Accurate Measurement of Velocity and Acceleration of Seismic Vibrations near Nuclear Power Plants

By

Syed Javed Arif

Department of Electronics Engineering, A.M.U., Aligarh, India
CONTENTS

• INTRODUCTION
• THEORY
• REALIZATION
• EXPERIMENTAL RESULTS

A. When the vibration system is stationary

B. When the system starts vibrating

• CONCLUSION
• REFERENCES
INTRODUCTION

• Earthquake causes
  • Heavy Desetruction to Buildings and Structures
  • Heavy Economic Losses
  • Destruction of Nuclear Power Plants with its Cosequences
  • Heavy losses to Human Lives
As an Example Earthquake of

• Japan in 2011 Caused Heavy Destruction and Nuclear Tragedy
• Haity in 2011 Killed nearly 230,000 people
• Sumatra (Tsunami) in 2004 killed more than 300,000 people in 11 countries
Drawbacks of Existing Methods of Measurement are

- instruments like seismometers
  Misses the peaks
- Accelerometers, measures only one parameter ie acceleration
- fails to record the peak values of acceleration, displacement, speed & rise time
Drawbacks Continued

• due to poor resolution, it causes problems in the consistent design of nuclear power plants, industrial plants and buildings, resistant to strong earthquakes.
In the proposed method

• A microprocessor based vibration generation system is developed to generate rocking motion and vibrations.

• The vibration system vibrates the rotor of synchro back and forth, which ultimately varies the frequency and voltage in the rotor circuit.

• It gives the spectrum of pulses which corresponds to the velocity of seismic vibrations.
The speed of Rotor of Synchro is given by

\[ n_s = \frac{120 f_s}{P} \]

and

\[ f_r = f_s + \frac{n_r P}{120} \]
Microprocessor based control of stepper motor

Microprocessor based vibration generation and measurement setup
REALIZATION CONT'D

Single-phase to three-phase voltage conversion system
Measured waveforms $V_A$, $V_B$, $V_C$ at the output of power amplifiers (CH#1, CH#2 and Ch#3).
Measured three phase voltages, $V_A$, $V_B$, $V_C$ at stator winding of synchro (CH#1, CH#2 and Ch#3). $V_r$, $f_r$ (CH#4).
EXPERIMENTAL RESULTS

When the vibration system is stationary

Measured output of rotor, $V_r$, $f_r$ of synchro, $S$ (Ch#4) and Output of ZCD, $V_R$, $f_R$ (Ch#1) at 50 Hz.
Waveforms of signals, $V_R$, $Q$, $Q'$ and output $T_{WG-}$, when the vibrating system is stationary.
Measured output of ZCD, $V_R$ (Ch#1), output of OS $Q'$ (Ch#2), output of gate G-1, $T_{WG}$ (Ch#3) at 50Hz and output of synchro $V_r$ (Ch#4) when the vibrating system is stationary.
When the system starts vibrating

Waveforms of signals $V_R$, $Q$, $Q'$ and output $T_{WG-}$, when vibration is started.
### TABLE 1
RESULTS OF THE VIBRATION MEASUREMENT

<table>
<thead>
<tr>
<th>S.No</th>
<th>$T_{WG} \ (\mu s) = T_{WR+} - T_{WQ-}$</th>
<th>Velocity of Vibrations (cm/s)</th>
<th>Acceleration (cm/s$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>153.66</td>
<td>4.29</td>
<td>214.5</td>
</tr>
<tr>
<td>3</td>
<td>360</td>
<td>9.94</td>
<td>282.5</td>
</tr>
<tr>
<td>4</td>
<td>455</td>
<td>12.45</td>
<td>125.5</td>
</tr>
<tr>
<td>5</td>
<td>520</td>
<td>14.15</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>1000</td>
<td>26.03</td>
<td>594</td>
</tr>
<tr>
<td>7</td>
<td>1600</td>
<td>39.52</td>
<td>306</td>
</tr>
<tr>
<td>8</td>
<td>554</td>
<td>-15.02</td>
<td>-225</td>
</tr>
<tr>
<td>9</td>
<td>400</td>
<td>-11</td>
<td>-201</td>
</tr>
<tr>
<td>10</td>
<td>320</td>
<td>-8.86</td>
<td>-107</td>
</tr>
<tr>
<td>11</td>
<td>160</td>
<td>-4.49</td>
<td>-218.5</td>
</tr>
</tbody>
</table>
Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3) in roll mode at 400ms.
Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3) in roll mode at 400ms.
Measured Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3).
Measured Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3).
Measured Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3).
Measured Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3)
Measured Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3)
Experimental setup for the measurement of velocity and acceleration.
CONCLUSION

• A novel synchro and RMF based seismic vibration measurement technique is proposed

• Provides high accuracy and resolution.

• proposed method measures the vibrations with a resolution of 20 ms
CONCLUSION Contd

• It captures those peaks of vibration which are missed by conventional measurement systems due to their poor resolution.

• fast measurement of velocity and acceleration of vibrations from the proposed system will help in the prediction of earthquakes.
CONCLUSION CONT'D

• Also proposed method is very suitable for proper design of earthquake resistant nuclear power plants, buildings and structures.
REFERENCES CONT'D


- Department of Earthquake Engineering, Indian Institute of Technology, Roorki, U.P., India.