Simulation of rotating blades which vibrates using arbitrary wave generator and AM modulator

GOAL

For an electronics manufacturer it’s not “easy” to have a real turbine engine in the lab in order to evaluate the performances of a new measurement product.

So in order to avoid this situation, the idea is to simulate the real signal thanks to an arbitrary wave generator which feeds a modulator whose carrier frequency is the signal used to feed the probes.

The other advantage is the possibility to apply a frequency modulation to the signal which mimics the passing blades one in order to simulate blades vibrations. With this mean, it becomes possible to simulate realistic blade tip clearance and tip timing signals.

With this system, it becomes easy to compare the performances of one electrode probe to double electrode probe.

SYSTEM DESCRIPTION

The system includes to generators: the arbitrary wave generator and a low frequency generator. The arbitrary wave generator generates a signal having the same shape than blade passing one on the first channel, the second one generates the same signal but with a phase shift in order to simulate the delay between the two electrodes incoming signal.

The low frequency generator is used to modulate the blade passing frequency in order to simulate the vibration.

A two channels AM modulator is used to create the 2 signals which feed the two equivalent “blade electrodes” by using the carrier frequency which feed the probe.

Two signals are available at the output: the signal (BTC) whose amplitude is proportional to clearance, and the other one (DIFF) whose amplitude is not clearance dependant but time shift dependant (the difference of time of arrival between the two probe electrode).
REAL SIGNAL EXAMPLE

In order to show that simulated signal gives the same processing results compared to real signal, such real processed signal is displayed using EDAS software.

A simple 6 blades fan running at 1000 RPM is used for this example.

The under screen shot shows a better S/N get with double electrode probe (low end graph)
With the test bed used, it is possible to force one blade to vibrate thanks to an electromagnetic exciter.

The result is easily seen on the lower graph (get with double electrode probe – scale 1 mil) compared to the upper one (scale 10 mils).

The S/N is better with the DIFFERENCE signal processed.

1 mil = 25 µm.

With the double electrode probe, it becomes possible to measure vibration as low as about 0.1 mils (2.5µm).
SIMULATION RESULTS

A nine blades fan is simulated. The RPM ranges between 10000 and 50000. The simulated blade vibration is set in the 1/10 of the blade passing frequency range.

The typical shapes of the graphs are very similar to those get with real signal.

It is confirmed than the S/N is much better with difference signal (lower graph) compare to BTC signal.
Another screen shot without blade vibration simulated is given below.

The lower left display shows the “probe quality” record. It can be seen that the signal has a better S/N with difference compared to direct output (BTC).
WHY THE DIFFERENCE GIVES BETTER RESULTS?

In order to explain why the S/N is better when difference signal is processed compared to simple output, a LabView program was develop to compare the results of the two ways to process the signal.

UNDER DEVELOPMENT