A Low-Cost Solution For Multi-Sensor Integration Via Single Analog Pin

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Abstract- *This paper presents a novel method for efficiently record or capture multi-sensor Data using a 4017 decadal counter. The new method configures the function of the sensor, allowing each sensor to use each pulse of the clock in sequence. Using this technique, a pair of sensors talk seamlessly through a single Analog pin, greatly reducing hardware complexity and cost. The use of the 4017 counter optimizes support distribution, allowing better integration of sensors. The simplicity, affordability, and scalability of the technique all combine to make it an attractive answer for systems that need to acquire multi-sensor data. This technique demonstrates its effectiveness, and provides a powerful response for receiving simultaneous sensor records. This study suggests a promising approach for rational, cost-effective implementation in various applications that require robust multi sensor capabilities.*

Keywords- Sensors, Decade counter, Analog, Hardware, Cost Effective ,Efficiency, IOT, Electronics.

I. INTRODUCTION

The integration of multiple sensors into a cohesive system for comprehensive data capture has long been an area of interest and challenge in sensor technology. Traditional methods often involve dedicating individual pins to each sensor, resulting in increased hardware complexity, higher costs, and inefficiencies in resource utilization. Addressing these challenges, this paper presents a pioneering methodology harnessing the capabilities of the 4017 decade counter to revolutionize multi-sensor data capture.At its core, this innovative technique orchestrates the activation of sensors in a sequential manner, synchronized with each clock pulse generated by the Microcontroller. This orchestrated activation empowers a single Analog pin to engage with multiple sensors in a systematic sequence, transcending the limitations of conventional one-to-one sensor-to-pin configurations. By leveraging this methodology, we aim to streamline sensor integration, significantly reduce hardware complexity, and optimize resource utilization without compromising the quality and accuracy of captured data.The counter's inherent ability to cycle through ten outputs in a predetermined sequence aligns seamlessly with the requirement for changing multiple sensors through a singular Analog pin. By providing a comprehensive elucidation of the operational principles and the integration process, this research establishes a robust framework for implementing this groundbreaking technique.The significance of this methodology lies in its potential to transform the landscape of multi-sensor data capture, especially in scenarios where cost efficiency, compact design, and streamlined integration are paramount. Moreover, the simplicity and cost-effectiveness of our technique hold promise for applications in resource-constrained environments, IoT deployments, industrial automation, healthcare, and beyond.By shedding light on the practical implementation, performance, and versatility of this novel approach, this research aims to contribute to the advancement of sensor technology, offering a new paradigm for efficient, low-cost, and robust multi-sensor data capture.

II. METHODOLOGY

2.1 Component Overview

2.1.1 4017 Decade Counter

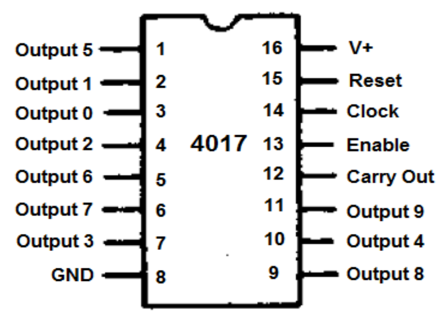

Fig 1 4017IC Pinout

A decade counter counts to 10. The counter increases with one for every rising clock pulse. After the counter has reached 9, it starts again from 0 with the next clock pulse. [1]CD4017 work on 3v to 15v .Connect the VDD pin to the positive terminal and the GND pin to the negative terminal. The Clock (CLK) pin increases the counter with one every time the pin goes from low to high. And as the count increases, the output pins (Q0-Q9) get high one by one. After the 10th input pulse, the counter resets and starts from 0 again.

Change this pin from low to high to increase the counter. The output pins Q0 to Q9 goes high one by one as the counter increases. Connect each to a resistor and LED if you want to see pins change state. The Clock Inhibit (CI) pin disables the counter so that any clock pulse on the CLK pin is ignored. Set this pin to low to enable the counter. The Carry-out (CO) pin goes from low to high when the counter reaches 10 and resets back to 0. It stays high for 5 clock pulses, then goes low again. Connect this pin to the clock input of another decade counter if you want to count higher than 10. The Reset pin is use for resetting the counter if any point of output we want to reset so we provide high power to this pin. For example we want to only count 4 output so pin 10 connect with reset pin so when pin 10 is high so it reset and again start with 0.

