Robotized assembly simulation of a coupling

Niklas Klevendal
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Abstract

The goal of this master’s thesis is to simulate a robotized assembly of a small model of VBG Group couplings. By the software; Process simulate has the simulation model built up and the simulation been done. The simulation model is built up of the coupling parts and resources; conveyor, fixtures, compress machine, grippers, nut and screw sorter. All parts and resources, except the compress machine, the fixture and cage for the shaft, have been designed under the whole project. A study on how assembly simulation works in the software has also been done.
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Symbols and glossary

CAD = computer-aided design
3D = three-dimensional
GP = Geometry point
TCP = Tool centre point
TCPF = Tool centre point frame
1 Introduction

Industrial robots has been around since the sixties[1] and are more and more used for robotized assembly manufacturing. This because robots can do things that human’s can’t and they can work in dangerous and heavy environment. Robotized assembly is also more and more used in manufacturing. This for reduce employed operators, the assembly time and also the cost. Robotized assembly can also increase the production of manufactured. All this should been achieved so if it will be worth investing in.

1.1 Background

VBG Group makes coupling for trucks. VBG moved their manufacturing from Germany to Sweden last year to become more effective. They want to reduce the cost and to automate the manufacturing. To do so, they realized that they have to robotize their assembly as far as possible. A background to this master’s thesis a pre-study[20] has been done. In that pre-study a proposal of a robotized assembly cell was developed, see figure below.

In that pre-study different methods to solve the supply of material were investigated. The result was that the work cell should consist of nut- and screw-sorter and different conveyor. To be able to assemble a coupling some other resources were also needed. These resources are a robot, cage for the shaft, two fixtures and the compress machine. All these resources with the cad model of the couplings part were set up in the proposed work cell layout. The question that was answered in the pre-study was how to solve the material supply problem. The question that still remains if it is possible to robotized the assembly with respect to different variants.

Fig. 1 The pre-study solution of cell layout
1.2 The goal
The goal is to simulate the robotized assembly in the work cell. In the simulation the coupling will be assembled. The assembly time should not be more then the manual time it takes to put the parts together.

1.3 Limitation
One thing that doesn’t have to be considered is the marking the coupling with a sticker. Assembly that would be to advance for a robot doesn’t have to be simulated. Only one manufacture coupling will be simulated.

2 Methodology
First is a literature review of how assembly simulation works in the software done. This by study the Process simulate and its manual. Information about how the assembly looks like today will also be available from VBG Group. The work processes were put up so initially will the software be studied. After that is the proposed work cell built up in Process simulate and optimized by change resources placement after reachability of the robot. Then is the simulation built up after the process structure. Finally is the simulation optimized by changing the robot paths.
3 Simulation

Simulation is a valuable tool for test and to understand system behavior. A process flow can be modeled and simulated in two common ways; discrete events and robotic simulation. Event simulation is built on prioritized event queue where the highest priority corresponds to the lowest value of time. Because each event has a time associated with it. Then the highest priority event are processed other events are sorted out and added to the queue, this in the right priority. Robotic simulation is not like event simulation as it studies the robots behavior in detail[2][3][13].

Robotic simulation is a simulation of how a robot moves in its environment. It is also a kinematics simulation tool that could be used as a highly detail validation tool. This is done in a 3D-visual layout. A robotic simulation verifies the robotic work cell process operation for test and evaluates different parameters, e.g. object collisions, optimal path, cycle times and work cell layout. Usually, the robot simulation tools has an integrated CAD module or other graphical visualization tools[3].

The benefits of using simulation are cost- and time- reduction since the simulation is used for designing, testing and improving[3]. To develop a real manufacturing environment is expansive, without simulating first. If changes are needed it is easier to change in the simulation. But this is not the only large benefits, also to get a perfect result which is close to the real life and in real scale are a large benefits of simulation. From the visual simulation can the real life layout be developed. By comparing the current model with the planned model can the parameters be more effective. These parameters can be cost for each unit, time and quantity[4].

To get realistic idea of the systems behavior the simulation model has to be so close to the reality as possible[5]. The system behavior is the devices movements, the assembly order and size on each part. Simulation is a good tool to use for modeling and test operation in complex problem situation[4].

