

Safety Hazards Instrumentation Laboratory Room 214

HAZARD: Rotating Equipment

Be aware of pinch points and possible entanglement

Personal Protective Equipment: Safety Goggles; Standing Shields,
Sturdy Shoes

No: Loose clothing; Neck Ties/Scarves; Jewelry (remove);
Long Hair (tie back)

HAZARD: Projectiles / Ejected Parts

Articles in motion may dislodge and become airborne

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Heating - Burn

Be aware of hot surfaces

Personal Protective Equipment: Safety Goggles; High Temperature Gloves;

HAZARD: Electrical - Burn / Shock

Care with electrical connections, particularly with grounding and not using frayed electrical cords, can reduce hazard. Use GFCI receptacles near water.

HAZARD: High Pressure Air-Fluid / Gas Cylinders / Vacuum

Inspect system integrity before operating any pressure / vacuum equipment. Gas cylinders must be secured at all times.

Personal Protective Equipment: Safety Goggles

HAZARD: Water / Slip Hazard

Clean any spills immediately.

HAZARD: Noise

Personal Protective Equipment: Ear Plugs

HAZARD: Light Induced Epileptic Seizure

Stroboscopic flashing light may trigger epileptic seizures in persons with photosensitive epilepsy

Rotation Speed Measurement and General Data Analysis

Objectives:

1. Least square method application (Linearity)
2. Random Data Analysis (Gaussian Distribution): Rotation speed measurement by Digital Tachometer
3. Noise Filtration: Characteristics of High and Low pass RC Filters
4. Additional methods of rotational speed measurement
 - a. Stroboscope
 - b. Oscilloscope Direct Measurement
 - c. Lissajou Figures

Major Equipments:

D.C. Generator with Magnetic Pickup Output and D.C. Motor; Electronic Frequency Counter; Digital Multimeter; Electronic Tachometer; Stroboscope; Oscilloscope; Function Generator; Hi/Lo RC Filter

Procedure:

A. Least Square Method Application (Linearity)

1. Connect magnetic pickup to electronic frequency counter. The counter measures rotation speed in revolution per minute (rpm), as the gear on the motor shaft has 60 teeth, which produces 60 counts per revolution.
2. Connect D.C. generator to digital voltmeter. Set motor speed to 1500 rpm on the electronic frequency counter with the motor speed control knob.
3. Turn the D.C. amplifier knob to 15.0 Volts and lock the knob on Test Rig.
4. Adjust the **motor speed from** 1500 to 0 rpm in interval of 300-rpm, at each point, record the electronic frequency counter reading and voltage.

B. Random Data Analysis: Rotating Speed by Digital Tachometer

Caution: Use minimum pressure needed to record the actual shaft speed, in order to minimize the loading error and to avoid damage to the equipment.

1. Set the motor speed to 1000 ± 10 rpm (as read on the electronic frequency counter).
2. Repeat the first step at least for 60 measurement data with each member of the team should record at least 15 readings with the digital tachometer.

C. Additional Methods for Rotational Speed Measurement

1. Stroboscope

- a. Set motor speed to 1000 rpm and record the electronic frequency counter reading.
- b. Set the stroboscope frequency to approximately the electronic frequency counter reading by fine-adjust the stroboscope frequency, until the timing mark appears stationary. Record the stroboscope reading, and sketch the mark on the gear face (or take a picture for record).
- c. Without changing the motor speed, increase the stroboscope frequency until it is doubled. Record the stroboscope frequency. Sketch the timing mark pattern (or take a picture for record).
- d. Repeat step "c" for a stroboscope frequency of 3 and $\frac{1}{2}$ times true shaft speed.

2. Lissajou Figures

- a. Connect the output of the electronic frequency counter to the vertical amplifier of the oscilloscope.
- b. Set the motor speed to 1500 rpm, adjust the vertical amplifier gain until a 4 or 5 cm peak-to-peak sine wave appears on the screen. The time sweep setting can be set at any convenient value.
- c. Leave the motor speed and all the setting which you just made unchanged; but temporarily disconnect the input to the vertical amplifier of the oscilloscope. Turn your attention now to the horizontal amplifier of the oscilloscope as explained below.
- d. Connect the output of the audio-oscillator to the horizontal amplifier of the oscilloscope.

