DESIGN AND CONSTRUCTION OF AN INTELLIGENT PHASE SELECTOR SYSTEM

BY

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DEDICATION

This project work is dedicated to Almighty Allah

ATTESTATION/DECLARATION

I, Bello Aliu, declare that this work was done by me and has never been presented else were for the award of a degree. I also hereby relingquish the copy right to the Federal University of Technology, Minna.

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ABSTRACT

The system is designed for AC main power supply application it involves automatic phase selector and change over between the phases of main power supply from power holding company of Nigeria (PHCN) Red phase, Yellow Phase, and Blue Phase. The project implements an automatic switching of load from any phase that has low power supply or no power supply to another phase of standard power supply. Processes like surgery operation in hospitals, transfer of money between banks, transfer of data and lots more should not be interrupted because of their importance in order to avoid damaging of machine, time delay etc. The idea of intelligent phase selector and change over came up since the power sector has improved on their regular power supply. This is achieved with the help of bit microcontroller (AT89C51) with 4Kbytes of flash memory, (PEROM) programmable and Erasable Read only memory, that has timing ability, relays incorporated for switching effect, the uses of computers and regulators was also employed to compare the voltage levels. The system uses an electronic control circuit which includes IC, Transistor and electro mechanical devices (Relay)

The project eliminates the stress of manually changing over from one phase of low or no power supply to another.

CHAPTER ONE

1.0 INTRODUCTION

1.1 The necessity of power in every industrialized nation is un-comparable to any other social infrastructure as it is the back bone of the nation and its demands is continually on a rapid increase. Failure of it is completely not acceptable and there is danger involve as well as losses.

Power transmission and distribution are carried out mainly through the over head lines (bare conductor) mostly used in Nigeria for both transmission and distribution or gas insulated transmission line (GIL). The lines consist of three phase and one neutral (Red Phase, Yellow Phase and Blue Phase). According to institute of Electrical Engineering (I.E.E) regulation any building (a resident) is only meant to be connected to a single phase of the three phase and the neutral line, but due to epileptic power supply from PHCN in Nigeria, the industries, hospital, Bank etc. To be connected to the three phases so as to meet up with the required maximum power supply for the business. For the aim to properly achieved, a computerized phase selector become very necessary in order to save time, risk of electrocution, money and maintenance of A.C mains power appliance.

Due to inadequate power supply, a generation set is needed in order to compensate for power failure i.e to supply power till the A.C main is restored. In order to minimized power failure to the barest minimum a computerized phase selector (automatic change over) system that will select and switch the generating set on without the notice of the user, immediately utility power failure and equally select back to the A.C mains immediately utility power is restored.

This project on intelligent phase selector system is basically concer ed with the selection of the best of the voltage level (Normal) supplied on the three phase net work which is either Red, Yellow or the Blue phase. If the any selected phase failed the system will automatically select and change over to another phase of voltage variation of +10 above the other phase. The design of this special project is taking into consideration the wise and real life situations event though it's a prototype design.

AIMS AND OBJECTIVE

1. To improve the availability and efficiency of power supply so that the delivery of normal output voltage will be continuous regardless of (normal) any low voltage state of the phase provided
2. To design and construct phase selector system and generator control. The service moniter the three phase power supply a building. Its operation is to select and switch over from one A.C main to another and of the three phases fail, it will automatically select to 'ON' a generation set
3. To display the information about the state of the phases (on low voltage etc.) That is E1, E2,E3, and E4 as the over voltage, under voltage, over voltage, and under voltage (Normal), and error respectively.

1.2 METHODOLOGY

1.2.1 CONSULTATIONS

This involved seeking technical advice about what the project would entail in terms of finance and time. Advice was gathered from the students with the technical knowledge on how the project could achieve.

1.2.2 RESEARCH AND DESIGN

This involved information from the relevant material and books about how to carry out the project relevant websites with useful information about the designs, constructions and implementation of electronic devices were also visited The aim is to get the most effective and economically viable design for the project, This stage also involved the simulation of the circuit design on an electronic work bench.

1.2.3. CONSTRUCTION

This was the actual fabrication of the project. Here the circuit was first tested on a bread board, before couple the component to the panel. This stage involved component testing, soldering and the packaging of the project design.

1.3 ORGANIZATION OF THE WORK

This work is organized in five chapters Chapter one is the introduction which include aim/objective, motivation, economic importance and methodology. Chapter two gives the literature review of the system, which reveals the materials used for the construction of the project. Chapter three gives the design analysis of the system to ensure accuracy. Reliability and efficiency of the system chapter four is the implementation of the system and chapter five gives the recommendation and conclusion

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORICAL/THEORETICAL BACKGROUND

Electricity was discovered by Michael Faraday (1791-1867 during his discoveries he noticed that the movement of a magnet in coil of wire produces current in that wire. Although no one can see electricity, there is evidence of its presence? Everywhere. Electric power is very much in abundant and easy to use. It can be seen in our daily life for purposes such as industrial process, commercial purpose, domestic use, communication and transportation purpose.