The simulation is built up like an animation. In this animation each movement are registered in order to detect errors like collision and rechability problem. In the knowledge of these detected errors can the whole operation be more effective. This also results in that each task will be optimal. The simulation displays the cycle time for each operation and task. This cycle time is equal to the time it take in the real system[4].
The methodology of the simulation can be divided into six steps, showed in figure 2:

1. Part model is a low-level or geometric entity. The parts are created using basic elements of solid modeling features.

2. Device models represent the work cell parts. Building them start from positioning the base of part model as the base ordinate system. They are categorized in robotic and no robotic device model.

3. The layout of work cell refers to the actual work cell environment and consist the placement of the model and devices.

4. Motion limits of the joints are defined of the device model. This in the terms position, speed and acceleration. Each joint has its own motion limits.

5. A robot arm movements are the device model referring to. This during the palletizing process, there the geometry points is determined. That series of Geometry Points create path of motion for the robot. The series and position of the GP are based on the movement pattern.

6. After the simulation has been programmed the device model layout can be simulated over time[4].

![Diagram](image)

Fig. 2 Chengs simulation methodology(4)

This was the methodology for develop robotic work cell simulation model. Another methodology of robotic simulation in eight steps is present in figure 2[3][4]. These eight steps are:

1. Monitoring the operation and identifying the problems in the process. Identification is done during the analysis of the problems background and defines the actual problem.

2. This step is limited to the project scopes and requires right decision on which tools, robot and methodology are plan to use. It also requires a proper planning.
3. The conceptual model requires collection of robot data, for develop the robotic work cell. The robot data include geometry configuration of the robot, robot motion parameters and the robot cycle time.

4. Modeling the robot application are based on three activities; building the robot, motion path programming of the palletizing process and run the simulation.

5. This step aims to improve the models precision and motion. The validation on the model is based on visualization of the system layout and the robot cycles time.

6. This step is the testing phase, which are required to make sure each moment is safe mode and will not collapse if any collision happens. In this step is the simulation running in order to visualize the robot arm movements and check for collection. The cycle time is also showed, during the simulation.

7. This step are the optimize phase, there efficiency, speed and time are optimized.

8. This step gathers and documents all results generated from the simulation. Written reports provide better understanding of the experiment’s executions and analysis[3][4].

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Fig. 3 Grajos simulation methodology(4)
With assembly simulation it is not only important to study the process flow even assembly relation and constraints of variants products. This for being able to analysis the static assembly and to simulate the assembly sequences. Assembly simulation is to check the assembly sequences and go get the interference information between the part and the environment. This can be described in 5 steps:

1. The initialization. There the part from the CAD software is put in to the simulation model. This for change their color or just adjust their posture and position.
2. Process planning. To learn the assembly sequence and the initial assembly path.
3. Preparation where the simulation environment is set up, with minimum distance between resources.
4. Assembly simulation where the assembly is animated according to the sequence, parts posture and its path.
5. The last step is to analysis the simulation result. This for modifying the optimal assembly path and maybe come up with other suggestion to get a better simulation[15].

Offline programming is programming without having physical contact with the robot. It is done so it doesn’t affect the production. Offline programming gets rid of safety issue while programming the robot. Therefore are simulations a good tool to use in offline programming. The benefits by using offline programming are high productivity and get experience of the systems behavior before using the program in the real life. Simulation based offline programming requires CAD models and the programmer need to have good knowledge in computer technology, such as the software and data communication[18][19].

When designing the robotic work cell simulation is used. The first thing to do is designing the work cell via a robotic simulation. In that way, the unrealistic expectations from the specification of the technical equipment are eliminated. Secondly, this modification on the work cell design is made. Then this modification must be inserted into the corresponding work cell. It is much easier and faster to change a simulation model than a real work cell. Robotic simulation provides a safe design environment for modification[6]
4 The structure of assembly

The structure of assembly can be divided into three steps. These three are Product, Assembly process and Assembly system[7]. Product contains variant of the product, how many parts and the product structure. Assembly process contains the process strategy, the process structure and which that operations should be used. Operation could be feeding, handling, assembly, checking or adjusting[8]. The process strategy means how the process will be as good as possible and as many parts as possible can be assembled. The process structure means how the sequence will look like so the product can be made. Assembly process contains which movements that are needed for the sequence. The movements are different just for fit parts of the product[10].

Assembly system contains the layout, the system structure and system resource. The system layout means position of the resource and is the result from the system structure. The system resource are which resource that is needed[9]. The system structure means how the parts are related to each other[10].

