Fraunhofer

Our highlights at the Fraunhofer joint booth will offer you new technologies and solutions in the areas of

- Edge AI
- Sensor Technologies and Systems
- Efficient Sensor Communication
- Green ICT.

intelligent.efficient. connected

#WeKnowSolutions

Topics

Fraunhofer@ew24: efficient – intelligent – sustainable

Sensor Technologies and System Measurement, Efficient Sensor Communication, Edge AI, and Green ICT

In today's era where sustainability and efficiency are gaining increasing importance, embedded systems play a crucial role. Sensor systems are becoming increasingly smaller and more communicative. Artificial intelligence is no longer just a tool but an integral part of embedded systems, both within and on the edge of the application or cloud. From industrial automation to the Internet of Things to mobility applications, embedded systems are the architects of the connected industry.

Our interconnected sensor systems not only enable precise data capture and analysis but also seamless communication between various systems and devices. By integrating advanced sensor technologies and intelligent communication systems, we can optimize processes, save energy, and increase productivity. Furthermore, the use of artificial intelligence enables the development of autonomous systems capable of independently tackling complex tasks.

At the Fraunhofer Gesellschaft for Applied Research, current cutting-edge research on embedded systems converges with focuses such as artificial intelligence, networking technologies, sensor technology, and sustainable energy supply.

The current trends of embedded systems for industrial applications, from smart meters to the embedding of artificial intelligence on the edge of a system, to energy-autonomous sensor systems for a greener industry, can be found at our joint booth.

Eight Fraunhofer institutes will present their latest solutions on topics such as Sensor Technologies and System Measurement, Efficient Sensor Communication, Edge AI, and Green ICT. Here, you can experience applied research and technological solutions on embedded systems.

Visit us at the Fraunhofer joint booth number 422 in Hall 4 at embedded world 2024 in Nuremberg. We look forward to presenting our research to you!

Extreme Edge Computing: A New Era of Data Processing

In a world where more and more data is being generated, the question of how this data can be processed and analyzed in real time is becoming increasingly important. While edge computing is already pointing the way with its data processing close to the source, Extreme Edge Computing goes one step further: the inferences of neural networks are executed in a distributed manner and processed directly on the end devices.

Extreme Edge Computing will revolutionize the Internet of Things (IoT) in particular. This is precisely where the discrepancy between data volume and device capacity poses an enormous challenge: Neural networks are usually extremely large and contain billions of parameters – at the same time, the computing power and storage capacity of IoT devices such as intelligent sensors is limited.

This is exactly where Extreme Edge Computing comes in: Data is distributed decentrally and processed on multiple devices in an energy-efficient manner without having to transfer information to the cloud and store it there. Confidentiality, integrity of sensitive information and full control over your own data are thus maintained. At the same time, latency times are minimized, and real-time applications are made possible. The use of established wireless standards such as Bluetooth also offers the advantage that existing hardware can be used to set up the necessary ad hoc network.

However, it is not only the amount of data but also the mobility of many edge devices that pushes IoT networks to their limits. If one or more devices leave the network, it must be able to automatically adapt to the new circumstances. A highly dynamic network architecture is therefore the key to smooth data transmission.

Our novel concept solves these problems by distributing AI algorithms to multiple IoT devices within a wireless ad hoc network in a self-regulated manner. Even if individual devices fail or are not operational, the network remains stable as the tasks are redistributed by intelligent algorithms. The neural network is no longer executed on a single end device, but several devices work together cooperatively and automatically.

Extreme Edge Computing

A highly dynamic network architecture is the key to smooth data transmission.«

Felix Kreyß, Fraunhofer IIS

This paves the way for completely new application possibilities in the Internet of Things.

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Neural Architecture Search: The Link between Application and Hardware

There is a rising amount of data produced in the world. This increases the need for efficient processing to reduce the costs for energy and infrastructure. As a result, processing is moving towards the edge, where the data comes from. But processing data in the edge is not an easy task, so how do we create the link between application and hardware that scales with the demand?

A promising technology is machine learning, especially Deep Neural Networks (DNN). They are very flexible and can process a very broad range of inputs, such as images, videos, text, and speech.
But taking off-the-shelf DNNs and trying to put them on an embedded system often fails, since the models are too large if not designed specifically for the edge case. A recent and promising technique to find optimal DNNs automatically is Neural Architecture Search (NAS). NAS searches for a DNN structure, so that the DNN fits onto the hardware and meets the application goals.

At the Fraunhofer Institute for Industrial Mathematics ITWM, we are developing hardware-aware NAS. This type of search also considers the constraints from the hardware platform and finds optimized solutions. Users only provide the problem in the form of data and need little to no knowledge about DNN.
Since both the search and the training of the NAS are automatic, this represents a very scalable method of obtaining solutions for hardware fast.

