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Power Grid Synchronization Failure Based On Voltage and Frequency Variations beyond Limit

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ABSTRACT—In this project we are going to implement the use of up-to-date technology in sensing the very low variations in frequency or voltage magnitude of a generator in a Power grid in which there may be many generators working in synchronism with the grid in terms of phase sequence, voltage magnitude and frequency. In today's practical Power grid as we all know many generators or power source are working together and to maintain stability between all, the detection and isolation of the sources falling out of synchronism, is of crucial significance as otherwise it would have caused the entire system to fail. Hence various techniques have been developed in industries and power plants (especially solar power plants) to keep all the generators and sources in synchronism with the Power Grid and in case of and failure detect and isolate the failed generator out of the grid and hence maintain a stable operation of the Power System.

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I. INTRODUCTION

The project is designed to develop a system to detect the synchronization failure of any external supply source to the power grid on sensing the abnormalities in frequency and voltage.

There are several power generation units connected to the grid such as hydel, thermal, solar etc. to supply power to the load. These generating units need to supply power according to the rules of the grid. These rules involve maintaining a voltage and the frequency variations within limits.

If there is any deviation from the acceptable limit of the grid it is mandatory that the same feeder should automatically get disconnected from the grid which by effect is termed as islanding. This prevents in large scale brown out or black out of the grid power. So it is preferable to have a system which can warn the grid in advance so that alternate arrangements are kept on standby to avoid complete grid failure.

This system is based on a microcontroller of 8051family and/or Arduino. The microcontroller monitors the under/over voltage being derived from a set of comparators. As the frequency of the mains supply cannot be changed, the project uses a variable frequency generator (555-timer) for changing the frequency, while a standard variac is used to vary the input voltage to test the functioning of the project.

A lamp load (indicating a predictable blackout, brownout) is being driven from the microcontroller in case of voltage/frequency going out of acceptable range.

Further the project can be enhanced by using power electronic devices to isolate the grid from the erring supply source by sensing cycle by cycle deviation for more sophisticated means of detection.

II. MAIN OBJECTIVE

The main objective of this project is aimed at development of such a system so as to avoid any over/under voltage and /or over/under frequency in Power System.

It also uses phase sequence indicator to show any phase sequence of the system (RYB or RBY).

This project further enhances the system reliability and security by avoiding failure of the entire system due to abnormalities in one or two of system units.

In case of any abnormal conditions pertaining to voltage or frequency the fault has to be detected and the system to be islanded or disconnected from main grid. The faulty unit shall be replaced by a standby unit to meet the load requirement; this can be achieved by further implementation of electronics devices.

The project aims to detect voltage variations beyond (200-250) volts and frequency variation beyond (49-50)Hz. A phase sequence indicator is used to indicate the phase sequence of the 3-phase system. The entire projects works on three phase basis to achieve practical power system protection goals.

III. PROPOSED SYSTEM

The system uses Arduino UNO / Microcontrollers of 8051 families or could potentially

use any microcontroller as the brain of the project sensing the input parameters i.e. voltage and frequency, comparing it to pre-set values and accordingly making tripping decisions.

The system uses a 555 timer to generate a variable frequency of the desired value for project observations. The voltage is stepped down and fed to the controller through a regulator. The voltage adjustments can be done using screw driven potentiometers.

System Design:

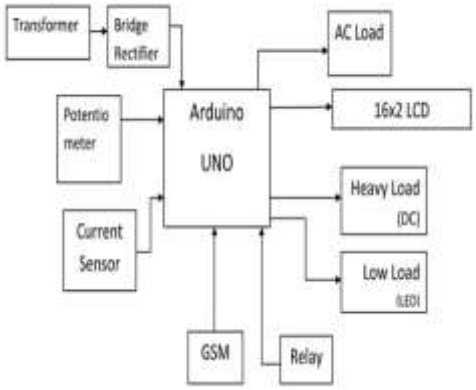

Fig 1. Block Diagram

Project Circuit Diagram:

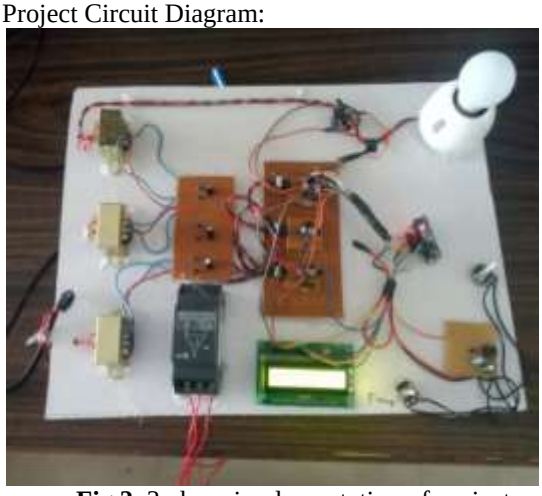

Fig 2. 3 phase implementation of project

Working Priciple:

230v power supply is given to the step down transformer. Rating of the transformer is 12v. It can be given to bride rectifier which consists of rectifier, filter and a voltage regulator. Rectifier converts the ac into dc and filter gives the pure dc signal by blocking ripples.

The dc voltage is further regulated and Microcontroller receives this DC power from rectifiers. The output of the microcontroller is connected to16×2 LCD Display.

The voltage can be varied by varying the voltage potentiometer. The variable frequency is obtained from a 555 timer to test the functionality of the project.

In case one for proper synchronization load testing is done by connecting Heavy load lamp of 20W and for light load LED are connected. A Pot is connected at theinputofthemicrocontroller. By varying pot the voltagechangesafterreaching the acceptable voltage theLCDdisplaystripvoltage. The relay circuit will be opened and the lamp will be protected. The frequency variation is shown before tripping. The light will flicker before it turned OFF.

An addition phase sequence detector is used to indicate the phase sequence of the power supply. RYB is the normal phase sequence. If the phase sequence of the supply changes due to any reason i.e. reversal of generator rotation then the phase sequence indicator detects the phase sequence and accordingly a tripping signal should be generated to avoid mal operation of the entire grid.

Hardware Description:

- Arduino UNO MC
- LCD 16x2
- Transformers (230/12v)
- Diode Rectifier+ Capacitor Filter
- Relay
- Lamp Load
- Potentiometer
- Data Monitoring System(PC/Laptop)

ARDUINO SOFTWARE IDE: Language used: Embedded C. The Arduino integrated development environment (IDE) is a cross-platform application that is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program Arduino to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, notably using significant

whitespace. It provides constructs that enable clear programming on both small and large scales.

Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library. Python interpreters are available for many operating systems. CPython, the reference implementation of Python, is open sourcesoftware and has a community-based development model, as do nearly all of its variant implementations. CPython is managed by the non-profit Python Software Foundation.

IV. ARDUINO UNO

Arduino Uno is a microcontroller board based on the mega 328. It has a ceramic resonator that is 16MHz, fourteen digital input/output pins (six of which can be used as PWM outputs), a reset button, a USB connection, a power jack and six analog inputs. It is an 8-bit microcontroller based on RISC architecture.

The Arduino does not use a RC oscillator, but rather a crystal oscillator because of the quality factor (Q). The quality factor for a crystal oscillator is of the order 100,000 whereas the quality factor for an RC oscillator is of the order 100. A quality factor is defined as: $Q = f/BW$
Where f is the resonant frequency and BW is the bandwidth.

Fig: 2 Arduino block diagram

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector. The board can be operate on an external supply of 6-20volts. If supplied with less than 7V, however, the 5V pin may supply less than 5V and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended voltage is between 7-12V because if the voltage dips below 7V, the 5V pin on the Arduino board will become unstable and if the voltage rises above 12V, the board may overheat and become damaged.

The power pins are as follows:

VIN The input voltage to the Arduino board when it's using an external power source (as opposed to 5volts from USB connection or other regulated power source).You can supply voltage through this pin or,if supplying voltage via the power jack, access it through this pin.5V.The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V.3V3.A3.3 volt-supply generated by the on-board FTDI (Future Technology Devices International) chip. Maximum current draw is 50mA.

