SUPERVISORY CONTROL AND DATA ACQUISITION

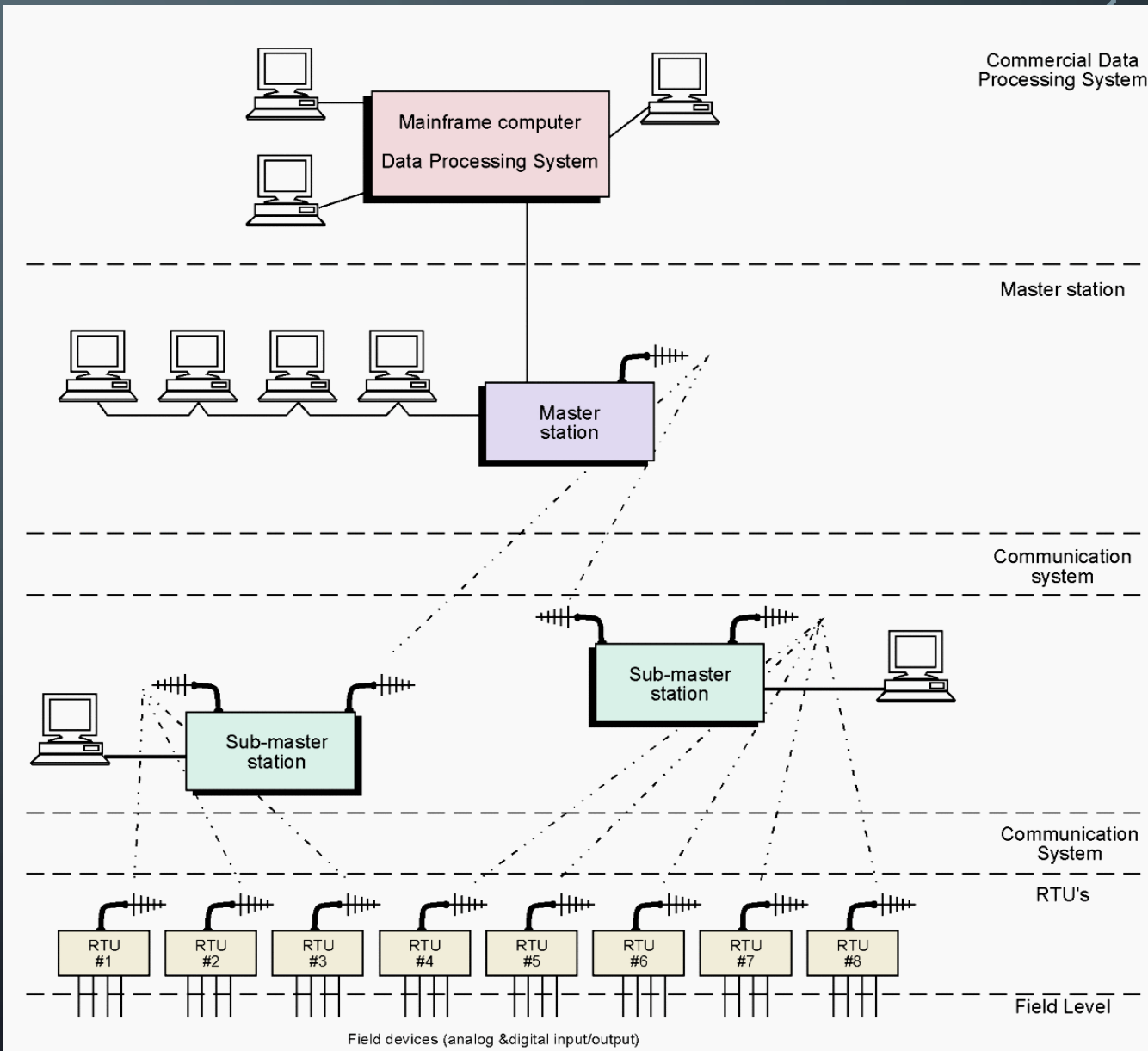
ARCHITECTURE, WORKING AND RTU

INTRODUCTION

- SCADA stands for supervisory control and data acquisition.
- A SCADA is a system consisting of **a number of remote terminal units (or RTUs)** collecting field data connected back to a master station via a communications system.
- The master station displays the acquired data and also allows the operator to perform remote control tasks.
- The accurate and timely data (normally real-time) allows for optimization of the operation of the plant and process. A further benefit is more efficient, reliable and most importantly, safer operations.
- This all results in a lower cost of operation compared to earlier non-automated systems.
- SCADA is a pure software package that is positioned on top of hardware to which it is interfaced, in general via a Programmable logic controller (PLCs), or other commercial hardware modules.
- SCADA enables a user to collect data from one or more distant facilities and send back the control action.

