DESIGN AND COSTRUCTION OF A DO-IT-YOURSELF ELECTRONIC TRAINER

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Abstract
The problem of carrying out experiments with traditional trainers in which components and other accessories are enclosed in a box renders such trainers to mysterious boxes which are not suitable and accessible for students to study. Therefore, these associated problems with traditional trainers necessitate the need for a Trainer namely do-it-yourself Electronic Trainer which will expose both the components and accessories for students to their class works to address industrial challenges. The fundamental method of calculating and selecting standard and universal Electrical/Electronic components in a bit to design an Electronic Trainer was discussed in this study. Special attention was given to semi-conductor devices, electrical components, measuring instruments, transducers and splinted power supplies each component is connected to terminals, and a wiring sequence is included with each experiment, each experiment has its own schematic symbol printed next to it. The trainer is partly made up of breadboard that accommodates unfixed number of components on the board and also constructed with inbuilt ammeters, voltmeters and splinted DC power supplies. It contains 26 compartments that make up different electrical/electronic devices and components to fulfill the experimental requirements with breadboard prepared for removable components and splinted power supplies. The trainer was found suitable for the task it was developed for and its performance has been evaluated to be fit to bridge the gap between the student's classroom works and the industries.
Keywords: Measuring instruments, Schematic symbol, Semi-conductor devices, Splinted power supplies, Schematic symbol

1.0 Introduction

"Do – it – yourself electronic trainer" is an electronic training device that contains several numbers of fixed and unfixed electronic components that teach basic electronic practicals from low level up to the higher level. The trainer manual is provided with numbers of working projects from which students can generate unlimited number of new ideas to tackle practical electronic problems.

The trainer consists of simple and complex electronic circuits. The projects and the information in the manual are organized in a logical sequence in such a way that the simple circuits are first treated and worked toward more complex ones. This arrangement is helpful for the student because the knowledge that have been picked up in the earlier experiments will aid in understanding the later ones.

Simple clearly-written instructions help to operate and experiment with each project, the breadboard is made simple, no soldering is required, each component is connected to terminals, a wiring sequence is included with each project which include schematic diagrams (Samarajit, 2012) This schematic diagram in Fig. (i) is an electronicsblueprint that shows how various components are wired together, each component has its own symbol. The symbols for the various components in the lab kit are printed next to each component on the breadboard.

To build a working project, wiring connections are carried out between the terminals listed in wiring sequences from No.1 to 187 on the board. The trainer contains both fixed components and breadboard which makes it adaptable to a large number of experiments.

The aim of this project was to build a model capable of bridging the gap between the student's classroom works and the industries; that is, the practical application of their class works to address industrial challenges.

This trainer is locally built to solve our local challenges in the area of practical in our secondary schools, technical colleges and tertiary institutions in Nigeria. It will also act as solid ground for basic practical comparison between excessive dependence on imported electronic trainers which is not sustainable to national development.

The objectives of this study, therefore, are to teach basic electronic practical for students to understand the rudiments in electronics and the prospect of the chosen career. Also, to equip

students with wide range of experience, knowledge and skill to find the best solution to technical problems and to encourage the students to start building new ideas extracted from the experiments provided on the board. In addition, this will expose students to be independent on how to start working on their final projects instead of contracting them out to road side Engineers. Lastly, this will serve as a student's companion to keep them busy with electronic practice always.

2.0 METHODOLOGY

2.1 Design construction

The methodology deployed in the design includes selection of Electronic/Electronic components by deploying the relevant and significant equations for active and passive components use. This Trainer was provided with numbers of experiments and working projects. The types and values of the components were calculated through semi-conductors design, "diode and transistor". The two components are typical example of basic electronic components used in this Trainer.

2.2 Design analysis

Component values were determined using equations 1 to 4 as expressed by Philip (2014).

Ohms Law $V = IR$ …… (1),

where V is voltage, I is the current and R the Resistance in the circuit

Applying voltage dividing rule, therefore;

$$V_{R1} = \frac{V_{CC} \times R_1}{R_1 + R_2} \qquad 2$$

Time constant - $T = RC$ 3

Where T is the time taken, R the resistance and C capacitance in the circuit.