MEMORY: The Atmega328 has 32 KB of flash memory for storing code (of which 0.5 KB is used for the bootloader). It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50KOhms. In addition, some pins have specialized functions:

• Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

• External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

• PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.

• SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

• LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference ()

function. Additionally, some pins have specialized functionality:

• I 2C: 4 (SDA) and 5 (SCL). Support I2C (TWI) communication using the Wire library. There are a couple of other pins on the board:

• AREF. Reference voltage for the analog inputs. Used with analog Reference ().

• Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

WORKING MODULE: The Arduino Uno can be programmed with the Arduino software (download). The ATmega328 on the Arduino Uno comes Pre Burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labelled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line.

TRANSFORMER**:** In detecting power grid synchronization failure system on sensing frequency or voltage beyond the acceptable range, the transformer is used for step down the ac voltages. It steps down the 220V ac into 12V.

RELAY-In this system, the load relay is used for switch on or off the output load and it consists of normally open and close contacts.

LOAD**:** In this system, the lamp is used as an output load.

SINGLE PHASING PREVENTOR:

Protection of induction motors against single phasing or reverse phasing or unbalance supply is one of the major problems in electrical systems. For safe running of 3-phase motors, special protections that keep a continuous watch on supply conditions are very essentials. The major cause of motors burn-out is overloading which occurs due to unbalance supply or single phasing. Phase failure occurs in case of fuse blown-off, loose connections or loss of phase from supply itself.

ARDUINO TO 16×2 LCD MODULE: RS pin of the LCD module is connected to digital pin 12 of the Arduino. R/W pin of the LCD is grounded. Enable pin of the LCD module is connected to digital pin 11 of the Arduino. In this project, the LCD module and Arduino are interfaced in the 4-bit mode. This means only four of the digital input lines (DB4 to DB7) of the LCD are used. This method is very simple, requires less connections and you can almost utilize the full potential of the LCD module. Digital lines DB4, DB5, DB6 and DB7 are interfaced to digital pins 5, 4, 3 and 2 of the Arduino. The 10K potentiometer is used for adjusting the contrast of the display. 560 ohm resistor R1 limits the current through the back light LED. The Arduino can be powered through the external power jack provided on the board. +5V required in some other parts of the circuit can be tapped from the 5V source on the Arduino board. The Arduino can be also powered from the PC through the USB port.

V. RESULTS

It is observed that the tolerance of voltage is ± 10 volt and tolerance of frequency is ±2.0 as per

standard. Normally the range of the voltage and frequency is 230 volt and 50Hz respectively according to Indian standard. In this paper according to the results we observed the following conditions. Condition 1: When supply is constant that is 230 volts, 50Hz then we get constant sinusoidal waveform as output. (230volt), Frequency: (50Hz) These Parameters Limits Voltage (Volts) Frequency (H z) Over Limits 240 52.5 Constant Limit 230 50 Under Limits 220 47.5 38 Stable sinusoidal waveform Condition 2: When given supply voltage is below tolerance limit that is below 220 volts then we get the sine waveform with reducing magnitude .Sinusoidal waveform with decrease in amplitude Condition 3: When given supply voltage is above tolerance limit that is above 240 volts then we get the sine waveform with increasing magnitude. Sinusoidal waveform with increase in amplitude Condition 4: Similarly, when frequency is above tolerance limit we get large number of oscillation in sinusoidal waveform. : Sinusoidal waveform with increase in frequency Condition 5: When frequency is below tolerance limit we get less number of oscillation in sinusoidal waveform. : Sinusoidal waveform with decrease in frequency. These outputs are obtained in the PC or in the lab oscilloscope and can verify the result.

VI. CONCLUSION AND FUTURE SCOPE

This paper gives brief idea about developing a system to detect the synchronization failure of any external supply source to the power grid on sensing the bad voltage and frequency. Number of distributed generators connected in parallel to the grid, to supply power to the load. Each generator having follow the rules of grid. These rules involve maintaining a voltage and frequency variation within limits. When any fault occurs on grid and due to this grid broken a rules and deviation occur in voltage and frequency. When deviation occur in grid feeder is mandatory to open from grid and this process is term as islanding. This prevent grid failure or blackout

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