ELEMENTS OF A SCADA SYSTEM

- HMI-A Human – Machine Interface (HMI) is the apparatus which presents process data to a human operator, and through this, the human operator monitor and control the process.
- HMI offers real-time monitor of data about the process and through which an operator can send commands to the controller.
- RTU-MTU (master control unit), which is the system controller. Some industries use the term “host computer” instead of MTU.
- MTU communicates with the RTU that is located away from the central location. There can be many RTUs in the field, MTU can monitor and control the field using the scheduled program even when the operator is not present.
- Changes can be done in the process from the MTU end, can read some process parameter.
- Remote terminal unit (RTU) connection to sensors in the process and converting sensors signals to digital data and sending digital data to the supervisory system.
- RTU communicate with the MTU using modulated signal. RTU receives the modulated data from MTU and connection can be through cable or radio.
- RTU field device connection is through cables. RTU supplies both electrical power and actuator signal to the field device.



RTU

- The Remote Terminal Units (RTUs) are basically distributed SCADA based systems used in remote locations in applications like oil pipelining, irrigation canals, oil drilling platforms etc.
- They are rugged and should be able to work unattended for a long duration.
- There are two modes in which Remote Terminal Units work.
  1. Under command from central computer
  2. Stand alone mode

  Since these RTU's have to operate for a long duration unattended, the basic requirements would be that they consume minimum power and have considerable self-diagnostic facility.

  Following are the main parts of remote terminal units.