One of the known contributors to electricity was Benjamin Franklin who proved lightning is electricity and invented the lightning rod in 1752[2] George ohm who postulated the ohms law (V=IR) also, Henry Rowland that invented the first electric machine, another development of a bulb in 1879 by Thomas Edison[2], He also established the first power plant in 1881[2]. The development of a bulb in 1879 by Thomas Edison [1], he also established the first standardization of commercial electricity supply made in 1897 known as the first electric code [3]. The first successful hydro electric power project was in the Niagara Falls in the U.S.A [1].

As early as the beginning of the twentieth century, different companies in the U.S.A Started manufacturing and development of electric building wiring devices Examples are the cutter manufacturing company located in Philadelphia and the national electric company (NEC). They produced electric elements such as circuit breakers, Fuse boxes, conduit wires, power changes and lots more [3]. Their technologies were based on modern electronic controls. In 1975, Kon doh and toyoshi patented a unique changeover type loading assembly which was designed for non utility power generators. They were installed in high rise buildings or other facilities in order to deal with situations such as power failure [3]. This invention was concerned with a loading device assembly for dry type testing equipment in which series of resistors made of metal member use for testing purposes without regard to water resistance. The invention was quite significant but it did not employ advantages of modern electronics.

The entire project can be summarized in three parameter. The power supply unit, the control unit, the load unit.

2.2 POWER SUPPLY UNIT

The power supply unit consists of a 240/12vac step down transformer, a single-phase full wave bridge rectifier, a 2200µF/25V capacitor, a 5V voltage regulator; all these are contain on each of the three phases of the power supply circuit. The 240/AC step down transformer steps the 240V being supplied to the building via the distribution lines to 12V, the single-phase full wave bridge rectifier converts the A.C to D.C, THE 2200µF/25V capacitor, helps in the filtering of the D.C voltage to remove the remaining A.C ripples present in the circuit. The 5V voltage regulator (LM7805) regulates the 12V and passes it onto the logic unit.

2.3 CONTROL UNIT

The control unit consist of 8-bit Analog to digital converter (ADC0804) CD4052 dual one of four analog multiplexer and 8-bit system controller.

2.3.1 8-BIT MICROCONTROLLER

The AT89C51 is a low power, high-performance with 4 killo-bytes of flash programmable and Erasable Read only memory (PEROM) manufactured using Atmels high density non volatile memory technology and is compatible with the industry standard MCS 51™ AT89C51 is a powerful microcomputer which provides a highly flexible and cost affective solution to many embedded control applications

The following features are provided by the clip

- 4 k bytes of flash
- 128 bytes of Random Access Memory (RAM)
- 32 input and output times
- Two 16-bit timer/counters
- Six interrupt sources with a full duplex serial port
- On clip ascillator and clock circuitry
- Fully Static Operation: OH_Z to 24 MH_Z.

PIN DESCRIPTION

The clip has forty pins (40pin)

* VCC Supply voltage pin (40)
* GND Ground pin (20)

Part O, PORT1 AND port 2, ports 8 bit are bidirection input/output port. Port an sink eights TTL inputs as an output port while port 1 and port 2, port 3 have internal pull ups and their out put butters can sink or source four TTL inputs. When is are written to port o pins, the pin can be used as high impendence inputs and as such configured to be the multiplexed low-order address/date low during accesses to external program and data memory. Is when 1st are written to port 1 pins and port 2 pins they are pulled high by the internal pull up and can be used as inputs. As input, port 2 Pins that are externally being pulled low will source current be cause of the internal pull-up.

To put briefly, an integrated circuit (I.C) is just a packaged electronic circuit. It is a complete electronic circuit in which both the active and passive components are fabricated on a tiny single chip of silicon. Active components are those which have the ability to produce gain e.g. transistors, while passive components are those which do not have this ability e.g. resistors, capacitors and inductors [4]

2.3.2 LOAD UNIT

This load unit consists of three outputs, the RED-phase, the YELLOW-phase, and the BLUE-phase. A relay is connected to each of these outputs for automatic switching of the outputs from the phase that have low voltage to another phase of standard voltage, 220V supply provided the power variation (+10) rules has been obey and as soon as the power is restored on the other phase with high magnitude the system will select to the phase and change over automatically to the input phase.

Many projects have been done on changeover switches both mechanically and electrically controlled. Lots of projects have also been done on power supply phase-selectors. A graduate Student FUT Minna (Aisha, Ruth Tolulope) of electrical and computer engineering of matriculation number 98/7260FF designed and constructed a digital automatic three phase changer. There were limitations.

1. Too many components cluster.
2. It doesn't change-over to an auxiliary power supply where there is complete power failure on all three phases.
3. It dose not display error codes due to the absence of display unit.

Also, another under graduate student of FUTM (Ibu, Edwin Adoga) of matriculation number 2000/9838EE of electrical engineering designed and constructed an automatic power changeover. This also have some limitations:

1. Only one phase is involved and not three phases.
2. A delay is involved which restrict the immediate change-over to the generator.

This project 'An intelligent phase selector has the following advantages over these past projects:

1. Three-phases are involved.
2. It selects power from any of the three-phases that has supply and over voltage +under voltage.
3. It automatically transfers load to any phase with a line level conforming to the desired limits.
4. It provides a visual display of the selected phase and also provides a measurers of visual system diagnosis.
5. All the actions of the circuit are controlled by the microcontroller.
6. The use of integrated circuits reduces the total number of components used.
7. It provides a semi-permanent storage of system operating parameters.

