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Energy-Efficient Solutions for Wearables and IoT Edge Nodes

How to approach challenges in terms of performance- and energy-efficiency while designing IoT applications by utilizing synergies within a single product portfolio.

The Importance of FPGAs for HPC

The MANGO project mixes high-end CPUs, GPUs and FPGAs to meet challengic application needs. **Page 16**

MMI in virtual and augmented reality

The latest VR- and AR-systems track movement to offer intuitive ways to interact with machines. **Page 26**

Interconnects and the Need for Speed

The need to transit more data at higher speed is changing modern system design. **Page 34**

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CONTENT

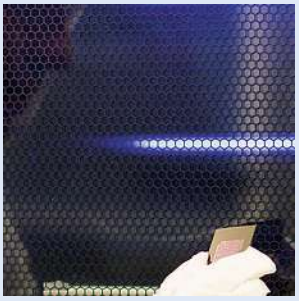
INTERNET OF THINGS

Energy-Efficient Solutions for Wearables and IoT Edge Nodes

The special aspects of IoT applications or remote installation sites often make it impossible to reach edge nodes with a cable. Thus the vast majority of things communicates by radio and are not connected to a centralized power grid. When it comes to the power supply, IoT applications are largely dependent on batteries, rechargeable power packs and energy harvesting. In order to be successful over the long term, the energy efficiency of IoT applications needs to be a main focus.

9

TOPICS



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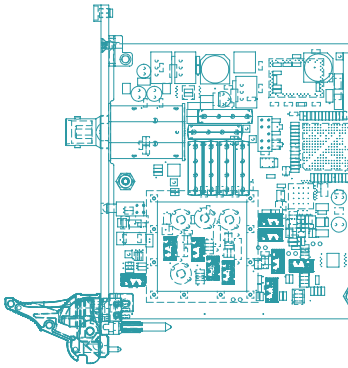

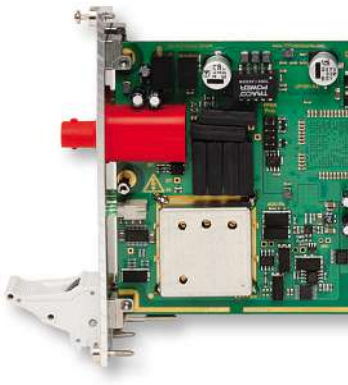

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TITELSTORY

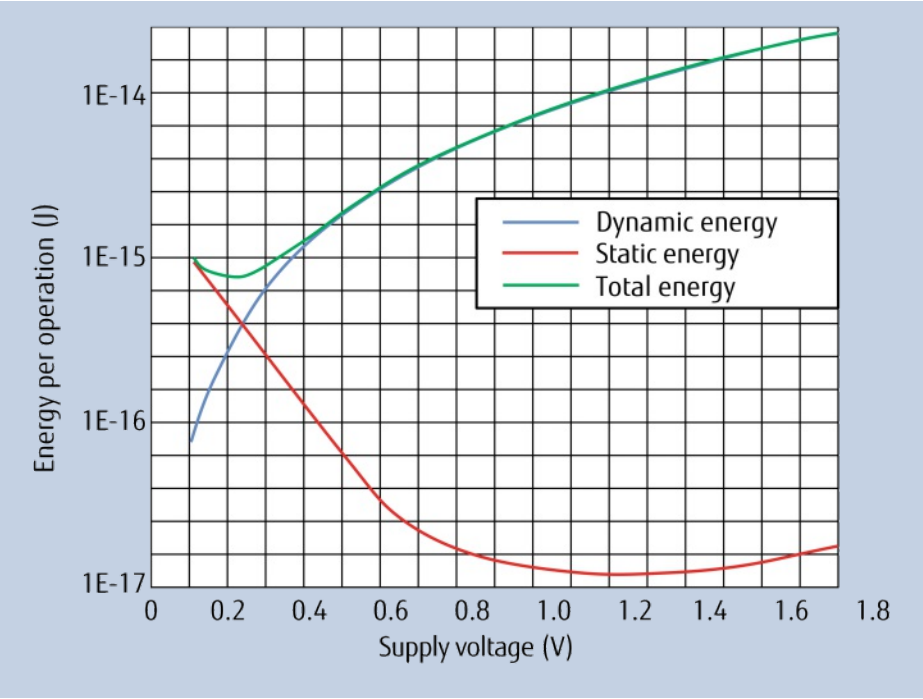
The special aspects of IoT applications or remote installation sites often make it impossible to reach edge nodes with a cable. Thus the vast majority of things communicates by radio and are not connected to a centralized power grid. The same applies for wearables. When it comes to the power supply, IoT applications are largely dependent on batteries, rechargeable power packs and energy harvesting. Energy's a scarce and valuable commodity with the Internet of Things. Nevertheless, all of these technologies have certain limitations. In order to be successful in this market segment over the long term, the energy efficiency of IoT applications needs to be a main focus.

