BITS Pilani
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BITS Pilani presentation

Faculty Name
Faculty Department

BITS Pilani
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AEL ZG512 Embedded Systems
Lecture No. 2

Small Scale Embedded System Design

Problem Specification

User and System Design Requirements

System Block Diagram Development

Selection of Hardware and Software – Considerations

Hardware/Software design & Testing Considerations

Final System Design

Problem Specification

There are five steps to design a simple embedded system

- Requirements Definition
- System specification
- Functional Design
- Architectural Design
- Prototyping

Requirements Specifications

Capture the formal system description from customer point of view.

Document the requirements using natural language descriptions

Knowledge of the application domain is required and customer is involved in arriving at specifications.

Requirements definition provides the interface between the customer and the engineering process.

Required functional capabilities and operations are captured.

System design and its interaction with the environment in the form of inputs/outputs are written down.

Description of the environment in which the system will work can be written down. Reliability and safety parameters recorded.

The requirements are formalized into a specification.

Requirements for a Counter Simple Embedded System

Description:

Counter should measure frequency, time period, time interval, events. System supports three measurement ranges for each signal, two ranges for events.

Ability to operate manually or remote

Low cost

External Environment:

Industrial environment, commercial grade temperature and Lighting background

Line power or battery operation.

Requirements..

Freq range:

- High range 150.0 MHz
- Midrange: 50KHz
- Low range: 100Hz

Period:

- High resolution 1.0000ms
- Mid resolution: 10.000ms
- Low resolution: 1.000 sec

Time interval range

- High resolution 1.0000ms
- Mid resolution: 10.000ms
- Low resolution: 1.000 sec

Requirements..

Events:

- Upto 99 events in 1 minute

Signal input in the range of 0.0 to 4.5V DC

Digital input

System Outputs:

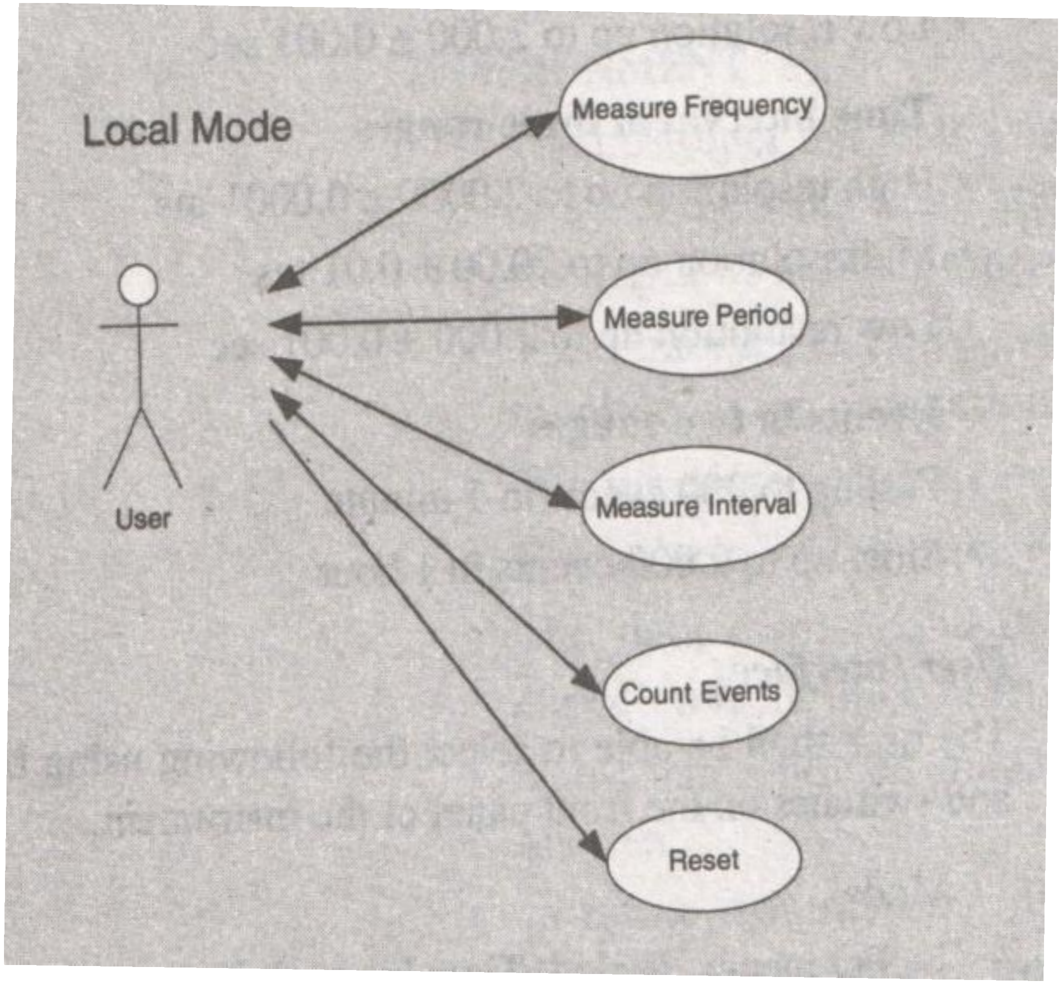
- 6 digit display

User Interface

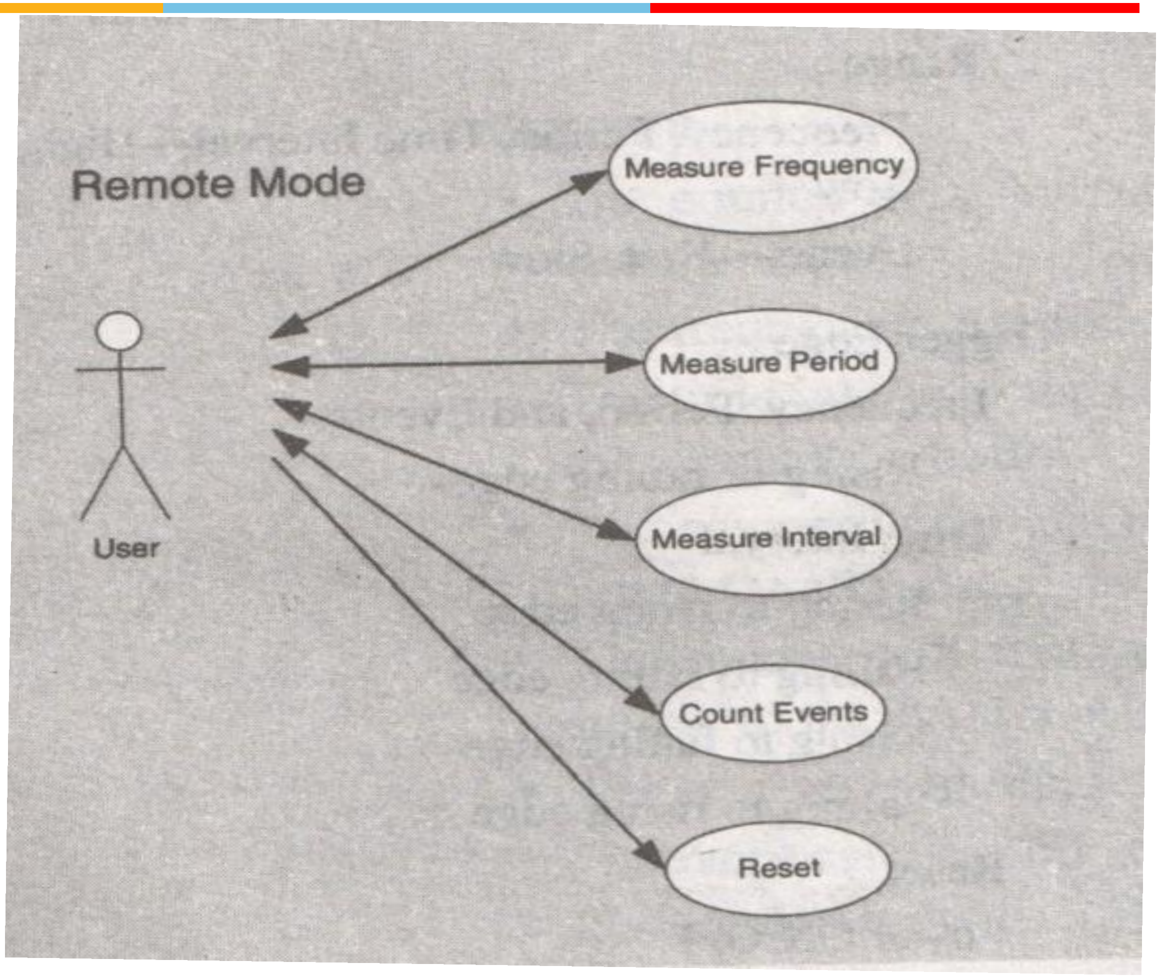
- Buttons and switch inputs to select Mode, Trigger edge, Power ON/OFF

