Single-board Computers For Embedded Applications

Developments in VLSI technology have led to implementation of an entire microcomputer on a single board. Single-board computers (SBCs) today include latest microprocessors based on ARM and standard connections like LAN, PCIe, USB and Ethernet with minimal component count and smallest package size.

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One of the quickest and easiest ways to start building your project for demanding applications is to use single-board computers (SBCs). Unlike the motherboard of a personal computer that functions with various daughter boards to perform different tasks, an SBC combines all the features onto a single board that is as small as a Parle-G biscuit. Introduced in early 80s, SBCs have gained huge market acceptance for embedded applications like process control, industrial computing, data acquisition, research and development, and military projects.

“Although today’s industrial and business markets are highly fragmented, there seems to be the need for an aggregated solution, i.e., embedded solution. Single-board computers help in producing a configurable, customised solution to address the targeted market,” says Royson Rajan, vice president, Solusoft Technologies. SBCs are at the core of embedded solutions and have gained huge market as these come as a working board.

Some of the PC-compatible SBCs are based on the form-factor of IBM’s ISA PC bus, while non-PC-based popular form factors include VME, PCI and PCIe. “Today’s smallest SBCs are based on form factors like Mobile-ITX, Pico-ITX, Nano-ITX, Mini-ITX to Em-ITX boards,” shares Sathya, director, Shresta eTechnologies.

ARM processors have also entered the SBC space, which was earlier dominated by PowerPC and Intel architecture. Some of the latest SBCs also include multi-core processors for applications requiring intense computing.

SBC requirements

To serve constantly changing demands of the embedded market, time-to-market is a critical need. “Single-board computers help address these demands by offering convenience, flexibility and scalability of commercial off-the-shelf products while at the same time incorporating latest chips and technology,” says S. Manikandan, managing director of Pentagon Rugged Systems.

Size is an important requirement for most SBC designers, as the computing device may not fit the location where it is going to be inserted. “The users normally have requirements regarding size (dimensions) of the board or appliance (box-level products),” says Rajan.

“The processor is the main component of the SBC. Hence it is essential to know the type of the processor, processing speed, etc,” shares Rajesh V., managing director of MRR Embedded Systems. “The requirement for communication peripherals depends on the application area. However, designers are keen on knowing the availability of Ethernet, CAN bus, RS232, RS485, Wi-Fi, Bluetooth, etc. They also want information related to display options like...
VGA, touchscreen and TFT display.” Other requirements include analogue inputs/outputs (I/Os), digital I/Os, voltage and current input.

Sathya shares, “Longevity of up to three-five years and heavy technical support have always been a concern for the designers. They also look for embedded operating-system support and possible security issues.”

SBCs can be used in a variety of applications and the processor requirement varies. “For example, in an industrial environment, where the importance is given to ruggedness of the box rather than the CPU performance, the preference would be fanless processors like those from Intel (Atom) and VIA. But for billing systems, which call for more processing power, the SBC may require a dual-core or higher-performance processor,” explains Sathya. “For a network appliance, it will be the external interface like LAN port that plays an important role, while in a PDA or other handheld, where integration on the chip is important in compact space, it is based on ARM.

For high-performance defence applications, where the processing speed (in million instructions per second (MIPS)) plays a key role in the CPU selection, it will require PowerPC core,” he adds.

Manikandan shares, “Industrial computers focus on improved mechanics to overcome the limitations posed by the standard consumer PC set-up.” The ultimate deciding factors thus are size, power consumption, availability of compatible software and peripheral hardware, and the low mean time between failures (MTBF), all at the most affordable price point.

**ARM-core SBCs**

Single-board computers with ARM-based microprocessor have made a big impact on the embedded sector. Though the first truly functional SBC was based on Intel’s C8080A and C1702A (Intel’s first EPROM), today, there are hundreds of processors that are used in single-board computers. ARM, which was prevalent in the handset space, has entered single-board computers with its Cortex A series processors.

At the *Embedded Systems Conference Silicon Valley*, a single-board computer based on 800MHz Cortex A8 CPU was showcased by Microsys. An interesting aspect of this single-board computer is its cost, which is roughly $100 to $300 less than an Intel-based board. Freescale’s single-chip solution as opposed to two-chip solution for Intel-based board is one of the contributors to the price drop.

