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ELECTRONICS TESTER

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***Abstract*—Electronics is the most sensitive part of any project as the minor difference can result in failure. So, the electronic component must be tested first, before they are used otherwise they, might be the reason for project failure. It is a tedious work to debug the circuit and confirm whether the circuit is creating the problem or the electronics component if the project produces undesirable results. Thus, this paper describes the idea of the checking the electronics components. Electronics Tester is built around the Arduino mega as a micro-controller and a Nokia LCD 5110 graphical LCD. The system is capable of testing digital IC's up to pin 20, 555 timer IC, IC 741 operational amplifiers, Resistor, Capacitor, and Transistor.**

***Index Terms*—Nokia LCD 5110, Digital IC, 555 timer IC, 741 Op-amp Electronics Tester, RJ45 cable, On board testing**

I. INTRODUCTION

Electronics components like resistor, capacitor, diode, IC (Integrated Circuit), etc. have the different configuration so, they have to be tested by a particular kind of testers which involves more complicated and time involved in it will also be more. Thus, here's an Electronics tester to overcome such problem which can test resistor, capacitor, transistor, RJ45 cable, different kinds of digital ICs and 555 timer IC and 741 op-amp.

Dramatic improvement of integrated technology in IC manufacturing is rapidly leading to exceedingly complex, multi-million transistor chips. All the functionalities of an electronic system are being integrated on a single chip in less than 2 cm square silicon area. This growth is expected to continue full force for the future years. With the increase of such integration densities and complexities, problems associated with testing of ICs have become much more Complex and acute [1]. IC testing have now become a front-end issue in the semiconductor world, which needs an effective solution with reliable performance. For the first two decades of the industry, semiconductor manufacturers custom-built most of their own tools and equipment in-house. In the early 1960s, Fairchild Semiconductor, Signetics, Texas Instruments, and others began to sell their specialized semiconductor test equipment to their customers and competitors [2]. TI engineers developed a Centralized Automatic Tester (CAT) transistor-testing machine in 1958. TIs Transistor and Component Tester (TACT) introduced in 1962 served the company and its customers for many years. One of the first integrated circuit testers offered commercially was the Signetics Model 1420 [2]. Along with the time after the innovation of first integrated circuit tester there came several different IC's testers some tester available commercially include GUT-7000 Linear IC, Model 570A Analog IC Tester, Model 575A Digital IC Tester, DICT 02 and DICT 03 Universal IC Testers. All these testers available commercially are not economical and an addition of new IC is not possible, thus to overcome these kinds of problem digital IC Tester is integrated into Electronics Tester. It is capable of testing different kind digital IC up to pin 20 in two modes i.e. automatic and manual mode along with features of adding of new IC's with a slight update on the database.

Electronics tester test digital IC by applying necessary inputs to the gates of the IC to be tested, which is placed in the ZIF socket, output response is received from the micro-controller and corresponding outputs are also accumulated by Arduino board where the output is compared with the functional or the logic table and if any discrepancy results, it displays the failure results on the LCD display screen. 741 op-amp operates in comparator mode for testing and 555 timer IC testing is integrated with capacitor testing. Resistor measurement is done by connecting an unknown resistor with a known resistor in series and then applying the voltage divider rule. Capacitance measurement uses two approaches first charging and discharging approach Arduino capacitance meter for the range 1pF to 100nF and second multivibrator approach for range 1μF to 1000μF. For the testing of Rj45 cable, they are simply considered as the transmission path for the clock pulse generated and it simply checks the output sequence generated in different pins of Rj45 when the input is given to the one end of a Rj45 cable. On the basis of that, it tells whether the cable is connected in straight through or cross-over connection and it is operational or not. Transistor testing is carried through the measurement of forward bias voltage between Base-Emitter and Base-Collector to distinguish between NPN and PNP transistor.