These three steps are very important for the whole structure of assembly and that they work together. Even the contents in this should work together, that is showed in fig.5.

Fig. 5 Assembly structure(8)
4.1 A product structure

A product structure can be divided into three levels:

1. Single-level; where the lowest level consists of a set of parts and the highest level is the final assembly, see figure 6.

2. Two-level; where the lowest level consists of the parts, the intermediate level consist of the sub-assemblies and the highest level is the final assembly, see figure 7.

3. Three-level; where the lowest level consists of the parts, next higher level consist of the sub-sub-assemblies, next higher level consists of the sub-assemblies and the highest level is the final assembly, see figure 8[14].

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**Fig. 6 Single-level structure(14)**

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**Fig. 7 Two-level structure(14)**

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For different products, the number of items, parts, sub-assemblies, or sub-sub-assemblies at different levels varies. The number of operations for the three different product structures is assumed to be uniformly distributed. This also concerns the processing times for each operation of the items. A higher level processing can only start when processing of all its lower level items is completed. Therefore, higher level items are assembled from the immediate lower level items. The two-level structure means that it has three levels of operation. So the three-level structure has four levels of operation [14][16].

The design of assembly cell requires the sequence, which assembly tasks are required and allocation of the assembly parts [10].

Another way to divide the structure of an assembly could be in following three steps. In the first step are the robots states presented, which movements and position the robot have in each state. Then the assembly rules are made by the layout and the process structure. By these rules the suitable assembly task is decided [11]. The tolerance between parts is generally small for assembly task [12]. For the coupling parts, the tolerance will be low, since each part needs to fit in the right way.
5 The couplings part and structure

Couplings are made in two common variants, one large and one small model. They are built of similar parts; the size is the only thing that is different. Therefore only one model will be simulated; the small variant, see figure 9. Each coupling consist of 27 parts, see figure 10.

Fig. 9 The real coupling(17)

Fig. 10 CAD model of a coupling parts
The process structure is:

1. Assembly the shaft(13), the lower bushing(4) and the coupling mouth(15) together in the compress machine.

2. The nose plate(5) and the return spring(23) put together and with the adapter(2), see figure 10, are this screwed on the coupling mouth under part.

3. The locking pin(8), looking cover(1) and the signal pin(9) together with the looking spring(14) be assembled in the right hole on the coupling mouth.

4. The locking and lifting arm(3) put together with the axes for spring holder(10), and then with the spring holder(7) assembled in the coupling mouth over part.

5. The axis for lifting arm(20) push in the rite hole, throe the over part of the coupling mouth.

6. Hand lever(23) with the bushing long(21) put on the axis for lifting arm. This is screwed together with two nut.

7. The coupling bolt with lifting sleeve(24) and wear plate(5) be assembled in respectively on the coupling mouth.

8. After that will the two close spring and the cover be assembled on the coupling mouth. The cover is screwed on the coupling mouth with three nuts.

9. The rubber spring(20), the push washer(19), pull washer(15) and rubber spring(16) be assembled on the shaft. This four parts are screwed together with the shaft by the castle nut(18), see figure 11.
6 The simulation model

The simulation model, on next side shows how the proposed work cell, see figure 13 has been changed after built up in the software. Placement of conveyor, nut and screw sorters has been changed from its proposed placement. This is for a more effective and smoother assembly. The conveyor for pre-assembled parts(1) has not been necessary in the simulation. The palette has been designed for all parts, except the coupling mouth, castle nut and the shaft. Since only one model was simulated the conveyors up to the right(2) has not been necessary. For building up the work cell in the real life these conveyors are necessary for the larger variants parts. The conveyor for assembled couplings(3) has been moved to the larger variants conveyor placement.

