Starter Motor – End Of Line Testing

Vibration And Noise Signature Analysis

What is Starter Motor?

A starter motor is an electrical device used to start an internal combustion engine. The starter motor is a part of a starting system consisting of the starter, a starter solenoid and the battery.

As the ignition switch is turned, it sends an electrical charge to the starter solenoid. This, in turn, sends the charge to the motor that cranks the engine until it starts. Once the engine fires to life, the starter motor clicks off and disengages the starter ring.

How Starter Motor Works?

The typical starter motor is composed of heavy copper wire wound around an armature. This device is placed inside of a heavy steel or aluminum case equipped with electrical brushes that contact the armature and pass the electrical charge to the heavy wire.

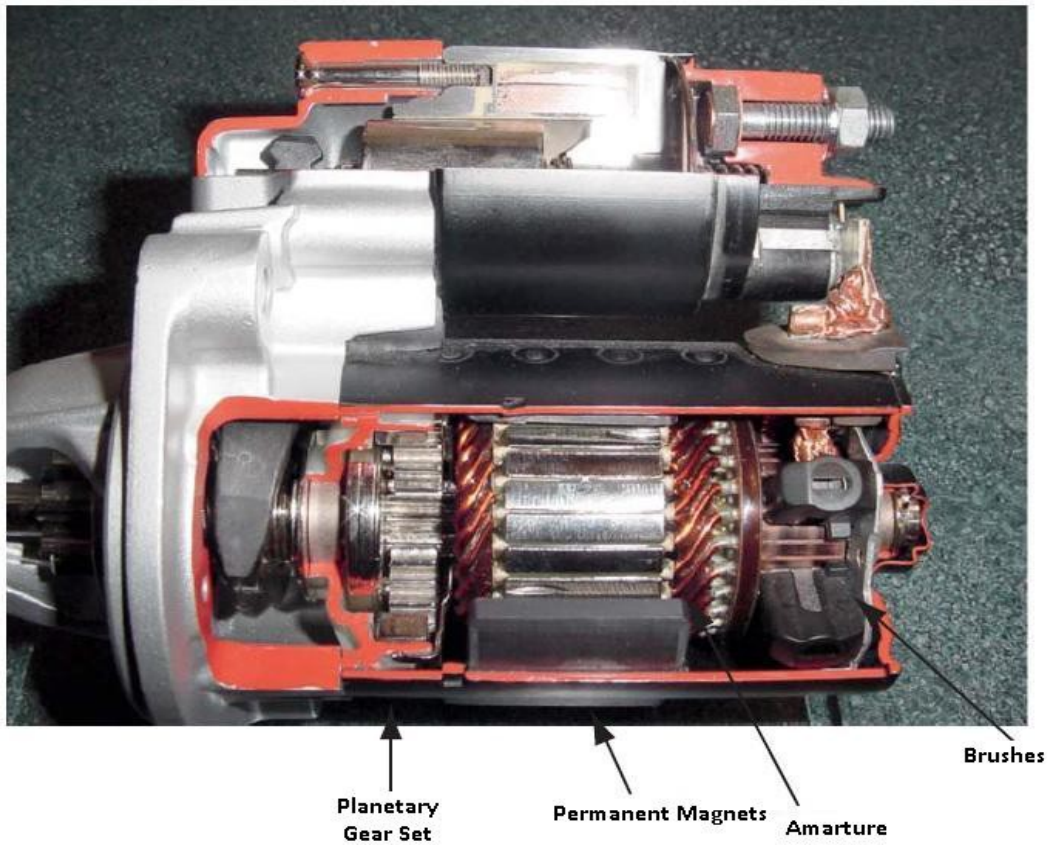
As the electricity flows through the wire, it causes the armature to spin. A small gear is attached to the output shaft of the armature and moved in and out by means of a Bendix. The Bendix engages the small gear with the starter ring, which turns the engine as the armature turns.

Problems

- The brushes become burned and fail to transfer the electrical charge to the armature.
- The Bendix can also become sticky and fail to engage the starter gears.
- A bench test, which is accomplished by running an electrical charge through the starter while it is out of the engine bay, will usually determine the problem.
- A starter that fails to run when a charge is placed to it typically implies a brush defect.
- A starter that spins but does not send the starter gear outward is often suffering from a broken or defective Bendix
- Loose mounting bolt(s)
- Starter problems can be caused by worn brushes (carbon pads inside the motor that supply current to the rotating armature), by shorts or opens in the armature or field coils or by worn bushings that increase drag or allow the armature shaft to rub against the pole shoes.
- Sun and Planet gear assembly deffects.

Approach

- Acoustic Enclosure was designed and used
- Vibration and sound pressure data was simultaneously acquired
- Vibration data was acquired on the stopper platform
- Sound pressure data was acquired just above the motor within the Acoustic Enclosure
- Three sets of motors were used – known to be good, known to be bad and known to be overlapping cases
- In the current report vibration envelop spectrum analysis has been used as one of the indicators
- Second indicator is sound pressure level on dB and dBA scales



Design Data

Number of Teeth:
Sun Gear: 9
Planet Gear: 18
Stationery Wheel: 45

Sun gear rotational speed = 3750 RPM = 62.5 cps
Sun GMF = 562 Hz
Planet rotational speed = 937.5 = 15.625 cps
Planet GMF = 281.25
Arm/Output RPM = 625 = 10.4 cps

