Question 1(a) [3 marks]

Draw TIFR register and write its full name.

Answer:

TIFR Register Diagram:

```
+----+----+----+-----+-----+----+----+----+
| 7  | 6  |  5 |  4  |  3  | 2  | 1  | 0  |
+----+----+----+-----+-----+----+----+----+
|OCF2|TOV2|ICF1|OCF1A|OCF1B|TOV1|OCF0|TOV0|
+----+----+----+-----+-----+----+----+----+
```

Full Name: Timer/Counter Interrupt Flag Register

- **TOV0**: Timer0 Overflow Flag
- **OCF0**: Timer0 Output Compare Flag
- **TOV1**: Timer1 Overflow Flag

Mnemonic: "Timer Interrupts Flag Register"

Question 1(b) [4 marks]

Discuss data memory of ATmega32.

Answer:

Memory Type	Size	Address Range	Purpose
General Purpose Registers	32 bytes	0x00-0x1F	R0-R31 registers
I/O Memory	64 bytes	0x20-0x5F	Control registers
Internal SRAM	2048 bytes	0x60-0x85F	Variable storage

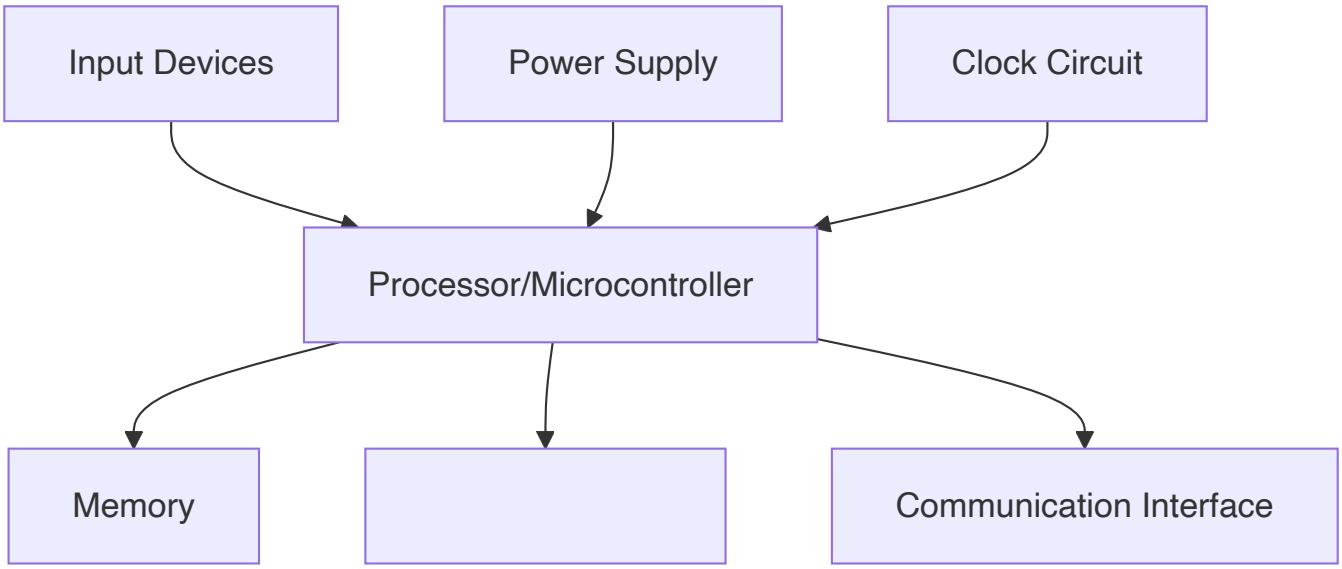
- **General Purpose Registers**: Used for arithmetic operations and temporary storage
- **I/O Memory**: Contains peripheral control and status registers
- **Internal SRAM**: Used for stack, variables, and dynamic memory allocation

Mnemonic: "General I/O SRAM Memory"

Question 1(c) [7 marks]

Draw and explain general block diagram of embedded system.