II. Methodology

A. IC Testing

In IC testing mode, there are two different modes, i.e. automatic and manual mode.
Automatic Mode: In this process, at the first number of pins of an IC that undergoes testing is taken as input. The device then starts manifesting all the possible input signal to the IC and takes backs each possible output. If the responses match the output of a particular IC's in the DATABASE, then it declares that the IC is functioning properly. It also displays the truth table of the IC that undergoes the testing procedure. If an IC is being tested in automatic mode then it provides with the possible name of the IC, that is included in the database after comparing the results obtained.
Manual Mode: At first IC number is entered, after that it applies each possible input for that IC defined and records the output of that IC. If the output obtained matches the response defined in the DATABASE for that IC, then the IC is declared good otherwise, indicates the bad gate among the number of gates in that IC. Furthermore, different kinds of digital ICs other than logic gates can be tested with this device as the logic gate is an elementary building block of a digital circuit so, the output is either 1's or 0's. Thus, comparing the output obtained from the applied input to the pre-defined response at DATABASE device confirms that, the digital IC under test is functioning well.

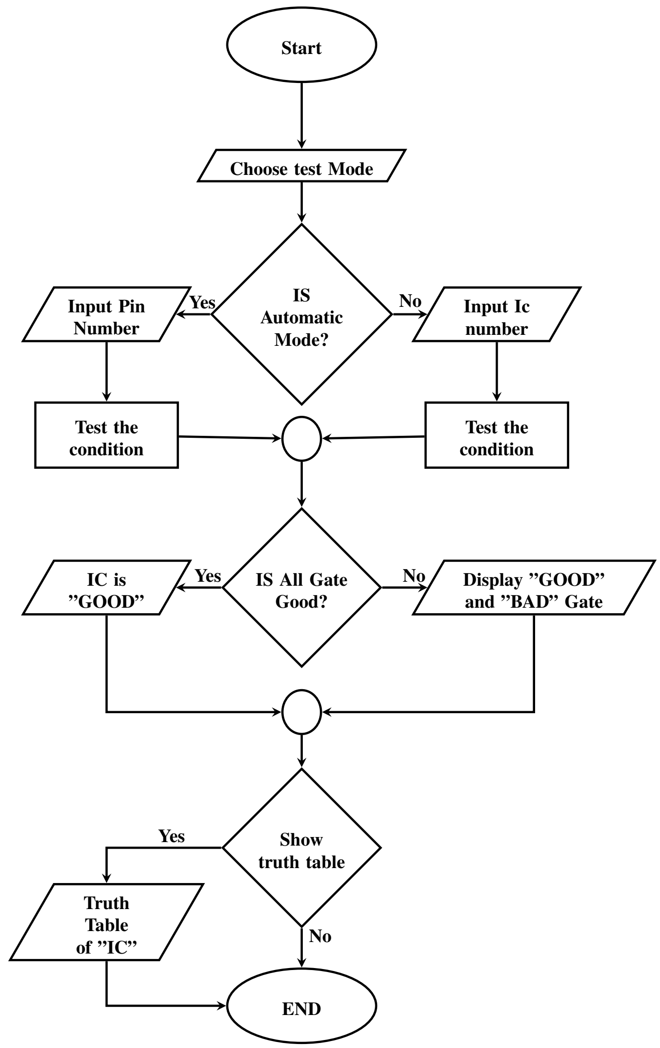

Fig 1: Flowchart of the IC testing

B. Resistance measurement

If an unknown resistor and the known resistor are connected in series then using the voltage divider rule. we get

$$R_2 = V_{out} \times \frac{R_1}{V_{in} - V_{out}} \tag{1}$$

Where,
R_1 = known resistance
R_2 = Unknown resistance
V_{in} = input voltage
V_{out} = output voltage
Thus, form above equation 1 calculation of resistance measurement can be done. For precision, range are provided i.e upto $2.2K\Omega$, $2.2K\Omega$ to $22K\Omega$, $22K\Omega$ to $220K\Omega$ and upto or greater than $1M\Omega$.

C. Transistor Testing

A Bipolar junction transistor (BJT) can be considered a back-to-back pair of diodes.

