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Automatic Multiphase Selector Using PIC16F876 Peripheral Interphase Controller

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Abstract

Power inconsistency in developing Nations like Nigeria has created the current use of other sources of power like generating set, inverters, wind mill to mention but few. Not only is power failing, phase inconsistency is another alarming condition in the country. This had led many to stay in light out condition even when there is availability of power. The cause of changing over from one phase to the other or to a generating set often results to time delay and equipment damage. This paper presents the design and construction of an artificial intelligent multiphase selector that switches electric supply from one phase to another within public supply and to a Generator in the situations of power outage or abnormal power supply. This system is made up of relays being controlled by a microcontroller as the brain.

Key words: Microcontroller, Transistor, Relay, Public Supply, Generator, Rectifier

1.0 Introduction

Modernization has made power a compulsory and acceptable use to drive industrial and commercial process for both equipments and home appliances, unfortunately the poor availability of public utility power in the developing countries has pushed her citizens to seek alternatives and dependent means of electricity .This has resulted in individuals buying wind turbines, solar panels, generating sets and so on. Unavoidably this requires careful selection of the one to be ON to their use – alternative power or public power utility [1].

In the event of power interruptions, the change-over from power supplied by a public utility to a generator is usually performed manually, often resulting in wasted time. Moreover, machine damage sometimes occurs because of human errors. These can cause significant financial losses [2]. The essence of automating change over is because the erratic nature of power supply in developing nations has increasingly been of danger to its citizens and it is imperative that adequate attention be paid to the prospects of the power industry by planning effectively to put an end to the problems and causes of irregular power supply since socio-economic development is one of the indices for comparison of the standard of living in various countries [3]. Hence, there is need for automation of phase change during phase failure or total power failure in order to safe guard consumer appliances from epileptic power supply [4]. Automatic phase changeover has earlier been worked on[2,4], but they are defected in that, they use mostly comparator for their logic which makes the design bulky, expensive and unable to accommodate more input phase. Even the ones designed with AT89C52 microcontroller[1] lack the ability of analogue to digital conversion, therefore comparing mains voltage if they are within safe usage margin becomes impossible. This Automatic change over will be able to accommodate different source of electrical power supply according to the users choice and also capable of selecting, an appropriate phase from the three phase of mains by consistently checking the voltages of the three phases to be able to protect the user's equipment. This can be easily achieved by the use of a peripheral interface controller PIC16F876, which are very cheap, Although there are many models of PIC microcontrollers, the nice thing is that they are upward compatible with each other and a program developed for one model can very easily, in many cases with no modifications, be run on other models of the family [5]. The general circuit has a voltage sensing part that senses the presence of a phase and also the voltage range if it is in a safe region or it would be harmful to the load before sending the signals to the microcontroller which will finally make the appropriate decision then chooses an appropriate phase input then

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sends it out as a signal to a transistor which then energies a relay to produce the desired output phase as its logical decision while deactivating the probability of any other relay with phase input to be turned ON.

2.0 Design Methodology

The automatic multiphase change over's complete circuitry is been analyzed here with the different modules in focus

1. SUPPLY UNIT

As seen in Fig1, the design is powered by a DC supply from a battery which is recharged when there is power and can serve in the switching sequence even when there is no available power.

