Voltage Sag Detection Using 8051 Microcontroller

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Abstract: **In recent years, there is an increasing concern with power quality problems due to voltage sags. The most important reason for this is that the customers in all kinds of industry now have many more loads that are sensitive to voltage sags. When heavy loads like induction motor started voltage sag has occurred. In this paper, the voltage sag due to starting of induction motor is detected using 8051 microcontroller. Hardware developed to detect the voltage sag is discussed. Keil software is used to write the programs. This circuit triggers a device like DVR that corrects the voltage across load.**

***Keywords**: Analog to digital converter; Full wave rectifier; Microcontroller8051; Sample hold circuit; Voltage sag; Zero crossing detector.*

I. INTRODUCTION

Voltage sag is defined as "an rms variation with a magnitude between 10% and 90% of nominal voltage and duration between 0.5 cycles and one minute" [1]

"Power quality just meant the ability of utilities to provide electric power without interruption.. New power quality problems such as sag, swell, harmonic distortion, unbalance, transient, and flicker may impact on customer devices, cause malfunctions and cost on lost production.[2]

Voltage sags are generally created on the electric system when faults occur due to lightning; accidental shorting of the phases by trees, animals, birds, human error such as digging underground lines or automobiles hitting electric poles, and failure of electrical equipment. Sags also may be produced when large motor loads are started, or due to operation of certain types of electrical equipment such as welders, arc furnaces, smelters etc. Even very short voltage dips can provoke irreversible damage to sensitive equipment and impose significant economic losses due to unexpected interruptions of industrial production processes. So, it is necessary to detect the sag and mitigation of the sag [3].

Power systems have non-zero impedances, so every increase in current causes a corresponding reduction in voltage. Usually, these reductions are small enough that the voltage remains within normal tolerances. But when there is a large increase in current, or when the system impedance is high, the voltage can drop significantly. Voltage sags are the most common power disturbance.[4]

The main reasons of the voltage sags are the lines short circuit faults, transformers energizing and large-capacity induction motors starting, which make the system current suddenly increases several times or more, and the voltage of points of common connection (PCC) reduces in a short-time. The induction motors are important in the society nowadays, and nearly 60% of the electricity consumption is occupied by induction motors. It will derive a big current from the sources when the motor starts, whose typical value is 5 to 6 times of rated current, and then the sag happens. The sag resumption is a gradual process and the sags due to induction motors usually have a depth above 85%. If the depth of some one of the three phases is less than 7% of the rating value, it is the situation of short circuit. If all the three phases' depths are larger than 85% of the rating value, it is transformer energizing or the induction motor starting. If the depth is between 70% and 85% of the rating value, it is most likely the asymmetry short circuit.[5]

II. METHODOLOGY

The voltage sag due to the starting of induction motor is detected by using the following algorithm.