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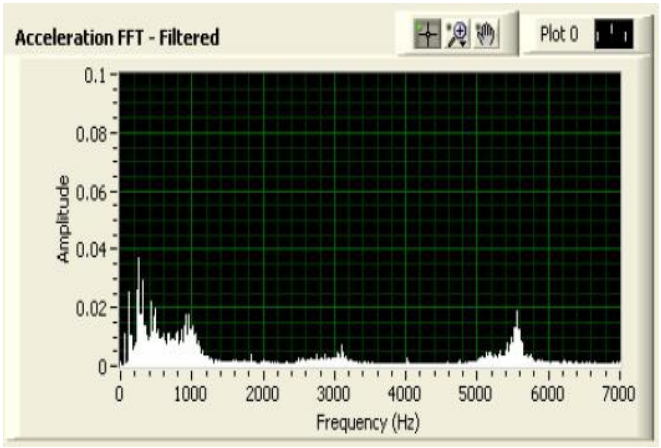
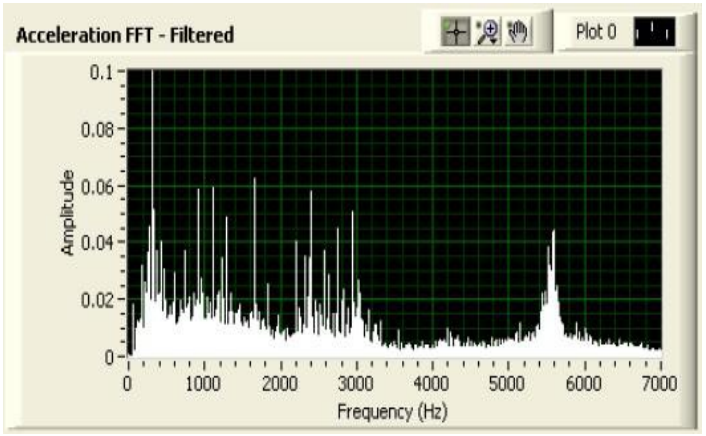
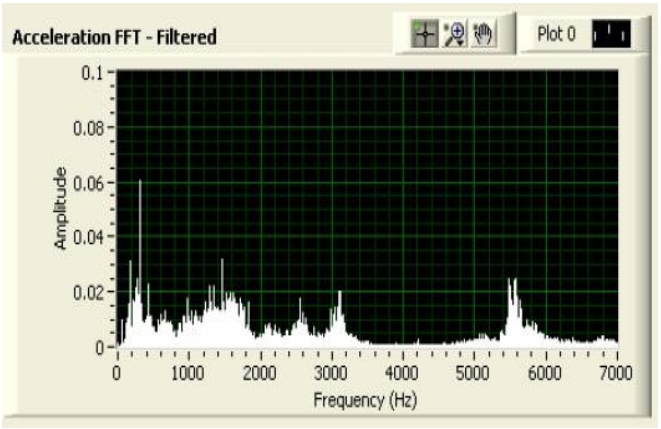
Good Motor 1
Acceleration FFT