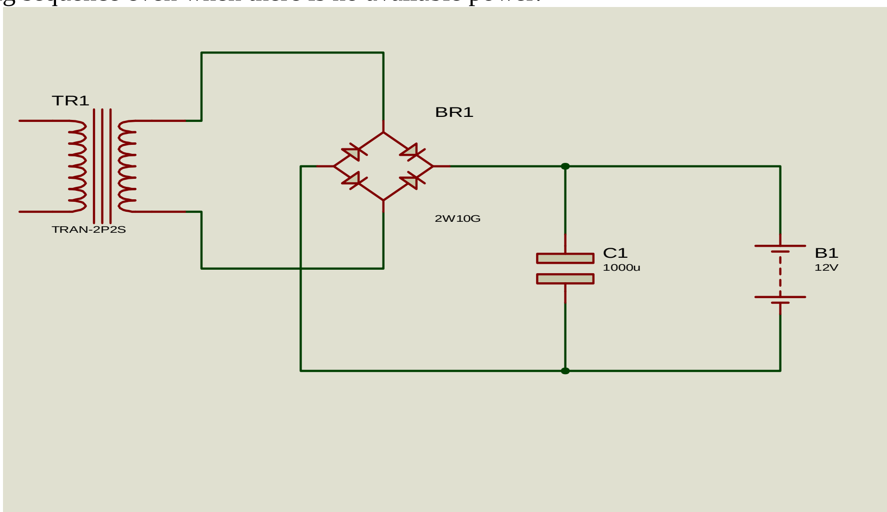

Fig1: Power supply unit with rechargeable battery

The circuit utilizes a step down transformer which is connected to the output of the automatic multiphase change over so that whichever phase or source of power is the output, be it a generating set or an inverter the battery would be charged. The step down transformer is connected to a bridge rectifier where the ac voltage is rectified to dc voltage then to a capacitor for further filtering then to the battery for proper charging.

2. ANALOGUE DIGITAL CONVERTER

A 220V signal cannot be connected directly to a PIC microcontroller's input channel, it is far higher than its operating voltage, and the microcontroller could be damaged. So, a voltage scalar that will scale down the input voltage to the safe operating voltage range of PIC16F876 is applied as seen in Fig2. It can be achieved by stepping down the transformer voltage to a maximum of 10volts(Vac) then rectifying before using simple resistor divider network shown below. The calculation involving the transformer step down to 10volts is actualized using

$Ns/Np = Vs/Vp$ = output = 220/22 = 10 …………………………………….. (1)

Eqn.(1) is used when calculating for the turn ratio of the transformer to be used.

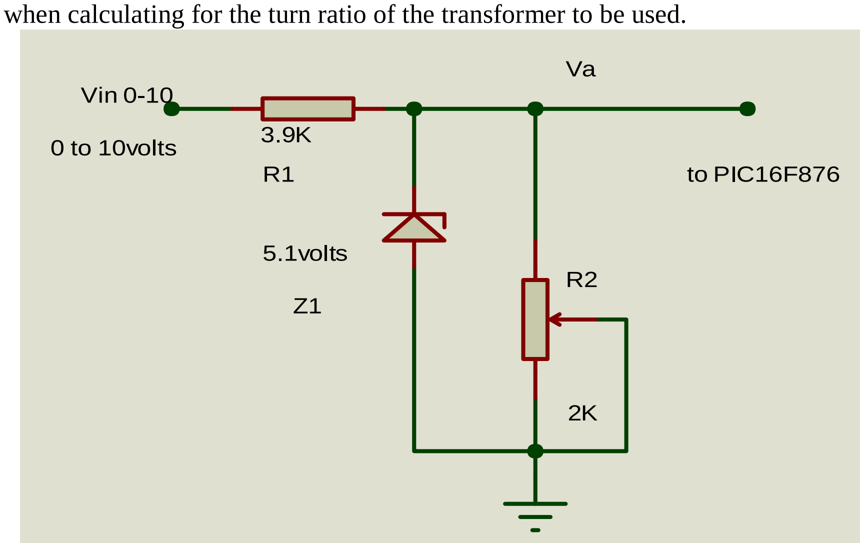

Fig 2: Voltage divider network for ADC

Therefore I/P voltage ranging from Vin = 0 – 10volts is scaled down to the output Va which varies from 0 – 5volts.
Next, 0 – 5 V Analog I/P is mapped to one of the 1024 levels (0-1023 Digital Count) to give a resolution of :
Resolution = 5/1024 = 0.0049 V/Count ……………………………………… (2)
When R1 is checked for exact value using a multimeter the value was 3890, while R2 is adjusted to 1267 so that Va gets to 5volts.
Va=R2*Vin/(R2+R1) = 1267*Vin/(1267+3890) = 0.2457*Vin ………………. (3)