The number of nut and screw sorter has been changed. This so all nuts and screws that are needed for assemble one coupling are delivered to the robot. The nut and screw sorters have been moved for the tool change. The tool change is for the grippers, placed so the robot can mount and unmount them. The wagon with material, fixtures and the compress machine placement has not been change. The robot model has not been changed, only the size changed to one size smaller, even this to reach all parts and resources. The robot has also been placed on an external axis, which it can travel on. This is for reaching position that the robot would not be able to, if the robot had a fixed placement.
6.1 Fixtures

The right fixture is for fix the shaft in and the left is to fix the coupling mouth in. The hole in the right fixture is like a rhomb, which match round parts. The rhomb is built up in two separate parts. The upper part is connected to the cylinder on the top. Its level change through a sprint on the back that sets in different level. This so different size of shaft should be able to fit in the fixture. Since only one variant of couplings will be simulated is the fixture fix to match only the small variants shaft. The left fixture is simple, it only fix the coupling mouth in one direction.
6.2 Palettes

The robot could collect the parts from its incoming palettes. But then will these palettes take up too much space, both around and in the work cell. The coupling mouth is packed against each other, so they are hard to grip without damage each other. So instead is one palette use for the coupling mouth and one for the rest of the parts. The palette for the coupling mouth is equal with the fixture for the same part. On the blue palette are all parts laying oriented, with a certain distance between each other and fixed in tracks so the robot can grip them. Some part is built up in sub-assemblies, before they are assembled with the coupling mouth. The return spring are laying fixed in tracks on the palette. The nose plate is placed, by the robot over the return spring. Then the robot grip them both the return springs get together with the nose plate. The adapter is laying centred in the return spring. When the robot grip, will the adapter automatic follow with the other two parts.

The locking spring and the close spring are not real springs in the simulation, only like cylinders. But they are griped and used in the simulation like they would in a real cell, so long way it is possible. The locking spring are placed on the signal pin. When the robot grip them it first press the locking spring and then grip the signal pin. The same principal concerns the close springs and the spring holders. But they are first assembled on the axle for spring holder, which is assembled on the locking and lifting arm in an early step. All these are assembled on the coupling mouth over part. The coupling bolt and lifting sleeve and also the hand lever and the knob are placed together on the palette.

![Fig. 16 Palettes](image-url)
6.3 The compress machine

The compress machine compresses the shaft and coupling mouth together with the lower bushing. The compress machine consists of:

- A palette, for the shaft and coupling mouth to fix on and travel on.
- Compress tool, which fit with the lower bushing.
- Hydraulic piston, which compress the compress tool, and the lower bushing together with the coupling mouth and shaft.

The sequence is as follow:

- First is the shaft, then the coupling mouth and last the lower bushing placed on the palette.
- The compress tool is placed in the coupling mouth over part hole, against the lower bushing.
- The palette, with the parts and compress tool are moving to the position under the hydraulic piston.
- The hydraulic piston goes down and compresses the parts together.
- The hydraulic piston goes up.
- The pallet are moving back to its early position, so the robot can grip the new part.
- The compress tool is back placed, to its early position.

Fig 17 The compress machine, and the cage with the shaft and the castle nut
6.4 Grippers

The robot needs 9 different grippers to grip all parts. Two of them are screwdriver(8) respective nut machine(9). Three of them are for gripping round parts; number 1, 2 and 3. Gripper 1 and 2 are built on the same principle, like the fixture for the shaft. They can grip from the side and from the top. Gripper 3 can only grip from the side. Gripper 4 works like a magnet, to grip round parts which should be assembled into the holes in the coupling mouth. Gripper 5 is a simple gripper for gripping the cover and the locking and lifting arm. Gripper 6 are for gripping the coupling mouth, this by grip the top and in the hole of it. Gripper 7 is for gripping the wear plate and the insect-screw for it. All grippers are designed to grip both the small and the large variant of coupling parts.

For the robot to be able to mount and unmount gripper they have to be defined. When a gripper is defined its TCPF and its gripping position are defined. This so the robot is aware of its new TCPF when it has mounted a gripper and moves in the work cell. Gripping position is set so a gripper know which position it is supposed to go to.

Fig. 18 The robots grippers
7 The structure of a simulation

To be able to simulate an assembly the assembly have to be well structured in the software. This is to get a good sequence and over view of the assembly. It also becomes much easier to debug. To get this structure the assembly are split into different operation that together set up the whole assembly. An assembly are usually split in to different sub-assemblies, this sub-assemblies is off course done in a corresponding operation. The rest of the assembly is split in to different operation according to which assembly task that want to be achieved. For example when two parts are assembled together and then supposed to be assembled to another part can the first assembly be done in one operation, and so on. If it consists of any assembly where machines are involve should that assembly be done in a corresponding operation.

The assembly is also split into different operation so attachment and detachment can be set between operations, but it is in the same assembly task. For example when a part should first be attached to the gripper, after that it should be assembled together with another part and then detached from the gripper.

