

## Highly Automated and Flexible Manufacturing of Frequency Converters

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Danfoss Drives A/S introduces its new series VLT® Automation Drive FC 300 produced on a highly automated and flexible manufacturing line with a genius logistic set-up and a capacity beyond 500,000 units annually. Danfoss Drives has set the trend in manufacturing individual customer specific VLT® Frequency Converters by means of a unique control software, driven directly from the customer order, entered on the Internet, with next day delivery.

### **A Mass Customisation plant**

We want to be respected by our customers and to serve them in the best possible way. We have seen that our customers have a variety of different needs that we want to meet in terms of products and services.

The logistic set-up must reflect this strategy. That is the reason why the numbers of different products and services have exploded over the last years, due to the highly mixed nature of the manufacturing environment. To serve our different customers within our core strategic business areas we need a highly flexible set-up to achieve our goals. Therefore Danfoss Drives A/S has developed the manufacturing plants into a Mass Customisation plant by combining Mass Production, Just-in-time and KanBan philosophies into a logistic set-up. This means that we are able to customize one single product in a mass-producing environment.

### **Leading manufacturing control software**

The fact that we have thousands different commercial combinations of the final FC 300 products resulted in a need to automate the manufacturing set-up by means of automatic generation of bills of material and the generation of insertion programmes on the odd form mounting machines. The customers fill in the type code through the Internet during the ordering process. The system checks if this variant has been produced before. If the Shop Floor system recognises the variant, the bill of material is retrieved from the Shop Floor system and the unit is produced with a specific manufacturing set-up. If the combination is not recognised by the system, the Shop Floor system generates a customer specific bill of material, generates the specific manufacturing set-up and then the unit is build and tested in less than 2 hours.

In the selection of machinery, none of the machine suppliers we asked had a system, which complied with our software requirements. This is the reason why we have developed such a system together with our machine provider and we believe that this is the first set-up with such advanced control software, and that Danfoss Drives A/S has set the trend.

### **Unique specified product with next day delivery**

By means of the integration of market driven product development based on a platform design philosophy and design manufacturing processes with market demands in mind, we have achieved a unique set-up allowing us to deliver exactly the unique specified product built to customer order, with next day delivery. With this set-up we deliver thousands of different code numbers - Just In Time.

When we designed the VLT® Automation Drive FC 300, with all the needs in mind, we saw a big need to use techniques such as “Design for Manufacturing” and “Design for Automation” in order to come up with a product series that cut costs and ensure high quality and was designed for rapid delivery. By having flexible modules that are produced in high volume, putting these modules together in different combinations gives all the scale advances in the whole supply chain. By combining these different modules and dedicating the product at a late stage in the value chain, gives all the advances from single unit manufacturing. Also the mechanical design is not only user-friendly but also designed with

automation in mind. An example of using DFA was to make sure that robots could assemble the unit. By having a well-prepared product it allows us to automate successive as our volume and market share grows.

## **Automation**

The evolution in producing frequency converters has been drastic in terms of degree of automation. In past year's manufacturing set-up, a lot of labour was involved through a lot of manual processes and lead-time was measured in days. Today our lead-time is measured in hours and labour cost is reduced dramatically.

The investment in machinery and knowledge of production processes have become core competences that need to be maintained and developed in every electronic manufacturing company. To have well trained engineers who are able to work integrated in the organisation is crucial to success in the automation world.

The process flow goes from high-speed fully automated mounting processes to highly automated mounting processes.

In our SMD mounting area we run batch sizes from a few pieces to several hundred pieces. The reason for batch production in this area is to achieve high efficiency and reduction of changeover time. The SMD mounting area has a variety of different PCB (Printed Circuit Board) boards, which can later be dedicated into other types. KanBan controls the number of batches and batch sizes electronically by means of an electronic Shop Floor System. This allows us to dedicate different PCBs into individual PCBs depending on the specific customer order. A customer order will then pull the specific boards and components and subsequently a VLT<sup>®</sup> frequency converter is built for the individual.