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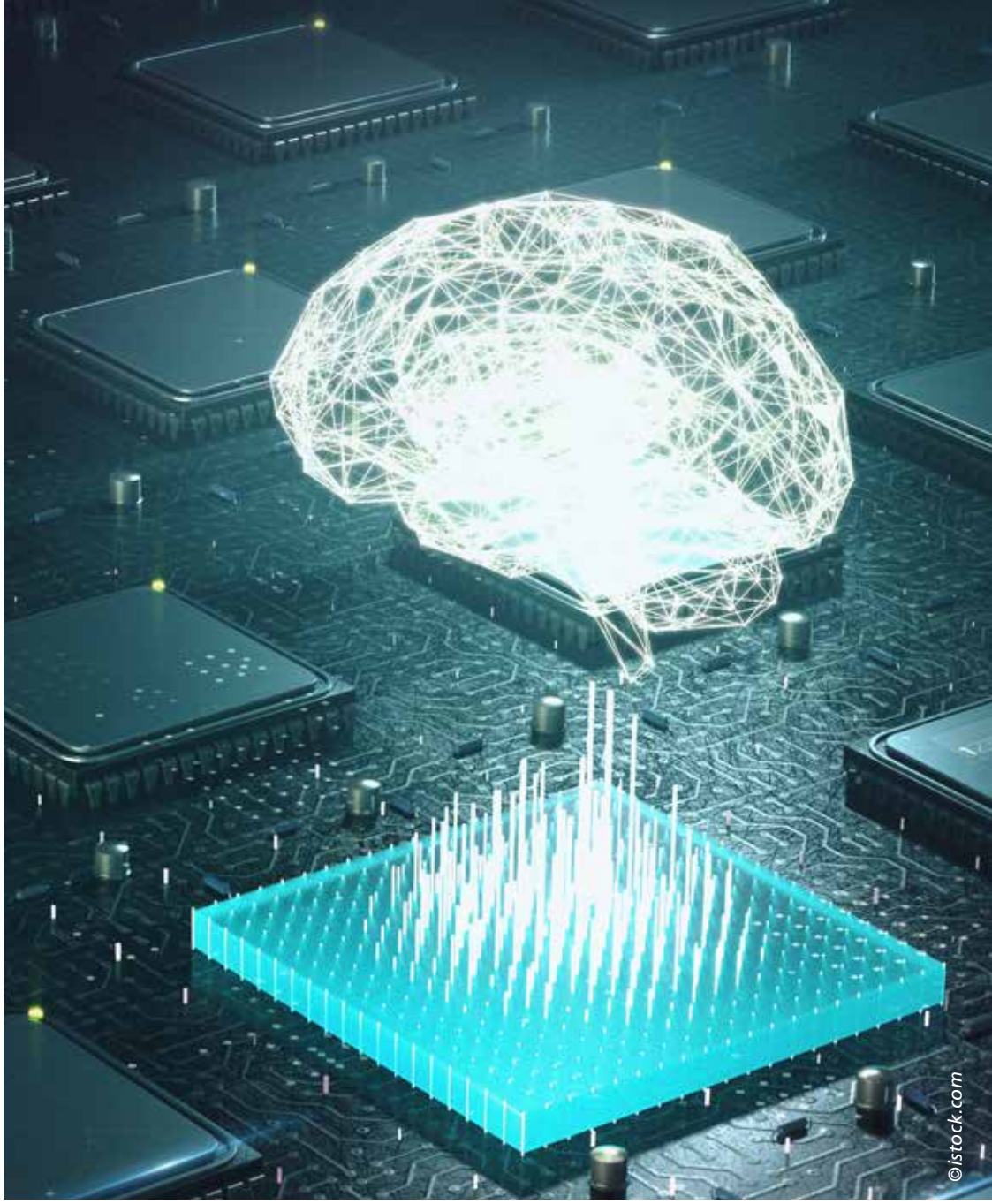

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With NASE Your AI Future Starts Today

Automated Deployment of AI on (Embedded) Hardware Using Neural Architecture Search

Step into the future of Artificial Intelligence with a groundbreaking innovation straight from the heart of Germany! A team of visionary scientists from the Fraunhofer Institute for Industrial Mathematics ITWM and the University of Kaiserslautern-Landau have clinched the prestigious »Energy-efficient AI systems« pilot innovation competition hosted by the German Federal Ministry of Education and Research (BMBF).

Introducing a masterclass in AI software and hardware synergy – a system crafted for excellence, capable of detecting atrial fibrillation in ECG data with jaw-dropping accuracy of at least 90 percent, all the while being the epitome of energy efficiency.