To get this structure should the resources and parts be well structured. Their placement, in the software is correct from the beginning and is well sorted in different libraries. This so they are easy to find and can be implemented in the simulation model. For example if some part or recourse is needed more than one of it, it is only to put one from the library to the model.

To get the whole assembly sequence, all operations are linked to each other. In the first operation is the first location, where the robot should go to set. After that location are other locations set and so on. In each location is the robot orientation and direction in x, y and z set. This so the robot knows how to go to a certain location. Every operation has a fist and a last location. Between the first and last location are locations set in that order the robot should move. This means that after every last location goes the robot to the next operations first location and so on. These except the final location, where the simulation ends. In each location is the assembly task defined, see figure below. If the robot supposes to grip, release, attach or detach a part, is defined in that certain location. In each location can mount or unmount of a tool also be defined. Not every location is assembly task, mount or unmount tool defined, it can be location that the robot only should go through.
The locations are set after each other so the robot get small movements, both in orientation and distance. This is for a more effective and smoother assembly. The robot or grippers orientation between two locations is not necessary to be changed. Specific when the robot has moved to a location and under the way got the orientation which is needed. For example when the robot has one orientation and by going back to its early location got the old orientation that was needed.
8 The simulation

The goal by simulate an assembly is to test the robot usefulness. This so the process structure is achieved and if it can increase the production of assembled. Also test if the robot can facilitate the assembly and the speed of the assembly. All this should be in accurate scale and free from errors[4].

The simulation is build up by the parts and resources in the cell. All these are stored in the software. All parts are saved in a part library and all resources are saved in a resources library. The assembly are split into different operations. If the simulation is not split, the robot gets problem to remember which gripper that belong to which gripping moment. This because in each operation is set which gripper and robot that is allowed to be used. One operation can be to mount a gripper or to grip a part. When too parts are assembled together, they are attached together. If they are not attached and the robot grip one of the part, will only the gripped part move with the robot. Each operation consists of defined location that together set the path for the robot. In each location can gripping, mount and unmount tool, release, attach and detach moment be set. All operations are linked to each other.

Like other robotized assembly simulation[21] are also this built up by defined location. This location is for the robot to go to or just pass for come to the next one. After the location are defined can its mutually order be changed. The order of the locations set up the robot path. The assembly time was 410 sec in the software.
9 Conclusions and discussion

The proposed work cell has been built up in Process simulate[22]. The robotized assembly of a coupling, whit all parts has been simulated in the software. Both the large and small variant could be assembled by a robot, since the proposed work cell could easy build up in the real life. The assembly time in the software was 410 sec and the manual time for put the parts together are 540 sec. The assembly can still be more optimized and that would decrease the assembly time. This means that the real sequence time should be some were between 5 min and 7 min, as VGB Group have approximately calculated. The time it takes to load the palette with parts is not taking into consideration; it should approximately take about one minute.

Things that have been hard to simulate are greasing of parts and screwing parts together. The greasing is not a simulation problem, more for the company that will built up the cell to solve. Since the developing of the work cell has been the driving force only necessary time has spent on the grippers. To save time and money could some grippers be put together to one, with the same function as before. This should reduce the numbers of grippers and still be able to grip all parts.

Screwing the wear plate on the coupling mouth would need one more robot or a simple machine. One holding the screws and the wear plate fix on the right place and one screwing the nuts on the screw. The proposal solution on this are a small robot on the side of the shaft fixtures, see figure 20. Since this robot only have to reach to the shaft fixtures middle point; 0,8 meters choose ABB model 140. The simple machine could be a arm that have same placement and reachability as the small robot.

![Fig. 20 The proposal solution whit two robots](image)
References


[18] Robot technology chapter 5 [RCS 900]

[19] rs-2_off-line-eng [RCS 900]


A. A short guide of Process simulate

The name of this project in the software is NiklasVBG5. Under the project name, in the Navigation tree are different folders:

- Administrative folder, there all import parts and recourses get a folder. Under the administrative folder are the PrStation and PrStationProcess.
- StudyFolder, there the RobcadStudy with the cell, PrStation, PrStationProcess and all parts is showed under. The project loads by right click on the RobcadStudy and press load.
- The cell folder, there all resources are showed.
- Robot folder, there the robot is showed.
- Vbg machines, are a recourses library.

