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

By

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CONTENTS

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 nearly230000 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.**

THEORY

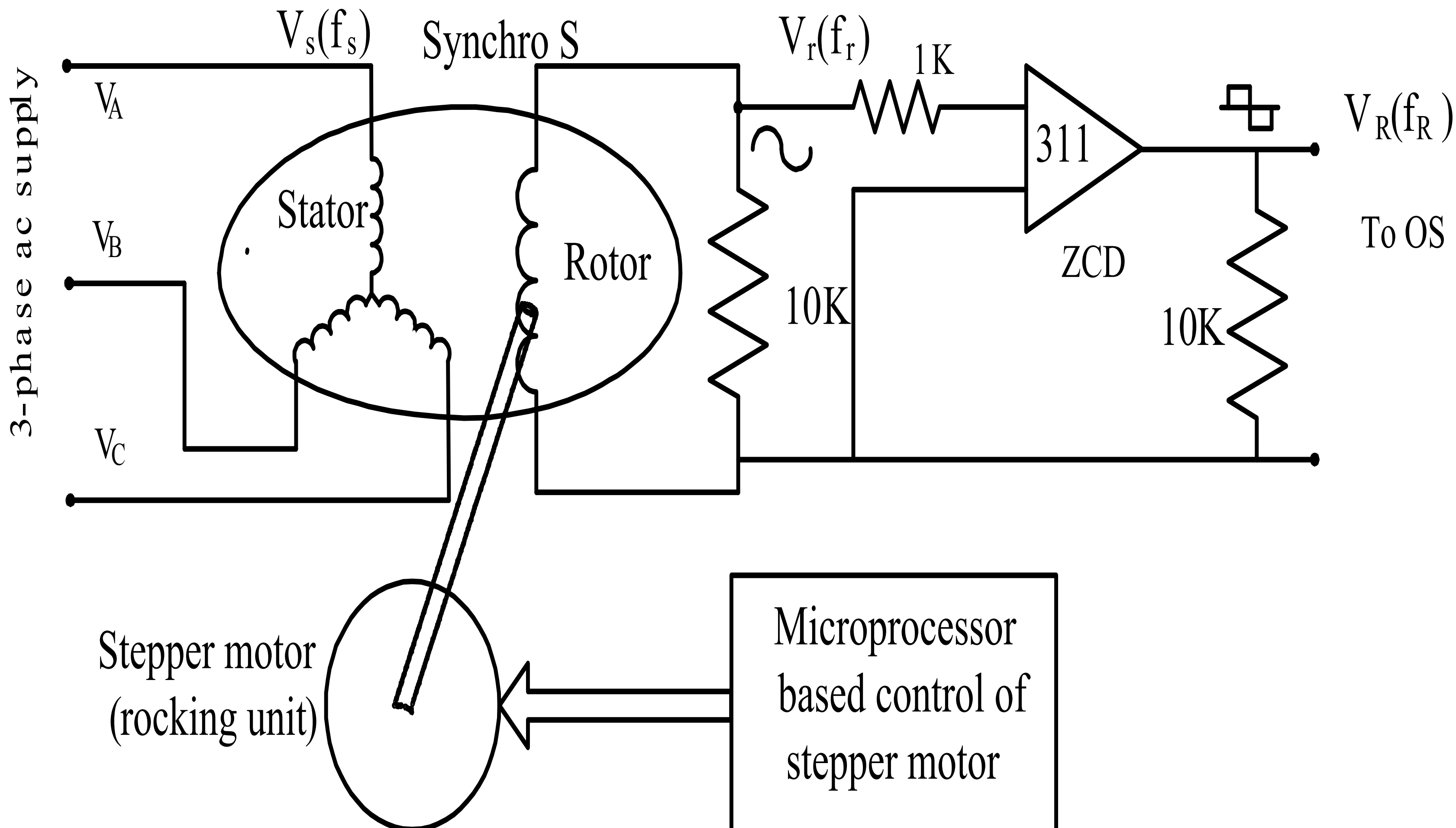
- **The speed of Rotor of Synchro is given by**