- e. Adjust the oscillator frequency to equal approximately the frequency of the electronic frequency counter output. Turn the trigger control to the x-y position.
- f. Adjust either the amplitude setting of the oscillator or the gain setting of the horizontal amplifier of the oscilloscope, or both, until the resulting display on the oscilloscope screen will be a "line" of approximately 5 cm length.
- g. Re-connect the output of the electronic frequency counter to the vertical amplifier of the oscilloscope. The resulting Lissajou figure should remain essentially stationary, although it will be subject to some fluctuation.
- h. Sketch the Lissajou figure (or take a picture for record) and record both oscillator frequency and motor speed from the electronic frequency counter.
- i. Increase the oscillator frequency until a double loop figure appears (leaving the motor speed unchanged). Sketch the Lissajou figure (or take a picture for record) and record both oscillator frequency and motor speed from the electronic frequency counter.
- j. Decrease the oscillator frequency until another double loop figure appears. Sketch the Lissajou figure and record both oscillator frequency and motor speed from the electronic frequency counter.
- k. Leave the oscillator frequency unchanged, and change the motor speed until a single loop appears. Sketch the figure and record oscillator frequency and the motor speed from the electronic frequency counter.

D. Signal to Noise Ratio Improvement by RC Filter

1. Set oscillator (frequency generator) to 1000 Hz.
2. Connect the output to the electronic counter and to the input terminals A & B of the low pass RC filter and also to CH 1 of the oscilloscope.
3. Adjust the vertical gain to produce a suitable (say 4.0 cm peak-to-valley) display.
4. Connect the output of the low-pass filter to CH 2 vertical input of the oscilloscope. Record:
 - i. Vertical peak-to-valley CH 1 display (cm) and gain setting (volts/cm).

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- ii. Vertical peak-to-valley CH 2 display (cm) and gain setting (volts/cm).
- iii. Phase lag of the filter output signal with respect to the filter input signal, i.e. record “M” and “N” (see Fig.4).

Note: $\phi = (N)(360)/M$, where ϕ = phase angle in degrees.

(In Fig.4, there is a phase lag ϕ is negative)

Note: Gain Controls must be in “detent position!!

Repeat the above for the following oscillator frequency settings: (making sure that the input signal amplitude remains unchanged).

200; 500; 1,000; 2,000; 4,000; 8,000; 20,000; 40,000 Hz

Repeat the above measurements for the high pass filter. Clearly note what lags (or leads) what.

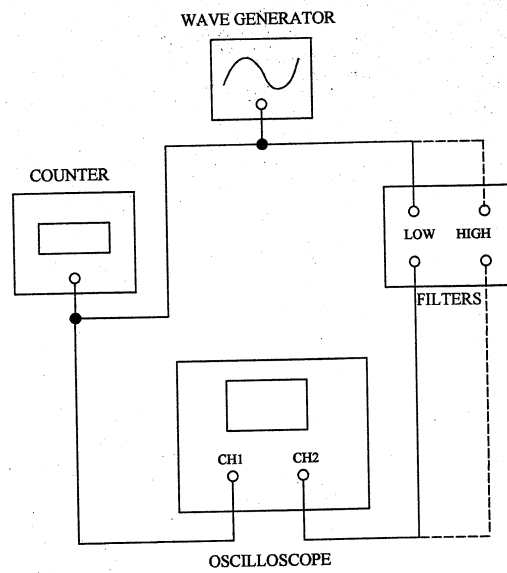


FIGURE 1 LAYOUT OF TEST APPARATUS

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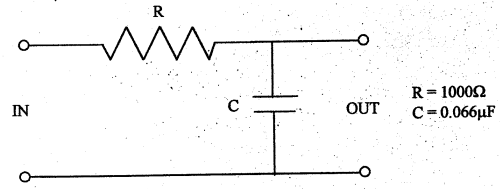


FIGURE 2 LOW PASS FILTER (Ref 1 Fig7.27a)

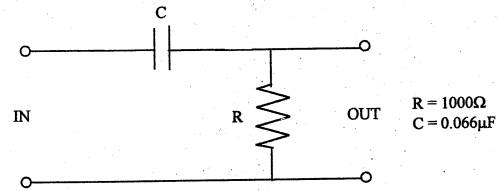


FIGURE 3 HIGH PASS FILTER (Ref1 Fig 7.27b)

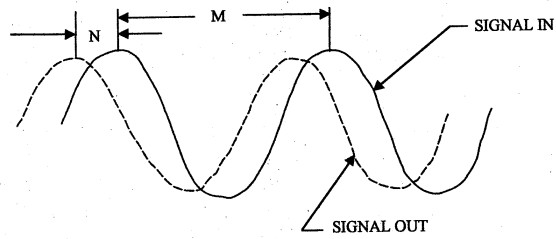


FIGURE 4 PHASE CHANGE