2.1.2 Transistor

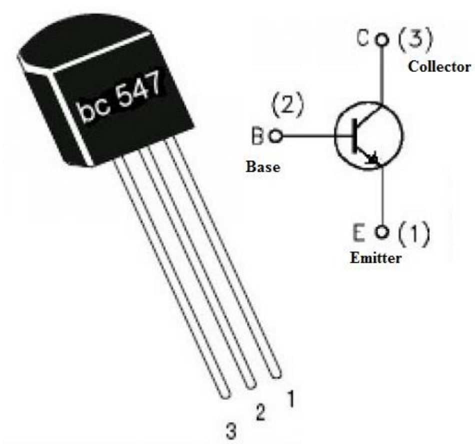

Fig 2 Transistor

In Transistor When a small current flows through the base, it controls the flow of a much larger current between the emitter and the collector. [2] This is due to the fact that the base-emitter junction is forward-biased, thereby allowing electrons to flow from the emitter to the base. The base-collector junction is reverse-biased, which means that electrons are prevented from flowing from the base to the collector. However, when a current flows through the base it opens up the base-collector junction and allows electrons to flow from the emitter to the collector. Here we use transistor for MQ sensor power supply.

2.1.3 Capacitor

Fig 3 Capacitor

A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge. [3]Here we use capacitor for stopping resetting the output to some unwanted voltage and always start counter to 0. If we not use this capacitor so it randomly start with any output pin.

2.1.4 Resistor

Fig 4 Resistor

The resistor is a passive electrical component that creates resistance in the flow of electric current. Here we use resistor for controlling current.

2.1.5 Sensors

Here we use MQ series sensor like mq2,mq3,mq4,mq5,mq6,mq7,mq8 this all sensor we use for testing purpose. [4] We can use multiple sensor according to our applications. Here this all sensor required more power that’s why we use transistor if we have low power sensor so we can directly connect with ic4017.

2.2Circuit Design and Interfacing

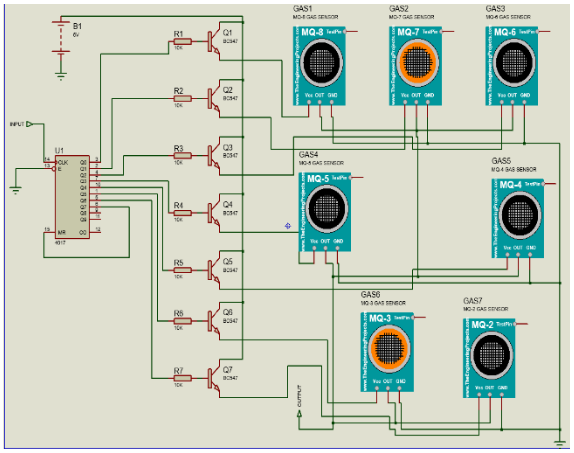

Fig 5 Circuit Diagram

In the above circuit all the MQ sensor ground pin is connect with each other and same for the output pin A0(Analog output) for all sensors. the cd4017 IC CLK pin is for clock input and the pin 13 is active low so it connect with ground, pin 6 and pin 15 are connect for resetting after 7th clock. Then all output pin from q0 to q6 is connect with each sensor VCC pin. When we power up the circuit so first it turn on the first sensor like wise each clock pulse it turn on the next sensor and using common Analog pin we can read the output or sensing the data of the particular sensor.(Here we use transistor because MQ sensor required more power but if you want use IR sensor or LDR sensor so you can directly connect sensor VCC pin to the 4017ic).

III. PROTOTYPE AND EXPERIMENTAL SETUP

So in our experiment we take 7 MQ series sensor and each sensor ground and Analog output pin connect with common showing on above circuit diagram. Here we use bc547 transistor for active each sensor according to the clock pulse. For clock pulse and reading the output we use Arduino uno. In our setup we connect VCC to the Arduino 5V pin , ground is connected to Arduino GND pin and Cooman Analog pin is connect with Arduino Analog pin A0 and clock pin is connect to the Arduino digital pin 7. In prototype we use breadboard for easy connection.