$$n_s = \frac{120\, f_s}{P}$$

and

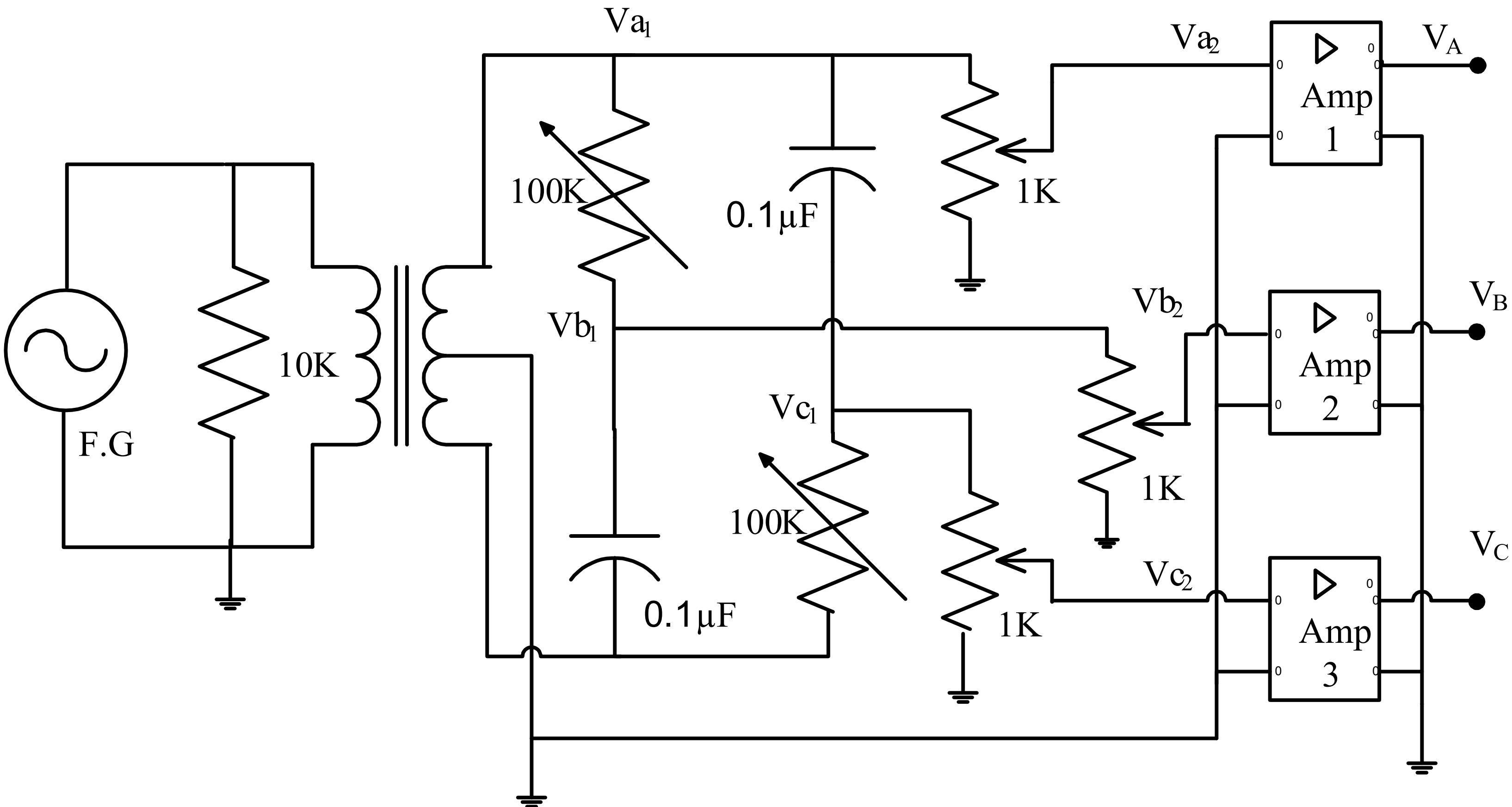
$$f_r = f_s \mp \frac{n_r\, P}{120}$$

REALIZATION

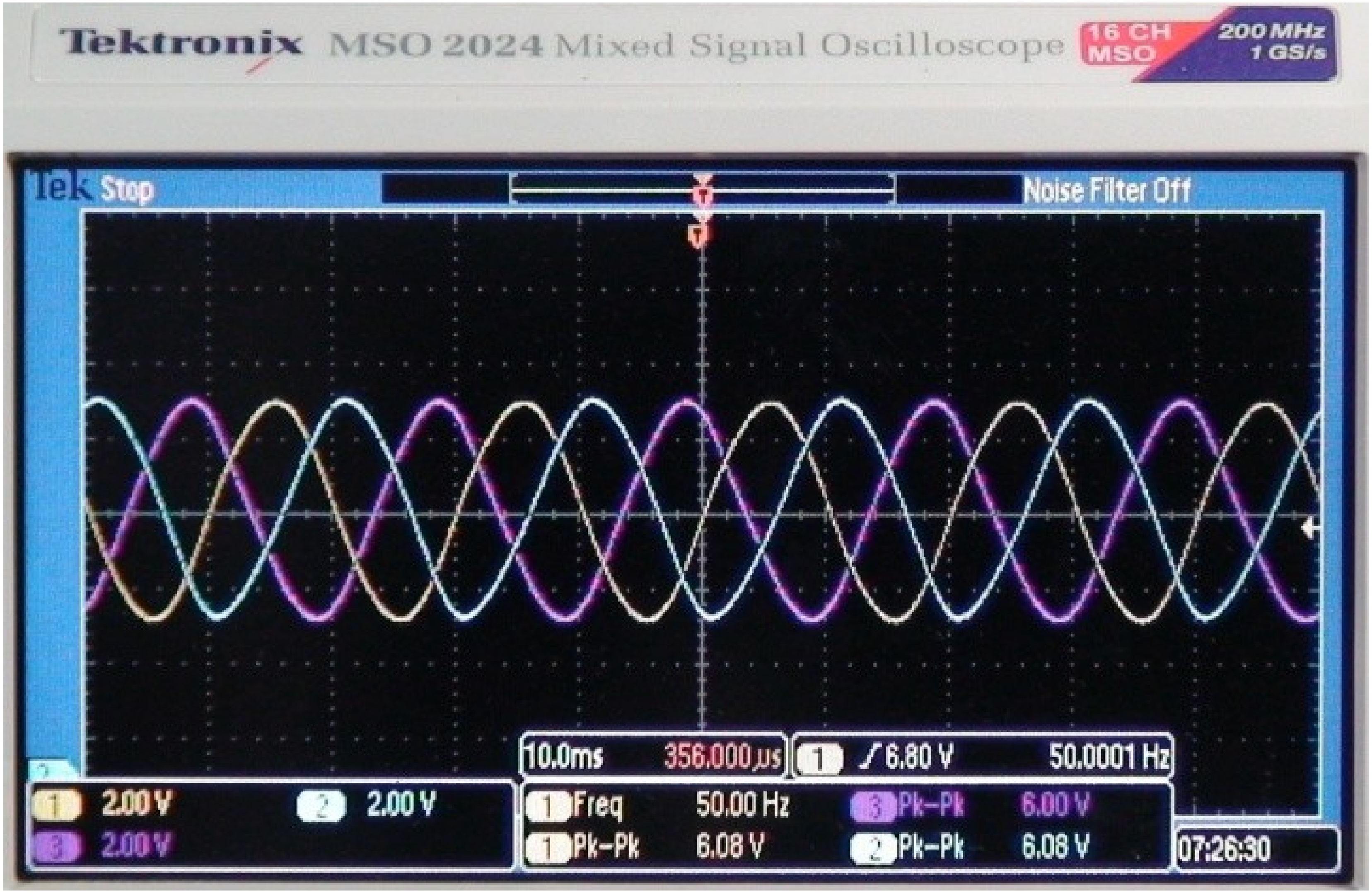


Microprocessor based vibration generation and measurement setup

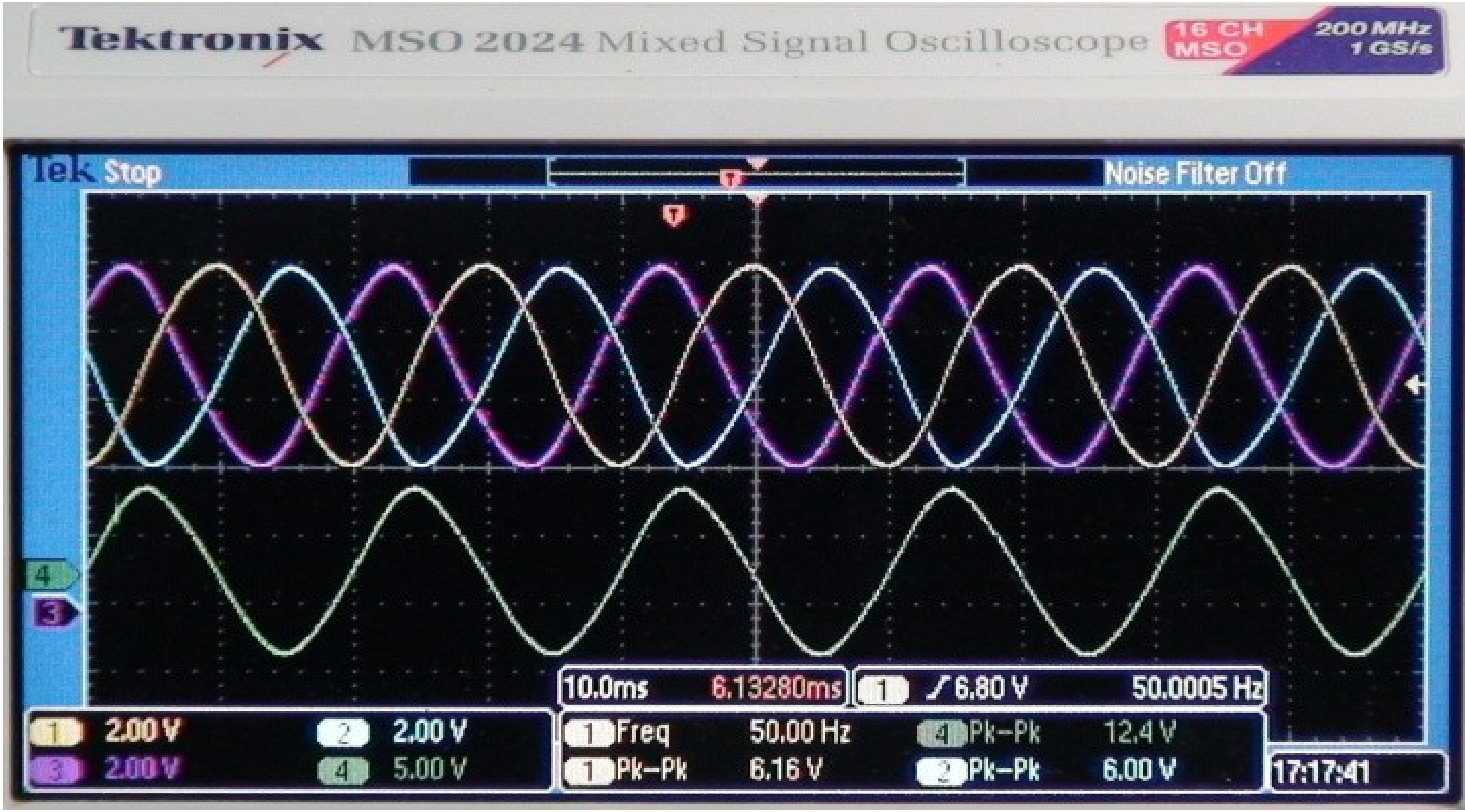
REALIZATION CONTD



