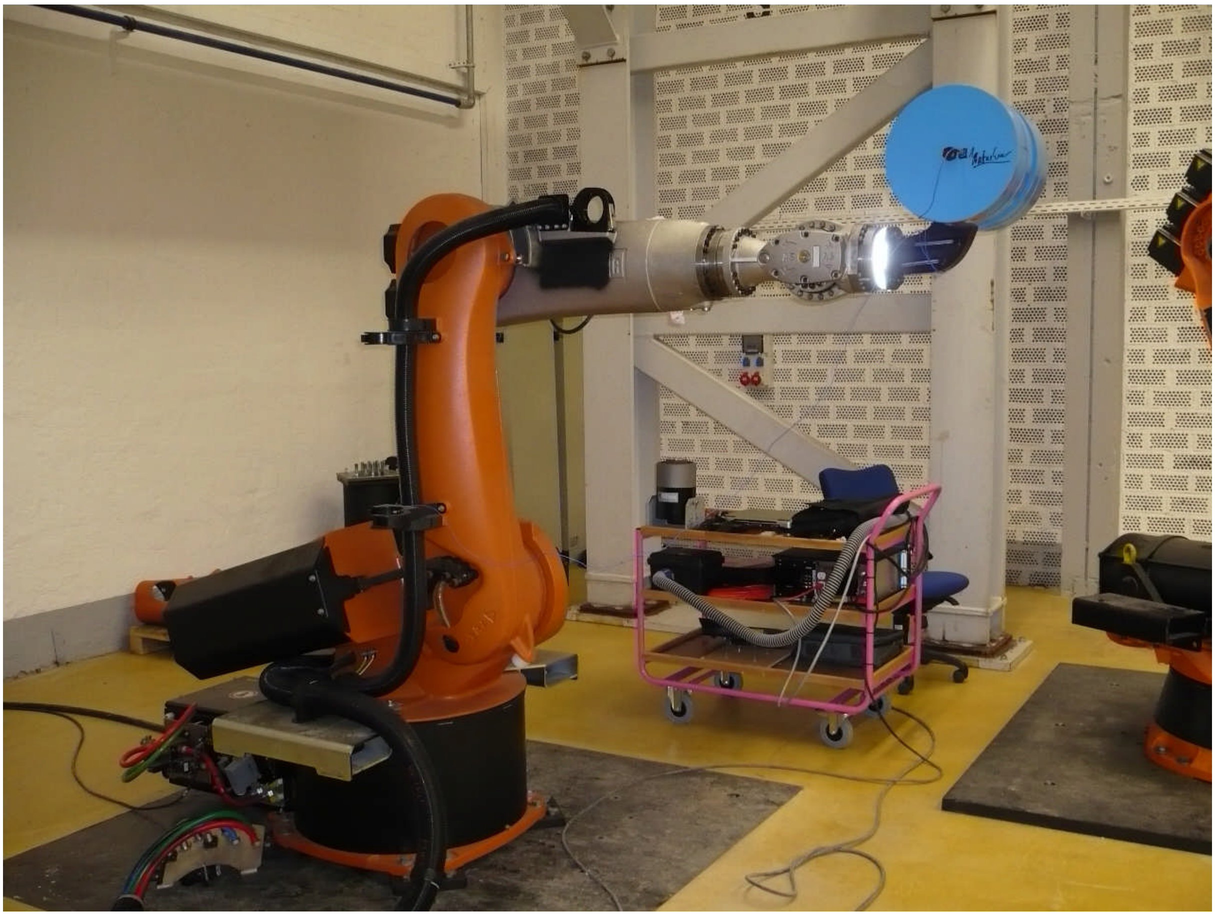
Modal Testing at KUKA Roboter GmbH

Modal Testing Of Industrial Robots Using OROS Modal 2 V5.0

OROS APPLICATION NOTE

Structural analysis of industrial robots is always difficult. Robot gears have a certain amount of backlash, the rigidity of the gears is depending of the torque, the friction of the backward driven gear is much higher compared to the friction when the gear is driven forward by the servo motor, the inertia of the servo motors, shafts and so on can make up to around 50 % of the overall rotating mass and last but not least, the dynamic behaviour of the robot can be modified using advanced control algorithms.