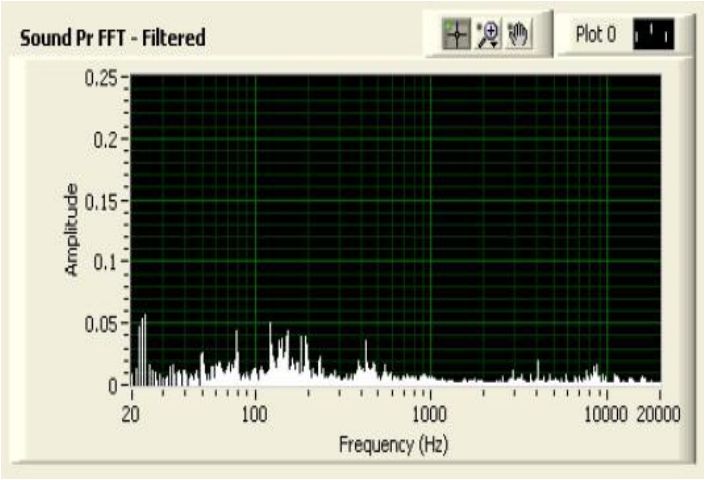
Bad Motor 1
Acceleration FFT



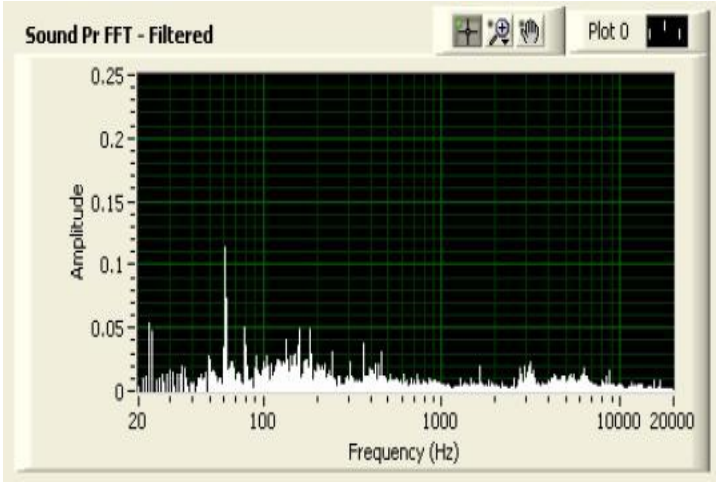
Overlap motor 1
Acceleration FFT



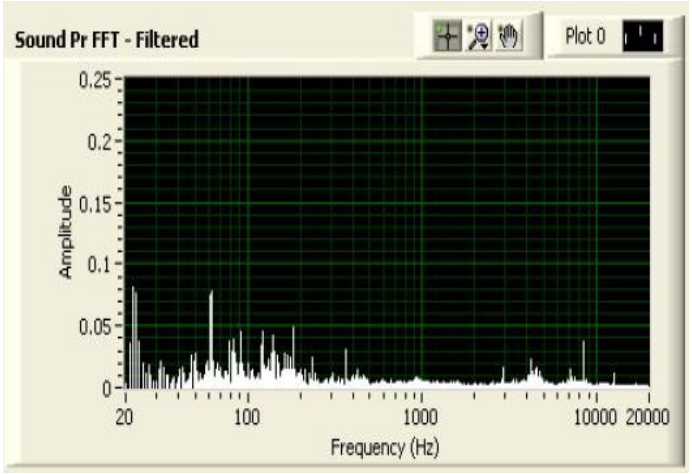
Good Motor 1
Sound Pr FFT



Bad Motor 1
Sound Pr FFT



Overlap motor 1
Sound Pr FFT



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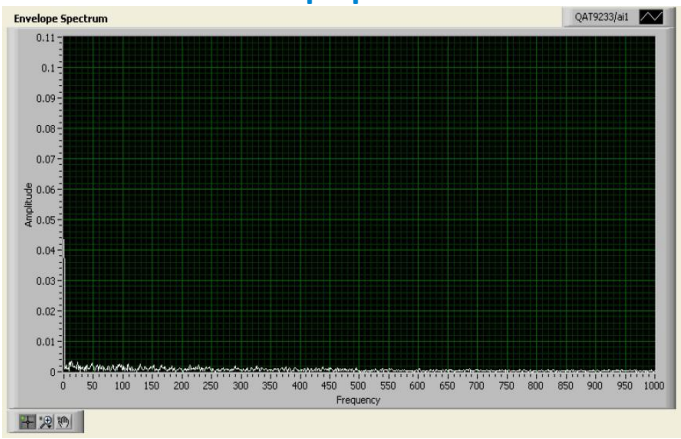
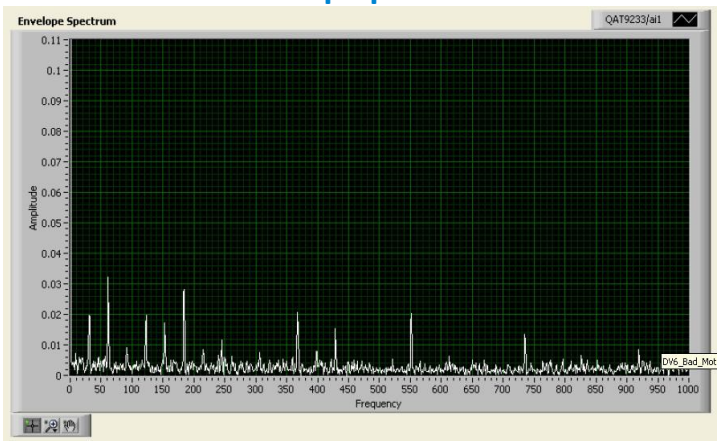
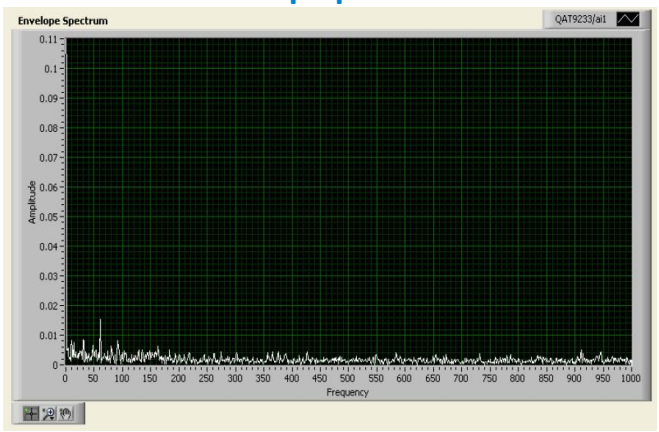
Good Motor 1
Envelop Spectrum



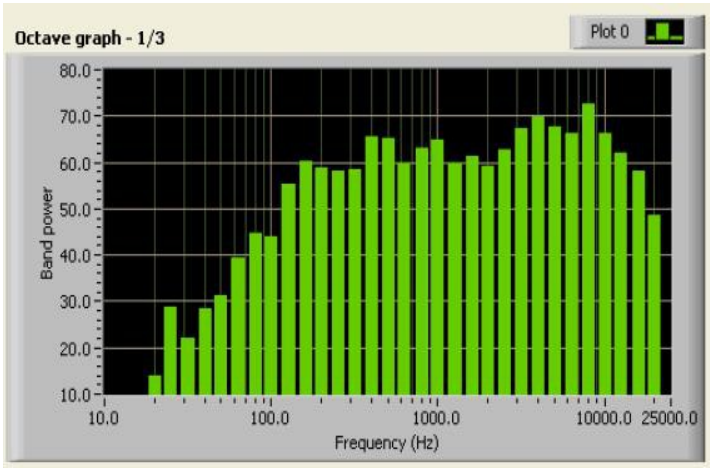
Bad Motor 1
Envelop Spectrum



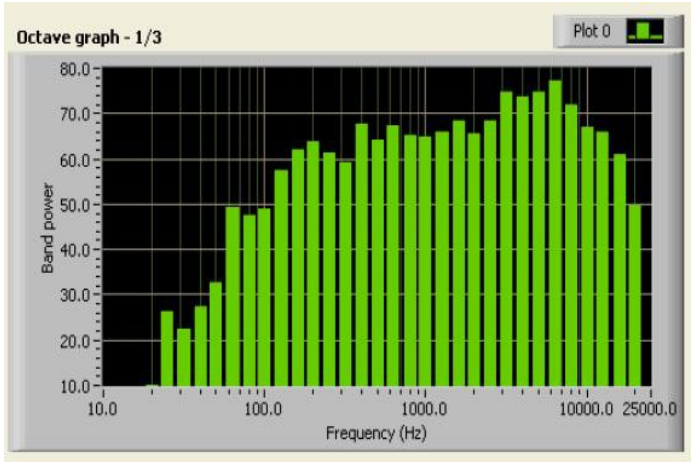
Overlap motor 1
Envelop Spectrum



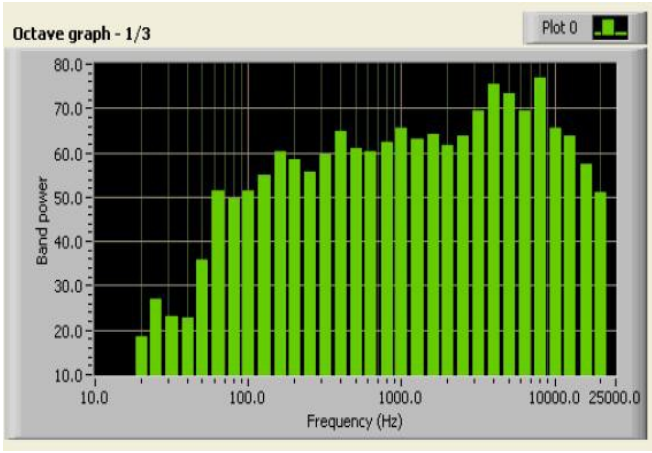
Good Motor 1
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 78.45



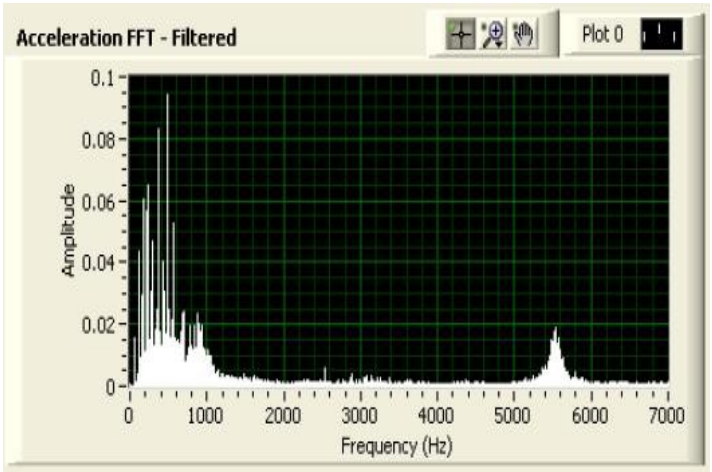
Bad Motor 1
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 83.18



