Contribution ID: **406** Type: **Oral Presentation**

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

Saturday, 11 June 2011 11:45 (20 minutes)

In spite of all prerequisite geoligical study based precautions, the sites of nuclear power plants are also susceptible to seismic vibrations and their consequent effects. The effect of the ongoing nuclear tragedy in Japan caused by an earthquake and its consequent tsunami on March 11, 2011 is currently beyond contemplations. It has led to a rethinking on nuclear power stations by various governments around the world. Therefore, the prediction of location and time of large earthquakes has regained a great importance. The earth crust is made up of several wide, thin and rigid plates like blocks which are in constant motion with respect to each other. A series of vibrations on the earth surface are produced by the generation of elastic seismic waves due to sudden rupture within the plates during the release of accumulated strain energy. The range of frequency of seismic vibrations is from 0 to10 Hz. However the variation in magnitude, velocity and acceleration of these vibrations is very fast. The response of existing or conventional methods of measurement is very slow, which is of the order of tens of seconds. A systematic and high resolution measurement of velocity and acceleration of these vibrations are useful to interpret the pattern of waves and their anomalies more accurately, which are useful for the prediction of an earthquake. In the proposed technique, a fast rotating magnetic field (RMF) is used to measure the velocity and acceleration of seismic vibrations in the millisecond range. The broad spectrum of pulses within one second gives all possible values of instantaneous velocity and instantaneous acceleration of the seismic vibrations. The spectrum of pulses in millisecond range is used to measure the pattern of fore shocks to predict the time and location of large earthquakes very accurately. The proposed measurement scheme is successfully tested and the overall performance is recorded at dynamic conditions.

SUMMARY

The heavy disaster and destruction from the earthquakes are common. The earthquake of Japan on March 11, 2011 has raised alarm worldwide regarding nuclear power generation. The earth quake in Haiti on Jan 12, 2010 had killed more than 230,000 people. The earth quake of Sumatra on December 26, 2004 (Tsunami) killed more than 300,000 people in 11 countries. Therefore the prediction of location and time of large earthquakes has regained a great importance. The measurement of velocity and acceleration of seismic vibrations helps the prediction of earthquakes based on fore shocks. As the resolution of measurement of seismic vibrations is of the order of tens of seconds, the existing techniques are slow and less accurate, hence these methods do not give high resolution (less than one second) data for better prediction.

A number of methods for the measurement of seismic vibrations have been reported in the literature [1-4]. In the proposed technique, for the measurement of displacement, velocity and acceleration of seismic vibrations, a synchro is used whose rotor is attached with the vibrating system. The three-phase stator winding of the synchro, S is energized by a signal of 50 Hz from a stable arbitrary function generator. This signal is supplied to a centre-tapped transformer and the output of transformer is applied to a single-phase to three-phase conversion system consisting an RC network to generate a balanced three-phase, 50 Hz voltages. These three voltages are attenuated to a low value (about 100 mV), before feeding into three audio power amplifiers. The outputs of these three amplifiers are in turn applied to the stator winding of synchro, S to produce a sinusoidal signal Vr, fr in rotor winding. This waveform Vr, fr is then applied to a zero crossing detector (ZCD) of very high slew rate, to give a rectangular wave of 5 volts. As long as the vibrating system is stationary, the speed of rotor of synchro, S is zero. The synchro acts as a transformer. So the frequency fr of Vr of rotor circuit is equal to fs of Vs of stator circuit. The signal Vr is now applied to a ZCD to produce a rectangular waveform VR. The positive going transition (PGT) of signal VR with a positive width of 10 ms is used to trigger a one shot mono-stable multivibrator (OS). It produces a pulse with stable positive width (Q) and its complement (Q´). The signal Q´ from OS with VR is fed to a NAND gate. The output of NAND gate remains high as the positive

width of signal VR is equal to negative width of Q´. As the rotor of the synchro moves an infinitesimal distance (one tenth of a radian per second) back and forth, due to its attachment with the vibrating body (mass), the RMF revolves in the air gap at a very fast speed of 3000 rpm. This infinitesimal angular movement of rotor of synchro, S generates an emf, Vr of frequency, fr in the rotor circuit. Therefore, a pulse with negative width appears within 10 ms, for every instantaneous change in the velocity of seismic vibrations. A wide spectrum (with variations) of velocity and acceleration of vibrations is observed and recorded by DSO. It shows a significant variation, even within one second, which is normally not sensed and recorded by the conventional seismic vibration measurement systems. The spectrum of one second is provides all possible instantaneous velocity and acceleration of seismic vibrations with 10 ms resolution. Hence the measurement for the pattern of fore shocks becomes very fast and accurate for the prediction of time and location large earthquakes very accurately.
To realize the seismic vibrations, a stepper motor is interfaced with a microprocessor. The microprocessor is programmed to vibrate the stepper motor to generate the vibrations similar to the seismic vibrations. The stepper motor is coupled to the rotor of a synchro, S. As long as the stepper motor is stationary, the rotor of synchro, S is also stationary. The vibrations generated by the stepper motor are transmitted to the rotor of synchro S. The vibratiions of known velocity takes place in both clock wise and anti-clock wise directions. Accordingly the frequency of rotor voltage changes and a pulse train of variable pulse-widthis recorded which corresponds to the seismic vibrations. It gives complete information for displacement, velocity and acceleration. The resolution of the recorded pulses of the pulse train (spectrum) is less thal 10 ms.

REFERENCES

[1] S. J. Arif and S. Laskar, "A rotating magnetic field based high resolution measurement of velocity and acceleration of seismic vibrations,"A patent filed in Indian Patent Office, C.B.R. No. 2589, application no. 778/DEL/2011, March 21, 2011.
[2] T. Bleier and F. Freund, 2005. "Earthquake alarm,"IEEE Spectr., vol. 42, no. 12, pp. 22–27, Dec. 2005.
[3] R. Rupakhety, and R. Sigbjornsson, "A note on the L'Aquila earthquake of April 6, 2009: Permanent ground displacements obtained from strong-motion accelerograms,"Journal of Soil Dynamics and Earthquake Engineering, vol. 30, pp. 215–220, 2010.
[4] P. Mandal, "Crustal shear-wave splitting in the epicentral zone of the 2001 Mw 7.7 Bhuj earthquake, Gujarat, India,"Journal of Geodynamics, vol. 47, pp. 246–258, 2009.

Primary author: Mr SYED, Javed Arif (A.M.U., Aligarh)

Co-author: Mr ., Imdadullah (A.M.U., Aligarh)

Presenter: Mr SYED, Javed Arif (A.M.U., Aligarh)

Session Classification: Machine Det. Interface and Beam Instr.

Track Classification: Machine Detector Interface and Beam Instrumentation