CHAPTER THREE

The 3- phase intelligent selectors system comprises the following subsystems.

1- 3-phase DC power supply

2- CD 4052 dual 1 of 4 analog multiplexer

3- 8-bit system controller

4. 8-bit analog to digital converter

5. 2-digit 7-segement display

6. 6V DC relay switches

3.1.1. Power Supply

This was derived from the AC inputs as shown below

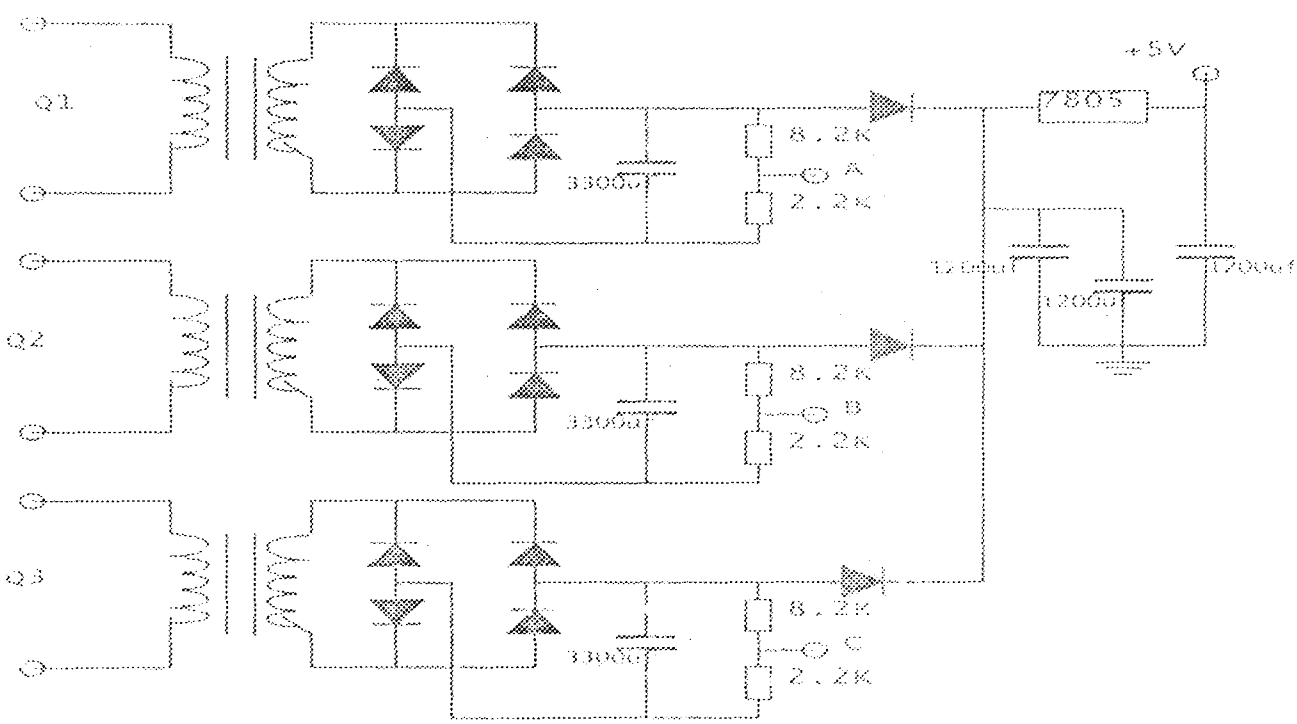

Fig. 3.0 Power Supply Circuit

3.1.2. Bridge Rectifier

The AC input on each phase was 220/240V input into a 12V step down transformer and connected to bridge rectifier as shown in fig. 3.0

The DC output of each rectifier was smoothened by a 330μF capacitance connected across a potential divider composed of an 8.2kΩ and 2.2kΩ resistor as shown below.

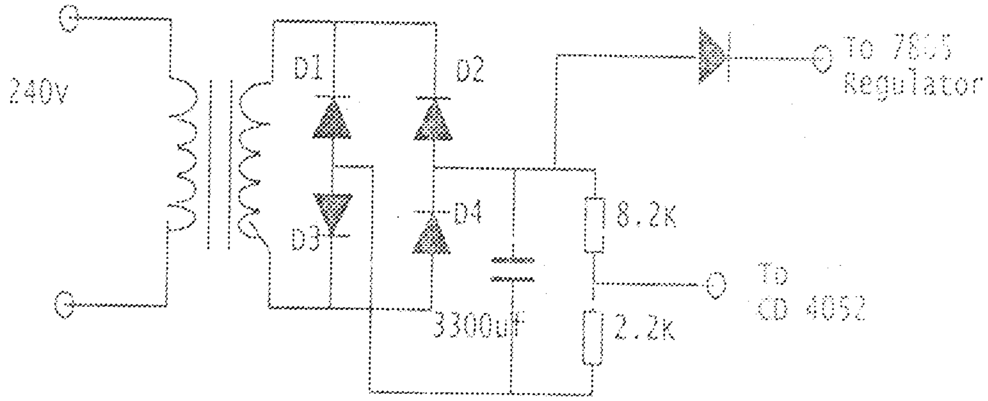

Fig. 3.1 Bridge Rectifier Circuit

Representative bridge rectifier on each phase.

