Modular

Expandable

Flexible

CONNECT AND PROTECT

Essential guide to select an integrated COM Express system

Save time and cost by selecting the right embedded system solution

nVent

SCHROFF

Ebook: Essential guide to select an integrated COM Express system

SAVE TIME AND COST BY SELECTING THE RIGHT EMBEDDED SYSTEM SOLUTION

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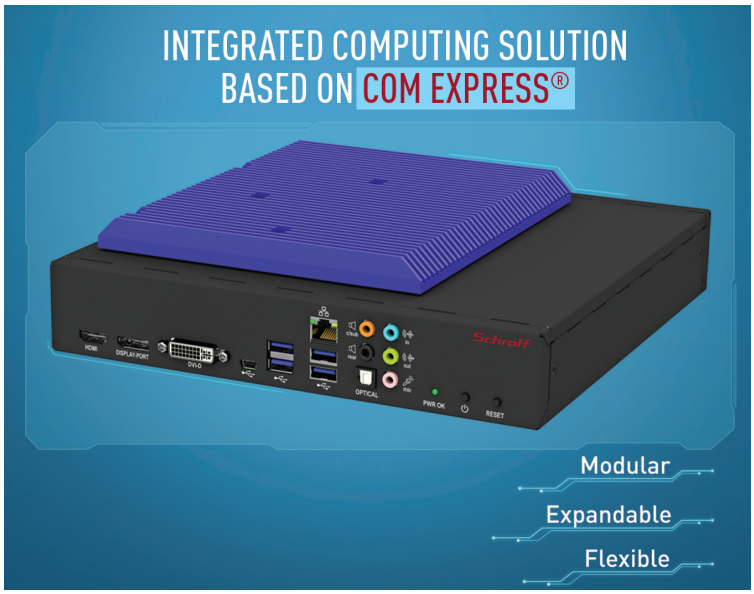

1. INTRODUCTION

Problem statement

The performance increase of modern processors, the integration of graphics solutions into processors and the integration of countless interfaces into processor chipsets are driving the trend away from 19" systems and towards solutions with a smaller form factor. Today a high-performance multi-core processor can accomplish what it took a modular multi-processor system to do in years past. Fewer expansion boards are needed because chipsets feature direct integration of many interfaces. Even the I/O concepts have changed. Today, designs use fieldbuses to accomplish what previously took many sensors and actuators separately connected to the system through I/O boards. In addition, trends like IoT and Industry 4.0 are creating a stronger push towards the use of smaller computer systems with increased performance, such as IoT gateways, in a wide variety of applications. One technology in the field of small form factor solutions is computer-on-module (COM). Embedding these COM modules into the proper infrastructure creates functional computer systems for a wide variety of tasks and application areas.

This ebook provides answers to the following key questions:

1. What are the advantages and disadvantages of mainboard versus COM modules with customized or modular carriers and compared to completely integrated COM systems?
2. Which solution is ideal in terms of quantity, complexity, project duration and long-term availability of implemented components?

Market situation

In addition to the advantages and disadvantages of various technical solutions, users also need to have good working knowledge of the realities of the market. The question is: Who can provide the user with what and in what configuration? The market features a number of standard mainboard with common PC interfaces, companies that develop customized mainboard, and a multitude of businesses that manufacture and sell different standard COM modules. Companies usually opt to develop the necessary COM carrier only for very large quantities or for projects that are important from a business strategy perspective. That area largely consists of smaller companies that have specialized in the development of carriers. The components to create a complete and functional system are still missing, such as the power supply, cooling and a suitable case for protecting the entire system from environmental factors at the location of use. This is why customers that wish to focus on their own core area of expertise, such as the application, seek out companies that can cover every aspect and provide a complete, coordinated system anywhere around the world. Others, such as those that view carrier development as an internal expertise, may only require a supplier for the power supply, cooling and case.

2. FIRST STEPS

A variety of options are available to the user for designing a system with a small form factor. But where is the best place to start? What criteria would provide a fitting solution in terms of technical design and cost efficiency? The user starts by defining the requirements. The user is familiar with the application and knows which functions and interfaces are needed.

Step 1: The user examines the market looking for a standard solution, such as a standard mainboard, that offers all of the functions and interfaces needed for the application. This offers the user the advantages of immediate availability, zero development costs, and availability in large quantities, resulting in very low costs. The user must consider, however, that standard mainboard lifecycles are very short and it may be necessary to replace the mainboard with a successor board every two to three years. This, in turn, leads to high subsequent costs from re-evaluation and re-certification. The average duration of a project in industry is ten years and could last as long as thirty years. In the ideal situation, the hardware would have to be changed five times at corresponding cost. In addition, the user lacks a large degree of flexibility for developing the application or product; in many cases, the lack of some interface or other only becomes evident down the line.