A. Algorithm

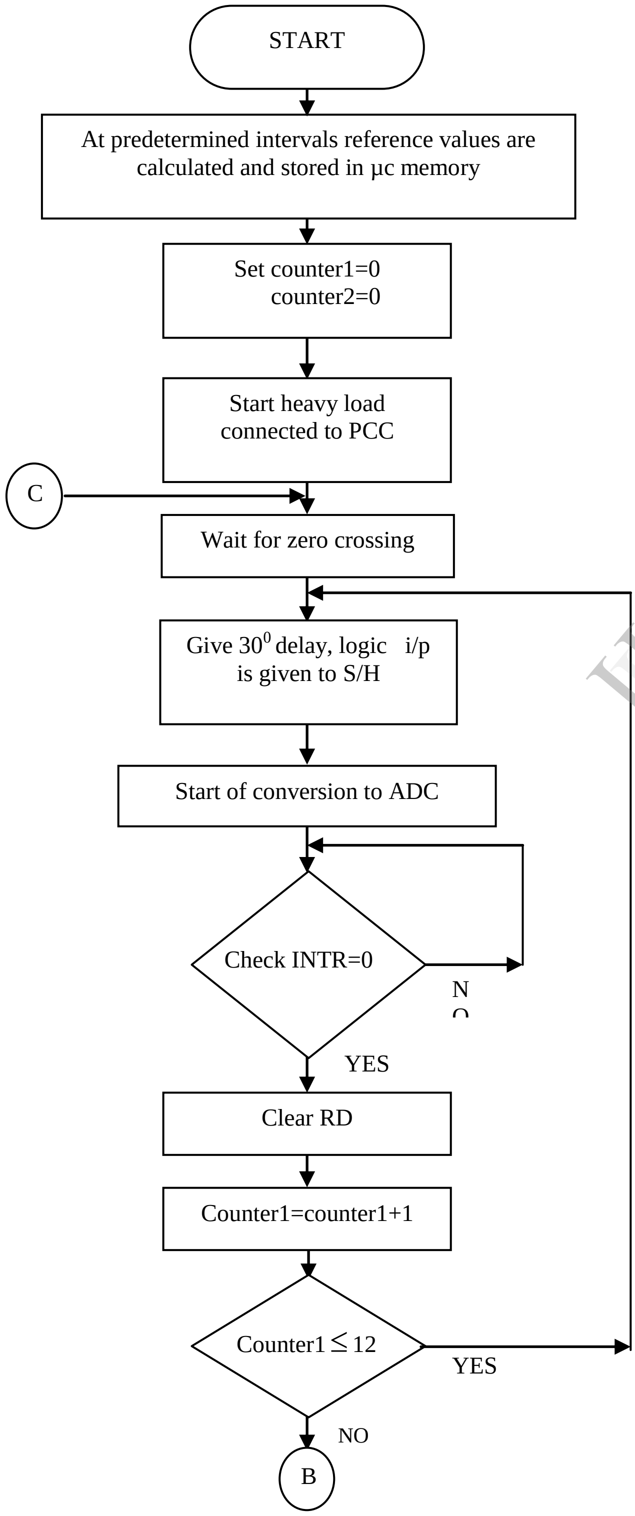
Following is the algorithm for detecting voltage sag

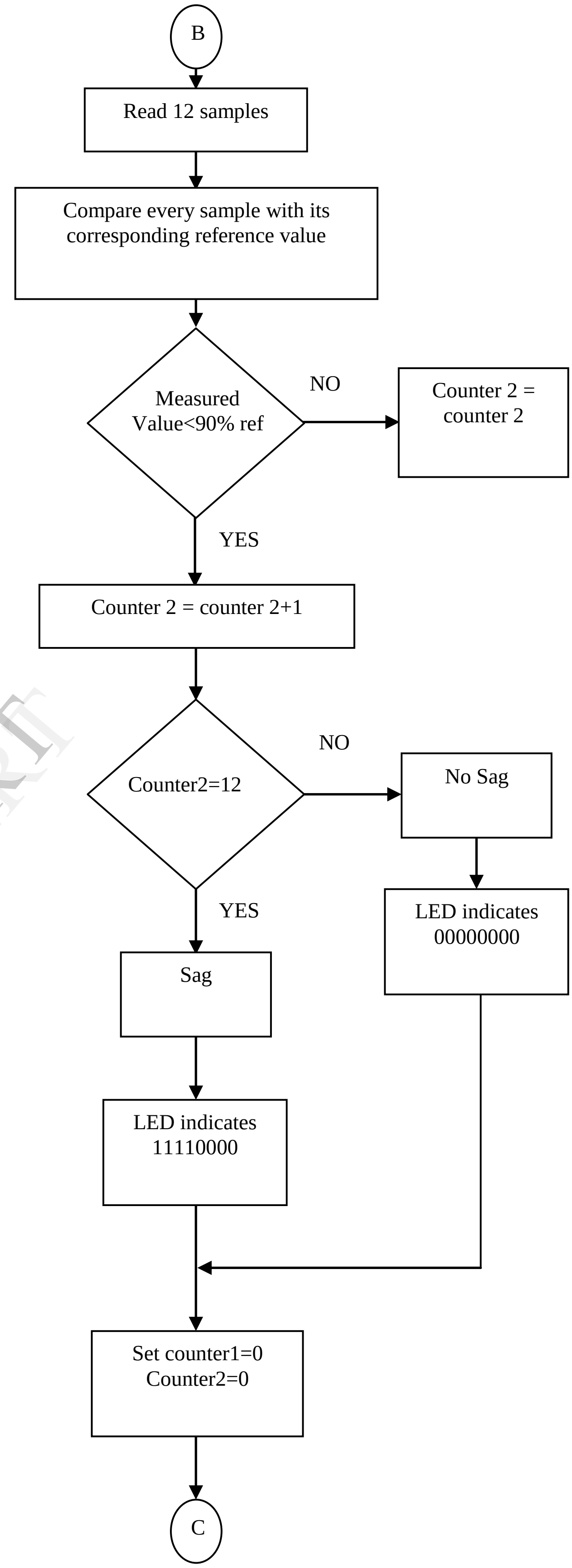
1. A 230/12 V transformer is connected to PCC. From secondary a 5V signal, under normal conditions, is obtained using a potentiometer. This signal is given to full wave rectifier circuit. Output of full wave rectifier is connected to input pin (3) of sample hold circuit and to the 3 pin of zero crossing detector. Reference values at predetermined intervals are calculated and stored in the 8051 microcontroller memory.
2. Set the counter1=0 and counter2=0
3. Heavy load like Induction motor at PCC is started.
4. Wait for zero crossing of the signal. After voltage crosses zero interrupt is activated.
5. Give 30^0 delay, for every 30^0 give logic input (pin 8) to sample hold, it samples and holds the value at that particular instant, this sampled value is given to the ADC.
6. Start of conversion is given to the ADC (by sending a low-to-high pulse to pin WR).
7. Keep monitoring the INTR pin. If INTR is low, the conversion is finished and we can go to the next step. If INTR is high, keep polling until it goes low.
8. Reading the contents of ADC (by clear RD pin).
9. Increment the counter1 by 1.
10. Check if counter1<=12, if less than or equal to 12 go to step 5, otherwise go to next step.