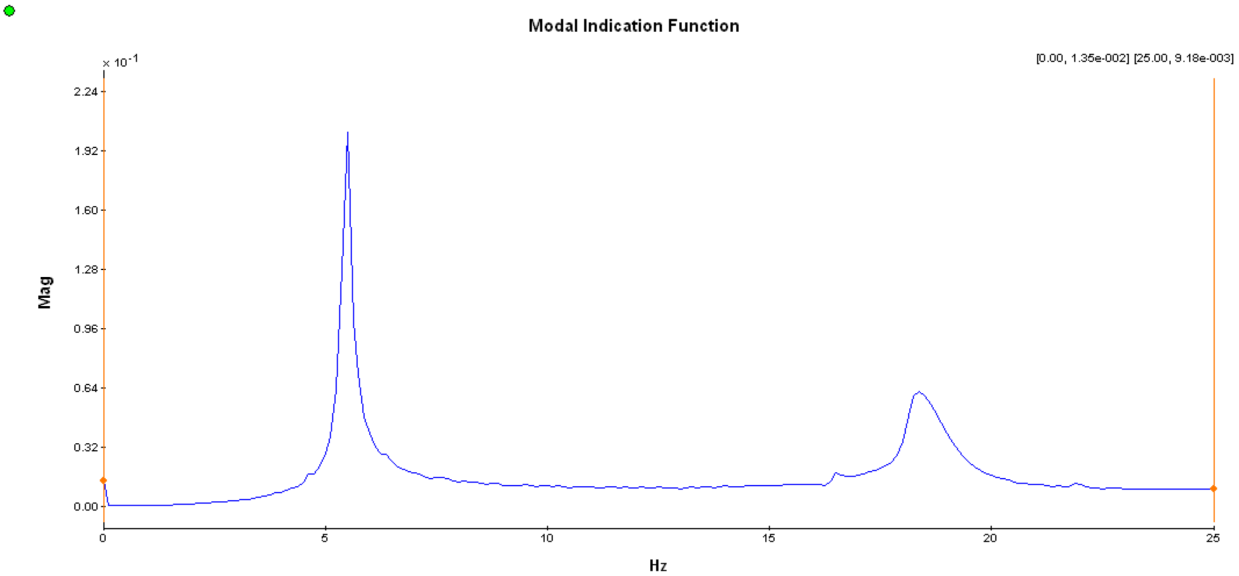
Experimental Version Of An Industrial Robot Undergoing Structural Testing.

In the past, the common way to characterize the robot´s structure was to perform an impact test on several points of the robots structure in several positions of the robot. During these tests the brakes of the servo motors are kept closed and no influence from the input side of gear can be seen. However, as all joints stand still, the dynamic behaviour of the robot would be nearly the same even with control active because of the high friction of the backward driven gears, so the impact test only gives some information about the stiffness of the final gear stages, the main bearings and the structural parts of the robot.

In a first step, the measurement nodes will have to be defined for the impact test. On an industrial robot some few nodes on the joints and the structural parts are sufficient to gain valuable information as the structural parts of an industrial robot are stiff compared to the joints. On the robot shown above eight nodes (test weight, axis 6 flange, axis 5, axis 4, axis 3, middle of shoulder, axis 2 and counterbalancer) were used for a basic test.

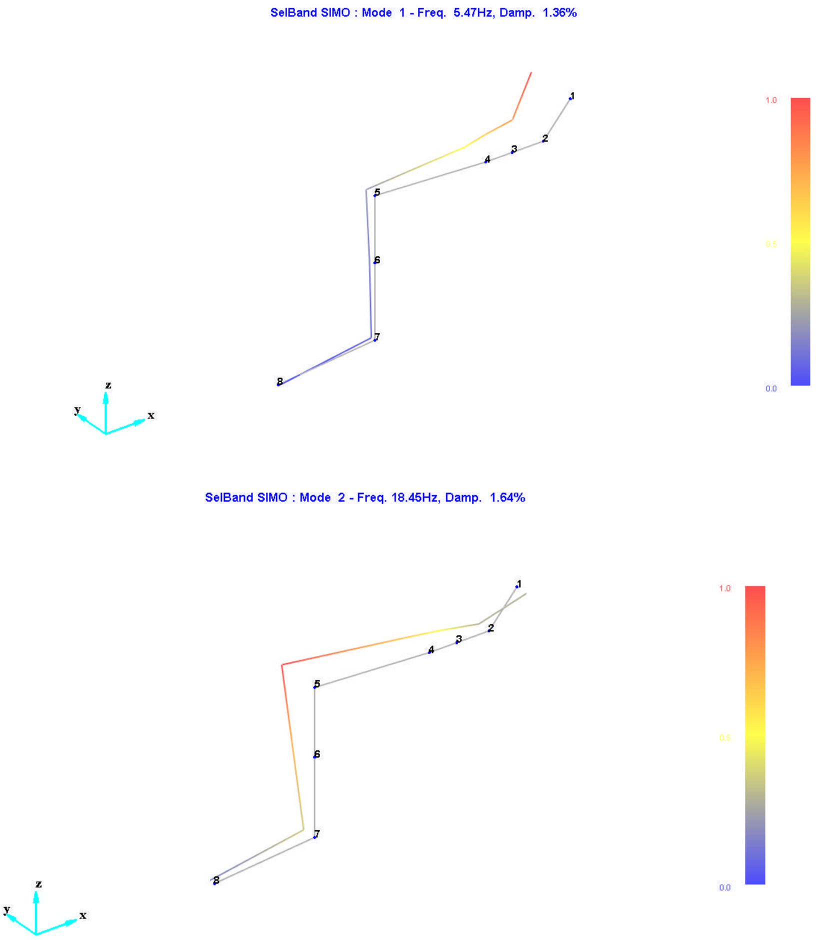
OROS OR34 is an advanced but yet very compact instrument to perform such testing with the possibility to measure FRF and coherence curves. OROS MODAL 2 offers a comfortable to use measurement interface for OROS analyzers. It shows the node to be measured after a brief setup of the measurements to be done. It also allows to control the FFT analyzer without any effort by some few mouse clicks when connected to the NVGate software.

