An I/O view of small form factor choices

By Eric Rossi

With all the small form factor choices available, the process of selecting an SBC takes more than a little time and consideration. Evaluating each option based on a handful of significant factors including I/O requirements helps designers make informed decisions.

Designers looking for small form factor SBCs have many choices, including the more widely fielded PC/104, EBX, and System-On-Module (SOM). With so many options, how do designers determine which one to use?

The right choice depends on three key issues plus several other considerations listed in Table 1:

- What are the I/O requirements?
- How much processing is required?
- What are the constraints (power consumption, size, temperature, and so on)?

The answers to these questions will provide the criteria needed to make an informed choice. Let's examine some of these issues for each form factor with a focus on how I/O can be added.

PC/104

PC/104 is a small (3.55" x 3.78") expandable format. Due to this size, PC/104 SBCs usually are based on lower-end 32-bit x86 processors (386 to Pentium). Some manufacturers take liberties with the specification and add small *wings*, increasing the size of the board and thus allowing faster processors and/or more I/O.

Derived from the legacy PC x86 architecture, the PC/104 standard provides ISA bus connectivity through a special PC/104 connector. Although this form factor has x86 roots, new PC/104 SBCs based on RISC (primarily ARM) architecture recently have been introduced. This allows RISC-based SBCs to make use of the various PC/104 peripheral modules.

One of the definite advantages of the PC/104 format is the number of SBC and peripheral options and enclosures available. The PC/104 standard allows these peripheral modules to be stacked one on top of another so that almost any application can be implemented with a PC/104 module stack (see Figure 1). To keep up with the higher PCI-based I/O bus speed the PC/104 standard was expanded to include PCI bus connections. This updated specification, called PC/104-*Plus*, has a derivative called PCI-104 that omits the ISA bus.

Due to the popularity of the x86 architecture, the PC/104 format will run just about any Operating System (OS) with any programming language. Some of the x86 PC/104 options draw less power than other larger form factors with higher-end processors, however RISC-based PC/104 boards can offer even lower power consumption. A PC/104 peripheral module will cost quite a bit more than an equivalent commodity ISA/PCI card, but the PC/104 card is a much smaller and more rugged alternative.

Important considerations when selecting an SBC
Is it a new application or a retrofit?
What is the target cost?
What is the development budget?
What Operating System (OS) and programming language are being used?
Is there existing software that will be reused?
Will the system run on a battery or have any other special power supply requirements?
Is there a special card/module that must be used?

Table 1

Figure 1

EBX

EBX is a larger (5.75" x 8.0") format usually utilized with higher-end processors, although low-end processor EBX boards are available. EBX allows both PC/104 and PCI expansion. A standard PCI card slot provides for PCI bus connection (see Figure 2). Numerous manufacturers provide boards with the EBX form factor and mounting holes but do not abide by the designated connector locations or in some cases, eliminate the PC/104 connectors altogether. This normally is not an issue unless a designer is trying to replace a true EBX board or needs PC/104 when it is not provided. Some manufacturers such as EMAC have enhanced their EBX offerings by providing PC/104-*Plus* and Mini PCI.

Figure 2

Having a PCI card slot can be handy when a specialty card that does not come in any other format is required. If more than a single PCI slot is required, a riser card can provide two PCI slots that fold over the EBX board at a right angle. The problem with using PCI cards in this way is that they are difficult to mount and hold secure without fabricating custom brackets. EMAC offers enclosures that handle EBX boards with PCI cards holding them securely.

EBX, like the PC/104 form factor, is based on x86 architecture and will run almost any OS with any programming language. In addition, since EBX is relatively large, four serial ports and four or more USB ports are usually provided as well as one or more Ethernet ports. As mentioned, some EBX boards provide Mini PCI expansion, which is ideal for adding wireless 802.11 Ethernet.

The 3.5" Half EBX format is a very popular derivative of the EBX form factor, which as its name indicates is half the size of a full EBX board. In addition to its smaller size, the Half EBX board utilizes onboard connectors for its standard I/O (such as serial DB9, RJ-45 Ethernet, USB, PS2 keyboard, and DB15 video), eliminating some of the cables EBX and PC/104 boards require. The cables are usually not included with a full EBX board and are purchased separately.

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SOM

While PC/104 and EBX have been around for a while, the System-On-Module (SOM, also referred to as *Computer-On-Module* or *COM*) alternative is relatively new. PC/104 and EBX solutions usually have myriad cables. Many applications such as data acquisition and control, for example, will require one or more PC/104 expansion modules and possibly a terminal board or two. Although this is a less than optimum solution, it is off the shelf, minimizing time to market and incurring minimal design cost. Alternatively, a full custom solution might be favorable but would incur a large engineering design effort. Additionally, the processor core can be the riskiest part of the design, especially with higher-end processors.