Requirements..Use case Local

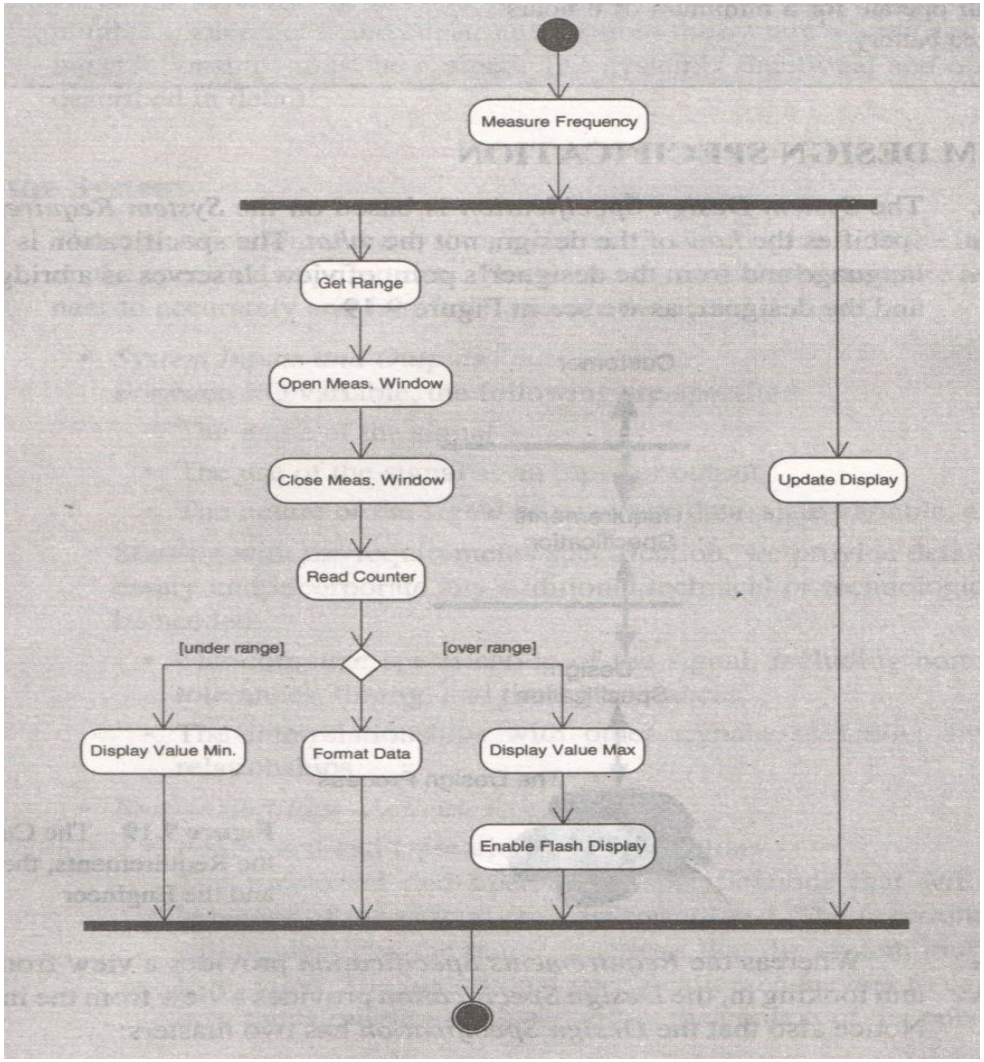
***Rajkamal (Embedded Systems)**



Requirements….
Use case for Remote operation



Functional Requirements



Reliability, Power, Certification Requirements

Operating Specifications
Commercial-Industrial environment
0-85 deg C
Humidity: 95% RH non-condensing
Power input: 120V-240V, 50Hz or 60Hz
15V DC input
Ability to operate for 8hrs on battery

Safety: UL-3111-1, IEC-1010, CSA 1010.1
EMC: CISPR-11, IEC 801-2,-3,-4, EN50082-1

Requirements Specifications

- Requirements may be in a Word document with natural language description
- After reading the requirements the form, size, weight, power requirements, display features, user interface features, functionality and how the customer will use the system may be clear.
- Reliability, working environment with regards to temperature, humidity, ruggedness and vibration handling capability may also be determined.
- Certification by govt. agencies, calibration features, back-up battery based operation may also be determined by reading the document.

Functional Requirements

Flow diagrams, Use case Diagrams, State flow disgrams may be used to pictorially represent the interaction of the system with the environment.

Input-Output interface in the form of switches, potentiometers, serial interfaces may be used to indicate how the system interacts with the outside world.

System Design Specifications

innovate achieve lead

Specify the system's interface from inside the system

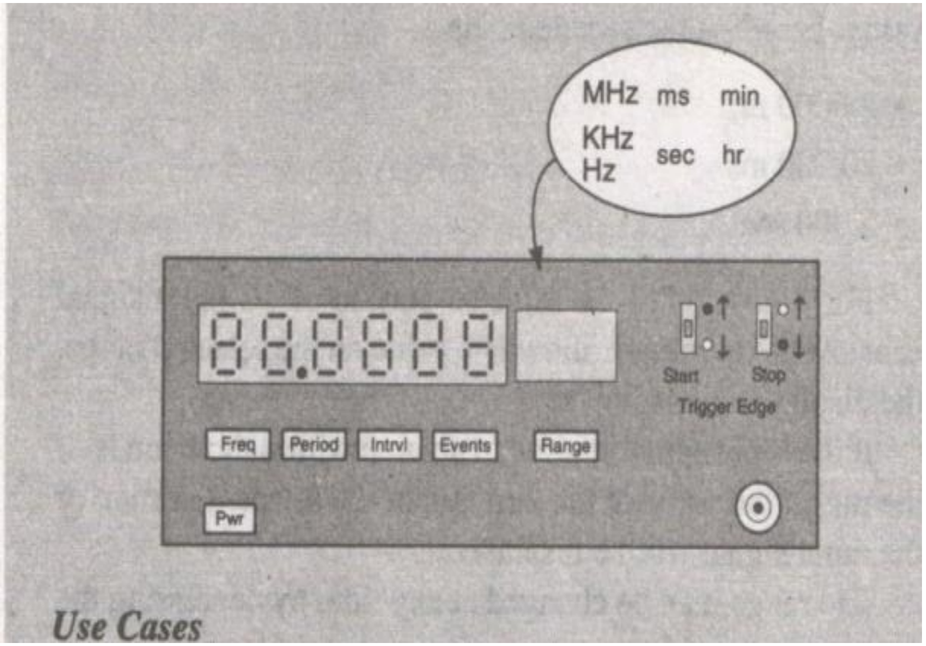
Specify how the requirements defined for and by the public interface are to be met by the internal functions of the system.