Answer:



Component	Function
Processor	Controls entire system operation
Memory	Stores program and data
Input Devices	Sensors, switches, keyboards
Output Devices	LEDs, displays, motors
Communication	UART, SPI, I2C interfaces

- **Real-time Operation**: System responds to inputs within defined time limits
- **Dedicated Function**: Designed for specific applications
- **Resource Constraints**: Limited memory, power, and processing capability

Mnemonic: "Processor Memory Input Output Communication"

Question 1(c OR) [7 marks]

Define real time operating system and explain its characteristics.

Answer:

Definition: Real Time Operating System (RTOS) is an operating system that guarantees response within specified time constraints for critical tasks.

Characteristic	Description
Deterministic	Predictable response times
Multitasking	Multiple tasks execution
Priority-based	High priority tasks first
Minimal Latency	Fast interrupt response

- **Hard Real-time**: Missing deadline causes system failure
- **Soft Real-time**: Performance degrades if deadline missed
- **Task Scheduling**: Preemptive priority-based scheduling ensures critical tasks run first

Mnemonic: "Deterministic Multitasking Priority Minimal"

Question 2(a) [3 marks]

Write Criteria for choosing microcontroller for embedded system.

Answer:

Criteria	Importance
Processing Speed	Match application requirements
Memory Size	Sufficient ROM/RAM
I/O Pins	Adequate peripheral interfaces
Power Consumption	Battery life consideration
Cost	Budget constraints
Development Tools	Compiler, debugger availability

Mnemonic: "Speed Memory I/O Power Cost Tools"

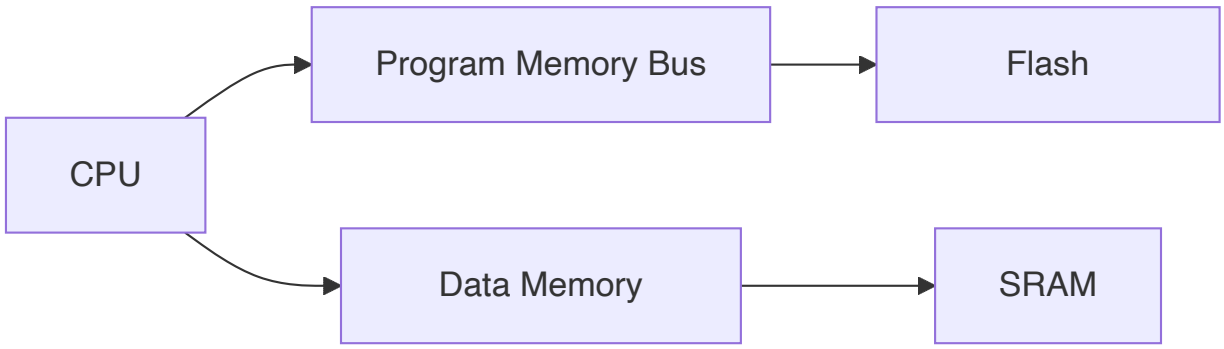
Question 2(b) [4 marks]

Discuss Harvard Architecture in the AVR.

Answer:

Harvard Architecture Features:

Feature	Description
Separate Buses	Program and data have independent buses
Simultaneous Access	Can fetch instruction and access data simultaneously
Different Memory Types	Flash for program, SRAM for data



- **Advantage**: Higher performance due to parallel access
- **16-bit Instructions**: Most instructions execute in single clock cycle

Mnemonic: "Separate Simultaneous Different Performance"

Question 2(c) [7 marks]

Discuss different ways of connecting clock sources to the AVR.

Answer:

Clock Source	Frequency Range	Application
External Crystal	1-16 MHz	High accuracy applications
External RC	1-8 MHz	Cost-effective solution
Internal RC	1-8 MHz	Default, no external components
External Clock	Up to 16 MHz	Synchronized systems

Clock Selection via Fuse Bits:

```
CKSEL3:0 bits determine clock source
CKDIV8 bit divides clock by 8
SUT1:0 bits set startup time
```

- **Crystal Oscillator**: Most stable, requires external crystal and capacitors
- **RC Oscillator**: Less accurate but cheaper
- **Internal Oscillator**: Factory calibrated, temperature dependent

Mnemonic: "Crystal RC Internal External"

Question 2(a OR) [3 marks]

Write size of code ROM, SRAM and EEPROM, Number of I/O pins, ADC and Timers for ATmega32.

