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Low Cost 'Smart' Switch for Designing Electronic Nose (e-nose) for Gas Sensing Applications

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Abstract: **Gas detection is important not only because of the manufacturing industry but also because of a number of wider societal benefit s accruing from the use of gas sensors. Some of the envisaged utilities include providing early and rapid diagnostics in healthcare, monitoring complex industrial processes, monitoring and reducing pollutants in the immediate environment, providing early detection and forensic analysis for homeland security, curbing pollution by improving efficiency in transport etc.**

The present work describes development of a 'smart' switch which allows sequential measurement of four separate outputs from individual gas sensing elements configured as an Electronic Nose (E-Nose) by an interfaced digital multimeter (DMM). The 'smart' switch allows data acquisition on the RS-232 enabled DMM automatically from the E-Nose in a timed sequence wherein the interval is user controlled (2 – 30 seconds).

The low cost 'smart' switch enabled with autonomous function has been put together using modular discrete electronic circuits consisting of a 555 timer driving a 7474 based asynchronous counter that sources signals from the analog multiplexer designed using 74HC4051. Output from the array of partially selective gas sensors where each sensor acts as a receptor to a particular gas is sequentially selected by the stand-alone switch with autonomous capability devoid of any human interference.

Keywords: **Gas Sensing, Electronic Nose, Smart switch, Data Acquisition**

1. INTRODUCTION

Sensors are devices that sense a stimulus and convert it into an electrical output directly or in a tandem way and therefore basically translate a generally non-electrical value to an electrical value. Sensor technology plays a major role in, protecting the environment, security of the nation, and improving reliability and efficiency of manufacturing operations. Gas sensors typically detect chemical pollutants like CO_2, CO, NOx, SOx, HCl, H_2S, volatile organic compounds (VOCs) and fluorocarbons the onslaught of which the humans face in day to day lives. The gas sensors detecting these gaseous pollutants typically find applications as domestic gas alarms, medical diagnostic apparatus, mine safety, real-time environment monitoring, chemical plant instrumentation and homeland security to name a few.

Typically the four functions of any gas sensing measurement module would include a) detection of target gas, b) recording of its sensing characteristics c) acquisition of the recorded data onto a storage device like computer etc. and d) memory search and identification of the acquired data.

Existing gas sensors with small size and rigid construction allow both online and offline measurements at domestic or environmental sites, however single sensors designed to detect specific gases fail to muster the final hurdle because of "cross-sensitivity" problem [1 - 3]. Since target gases do not occur individually hence there is an urgent need to reliably detect a mixture of gases in real-time. Mimicking the human nose to provide rapid olfactory information at low cost is the need of the hour especially as one gets limited by human factors such as fatigue and exposure to toxins.

In the last two decades detection of simple and complex gas mixtures by means of an array of electronic sensors has led to the development of so called 'Electronic nose' (E-Nose). E-Nose comprises of an array of partially selective sensors where each 'sensing element' behaves like a receptor by responding to different odours (gases) to varying degrees followed by processing and identification using a pattern recognition system [4 - 6]. The pattern recognition system allows the E-Nose to perform akin to the mammalian sensor signal processing system.

In the present study a 'smart' switch is constituted which allows seamless transfer of measured gas sensing characteristics by four partially selective gas sensors to be measured using a Digital Multimeter (DMM).

2. EXPERIMENTAL

Initially four partially selective gas sensors are hardwired and configured to constitute the E-Nose module. The commercially available sensors have a common 5Vdc power supply and are set with appropriate trigger levels for detection of respective target gases. Four different outputs from the E-Nose module are fed onto the 'smart' switch. In the 'smart' switch the E-Nose module feeds are further connected to the analog inputs of the 74HC4051 multiplexer IC. The 'smart' switch is essentially constituted out of three individual component modules a) 555 based astable timer, b) 7474 based MOD – 4 asynchronous counter and c) 74HC4051 based analog multiplexer with one selection line grounded

The block diagram of the 'smart' switch module acquiring data and passing it to the interfaced DMM is shown as follows