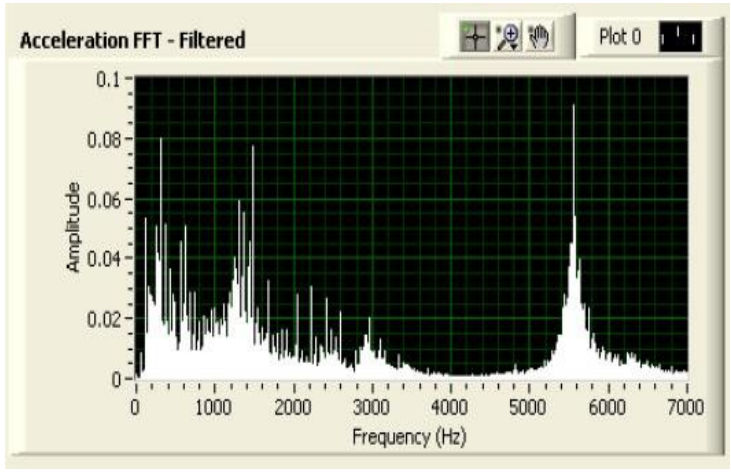
Overlap motor 1
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 81.76



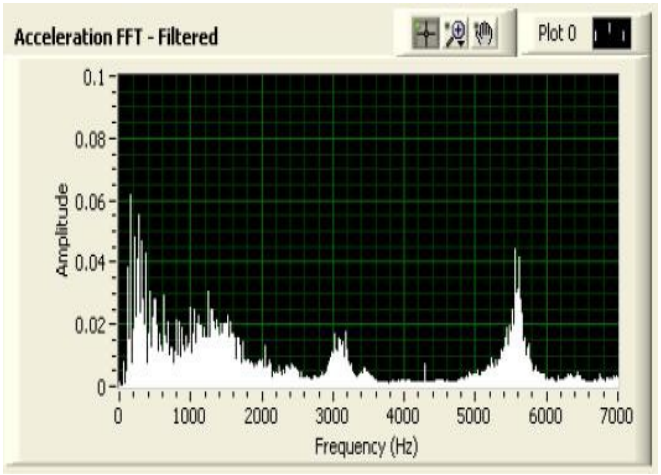
Good Motor 2
Acceleration FFT



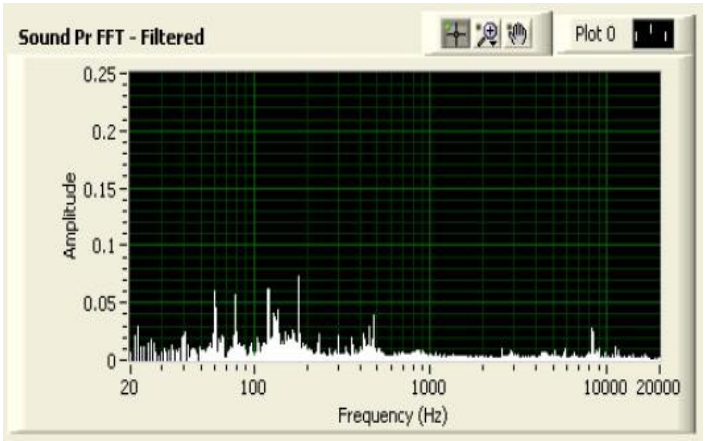
Bad Motor 2
Acceleration FFT



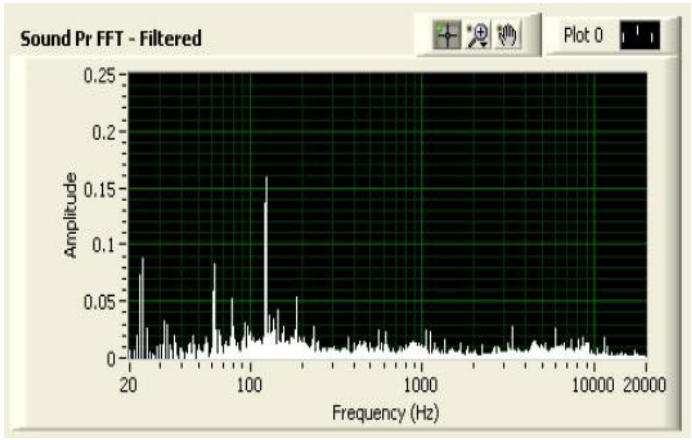
Overlap motor 2
Acceleration FFT



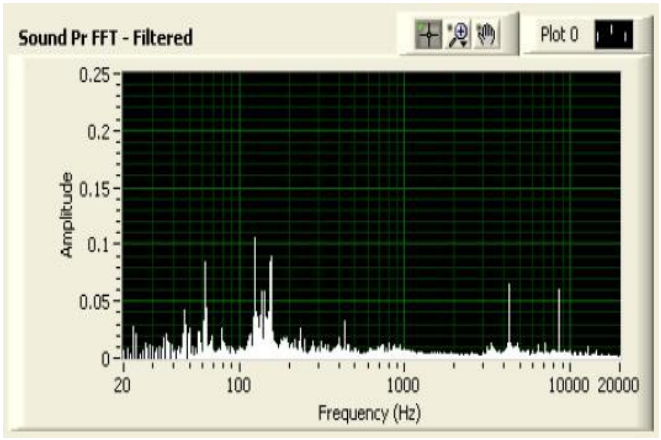
Good Motor 2
Sound Pr FFT



Bad Motor 2
Sound Pr FFT



Overlap motor 2
Sound Pr FFT