Rajesh shares, “Some of the compact, full-featured SBCs based on Cirrus EP9302 ARM9 CPU provide a standard set of on-board peripherals. These low-cost Linux computers are completely manufactured in India to benefit the designer’s local needs.”

“The Mini2440/MICRO2440 is a low-cost single-board computer based on Samsung’s S3C2440 ARM920T core. It supports WinCE 5.0/6.0, Linux, Android and Ubuntu, making it simple and suitable for applications like industrial control, check-out facilities, meters, safe monitoring, medical instruments, high-end embedded applications and intelligent terminals,” shares Pritesh Patel, managing director, Amp Tronics.

Beagle Board is another popular single-board computer that is powered by a 1GHz ARM Cortex A8 processor.

**The ITX world**

Many vendors today offer VIA Technologies’ latest SBCs based on the new super-scalar Nano-E processors. “The EPIA embedded boards from VIA Technologies features low-power embedded processors, core logic, networking, connectivity and multimedia components. Vendors develop their own SBCs based on a variety of form factors from the company, namely, Mini-ITX, Nano-ITX, Pico-ITX and Pico-ITXe embedded boards” shares Sathya.

Mobile-ITX is currently the smallest form-factor (6x6cm²) board based on x86 platform. It brings ultra-compact and extremely light-weight devices to the market. The Pico-ITXe form factor (10x7.2cm²) was adjudged as ‘Best Choice’ at *Computex Taipei 2009* for its small form factor and stackability. Pico-ITXe is adopted by the Small Form
The success of VIA’s Mini-ITX has increased the use of SBCs in power supplies, slim-line drivers, Flash-to-IDE adapters and many handy computing components. “Mini-ITX 17x17cm^2 is targeted at new-generation, low-power, small-size, infotainment systems to enable innovative developments,” says Sathya. Some of the latest offerings include SBCs using Intel’s Atom CPU. It’s a huge leap forward exploding its popularity between home users and hobbyists. Many SBC manufacturers have realised the potential in Mini ITX form factor and offer several products in this form factor using either VIA’s chips or Intel’s chipsets.

**EBX: Fit for Pentium**

The Embedded Board eXpandable (EBX) offers suitable features to support embedded designs with high performance. It serves as the right mix of size (20.32x14.6 cm^2), economy and functionality, which makes it suitable to embed Pentium CPUs. Many OEMs are able to include high-performance graphics and advanced networking on EBX.

Derived from Ampro Little Board form-factor, EBX combines a standard footprint with open interfaces. The EBX standard is the result of collaboration between industry leaders, Motorola and Ampro, to unify the embedded computing industry on a small-footprint embedded single-board computer standard. This form-factor is small enough for deeply embedded applications, yet large enough to contain the functions of a full embedded computer system (CPU, memory, mass storage interfaces, display controller, serial/parallel ports and other system functions).

**Built-in display function**

Today’s embedded systems are incomplete without a human-machine interface, where use of high-end displays like VGA, TFT and touch screens is rapidly growing. As these display interfaces become affordable, the usage becomes more lenient. “To support the fully-functional, feature-rich product development, SBC manufacturers have started integrating display as well as link to inputs/control,” shares Patel.

“SBCs traditionally had 7-segment LED displays useful for control applications. Easy and low-cost availability of LCDs, TFT displays as well as touchscreen panels have made their way on SBCs. These are suitable for applications like automation, automotive electronics, medical devices and GPS navigation systems,” explains Patel.

Display panel manufacturers are realising a large and growing market in industrial areas. The display units are made rugged to survive and work in temperature range of -25°C to +85°C. Such rugged systems can be fitted into industrial computers and automation.

**Open source SBCs**

Open source software and hardware have become increasingly famous for development as these offer all the flexibility to change and use the way a designer wants to. There are several single-board computers that come under open source hardware category, allowing design development with reduced time-to-market and low cost.