Design specifications must formalize the requirements in precisely that the designers can implement without consulting the specification of the author.

Limitations of the design in terms of resolution, speed of operation, accuracy, type of interaction with the outside environment may also be specified at this stage.

Specifications are written in a textual form with pictorial representation as needed

System Specifications- Front Panel



System Specifications

System Input and Output Specification

System Inputs

The system shall be able to measure the following signals

Frequency in three ranges

- High range up to 150.000 MHz
- Midrange up to 50.000 KHz
- Low range up to 100.000 Hz

Period in three ranges

- High resolution up to 1.0000 ms
- Midresolution up to 10.000 ms
- Low resolution up to 1.000 sec

Time interval in three ranges

- High resolution up to 1.0000 ms
- Midresolution up to 10.00 ms
- Low resolution up to 1.000 sec

Events

- Events to 99 per minute
- Signal level 0–4.0 V ± 0.5 V
- Transition time $10\text{ns} \le t_{rise} t_{fall} \le 50\text{ns}$

Voltage Sensitivity

- 50 mV RMS to ± 5.0 V ac signal + dc signal

All signal inputs will be

- Digital data
- Voltage range 0.0 to 4.5 VDC

System Outputs

The system shall measure and display the following signals using a 6-digit display

Frequency in three ranges

- High range
  - Measure: 0 – 200 ± 0.0001 MHz
  - Display: 0 – 200.000 MHz
- Midrange up to 200.000 KHz
  - Measure: 0 – 200 ± 0.0001 KHz
  - Display: 0 – 200.000 KHz
- Low range up to 200.000 Hz
  - Measure: 0 – 200 ± 0.0001 Hz
  - Display: 0 – 200.000 Hz

Period in three ranges

- High resolution up to 2.0000 ms
  - Measure: 0 – 2.00000 ± 0.00001 ms
- Low resolution up to 2.000 sec
  - Measure: 0 – 2.0000 ± 0.0001 sec
  - Display: 0 – 2.000 ± 0.001 secUser Interface

Time interval in three ranges

- High resolution up to 2.0000 ms
  - Measure: 0 – 2.00000 ± 0.00001 ms
  - Display: 0 – 2.0000± 0.0001 ms
- Mid resolution up to 20.00 ms
  - Measure: 0 – 20.0000 ± 0.0001 ms
  - Display: 0 – 20.000± 0.001 ms
- Low resolution up to 2.000 sec
  - Measure: 0 – 2.0000 ± 0.0001 sec
  - Display: 0 – 2.000 ± 0.001 sec

Events in two ranges

- Fast up to 200 events in 1 minute
  - Measure: 0 – 200 ± 1 event
  - Display: 0 – 200 ± 1 event
- Slow up to 2000 events in 1 hour
  - Measure: 0 – 2000 ± 1 event
  - Display: 0 – 2000 ± 1 event

User Interface

The user shall be able to select the following using buttons and switches on the front panel of the instrument.

Mode

Frequency, Period, Time Interval, Events

Range

Frequency, Period, Time Interval—High, Mid, Low

Events—Fast, Slow

Trigger Edge

Frequency, Period, and Events

Rising or falling edge

Time Interval

Rising to rising edge

Falling to falling edge

Rising to falling edge

Falling to rising edge

Reset

The reset button will clear the display to all 0's and reset the internal timing/counting chain.

The counter will be placed in the *frequency* mode with the *range* set to KHz, and the *trigger edge* set to

Functional Specifications

A specification is a precise description of the system that meets stated requirements.

Specification document should be

Complete

Consistent

Comprehensible

Traceable to requirements

Unambiguous

Modifiable

Able to be written in a formal language or notation

Design Engineering

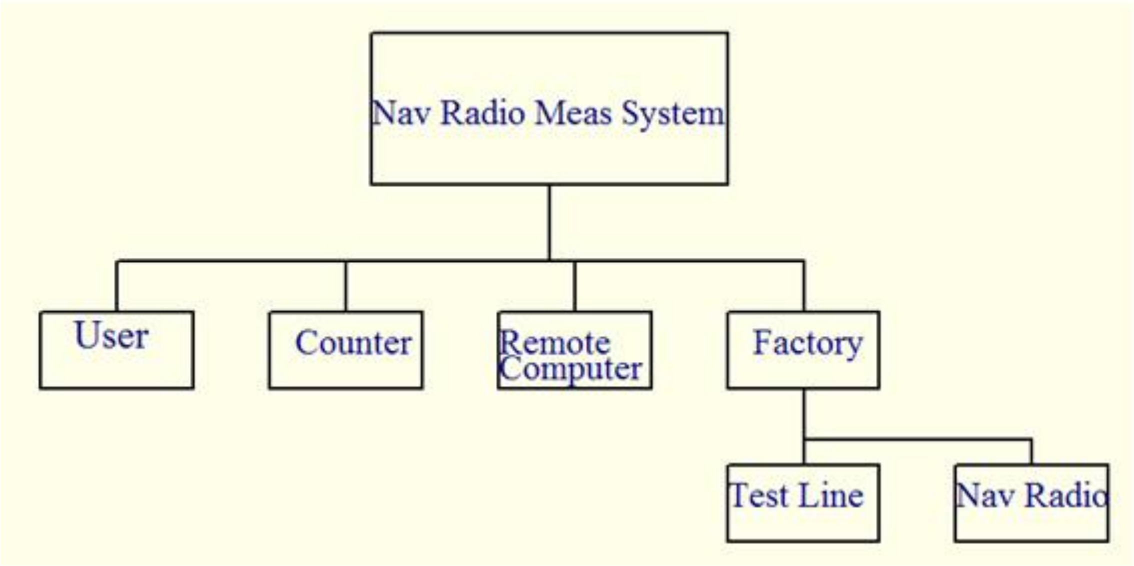
System should have Input and Output tasks that can be used to interact with the the outside world.

