CHAPTER 3

NONSYNCHRONOUS SIGNAL SIMULATION

In order to pursue the main goal of this research, a vibration with a subsynchronous component had to be obtained in a test rotor. This represented one of the major challenges of the present work. Many possibilities were considered by the author. The first one was the use of a Bently Nevada rotor kit, available in the Rotordynamics Laboratory at Virginia Tech, shown in Figure 3.1. Kirk (1997) found that this one-mass at the midspan and two-mass overhung configuration produced instability when operating above 9500 RPM (158 Hz). This option did not work out because when the radial mass of the AMD was placed on the rotor, a change in the dynamic of the rotor prevented the instability to arise in the operational range of the rotor kit. Modifications to the rotor kit including the addition of a hydrodynamic fluid film bearing were considered but later discarded due to complexity of modification to rotor kit.

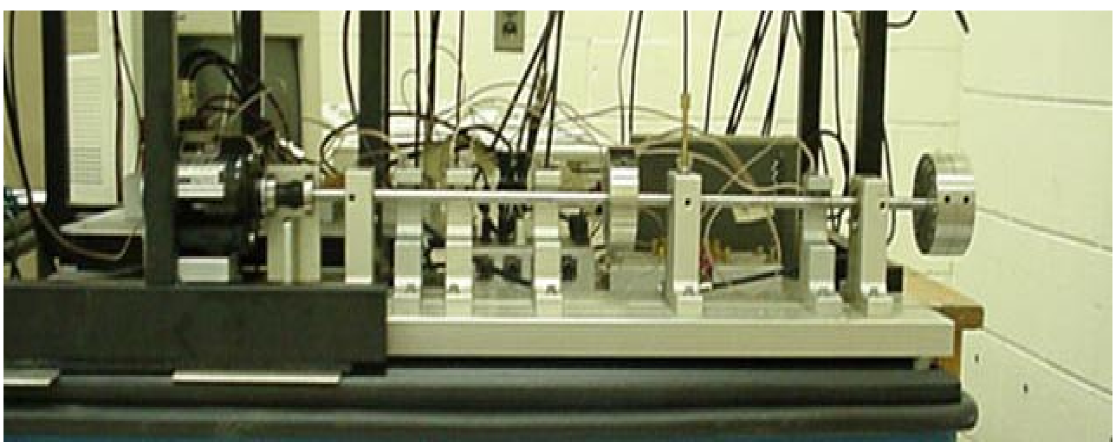

Figure 3.1: Rotor kit configuration for instability

Muszynska A. (1985) demonstrated different types of instabilities, including oil whirl/whip, rub, effect of loose rotating parts, among others, using a Bently Nevada rotor kit and different attachments. These options were considered at first, but further discarded for two reasons; the impossibility of finding parts for the old Bently Nevada rotor kit, which was compatible with the fittings of the AMD available for this research and the incompatibility of the fittings of the AMD and the new Bently Nevada rotor kit. The possibilities of designing adapters or machining parts were not considered practical due to the high level of accuracy required.

Ewins (1998) in his work titled "Modal Analysis for Rotating Machinery" considers three methods to excite a rotating shaft for modal analysis testing:

- The use of a shaker applied radially on the outer race of an auxiliary bearing
- The use of an out-of-balance device rotating with the shaft at a synchronous or at a nonsynchronous speed
- The application of an Active Magnetic Bearing (AMB)

The third alternative offers the possibility of using an AMB to inject a controlled excitation into the rotor in a great diversity of patterns. The application of an AMB was the most suitable option because all the necessary equipment was available in the Rotordynamics Laboratory at Virginia Tech, while also considered state-of-the-art technology in modal analysis testing.

3.1 Signal Injection

A sine wave was chosen as the signal to be injected into the rotors through the AMBs (AMB-13 and AMB-24) to simulate a nonsynchronous vibration. An HP 35665A Dynamic Signal Analyzer with a source output level of five volts and the capability of selecting the frequency and level of the signal was used to generate the sine wave. The HP Dynamic Signal Analyzer also offered the advantage of having two channels available for monitoring purposes.

Once generated, the sine wave was taken to the MB Research box connected to the MB 350 Controller. The SISO Tune tool of the MB Scope software allowed the selection of the axis of injection (V13, W13, V24 or W24) and offered the option of injecting a pre-filtered signal (position disturbance) or a post-filtered signal (current disturbance). The sine wave signal was injected as a current disturbance. Figure 3.2 shows the system configuration for signal injection and Figure 3.3 shows a signal flow diagram for the injection process.

The voltage of the signal to be injected in each case considered in this research was selected in the following fashion. The rotor kit was ramped up to the speed selected to perform the test, a voltage of 0.1 V was initially injected and the subsynchronous response was observed. Then, the voltage was increased until obtaining a subsynchronous vibration with the same or higher amplitude than the synchronous component. In some cases, a significant subsynchronous component could not be achieved because the system became unstable, in whose case the test was performed with small subsynchronous amplitude.

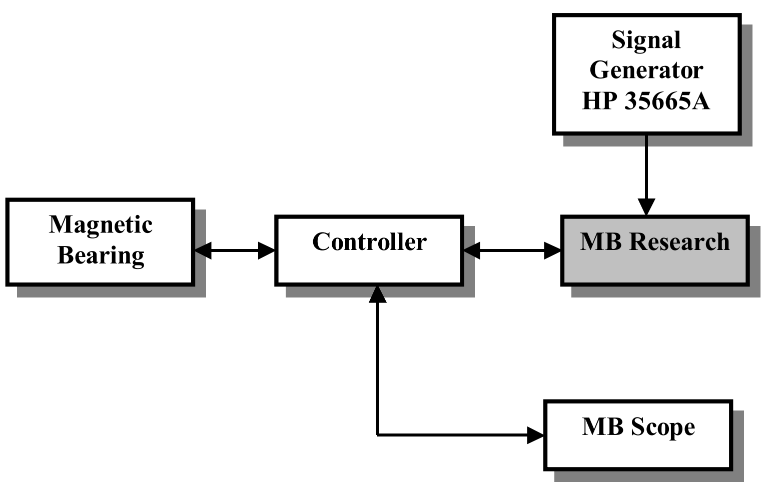

Figure 3.2: System configuration for signal injection