One of the commonly used open source SBCs is the Beagle Board (7.6×7.6cm^2) based on Texas Instrument’s OMAP3530 system-on-chip. The USB-powered Beagle Board offers a low-cost, low-power solution that unleashes laptop-like performance and expandability without the bulk expense or noise of a typical desktop machine.

Another widely used SBC is OMAP L138 dual-core processor based Hawk Board that also includes floating-point DSP C674x application from TI. Hawk Board is an ultimate tool for digital media and storage applications with a wide range of peripheral support. An SBC named Gumstix, of the size of...
a chewing gum stick, was developed as a hobby project but has become increasingly popular in commercial applications like power management metering, medical devices, security devices, unmanned aerial vehicles, and wireless and handheld products. It has two product lines, one based on TI OMAP and the other based on Marvell XScale processor. Some of the other open source options are Leopard board and Maple board that allow full computing capability.

**Latest picks**

SBCs are traditionally known for industrial computing applications. However, Samsung recently introduced an SBC virtualisation environment to bring it to office. The environment will strengthen internal security and is based on a test project with Samsung SDS.

A company called Intercept Concept claims that its ultra-low-power single-board computer based on Freescale’s PowerPC provides Gigabit Ethernet interfaces for high-performance network connectivity, redundant fail-safe links, powerful control elements for network switches, data storage sub-systems, network appliances, and print and imaging devices.

The latest offering from GE Intelligent Platforms, a 6U VMEbus SBC based on Freescale’s QoriQ dual-core processor, delivers around ten times the processing performance depending on applications. Many such PowerXtreme SBCs are deployed in demanding military/aerospace applications in the US and Europe.

California-based ACCES I/O Products offers multiple-function single boards through optically isolated inputs. This allows individual channel-to-channel isolation, that is, every channel is separated physically and electrically. The solid-state FET outputs capable of switching up to 3A each and two 16-bit analogue inputs make this module suitable for control and instrumentation application.

ADLINK Technology announced its latest LittleBoard 735 EBX SBC based on Intel Atom N270 processor at 1.6 GHz, codenamed ‘Diamondville,’ at the ESC San Jose in April. The board combines Navy Pier platform, Atom N270 with ADLINK Extreme Rugged design methodology to create a feature-rich upgrade path for previous end-of-life products. It is designed to tolerate shock, vibration, humidity and temperature extremes.

The FeaturePak Initiative, originated by Diamond Systems, was launched at the Embedded World tradeshow in March 2010. Gurunatham G.V., managing director, Electro Systems Associates, shares, “This new standard defines a highly-compact, low-profile and inexpensive way to add configurable input/output functions to embedded systems.” He adds that the tiny FeaturePak modules that are just 4.3×6.5 cm² (1.70×2.55 inch²) in size can be used for providing snap-in options or upgrades for off-the-shelf single-board computers and computer-on-module baseboards, or as building blocks to simplify the development of fully-custom embedded electronics.

Gaming is one of the most aggressive growing industries. “Single-board computers of MB 62000 series are designed specifically for the gaming and amusement industry. These are based on Intel’s GMA 900 graphics engine for 2-D/3-D applications and are supported by VGA+LVDS dual-display option. They also feature high-level security by TPM 1.2, FPGA and Authenix chip, and are ideally meant for video slot machines, amusement game machines, master units of roulette machines, downloadable gaming terminals, high-end vending machines, ATM/cash machines and kiosks. Gaming manufacturers benefit from single-board features like integrated and economical assembly and purchasing costs,” shares Rajan.

**In sync with technological advancements**

The concept of single-board computer is now new. It’s a system that has survived for more than two decades now and evolved with changing technologies. By principle, it is a single board, but expandability is the most important feature of single-board computers. Due to standardisation and aggregation, expansion options are backward-compatible and forward-looking.

With the advancement in silicon technologies, high-end processors like ARM-based processors and Intel’s multi-core processors have found a space on the tiny board to support high-performance products.

Connectivity is another trend that has been well-incorporated in single-board computers. SBCs are ready with Wi-Fi, 3G, Ethernet, USB, Bluetooth, ZigBee and other connectivity options. As embedded products become more interactive, display options are supported on single-board computers to make these a complete, feature-rich, ready-to use solution for a variety of applications.

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