$D_1 - D_4$ form a bridge rectifier that converts the 12V secondary AC voltage to a pulsating DC voltage of amplitude given by

$$V_{pe} = V_{rms}\sqrt{2} - 1.4$$

Where $\sqrt{2}$ = RMS to peak single factor

1.4 = voltage drop across two diode in the rectifier for a 12V AC input

$$V_{pe} = 12\sqrt{2} - = 15.5V$$

The 15.5v was smoothened by a capalitana of 3300μf to provide a fast responds true, and fed across the potential divides as shown in fig 3:1

The DC Voltage across the divides is given by

$$V_L = \frac{V_{pc}}{1 + \frac{1}{4FCR_L}}$$

V_{PC} = 15:5V

F = 50 H_z

C = 3300μf

R_L = 8.2k + 2.2k= 10.4K

$$V_L = \frac{15.5v}{1 + \frac{1}{(4x50H_zX3300\mu f x\ 10.4k)}}$$

$$\frac{1}{4 \times 50 \times 3300 \times 10^{-6} \times 10.4 \times 10^{3}} = \frac{15.5}{1.0015}$$

V_L = 15.48V

The input into the analog to digital converter was specified as a maximum of 5v. The voltage across the alternator was calculated such that even at over load condition (Vpc>270V) the analog to digital converts would still not be overloaded. At 240V, the voltage into the analog to digital converter is given

$$V_{ADC} = \left(\frac{2200}{2200+8200}\right) VL$$

$$= \left(\frac{2200}{10400}\right) (15.48)$$

V_{ADC} = 3.2746V

This was converted to a digital value by the analog to digital converter and stored in the RAM (Memory) for each digitized phase

3.2.1 CD4052

Since the analog to digital converter used has only a single input and a three input fronts end was needed, a means of selecting one of the three inputs was required this was realized using a CD 4052 dual 1 of 4 analog multiplexer as depicted below.

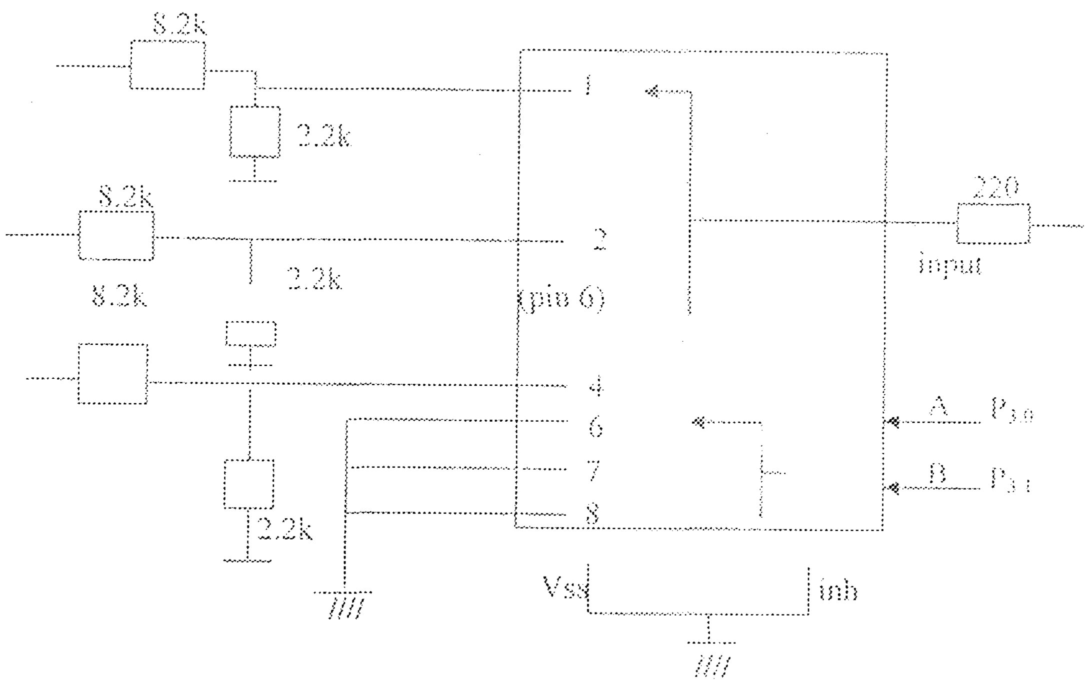

Fig 3.1 ANALOQ TO DIGITAL CONVERTER MULTIPLEXER FRONT END

The multiplexer device was capable of switching any pair of a 4 input pair. It selection was controlled via A, B address inputs (Pins 9, 10) over $P_{3.0}$ and $P_{3.1}$ of the microcontroller.