Step 2: If the user is unable to find a standard mainboard that meets the requirements, the user can develop or commission the development of a mainboard. However, the large amount of time and effort this development entails, along with the expenses incurred, normally makes this feasible only for very large production quantities. There are other considerations as well. While this does provide a practical one-board solution, every single change to the product requires a complete revision of the mainboard. This also entails follow-up costs and development time.

Step 3: If a customized mainboard is not an option, the user can opt for a COM solution. The user utilizes a COM module available on the market and that contains the base computer components and develops a suitable COM carrier (or has one developed). This carrier is the I/O part of the computer and holds all of the interfaces and functions necessary for the application. Or the user makes use of a modular COM carrier that provides flexible configuration options for the desired functions and interfaces using add-on boards.

Compared to a mainboard, COM module and COM carrier solutions use embedded processors that typically have an availability of seven years (Intel processors) or even longer (ARM processors). The manufacturers here also offer last time buy options or deliveries after discontinuation of the processor and even provide special storage services in order to ensure product availability beyond that seven year time frame. This extends the availability of modules and carriers. The combination of COM module plus carrier is inherently somewhat more expensive than a mainboard because two printed boards and transfer connectors are necessary. In the case of a COM module and COM carrier solution, it is also possible to work with smaller quantities, but this too entails higher costs compared to a mainboard. Looking at the costs of both solutions over the entire product lifetime, the COM module and COM carrier solution is always more cost-effective compared to the mainboard. (The longer it operates the greater the cost difference because of the frequent corresponding changes in mainboard that are required). This can make the COM solution more appealing than a mainboard solution in every regard. It often serves as a sample calculation; the key factors are quantity, complexity, duration and long-term availability of components.

In general:

- The configuration of a modular COM carrier is suitable for quantities of 50 to 100 and for laboratory applications.
- A custom carrier design is suitable for quantities of 100 to 1,000/2,000/3,000 or even 5,000 (depending on the complexity).
- The time and effort for a customized mainboard development is suitable for quantities of 5,000 or more. In some cases customized mainboard development may even be suitable for quantities as small as 500 or 1,000.

In order to assist the user in making a decision, the individual components of a COM solution are described below. Since a COM system cannot function without the necessary infrastructure, it is accompanied by power supply, cooling and case solutions.

3. THE COM MODULE

The COM module forms the heart of a COM system. It is a plug-in mezzanine card with defined plug connectors and resembles a complete single-board computer with processor, chipset and central memory. The COM module is mounted on a board called a carrier. The carrier routes the I/O signals from the COM module to interface connectors, such as PCIe slots, Ethernet connectors, USB interfaces etc.

The carrier also holds additional or special interfaces that the user needs for the specific application. In other words, this I/O part always entails custom development. COM module solutions are primarily used if a simple single board solution is unable to meet all requirements. There is a wide assortment of specified COM modules, including those that use common bus systems or combine the PCI bus and ISA bus or others that use PCI Express.

The COM modules used most frequently today are COM Express modules specified by PICMG (PCI Industrial Computer Manufacturers Group), QSeven modules developed by Congatec and incorporated into SGET (Standardization Group for Embedded Technologies e.V.) as an open standard since 2015, and SMARC (Smart Mobility Architecture) modules standardized by SGET.

QSeven – These COM modules are smaller than other COM module standards such as COM Express, ETX or XTX. It primarily supports x86 CPU designs, but ARM architecture is supported as well. Thanks to the use of cost-efficient connectors, the module as a whole is cost-efficient. However, there is a fair chance that these connectors will no longer be available in a few years.

SMARC – These COM modules are specially designed for the development of extremely compact systems and are based primarily on ARM processors. The modules typically have a power requirement well under 5 W. This makes them the preferred option for use in low-power and mobile applications.

COM Express – These COM modules are available in eight different pinout types based on x86 CPU architecture. Due to the variety of types, these modules offer a wide range of interface

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options. Type 7, the newest type, does not offer any graphics interfaces, but it does provide 2 × RS-232 and 4 × 10GBaseKR Ethernet in its place, making it especially well-suited for server applications. Type 6 currently offers the latest PC interfaces such as 4x USB2.0, 4x USB3.0, 2x RS-232, LVDS, VGA and 3x DDI (SDVOb, DP, HDMI/DVI) etc. In addition to the pinout types, the COM Express modules are available in four different sizes: Extended, Basic, Compact and Mini. COM Express modules are interchangeable thanks to the defined pinouts.