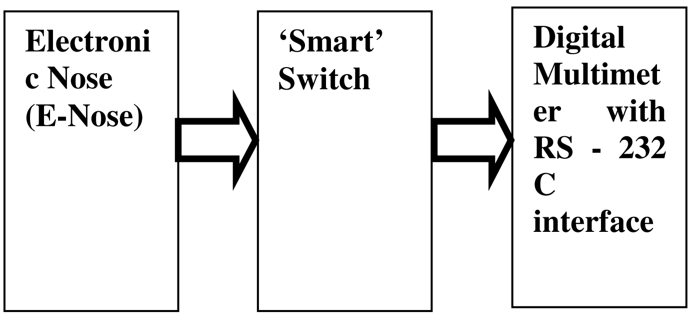

Figure1: Block diagram of the 'smart' switch transferring data from E-Nose

3. RESULTS AND DISCUSSION

The 7474 IC has in its folds two independent positive-edge-triggered D flip-flops with complementary outputs. The pin-out of the 7474 IC is shown as follows.

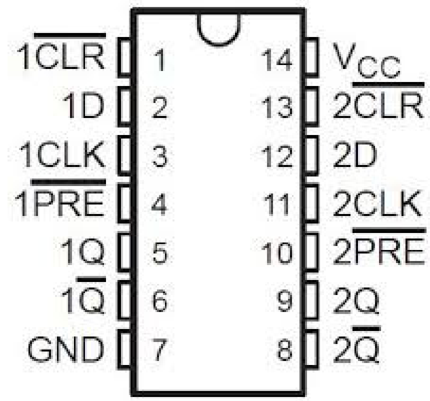

Figure 2: Pin-out of 7474 D flipflop IC

It is noted that the positive going edge of the clock pulse influences transfer of the information on the D input into the flip-flop. Also the triggering occurs at a particular voltage level and is not directly related to the transition time of the rising edge of the clock. Further, within data setup and data hold times, data on the D input may be changed while the clock is low or high without any effect. Going further, a low logic level on the clear or preset inputs resets or sets the outputs regardless of the logic levels of the other inputs. The block diagram of the 2-bit asynchronous MOD - 4 counter used for data acquisition from the E-Nose and designed using 7474 IC is shown as follows

