SOM Selection Guide - a guide for the selection of the perfect formfactor

Individual, manufacturer-specific or industry standard? When selecting the form factor for System on Modules, there are three options with their respective strengths and weaknesses. This article helps to select the form factor for the next embedded project. By Andreas Geisreiter

A System on Module (SoM) is an embedded computer module, often also referred to as a Computer on Module (CoM). It is soldered or plugged onto a carrier board. All relevant functions or functional units are located on the module. For example, processor and graphics unit, working (DRAM) and program memory (NOR, NAND, eMMC), clock and energy management as well as numerous communication interfaces such as Ethernet, WiFi, Bluetooth, USB or I2C. A SoM encapsulates the essential parts of an embedded computer and, unlike a single board computer (SBC), is not a ready-to-use system. The components that are missing for this purpose, such as power supply or connectors, must be accommodated on the SoM carrier board.

Why are System on Modules so popular?
With the advancing digitalization and the increasing demand for ever more powerful as well as smaller embedded computers, the complexity of the systems is rapidly increasing. In order to simplify the development of SoMs for the user, semiconductor manufacturers are integrating more and more functions into their System on Chips (SoCs). For this reason, manufacturers of SoMs are challenged to accommodate the critical high-speed components as well as the large number of interconnections in the smallest possible space and to produce computer modules in high quality and quantity. In summary, the use of System on Modules accelerates product introduction, saving time and costs. In addition, SoMs allow developers the flexibility they need in product design. System on Modules offer many advantages and allow a high degree of freedom in development. At the same time, their use always raises the same question: Which SoM form factor is the right one for the application in question? There is no one-size-fits-all answer to this question, but a series of questions can help to make the selection easier. To do this, however, one

should know the three basic options for SoM form factors: individual, manufacturer-specific and industry standard.

Overview of the advantages and disadvantages of the individual options for SoM standards

1) Individual formfactor

- Normally all SoC functions are available (++)
- No additional costs due to lack of compatibility (++)
- Easy handling for developers: They can concentrate on SoC functions during SoM design (++)
- Not interchangeable. No second source (--)

2) Manufacturer-specific formfactor

- Not all SoC features are available due to the family concept (--).
- Additional costs due to lack of compatibility (-)
- Short learning curve for new SoM designs if the manufacturer standard is known (+)
- Interchangeable with other SoMs from the same manufacturer (+)
- Manufacturer standard is only available from a single manufacturer (-)

3) Industry standard

- Not all SoC features are available due to the family concept (--)
- Often high additional costs due to lack of compatibility (--)
- Very short learning curve for new SoM designs if the standard is known (+)
- Interchangeable with SoMs from any manufacturer (++)

As a specialist for individual embedded applications, DH electronics offers SoMs with individual or manufacturer-specific form factor with SODIMM socket. Industry standards in the embedded market include, for example, the form factors of the Standardization Group for Embedded Technologies (SGET) such as SMARC or Open Standard Module (OSM). The form factor should be selected based on the product-specific requirements, with each option having its advantages and disadvantages. For this reason, the selection of the SoM form factor plays an essential role - developers should therefore definitely make it at the beginning of a project. This is

helped by a series of questions relating either to the SoM category and form factor in general, or to the specific SoM vendor.

Questions about the SoM category and the form factor

1. Do I need special features of the selected SoC that certain standards may not offer? For example: Cortex-M co-processor, neural processing unit (NPU), analog-to-digital converter, timer outputs.
2. Which special functions or interfaces are required? For example: LVDS display, Dual Ethernet, CAN, RGB, WiFi/Bluetooth, PCIe
3. What quantities are to be produced?
4. Is a second source necessary to procure the system on module?
5. Should the SoM later be replaceable by a more powerful computer module?
6. What is the installation situation and space conditions? For example: How much space is available for the SoM? How is the SoM installed? Is it to be fixed and if so, how? Is fully automated production desired? Should the computer module be pluggable or solderable?
7. Is the CPU to be cooled - and if so: What possibilities are there for this with the selected SoM?
8. Is there already a concept for the power supply of the SoM?
9. Are power saving modes provided? If so, are they supported and what minimum values are achievable?
10. Is the flash memory located on the SoM or is it to be connected on the mainboard?
11. What processor or Graphics Processing Unit (GPU) power is required?