Using two resistors, R1 and R2, the input voltage ranging from 0-10V can be then converted to 0-5V. For the chosen values of R1 and R2, it is seen that the output (Va) from the resistor divider network is 1/2th of the input voltage. If the input voltage goes beyond 10V, Va will exceed 5V, and this could be harmful for the PIC microcontroller. With the 5.1V Zener diode across the R1 resistor, the output Voltage(Va) will never exceed 5.1V. This will protect the microcontroller from any possible damage due to high voltage input. The voltage(Va) will go to ADC channel of the PIC16F876 microcontroller.
The voltages of the three input phases from public supply would be displayed and seen in the LCD. The source code for the ADC is written in such a way that after calibration of the circuit, 220volts from mains would be 3volts DC from Va. Table 1 is the table of LCD read out and the corresponding logic decision by the circuit. From Table1, when AC voltage is low or high the logic control would not accept it to be output for the load as this is dangerous to equipments and appliances thereby protecting them against under and over voltages.

Table 1: LCD read out from Va at different voltages

Va(DC)	0volts	1volts	2volts	3volts	4volts	5volts
LCD Readout (AC)	0volts	73volts	147volts	220volts	293volts	365volts
Control Logic	0	0	0	1	0	0

Where:

Va = output from the voltage divider network
Vin = voltage input to the voltage divider network
I/P = the input analogue voltage to microcontroller
DC = direct current
AC = Alternating current
Np = Number of turns in the primary side of the transformer
Ns = number of turns in the secondary side of the transformer
Vs = voltage form the secondary side of the transformer
Vp = voltage from the primary side of the transformer
1 = logic TRUE
0 = logic FALSE
X = either 1 or 0

3. PHASE SENSING & SWITCHING

The phase from which the power has to be taken is sensed and sent to the control logic.

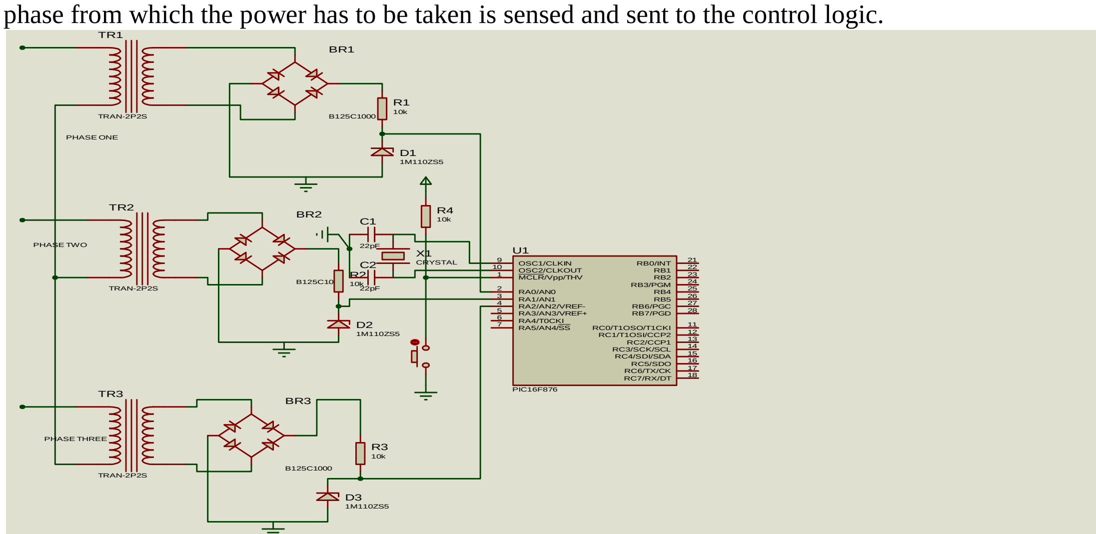

Fig 3: Three phase input from mains

In Fig 3 the three phase from public supply has been stepped down, rectified then connected to the microcontroller which at all times would be monitoring the voltages of the input voltages using its analogue digital converter (ADC). The transformers TR1, TR2 and TR3 is been connected so that TR1 is coming from phase one, TR2 from phase two and TR3 from phase three. All the neutrals are connected together. The crystal oscillator is connected to pin 13 and 14 of the PIC16F876, this generates the operating frequency of the microcontroller. The PIC16F876 receives these signals from the phases then compares the voltages and finally switches ON only the phase that is appropriate at that time