  1. Input-output modules
- 2. Communication Module-wireline and wireless communication
- 3. Software Module

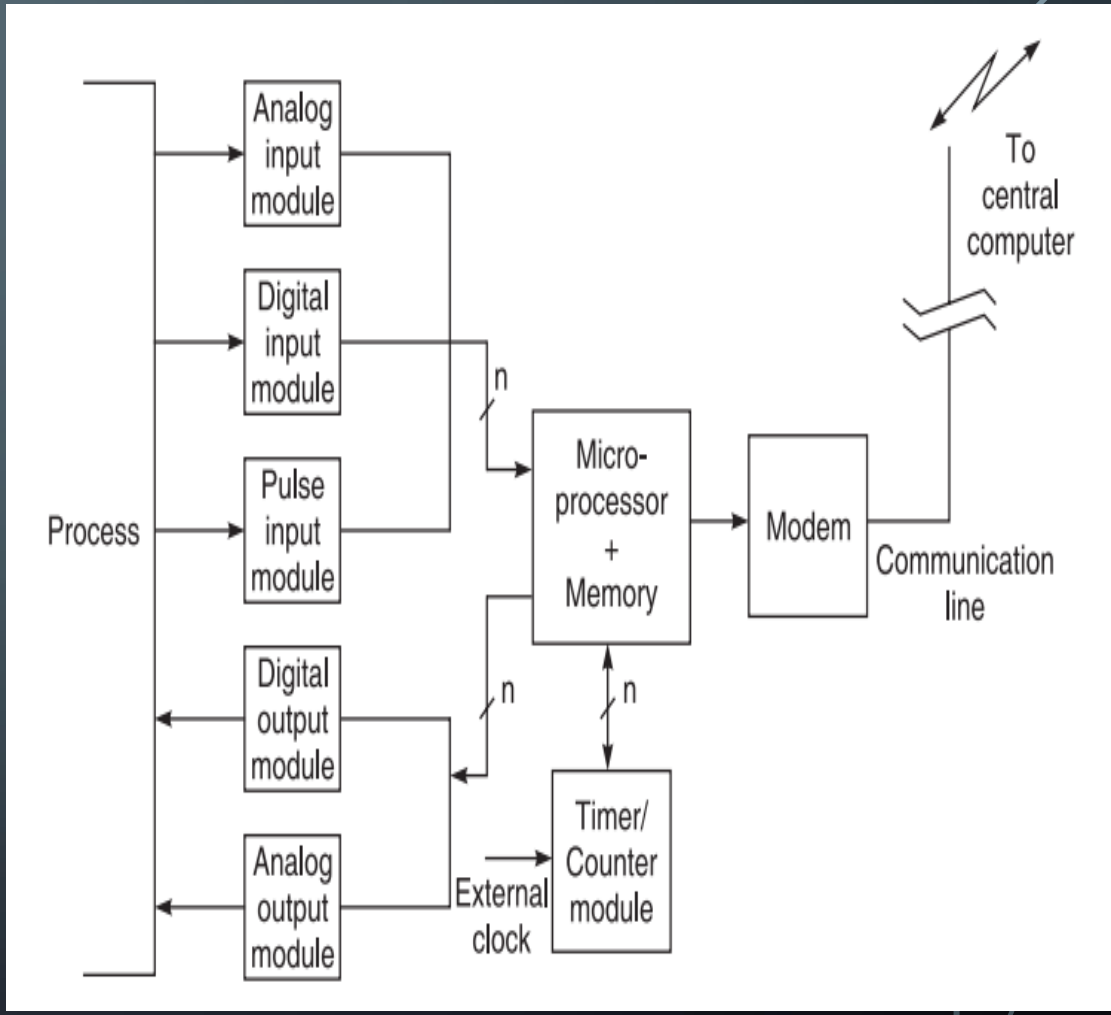


Figure: Block diagram of RTU

ARCHITECTURE

- A supervisory system gathers data on the process and sends the commands control to the process.
- The SCADA is a remote terminal unit which is also known as RTU.
- Most control actions are automatically performed by RTUs or PLCs.
- Generally SCADA system is a centralized system which monitors and controls entire area.
- It is purely software package that is positioned on top of hardware.
- Functions are performed by sensors, RTUs, controller, communication network.
- The sensors are used to collect the important information and RTUs are used to send this information to controller and display the status of the system.
- According to the status of the system, the user can give command to other system components.
- This operation is done by the communication network.

DATA ACQUISITIONS

- Real time system consists of thousand of components and sensors.
- It is very important to know the status of particular components and sensors.
- For example, some sensors measure the water flow from the reservoir to water tank and some sensors measure the valve pressure as the water is release from the reservoir.

DATA COMMUNICATION

- The SCADA system uses internet communications.
- All information is transmitted through internet using specific protocols.
- Sensor and relays are not able to communicate with the network protocols so RTUs used to communicate sensors and network interface.
- The SCADA system uses wired network to communicate between user and devices.
- The real time applications use lot of sensors and components which should be control remotely.

HUMAN MACHINE INTERFACE

- The HMI provides the graphical presentation of the system.
- The information is displayed and monitored t be processed by the human.
- HMI provides the access of multiple control units which can be PLCs and RTUs.
- The important part of the HMI is an alarm system which is activated according to the predefined values.

MONITORING/CONTROL

- Any part of the process can be turned ON/OFF from the control station using these switches.
- SCADA system is implemented to work automatically without human intervention but at critical situations it is handled by man power.
- The SCADA system uses different switches to operate each device and displays the status at the control area.