SOM splits the difference between off-the-shelf and full custom designs, taking the best elements of both approaches. This semicustom SOM approach comprises two components: the processor module and the carrier board. The off-the-shelf processor module contains the processor, memory, real-time clock, Ethernet, serial ports, hard disk and/or flash disk interface, and other processor-specific I/O. The module plugs into a carrier board, which provides all the system connectors and any additional I/O components required for the application.

While carrier boards can be purchased off the shelf, enabling immediate software development, the carrier board must be custom designed for the application at hand to reap the benefits of the SOM approach (see Figure 3). The customer or module manufacturer can perform a custom carrier board design, but regardless of who performs it, the time frame, design cost, and risk are reduced over a full custom design. An SOM design can decrease the cabling and expansion module stacking found in a strictly off-the-shelf approach, not to mention the system unit cost savings. In addition, the reduction in cabling and module interconnections makes an inherently more reliable system.

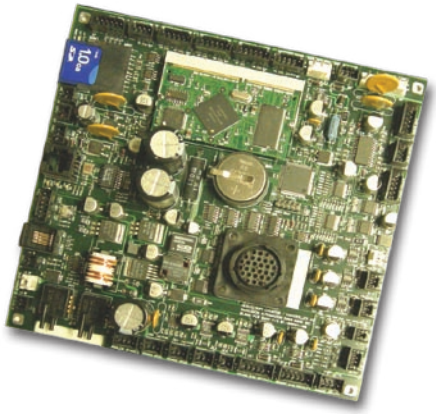

Figure 3

Like SBCs, SOMs come in a variety of flavors, some of which are standards based and others that are propriety designs. ETX, COM Express, XTX, and STX are examples of standard SOMs covered by the ETX Industrial Group (www.etx-ig.org), PICMG (www.picmg.org), the XTX Consortium (www.xtx-standard.org), and the STX Consortium (www.stx-consortium.com), respectively. These standards are primarily based on 32-bit x86 architecture and feature a combination of ISA, PCI, or PCI Express expansion buses. The advantage of these SOMs is that a number of manufacturers second source them. Proprietary SOMs, which are usually smaller and less expensive than their standard counterparts, come in a variety of form factors and use a mix of 8-, 16-, and 32-bit processors. They are usually pin compatible within a manufacturer's product line but not from manufacturer to manufacturer even when the exact same form factor is used.

In either case, by utilizing a pin compatible SOM product line, the SOM approach provides an upgrade path when future enhancements call for a more powerful processor. In addition, once an application is built around a particular processor module, the development environment and all the code written for it should come across seamlessly to the next project. SOM also increases product longevity. Unlike what's possible with a full custom approach, the processor module can be replaced easily once the processor, flash, or RAM becomes obsolete.

Narrowing the choices

PC/104 is an ideal solution for applications that demand an off-the-shelf small form factor with low- to mid-range processing power. The primary disadvantages are multiple cables that tend to come loose if not secured and relatively expensive system cost when several modules are required.

EBX is well suited for high-end applications especially when a PCI card is required. It has the same cabling issues as PC/104 and is much larger than a PC/104 module. The 3.5" Half EBX resolves some of the cabling issues and is smaller than EBX.

Any SOM solution will usually provide the best fit for an application although it can incur an engineering design charge. SOMs support a wide variety of both RISC and CISC processors. RISC processors tend to be lower power and are most advantageous for battery-backed applications.

Carefully considering the application from a number of angles, as demonstrated in Table 2, will help designers make the right choice. ➤

Eric Rossi *is a senior manager at EMAC, Inc. where he is responsible for new product development and custom engineering management. Eric has more than 25 years of experience in embedded system design and holds a BS in Electrical Engineering Technology as well as a BS and MS in Computer Science from Southern Illinois University.*

Form factor	Power consumption	Size	Processing power	Expandability	Time to market	Development cost	Development risk	Advantages	Disadvantages
PC/104	Low to mid	3.55" x 3.78"	Low to mid	PC/104 PC/104-*Plus*	Off-the-shelf Fast	Off-the-shelf Inexpensive	Off-the-shelf Low	Stacking of peripheral modules; rugged, small size	Multiple cables and interconnections, expensive system cost
EBX	Low to high	5.75" x 8.0"	Low to high	PCI Slot PC/104 (optional) PC/104-*Plus* Mini PCI	Off-the-shelf Fast	Off-the-shelf Inexpensive	Off-the-shelf Low	Supports high-end processors, PCI slot, and PC/104; more I/O ports than PC/104	Multiple cables, awkward expandability, large size
SOM	Very low to mid	Small to large	Low to mid	Unlimited	Semicustom 4 to 8 weeks (typical)	Semicustom Moderate	Semicustom Moderate	Protection from obsolescence, eliminates cables, unlimited I/O, best fit	Not off-the-shelf, may require custom drivers
Custom	Very low to high	Very small to large	Low to high	Unlimited	Full custom 4 to 24 weeks (typical)	Full custom Expensive	Full custom High	Eliminates cables, exact fit, unlimited I/O, lowest production cost	Not off-the-shelf, may require custom drivers, longer software development

Table 2