Single-phase to three-phase voltage conversion system



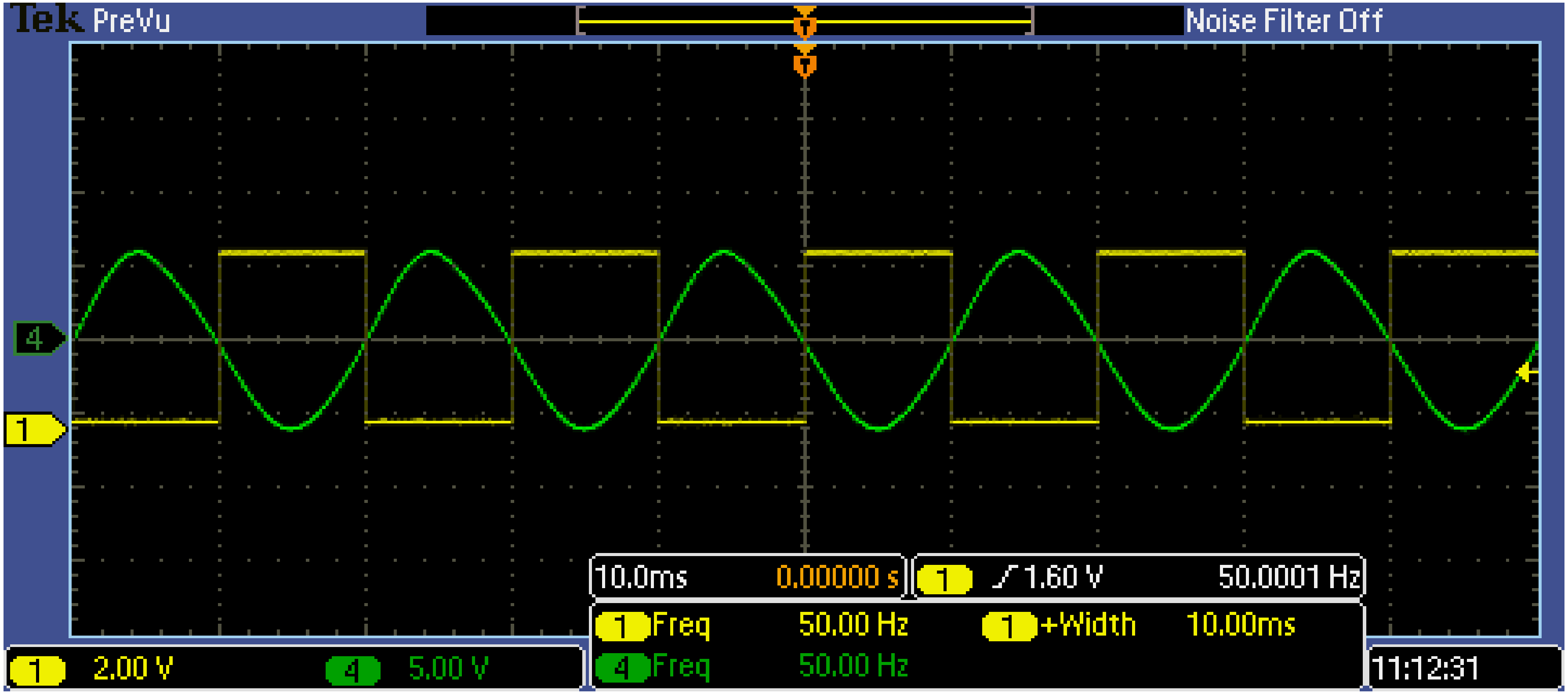
Measured waveforms V_A, V_B, V_C at the output of power amplifiers (CH#1, CH#2 and Ch#3).



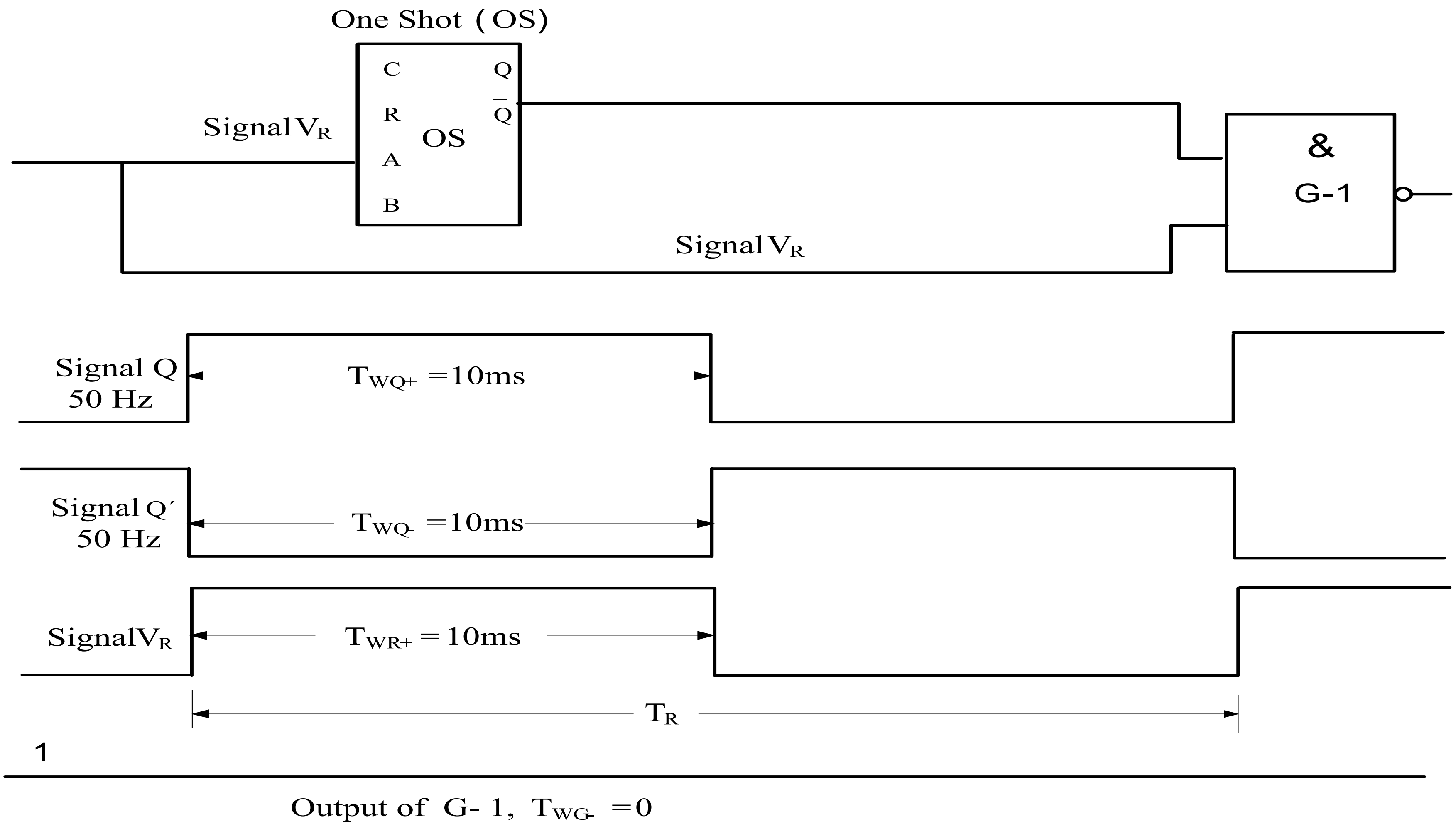
Measured three phase voltages, V_A, V_B, V_C at stator winding of synchro (CH#1, CH#2 and Ch#3). V_r, f_r (CH#4).