FUNCTIONS OF SCADA

- Channel scanning
- Conversion into Engineering Units
- Data Processing

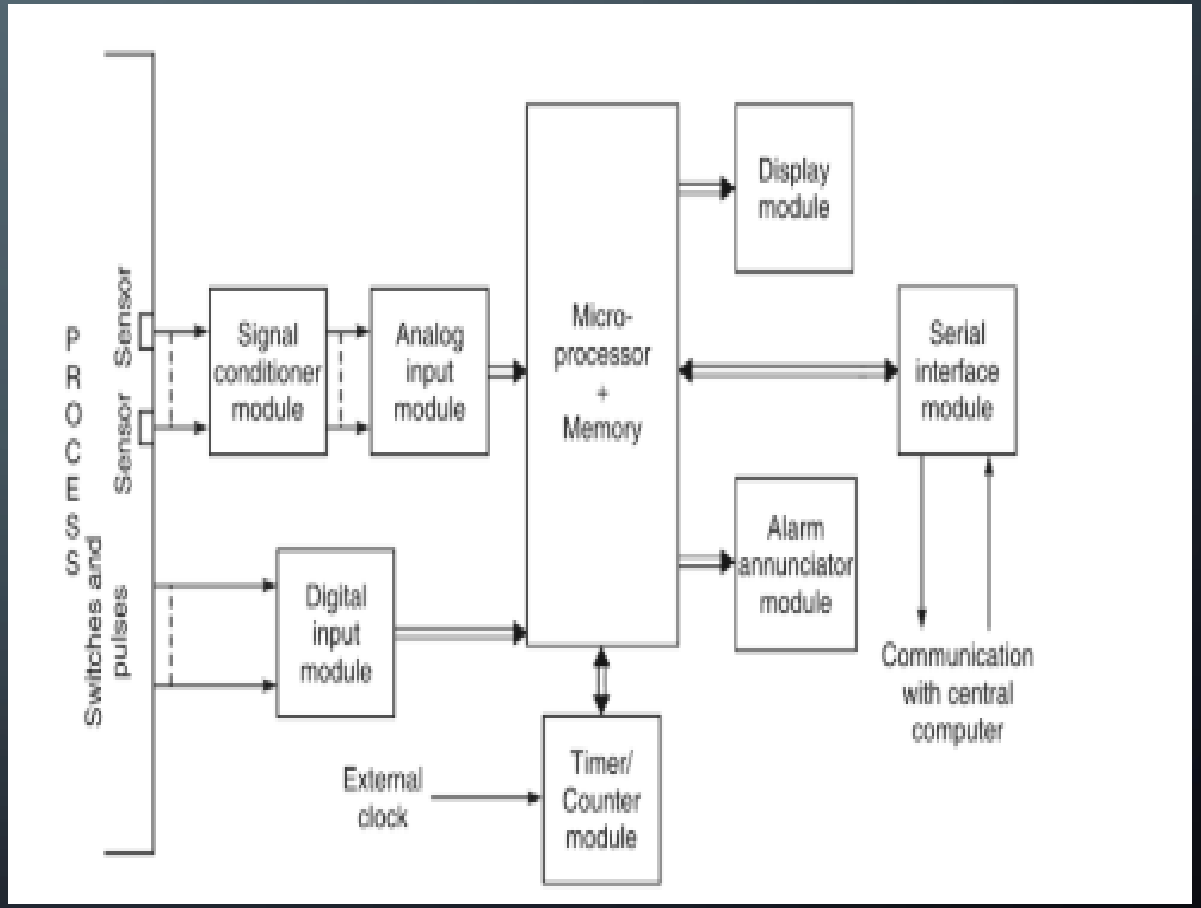


Figure: Block Diagram of SCADA SYSTEM

CHANNEL SCANNING

- There are many ways in which microprocessor can address the various channels and read the data.
- Polling
- The microprocessor scans the channels to read the data, and this process is called *polling*.
- In polling, the action of selecting a channel and addressing it, is the responsibility of processor.
- The channel selection may be sequential or in any particular order decided by the designer.
- It is also possible to assign priority to some channels over others, i.e. some channels can be scanned more frequently than others.

CHANNEL SCAN ARRAY

- For reading the digital data at ADC output, the end of conversion signal of ADC chip can be read by processor and when it is 'ON', the digital data can be read.
- Alternatively, the microprocessor can execute a group of instructions (which do not require this data) for the time which is equal to or greater than conversion time of ADC and then read ADC output.
- Another modification of this approach involves connecting the end of conversion line to one of the interrupt request pins of the processor.
- In this case the interrupt service routine reads the ADC output and stores at predefined memory location.