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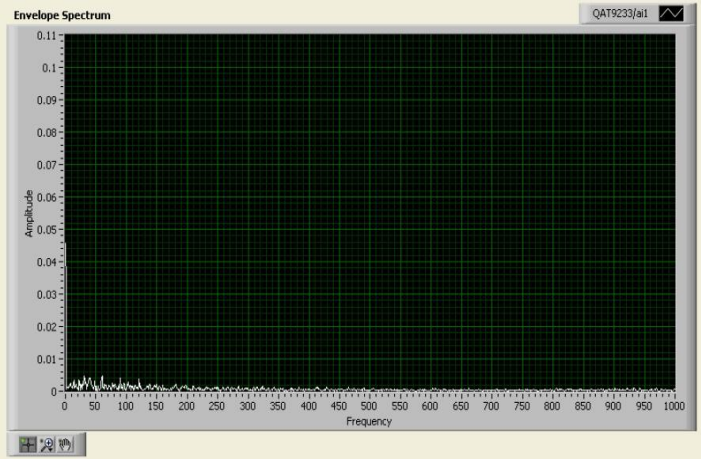
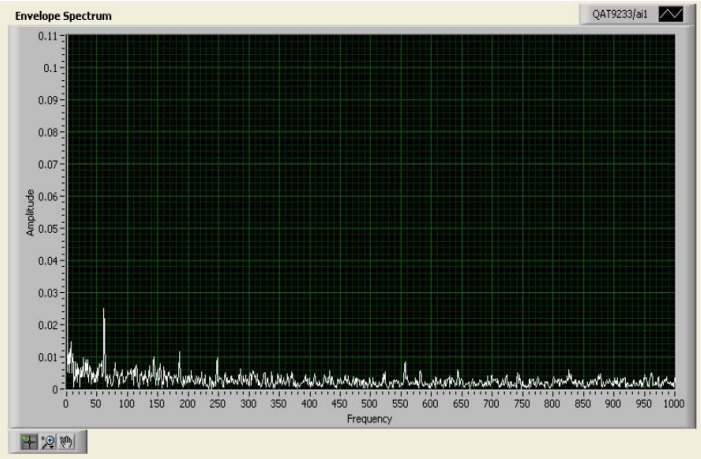
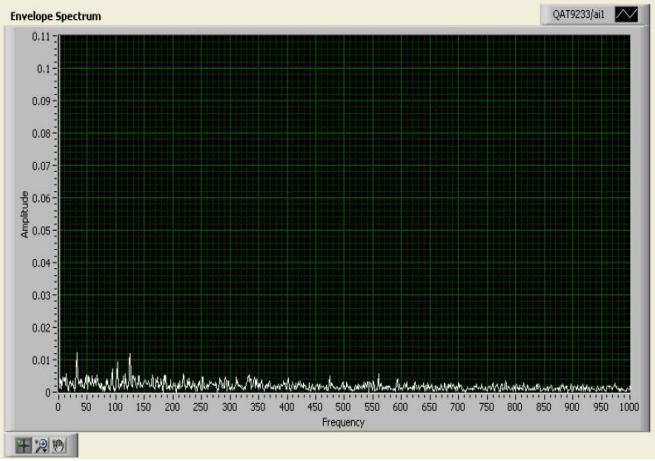
Good Motor 2
Envelop Spectrum



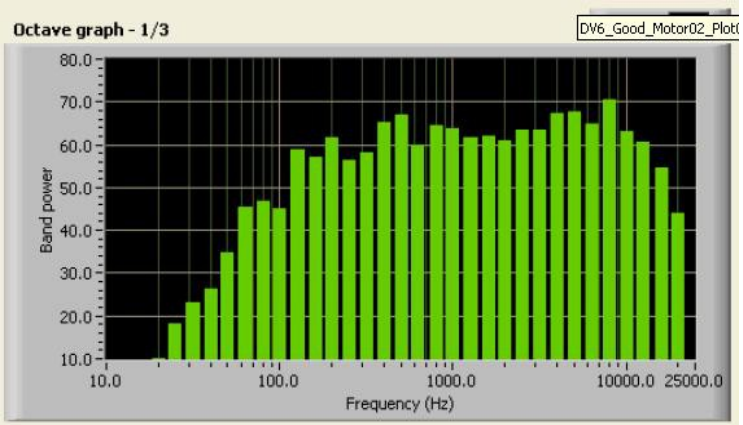
Bad Motor 2
Envelop Spectrum



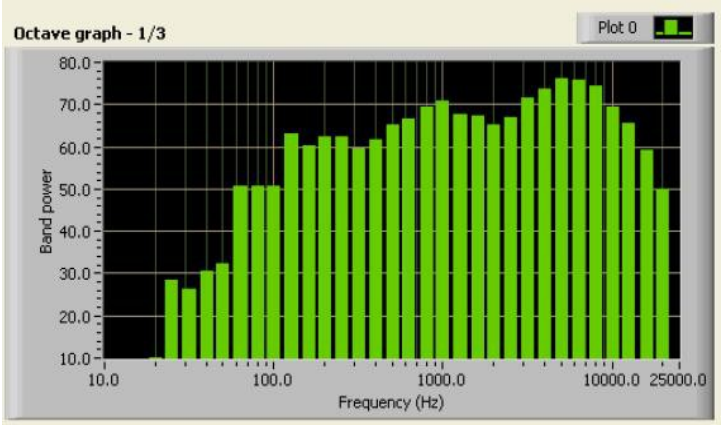
Overlap motor 2
Envelop Spectrum



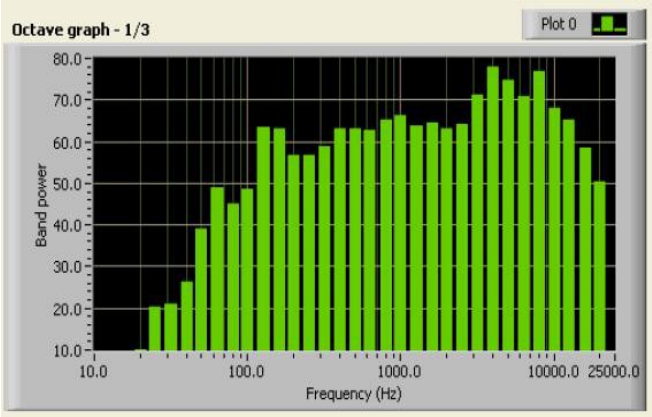
Good Motor 2
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 77.43