The design analysis proceeds to identify the messages that flow between the user and other external objects and the system as well as the internal signals that flow between the various functional blocks.

The environment in which the counter exists is shown with a collection of the user, factory, a remote computer and how they interact with one another.

Interaction with the environment

Counter and its position in the factory

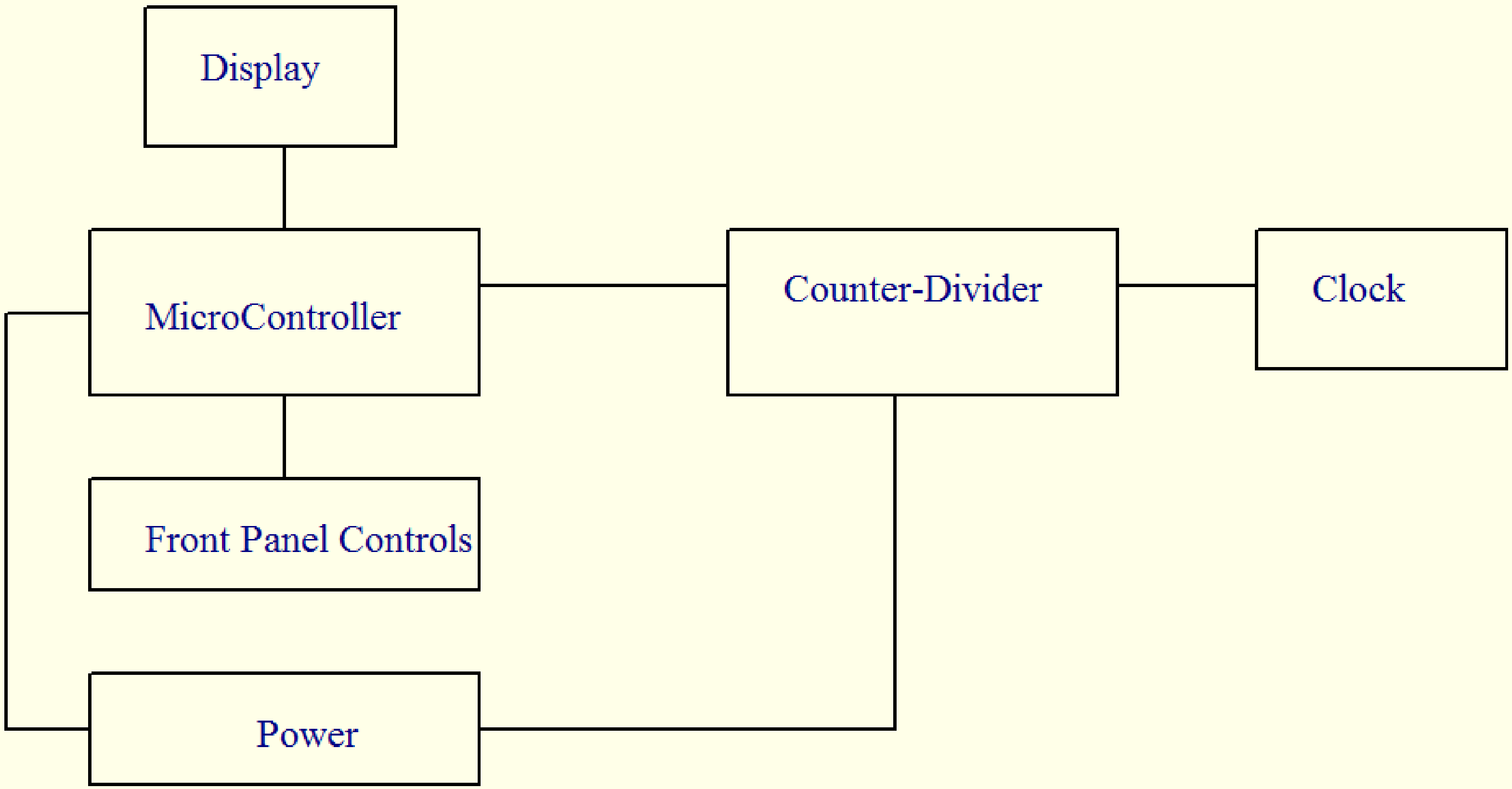


Software and Hardware Partition

System architecture is formulated and mapped to software and hardware blocks.