3.1 Setup

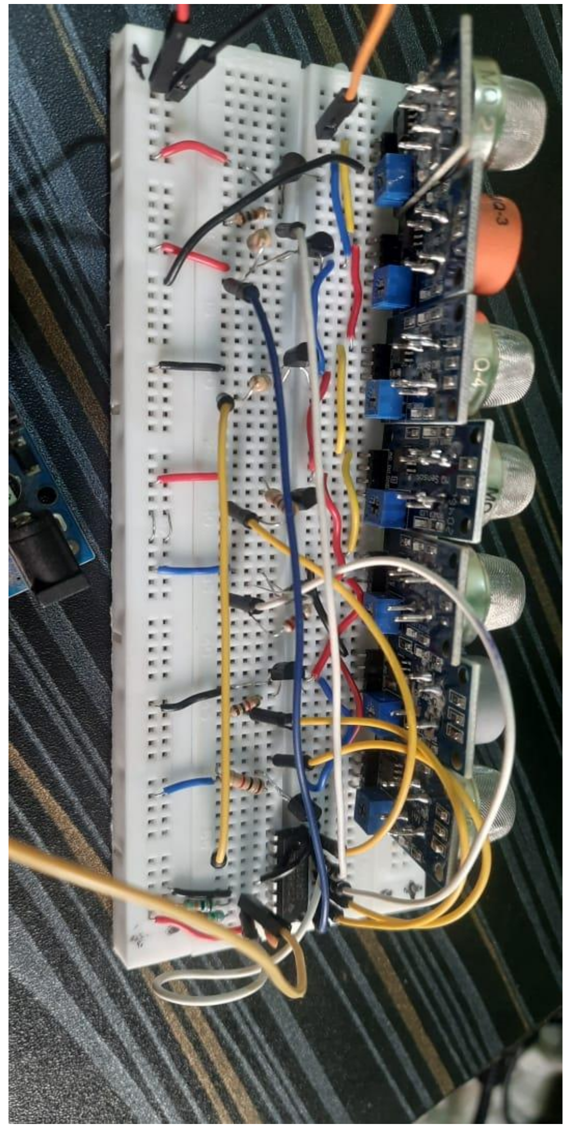

Fig 6 Prototype

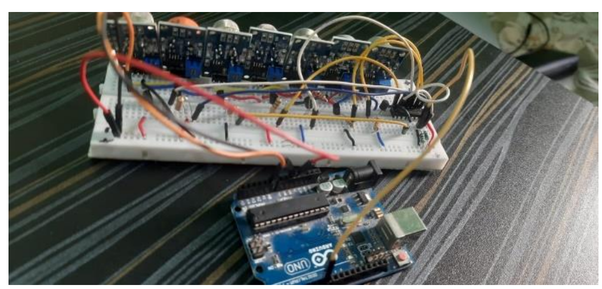

Fig 7 Prototype

3.2 Code for Arduino

```
int total_sensors = 7;
int current_sensor = 1;
String sensors_name[7] = {"MQ135","MQ7","MQ6","MQ5","MQ4","MQ3","MQ2"};
void setup() {
Serial.begin(9600);
```

```
pinMode(7,OUTPUT);
pinMode(A0,INPUT);
digitalWrite(7,LOW);
}
void loop() {
  int output = analogRead(A0);
Serial.print(sensors_name[current_sensor-1]);
Serial.print("  :  ");
Serial.println(output);
delay(1000);
digitalWrite(7,HIGH);
delay(5);
digitalWrite(7,LOW);
current_sensor = current_sensor + 1;
  if(current_sensor==total_sensors+1){
current_sensor = 1;
Serial.println("");
  }
}
```

In Arduino code we print sensor name and also print the output value of the sensor total_sensors variable store how many sensor we attach with counter IC if we have more than 10 sensor so we can cascade the 4017 IC and add more sensors. here sensors_name array if just for the experiment purpose to show exactly which sensor give value.

IV. RESULT

So in result we can show that each clock pulse it turn on a single sensor and read data and print value on serial monitor, here we take 7 sensor so it print 7 value and after 7 clock pulse it reset IC and Goto the first sensor value. So using this approach we can capture multiple sensor data using single Analog pin and one digital pin.