Once the user has chosen a COM module, the carrier development is the next item. Either the user develops a customized carrier that specifically has the necessary functions and interfaces (or has one developed) or the user utilizes the modular nVent SCHROFF COM carrier, which can be configured using an abundance of add-on boards to meet the requirements.

4. THE MODULAR COM CARRIER

As the basis for developing a modular COM carrier, nVent selected the type 6 COM Express module. This specification defined and published by PICMG is very broad and primarily geared towards high-end applications with fast data transmission, high processor performance as well as demanding cooling and power supply. Today, due to miniaturization, small form factor solutions are preferred in cases where a high-performance 19" system was the first choice in the past: Image processing, test and measurement, medical technology, industrial automation, IoT gateways, vehicle-based WiFi, machine monitoring, etc.

Illustration: Applications

The modular SCHROFF COM carrier has been designed such that new developments can make use of standardized COM modules from different manufacturers and only the modular SCHROFF COM carrier with the interfaces and additional functions is modified. It includes conventional interfaces such as Gigabit Ethernet, USB 2.0 and 3.0, 5.1 HD audio, DVI-D and Display ports located on the front side. Additionally, one VGA and one UART port are located on the opposite side, as well as two SIM card retainers and one microSD card retainer. Additional RS-232 interfaces, such as for Modbus or Ethercat controllers, as well as an LPT and PS/2 (male) plug can be connected using optional cable adapters. A case touchscreen via the LVDS interface, S-ATA interfaces, two mini PCIe interfaces and one PCIe x4 interface as well as fan, power and status signal connectors are also available on the carrier.

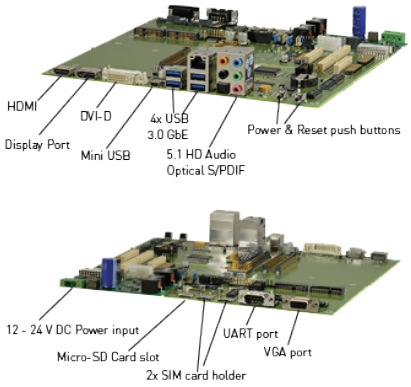

Illustration: Modular COM carrier with interfaces

The carrier also offers additional interfaces for expansion boards. A supplementary post code and prototype module can also be used for debugging the application, as well as to design customized circuits for testing in a laboratory setting. For this purpose, the prototype module has a hole grid so that the user can create simple circuits in a laboratory setting. An interface for fieldbus modules gives the user the ability to connect different fieldbus controllers to the carrier. In addition, the carrier has also an XMC slot. The system designer has access to a comprehensive selection of mezzanine cards from various manufacturers to expand the carrier's functionally. With an FPGA-XMC, it is possible to process customized I/O signals or to design a multiprocessor system with a processor mezzanine card. By simply attaching the corresponding mezzanine card, this function can be tested immediately without having to first start a complex development process. The XMC slot is connected to the COM module via PCIe, and the I/O signals from the mezzanine card are routed to corresponding connectors on the carrier, at which point they can be picked up by the user. An additional Gigabit Ethernet switch is on the roadmap to be implemented soon, which will make additional Ethernet interfaces available. nVent develops add-on modules for the various interfaces; these modules expand the carrier's range of functionality accordingly. The connector types and pinouts of the modules are also described in the manual, allowing the customer to independently develop corresponding add-on cards.

Based on the modular COM carrier, the only thing the customer may have to do is develop an add-on board for a special function. Everything else can be configured from standard boards through the modular design. This reduces the overall hardware development complexity for the customer, providing a head start on other areas such as software development.

The modular design makes the carrier more expensive than a customized carrier and it is not intended for large production quantities or series production applications for this reason. It is primarily used as a development tool in a laboratory or, depending on the complexity; the modular concept is suited to projects with small or moderate quantities. If the individually configured modular COM carrier is used primarily as a development tool, this tested base can be used for the development of a customized COM carrier for series production with larger quantities. nVent also offers its customers a customized solution.

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Advantages and disadvantages of a customized COM carrier

Advantages	Disadvantages
Simple testing of add-on modules in the application without the development time and complexity	Unnecessary functions and interfaces are also included in the purchase
Many interfaces available	Higher procurement costs per unit
Low development time and complexity	
Low development costs	
Ideal as a development tool for laboratory use	
Ideal for small production quantities	

5. THE MODULAR POWER MODULE

Different voltage levels are available depending on the type of application for which the COM module and COM carrier are used. Examples include 9 to 36 V DC in the automotive industry, 48 V DC in telecommunications, 16.8 to 150 V DC in railway applications, etc. For this reason, the power supply, including management for the SCHROFF COM carrier, is also designed as a separate module, allowing flexible adaptation to case-by-case conditions. This means nVent will provide a variety of power modules with different input voltage ranges and these modules can be swapped at any time if the application changes, potentially altering the voltage range as well. The first available power module from nVent covers an input power range of 12 to 24 V DC, with other modules on the development roadmap.