Answer:

Specification	ATmega32
Flash ROM	32 KB
SRAM	2 KB
EEPROM	1 KB
I/O Pins	32 pins
ADC Channels	8 channels
Timers	3 timers

Mnemonic: "32K Flash 2K SRAM 1K EEPROM 32 I/O 8 ADC 3 Timers"

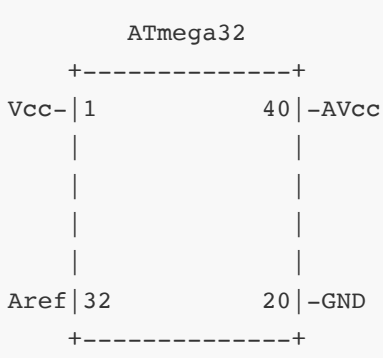
Question 2(b OR) [4 marks]

Draw ATmega32 pin diagram and write function of Vcc, AVcc and Aref pin.

Answer:

Pin Functions:

Pin	Function
Vcc	Main power supply (+5V)
AVcc	Analog power supply for ADC
Aref	ADC reference voltage



- **Vcc**: Supplies power to digital circuits

- **AVcc**: Separate supply for ADC to reduce noise
- **Aref**: External reference for ADC conversion

Mnemonic: "Vcc Digital AVcc Analog Aref Reference"

Question 2(c OR) [7 marks]

Explain AVR status register in detail.

Answer:

SREG (Status Register) Bits:

Bit	Name	Function
7	I	Global Interrupt Enable
6	T	Bit Copy Storage
5	H	Half Carry Flag
4	S	Sign Flag
3	V	Overflow Flag
2	N	Negative Flag
1	Z	Zero Flag
0	C	Carry Flag

```
+---+---+---+---+---+---+---+---+
| I | T | H | S | V | N | Z | C |
+---+---+---+---+---+---+---+---+
  7   6   5   4   3   2   1   0
```

- **I Flag**: Controls global interrupt enable/disable
- **Arithmetic Flags**: C, Z, N, V, S, H updated after ALU operations
- **T Flag**: Used by BLD and BST instructions for bit manipulation

Mnemonic: "I Transfer Half Sign oVerflow Negative Zero Carry"

Question 3(a) [3 marks]

Explain RESET circuit for the AVR microcontroller.

Answer:

Reset Sources:

Reset Source	Description
Power-on Reset	When power is applied
External Reset	Through RESET pin
Brown-out Reset	When voltage drops
Watchdog Reset	Watchdog timer overflow

```
Vcc ----[R]----+---- RESET pin
               |
               C
               |
              GND
```

- **Reset Duration**: Minimum 2 clock cycles
- **Reset Vector**: Program starts from address 0x0000

Mnemonic: "Power External Brown-out Watchdog"

Question 3(b) [4 marks]

List I/O registers associated with EEPROM. Write programming steps to write data on EEPROM.

Answer:

EEPROM Registers:

Register	Function
EEAR	EEPROM Address Register
EEDR	EEPROM Data Register
EECR	EEPROM Control Register

Programming Steps:

1. Wait for previous write to complete (check EEWE bit)
2. Set address in EEAR register
3. Set data in EEDR register
4. Set EEMWE bit in EECR
5. Set EEWE bit within 4 clock cycles

Mnemonic: "Wait Address Data Master-Write Enable-Write"

Question 3(c) [7 marks]

Draw and explain TCCR0 register in detail.