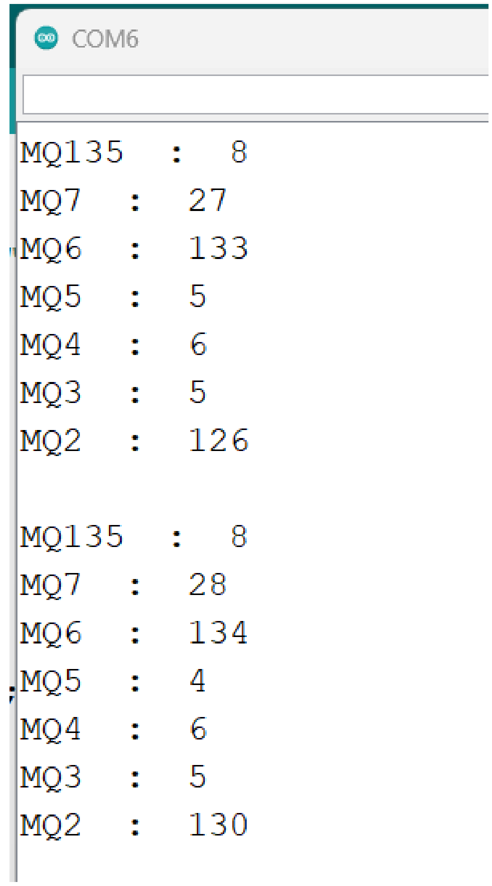

Fig 8 Result

V. ADVANTAGES

Cost Efficiency: Drastically reduces hardware costs by utilizing fewer pins and simplified circuitry.

Hardware Simplification: Minimizes the complexity of the sensor interface circuitry.

Resource Optimization: Efficiently utilizes Analog pins, optimizing resource allocation.

Reduced Component Count: Decreases the number of required components for sensor integration.

Space-saving Design: Enables a more compact and streamlined hardware setup.

Ease of Integration: Simplifies the process of integrating multiple sensors into a system.

Scalability: Offers potential for scalability without proportional increases in hardware complexity.

Versatility: Accommodates various sensor types, enhancing system flexibility.

Lower Power Consumption: Reduces power requirements compared to conventional methods.

Real-time Data Acquisition: Facilitates near-real-time data capture from multiple sensors.

Reliability: Provides consistent and reliable sequential sensor readings.

Improved Resource Utilization: Enhances efficiency in resource usage, reducing waste.

Time Efficiency: Speeds up the process of reading data from multiple sensors.

Customization: Allows for tailored configurations for specific sensor setups.

Adaptability: Adapts well to diverse application scenarios and environments.

Reduced Signal Interference: Minimizes signal interference among sensors due to sequential activation.

Ease of Maintenance: Simplifies troubleshooting and maintenance of sensor systems.

Compatibility: Compatible with a wide range of microcontrollers and systems.

Lower Development Complexity: Eases the complexity of sensor system development.

Suitability for IoT Applications: Ideal for compact and cost-effective IoT sensor nodes.

VI. APPLICATION

Internet of Things (IoT) Devices: Facilitates cost-effective and compact sensor nodes for IoT applications.

Environmental Monitoring: Enables comprehensive data collection for climate monitoring, air quality assessment, and weather stations.

Industrial Automation: Integration into machinery for monitoring parameters like temperature, pressure, and vibration, enhancing operational efficiency and predictive maintenance.

Healthcare and Biomedical Devices: Data acquisition for medical monitoring devices, supporting advancements in remote patient monitoring and diagnostics.

Agriculture and Precision Farming: Monitoring soil conditions, moisture levels, and environmental parameters for optimized farming practices.

Consumer Electronics: Integration into smart home devices or wearables for enhanced functionality and user experience.

Automotive Systems: Application in vehicles for monitoring engine performance, tire pressure, and environmental conditions, contributing to safety and efficiency.

Energy Management: Monitoring power generation, consumption, and distribution for optimizing energy efficiency and grid management.

Security and Surveillance: Utilization in security systems for integrating sensors like motion detectors and environmental sensors for enhanced surveillance

VII. CONCLUSION

This research introduces a novel methodology harnessing the 4017 decade counter for multi-sensor data capture through a single analog pin, revolutionizing traditional sensor integration. The sequential sensor activation approach demonstrated consistent and accurate data acquisition across diverse sensors, showcasing cost-efficiency, hardware simplification, and resource optimization. The methodology's versatility spans IoT, healthcare, industrial automation, and more, promising significant advancements in sensor technology. While validating its efficacy, future research avenues include scalability for larger networks and optimization for specific sensor types, further solidifying its potential as a game-changer in concurrent multi-sensor data capture, driving innovation in various industries.

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