Software Precision with NASE (Neural Architecture Search Engine)

Maximize your AI potential and streamline your project pipeline with NASE – your Deep Neural Network Productivity Booster. Overwhelmed with AI initiatives and a shortage of experts? Dive into the future with confidence as NASE slashes the complexity and time needed to develop sophisticated DNN models from three months to just two weeks. Wondering if AI can give you that competitive edge? Let NASE, the DNN Product AI Enabler, be your guide. We don't just theorize, we analyze your products and processes in-depth, potentially saving you up to 84 percent in consultancy fees. NASE is tailored to your unique needs, whether that's accuracy, execution speed, energy efficiency, memory requirements, or beyond – transcending traditional hyperparameter optimization. Experience the Fraunhofer ITWM difference with NASE. It's not just a software framework, it's your strategic ally in the AI revolution.

Hardware Excellence with HiL (Hardware in the Loop)

Unlock the full potential of Deep Learning with HiL – the ultimate Deep Neural Network (DNN) Deployment and Benchmarking Tool, that transforms the complex process of deploying and testing DNN models from a daunting task into a streamlined, efficient operation. Imagine reducing the deployment time from months to mere days or hours, even for a seasoned expert. HiL makes this a reality by simplifying the deployment and benchmarking process, allowing you to bypass the steep learning curve of hardware intricacies, diverse operating systems, and complex toolchains.

Our innovative hardware zoo is your gateway to finding the perfect hardware match for your needs, considering critical factors like on-device latency, accuracy, and power consumption. Say goodbye to the financial burden of upfront hardware purchases and hello to boosted productivity and cost savings. HiL provides crystal-clear feedback on key deployment metrics such as latency, power usage, and any deployment errors, all in a format that is accessible and easy to comprehend, even for those without hardware expertise. Whether you're innovating in Embedded Systems, revolutionizing medical technology, pioneering IoT solutions, or leading the charge in Industry 4.0, HiL is your partner in achieving excellence in DNN deployment. Embrace the future of Deep Learning with HiL – where complexity meets simplicity and efficiency.

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Virtual Test Benches Validate ADAS Functions in Virtual Worlds

Testing driving functions requires thousands of kilometers of test drives after each software change. Virtual test benches enable virtual test drives when real test drives on this scale are not possible. Our toolbox FERAL enables technical coupling of different simulators and executable software components through virtual communication buses across different levels of abstraction to create executable virtual test scenarios.

Drive millions of virtual kilometers to test ADAS functions

Virtual test benches allow extensive testing at development time and thus early detection of faults in system and function design. This makes it possible to precisely analyze architectural design alternatives through simulation and virtualization of physical devices and functional behavior.

Inject faults to assess system resilience

Virtual test benches are used for virtual consolidation of functions on ECUs and for fault injection to detect system faults early and localize root causes faster. Additionally, they are used to investigate how your systems react to rare events such as faulty system components and unexpected inputs.

Deploy to realistic virtual platforms and networks

Tests run in a fully virtual setup. Expensive HiL tests can be replaced by virtual validation scenarios through the coupling of simulation models and tools. For that purpose, our **FERAL** toolbox integrates numerous aspects: E/E platforms, networks, driving functions, as well as driver, camera, and environment models. This allows your test team to test driving functions from home – without expensive and limited HiL testbeds.

Enable CI/CD for automotive function development

The integration of virtual test benches into your development and test processes enables continuous engineering for your vehicle functions. **FERAL** has a flexible interface to integrate virtual test benches into your CI/CD tool pipeline. This speeds up your development processes and shortens time to market.

Enable end-to-end continuous engineering for your vehicle functions and thus reduce time to market by integrating virtual test benches into your development and test processes.«

Dr. Thomas Bauer, Fraunhofer IESE

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JPEG XS Enable High-Resolution Video Transfer over IP With Ultra Low Latency

Many applications in the broadcast or automotive sector or in industrial applications call for an efficient way to transfer high-resolution video with almost no latency to guarantee an optimum processing and reaction time. Nevertheless, it should fit in nearly every programmable component e. g. a camera, an image processing board, an embedded computer or similar hardware. With the integration of JPEG XS – developed and designed even for these demands – there is a clever solution to boost your electronics, hardware or application to the next level.

More than one camera is already used in cars, industrial inspection systems or medical applications. Broadcast studios are using multiple upstream and downstream channels at the same time. And, ultra-low latency – below one frame – is what the industry calls for.

With the **Fraunhofer JPEG XS Software Development Kit SDK** there is a solution available on the market that can solve this problem.