Answer:

TCCR0 (Timer/Counter0 Control Register):

Bit	Name	Function
7	FOC0	Force Output Compare
6,3	WGM01,WGM00	Waveform Generation Mode
5,4	COM01,COM00	Compare Output Mode
2,1,0	CS02,CS01,CS00	Clock Select

```
+-----+-----+-----+-----+-----+-----+-----+-----+
|FOC0 |WGM01|COM01|COM00|WGM00|CS02 |CS01 |CS00 |
+-----+-----+-----+-----+-----+-----+-----+-----+
  7     6     5     4     3     2     1     0
```

Clock Select Options:

- 000: No clock (Timer stopped)
- 001: clk/1 (No prescaling)
- 010: clk/8, 011: clk/64
- 100: clk/256, 101: clk/1024

Mnemonic: "Force Waveform Compare Clock Select"

Question 3(a OR) [3 marks]

List registers associated with Timer 1.

Answer:

Timer1 Registers:

Register	Function
TCCR1A	Timer1 Control Register A
TCCR1B	Timer1 Control Register B
TCNT1H/L	Timer1 Counter Register
OCR1AH/L	Output Compare Register A
OCR1BH/L	Output Compare Register B
ICR1H/L	Input Capture Register

Mnemonic: "Control Counter Output-Compare Input-Capture"

Question 3(b OR) [4 marks]

Write an AVR C program to store 'G' into location 0x005F of EEPROM.

Answer:

```
#include <avr/io.h>
#include <avr/eeprom.h>

void eeprom_write_byte_custom(uint16_t addr, uint8_t data)
{
    while(EECR & (1<<EEWE));  // Wait for previous write
    EEAR = addr;              // Set address
    EEDR = data;              // Set data
    EECR |= (1<<EEMWE);       // Master write enable
    EECR |= (1<<EEWE);        // Write enable
}

int main()
{
    eeprom_write_byte_custom(0x005F, 'G');
    return 0;
}
```

Program Steps:

- Check EEWE bit for completion
- Load address 0x005F into EEAR
- Load 'G' (ASCII 71) into EEDR
- Enable master write, then write enable

Mnemonic: "Wait Address Data Master Write"

Question 3(c OR) [7 marks]

Write a C program to toggle only the PORTB.4 bit continuously every 70 µs. Use Timer0, Normal mode, and 1:8 prescaler to create the delay. Assume XTAL = 8 MHz.

Answer:

```
#include <avr/io.h>

int main()
{
    DDRB |= (1<<4);           // Set PB4 as output
    TCCR0 = 0x02;             // Prescaler 1:8

    while(1)
```

```
    {
        TCNT0 = 186;           // Load initial value
        while(!(TIFR & (1<<TOV0))); // Wait for overflow
        TIFR |= (1<<TOV0);     // Clear flag
        PORTB ^= (1<<4);       // Toggle PB4
    }
    return 0;
}
```

Calculation:

- Clock = 8MHz/8 = 1MHz
- For 70μs: Count = 70 cycles
- Initial value = 256-70 = 186

Mnemonic: "Direction Control Count Wait Clear Toggle"

Question 4(a) [3 marks]

Write an AVR C program to monitor bit 5 of port C. If it is HIGH, send 55H to Port B; otherwise, send AAH to Port B.

Answer:

```
#include <avr/io.h>

int main()
{
    DDRC &= ~(1<<5);           // PC5 as input
    DDRB = 0xFF;               // Port B as output

    while(1)
    {
        if(PINC & (1<<5))      // Check PC5
            PORTB = 0x55;      // Send 55H if HIGH
        else
            PORTB = 0xAA;      // Send AAH if LOW
    }
    return 0;
}
```

Program Logic:

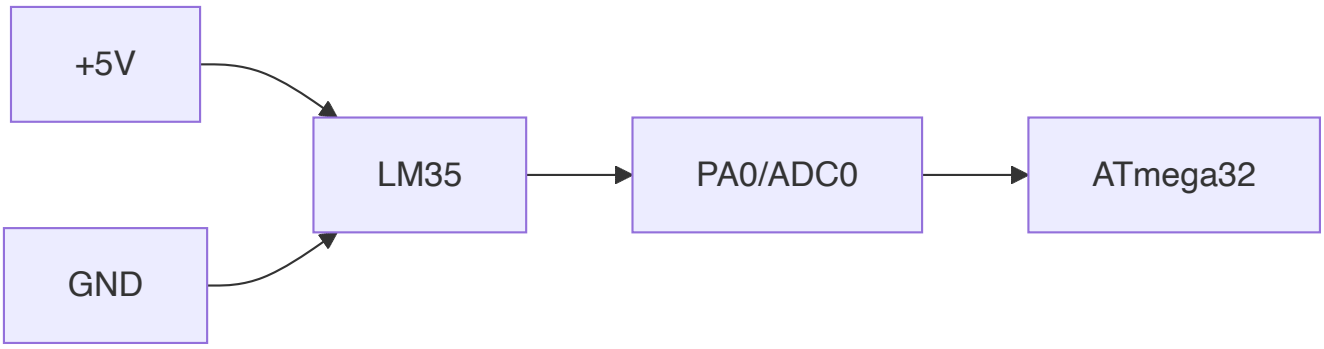
- Configure PC5 as input, Port B as output
- Continuously check PC5 status
- Output 0x55 or 0xAA based on input

Mnemonic: "Direction Check Output"

Question 4(b) [4 marks]

Draw and explain interfacing of LM35 with ATmega32.

Answer:



Connection Table:

LM35 Pin	ATmega32 Pin	Function
Vcc	+5V	Power supply
Output	PA0 (ADC0)	Analog voltage
GND	GND	Ground

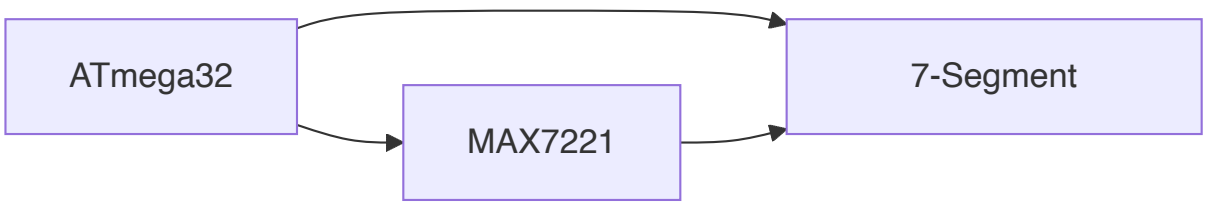
- **Temperature Conversion**: 10mV/°C output
- **ADC Resolution**: 10-bit (0-1023)
- **Voltage Range**: 0V to 5V (0°C to 500°C)

Mnemonic: "Power Output Ground Temperature"

Question 4(c) [7 marks]

Draw and explain interfacing of MAX7221 with ATmega32.

Answer:



Connection Table:

MAX7221 Pin	ATmega32 Pin	Function
DIN	MOSI (PB5)	Serial data input
CLK	SCK (PB7)	Serial clock
LOAD	SS (PB4)	Chip select

Features:

- **SPI Interface**: Serial communication protocol
- **8-Digit Display**: Controls up to 8 seven-segment displays
- **Built-in Decoder**: BCD to seven-segment conversion
- **Brightness Control**: 16 intensity levels

Programming Steps:

1. Initialize SPI in master mode
2. Send address and data bytes
3. Pulse LOAD signal to latch data

Mnemonic: "Serial Clock Load Display"

Question 4(a OR) [3 marks]

Write an AVR C program to get a byte of data from Port B, and then send it to Port C.

Answer:

```c
#include <avr/io.h>

int main()
{
    DDRB = 0x00;              // Port B as input
    DDRC = 0xFF;              // Port C as output

    uint8_t data;

    while(1)
    {
        data = PINB;          // Read from Port B
        PORTC = data;         // Send to Port C
    }
    return 0;
}
```

Program Function:

- Configure Port B as input, Port C as output

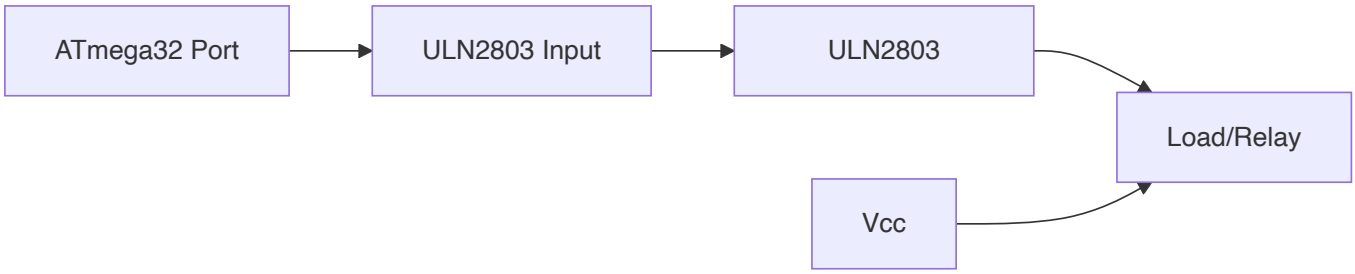
- Continuously read from PINB and write to PORTC

Mnemonic: "Input Output Read Write"

Question 4(b OR) [4 marks]

Draw and explain interfacing of ULN2803 with ATmega32.

Answer:



ULN2803 Features:

Feature	Description
8 Darlington Arrays	High current switching
Input Current	500μA typical
Output Current	500mA per channel
Built-in Flyback Diodes	Inductive load protection

- **Application**: Drive relays, motors, solenoids
- **Voltage Drop**: 1.2V typical across Darlington pair
- **Active Low Output**: Output goes low when input is high

Mnemonic: "Darlington Current Protection Drive"

Question 4(c OR) [7 marks]

Discuss registers used to program SPI in the AVR.

Answer:

SPI Registers:

Register	Bits	Function
SPCR	SPE, DORD, MSTR, CPOL	SPI Control Register
SPSR	SPIF, WCOL, SPI2X	SPI Status Register
SPDR	-	SPI Data Register

SPCR Register Bits:

- **SPE**: SPI Enable
- **DORD**: Data Order (MSB/LSB first)
- **MSTR**: Master/Slave Select
- **CPOL**: Clock Polarity
- **CPHA**: Clock Phase

SPSR Register Bits:

- **SPIF**: SPI Interrupt Flag
- **WCOL**: Write Collision Flag
- **SPI2X**: Double Speed Mode

Programming Sequence:

1. Configure SPI pins as input/output
2. Set SPCR register for desired mode
3. Write data to SPDR
4. Wait for SPIF flag
5. Read received data from SPDR

Mnemonic: "Control Status Data Enable Order Master"

Question 5(a) [3 marks]

Draw and explain pin diagram of L293D motor driver IC.

Answer:

```
        L293D
    +-----------+
1EN-|1        16|-Vcc1
1A--|2        15|-4A
1Y--|3        14|-4Y
GND-|4        13|-GND
GND-|5        12|-GND
2Y--|6        11|-3Y
2A--|7        10|-3A
Vcc2|8         9|-2EN
    +-----------+
```

Pin Functions:

Pin	Function
1A, 2A	Input signals for Motor 1
3A, 4A	Input signals for Motor 2
1Y, 2Y	Output to Motor 1
3Y, 4Y	Output to Motor 2
1EN, 2EN	Enable pins for motors
Vcc1	Logic supply (+5V)
Vcc2	Motor supply (+12V)

Mnemonic: "Input Output Enable Logic Motor Supply"

Question 5(b) [4 marks]

Draw and explain ADMUX register.

Answer:

ADMUX (ADC Multiplexer Selection Register):

Bit	Name	Function
7,6	REFS1,REFS0	Reference Selection
5	ADLAR	ADC Left Adjust Result
4-0	MUX4-MUX0	Analog Channel Selection

```
+------+------+------+------+------+------+------+------+
|REFS1 |REFS0 |ADLAR | MUX4 | MUX3 | MUX2 | MUX1 | MUX0 |
+------+------+------+------+------+------+------+------+
   7      6      5      4      3      2      1      0
```

Reference Selection:

- 00: AREF pin
- 01: AVcc with external capacitor
- 11: Internal 2.56V reference

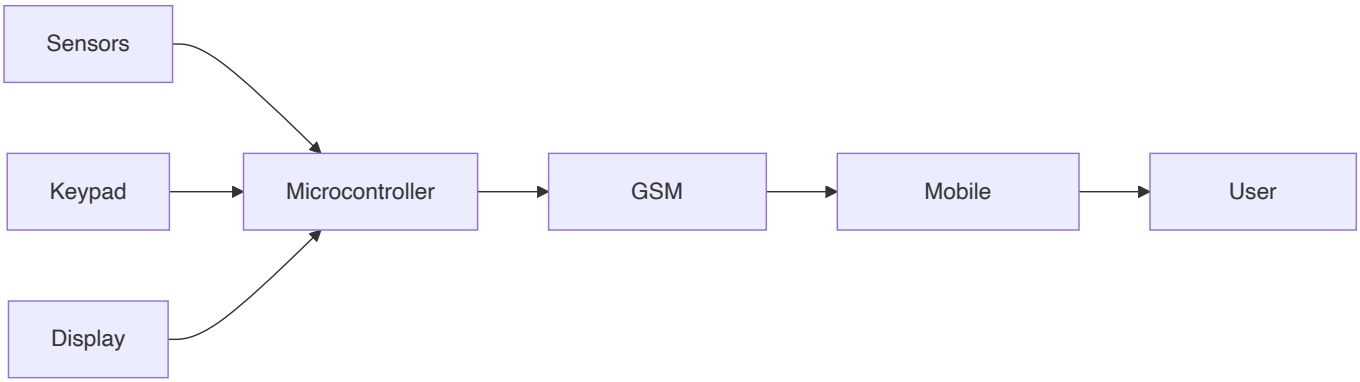
Channel Selection: MUX bits select ADC0-ADC7 channels

Mnemonic: "Reference Adjust Multiplexer Channel"

Question 5(c) [7 marks]

Explain GSM based security system.

Answer:



System Components:

Component	Function
PIR Sensor	Motion detection
Door Sensor	Entry detection
GSM Module	SMS/Call communication
Microcontroller	System control
Keypad	User interface
Display	Status indication

Working Principle:

1. Sensors detect intrusion
2. Microcontroller processes signal
3. GSM module sends SMS alert
4. User receives notification
5. System can be armed/disarmed remotely

Features:

- **Remote Monitoring**: SMS notifications
- **Multiple Sensors**: PIR, door, window sensors
- **User Interface**: LCD display and keypad
- **Emergency Response**: Automatic alert system

Mnemonic: "Sensors Process Communicate Alert Control"

Question 5(a OR) [3 marks]

Draw circuit diagram to interface DC motor with ATmega32 using L293D motor driver.

Answer:

```
ATmega32          L293D           DC Motor
    |               |               |
PA0 -----------> 1A(2)         1Y(3) -----> Motor +
PA1 -----------> 2A(7)         2Y(6) -----> Motor -
PA2 -----------> 1EN(1)
    |               |
   GND ----------> GND(4,5,12,13)
   +5V ----------> Vcc1(16)
   +12V ---------> Vcc2(8)
```

Connection Table:

ATmega32	L293D	Function
PA0	1A (Pin 2)	Direction control 1
PA1	2A (Pin 7)	Direction control 2
PA2	1EN (Pin 1)	Motor enable

Motor Control:

- PA0=1, PA1=0: Clockwise rotation
- PA0=0, PA1=1: Counter-clockwise rotation
- PA2=0: Motor stop

Mnemonic: "Direction Enable Control Stop"

Question 5(b OR) [4 marks]

Draw and explain ADCSRA register.