Hardware and Software Specifications: Hardware design includes choice of microcontroller, memory requirement, front panel controls, display type, communication interface to outside world, definition of input and output signals

Hardware Architecture



Software Flow Diagram

Software tasks are identified in a flow diagram.

Front panel is continuously checking for user interface input – either by polling the input ports or by using an interrupt event that occurs when a user enters a key input.

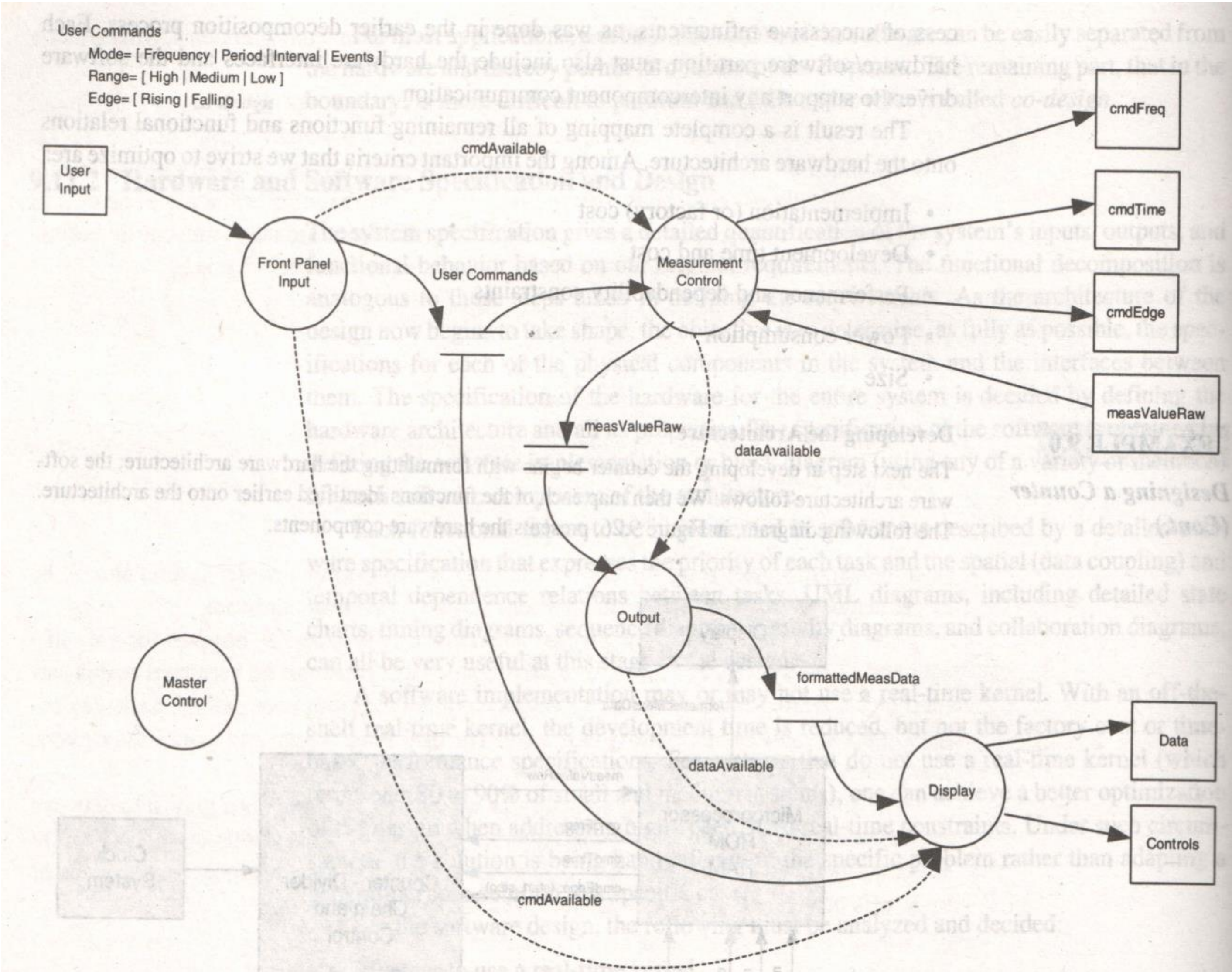
The display is activated upon reception of a user input and the measurement event is activated.

The measurement activity issues appropriate commands to the external counter-divider chain control block.

At the end of each measurement, the raw data is read from the counter-divider and passed to the output task. The output task properly formats the data and sends it to the display task for display on the front panel.

The master control task manages the scheduling of all tasks and performs the necessary housekeeping and other duties.

Software Flow Diagram

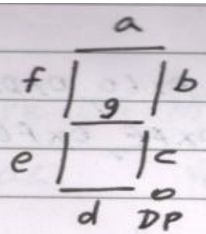


Prototyping and Testing

A prototype implementation includes

- Detailed Design
- Debugging
- Validation
- Testing
- Each level of the implementation must be validated. It must be checked for compliance with the specifications on the corresponding level in the top-down design.