The JPEG XS ISO standard was developed for high resolution video transfer over Internet Protocol of typical video formats in RGB, YCbCr color space or CFA Bayer. And it is optimized not only for natural content, but also for screen and mixed video content. Because of its special low complexity design it fits in almost any FPGA or ASIC hardware, CPU, GPU or graphic platform like Nvidia Jetson or ARM processors to guarantee the robust transfer of high-resolution video data.

The Fraunhofer JPEG XS SDK provides robustness because of its additional forward error correction and concealment. A predicitive and precise rate control supports RTP streaming (RFC 9134) for ST2110-22, and the MXF container format can store single track and multi-track essence (ST2124). A compression ratio of 2:1 up to 16:1 is possible along with the requirements of the application.

Easy to integrate via Application Support Package

The **Fraunhofer JPEG XS SDK** offers a free Application Support Package to guide and assist system integrators and developers with the fast and convenient implementation of JPEG XS applications into professional workflows and devices. Professionals can now speedup the process, profiting from subframe-latency, high error resilience and high-speed video transfer from standard to high-resolution displays.

Licensable solution

Fraunhofer offers licensing of SDKs and application support for different platforms on its own.

Together with industry partners FPGA IP-cores are available. And our partner Vectis provides as patent pool administrator all necessary patent licensing for the JPEG XS technology. This gives you everything you need for successfully integrating JPEG XS into your products.

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Robust and in Real-Time: mioty® for Bidirectional Long-Range Sensor Communication

In case of emergency, everything must happen quickly. A reliable warning in real-time can even save lives in extreme cases. The ETSI Standard based radio protocol mioty® from Fraunhofer IIS uses reliable bidirectional sensor communication to trigger an alarm chain in quasi-real time.

Robust communication thanks to Telegramsplitting

The radio protocol invented at Fraunhofer IIS **mioty®** has its robustness thanks to the innovative technology of Telegram splitting. With this Telegram Splitting Multiple Access method (TSMA), the data to be transmitted is split into small data packets and then transmitted on different frequencies and over time. An algorithm in the base station completes the received data packets back to the original information. The receiver only needs 50% of the data packets to complete the information again. This means that the impact of interference on the transmission is less than with other radio protocols functioning without telegram splitting.

New mioty® features at ew24

One out of many significant use cases showing new functionalities of **mioty®** will be demonstrated at embedded world 2024 in Nuremberg. Here we will show you how **mioty®** realizes an alarm chain in real-time. The alarm signal is triggered by an alarm button and transmitted to alarm lights with low latency and without any interference, thanks to the innovative telegram splitting method. The latest features of **mioty®** allow all actuators to be controlled via downlink or multicast in a group of actuators. With quasi-no latency for optimal control, it enables immediate downlink communication for fast activation. In case of emergency, the significant information will be transmitted reliably and without any time-delay, which can contribute to saving lives.

© Fraunhofer IIS

In critical situations, mioty® ensures fail-proof bidirectional sensor communication, enabling real-time alarm triggering, potentially saving lives.«

Ferdinand Kemeth, Fraunhofer IIS

For more information:

Facts and Data:

- More than one million devices per network
- More than 1.5 million messages per day
- Up to 5 kilometers distance
- Low power consumption of 17.8 µWh (end-point, 868 MHz) per message

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Self-powered Screw Monitoring System with AI Support Q-Bo®

Safety-critical screw connections on bridges or wind turbines must be regularly maintained to identify wear in time and prevent dangers. This maintenance is associated with high costs. Often, it is risky for workers to reach the screws. With the self-powered screw monitoring system Q-Bo®, condition monitoring is carried out specifically, wirelessly, energy-autonomously, and directly at the fastener without the need for modification to the screw itself.

Sensor directly on the screw

To check whether the screw is optimally and securely mounted and there is no loosening, **Q-Bo®** measures the preload force. A piezoresistive thin film layer as a sensor element on the washer changes its electrical resistance when the preload force of the screw connection changes. This change in resistance can be converted into a measurable voltage. The complete sensor system in the form of the piezoresistive thin film system, is integrated into the washer. The necessary electronics are fitted in an independent module that can be mounted above the screw head or in proximity. Thus, no modifications need to be made to the screw itself. Existing screw elements can be reused.

The measurement data are transmitted to a gateway via the Fraunhofer IIS LPWAN radio protocol mioty®. Transmission ranges of 5 to 15 km can thus be achieved. The gateway can receive and forward data from up to 100,000 screws.

Vibration data intelligently evaluated

Vibrations on a safety-critical screw connection can be an indicator of damage, wear or loss of preload force of the screw element. Such damage generates a high safety risk and can, for example, pose the danger of collapse on bridges or the failure of the system in wind turbines. Therefore, the acquisition and analysis of vibration spectra are important for estimating wear on mechanical systems.