EXPERIMENTAL RESULTS

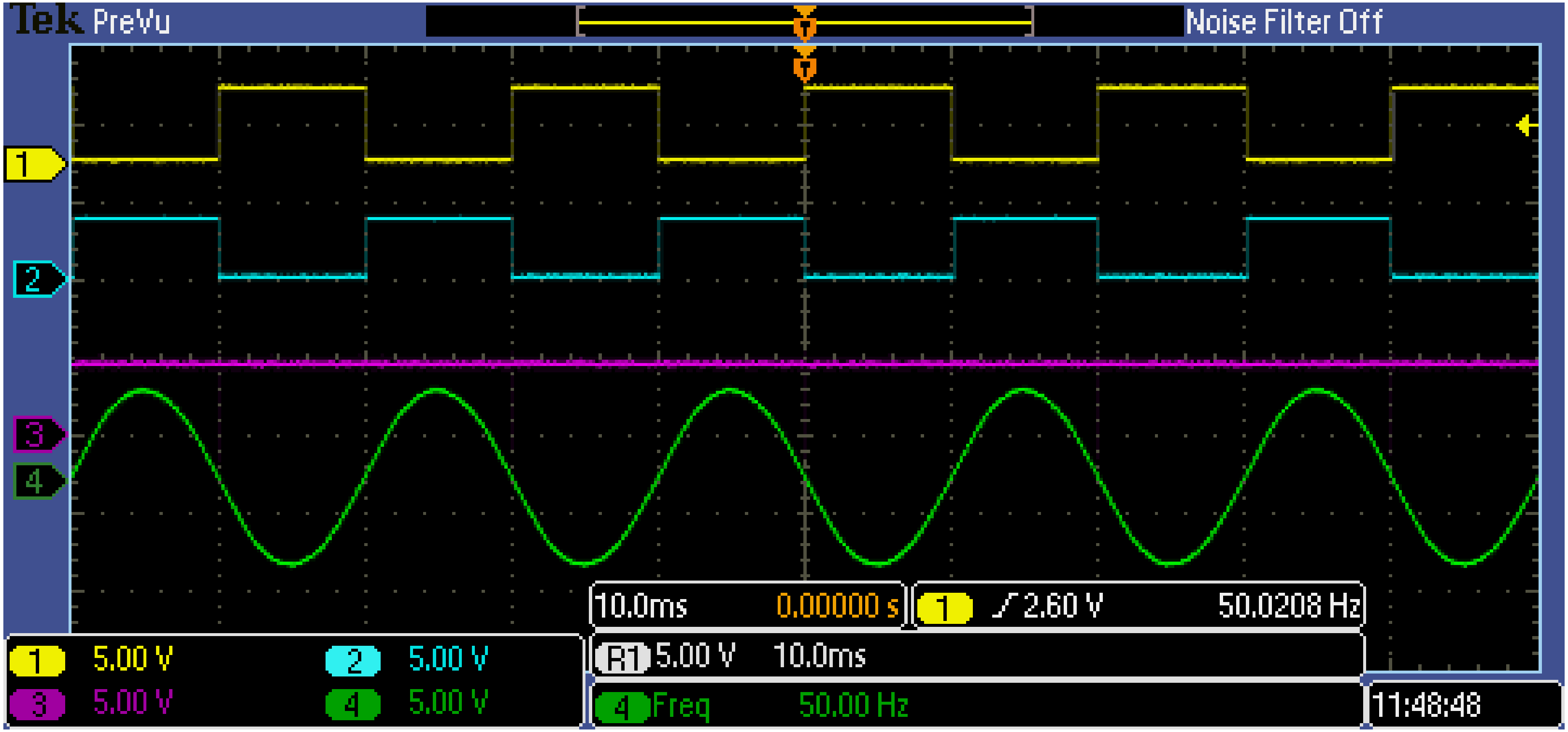
When the vibration system is stationary



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.