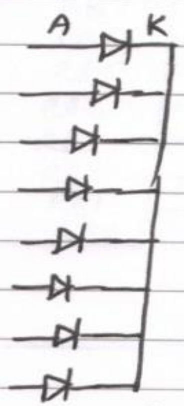
Interfacing with 7 segment Displays



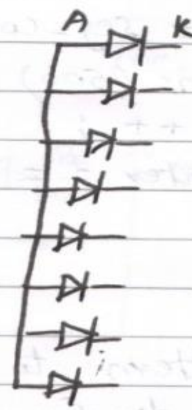
7 segments can be used to show decimal numbers 0 to 9 and can be used to display hexadecimal digits 0 to F

The 8th segment is used to show a decimal point.

Common cathode LEDs are arranged as follows.



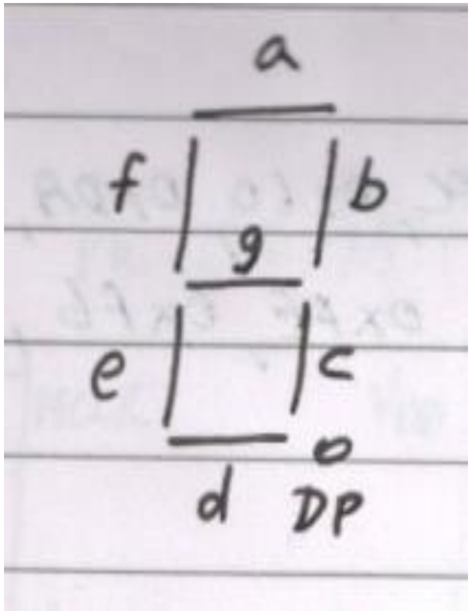
Common anode LEDs are arranged as follows



Cathode needs to be connected to GND and the anode to be connected to an I/o port through a resistor. Making a port pin logic high will turn on the LED.

Anode lead needs to be connected to +5V. Cathode lead needs to be connected to an I/o port.

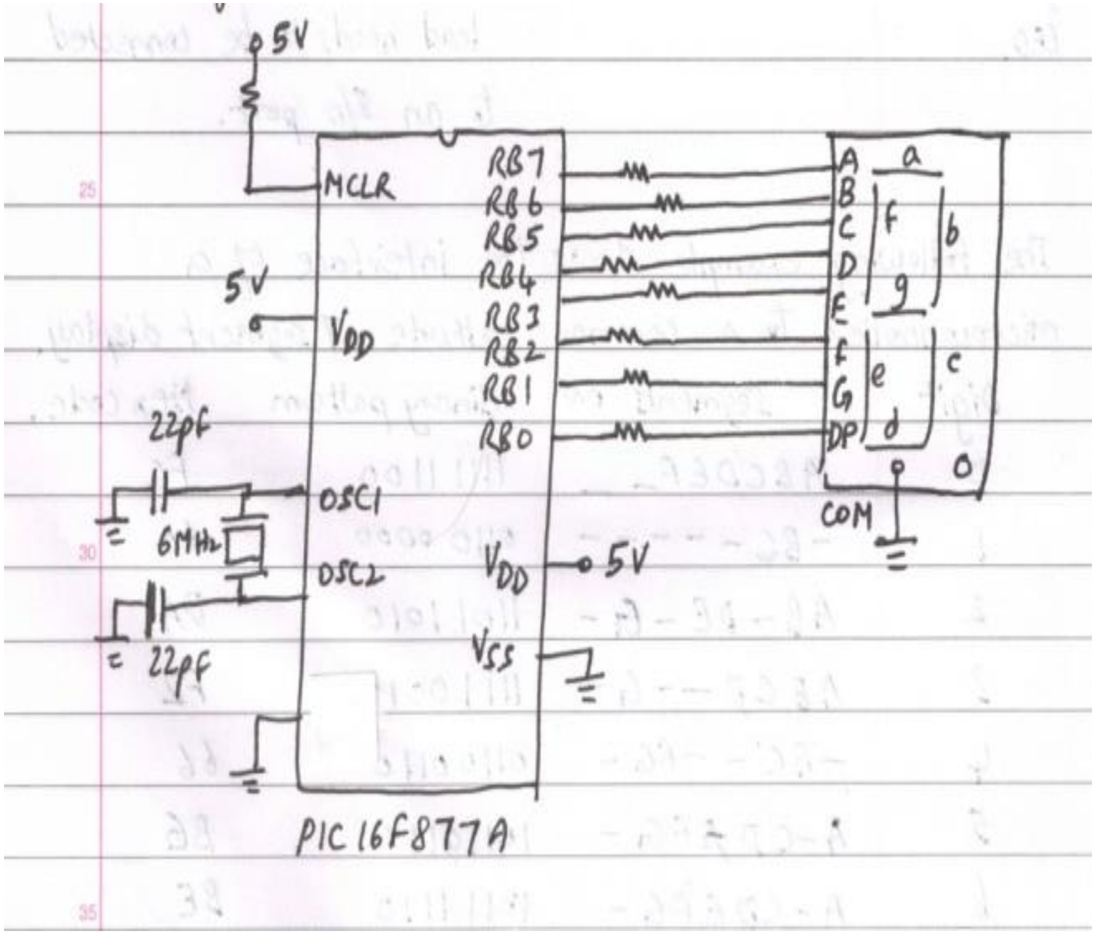
Writing Digits to a single segment



The following example shows the interface of a microcontroller to a common cathode 7 segment display.