The vibration data is measured using a three-axis acceleration sensor. Since here a large amount of data generated, wireless transmission means high energy demand. To save this energy for data transmission to a cloud, the data in the latest version of **Q-BO®** is analyzed directly on site at the sensor using artificial intelligence methods. For this purpose, we use a microcontroller with our edge technology, embeddif.[ai]. The edge application processes the data directly within the sensor, so that only anomalies are forwarded to the cloud.

Energy Harvesting makes it possible: Self-powered systems

The energy supply is autarkic thanks to Energy Harvesting, without the operator having to replace a battery. A kind of »power plant« is embedded inside the screw. This uses ambient energy to provide the supply power for the sensor, the AI application, and the radio module. For example, even the smallest temperature differences of 8 Kelvin can be used for the operation of the smart screw connection with the help of optimized voltage converters. Another option for powering the system is the energy conversion of solar power. In this case, a small solar panel is attached to the screw connection head. This is especially suitable for screws in locations with direct or indirect sunlight.

Q-Bo® in application

Q-Bo® is particularly suitable for safety- and function-critical screw connections on high-maintenance objects. These include bridges, for which permanent monitoring of the screw connection systems is essential.
In the case of the axels of freight trains, maintenance by on-site personnel is challenging because it must be done outside the normal operation. This also applies to the maintenance of wind turbines resulting in a high financial loss. By condition monitoring such systems with **Q-Bo®** save personnel, financial and ecological resources, and can guarantee a higher level of safety for the critical screw connections.

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Green ICT – Sustainable, Energy-Efficient and Modular Sensor Platforms

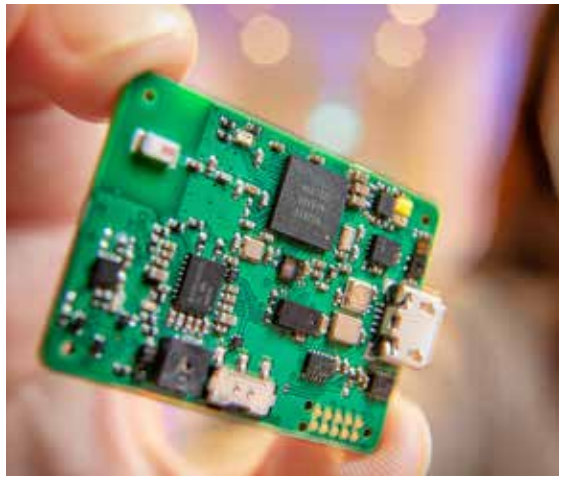
Energy efficiency and ecological hardware design plays a key role in the development and implementation of self-sufficient embedded systems, sensor nodes and networks for use in industry, monitoring of energy grids and infrastructures as well as in smart city applications.

The RF & Smart Sensor Systems (R3S) department at Fraunhofer IZM has developed two plug & play sensor platforms that can be used to quickly test and validate wireless and radar sensor concepts. Thanks to standardized interfaces and a simple, Lego-like process for configuring modules and assemblies, the time-consuming custom configuration of sensors and data evaluation is no longer necessary.

The **»SWARMY«** sensor-actuator platform enables modular sensor setups for a variety of common measured variables, including wireless interfaces, evaluation, and display. The platform is designed for industrial environments.

A universal radar platform for 24, 60 and 79 GHz applications is available for the efficient implementation of radar projects. Ranges from 0.1 to 260 meters and angular resolutions of less than 10° are possible.

Fraunhofer IZM is part of the »Green ICT@FMD« competence center. Together with the project partners, we are evaluating sustainability aspects of electronic products and ICT infrastructures in the BMBF-funded project.



The modular platform Swarmy-V2 acquires sensor data and can adjust its orientation flexibly
© Fraunhofer IZM/ Volker Mai