Input selection was effected by "rolling" 0 0, 01, 10, 00

The multiplexer inputs were derived from three potential divider networks connected to each phase input as diagramed bellow

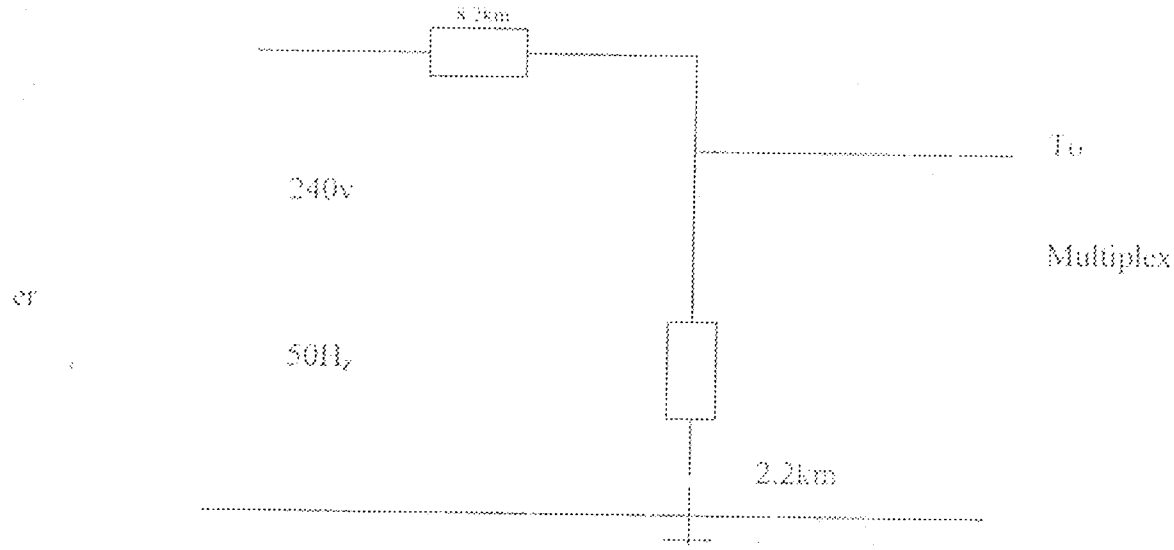

Fig 3.2 VOLTAGE TAKE OFF POINT FOR MULTIPLEXER

The selected input voltage was rated to the non-inverting input on pin 6 of the analog to digital converter for displaying

3.2.2 8 – bits Analog to Digital Converter

To effect a translation of the measured voltage from the analog domain to the digital domain, an analog to digital converter was required

This was in the form of a parallel binary output device (ADC 0804)

The device was selected because of its simplified control interfacing hard ware. It was interfaced with the microcontroller even port 7, and controlled Via its $\overline{WR}$ and $\overline{INTR}$ inputs on pin 3 and pin 5 respectively. The device has an on chip clock generator detailed below.

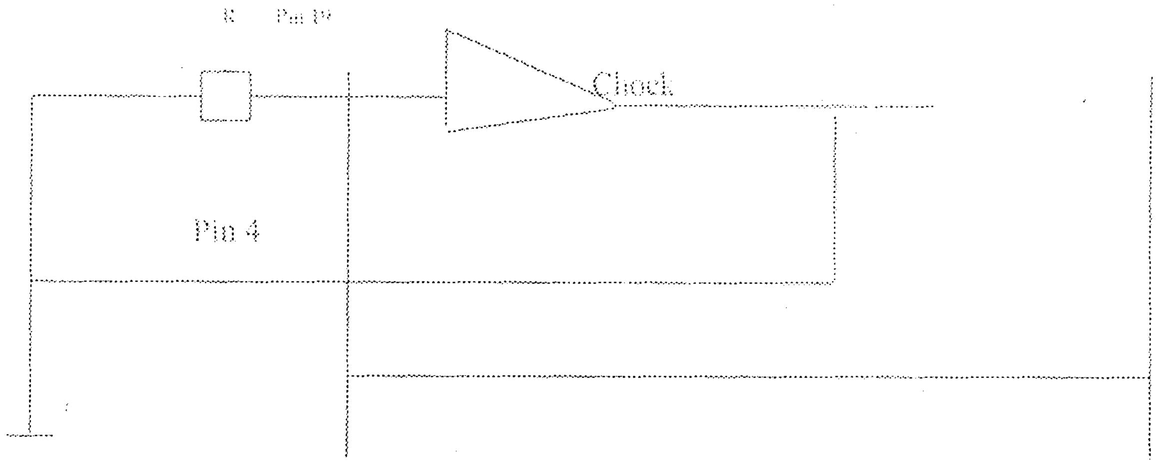

Fig3.3 Analog to digital converter

Internal clove Generator.

The device was specified for operation over a 100 KH_z to 1.46 MH_z clock frequency rate. A clock frequency of about 1 MH_z was chosen using the expression

$$F = \left(\frac{1}{1.1RC} \right) H_z$$

R is the resistance between Pin 4 and 19

C is the capacitance from Pin 4 to ground.

R. is typical 10 K (Manufacture specified)

C was made a 100PF capacitance.

The frequency therefore was

$$F_c = \frac{1}{1.1RC} = \frac{1}{1.1 \times 10^4 \times 10^{-10}} \quad H_z$$

$$= \left(\frac{1}{11 \times 10^{6}} \right) H_Z = 910 KH_Z$$

The device was configured for operation with a full scale input voltage of 5v by leaving the Vref pin (Pin 9) unconnected

The 5 volt reference established the constant of proportionality between the input voltage and the output binary value according to the equation

5 = 256

X = Y

256 = 2^8 = (0 – 255) Possible binary output 5Y= 256X

Y = Corresponding binary output for an analog input voltage X.