ISSN: 2278-0181
Vol. 3 Issue 2, February - 2014

11. After reading 12 samples, compare the every sample with its corresponding reference value.
12. If measured value is less than 90% of the reference value every time increment counter2 by 1.
13. If counter2=12 then it indicates the sag, give F0 to port0, value given to LED is 11110000.
14. If counter2<12 then there is no sag, 00 is given to port0, the given to LED is 00000000.Set counter1=0 and counter2=0 and go to step 4

B.Flowchart





III. HARDWARE SETUP TO DETECT THE VOLTAGE SAG USING 8051 MICROCONTROLLER

A.Power supply:

The term power supply generally refers to source of DC power that is itself operated from a source of AC power, such as a 120-V,50-Hz line. A dc power supply operated from an ac source consists of one or more of the fundamental components such as a rectifier, a low pass filter and a voltage regulator. A voltage regulator is a device, or combination of devices, designed to maintain the output voltage of power supply as nearly constant as possible. 78xx and 79xx ICs can be used in combination to provide both positive and negative supply voltages in the same circuit, if necessary.7812 is used to produce +12V and 7912 is used to produce -12V as shown in the fig 1.

B. Fullwave Rectifier Circuit:

By using 230V/15V step down transformer ac voltage is stepped down from 230V to 15V.Again 15V is stepped down to 5V.This 5V ac signal is given as the input to full wave rectifier circuit which convert negative voltage into positive voltage. This circuit is used because ADC0804 is a unipolar +5V Device. So we are converting negative cycles into positive by using this full wave rectifier circuit.

C. Zero Crossing Detector:To detect the zero crossing this circuit is used[8]. Op-amp LF741 is used. Output of full wave rectifier is given to the 3 pin of LF741. 7 pin is given to +12V .4 pin is given to -12V. LF741 is works as comparator. 1N4148 diodes are used to limit the output of zero crossing to the 5V.This output is given to the interrupt pin (12) of the microcontroller; it is activated when it crosses the zero

