Standards for embedded modules with the latest Intel Atom processors

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Users are faced with the question of how they can optimally use the latest generation of Intel Atom processors. Which module standard covers application requirements the best and helps to exploit the advantages of these processors? It pays to take a closer look, especially in the case of very tough requirements.

COM Express Compact module with the latest Intel Atom 'Apollo Lake -I' processors, 8GB soldered DDR3L RAM including ECC support, extended temperature range and options like conformal coating and nano-coating

Originally marketed under the 'Apollo Lake -I' product name, Intel now has three derivatives on the IOTG embedded roadmap: Intel Atom x7-E3950, Intel Atom x5-E3940 and Intel Atom x5-E3930. With these devices, the company is addressing the broader embedded market as well as industrial applications. An extended temperature range, high reliability, long service life and features that support tough real-time applications and virtualization should be highlighted here.

Those who are less concerned about temperature range or usage scenarios can also consider the Celeron N3350 or the Pentium N4200. These were previously sold under the 'Apollo Lake' code name and do not possess any special modifications for tough embedded use. Instead, they address PC-typical applications, for which low performance is typically sufficient, but they also have sufficient reserves to handle short-term peak loads (cf. turbo mode factor). All five devices are pin-compatible and are also uniform in terms of their external interfaces. All of these devices impress with very good performance-per-watt ratios and excellent graphic properties with up to three high-resolution 4K display interfaces. The use of standard module form factors has become established in recent years, especially for x86 embedded processors. Key concepts here are interchangeability, scalability, upgrade capability, second-source strategy, time-to-market and future viability. The following module standards have successfully established themselves in the German and international x86 embedded markets: COM Express (Mini, Compact, Basic), defined by PCI Industrial Computer Manufacturers Group (PICMG), COM.0, SMARC, defined by Standardization Group for Embedded Technologies (SGeT), SDT.01, and Qseven, defined by SGet, SDT.02. SMARC and Qseven cover the lower performance range of x86 processors, whereas COM Express is able to cover the full bandwidth of performance. Which module standard is best suited for applications with the new Intel Atom processors depends entirely on the technical requirements and environmental conditions of the application.

The Qseven form factor was introduced in 2008 for solutions based on the Intel Atom. Its dimensions are rather compact at 70mm x 70mm. The majority of interfaces offered by the new Intel Atom processors can be made available to the carrier board. Unfortunately, only two of the three possible display outputs can be used. One of the three USB 3.0 interfaces must also be omitted. Users who wish to use the MIPI-CSI camera interface are forced to connect a flat cable directly to the module. Connection to the carrier board is made via a 230-pin card edge connector. Gold-plated contact surfaces are provided on the module, which are inserted into the plug connector of the carrier board. This represents a clear advantage in terms of costs. Some users who want to use the new Intel Atom processors for especially rugged applications consider this type of contacting to be critical in terms of shock, vibration and risk of contamination, and they worry about mid-term contacting problems. With regard to sturdiness, the low PC-board thickness and mechanical integration continue to be recurring topics of discussion. The mechanical stresses that components and solder joints are subjected to might impair reliability and service life. The maximum power consumption of Qseven modules is limited to 12W by the specification and the connectors used. Therefore, it may be necessary to throttle back the maximum computing and graphic performance. Unfortunately, the premium processor variant, the Intel Atom x7-E3950 with 12W TDP (thermal design power) exceeds the module performance limits in terms of total power consumption.

The SMARC, like the Qseven, uses a card edge connector, so here too there is debate about issues relating to ruggedness, reliability and long service life. The dimensions of the short version are just 82mm x 50mm. This means that SMARC is the smallest of the form fac-