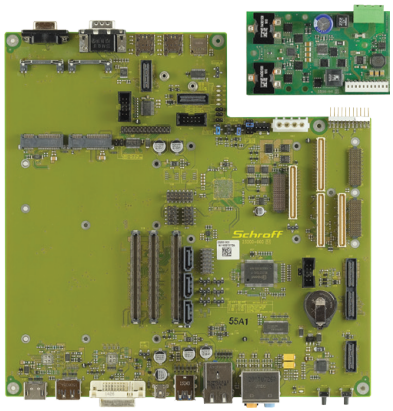

Illustration: Modular power module

Advantages and disadvantages of a customized power supply solution

Advantages	Disadvantages
Versatility for use in similar applications with different input voltages	Not for large production quantities
Easy replacement	Not for low-power applications

6. MODULAR COOLING SOLUTIONS

The focus on high-end applications with high computing performance also makes cooling an important aspect of the COM solution from nVent. The more performance a processor offers, the more heat is generated. And that heat requires efficient dissipation in a system with a small form factor in order to avoid overheating and potential damage to components.

Defining the cooling requirements requires taking into account not only the power loss of the processor and other installed components but the ambient conditions of the application site as well. These conditions include factors such as whether the COM system is operating in a climate-controlled laboratory with air conditioning or in a room without climate control but with air circulation or is installed in a vehicle or works under high ambient temperatures. All of this has a decisive effect on which cooling solution should be selected.

Normally, the power loss for systems with small form factors is dissipated using conduction cooling. This works by creating a direct thermal path from the processor to the heat sink and on to the environment.

nVent has also opted for a modular approach for cooling its COM solution. A variety of heat sinks will be available. They are suited to specific power loss values and application areas due to the differences in their geometry, covering a wide range of applications. The cooling capacity of the various heat sink geometries has been qualified by nVent thermal technicians in special thermal tests.

“Pin heat sink” example: This type of heat sink works especially well if the COM system is on the bottom and there is no air circulation in the room. Every individual pin dissipates the heat around itself evenly on all sides without having a negative effect on the others

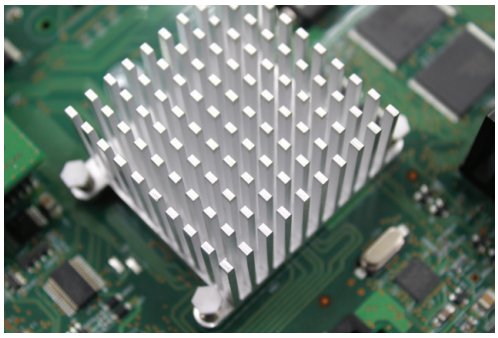

Illustration: Example Pin heat sink

“Profile heat sink” example: These heat sinks are relatively solid, have a large spacing between the individual fins and are ideal for COM systems mounted on a wall if there is no air movement in the room. The cooling fins are arranged vertically. This creates a chimney effect that automatically causes air movement, guiding the warm air upward.

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Illustration: Example Profile heat sink

"Narrow, closely spaced cooling fins" example: This type of heat sink has rather narrow cooling fins that are spaced very close together. This creates a large surface area for dissipating heat in a small footprint. This setup, however, requires constant air flow, such as movement created by a blower mounted above the heat sink.

Illustration: Example Air fan with heat sink

The noteworthy aspect of this modular cooling design from nVent is that the heat sinks are mounted directly on the COM module and not on the case or part of the case design like in a box PC. This provides immense flexibility for the user. As a comparison: A box PC with a case made of extruded aluminum lacks this flexibility (the case itself essentially acts as the heat sink in this instance). In a situation where environmental conditions change the cooling capacity determined by the case design may no longer be sufficient.