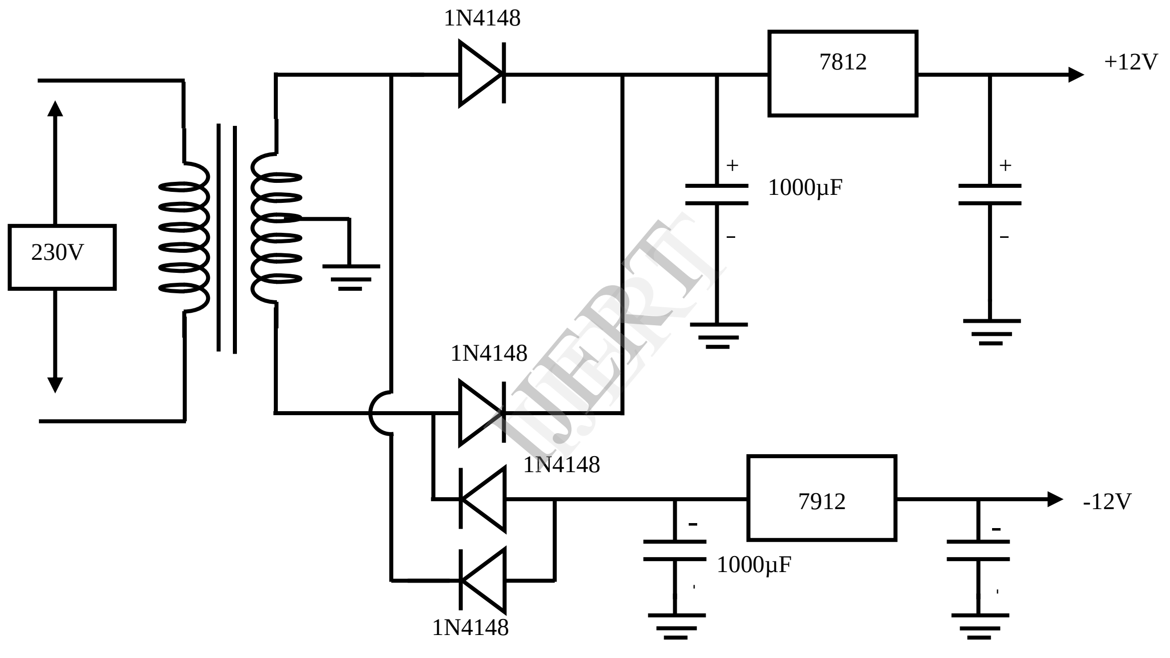


Fig:1. power supply circuit

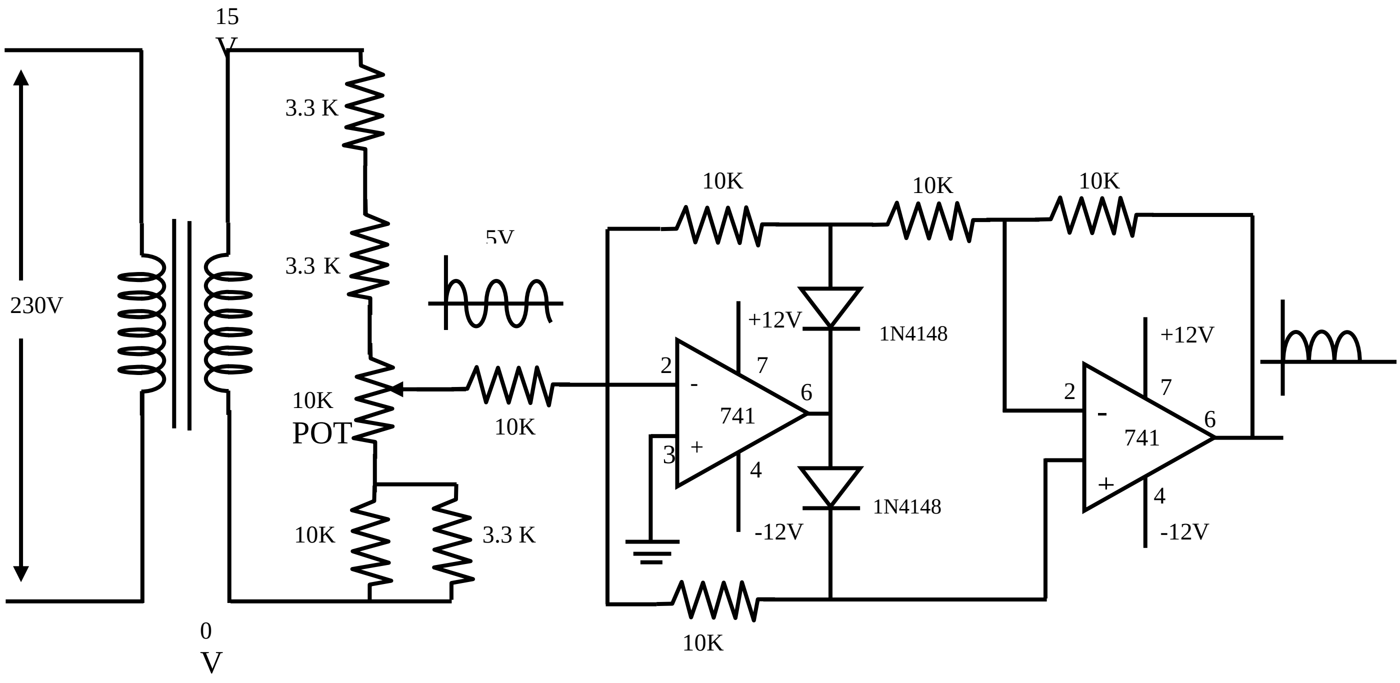


Fig2. Full wave rectifier circuit

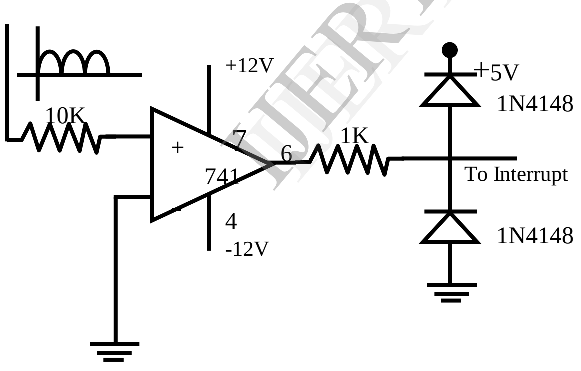


Fig.3: Zero crossing detector

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 2, February - 2014

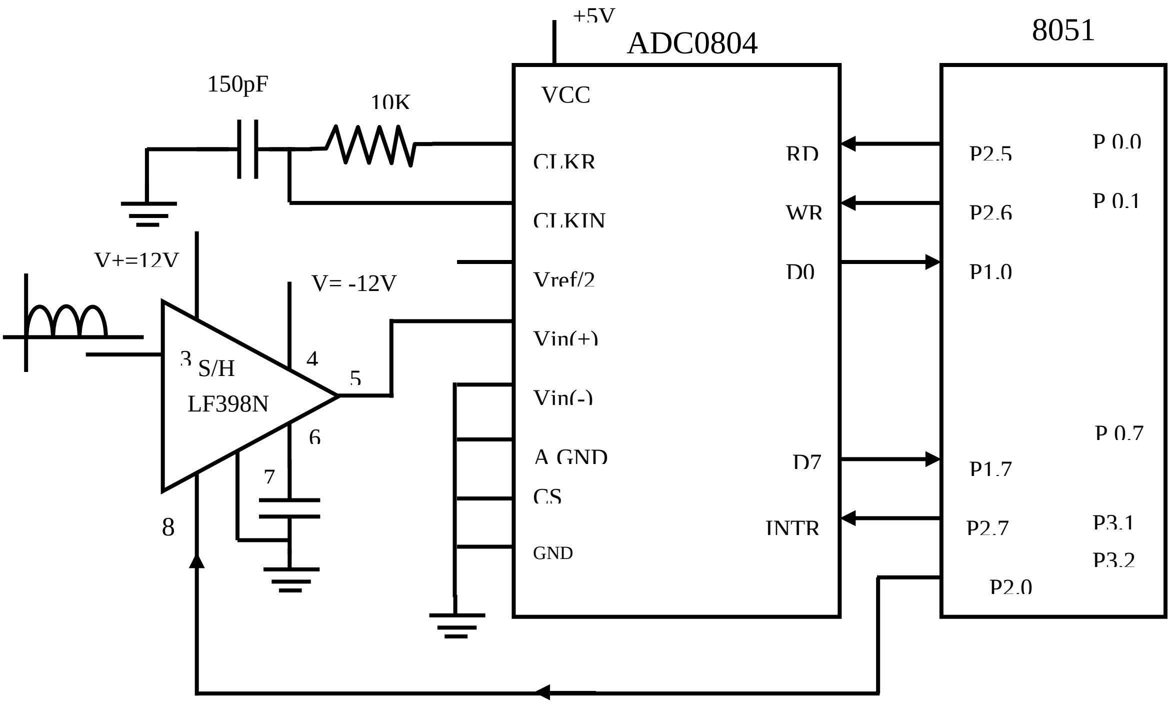


Fig.4. Sample Hold, ADC and Microcontroller Connections

D.*Sample Hold, ADC and Microcontroller Connections:*

The ADC0804 IC is an 8-bit parallel ADC in the family of the ADC0800 series from National Semiconductor. It works with +5 volts and has a resolution of 8 bits. In the ADC0804, the conversion time varies depending on the clocking signals applied to the CLK IN pin , but it can not be faster than 110µs.[7]