Y = 51. 2X

This is the equivalent binary output voltage X can be easily deduced using the expression above

3.2.4 8- BIT SYSTEM CONTROLLER

Due to the need for logical decision involving, an embedded process was incorporated in the design. This was in the form of an 8 – bit AT 89C51 Microcontroller the device was used to:

i Control the Multiplexer

ii Control the conversion pulses

iii Select the appropriate phase

The device was interfaced with other system components as shown in complete circuit diagram

The controller also drove a 2-digit 7-segment display that outputs a visual indication of the system status. Two common anode displays were used, and two digit driven transistors were incorporated to derive the display. Three PNP transistors were switched Via software to select the appropriate phase to connect to depending on the output of the logical test made on the Magnitude of the three phases.

DESIGN CALCULATIONS

POWER SUPPLY

A three phase supply produce a voltage with a 300H, Ac contents the value of smoothening capacitance required on the voltages is

$$C = \frac{IT}{V}$$

Where I = Maximum load currents

$$T = \frac{1}{F}$$

(F = mains frequency)

V = maximum allowable Ac ripple

Voltage on the DC supply

For a regulated 5 - volt Dc Supply the Minimum input Voltage required was 7V.

The output of the rectifier was (computed here)

A MAXIMUM ripple Voltage of about 5V was picked. The load current was computed from the total current drawing by the system and was put at 310mA from the values below

ADCO804...Negligible

89c51 ....15mA

Relay 15mA

Display 280mA

The total current required is 310mA = 0.31A

Inserting the variables into the equation

$$C = 0.31 \times \frac{1}{4\times50} = \frac{0.31 \times \frac{1}{300}}{5}$$

= 310μf

Thus, A 3300μf Capacitance was selected instead to make for a better system specifications

DISPLAY UNIT 7 SEGMENT DISPLAY:

The display was multiplexed to reduce on the number of wires needed to interface or with the system.

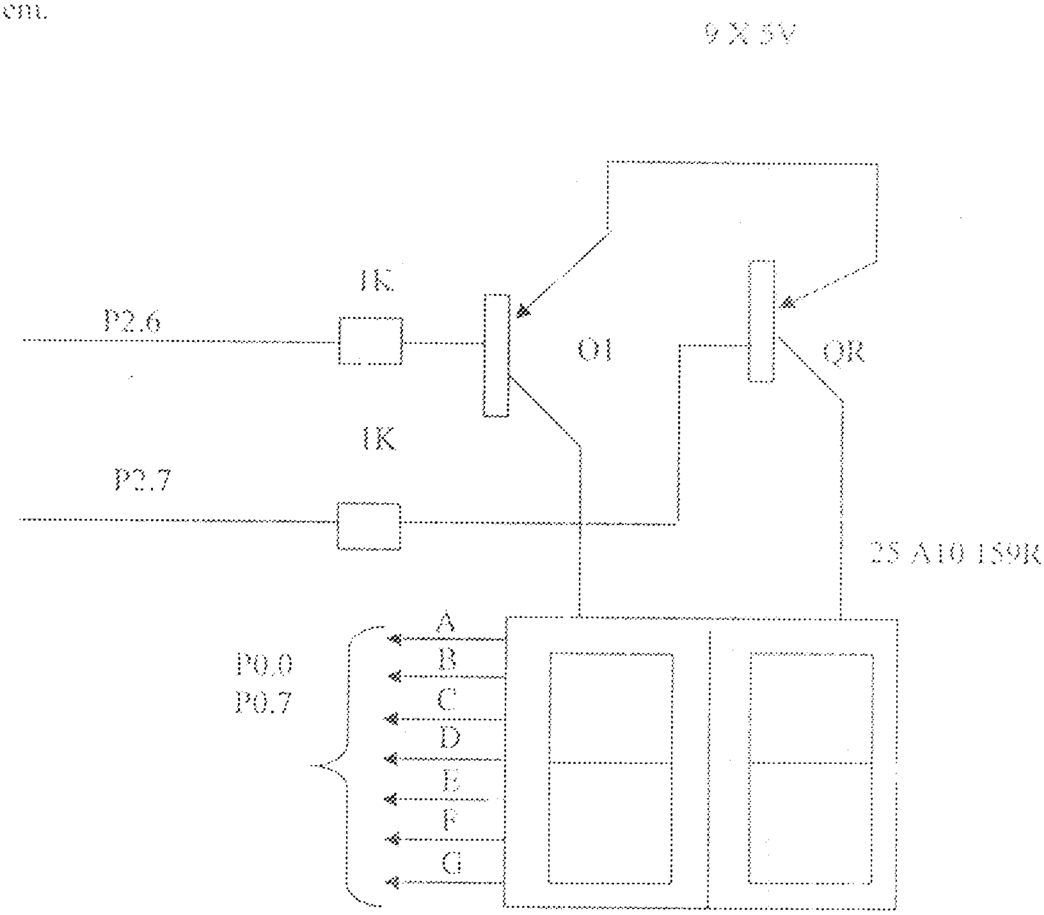

Fig. 3.4 2 digit display

The current required by each digit is computed from N x $I_{forward}$ x 7

N = number of digits in the display for G2 digit display with an I LED forward current of 10MA