The questions on the SoM category often point to hidden costs in the case of industry standard-based SoMs. However, an industry standard should not be viewed negatively in principle, but developers should carefully weigh up the advantages and disadvantages.

Questions about the SoM manufacturer

Furthermore, a number of manufacturer-related questions help to select the right SoM form factor. For example, the following questions can be helpful:

1. Are customized variants of the SoM available?
2. Can the SoM be replaced with the same SoM with larger DDR or flash memory at a later date - without the need for a complete redesign?

3. What is the bandwidth of the DDR memory (12, 32, 64 bits)?
4. How long is the module available (5, 10 or 15 years)?
5. How does the manufacturer handle Product Change Notifications (PCN) or End of Life (EOL) notifications?
6. What operating systems does the SoM vendor support?
7. What boot loader does the SoM manufacturer support?
8. What specific software components are required and what does the SoM vendor offer? For example: browser, Yocto, Debian, Buildroot or Qt.
9. Is the software open source, does the vendor support mainline Linux?
10. How is the initial installation of the software - can SoMs be ordered pre-programmed and how regularly does the SoM manufacturer provide software updates?
11. Does the manufacturer support Secure Boot or Fast Boot and offer a sample implementation?
12. What options and mechanisms are available for updates?
13. What support does the vendor offer and with which partners does it cooperate?
14. What documentation is provided and how easily accessible is it?

The manufacturer-specific issues often put the software in the foreground, because it is very important especially for the maintenance and care of a product over its lifetime. In addition, the usual issues such as availability and delivery times as well as price play an important role in the selection of a suitable SoM. Some of the points mentioned above will be dealt with again in detail below.

Choosing the right power management

Developers can implement power management either discretely or with the help of a power management IC (PMIC). The article now takes a closer look at the last variant with PMIC. Most SoMs do not return voltages from the PMIC back to the motherboard. If they do, the outputs usually only serve as reference voltages. However, some SoMs have the advantage that the entire mainboard can be powered by the PMIC. This way, the outputs on the baseboard can be used to supply all connected components and costs can be reduced, since only one buck regulator supplies the SoM itself. With such a solution, some PMIC power rails can be turned off when switching to low-power mode - allowing for a power-saving motherboard design. Also, power sequencing is much easier with just a single controller on the mainboard that

powers the PMIC on the SoM at power-up. The PMIC starts with the specific sequencing for that SoC and the peripherals are included directly in the sequencing since they are also powered by the PMIC power rails. This avoids strange power-up behavior and resulting complex sequencing circuits on the motherboard. An example for this is our DHCOR STM32MP15. With it, different PMIC output rails were led to the mainboard, which simplifies the mainboard design considerably.

A cooling concept saves time during development

Cooling the SoM is usually associated with additional costs. For one thing, it often requires a lot of space, and a cooling concept also increases the complexity of the assembly process during production. The additional costs are often regarded as hidden costs - if you simply compare the costs of two two SoMs with each other and disregard the costs for handling. With the 5-Cent Cooling Solution, we offer a time-, space- and cost-saving cooling option that does not require any heat sinks at all. The company uses a gap pad to dissipate heat from the processor via a 5-cent copper area and standard PCB vias into the inner copper layers of the PCB. In summary, the cooling option is cost-saving because only a gap pad is required and there are no heat sink and mounting costs. It is also space-saving, as a slim product design is possible and no space needs to be planned for a heat sink. Furthermore, the 5-Cent Cooling Solution saves development time because the gap pads are easy to handle by simply sticking them on. Last but not least, it is a robust cooling application with low weight, and is also shock- and
vibration resistant.