- NPN have the common anode on the base
- PNP have the common cathode on the base

This arrangement gives rise to one technique for testing BJTs is to measure the forward voltage between Base-Emitter and Base-Collector.

- if the positive forward voltage is found from Base to Emitter and Base to Collector, we assume a properly functioning NPN
- if the positive forward voltage is found from Emitter to Base and Collector to Base, we assume a properly functioning PNP
- the forward voltage will be around 0.7V for silicon transistors

When the transistor is tested Electronics tester distinguish the NPN or PNP transistor with its forward junction voltage.

D. RJ45 cable Testing

The circuit of RJ45 tester circuit is built around most popular timer IC NE555 configured in astable multivibrator mode which is designed to generate 1 Hz clock pulse and a decade counter IC CD4017B. The output is taken from pin Q_0 to Q_3 (pin 3, 2, 4 and 7) which drive LED sequence. This output is connected to CON_2 (RJ45 socket), through which clock pulse is sent and the returning pulse is connected to

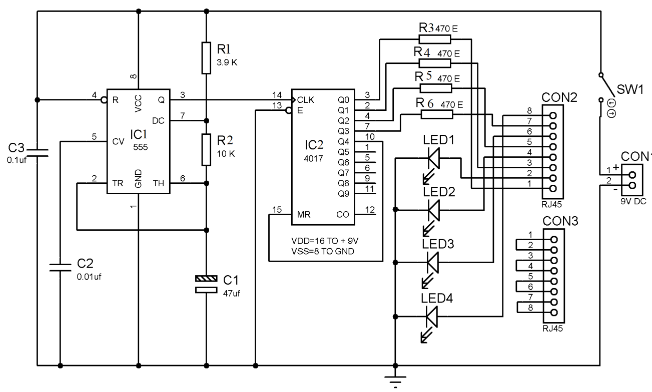

Fig 2: Circuit Diagram of RJ45 cable Testing

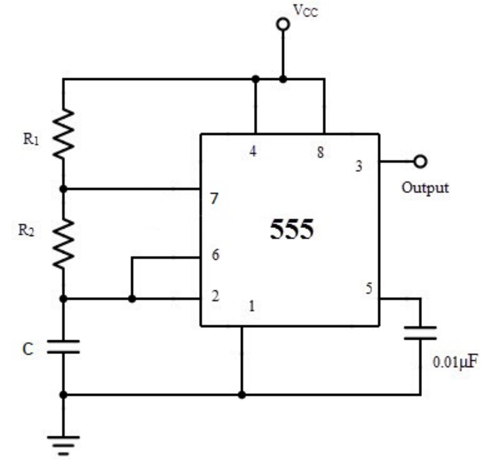

Fig 3: Circuit Diagram of Capacitor Measurement

the LED sequence as shown in figure 2. Simply, these wire is treated as a transmission path for the clock pulse. The resistors R_3 through R_6 is used here as a current limiting resistor which limits or drop current flowing through individual LED. The Reset pin (pin 15) of IC_2 is connected to its own output pin Q_4 (pin 10). This is because in fifth clock pulse it will reset the decade counter IC (IC_2). If the RJ45 cable which is under test is straight-through the LED_1, LED_2, LED_3 and LED_4 will glow in sequence. Similarly, for Crossover type LED_2, LED_3, LED_1 and LED_4 will glow in sequence. The cable which is to be tested is connected to the two connectors CON2 and CON3 and observe the sequence of glowing LED.

