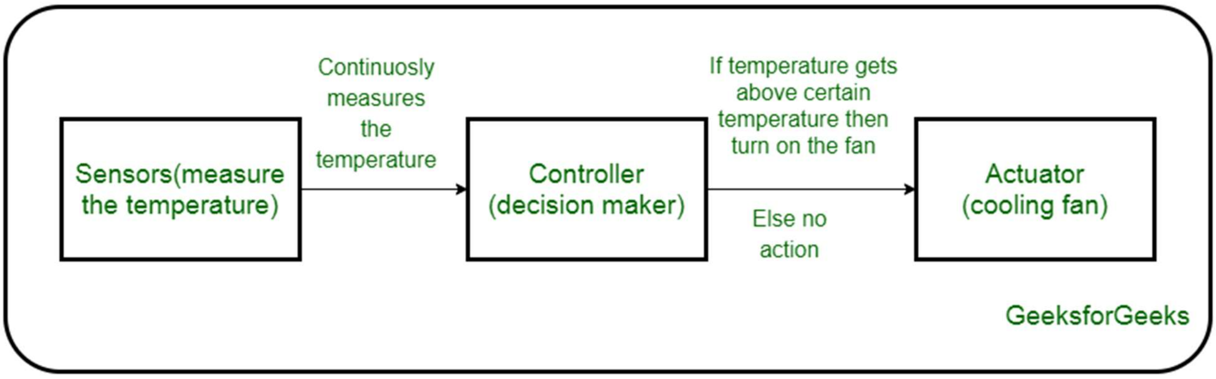
include energy-storing elements.
Ex. potentiometer measure, linear and rotary displacements.

- **First-order system –**
When the output approaches its final value gradually.
Consists of an energy storage and dissipation element.
- **Second-order system –**
Complex output response. The output response of the sensor oscillates before steady state.

ACTUATORS

An actuator is a machine component or system that moves or controls the mechanism or the system. Sensors in the device sense the environment, then control signals are generated for the actuators according to the actions needed to perform.

A servo motor is an example of an actuator. They are linear or rotatory actuators, can move to a given specified angular or linear position. We can use servo motors for IoT applications and make the motor rotate to 90 degrees, 180 degrees, etc., as per our need.



1. Hydraulic Actuators –
A hydraulic actuator uses hydraulic power to perform a mechanical operation. They are actuated by a cylinder or fluid motor. The mechanical motion is converted to rotary, linear, or oscillatory motion, according to the need of the IoT device. Ex- construction equipment uses hydraulic actuators because hydraulic actuators can generate a large amount of force.

2. Pneumatic Actuators –
A pneumatic actuator uses energy formed by vacuum or compressed air at high pressure to convert into either linear or rotary motion. Example- Used in robotics, use sensors that work like human fingers by using compressed air.

3. Electrical Actuators –

An electric actuator uses electrical energy, is usually actuated by a motor that converts electrical energy into mechanical torque. An example of an electric actuator is a solenoid based electric bell.

Thermal/Magnetic Actuators –
These are actuated by thermal or mechanical energy. Shape Memory Alloys (SMAs) or Magnetic Shape-Memory Alloys (MSMAs) are used by these actuators. An example of a thermal/magnetic actuator can be a piezo motor using SMA.
Mechanical Actuators –
A mechanical actuator executes movement by converting rotary motion into linear motion. It involves pulleys, chains, gears, rails, and other devices to operate.
Example – A crankshaft.

2. **Explain about system on chip in IOT?**

System on Chips

System on Chip in IoT designed by Redpine Signals is discussed below.This IoT SoC supports WLAN, bluetooth and Zigbee systems on a single chip. It also supports 2.4 and 5GHz radio frequencies.

