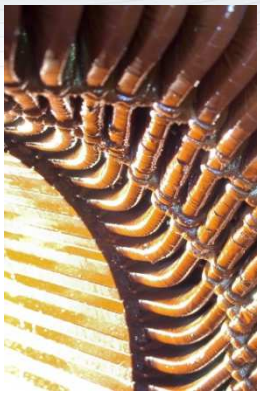
OROS
APPLICATION NOTE

OMA on industrial robots

Measurements carried out on robotised controls,

with Dr Gernot NITZ, KUKA Roboter GmbH, Augsburg, Germany



Introduction

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.

OR34 System

- **Made for the field**
- **Rugged, Rough, Reliable**
- **Portable**
- **Comprehensive FFT plug-in: Triggers, weighted windows, cross functions**
- **Accurate: +-0.02 dB/ +-0.02°**

OROS MODAL 2 software

Modern and user-friendly software with specific modules:

- **Geometry building**
- **Operating Deflection Shape in time and frequency domain**
- **Modal Indicator functions**
- **MIMO identifications methods for EMA & OMA**
- **Modal Validation tools (MAC)**

KUKA Robotics is the North American subsidiary of KUKA *Roboter GmbH*, one of the world's leading companies in the field of mechanical and systems engineering.
Their worldwide system partners and robot integrators offer their customers custom-tailored solutions. KUKA's customers are predominantly from the automotive industry and increasingly from other segments outside the automotive industry (General Industry). Robotics is among TOP 3 in the field of industrial robotics in the automotive industry worldwide and number one in Europe. In Europe and North America, Systems is one of the two leading suppliers of automation solutions for the automotive industry.

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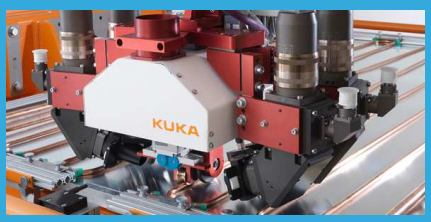


KUKA industrial robot

Environment

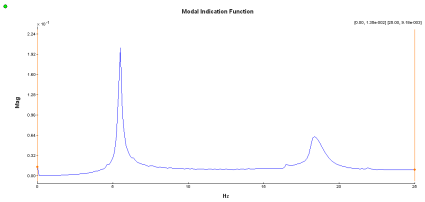
In the past, the common way to characterize robot structure was to perform an impact test on several points of the robot structure in several positions of the robot. During these tests the brakes of the servo motors were kept closed and no influence from the input side of the gear could be seen. However,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

Test configuration

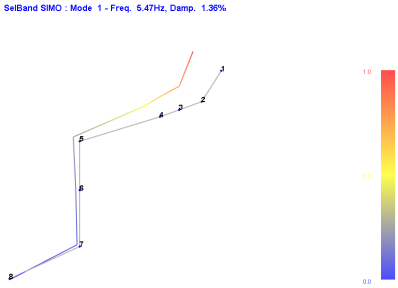
In a first step, the measurement nodes must be defined for the impact test. On an industrial robot only few nodes on the joints and the structural parts are sufficient to gain valuable information as the structural parts of an industrial robot are stiff compared to the joints. On the robot (see picture 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 analyzer, 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 measurement interface for OROS analyzers. It shows the nodes to be measured after a brief setup of the measurements to be done. It also allows to control the FFT analysis without any efforts.

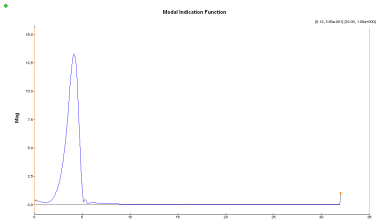
Modal Identification



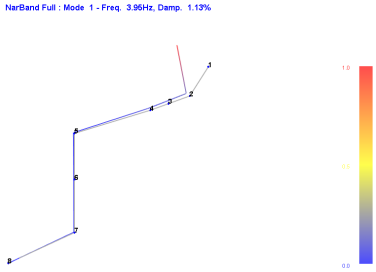
MIF of EMA impact test



Mode shape animation of an industrial robot using OM2 (from EMA results)



MIF of OMA test



Mode shape of OMA test

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

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

To determine the efficiency of control algorithms, it is a good idea to use 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 always at the same position, the other one is roved during the test. Only time domain data is acquired by the OR34 for an OMA test. The processing of the measurement data is performed by OROS Modal 2. The resulting MIF and the identified mode shape, frequency and damping both for EMA and OMA are showed beside.

It turns out that the second mode shape at 18.45 Hz found with the impact test with closed brakes nearly disappears with moving joints. Moreover the deflections of the base axis nodes are much smaller compared to deflections with closed brakes. The frequency of the first mode shape also turns out to be much lower with control than the one with closed brakes.

Conclusion

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

OROS, Leadership through Innovation

About Us

Now approaching 30-years in business, OROS' designs and manufacturing have been renowned for providing the best in noise and vibration analyzers as well as in specific application solutions.

Our Philosophy

Reliability and efficiency are our ambition everyday. We know you require the same for your measurement instruments: comprehensive solutions providing performance and assurance, designed to fit the challenges of your demanding world.

Our Emphasis

Continuously paying attention to your needs, OROS collaborates with a network of proven scientific affiliates to offer the latest of the technology, always based on innovation.

Worldwide Presence

OROS products are marketed in more than 35 countries, through our authorized network of representatives, offices and accredited maintenance centers.

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