Advantages and disadvantages of cooling permanently integrated into the case (e.g. aluminum profile case)

Advantages	Disadvantages
Heat sinks available in various shapes and sizes	Lower IP protection due to the cutout in the case
Cooling capacity can be tested in a laboratory using different heat sinks	Higher costs due to separate heat sink manufacturing
Easy to swap, including later in the application	
Direct installation on the COM module, better heat transfer, no issues with tolerances and thermal pads	

7. THE MODULAR CASE DESIGN

The case is another important component when using a COM solution. It protects the electronics from environmental factors like dust, moisture, EMC radiation and other effects. It also protects operating personnel from injuries due to unintentional contact. nVent also takes advantage of modularity in this area. The modular SCHROFF Interscale case platform provides options for the enclosure features. This case platform is based on a configurable model, allowing it to be adapted easily to any desired height, width or depth. The cases consists of just a few individual parts that fasten together easily with two screws. The Interscale C platform can support ingress protection (IP) up to IP 30. The case's special interlocking design ensures an integrated EMC protection of 20 dB at 2 GHz. Different options are available for fastening various modules and components into the cases. A wide variety of options for different cutout dimensions, locations, powder coating / printing as well as a wide range of accessories and mounting options (wall-mounting, horizontal rails with lips, supporting feet, etc.) guarantees a high level of flexibility for every application.

Illustration: Modular case design

Advantages and disadvantages of modular case design vs. one-piece aluminum profile cases

Advantages	Disadvantages
Flexible dimensioning thanks to configurable CAD model	Higher costs
Easy to modify and adapt	Less rugged
Different cutouts for connectors available	
Customized paint finish	
Customized design	

Advantages and disadvantages of modular cases design vs. customized case design

Advantages	Disadvantages
Already tested and verified	Potentially unnecessary components and functions (such as EMC) are also included in the purchase
Flexible dimensioning thanks to configurable CAD model, less development complexity	Not optimized for large production quantities
Lower costs	
Lower certification risk	

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8. THE INTEGRATED COM EXPRESS SYSTEM

If you combine all of the individual modular components from nVent that have been outlined, you get a fully integrated, tested COM Express system including the COM module that may also be certified. The level of integration is specified by the user:

- Standard COM module + modular COM carrier + separate power supply, cooling and case
- Standard COM module + COM carrier developed in-house + separate power supply + SCHROFF cooling and SCHROFF case
- Standard COM module + modular COM carrier + SCHROFF power supply, SCHROFF cooling and SCHROFF case
- Etc.

Advantages and disadvantages of SCHROFF Standard COM system vs. in-house development

Advantages	Disadvantages
User can focus on their own core area of expertise	User may give up expertise and control
One supplier, one contact partner	Higher costs for larger quantities
Everything coordinated, tested and potentially even certified	Dependence on a supplier
Saves resources for the customer	
Individual Design	

Illustration: Integrated COM Express system

9. SUMMARY

The concept you select for designing a solution with a small form factor depends primarily on the quantity, complexity, project duration and long-term availability of the components in use. Ultimately, functionality and cost-efficiency (including consideration for later costs) determine the proper course of action.

One option, especially as a development tool in a laboratory and in projects with small to moderate production quantities, is the use of standard COM modules available on the market in combination with the modular SCHROFF COM carrier.

The carrier has been developed as a standard, allowing it to be adapted for many requirements and applications with appropriate add-on boards. In addition, other modular building blocks – power supply, cooling, case – supplement all other necessary components for a complete, functional system. The customer can also inquire into just certain subareas if desired, such as looking into just having a modular case solution. This concept of a modular standard platform reduces development time and costs regardless of the circumstances.

Author:

Christian Ganninger, born 1971, studied electrical engineering at the University of Applied Science in Karlsruhe, Germany. Subsequently, he worked as design engineer und technical coordinator backplanes and later as project manager backplanes & systems in a company, which develops and produces 19”-systems and backplanes. Since May 2005 he is Product Manager Backplanes at nVent. Later he took over the Product Management for MicroTCA, Power Supplies and Rugged Enhanced Systems too. After one year being Category Manager Systems EMEA in 2011 he took over the Product Management Systems EMEA. Since January 2014 he is Global Product Manager Systems.

More information about the COM Carrier here:
https://schroff.nvent.com/en/schroff/embedded-com-system

ABOUT ENCLOSURES

Electrical systems come in all shapes and sizes, from massive industrial controls to single components. nVent offers a comprehensive range of enclosures that house these vital assets. Marketed under the nVent HOFFMAN and SCHROFF brands, our enclosures offer two-pronged protection: safeguarding electrical equipment from the operating environment and people from electrical hazards. The nVent SCHROFF brand includes server cabinets, data center cooling solutions, power supplies and subracks and cases.

ABOUT nVent

At nVent, we believe that safer systems ensure a more secure world. We connect and protect our customers with inventive electrical solutions. nVent is a $2.1 billion global company that provides enclosures, electric heat tracing solutions, complete heat management systems, and electrical and fastening solutions. nVent employs 9,000 people worldwide.

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