Digit current = 10 x 2 x 7 = 140mA

This digit current becomes the collector

Current of each digit driver

The transistor used (25A 10159R)

have a sum of typically 200 – 250

$I_C = BI_{B = 140\,MA}$

$$IB = \frac{I_C}{B} = \frac{0.14}{200} = 700\ NA$$

$$R_b = \frac{Va - V_{CE}}{I_b} = \frac{5 - 0.7}{0.0007} = 6\ km$$

$$= \frac{4.3 \times 10^4}{7} = 6km$$

$$= 6\ km$$

A 1Kilo-Ohm value was used since the higher collector current can easily be limited in software by making the on-time of the transistors short

Three relays were connected to the collector for phase switching. The three transistors were divided by $P_{2.2}$ – $p_{2.4}$ of the controller (microcontroller)

A representative circuit is shown below

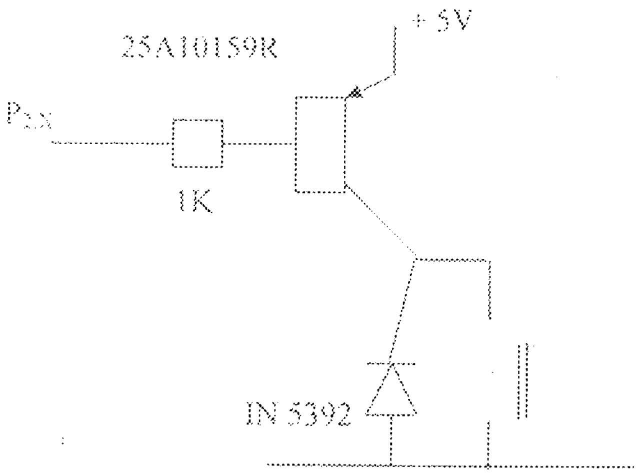

Fig. 5 Relay driver

6V 10A Contact current relays were used. Relay resistance were measured as 400 p_c

yielding a relay coil current of 15mA

Using the equation for R_b above the maximum corresponding base resistance needed for a 15mA collector current was

$$R_B = \frac{5 - 0.7}{0.015} = 0.28k$$

A 1kilo-Ohm resistance was adopted to allow for overdrive and relay switching at all possible times