The camera radar module in its housing
© Fraunhofer IZM/ Volker Mai

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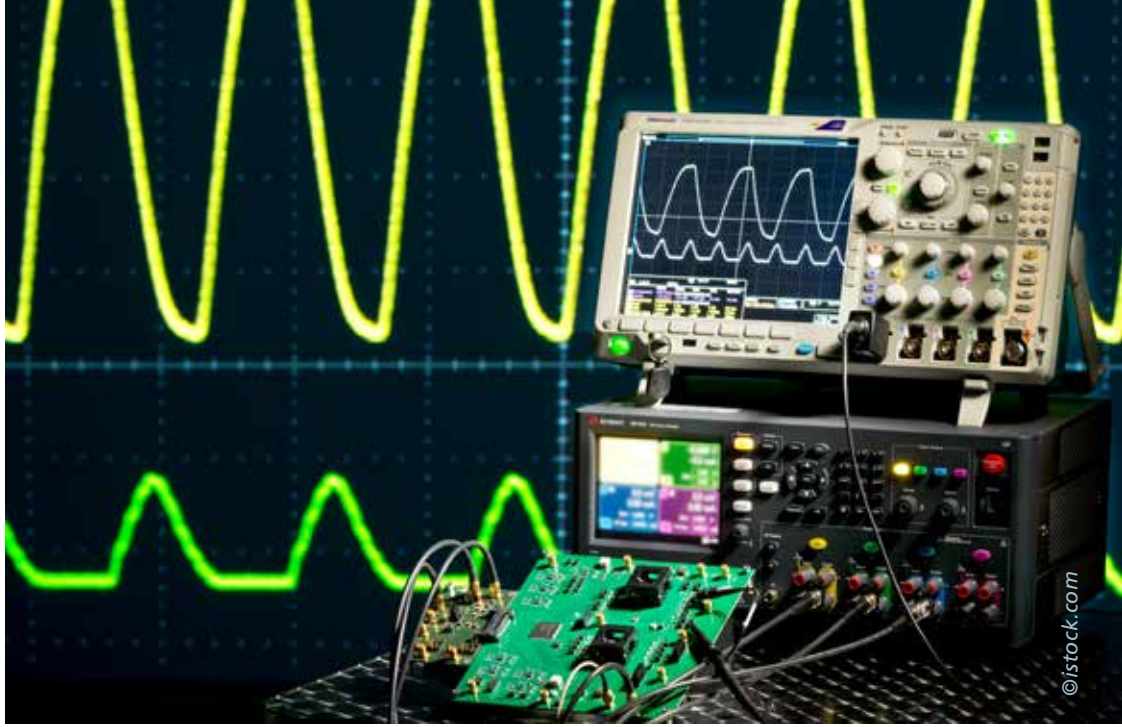
Development of HV-ASICs for the Integration of PMUTs and CMUTs for Advanced Ultrasonic Applications

Piezoelectric or capacitive MEMS sensors and actuators are used in various applications. The Fraunhofer EMFT Circuit Design Group designs HV ASICs for various MEMS sensors and actuators. Reference projects include HV driver ASICs for micropumps, HV transceiver ASICs for ultrasonic transducers and an energy-efficient readout ASIC for particle sensors.

Ultrasound is an established powerful tool for imaging applications. In recent years, however, capacitive micromachined ultrasonic transducers (CMUTs) have opened up completely new possibilities. They offer improved miniaturization, high frequency operation and level of integration with interface electronics. This has opened up a variety of new application areas, including medical imaging, non-destructive evaluation, robotics, consumer applications and automotive.

To take advantage of the unique benefits of CMUTs, Fraunhofer EMFT is working on an application-specific integrated circuit (ASIC) for the interface transceiver. This ASIC is characterized by low power consumption and area efficiency. It enables the assembly of a multi-channel ASIC with integrated high-voltage driver circuits and low-noise preamplifiers for various applications with a 2D array of CMUTs. This also facilitates the integration of sensor electronics into small systems.

An innovative approach developed at the Fraunhofer EMFT eliminates the need for external components to preload the CMUTs. This is achieved using a two-pulse scheme. This also eliminates the need for bulky high-voltage isolators in the receive path, which improves the noise performance of the preamplifier. Energy saving design techniques ensure that no static power is consumed by the high voltage supplies, keeping power consumption and heating within safe limits. An on-chip high voltage linear regulator provides all the high voltage bias required, while the system can be configured via a standard SPI serial communication protocol. A programmable clock divider enables the connection of CMUTs with different resonant frequencies from a single external clock source.



Chip design measuring environment for ultrasonic multi-channel system

The researchers plan to further integrate functional blocks for beam steering and signal processing and to evaluate other types of MUTs such as PMUTs. A test and evaluation platform for the overall characterization of the ultrasound platform is also under development.

These developments show the trend towards the integration of CMUTs and the development of HV-ASICs for advanced ultrasonic applications. They enable improved performance, miniaturization and efficiency in a wide range of applications.

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Chiplet Center of Excellence (CCoE)

Chiplets represent one of the most fundamental disruptions since the start of Moore's Law. The potential of this approach has been recognized for many years. However, due to the challenges of transforming supply chains, design and manufacturing processes, for example, it has so far only been used in isolated cases. To enable widely usable chiplet solutions, Fraunhofer is establishing the Chiplet Center of Excellence (CCoE).