E. Capacitance Measurement and 555 Timer IC Testing

Uses two approaches for capacitance measurement, i.e. charging and discharging approach and multivibrator approach Arduino capacitance meter. For measuring low-value capacitor charging and discharging approach and for measuring high-value capacitor multivibrator approach. In the charging and discharging approach, the capacitor is first charged and discharged through a known resistor. Time constant(τ) for a capacitor

$$\tau = R \times C \tag{2}$$

Where, R = Fixed value of resistor used for charging and discharging of capacitor
C = Capacitance of capacitor
The time constant is defined as the time in which charge on the capacitor goes to 63.2% of the maximum value of charge. The Arduino board basically measures the time taken by the capacitor to reach the 63.2% of its voltage when it is fully charged and 36.8% of its voltage when it is fully discharged. In multivibrator mode the timer 555 IC is used in astable mode. In this mode output swing between high and low at constant rate, i.e. frequency is generated. The value of capacitance can be found by the use equation 3

$$Frequency = \frac{1.44}{(R_1 + 2R_2) \times C} \tag{3}$$

Where, F= frequency generated in astable mode 555 timer IC. For the testing of 555 timer IC a known value of the capacitor is measured, if the device indicates the value of capacitor then a conclusion can be made that the 555 timer IC operated in astable multivibrator is good.

F. 741 Op-amp Testing

The op-amp IC 741 is a DC-coupled, high gain differential amplifier with external negative feedback. IC 741 is characterized by almost infinite open loop gain, almost infinite input impedance (2MΩ) and almost zero output impedance (75Ω). IC741 can be used as an electronic integrator or differentiator, depending on the R-C network in the input and feedback circuit. The circuit of operational amplifier 741 tester

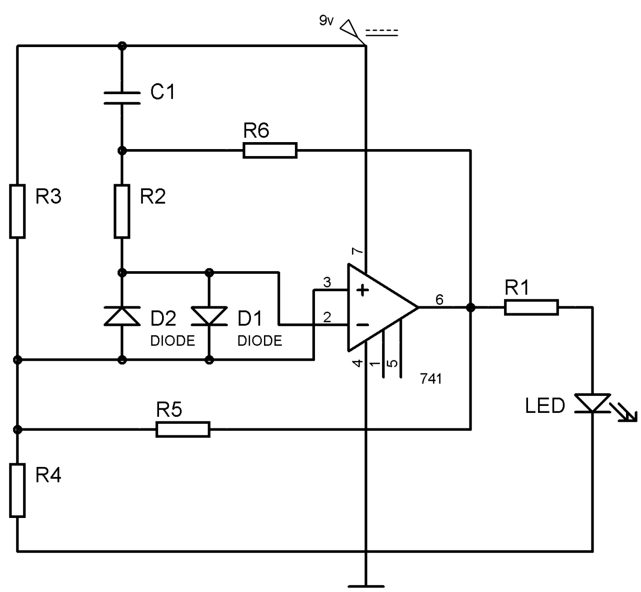

Fig 4: Circuit Diagram of 741 Op-amp Testing

comprises two diodes and very few passive components and a 741 IC to be tested. All the components are connected as shown in circuit diagram figure 4. An LED is used to indicate either IC is good or faulty. Blinking LED indicates IC is good. The IC to be tested is configured in a voltage comparator mode. The voltage at pin 3 (non-inverting pin) is fixed where the voltage at pin 2 (inverting pin) varying due to charging and discharging of capacitor C_1. Where the battery is connected to the circuit the voltage at pin 3 is high in comparison to the voltage at pin 2 due to the charging of a capacitor, as a result, an output of IC becomes high and LED start to glow. At this instant capacitor start to charge through the resistor R_4. When the charge (voltage) of the capacitor exceeds the voltage at the inverting pin (pin 2), the output of IC becomes LOW, as a result, LED stop to glow. When the voltage at the capacitor becomes higher than inverting input pin it starts to discharge and again the output of IC becomes high. This high and low output of IC generates a square wave and cause LED to blink. If the LED doesn't blink in a fixed interval of time, i.e. either stay ON or OFF the IC which is being tested is faulty.

III. Results

IC Testing: Let us consider a 4000 series Digital 4081 IC. It is a quad 2-input AND gate. If this IC is to be tested, then Electronics Tester configured in IC testing mode implies each and every possible combination input to the input pins of every AND gate present in IC. Table 1 shows the truth table of an

Table 1:
TRUTH TABLE

Input combination		Expected output	Observed
Input A	Input B		
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

AND gate if the gate is fully operational. Truth Table for all gates is shown and finally overall results is displayed. The

Table 2:
FINAL RESULTS

Gate No.	Result
1	Good
2	Good
3	Good
4	Good

above table 2 is the result when all gates of IC are good. If IC to be tested has a faulty gate no 3 then all other gates are displayed good except gate number 3.