Root mean square (R.m.s) of the secondary = 10V

Maximum voltage across the secondary = 10 x √2 = **14.14V**. ……………… (4)

4. CONTROL LOGIC

The control logic circuitry decides the phase priority for one out of Three phases and to generator or to the other provisional supply as the case may be when there is total absent of power.

Table 2: Truth table explaining the logic control of the automatic multiphase changes over

INPUT					**OUTPUT**
First phase of public supply	**Second phase of public supply**	**Third phase of public supply**	**Generator**	**Other source**	
1	X	X	0	0	1
0	1	X	0	0	1
0	0	1	0	0	1
0	0	0	1	0	1
0	0	0	0	1	1

If any two of the phases or all of the phases happens to be equal, the program then runs in a default mode where it makes its logical decision based on sequence as seen in Table 2. If at any time any of the phases happens to exceed 240volts the logic control would not respond to that phase and sees it as not available. In the absence of the three phase from public supply the Generating set is then set to be the active phase while the microcontroller sends a signal as low output to put on the generating set which should have been connected to a relay as its start key controlled by the microcontroller

3.0 General Circuit Operation

The schematic diagram shown in Figure 4 is the complete circuit diagram of the automatic multiphase change over, the circuit has three transformers which connects from the mains then to individual bridge rectifier, its then connected to a voltage divider to enable adjustment of the Va while a zener diode is used to protect against overvoltage. The three inputs are then connected to the PIC16F876. An LCD 16x2 is connected in 4bit mode to the microcontroller also, this is done so that the current state of the automatic multiphase change over can be seen via the read out.

The next stage is the transfer of the signals by the microcontroller from where the processed signals are sent to the Relay which will perform the control operation of the loads. These signals are transferred out from the microcontroller through Port C (Pin11-Pin14) to transistors then to the relays. The relays are powered by an unregulated 12v voltage from the power supply. still in the output, when there is no signal from any of the PHCN phases the microcontroller sends out a signal from pin 15(RC4) to a generator set to start it up while the load relay RL4 disconnects the load from PHCN to the generating set. The schematic diagram is shown below