All this folders, except vbg machines is needed for start the simulation and to be able to upgrade eMServer, this is like save the project, correct. All parts, robot and resources are showed in icons.

In the Object tree, behind the navigation tree are the RobcadStudy showed. Under the RobcadStudy are parts and recourses showed. Under recourses are PrStation and cell folder. Under the cell folder are the robot folder and all other resources showed.

In the Operation tree, the window under the object tree is PrStationProcess, and under that are all operation showed. By right click on the PrStationProcess and choose operation properties can which robot and grippers that are allowed be set. This is done under process and resources, in operation properties. The same principal for each operation. The types of operation that are used in this project are continuous robotic operation. Under each operation are defined locations. They are defined by moving the robot to a certain location and setting orientation in each location.

In the window to the right of the operation tree can Sequence or Path editor choose to be showed. To the left in the Sequence editor shows the PrStationProcess and the operation under it. To the right are a cycle time table showed, it show each operation cycle time and the project cycle time for the assembly. In Sequence editor can attachment and detachment set on the end or start of each operation. To the left in the Path editor shows the same as the Sequence editor. To the right are locations orientation, distance, speed, cycle time and so one showed. In Path editor can all this be changed, for example a locations x, y or z led. In both the Path editor and the Sequence editor can the simulation be started, stopped, play forwards and backwards.
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Different commands and task can set in each location. This by click on a location, go under menu Robotics and choose Teach pendant. There can mount and unmount tool, gripe and release moment, detachment and attachment sets for each location. In gripping moment sets which gripper that should be use and to which position the gripper should go to. Gripping position sets when the gripper is defined, in Pose editor. Grippers are defined in Tool definition, under menu Kinematics. There chose the TCPF of the gripper and it mountframe. The mountframe are made by three points on the back of a gripper. It’s the frame the robots six axis connect to when the robot mount a gripper. The TCPF are set by three direction(x, y and z led), like the mountframe. The TCPF and mountframe are set in the same orientation as the TCPF on the robot.

Attachment recommends only be set between parts in the Teach pendant when the robot grip the part whit a gripper. If the part only should be attached or detached to the gripper, then should the attachment or detachment be set in the Sequence editor. This in that specific operation there it should be done, in the end or start of the operation. Attachments sets in that location then the robot grip or release the part and the same concern detachments. All operation is linked to each other in the Sequence editor.
B. CAD model of parts

1. Locking cover
2. Adept
3. Locking and lifting arm
4. Lower bushing
5. Nose plate
6. Wear plate
7. Spring holder
8. Looking pin
9. Signal pin
10. Axes for spring holder
11. Close spring
12. Cover
13. Shaft
14. Looking spring
15. Coupling mouth
16. Pull washer
17. Rubber spring
18. Castle nut
19. Push washer
20. Rubber spring
21. Axes for lifting arm
22. Bushing long
23. Hand lever
24. Return spring
25. Coupling bolt and lifting sleeve
C. Robot 140 datasheet

IRB 140

Industrial Robot

<table>
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<th>MAIN APPLICATIONS</th>
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Small, Powerful and Fast

Compact, powerful IRB 140 industrial robot. Six axis multipurpose robot comprising IRB 140 manipulator and Si4Gplus industrial robot controller. Handles payload of 5kg, with long reach (810 mm) of axis 5, optional floor, wall and suspended mounting. Available as Standard, Foundry, Clean Room and Wash versions, all mechanical arms completely IP67 protected, making IRB 140 easy to integrate in and suitable for a variety of applications. Uniquely extended radius of working area due to bend-back mechanism of upper arm, axis 1 rotation of 360 degrees and flexible mounting capabilities.

The compact, robust design with integrated cabling adds to overall flexibility. The Collision Detection option with full path retraction makes robot reliable and safe.

Using IRB 140T, cycle-times are considerably reduced where axis 1 and 2 predominantly are used. Reductions between 15-20% are possible using pure axis 1 and 2 movements.

This faster version is well suited for packing applications and guided operations together with PickMaster.

IRB Foundry Plus and Wash versions are suitable for operating in extreme foundry environments and other harsh environments with high requirements on corrosion resistance and tightness. In addition to the IP67 protection, excellent surface treatment makes the robot high pressure steam washable. The white finish Clean Room version meets Clean Room class 10 regulations, making it especially suited for environments with stringent cleanliness standards.