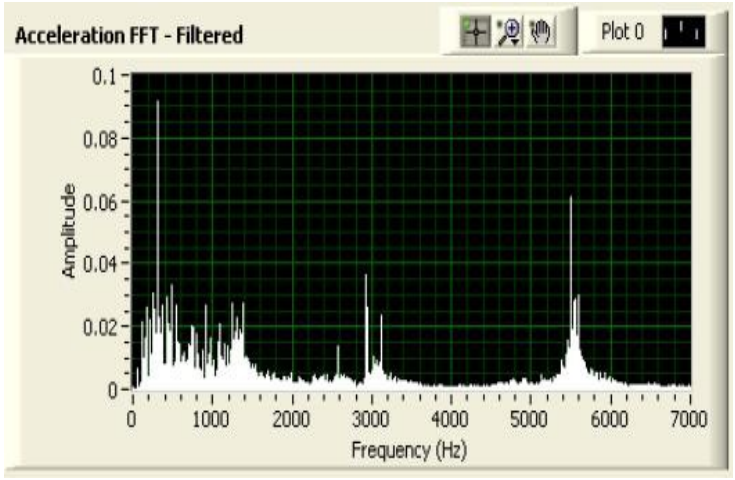
Bad Motor 2
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 83.27



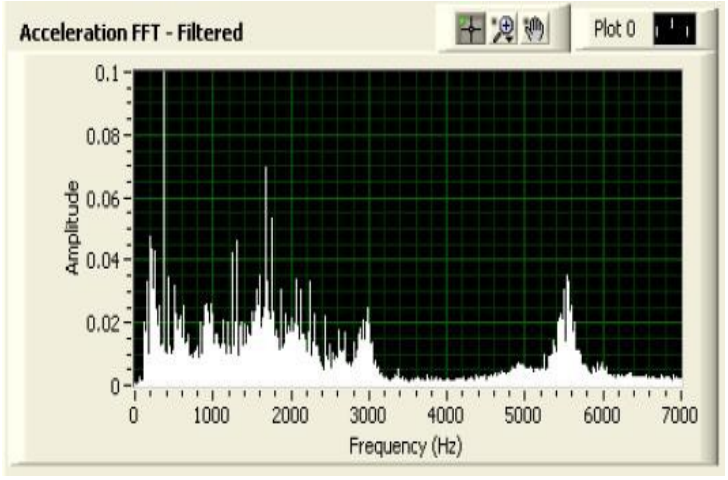
Overlap motor 2
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 83.10