Open source software increasingly popular

When selecting a system on module, the software and the operating system play an important role, with Linux taking a leading role in the embedded world. Here it is important to distinguish between open source in general and mainline Linux. You will learn why this is so important in the following paragraph. Open source basically means that a provider makes all sources available and companies can thus develop the software completely themselves. However, this is not always desirable, but at the same time it is good to leave this option open. Developers must keep an eye on the license of the open source software used. For example, the Linux kernel is licensed under the GNU General Public License (GPL), version 2, which requires that anyone who distributes software based on source code under the license

must provide the recipient with the original source code and any modifications under the same conditions. Therefore, Mainline Linux means much more than open source because of the GPL v2 license used. All changes are to be made available - thus all optimizations, improvements and bug fixes are accessible to everyone at any time. This has the great advantage that companies and developers all over the world work on the maintenance of Linux and the dependency on only one company is eliminated. For this reason, the SoM used should be equipped with mainline support, i.e. it should be "upstreamed". It follows from this that it is included in "linux-next", i.e. the latest available Linux kernel version. It is then theoretically always usable for this hardware. In terms of mainline Linux, there are a few more special features to consider, which our software team will be happy to explain in a consultation.

Customized System on Modules

Not every standard SoM is an ideal fit for a specific application. Instead, it can make sense to develop an individual SoM together with the manufacturer. The first question here is which SoM manufacturers offer customer-specific variants at all and to what extent individual wishes can be implemented (minor adaptations of an existing SoM vs. completely customer-specific development). In addition, the implementation of customer-specific SoM variants is often only possible from a certain quantity. DH electronics supplies customer-specific variants starting at 300 units per year. In this case, however, longer delivery times must be expected than for an off-the-shelf product. On the other hand, the customer-specific SoM is optimally suited to the respective application. The decision for or against a customer-specific SoM is usually a weighing up of the factors time, cost and sustainability.

Pluggable versus solderable

Whether a solderable or pluggable SoM should be used depends largely on the requirements of the end device. As a rule, the number of devices produced per year is decisive for the decision. If the number of units is in the range of 1,000 to 2,000 units per year, a pluggable SoM makes sense. For higher quantities, solderable and thus machine-assemblable SoMs offer significant advantages. The following three questions provide further assistance in making a decision:

1. How much space is provided for the SoM?

2. Can the EMS equip solderable SoMs with Land Grid Array (LGA) or Bald Grid Array (BGA)?
3. Does the SoM need to be replaceable at a later date, for example in the Return Merchandise/Material Authorization (RMA) process?

Many manufacturers offer solderable SoMs as LGA variants. A distinction is made between LGAs without solder on the pads and with solder. The former is usually not easy to process because more solder paste has to be applied to the motherboard to compensate for the unevenness of the PCB. This poses the risk of air bubbles in the solder balls, resulting in a poor connection. To avoid the problem, DH electronics advises to use LGA SoMs with pre-tinned pads or SoMs with real BGA balls.

Individual vs. standard form factor

At this point, the differences between an individual or standard form factor will be discussed once again. It is of secondary importance here whether it is a manufacturer-specific or an industry standard. The main argument for using an individual form factor is the optimized SoM design based on this SoC. This means that individual SoMs usually make all the features of the SoC used available externally, which is usually not the case with standard form factors. This means that if you want to use all the features of an SoC, the individual solution is the best choice - no more and no less.

Selecting the right SoM form factor

A customized SoM form factor makes sense when the SoC to be used and the required features are known. Complex design parts such as power management and DDR memory connection are eliminated, and the SoM vendor also provides software and design support. With SoM standards, you often have the problem that SoC-specific features are not available on the motherboard because the feature is not part of the standard. Furthermore, standardization always comes with additional costs because the SoM vendor has to adjust voltage levels with level translators and the like, for example. In return, compatibility with a standard is given, which means developers can use different SoMs in a single motherboard design - which in turn brings three major advantages:

1. Companies can offer several end devices with different performance but always with the same mainboard.
2. Companies can replace the SoM during the product lifecycle with a more powerful or better available SoM.

3. Developer training time for a new SoM based on a known standard is low.

So there is no right or wrong decision when choosing the SoM form factor. Instead, the choice must fit the product, the life cycle and the quantities produced. The above questions provide a good guide for the selection for the next project. In addition, other questions may arise during the course of the project. It is important to make the SoM form factor choice in a timely and careful manner. In addition, developers should not only pay attention to the costs, but also consider the technical properties of the overall product and the support of the SoM provider.