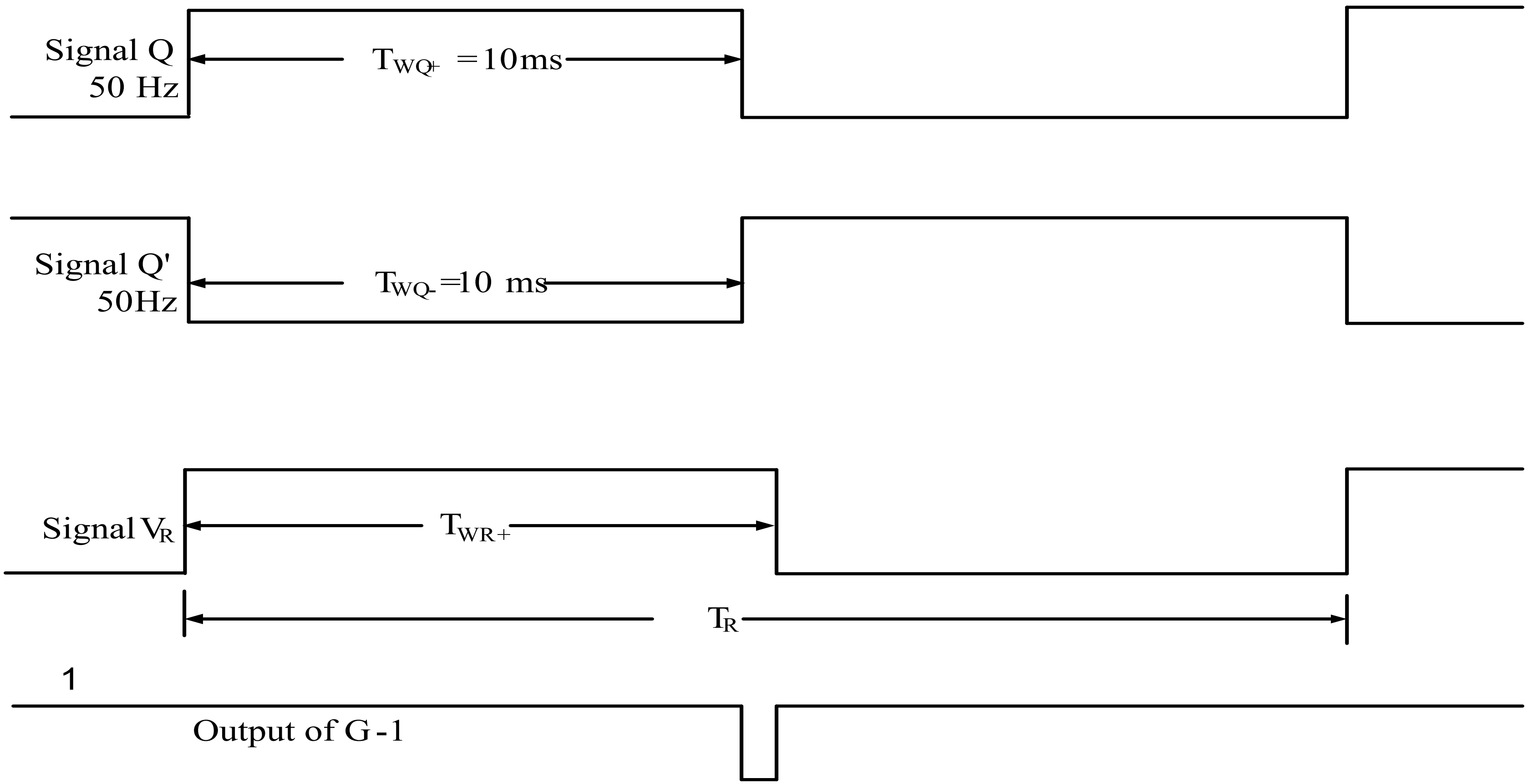


Waveforms of signals, $V_{R,}$ Q, Q´ and output T_{WG-}, when the vibrating system is stationary.



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 Vr (Ch#4) when the vibrating system is stationary.