Amplifier circuit (Transistor) - $H_{fe} = \frac{I_c}{I_b}$ … 4

Where Hfe is the transistor gain, Ic the collector current and Ib the base current

Switching in Transistor - Threshold Voltages 0.6V in case of silicon and Germanium 0.3*V (Singh A K(2007;* Fowler & Breekon (2006).

Voltage dividing rule was used to determine the threshold voltage of the transistor, the Ohm's law to find the values of the base resistor, time constant to calculate the timing period while the Hfe is to find the gain of the of a transistor, Ohm's law states that the current I flowing through an element is directly proportional to the voltage drop V, across it at a constant temperature. It is usually written in form of $V = IR$, ..(Charles K. A and Mathew S, 2009). To calculate any one of the three quantities if one is not known, the equations

$$I = \frac{V}{R} \ldots\ldots\ldots\ldots\ldots\ldots (5), R = \frac{V}{I} \; and V = IR$$

were used in this project.

2.3 Material selection

Figure (1) is one of the simple projects in the manual provided for the trainer.

A light emitting diode (LED) on terminals 31 and 32 on the board, is a device that gives off light when an electric current passes through it. It has limitations, first, the current must not exceed 20mA or the LED will get damaged. It is required to determine the value of the resistor in series with the LED to restrict the current to 20mA, if 9 volt is used. (Christian , 2004).

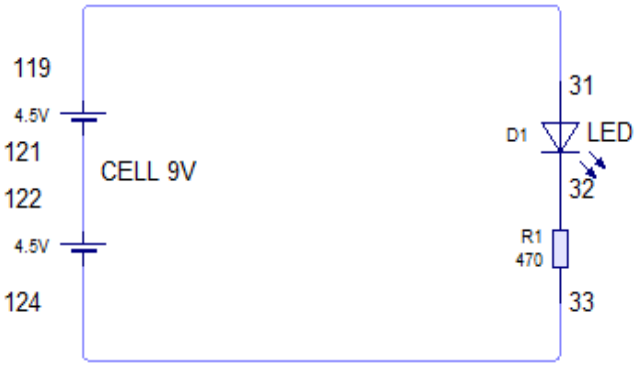

Figure 1: Light emitting diode circuit

Using Ohm's to find the Resistance,

From equation (1)

$R = \frac{V}{R}$ where V = 9 volt, I = 20mA

Therefore,

$R = \frac{9}{0.020}$ =450 Ohms

The nearest standard value above is 470Ω.

This resistor values appeared on the board at terminals 32 & 33, 34 & 35, 38 & 39 and 73 & 74 to perform similar experiments to the above problem or when this circuit is found in other complex circuits.Similar formulae above were used to get the values of other components on the board as treated in the procedure highlighted as shown in Fig. 2. The components were selected under characteristic process, that is, the function(s) and behaviors of each component

were taken into consideration before selection. Some components have up to two or more functions; like transistor which can be used as a switch, amplifier and sensor.The value of resistors on the board were selected under standard value of resistor chart, as treated in the previous resistor calculation Fig. 1 where, the calculation given 450Ω and 470Ω was chosen being the nearest standard value from the chart. (Christian, 2004).

The splinted power supply were used because different experiments require different voltage source. (Yopadh, 2012). The supply is split to 1.5v, 3v, 4.5v, 6v, 9, - 9v and +9v to perform different experiments and working projects on the trainer.The trainer carries measuring instruments like Voltmeter and Ammeter to measure different types of electrical quantities.The IC used in this trainer were standard universal integrated circuits for digital electronic and operational amplifier experiments. Quad 2 inputs NAND 74LS001N and Dual OPAM 471, in this compartment, IC stands were used; this gives room for other IC to be used apart from the ones on the board, in case of other experiments not available in the manual. The top side of the trainer breadboard were used for removable component; this make this trainer adaptable for a large number of experiments in the Faculty of Engineering.

Radio circuit - The fundamental crystal radio is made of tanks – the antennal coil and tuning capacitor," The detector – Diode, and the earphone which serves as an output (Smarajit, 2012).
It is easy to select component for crystal radio since the circuit resonates at a certain frequency when the coil and the capacitor are connected in parallel. But, now, a variable capacitor was selected so that the capacitance of the capacitor changes as it is rotated, when the capacitance changes, the resulting frequency for the circuit changes. This station can be tuned by rotating the variable capacitor. Without this selection several stations mixed together are heard.