	Atom x5-E3930	Atom x5-E3940	Atom x7-E3950	Celeron N3350	Celeron N4200
Code Name	Apollo Lake -I	Apollo Lake -I	Apollo Lake -I	Apollo Lake	Apollo Lake
Use Conditions (specified reliability)	Embedded / Industrial	Embedded / Industrial	Embedded / Industrial	Mobile / PC/Client	Mobile / PC/Client
CPU Cores	2	4	4	2	4
Cache	2 Mbyte	2 Mbyte	2 Mbyte	2 Mbyte	2 Mbyte
CPU frequency HFM / Turbo	1.3 / 1.8 GHz	1.6 / 1.8 GHz	1.6 / 2.0 GHz	1.1 / 2.4 GHz	1.1 / 2.5 GHz
Temperature $T_{junction}$	-40 °C / +110 °C	-40 °C / +110 °C	-40 °C / +110 °C	0 °C / +105 °C	0 °C / +105 °C
Max. Memory Speed / Channels	DDR3L: 1866 MT/s (Dual) LPDDR4: 2133 MT/s (Quad)	DDR3L: 1866 MT/s (Dual) LPDDR4: 2133 MT/s (Quad)	DDR3L: 1866 MT/s (Dual) LPDDR4: 2400 MT/s (Quad)	DDR3L: 1866 MT/s (Dual) LPDDR4: 2400 MT/s (Dual)	DDR3L: 1866 MT/s (Dual) LPDDR4: 2400 MT/s (Dual)
Max Memory	8 Gbyte	8 Gbyte	8 Gbyte	8 Gbyte	8 Gbyte
Memory ECC Option	Yes (DDR3L)	Yes (DDR3L)	Yes (DDR3L)	No	No
Intel® HD Graphics (Gen. 9)	500	500	505	500	505
GFX: No. of Execution Units	12	12	18	12	18
GFX: Base / Burst	400 / 550 MHz	400 / 600 MHz	500 / 650 MHz	200 / 650 MHz	200 / 750 MHz
Thermal Design Power (TDP)	6.5 W	9.5 W	12 W	6 W	6 W

Categorization of the latest Intel Atom E3900, Celeron N and Pentium N processors which Intel is offering for the embedded market with long-term availability.

tors considered here, which also makes the module somewhat more robust than the Qseven despite its very thin PC-board. The 314 pins of the module plug connector offer more signals overall than on the Qseven. Additional signals are available for graphics and MIPI-CSI to permit broader utilization of the capabilities of the new generation Intel Atom processors. Overall, the defined pinout is more advanced and aligned to future needs than that of the Qseven, and this can be of benefit to special new designs. When the SMARC module is operated with 5V supply voltage, the full performance range of the new Intel Atom processors can be covered. In this case, the potential limitations in the upper performance segment that occur in the Qseven do not apply.

The COM Express Mini module, which also has a very compact form factor (84mm x 55mm), primarily impresses with its very rugged construction with regard to mechanical design, plug connectors, PC-board and cooling connection. Consequently, the COM Express Mini offers ideal support for the new 'Apollo Lake -I' processors that are designed for tough environmental conditions in embedded and industrial applications. The 220-pin module plug connector also provides a large share of its interfaces for the carrier board. However, as was the case for the Qseven, there are limitations with regard to MIPI-CSI, USB 3.0 and third-party graphic interfaces. Since the pinout only offers single-channel LVDS (or alternatively eDP), there are also limitations in connecting high-resolution internal displays. It may be necessary to provide an eDP bridge on the carrier board that generates dual-channel LVDS. Some module manufacturers have responded to this need and have prioritized variants populated with eDP pinouts. The COM Express Mini offers sufficient reserves for all Intel Atom derivatives with up to 28W of reliable power consumption.

Users whose focus is on rugged and reliable Intel Atom designs with a lot of functional range and full performance capability will find that the COM Express Compact is a very good choice. Although its dimensions are larger at 95mm x 95mm, there is still enough available space to offer memory versions with fully equipped 8GB dual-channel DDR3L memory and an ECC option (automatic error correction). This is an important aspect for fully exploiting the computing and graphic performance of the new Intel Atom processors. Depending on the application area, there are module variants with two DDR3L SO-DIMM sockets (high flexibility in system configuration, but without ECC) or with soldered ROM (with ECC and high reliability under shock, vibration and harsh environmental conditions).

The COM Express Compact offers two plug connectors, each with 200 pins, so that nearly all interfaces of the new Intel Atom processors are available on the carrier board. This means that all three of the processor graphic outputs can be used with full performance capability and resolution. All three USB 3.0 interfaces are available as well. These signals are only lacking when MIPI-CSI cameras are used.

Since application areas for the new Intel Atom processors are so wide-ranging, all of the embedded module standards discussed here can demonstrate justification for their existence. In new, very compact designs, especially in the area of mobile applications, SMARC appears to be overtaking the Qseven form factor over the mid-term. Under harsh duty conditions, the COM Express is usually preferred. The Mini version is impressive here based on its small dimensions. Users who wish to exploit the entire performance range of the new Intel Atom processors for industrial applications generally find the COM Express Compact to be the best choice. ■