Answer:

ADCSRA (ADC Control and Status Register A):

Bit	Name	Function
7	ADEN	ADC Enable
6	ADSC	ADC Start Conversion
5	ADATE	ADC Auto Trigger Enable
4	ADIF	ADC Interrupt Flag
3	ADIE	ADC Interrupt Enable
2-0	ADPS2-ADPS0	ADC Prescaler Select

```
+-----+-----+-----+-----+-----+-----+-----+-----+
|ADEN |ADSC |ADATE|ADIF |ADIE |ADPS2|ADPS1|ADPS0|
+-----+-----+-----+-----+-----+-----+-----+-----+
  7     6     5     4     3     2     1     0
```

Prescaler Selection:

- 000: Division factor 2
- 001: Division factor 2
- 010: Division factor 4
- 011: Division factor 8

ADC Operation Steps:

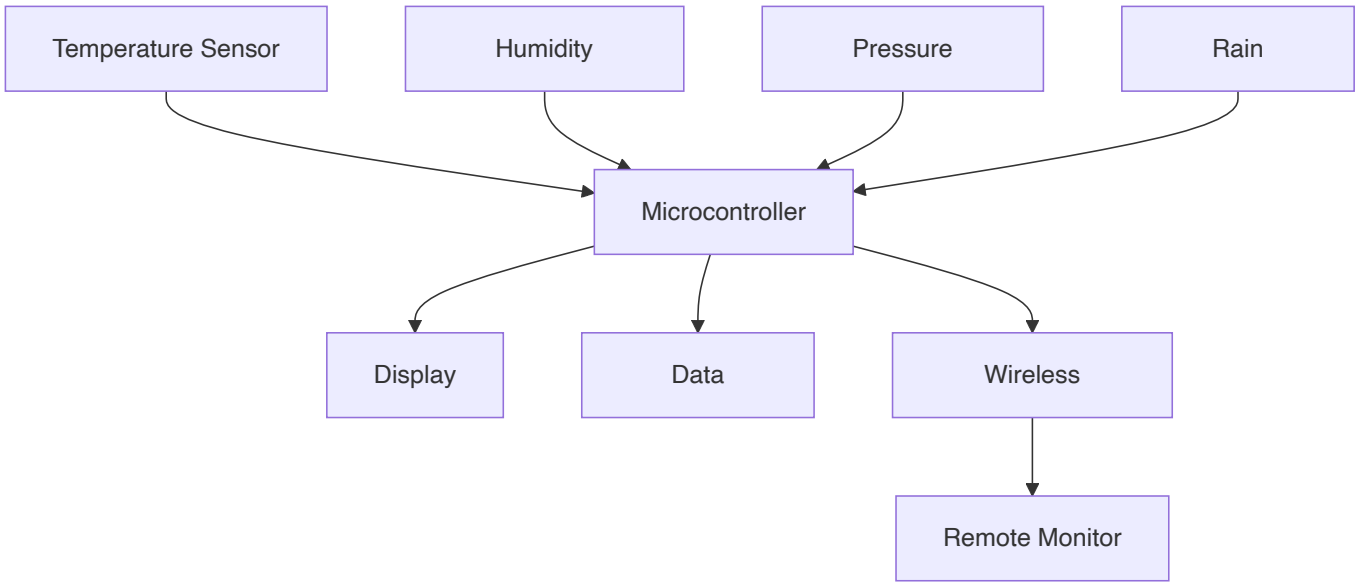
1. Set ADEN to enable ADC
2. Set ADSC to start conversion
3. Wait for ADIF flag
4. Read result from ADCH:ADCL

Mnemonic: "Enable Start Auto Interrupt Prescaler"

Question 5(c OR) [7 marks]

Explain Weather monitoring system.

Answer:



System Components:

Sensor	Parameter	Interface
LM35	Temperature	Analog (ADC)
DHT11	Humidity	Digital
BMP180	Pressure	I2C
Rain Sensor	Precipitation	Digital

Features:

- **Multi-parameter Monitoring**: Temperature, humidity, pressure, rainfall
- **Data Logging**: Store readings in EEPROM/SD card
- **Real-time Display**: LCD shows current readings
- **Wireless Communication**: WiFi/GSM for remote monitoring
- **Alert System**: Threshold-based warnings

Applications:

- Agricultural monitoring
- Weather forecasting
- Environmental research
- Smart home automation

System Benefits:

- **Automated Data Collection**: Continuous monitoring
- **Remote Access**: View data from anywhere

- **Historical Analysis**: Trend identification
- **Early Warning**: Extreme weather alerts

Mnemonic: "Temperature Humidity Pressure Rain Display Log Wireless"