Three transducers are used in this trainer; they are light dependent Resistor, speaker and light emitting diode. They are used to convert one form of energy to another. (Cathey J, 2006).The 50kΩ variable resistors are used as control while the switch and key are used to energize experiments and working circuits (Charles and Mathew, 2009). At the right top of this trainer breadboard was inculcated for removable components. This makes this trainer adaptable for a large numbers of experiments to be performed on the trainer.

2.4 Component Assembly and Circuitry Work
This Trainer contains about 26 compartments that make up different Electrical/Electronic devices and components to fulfill the experimental requirements in the Faculty of Engineering. There are fixed devices and components that cover the three loads in engineering. There is also a breadboard prepared for removable components and splinted power supplies. To perform an experiment on this board, it is categorized into two parts, (1) The experiments already prepared in the manual for the Trainer, (2) The imported experiments outside the manual. There is a need to first select the components required for a particular experiment either from the manual or otherwise. Check the board to figure out which of the components are not present on the board. Look for such components and place them on the appropriate compartment(s) on the breadboard, Fig 8, where additional resistors, Capacitors, Diodes, Transistors and variable Resistors are accommodated. The import components terminals are numbered as they are connected on the breadboard. Any experiment can be carried out by following the wiring sequence prepared for each experiment. In case of imported experiments, a wiring sequence must be prepared for it for easy connection. Experiments on this trainer are completed by the steps taken in the previous experiment (01) above. The wiring sequence should beunderstood. A wiring sequence of this nature, 1-2, 20-35 et cetera means, a connection between terminal 1 and 2, 20 and 35. Comma means the end of each connection et cetera. A splinted power supply is built with this Trainer. Terminals 119 & 120 supply 3V, 120 & 121-1.5V, 122 & 124-4.5V.. If 9 volts is required, connect a probe between 121 and 122, 9 Volts can be achieved between 119 and 124. In case of dual power supplies, where positive, negative and zero voltages are required to power some special circuit like operational amplifier Fig 13, connect terminals 143 and 119 with a probe to achieve positive voltage from 143, negative from 124 and zero Voltage from terminal 143 (9V-0-9V).

2.5 System Calibration, Testing Procedure
This trainer under testing and evaluation was used to carry out experiment in Figure 2. The

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output waveform of a half wave rectification using a single diode was verified.

2.6. Testing Procedure

The experiment is arranged following the wiring sequences below. Switch in the signal generator with sine-wave of 5Vpp at 50 Hz, Fig (05), this wave and the Frequency being sent out will be displayed on the screen of the Oscilloscope Fig: (05) and (06) below.

Connect oscilloscope to the output of the circuit and compare output wave form with the input signal from the signal generator.
Draw the AC wave form at the input and the resultant output wave form across the load Resistor.
Measure the voltage across the 10kΩ resistor and compare with the input AC voltage.
What is the disadvantage of half-wave circuit?
In which area in practice, is this circuit applicable?

Circuit Diagram

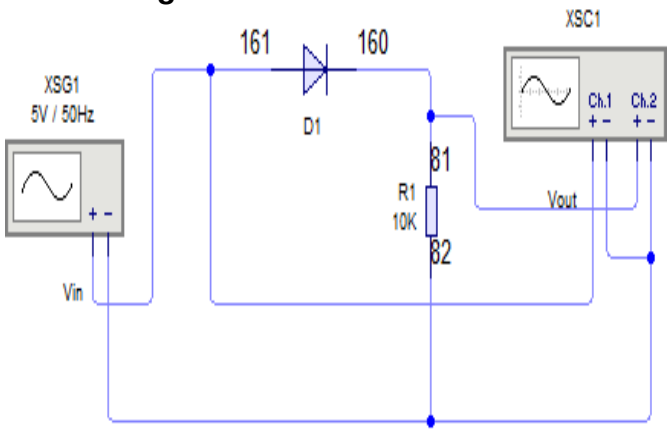

Figure 2: Half wave rectifier circuit
Wiring Sequence: 161-osc.CH1(+ve)-SGen(+ve), 160-81-osc.CH2(+ve) 81-osc.CH2-osc.CH1(-ve)-SGen(-ve)

Step (1) The materials and instruments needed for the experiments in Fig. 2 were first selected as shown in Fig. 3.