Energy-Efficient Solutions for Wearables and IoT Edge Nodes

How to approach challenges in terms of performance- and energy-efficiency while designing IoT applications by utilizing synergies within a single product portfolio.

DR. KLAUS-PETER DYCK *

The Internet of things is mostly wireless – cables are hardly ever used in the IoT. The special aspects of the applications or remote installation sites often make it impossible to reach edge nodes with a cable. Therefore, the vast majority of things communicates by radio and is not connected to a centralized power grid. The same applies for wearables. IoT applications are therefore largely dependent on batteries, rechargeable power packs and energy harvesting. However, all of these technologies have certain limitations. For instance, only relatively small energy can be generated by using energy harvesting. Battery and rechargeable power pack-operated devices, on the other hand, incur high maintenance costs since they must be regularly provided with new power storage units or be connected to the charging station. Energy is thus a scarce and valuable commodity with the Internet of Things. Therefore, in order to be successful in this market segment over the long term, the energy efficiency of your applications needs to be a main focus.



Credits: Fujitsu Electronics Europe

Figure 1: *Energy consumption per operation above supply voltage range*

Advantages of near-/sub-threshold technologies

An analysis of the leakage currents in a CMOS IC shows that the optimal voltage range is between 0.4 and 0.5 volts for applications that are considered to be particularly energy-saving. This area is commonly referred to as near- or sub-threshold and plays an important role in the IoT. A basic representation of standard technologies is shown here in figure 1. This clearly shows that leakage currents dominate power consumption starting with a process-dependent threshold.

*** Dr. Klaus-Peter Dyck**
... is Senior Manager Marketing & Application at Fujitsu Electronics Europe.

Fujitsu Electronics Europe (FEEU) is the distribution partner for the Deeply Depleted Channel Technology (DDC) from Mie Fujitsu Semiconductor (MIFS) and offers its customers the chance to realize applications in the low voltage range. Extremely energy-efficient near-/sub-threshold devices can be implemented by using a foundry model. The solutions that MIFS offers are intended for the 55nm and 40nm technologies because mask costs are comparatively low in this range.

The advantages low-voltage technologies have to offer for IoT are obvious. Whereas in most applications a constant increase in performance is the main goal, the IoT often only seeks to carry out certain measurements and then make this data available either on demand or at certain time intervals. The frequency of measurement data recording is often in the range of a few seconds. Therefore, speed is of secondary importance in most cases. This results in the breakdown of the building block shown in figure 2. The left side is permanently operated with the lowest power consumption. Processing and transmission of the data takes place only at certain intervals, which is why the right side can be operated dynamically.

