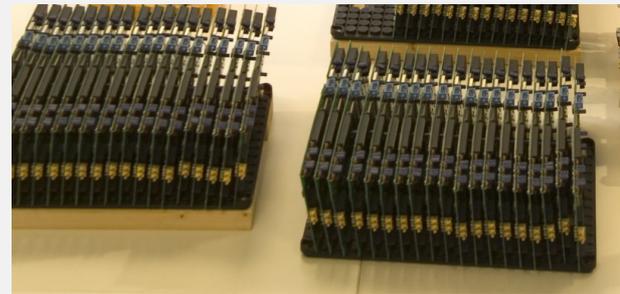


► **Production, Test, Calibration, Warranty and Maintenance Structure**

Build-to-Order

All products at Spectrum are BTO (build to order). All Spectrum products consist of a base module (M4i-PCIe, M2i-PCI, MX-PXI, ...) and one or two analogue modules plus some optional modules like star-hub. Analogue modules may differ in speed grades and the number of soldered channels. We stock these modules and typically have several hundred modules on our shelf.

If we get a request for delivery time or an order we first check whether we have all the necessary modules in stock. If yes, the production is placed in our BTO queue and the delivery time will be dependant on the other production requirements. The production process consists of the modules being assembled together, maybe some small soldering work (for any necessary changes) and then several hours of test, specification checking and calibration. The normal delivery time is one to two weeks. If there's an urgent delivery we can possibly put this at the beginning of the queue, depending on the promised delivery times of the other products already in production.



In the case where we don't have all needed modules in stock the delivery time will depend on the time it takes to produce the missing modules. This time may vary. Delivery times are then typically around six weeks. However, this time can be reduced if we have vision of a pending order. Again, in urgent cases, we can sometimes rework modules with different speed grades to generate the required modules. This will depend on the type of modules available and their suitability to be reworked.

In-house Testing

After production of the instrument an intense and defined test of the product is done. The test has two purposes:

- Check that all parts of the product are running and fully functional with all features of the card being tested against different limits.
- Check that the product reaches the stated quality as shown in the data sheet. Specifications are checked for each individual product that leaves our factory.

Spectrum makes a lot of effort to improve the quality of the products during development time, maintenance and production. Some of the steps taken by our in-house quality control team are listed below:



SPECTRUM Instrumentation GmbH

Ahrensfelder Weg 13-17 | 22927 Grosshansdorf / Germany
Geschäftsführerin: Gisela Hassler

Phone: +49 (0) 4102-6956-0 | Fax: +49 (0) 4102-6956-66
E-Mail: : info@spec.de | Internet: www.spec.de

UST-Ident-Nr. DE 811572240
St-Nr. 3029203525

HRB 444 AH
WEE-Reg.-Nr. DE 48577566

Sparkasse Holstein | BLZ 213 522 40 | Kto.: 900 646 44
SWIFT-BIC: NOLADE21HOL | IBAN: DE76 2135 2240 0090 0646 44

Dresdner Bank | BLZ: 200 800 00 | Kto.: 495 170 000
SWIFT-BIC: DRESDEF200 | IBAN: DE44 2008 0000 0495 1700 00

► Production, Test, Calibration, Warranty and Maintenance Structure

- Detailed test and calibration protocol for card production. Results are documented for every product that is delivered.
- Use of a semi-automated test procedure which stores test results in an in-house test data base for further checks and quality improvements.
- Use of automatic test routines that check technical figures.
- Documentation of all hardware and software changes and all versions that are delivered to customers. These changes are available online at our website for the customer as a revision history.
- Detailed service cards are maintained for every product that is delivered. These contain all versions, updates and upgrades and all return deliveries.
- Additional pre-delivery check by second person. This includes a detailed check protocol that is documented for every product that is delivered.

Calibration

All waveform digitizers and waveform generators are calibrated after they finish production and functionality testing. For calibration purposes Spectrum has a pool of different high-quality instruments that are annually calibrated by an accredited calibration laboratory following the guidelines of the manufacturer.

The calibration of the Spectrum products is done in-house by trained technicians following our internal quality control rules. Spectrum uses different self-made control software that automatically checks whether the hardware reaches the specified figures, without human errors.

Internal test and calibration protocols are archived in printed or electronic form. On special request Spectrum provides a calibration certificate for the delivered product. This certificate includes details of the instruments used for the calibration together with their serial number and last calibration date.

Spectrum checks the following parameters against the figures of the data sheet and certifies the calibration of these figures:

- DC error after calibration for every input channel and input range
- Gain error after calibration for every input channel and input range
- -3dB bandwidth for every input channel and input range
- RMS zero noise level for every input channel and input range
- Dynamic parameters SNR, THD, SFDR, ENOB as specified in data sheet
- Quartz clock accuracy
- Bus Transfer Speed (MByte/s)
- External Trigger Levels (Input and Output)

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► Production, Test, Calibration, Warranty and Maintenance Structure

Warranty + MTBF

The standard warranty of all our products is an industry-leading five years from the date of delivery. In that time all hardware failures that are not due to misuse by the user are repaired free of charge by Spectrum.

After the warranty period repairs are done based on a card check and quotation. Products are repaired as long as Spectrum is able to source all the needed parts. Based on our experience the service support time after the end-of-life of the product is in the region of 7 to 10 years.

MTBF figures are calculated from the returned and repaired products in relation to the delivered products average usage time. For new products the MTBF is not specified until a reasonable amount of repair returns have occurred.

Hardware and Software Maintenance

Driver updates are available for all customers free for the lifetime of the product. Firmware updates are also available for all customers providing the hardware hasn't changed between the firmware versions. All firmware and driver bugs that are reported are fixed within a short time and updates are available to the customer immediately. Firmware and driver bugs are corrected for all active products and for all products where a sale has been made within the last 5 years.

All key components are kept in stock for after sales repair issues. All product deliveries and all updates or upgrades, as well as the associated software versions, are detailed and documented. As product development and production is done in-house we're able to keep all the knowledge that is necessary to perform maintenance and service for many years.

All software development is also done in-house allowing us to keep the knowledge available at our facility. Software development follows detailed internal documentation rules that describe all key product parts and the relevant hardware interaction details.

Spectrum has dedicated software engineers that are focused on software and driver development. In addition, all our hardware engineers have good software knowledge and are able to do the maintenance of the drivers and kernel drivers. New engineers are trained from the very beginning of their work to gain a good knowledge of the driver structure as well.

By following this internal maintenance plan we're still able to maintain software drivers of ISA products that were released in 1991.

Spectrum has a lot of long-time employees with many of them working in the company for more than 15 years. Together with a very small employee fluctuation this guarantees that the technical know-how stays within the business. Also, the man power can then be focussed in development and support instead of doing training for new employees.

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