After zero crossing of signal is detected , for every 30^0 logic input is given to sample hold from microcontroller 8051(P2.0).Output of sample hold is given to the ADC 6 pin it converts the sampled value into digital form. Data from ADC (D0-D7) is given to port 1 of microcontroller 8051.The value at port 1 is given to port 0.Port 0 is connected to LED to know the sampled values. Time delay in detecting the sag by using 8051 microcontroller is 2 cycles. Because when the disturbance is occurred after zero crossing of voltage it take one cycle to detect the zero crossing of voltage and one cycle for taking the samples and comparison

IV.CASE STUDY

A source supplying power to Induction motor through a line as shown in fig. 5

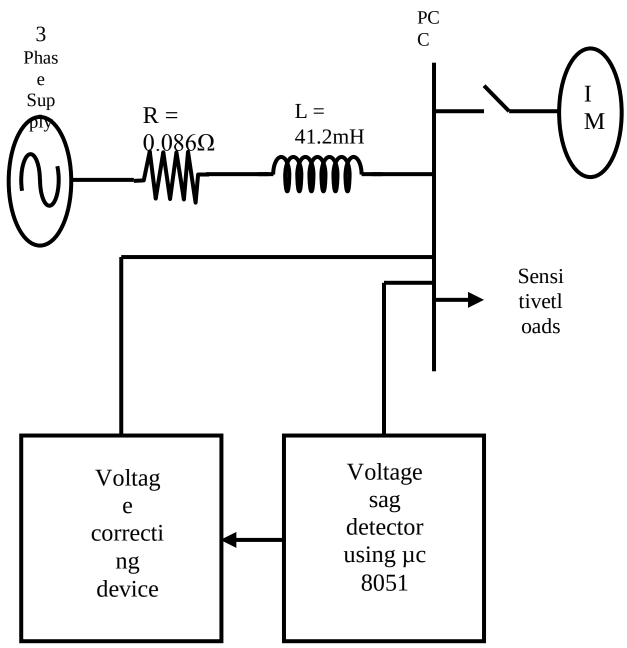


Fig.5: Experimental setup to detect the Voltage sag due to the starting of induction motor

Rating of induction motor:
Volts ---- 400 V
Current ---- 11.1A
Speed ---- 1480 rpm
kW ---- 5.5

It is assumed that sensitive loads are connected to PCC. The voltage before connecting induction motor is 245V.When the induction motor is switched on to PCC voltage waveform is shown in fig.6

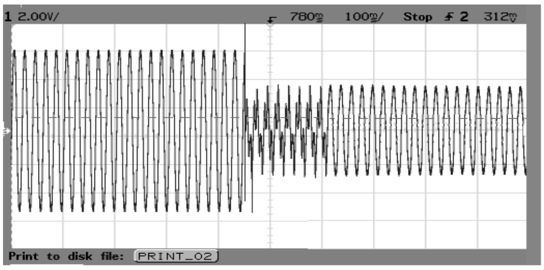


Fig.6: Voltage waveform with sag due to starting of Induction motor

The voltage sag has been detected by microcontroller based voltage sag detector with in 2 cycles as shown in fig .7

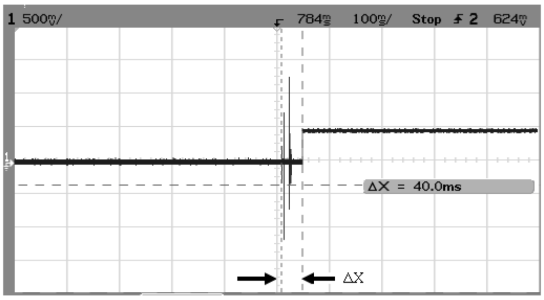


Fig.7:Response of voltage sag detector

This device triggers voltage correcting device like DVR, Dstatcom to correct the voltage of PCC. Results are in agreement with the design considerations .

V. CONCLUSIONS

In this paper, hardware is developed to detect the voltage sag using 8051 microcontroller . A source supplying power to induction motor through a line of R=0.086Ω and L=41.2mH is set up in the lab. It is assumed that sensitive loads are connected to PCC. The voltage before connecting induction motor is 245V.When induction motor is switched on to PCC voltage sag has occurred as shown in fig.6.This sag has been detected by microcontroller based voltage sag detector with in 2 cycles(fig.7). This device triggers voltage correcting device like DVR or Dstatcom to correct the voltage of PCC. Whenever there is voltage sag ,it is indicated by voltage sag detector by changing the value at LED display from 00H to F0H .

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