The challenges for the low-voltage range

Working in the low-voltage range comes with a number of challenges. To start with, neither the typical transistor models nor the logic libraries are suited for use in near-/sub-threshold applications. Also, SRAMs no lon-

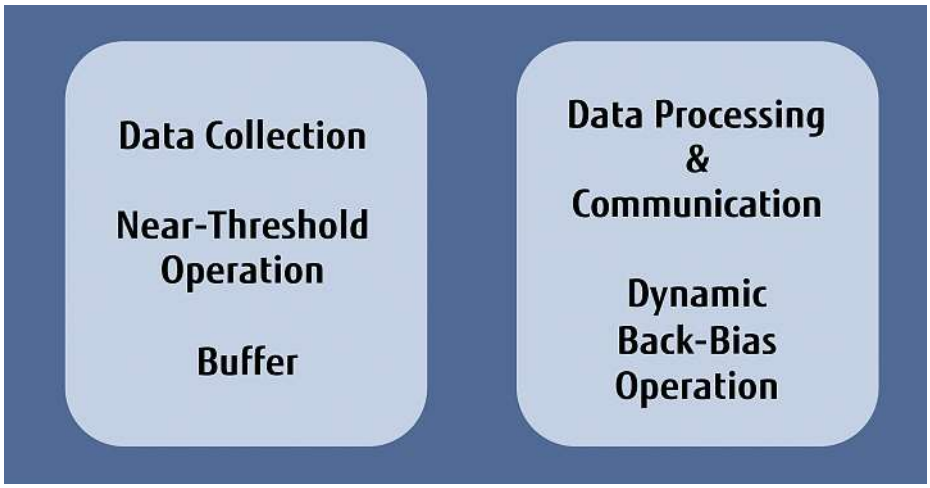


Figure 2: *Depiction of the principle of separating functions*

ger function reliably within this range, which makes temporarily storing the collected data practically impossible. The transistor itself, which has been optimized for 0.9 V operation, does not provide optimal results either. The transistor parameters are generally controlled only at rated voltage in subsequent series production.

MIFS addresses these challenges in three ways. First, they offer a transistor as well as the respective simulation models that are specifically designed for the ultra-low voltage range. Second, a logic library and memory compiler designed for low voltage were developed in cooperation with the Swiss research center CSEM. Third, MIFS monitors transistor parameters in production all the way into the sub-threshold region.

The DDC technology referred to earlier offers other advantages as well. In comparison with standard technologies, it shows much lower variance in the transistor parameters and stabilizes the SRAM memory content in the desired voltage range. Its unique advantage is its back-bias sensitivity, however: it allows for the characteristics of the logic to be influenced or modulated by applying a substrate voltage. Unlike DDC technology, in modern standard technologies, such influencing is only possible to a very limited extent. The DDC technology offers the option of carrying out this type of modulation either statically or dynamically. With static implementation, this procedure can be compared with the trimming of discrete circuits. In the dynamic case, circuit parts can be modulated depending on the current performance requirements of the application and thus has a positive effect on the leakage currents and therefore the energy balance. MIFS also offers the appropriate function blocks because the circuitry this requires is quite complex.

Creating synergies within the portfolio

As of just recently, FEEU also offers MCUs and RTCs from the American manufacturer Ambiq Micro. These products are of particular interest for customers who are not in a position to perform their own chip development. The two products also take advantage of the energy efficiency in the near-threshold region to significantly undercut the power of typical MCUs. An ARM Cortex M4F forms the processor core of the MCUs whose power is even lower than that of the Cortex M0+. The standard interfaces of the Apollo MCUs Ambiq Micro offers include not only a 13-channel ADC, but also configurable GPIOs that can be used to implement I2C and SPI interfaces, for example. A maximum of 512 KB Flash and 64 KB RAM are available as memory. The Apollo MCUs are available in two different packages: Either in a 2.49 x 2.90 mm 41-pin CSP with 27 GPIOs or in a 4.5 x 4.5 mm 64-pin BGA with 50 GPIOs in total. The RTC built into the MCU is also available as an individual component. An RTC version with an integrated power management unit is also available for users, who are unable to switch their current MCU. Such a solution is particularly well suited in cases where the data only needs to be recorded in relatively long intervals. In such applications, power consumption can be reduced to a minimum in periods of inactivity, thanks to the efficient RTC.