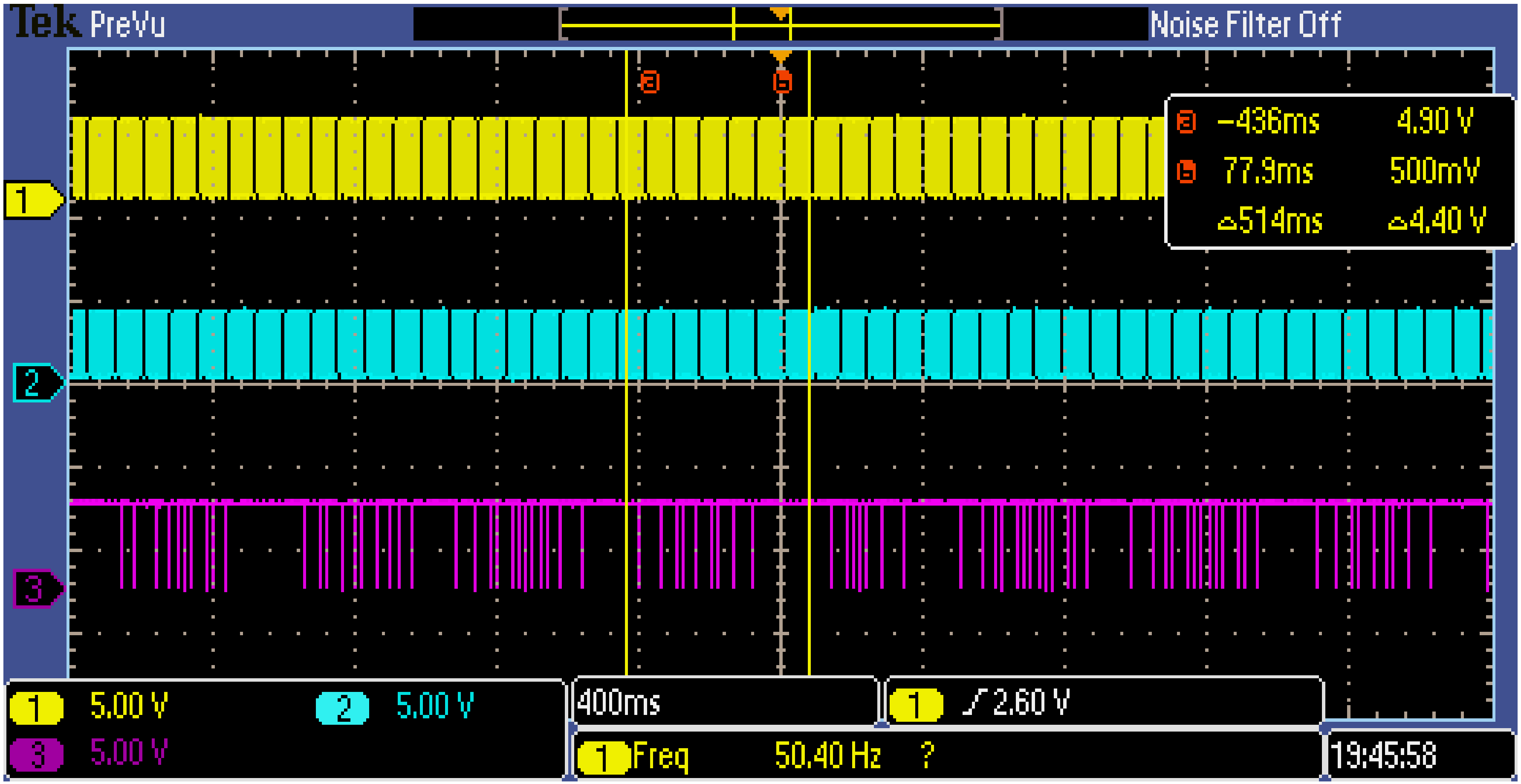
When the system starts vibrating



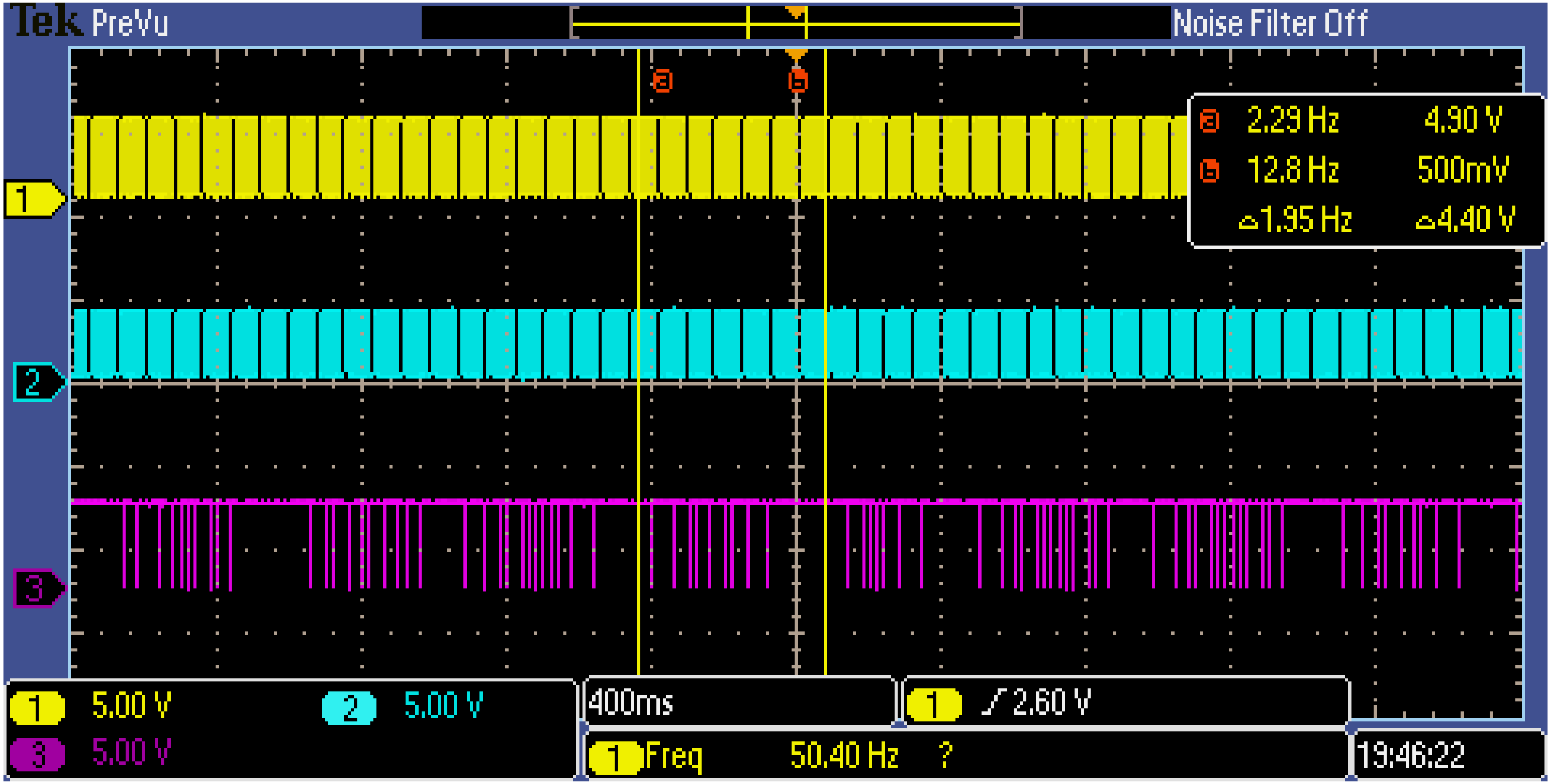
Waveforms of signals $V_{R,}$ Q, Q´ and output T_{WG-}, when vibration is started.

TABLE 1
RESULTS OF THE VIBRATION MEASUREMENT

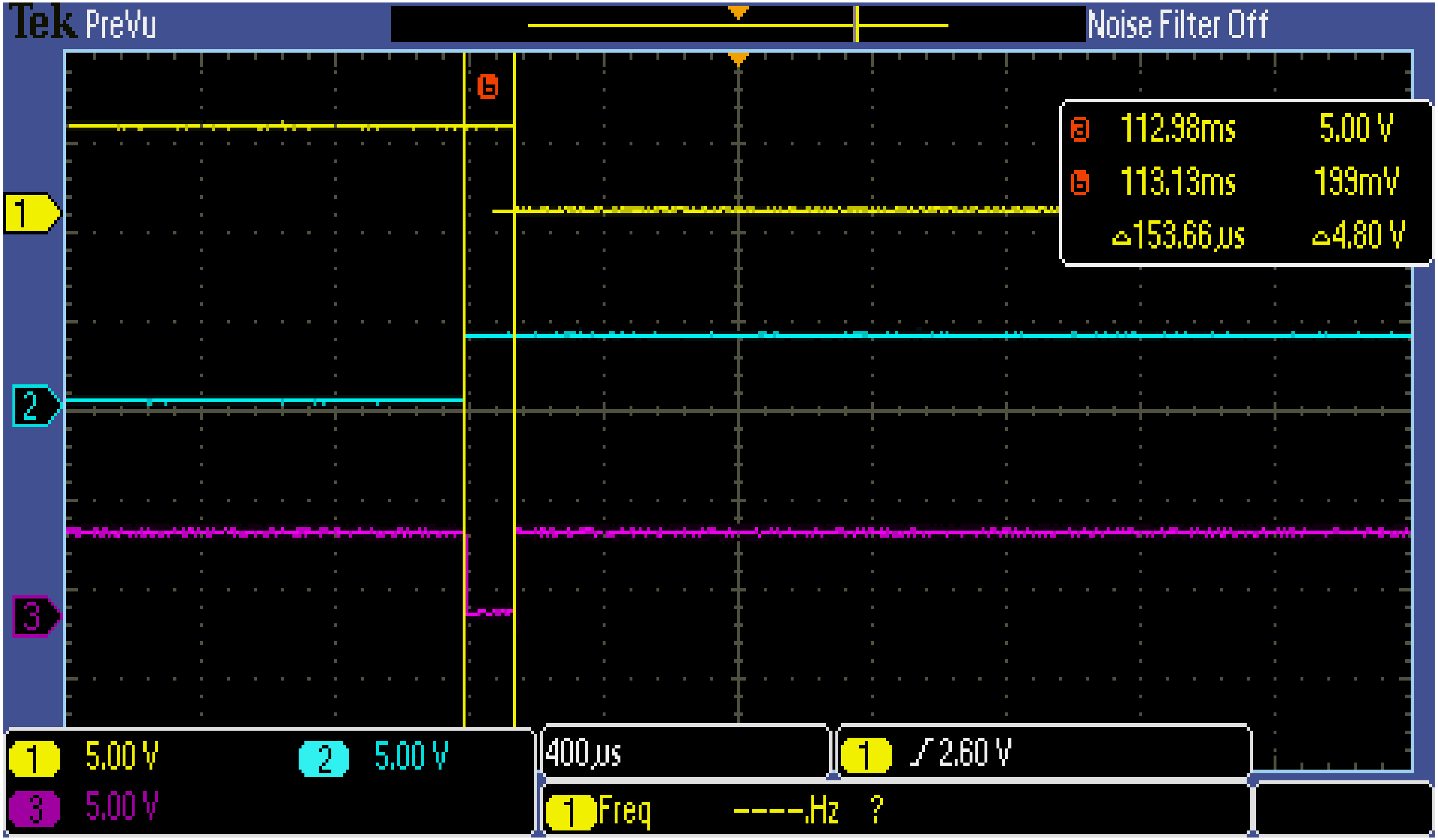
S.No	T_{WG-} (µs) = T_{WR+} - T_{WQ-}	Velocity of Vibrations (cm/s)	Acceleration (cm/s^2)
1	0	0	0
2	153.66	4.29	214.5
3	360	9.94	282.5
4	455	12.45	125.5
5	520	14.15	85
6	1000	26.03	594
7	1600	39.52	306
8	554	-15.02	-225
9	400	-11	-201
10	320	-8.86	-107
11	160	-4.49	-218.5