Digit	Segments ON	Binary pattern	Hex code.
0	ABCDEF_ _	1111 1100	FC
1	-BC-----	0110 0000	60
2	AB-DE-G-	1101 1010	DA
3	ABCD--G-	1111 0010	F2
4	-BC--FG-	0110 0110	66
5	A-CD-FG-	1011 0110	B6
6	A-CDEFG-	1011 1110	BE
7	ABC-----	1110 0000	E0
8	ABCDEFG-	1111 1110	FE
9	ABCD-FG-	1111 0110	F6
[illegible]	-------DP	0000 0001	01

Interfacing with a Controller



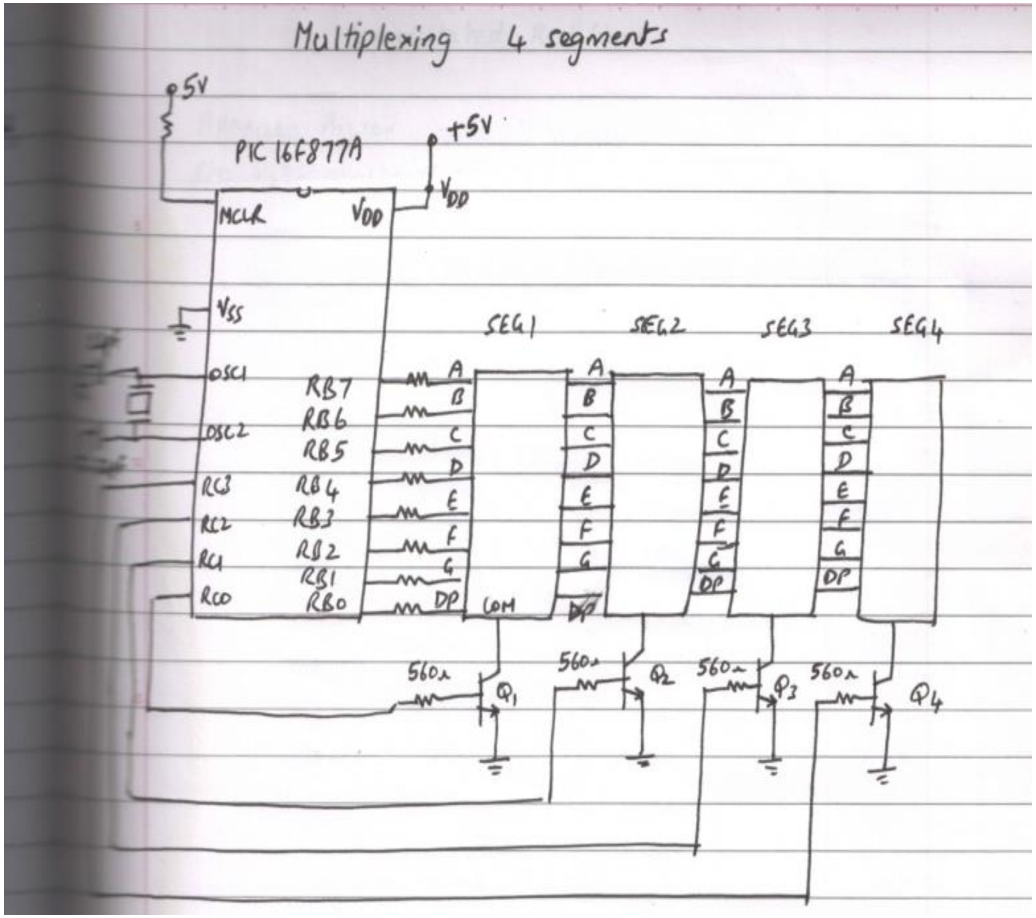
Program for Display

```
//Code written for PIC 16F877A controller using GPIO  (input-output pins)
unsigned seg_code[11] = {0xFC, 0x60,0xDA, 0xF2, 0x66,0xB6,0xBE,0xE0,0xFE,0xF6,0x01};
Unsigned char count =0;
void main ()
{
      TRISB = 0x00;      //Define PORTB for input
      Delay_ms(500);
      while(1)
            {
            PORTB = seg_code[counter];
            Delay_ms(500);
            counter++;
            if (counter==11) counter =0;
            }
}
```

Send the pattern to PORTB so that the display shows 0 to 9 and then decimal point with 0.5 second Delay between digits.

Displaying four segments

One 8-bit port is used to send the char. Code.
Four other pins are used to select one segment On at a time.



Declare PORTB and PORTC as outputs by

TRISC = 0x00 ;

TRISB = 0x00 ;

PORTC = 0x01 ; will make RC0 high and turn on Q1

PORTB = 0xFC ; will now write the bit pattern for digit 0 in SEG1

Delay_ms(10) ; Provide a delay so that the number is displayed in SEG1 for some time.

PORTC = 0x02 ; Deselect segment 1 by turning off the signal to base of Q1 by making RC0 = 0 and enable Q2 to turn on by making RC1 = 1 pattern on PORTC = 0000 0010

PORTB = 0x60 ; will now write the bit pattern in PORTB to write the digit 1 in SEG2

Delay_ms (10) ; Display 1 in SEG2 for some time

Cycle the pattern between SEG1 SEG2 SEG3 SEG4 and so on