Step (2) The materials and Equipment selected for this experiment were connected “Diode as a rectifier” according to the wiring sequence on the board above.

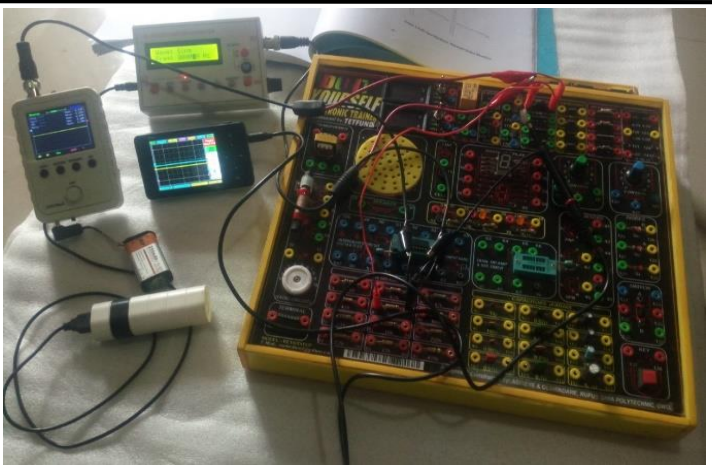

Figure 3: A view of the system set-up for Lab Experiment

Step (3) The signal generator was switched on to study the input wave generated on the Oscilloscope and the resultant output wave formed displayed on the Oscilloscope as shown in Figure 6.The experiment has been performed showing diode as a Rectifier. From above experiment, the questions 1 to 5 were answered from the screens of the two oscilloscopes F.

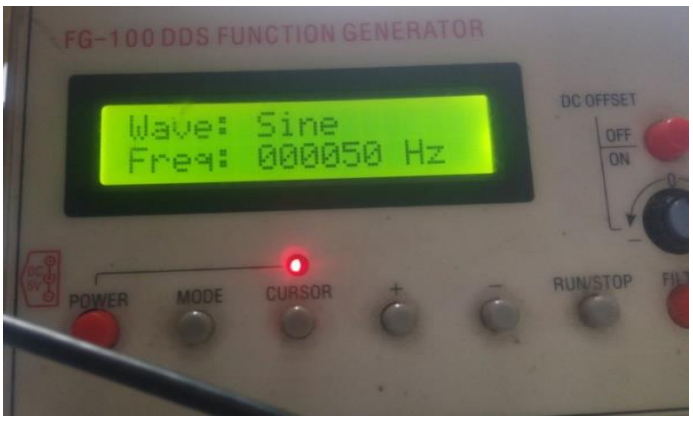

Figure. 4: Signal generated (50Hz sine wave of Vpp =5v)

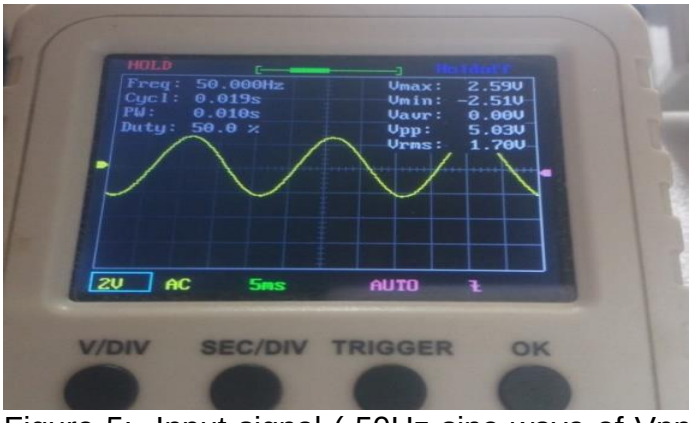

Figure 5: Input signal (50Hz sine wave of Vpp =5v)

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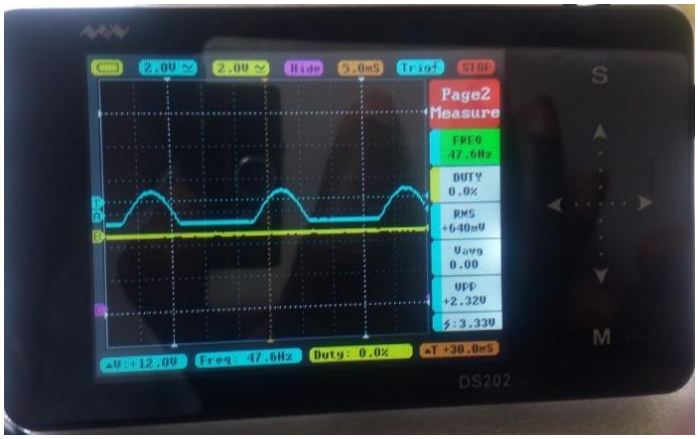