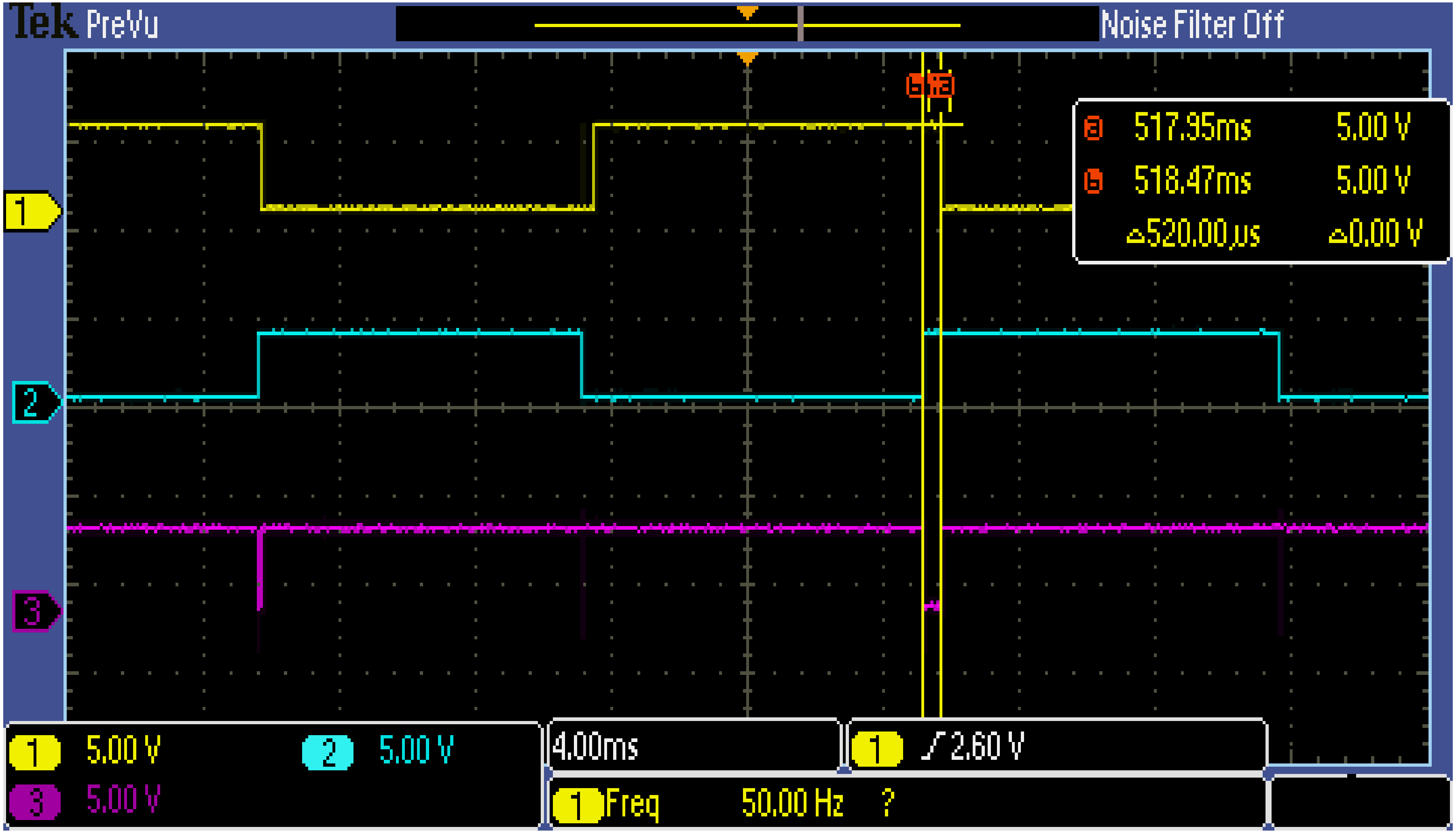
Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3) in roll mode at 400ms.



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).



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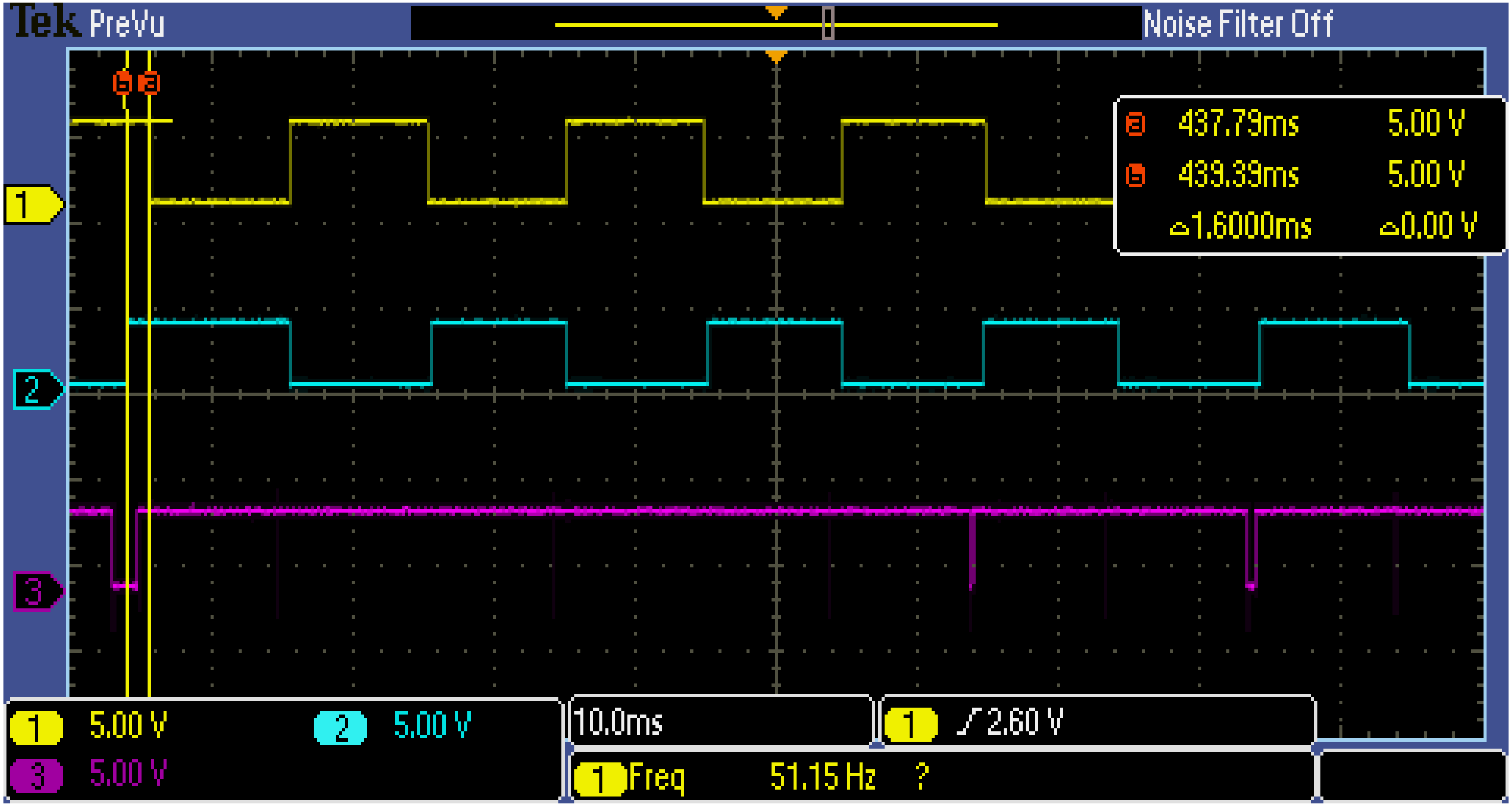