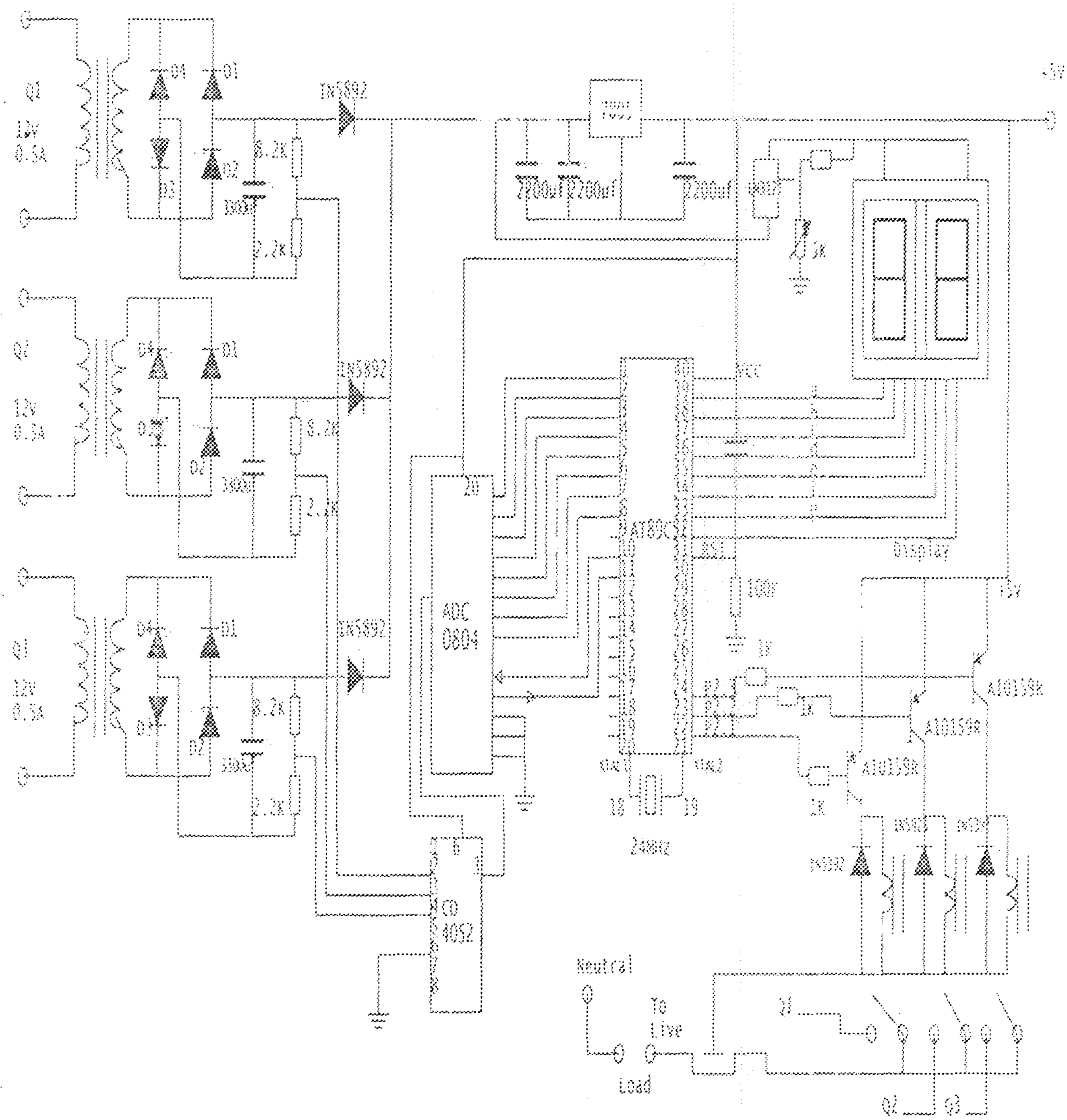

Fig. 3.6 Complete Circuit Diagram

CHAPTER FOUR

4.0 TEST AND DISCUSSION OF RESULT

4.1.0 TEST

The testing of the project work involved paltry the set up with a wring co necting the AC source to the circuit. The input supply were committed, with the aid of computer cable, to a phase socket box. It involved three plugs Red-phase, yellow phase and Blue phase respectively. The control of the device was done on socket box by putting off or removing one plug or two indicate that the supply from (PHCN) means either Red Phase is out of power.

4.1.1 STEP ONE

In step one the three pin plugs were put in place

4.1.2 STEP TWO

In step two the three plugs (Red, Yellow, Blue Phase) were powered by the socket, one was switched off indicating that three is no power supply from that phase or the supply is too low. Immediately the socket is switched off the device select to another phase whose magnitude is – 10V as the power variation required. IEE regulation leaving the other phase that may have it SV supply at -20v below the standard voltage supply

4.1.3 STEP THREE

The socket that was switched off or removed from the socket was put back to indicate that the red phase has been restored.

4.1.4 STEP FOUR

When the three socket were switched off or removed the circuit did not function which means there was not power supply in any phase.

4.2.0 RESULT AND DISCUSSION OF RESULT

4.2.1 THE FIRST STEP

Switching off the three socket box will make the device useless. When the socket R is switched on the bulb committed as load was on with no response from the other sources. Then the consolation remain the same when other socket were switched on.

4.2.2 THE SECOND STEP

Switching off socket R (red phase) result into switching off the lamp and immediately the system select another phase and log on to it this is done after about 4.32 second the lamp comes on again.

4.2.3 THE THIRD STEP

The Y-phase which was selected by the system was also switched off to show that the yellow phase is out of power the lamp off third the same operation performed by the system above repeated

4.2.4 THE FOURTH STEP

When the three socket were switched off the lamp went off with no response from the relay switch.

4.3 DISCUSSION OF RESULT

When the three plugs (R,Y & B) were switched off or removed the circuit yield of no result. The sketching off of phmp (P) allowed the controller through to relay switch which was connect the circuit to the incorporated microcontroller and then selected another phase of the higher magnitude (normal voltage) and log on to it thereby display the appropriate phase selected as either P1, P2 or P3 which indicate red phase, yellow phase and Blue phase respectively.

The was a delay of about four second, after which the lamp comes on again the switching on of other phases show no response useless the power variation of either -20 or +10 of the standard voltage supply is maintain which indicate under voltage or over voltage respectively.

4.4 CIRCUIT CONSTRUCTION

The coordinated steps were involved in the coupling of the components of this circuit construction with respect to the circuit diagram. Therefore, the design was of great importance because the circuit is supposed to operate as specified the circuit diagram was simulated on an electronic workbench. Each stage was tested accordingly using the system software and they all gave out the desired result.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1.1 CONCLUSION

After the construction and trouble shooting phases, the prototype device/system worked according to the specified constraints 200 watts lamp was used as load. Hence the device worked in accordance with the design specification (normal voltage 220V to 240V) and the voltage variation (-20 or + 10) before changing over to any phase.

5.1.2 RECOMMENDATION

1. The generating set terminal should be involved
2. Timing circuitry could be incorporated into the design to allow different delay in switching.
3. 3-phase power application of the circuit is possible

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APPENDIX A

Mode of operation of the intelligent phase selector system the phase selector system is essential in every home, Hospitals, G.S.M Operating rooms, Barking industry where operation require continuous/uninterrupted power supply and above all standard voltage supply of 220V.

The function performed are

* Monitor the voltage variation (-20 or +10) in any phase either over voltage, under voltage or normal
* Select and log on to any available phase with normal voltage from power holding company

CIRCUIT OPERATION

The 12V step down transformer connected to each phase step down the input voltage to 12V AC this was input to a half wave bridge rectifier, the output of the bridge rectifier was realized as 15.5V pulsating DC which is regulated by regulator (7805 and LM317T) to 5V.

The LM 317T monitor the input voltage to the seven segment display with the aids of potential dividers to put the terminals of the controller to appropriate voltage o that the reasonable change of input voltage result into power switching operation.

The output of the controller is then fed into the control switch which does the change over to the selected phase.