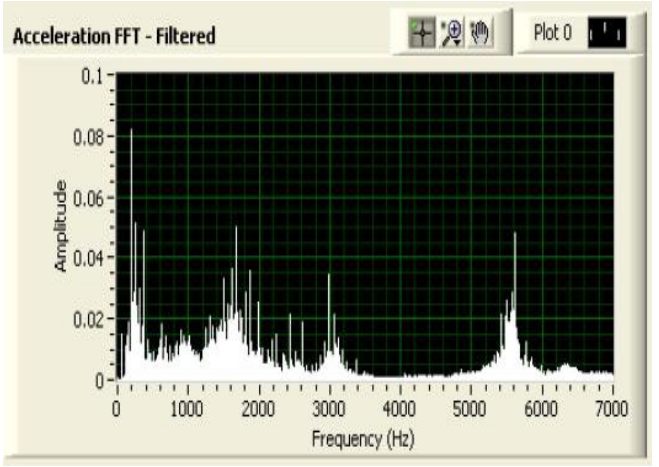
Good Motor 3
Acceleration FFT



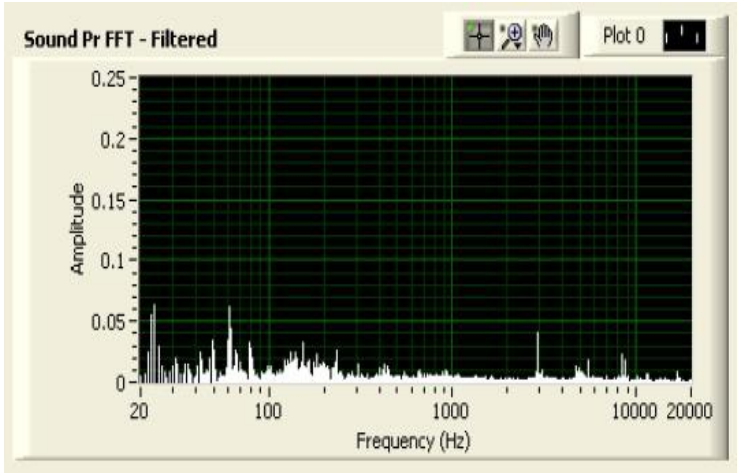
Bad Motor 3
Acceleration FFT



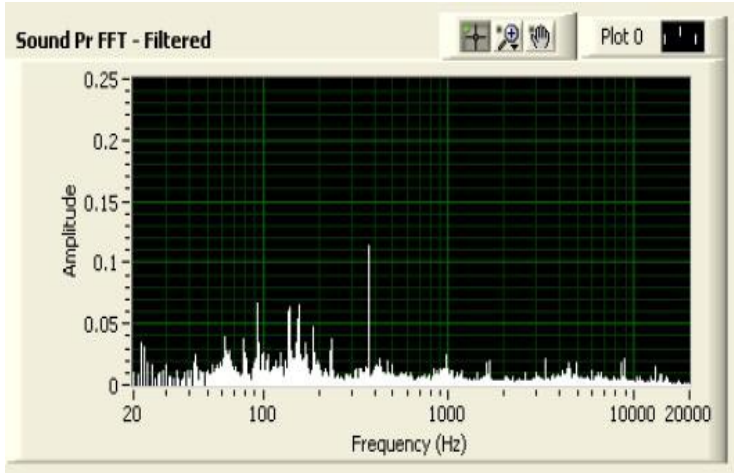
Overlap motor 3
Acceleration FFT



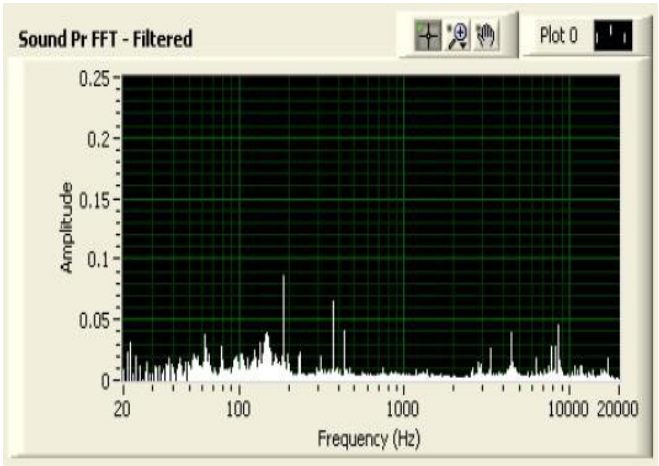
Good Motor 3
Sound Pr FFT



Bad Motor 3
Sound Pr FFT



Overlap motor 3
Sound Pr FFT



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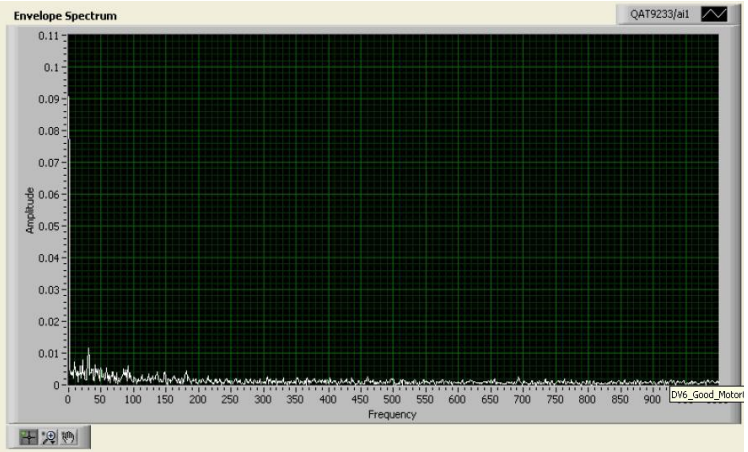
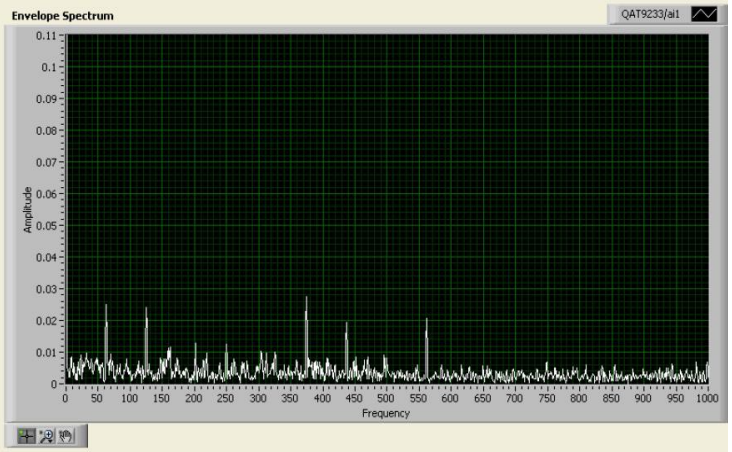
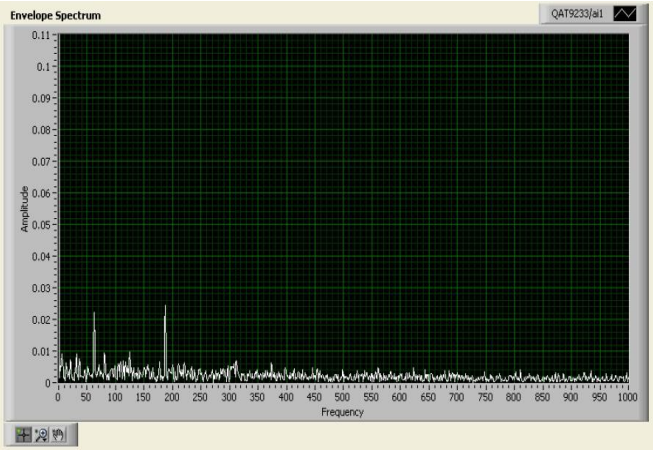
Good Motor 3
Envelop Spectrum



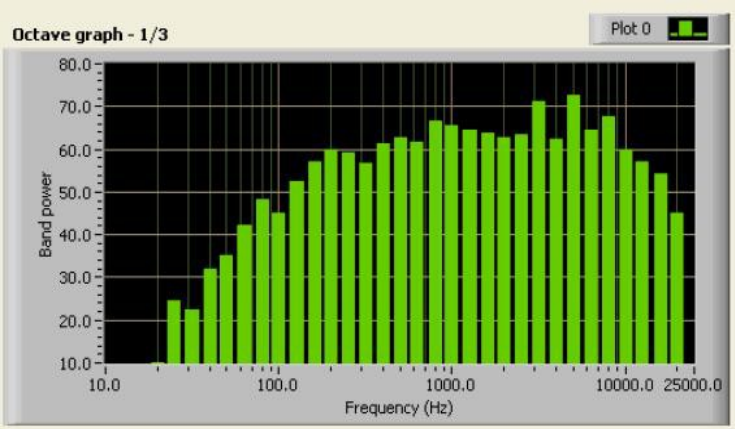
Bad Motor 3
Envelop Spectrum



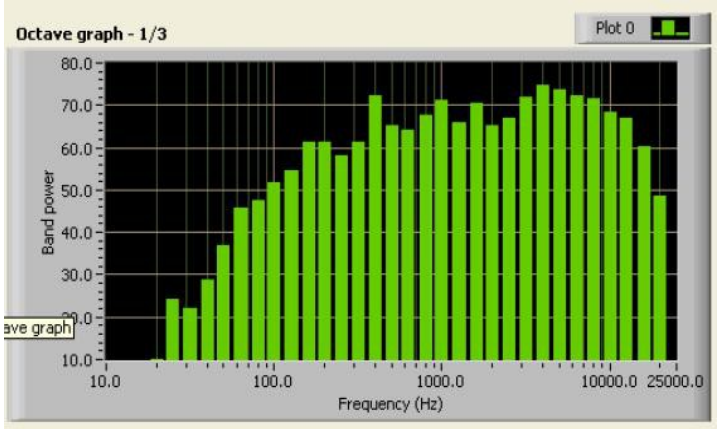
Overlap motor 3
Envelop Spectrum



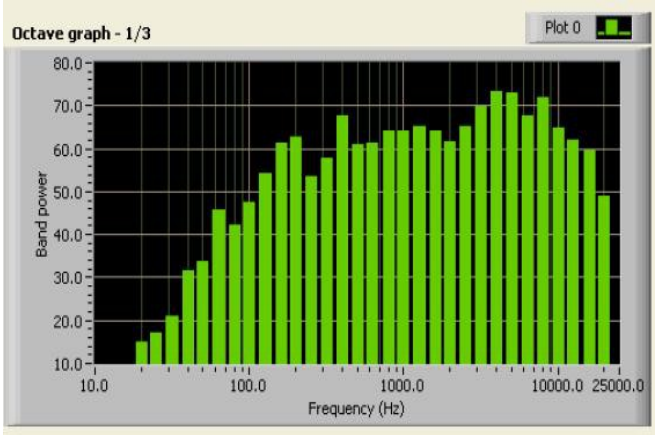
Good Motor 3
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 78.36