The Si4Gplus controller has the electronics for controlling the robot manipulator, external axes and peripheral equipment. Si4Gplus also contains system software with all basic functions for operating and programming, including two built-in Ethernet channels with 100 Mbit/s capacity. This ensures a significant increase in computing power as well as improved controller monitoring and supervision.
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**TECHNICAL DATA, IRB 140 INDUSTRIAL ROBOT**

**SPECIFICATION**
- Robot version: IRB 140/IRB 140T
- Handling reach (on trailer): 810 mm
- Colour: Orange
- Safety protection: White

**SUPPLEMENTARY LOADING**
- On upper arm: 1 kg
- On wrist: 0.5 kg

**PERFORMANCE**
- Position reproducibility: 0.05 mm (mean result from 50 load cells)

**AXIS MOVEMENT**
- Axis 1: 1.2.3 Arm: 300°
- Axis 4: D.2 Arm: 360°
- Axis 5: E.2 Arm: 360°
- Axis 6: F.2 Arm: 360°

**MAX. TCP VELOCITY**
- 2.5 m/s

**ACCELERATION TIME 0-1 m/s**
- 0.15 sec

**ELECTRICAL CONNECTIONS**
- Supply voltage: 200-600 V, 50/60 Hz
- Rated power: 4.5 kW
- Transformer rating: 4.5 kVA

**PHYSICAL**
- Mounting: Any angle
- Dimension: Robot: 400 x 460 x 850 mm
- Robot controller: 400 x 460 x 220 mm
- Weight: Robot manipulator: 95 kg
- Robot controller: 250 kg

**ENVIRONMENT**
- Ambient temperature: 5 – 45°C
- Robot manipulator: 5 – 55°C
- Relative humidity: Max. 95%
- Degree of protection, Manipulator: IP67

**CLEAN ROOM**
- High pressure steam washable

**DATA AND DIMENSIONS MAY BE CHANGED WITHOUT NOTICE**

**WORKING RANGE AND LOAD DIAGRAM**

www.abb.com/robotics

**ABB**
D. Robot 6640 datasheet

Robotics
IRB 6640/ IRB 6640ID
Industrial Robot

Main Applications
Material handling
Machine tending
Spot welding

IRB 6640 – a stronger robot – the next generation
The IRB 6640 is a new generation of large robots, replacing the highly successful IRB 6600.
It's based on proven components used for IRB 6600, which ensures easier maintenance and exchangeability as well as a high up time.
IRB 6640 comes in different arm lengths and matching handling capacities.
IRB 6640ID, Internal Dressing, has its process cables routed inside the upper arm. The cables follow every motion of the robot arm instead of coming into swing in irregular patterns.

The IRB 6640 is adaptive for various applications
Upper arm extenders and different wrist modules allow customization to each process. As the robot can bend fully backwards, the working range is greatly extended and the robot fits well into dense production lines. Typical application areas are material handling, machine tending and spot welding.

The robot is also available with different options for different working environments, such as Foundry Plus, Foundry Prime and Clean Room.

Higher payload - lower weight
One of the strongest benefits of IRB 6640 is the increased handling capacity. For the IRB 6640ID, the payload is increased from 185 to 200 kg, which meets the requirements from the heaviest spot welding applications.

The maximum payload is 235 kg, which makes the robot suitable for many heavy material handling applications. The robot also follows the tradition of having outstanding inertia capabilities, which makes it possible to handle not only heavy but also wide parts. Collision resistance is also a great feature ABB robots are well known for.

Easy maintenance and installation
There are several new features in the area of service, such as simplified fork lift pockets and more space in the robot foot, which gives easy maintenance. In order to simplify installation, the weight has been reduced by almost 400 kg.

Increased path performance
IRB 6640 runs the second generation of TrueMove™ and QuickMove™. This gives the robot more accurate motions, which, in the end, means less time for programming as well as a better process result. This software also supervises internal robot loads, which means reduced risk of overload and longer robot lifetime.

Passive Safety Features
Passive Safety Features include load identification, movable mechanical stops, EPS (Electronic Positioning Switches) and a stiff steel structure.

IRB 6640ID – Internal dressing in the upper arm
This version has the process cabling for spot welding routed inside the upper arm. This gives a controlled motion with different benefits, such as predictable dress pack lifetime, longer dress pack lifetime and less spare part costs: a more compact robot when dressed and also a reliable simulation of dress pack motion.