As an initiative of three Fraunhofer microelectronics institutes, the CCoE addresses numerous practical questions on the future development of chiplet technology in Europe. Working in a consortium of industry and research under the coordination of Fraunhofer IIS/EAS, the center will seek to make chiplet technology as usable as possible for European industry.

The common work will focus on strong European industrial sectors and will support competitiveness and technological sovereignty. The close, interdisciplinary collaboration will, among other things, establish guidelines for a development, production and testing methodology for chiplets.

The Center aims at creating a suitable chiplet development methodology. This goal is supplemented by recommendations to shape a multi-vendor chiplet ecosystem. To support the success of this results in industrial practice, the methodological approaches are to be incorporated into standards.

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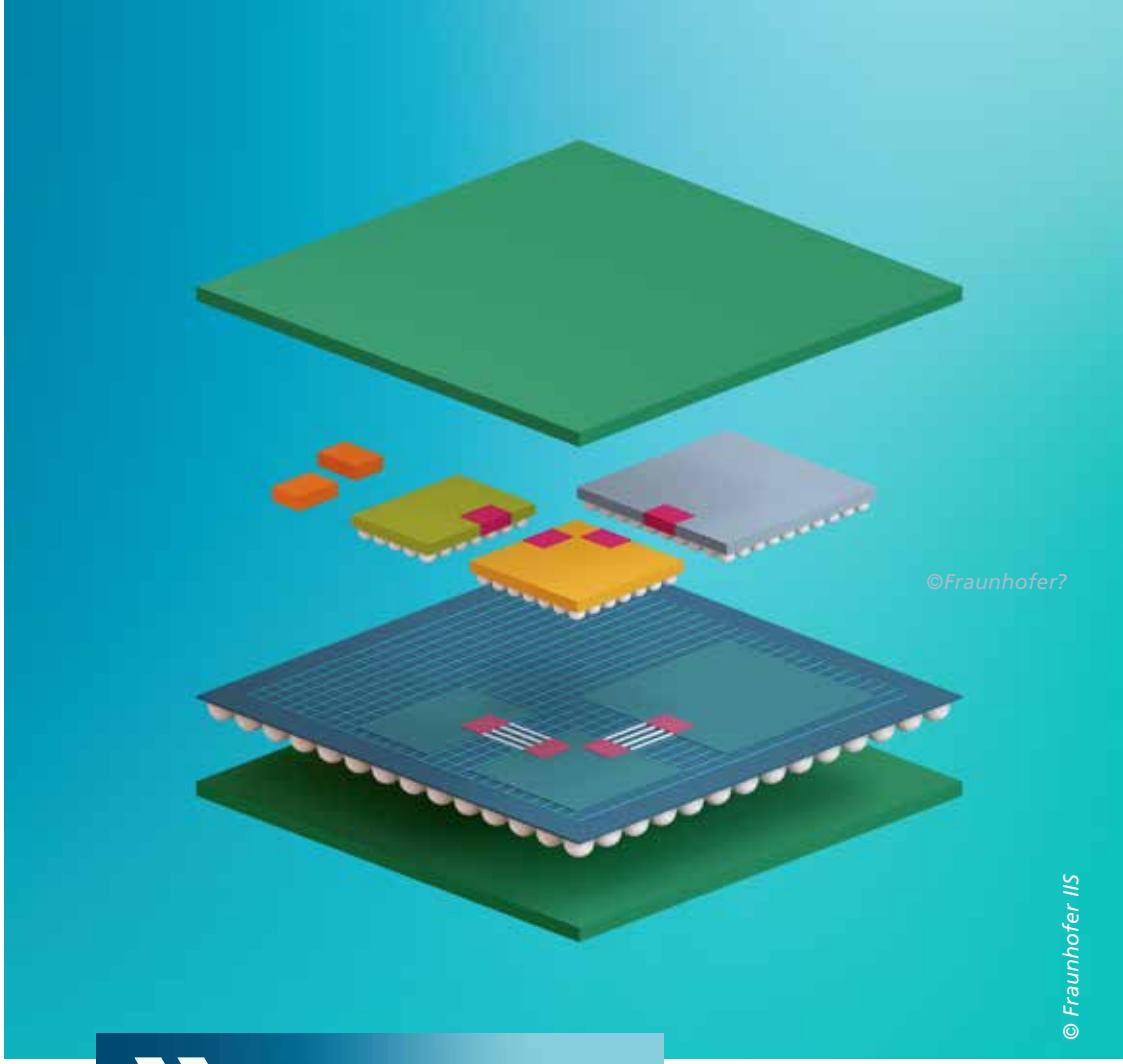