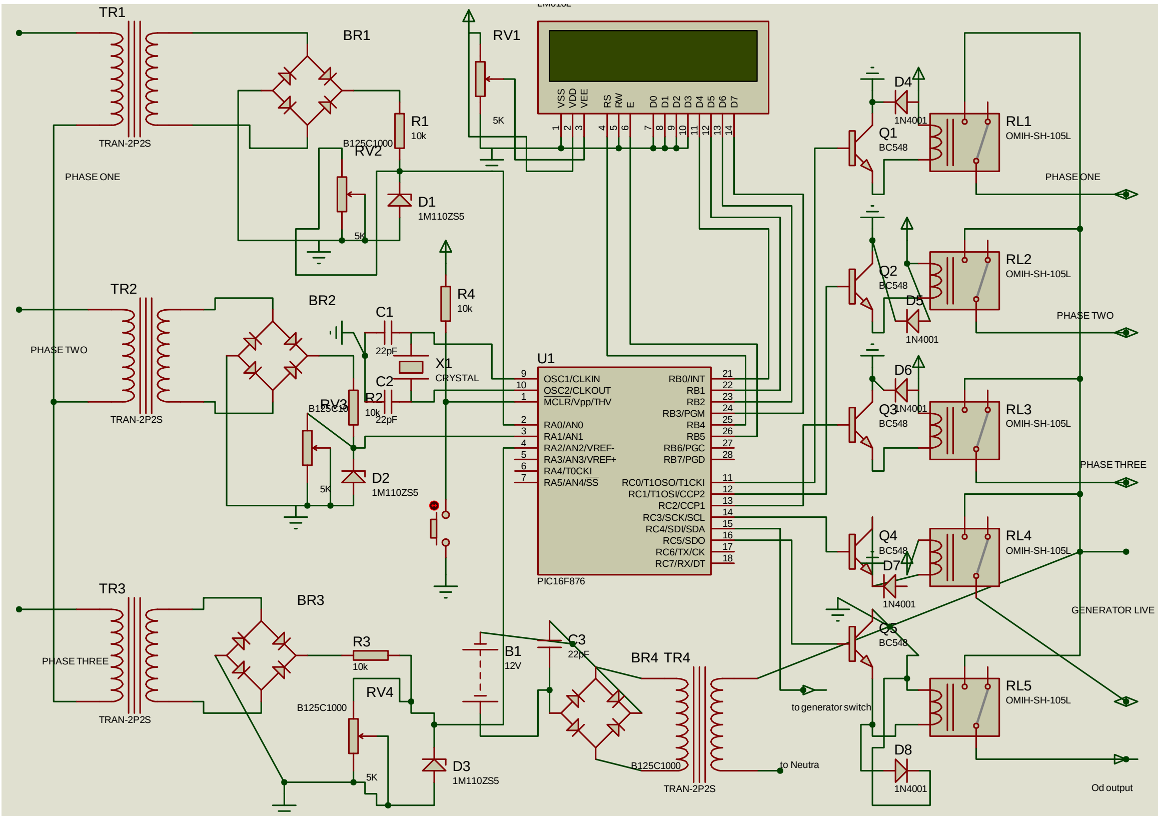

Fig 4: Complete schematics of the automatic multiphase change over

4.0 Software

The software is written in mikroC then complied and burned into the PIC16F876 using mikroelectronika development board as the programmer.

5.0 Testing

The design texting of the design was carried out in two stages

1. The use of software simulator called protease which was used in the circuit design was also used for the simulation of the circuit while measuring every signal movement from one section to another
2. Testing using multimeter section by section, starting from the bridge rectifier to the final output viz:
   - i. Testing the voltage across the bridge rectifier
   - ii. Calibrating the voltage three voltage divider network
   - iii. The switching of phase during logic control

6.0 Conclusion

The methodology employed in the design of automatic multiphase change in this study to is a better solution to epileptic and inconsistent phase failure mostly seen in developing nations. Unlike the methods earlier used[1,2,4], the designs were seen to be much bigger due to their component sizes, less intelligent, incapable of protecting the load in situations of overvoltage or under voltage and higher cost involved in their production. With the use of PIC16F876 in this study it was then possible to realize a smaller design which is more intelligent, capable of overvoltage and under voltage load protection, far less cheaper to produce and capable of handling more input phase as desired by the user, be it an inverter or a standby generating set alongside the three phase input from public supply. The design was fully optimized.

7.0 Reference

[1] Mbaocha, C. (2012). Smart phase change-over system with AT89C52 Microcontroller. IOSR Journal of Electrical and Electronics Engineering 1(3): 31-34

[2] Ahmed, M. S.,Mohammed, A. S. and Agusiobo, O. B.(2006). Development of a single phase automatic change-over switch. IOSR Journal of Electrical Electronics Engineering. 10(1):68-74

[3] Adedokun,G. and Osunpidan,I.B.[2010].Panacea to Epileptic Power Supply in Nigeria. The Pacific Journal of Science and Technology Volume 11.

[4] Ettah,E.B, Ekpenyoung,E.E and Oduobuk,E.J. [2014] Design and Implementation of Automatic Three Phase Changer Using LM324 Quad Integrated Circuit. International Journal of Engineering and Technology Research Vol. 2, pp. 1 - 15, ISSN: 2327 - 0349 .

[5] Bates, J, H, I. and Wilmshurst, M.S. (2008). PIC Microcontroller know it all. Newness Press, Chicago. 4p.