Table 3:
TRUTH TABLE OF GATE NO. 3

Input combination		Expected output	Observed
Input A	Input B		
0	0	0	0
0	1	0	1
1	0	0	0
1	1	1	1

Table 4:
FINAL RESULTS FOR BAD GATE NO. 3

Gate No.	Result
1	Good
2	Good
3	Bad
4	Good

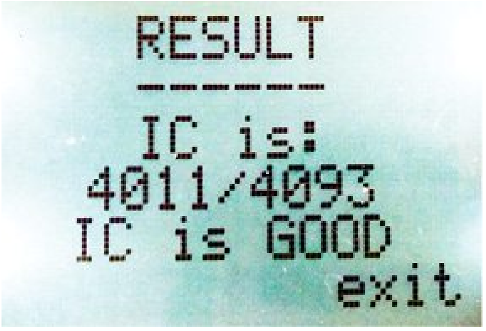

Fig 5: Result of testing IC in automatic mode

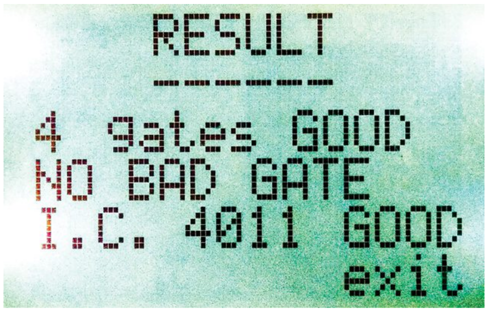

Fig 6: Result of testing of 4011 IC in manual mode

RJ45 cable testing: Rj45 cable are either connected in straight through or cross-over connection and which connection they are connected can be checked by the device. If LED_1, LED_2, LED_3 and LED_4 glow in sequence, then it is straight through connection and if LED_2, LED_3, LED_1 and LED_4 will glow in sequence then it is cross-over connected Rj45 cable. These sequences of glowing LEDs are obtained when straight through and crossover cable are tested.

741 op-amp testing and 555 timer IC testing: When 741 op-amp IC is tested, then the LED (figure: 4) start blinking which indicated that the 741 op-amp is good if the led not blink then the IC is considered to be bad.

For 555 timer IC testing, when the electrolytic capacitor is measured and indicates some values, then it is concluded that 555 timer IC configured in astable mode is working correctly. This result is obtained while testing a 555 timer IC.

Resistor, Capacitor and Transistor testing: Electronics tester can test different values of the resistor and capacitor within the percentage error of 5% while testing. Different ranges are available for the testing of resistor and capacitor which has to be selected, through a rotary switch. 5% of error is due to the use of non-ideal components and in capacitance measurement is due to the stray capacitance. Error percentage is evaluated based on the values obtained from the resistor color code and for capacitor from marked value and their values measured by the device.

IV. Conclusion

The idea to construct a device that could be helpful to test the digital IC, 555 timer IC, 741 op-amps, resistor, capacitor, RJ45 cable, and Transistor has been presented. Based on the prototype testing, the proposed design could test the functionality of IC's when properly inserted in the ZIF socket, properly test transistor, capacitor, resistor, 555 timer IC, 741 op-amps and RJ45 cable. The prototype developing process concluded that it is possible to develop an Electronics Tester that can auto-detect the unknown logic device and able to measure capacitor and resistor value within the tolerance level and can successfully test the RJ45 cable and transistor. Assisting with the implementation of the project of the system with microcontroller makes the testing procedure simpler. So, we can conclude that several electronic components can be tested and any digital IC with the given specifications can be implemented on Electronics Tester with the simplicity of adding newer IC's.

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