Bad Motor 3
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 82.58

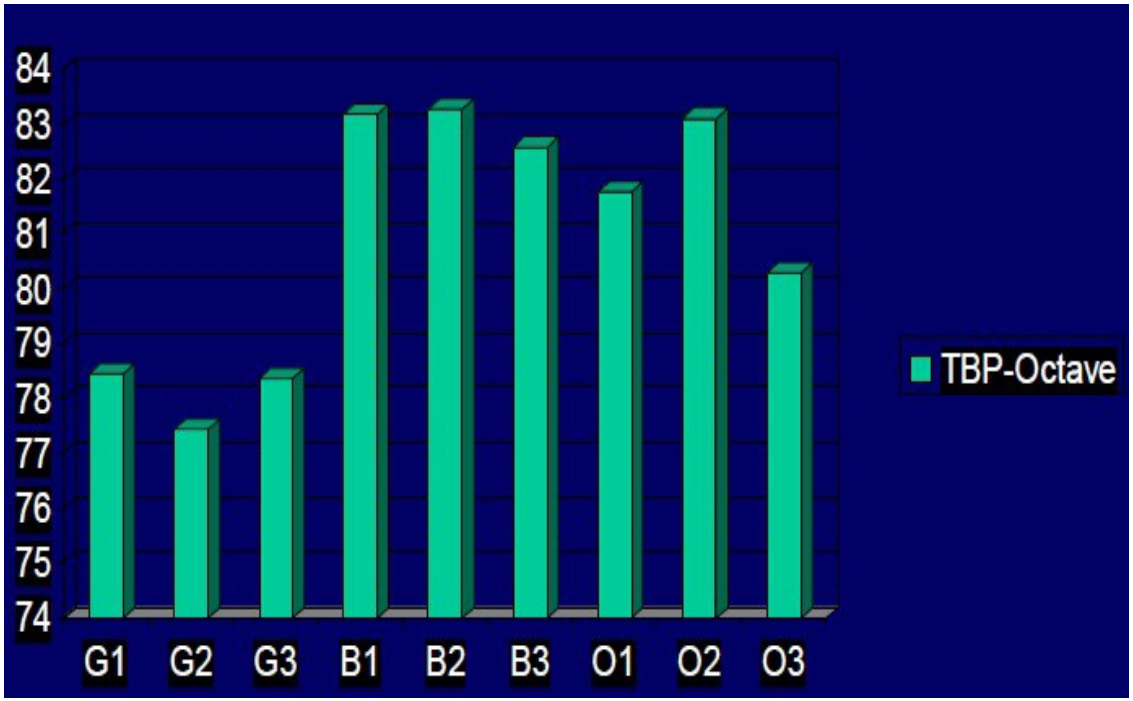


Overlap motor 3
Sound Pressure Spectrum – 1/3 Octave
Total Band Power-Octave : 80.29

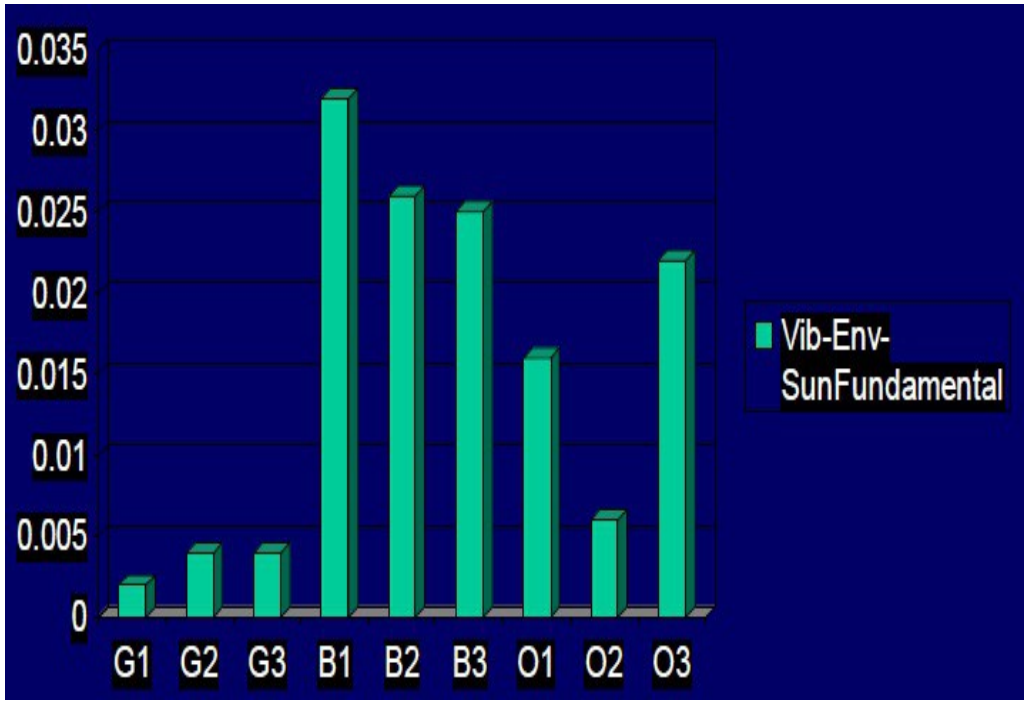


Data Comparision

Total Band Power – 1/3 Octave



Envelop Spectrum – Fundamental Frequency of Sun



Conclusion

- The approach used by us is able to identify motors
- Only two parameters have been presented in this report
- There are other sound quality and vibration analysis parameters that could be used based on requirements