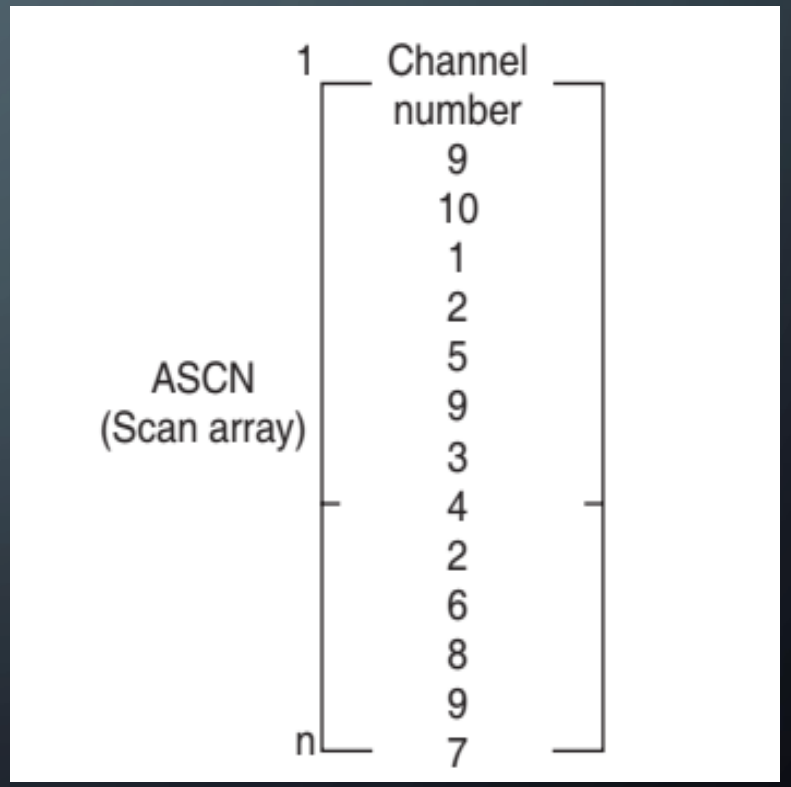


Figure: Channel scan array

INTERRUPT SCANNING

- Another way of scanning the channels may be to provide some primitive facility after transducer to check for violation of limits.
- It sends interrupt request signal to processor when the analog signal from transducer is not within High and Low limits boundary set by Analog High and Analog Low signals. This is also called *Scanning* by *Exception*.
- When any parameter exceeds the limits then the limit checking circuit would send interrupt request to microprocessor which in turn would monitor all parameters till the parameter values come back within pre-specified limits.
- This allows a detailed analysis of the system and the problems by the SCADA system

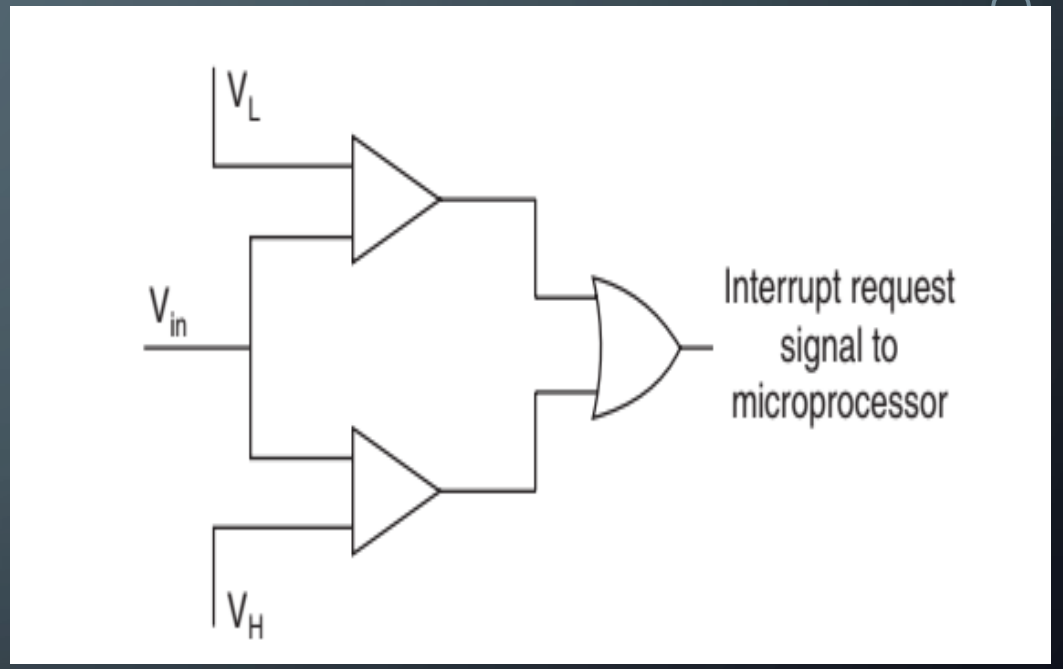


Figure: Interrupt request generation on limit violation.