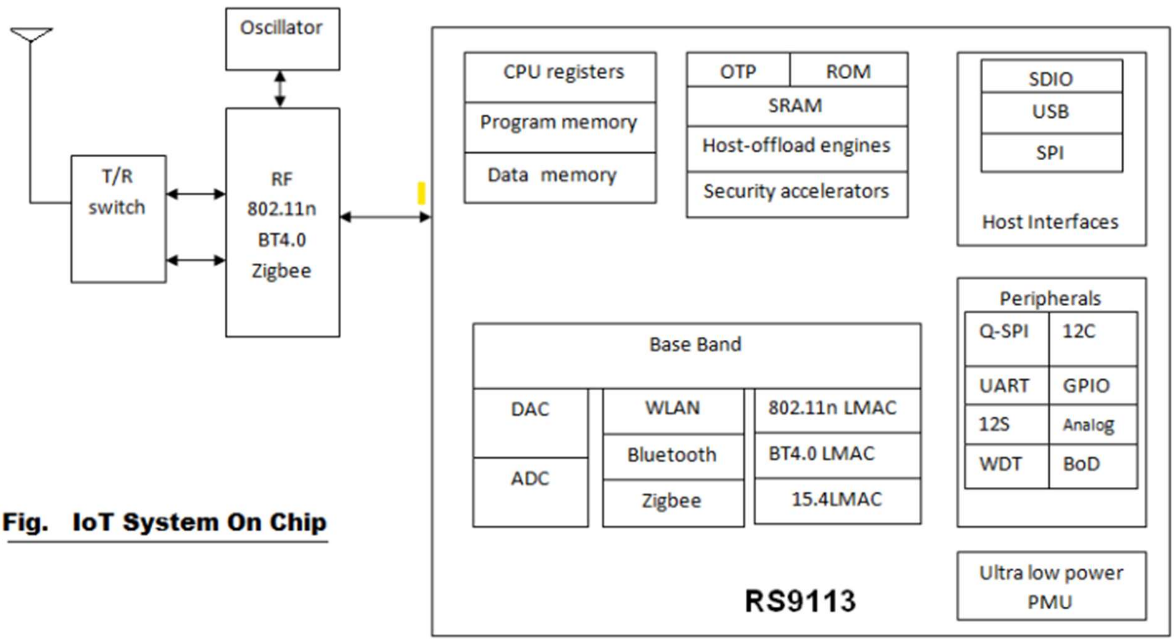


Fig. IoT System On Chip

As we know IoT is the technology which will provide communication between things, between
things and people using internet and IP enabled protocols. As we have seen in IoT tutorial any IoT compliant system will have two major parts viz. front end and back end. Front end provides connectivity with physical world and consists of sensors while backend consists of processing and network connectivity interfaces. Typical IoT system on chip support more than one RATs (Radio Access Technologies). It will have following modules.

• Transmit and receive switch.
• RF part mainly consists of Trasmitter, receiver, oscillator and amplifiers.
• Memoriesi.e. Program memory, data memory to store the code and data
• Physical layer(baseband processing) either on FPGA or on processor based on complexity and latency requirement.
• MAC layer and upper protocol stacks TCP/IP etc. running on processor
• ADC and DAC to provide interface between digital baseband and analog RF portions.
• Various interfaces such as SDIO, USB, SPI etc to provide interface with the host.
•Other peripherals such as UART, I2C, GPIO, WDT etc. to use the IoT SoC for various connections.

As IoT system on chip supports multiple wireless protocols and RF hardware to support multiple frequency bands, following factors need to be carefully analyzed and to be optimized.

• Power-consumption
•Data-throughput
• Device-size
• Performance in terms of latency and other factors

Figure depicts one such IoT System on Chip model no. RS9113,which has been designed and developed by Redpine Signals recently. It supports WLAN (802.11n), Bluetooth version 4.0 and Zigbee (802.15.4-2006) in the same chip. Hence the IoT device can be connected with any of the said wireless technology based networks.

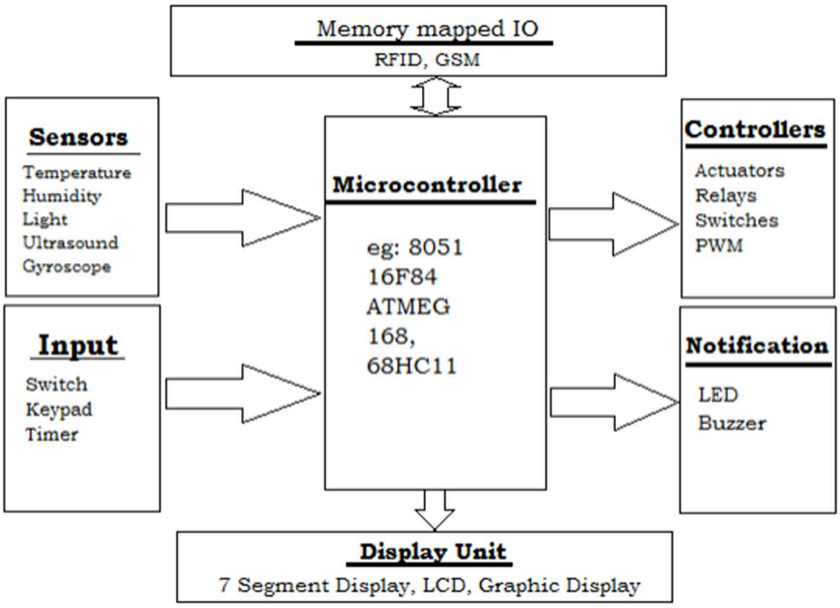
This IoT SoC (system on chip in IoT) can be used for numerous applications as mentioned below: • Mobile
• M2M-Communication
• Real time location finding tags
• Thermostats
• Smart meters
• Wireless sensor devices
• Serial to WiFi converter
• Voice Over WiFi compliant phones

• Home automation
• Health care devices and equipments

3. Explain about embedded system hardware?

Embedded System Hardware

The embedded system can be of type microcontroller or type microprocessor. Both of these types contain an integrated circuit (IC). The essential component of the embedded system is a RISC family microcontroller like Motorola 68HC11, PIC 16F84, Atmel 8051 and many more. The most important factor that differentiates these microcontrollers with the microprocessor like



8085 is their internal read and writable memory. The essential embedded device components and system architecture are specified below.

Embedded System Software

The embedded system that uses the devices for the operating system is based on the language platform, mainly where the real-time operation would be performed. Manufacturers build embedded software in electronics, e.g., cars, telephones, modems, appliances, etc. The embedded system software can be as simple as lighting controls running using an 8-bit microcontroller. It can also be complicated software for missiles, process control systems, airplanes etc.

Microcontrollers for Embedded Computing with IoT Devices

IoT devices are meant to be inexpensive, therefore the microcontroller needs to be chosen so that its capabilities are not underutilized by the application. The microcontroller specifications that determine the best part for your application are:

- **Bit depth:** The register and data path width impacts the speed and accuracy with which microcontrollers can perform non-trivial computations.
- **Memory:** The amount of RAM and Flash in a microcontroller determines the code size and complexity the component can support at full speed. Large memories have larger die area and component cost.
- **GPIO:** These are the microcontroller pins used to connect to sensors and actuators in the system. These often share their functionality with other microcontroller peripherals, such as serial communication, A/D, and D/A converters.
- **Power consumption:** Power consumption is critically important for battery-operated devices and it typically increases with microcontroller speed and memory size.