Focusing on high production capacity, compact design, simple service and low maintenance cost, IRB 6640 is the perfect robot for various applications!
IRB 6640/ IRB 6640ID

**Specification**

<table>
<thead>
<tr>
<th>Robot versions</th>
<th>Reach</th>
<th>Handling capacity</th>
<th>Center of gravity</th>
<th>Wrist torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRB 6640-160</td>
<td>2.55 m</td>
<td>180 kg</td>
<td>300 mm</td>
<td>981 Nm</td>
</tr>
<tr>
<td>IRB 6640-205</td>
<td>2.55 m</td>
<td>205 kg</td>
<td>300 mm</td>
<td>1324 Nm</td>
</tr>
<tr>
<td>IRB 6640-206</td>
<td>2.75 m</td>
<td>205 kg</td>
<td>300 mm</td>
<td>1264 Nm</td>
</tr>
<tr>
<td>IRB 6640-185</td>
<td>2.8 m</td>
<td>185 kg</td>
<td>300 mm</td>
<td>1206 Nm</td>
</tr>
<tr>
<td>IRB 6640-130</td>
<td>3.2 m</td>
<td>130 kg</td>
<td>300 mm</td>
<td>1057 Nm</td>
</tr>
<tr>
<td>IRB 6640D-200</td>
<td>2.55 m</td>
<td>200 kg</td>
<td>300 mm</td>
<td>1262 Nm</td>
</tr>
<tr>
<td>IRB 6640D-170</td>
<td>2.75 m</td>
<td>170 kg</td>
<td>300 mm</td>
<td>1106 Nm</td>
</tr>
</tbody>
</table>

**Extra loads can be mounted on all variants.**

- 50 kg on upper arm (except ID) and 250 kg on frame of axis 1.

- 50 kg on upper arm (except ID) and 250 kg on frame of axis 1.

**Number of axes:** 6

**Protection:** Complete robot IP 67

**Mounting:** Floor mounted

**Performance**

- Positions repeatability: 0.07 mm

- Path repeatability: 0.7 mm

**Axis movements**

<table>
<thead>
<tr>
<th>Axis</th>
<th>Working range</th>
<th>Axis max speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+170° to -170°</td>
<td>240°/s</td>
</tr>
<tr>
<td>2</td>
<td>+85° to -85°</td>
<td>240°/s</td>
</tr>
<tr>
<td>3</td>
<td>+70° to -180°</td>
<td>240°/s</td>
</tr>
<tr>
<td>4</td>
<td>+130° to -90°</td>
<td>240°/s</td>
</tr>
<tr>
<td>5</td>
<td>+120° to -120°</td>
<td>240°/s</td>
</tr>
<tr>
<td>6</td>
<td>+90° to -90°</td>
<td>120°/s</td>
</tr>
</tbody>
</table>

**Physical**

- Dimensions robot base: 1107 x 720 mm
- Weight: 1310 - 1405 kg

**Environment**

- Ambient temperature for mechanical unit:
  - During operation: +5° C to +50° C (41° F to 122° F) *
  - During transportation and storage for short periods: -25° C to +65° C (13° F to 194° F) (max. 24 h) up to +70° C (158° F)

- Relative humidity: Max 95%

- Noise level: Max 71 dB (A)

- Safety: Double circuit with supervisor, emergency stops and safety functions, 3-position enable device

- Emission: EMC/EMI-shielded

- Options: Foundry Plus

- Clean Room, class 5 certified by IPA

- Data and dimensions may be changed without notice

**Working range**

<table>
<thead>
<tr>
<th>Model</th>
<th>Series</th>
<th>Model</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRB 6640-180</td>
<td>2/255</td>
<td>IRB 6640-205</td>
<td>2/75</td>
</tr>
<tr>
<td>IRB 6640-235</td>
<td>2/55</td>
<td>IRB 6640D-200</td>
<td>2/55</td>
</tr>
<tr>
<td>IRB 6640D-170</td>
<td>2/75</td>
<td>IRB 6640D-130</td>
<td>3/2</td>
</tr>
</tbody>
</table>

**Electrical Connections**

- Supply voltage: 210-600 V 50/60 Hz
- Power consumption: ISO-C6:2 2.7kW

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**Appendix C:4**