CONVERSION TO ENGINEERING UNITS

- The data read from the output of ADC should be converted to the equivalent engineering units before any analysis is done or the data is sent for display or printing For an 8-bit ADC working in unipolar mode the output ranges between 0 and 255.
- An ADC output value will correspond to a particular engineering value based on the following parameters.
- Calibration of transmitters-The transmitter output should be in the range of 0-5 V or 4-20 mA range.
- Depending on the input range of measurand value for transmitter, a calibration factor is determined.
- ADC mode and digital output lines-The conversion of ADC output to engineering units, therefore, involves multiplication by conversion factor.
- The conversion factor is based on the ADC type, mode and the transmitter range.
- This multiplication can he achieved by shift and add method in case of 8-bit microprocessor.
- For 16-bit microprocessor, a single multiplication instruction will do the job .

DATA PROCESSING

- The data read from the ADC output for various channels is processed by the microprocessor to carry out limit checking and performance analysis.
- For limit checking the *Highest* and *Lowest* Limits for each channel are stored in an array.
- When any of the two limits is violated for any channel, appropriate action like alarm generation, printing, etc. is initiated.

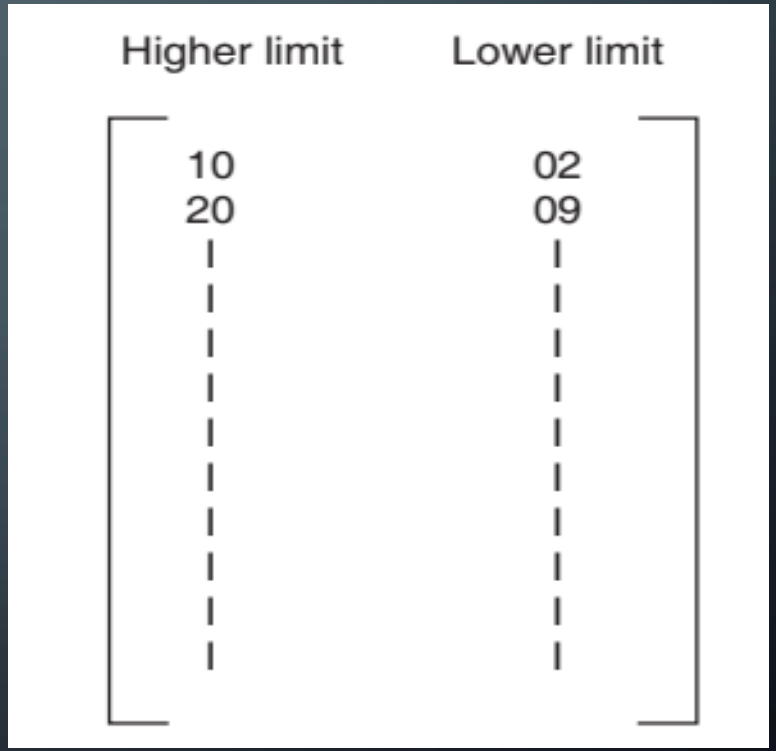


Figure: Limit array

BENEFITS OF A SCADA SYSTEM

- Improved operation of the plant or process resulting in savings due to optimization of the system
- Increased productivity of the personnel
- Improved safety of the system due to better information and improved control
- Protection of the plant equipment
- Safeguarding the environment from a failure of the system
- Improved energy savings due to optimization of the plant
- Improved and quicker receipt of data so that clients can be invoiced more quickly and accurately

ADVANTAGES OF SCADA

- Long distance monitoring
- Long distance training
- Protection against terrorism/vandalism-alarm
- Data management (engineering and operations)
- Automated operations with real-time control
- Reliability and Robustness (very large installed base, mission-critical processes)
- Rich functionality

APPLICATIONS

- Process control
- Power generation, transmission and distribution
- Water distribution and reservoir system
- Public buildings like electrical heating and cooling system.
- Generators and turbines
- Traffic light control system
- Air Traffic control
- Rapid Metro Control

Thanks