Figure 6: Output signal (50Hz sine wave of Vpp =2.32V)

.7Results and Analysis

The signal generator produces a sine wave (AC) of amplitude 5V at frequency of 50Hz at the input (Figure 5 and Figure 7) while a sine wave (DC) of amplitude 2.32V at frequency of 50Hz was produced at the output. The negative half wave has been clipped off by the Diode. From the theory, this result is possible due to the characteristic of a diode. Diode only conducts during the positive half circuit of a sinusoidal wave and switch off during the negative half circuit, (forward and reversed bias of a Diode). Diode allows the passage of current in only one direction.

Input wave was shown in Figure 5, while the resultant output in Figure 6, on the oscilloscopes above

v.pp -5v	1.16	2.32	1.16	0	-116	-2.32	-1.16	0
div-5ms	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10

Table (01) reading from Fig (05) input signal.

v.pp -5v	1.16	2.32	1.16	0	0	0	0	0
div-5ms	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10

Table (02) reading from Fig (06) output signal.

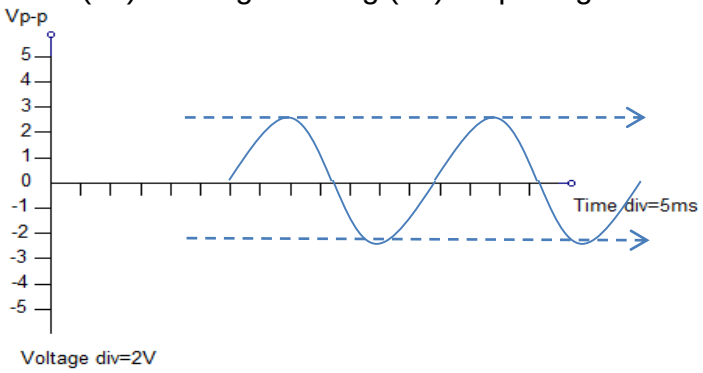

Figure 7: ac input waveform

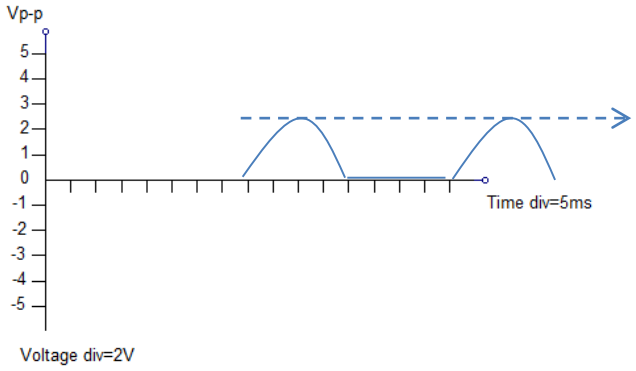

Fig 8: Resultant dc Output waveform

The voltage across the 10kΩ resistor was 2.32V while the input (AC) voltage was 5V. This shows that the output wave voltage is half of the input voltage.

The disadvantages of half wave voltage are that; (i) half of the power available is wasted and (ii) it is not applicable in biasing Electronic circuit because of high percentage of AC repulse.

The voltage is only applicable in charging accumulator battery and any other rechargeable batteries.

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Figures 4, 5, 6 and 7 show the reading signal generated input and output waveform. The half wave is well verified and is true replica of the theoretical result.

The trainer is recommended for students at all level of Electrical and Electronic

3.0 Conclusion

A do-it- yourself trainer has been designed and constructed. It was found suitable for the task it was developed for and its performance has been evaluated. The following conclusions, therefore, were drawn from this study:

1. It is built with a manual which has more than 150 working experiments.
2. Limitation of this project includes the use of dry cell batteries which can be replaced by rechargeable batteries and renewable devices.
3. Expansion on the board can be made to accommodate more devices and components which would increase the number of experiments on the board.

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