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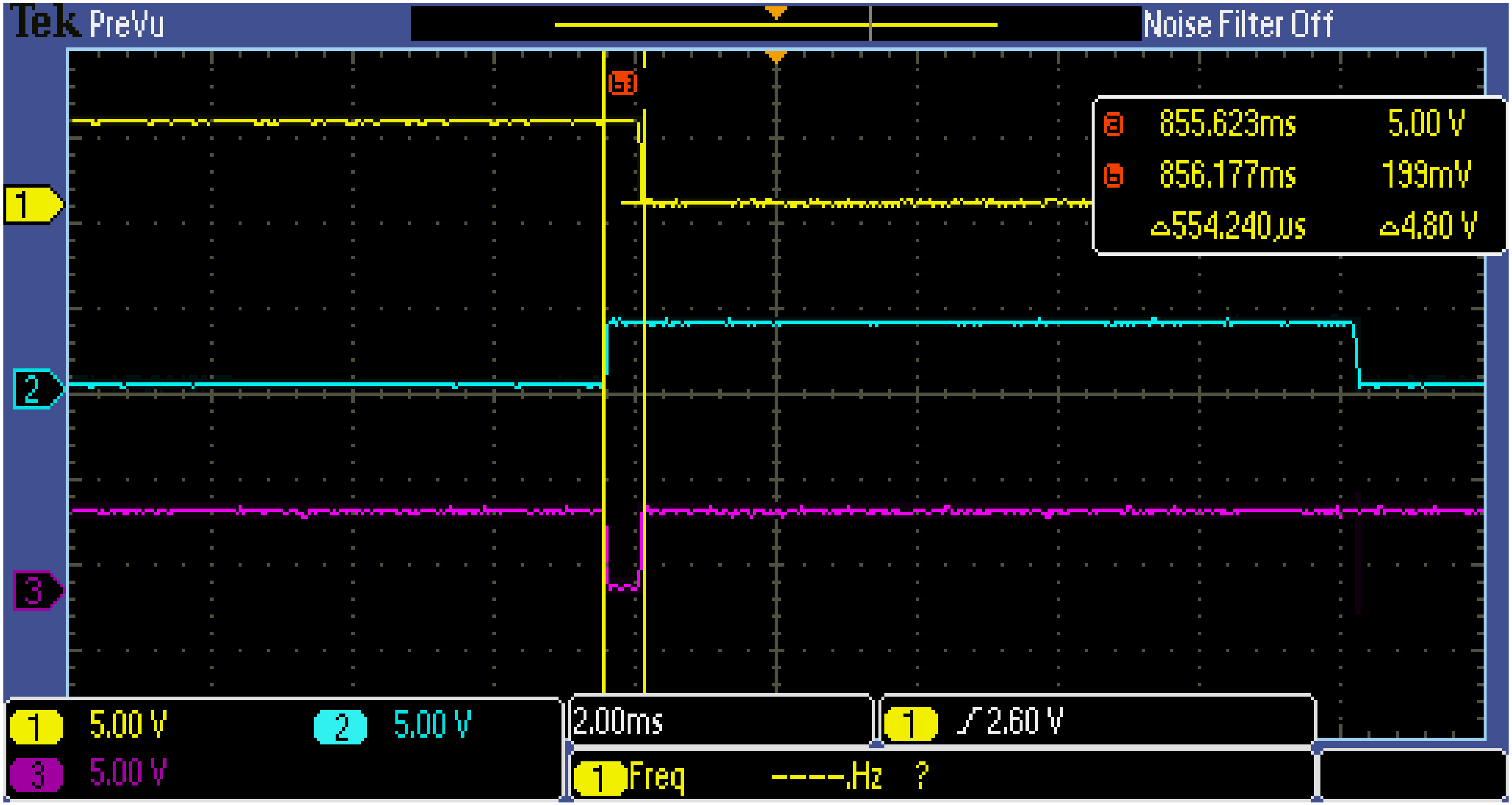

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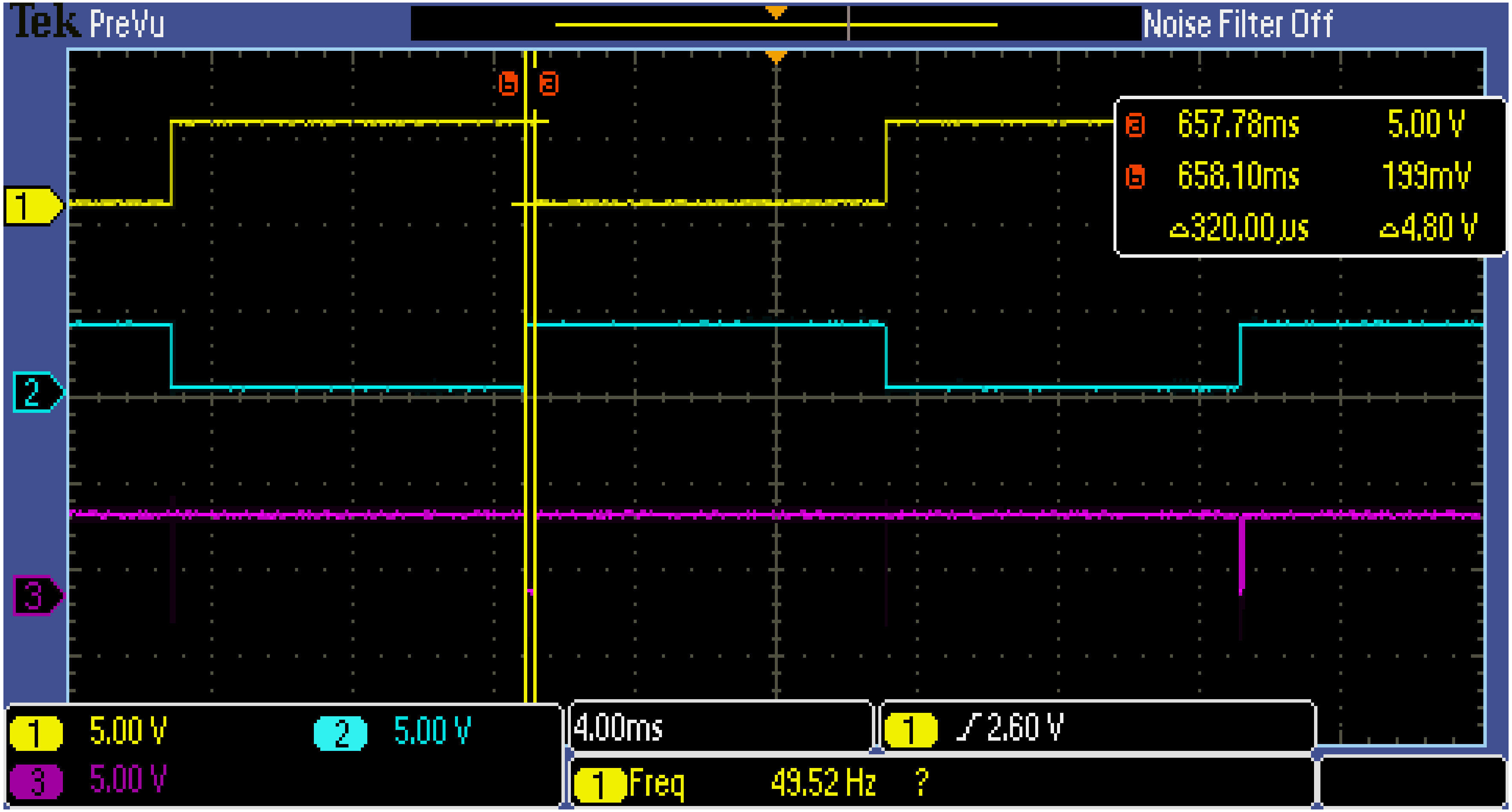

Measured Output of ZCD (Ch#1), output of OS (Ch#2) and output of gate G-1 (Ch#3

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 CONTD

- **Also proposed method is very suitable for proper design of earthquake resistant nuclear power plants, buildings and structures.**

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