FEEU's portfolio includes a number of other components that are particularly well suited for wearables and IoT Edge Nodes. FRAMs, which represent an excellent solution due to their low power consumption during write access compared to other nonvolatile memories, are a good example. There are also various standard components such as quartzes and chip resistors starting at a size of 0.4 x 0.2 mm that are quite helpful in developing compact solutions.

All of the semiconductor components referred to above are also available as wafers, in other words without packages. Together with its partners, FEEU thus also offers the components in a System-in-Package (SiP). The components must not necessarily come from the FEEU portfolio or be available as chips, especially because a combination of chips and packaged components is also possible. This offers a number of advantages for customers, such as the compact design of the solutions and the increased difficulty of copying a product. In addition, SiP solutions such as standard BGAs can be processed. This means that a customer can adjust the contact distance to the possibilities of his own production, for example, while FEEU and its partners can take care of the very fine structures on the package substrate and deal with the sensitive chips.

Energy efficiency in the Internet of Things

Because most edge nodes and wearables must function wirelessly, and replacing the batteries and rechargeable power packs incurs either high maintenance costs or is problematic for end users, energy efficiency is extremely important to the IoT. Near-/sub-threshold technologies are therefore indispensable. Exhausting their potential requires not only the right components, but also a high level of technical understanding, however. FEEU provides both: their experts offer customers high-quality components that are selected based on a "best-in-class" principle and enrich projects with their expertise, ideas and 35 years of market experience. This accelerates the development of innovative IoT applications. // **SG**

„The advantages that low-voltage technologies have to offer for the Internet of Things are rather obvious. But working in the low-voltage range comes with a number of challenges."

Dr. Klaus-Peter Dyck, Fujitsu Electronics Europe

Fujitsu Electronics Europe

INTERVIEW WITH AXEL TRIPKEWITZ

Axel Tripkewitz: *The Managing Director of Fujitsu Electronics Europe GmbH, talks about the successes in recent months and the company's future strategy in an interview,*

"Accelerating innovation is our core objective"

Fujitsu Electronics Europe (FEEU) has acted as a global value added distribution partner since the beginning of the year. How successful have you been in entering this market?

The response has exceeded all expectations. As a global value added distribution partner, we have pursued the goal from the very start of providing our customers not only with products and services, but also supporting them with expertise and new ideas in all stages of a project, from their early plans to the start of production and smooth delivery. These qualities are currently in high demand because many industries are undergoing a process of technological transformation. We were also able to constantly expand our product portfolio in recent months. This means our customers get everything from a single source, instead of having to negotiate with numerous suppliers at the same time.

How does the goal you just mentioned affect what you experience in practice? Where do you create added value?

Our core purpose is to accelerate innovation through smart sourcing and by delivering the appropriate technologies. We offer our customers a global gateway to the best products and services available and the proven Fujitsu supply chain ensures reliable and the fastest possible availability. In addition, our experts have a deep understanding of the markets and technologies they specialize in. Therefore, we can provide our customers with solutions that best meet their needs and fit together seamlessly.

How do you feel the distribution market will change in the years to come?

The products and components are becoming increasingly complex, development times ever shorter and expectations of the products continue to rise. Companies that want to continue to compete need a strong partner who is close to the vendor and has the necessary market expertise. This is where FEEU comes into play: we can fully exploit our qualities in this area. We deliberately do not act as broad liners, but concentrate on a few high-quality vendors and products because we want to offer only the best solutions.

Where do you currently see the greatest innovation progress?

The world is networking more and more rapidly; under the heading IoT, we see innovation progress in almost all aspects of everyday life, such as in the areas of connected cars, Industry 4.0 and the fields of wellness and health, which are increasingly growing together. The days when smartphones were the only networked devices are over: fitness trackers, smart watches, medical wearables and many other devices are gradually moving into the everyday domain. We contribute directly to the progress that is being made in these areas by providing energy-efficient components.

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