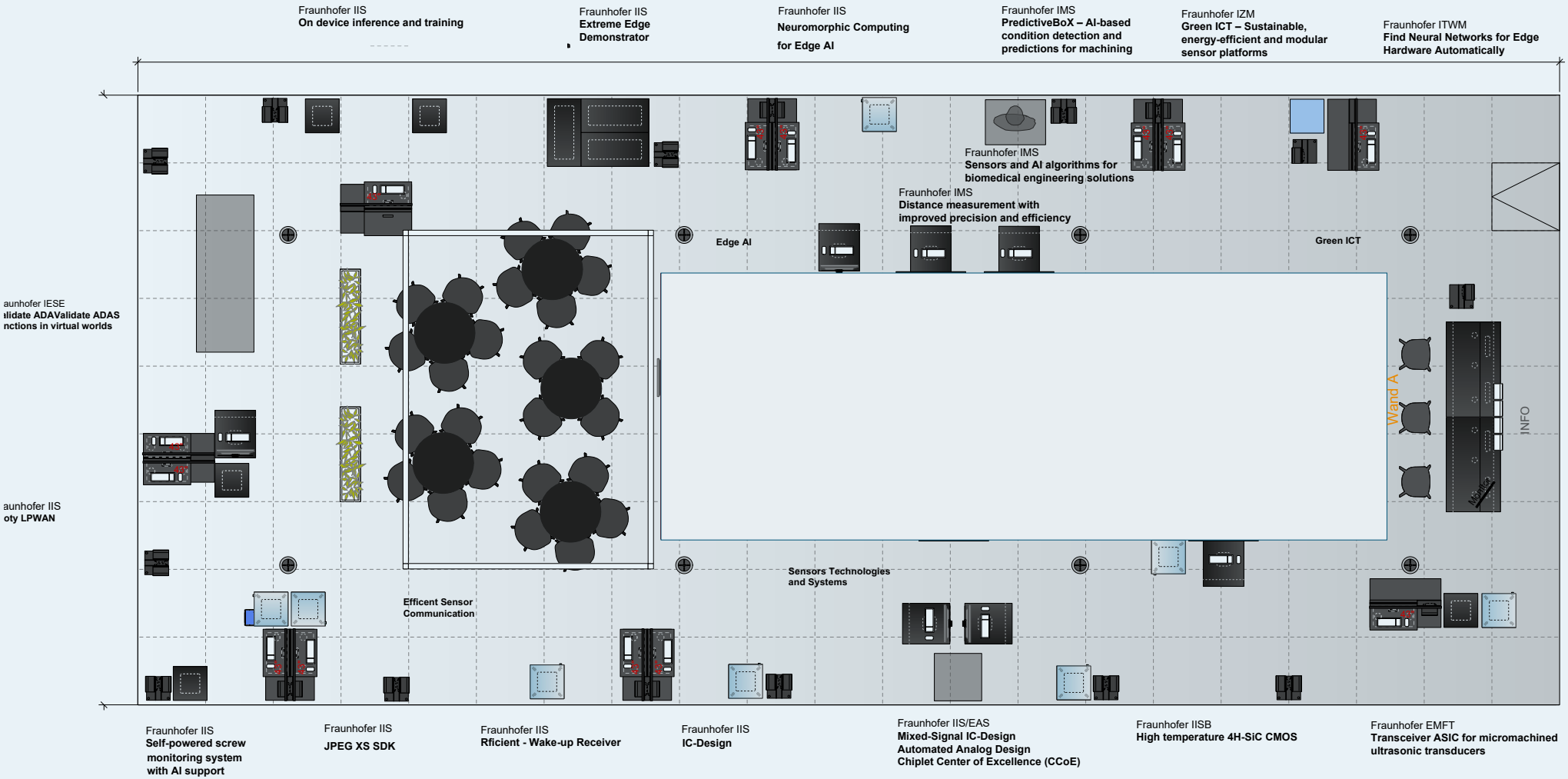


Chiplets represent one of the most fundamental disruptions since the start of Moore's Law.«

Andy Heinig, Fraunhofer IIS

Fraunhofer Booth Hall 4-422



The Fraunhofer Institutes demonstrate their latest developments, licensable solutions and technologies in the areas of edge AI, Green ICT, efficient sensor communication and sensor technologies and systems.

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Fraunhofer IESE
Institute für Experimental Software Engineering, Kaiserslautern

Fraunhofer IIS
Institute for Integrated Circuits, Erlangen/Nuremberg

Fraunhofer IISB
Institute for Integrated Circuits and Device Technology, Erlangen

Fraunhofer IIS
Division Engineering for Adaptive Systems EAS, Dresden

Fraunhofer IMS
Institute for Microelectronic Circuits and Systems, Duisburg

Fraunhofer IZM
Institute for Reliability and Microintegration, Berlin

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