OROS Modal 2 offers several methods to identify the mode shapes of an industrial robot very quickly. The picture of the MIF below shows the peaks of the two typical mode shapes of an industrial robot.



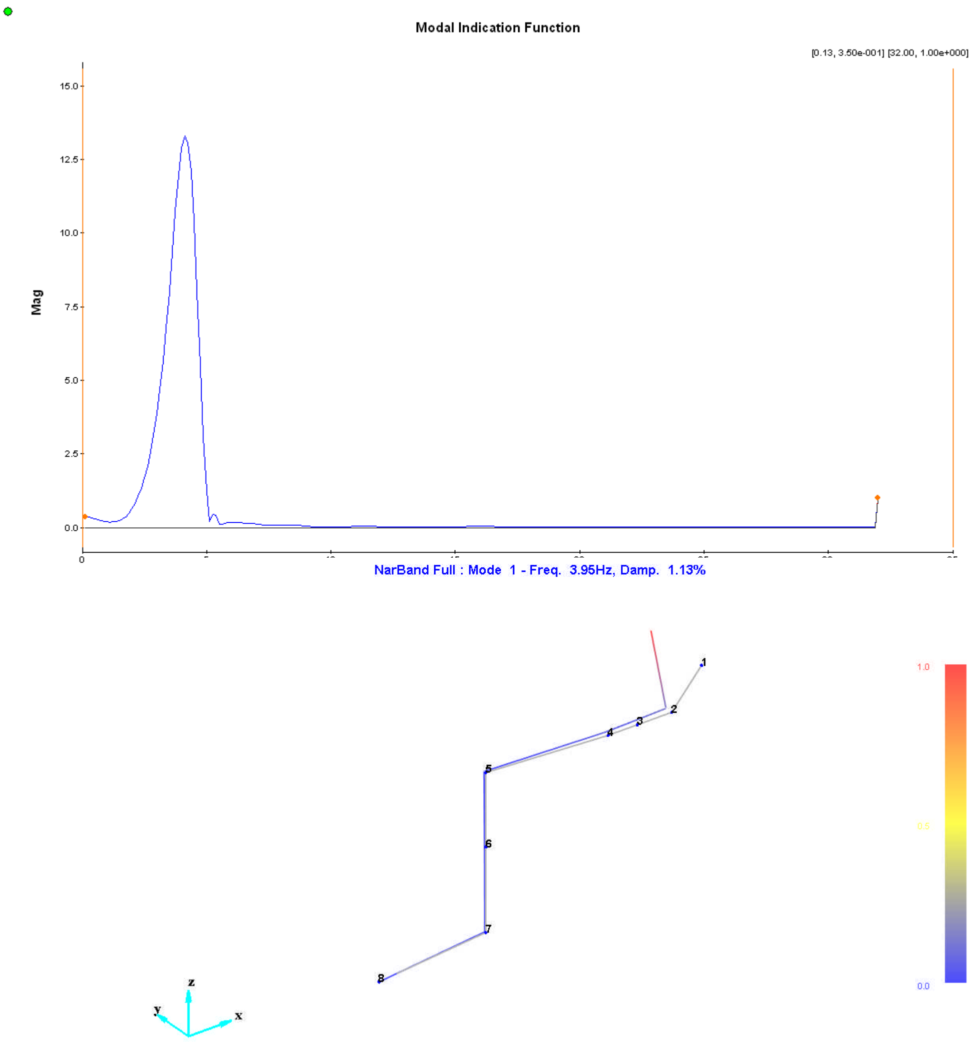
MIF Of Impact Test

Mode shapes can be found easily using the different indentification methods offered by OROS Modal 2. The pictures below are taken directly from the animation window of OROS Modal 2.



Mode Shape Animation Of An Industrial Robot Using OROS Modal 2

To determine the efficiency of control algorithms, it is a good idea to try OMA methods instead of EMA methods. On an industrial robot, excitation on the input side of the gears can be performed easily by the servo motors. On a KUKA robot, it is possible to define the command motion of the joints by user defined data tables. Instead of an impact hammer and an accelerometer at least two accelerometers are now used. One is kept as reference in always the same position, the other one is roving during the test. Only time domain data will be acquired by the OR34 for an OMA test. The processing of the measurement data will be performed by OROS Modal 2. The pictures below show the resulting MIF and the identified mode shape, frequency and damping.



MIF And Mode Shape Of OMA Test

It turns out that the second mode shape at 18.45 Hz found with the impact test with brakes closed nearly disappears with moving joints and the deflections of the base axis nodes are much smaller compared to node #1 (test weigth) deflection. The frequency of the first mode shape also turns out to be much lower with control on compared to the frequency with brakes closed.

Conclusion: OMA methods in OROS Modal 2 offer the possibillity to gain some valuable additional information about the dynamic behaviour of an industrial robot, which were not accessible with EMA or ODS methods so far.

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