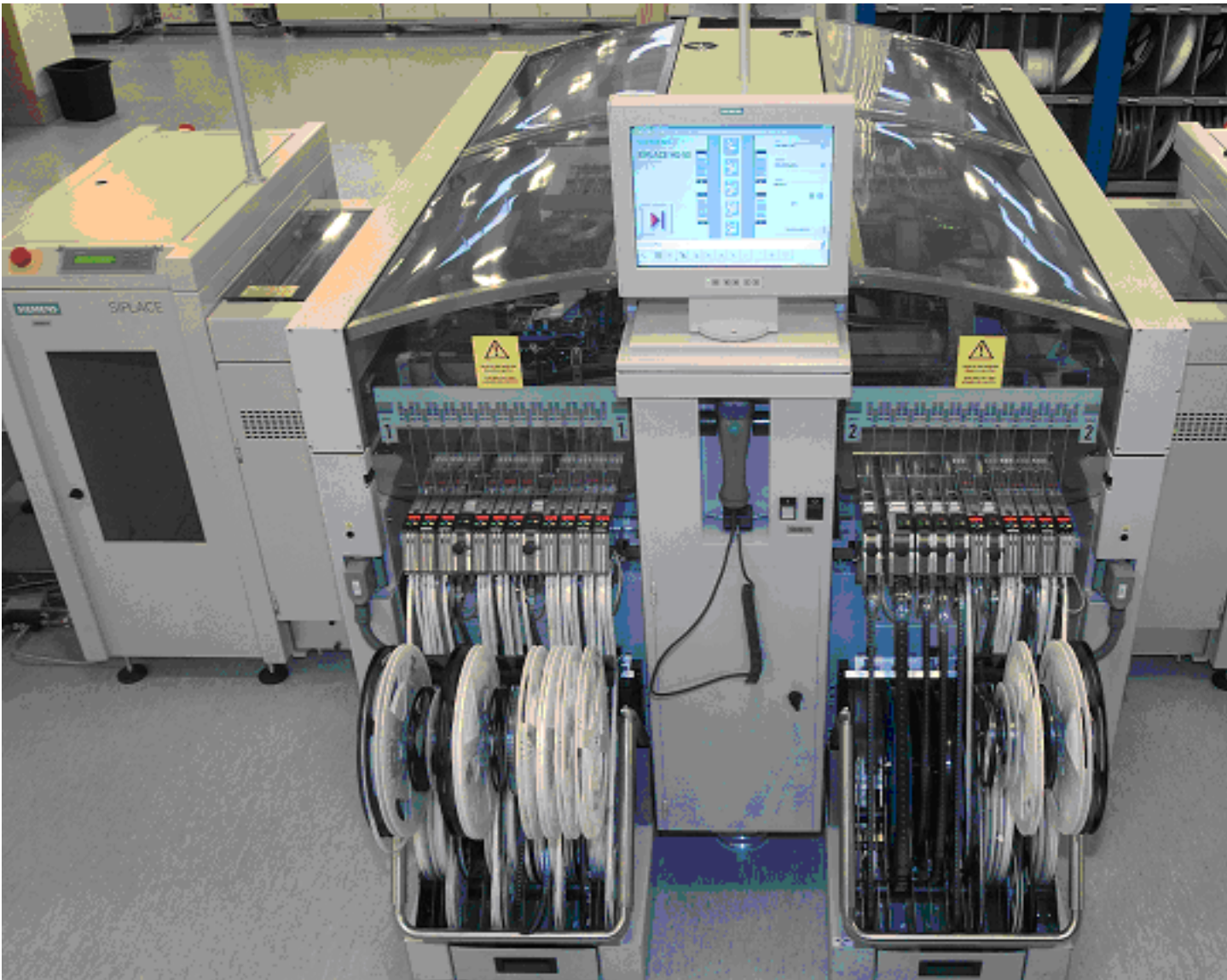
Process control is a highly integrated part of these processes right from the beginning throughout the lines in order to ensure a high quality, high yield and low rework cost. Statistically, process control is used to make sure that we have high-level soldering. To check the soldering process we use both vision technologies and electrical tests with flying probe devices.

By means of the integration of SMD mounting technology with high performance placement machines, we have achieved the automation of lead-mounted components directly at our SMD line; it is called "Pin In Paste" technology. By means of this technology we have ensured that the PCBs remain untouched until final assembly.

In the automation of electronic manufacturing the delivery of components from our supplier is crucial. The odd form mounting equipment is specifically designed to grab the odd form component. Therefore a high degree of cooperation with our supplier of components and the supplier of our machines is necessary in order to comply with the capability of the machinery.

## **Quality**

Product quality is a must and customers expect a correct product with long and hassle-free operation. A high degree of automation, automatic products and process inspection and solid test during the manufacturing process ensures a high quality product designed with quality in mind and designed to international standards. All process inspection is automatically performed in the field of vision and electrical and mechanical tests are made in order to secure uniformity and reduce labour cost in testing. All products leaving the factory are 100% full-scale tested under full load and temperature conditions.



*Components comes attached to tapes and are mounted on printed circuit boards by robots.*



*Danfoss Drives keeps no stock of frequency drive. Once the customer has specified his specific drive, elements are gathered for this specific drive. A manual containing relevant information in the relevant language is prepared along with the drive. The package is delivered within 24 hours.*