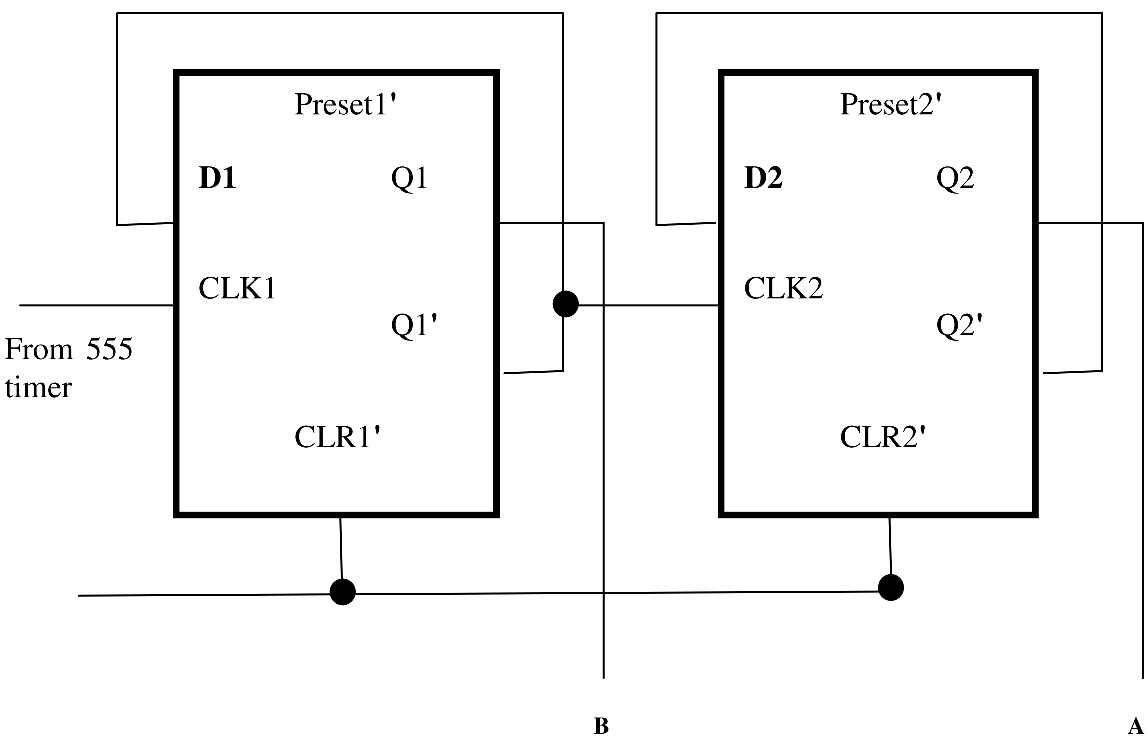

Figure 3: 7474 configured as MOD-4 asynchronous counter

Initially, the two flipflops are cleared of any data and clock pulses (user defined times) from the 555 timer configured in the astable mode are fed to it. The first arriving clock pulse gives counter output as AB = 00, second clock pulse as AB = 01 and so on and so forth till AB = 11. On the fifth clock pulse the output AB gets reset to 00, thus beginning the cycle all over again. This way the counter outputs 00,01,10,11,00,01,10,11,00……..in a continuous fashion. The output of the MOD-4 counter is fed onto the analog multiplexer circuit that sources the E-Nose gas sensor outputs.

74HC4051 is an eight channel analog multiplexer with three select lines (S0 to S2). The pin-out of the 74HC4051 IC is shown as follows.

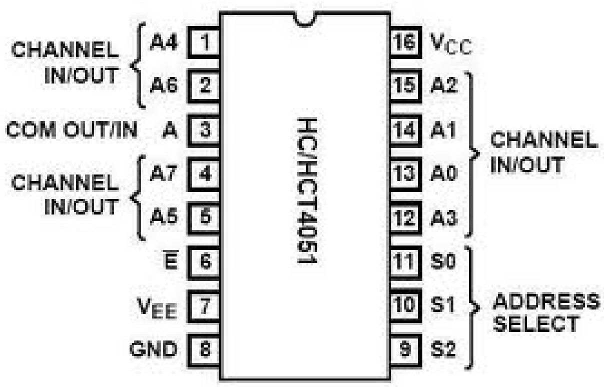

Figure 4: Pin-out of 74HC4051 analog multiplexer

Since the E-Nose in the present study was constituted of only four gas sensors hence, one select line, in this case (S2) was deliberately fixed at the ground level. The block diagram of the 74HC4051 analog multiplexer configured to select gas sensing data from four gas sensors sequentially at fixed times (user defined and controlled) and in a cyclical fashion is hown as follows.

	1	16	**Vcc**
	2	15	**Y2 [Gas Sensor 3]**
	3	14	**Y1 [Gas Sensor 2]**
	4	13	**Y0 [Gas Sensor 1]**
	5	12	**Y3 [Gas Sensor 4]**
GND	6	11	**S0 [B from 7474]**
Vee	7	10	**S1 [A from 7474]**
GND	8	9	**S2 (GND)**

Figure 5: 74HC4051 configured to acquire data from E-Nose

The following truth table summarizes the functioning of the 'smart' switch module

CLOCK PULSE	COUNTER		SIGNAL to Digital Multimeter (DMM)				SELECT OUTPUT
	A	B	Y_0	Y_1	Y_2	Y_3	
1	0	0	Y_0	0	0	0	Y_0
2	0	1	0	Y_1	0	0	Y_1
3	1	0	0	0	Y_2	0	Y_3
4	1	1	0	0	0	Y_3	Y_3
5	0	0	Y_0	0	0	0	Y_0

4. CONCLUSION

The 'smart' switch developed in the present work is noted to be a solution for realization of low cost E-Nose. It is seen to perform in tandem with the locally assembled E-Nose detecting hazardous gases. Specifically, it is seen to switch data of a target gas from a partially selective gas sensor from the array available sequentially devoid of any human interference. With the availability of user-controlled time sequence in the range of 2 – 30 seconds one gets to choose how fast data is to be acquired in the interfaced DMM. Time control is seen to influence how much data is to be collected. Choice of the acquisition speed is also noted to govern endurance of battery, powering autonomous operation of the E-Nose.

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