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Technical Article

ADLINK COM Express® Type 7 Starter Kit and Module Lab Test

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Executive Summary

The ADLINK COM Type 7 Evaluation components were sent to us for review by ADLINK, who paid for the research. It was their option to use or not use our findings. We were asked to use our server systems review experience to characterize the COM Express Type 7 Starter Kit system as an embedded system component, with an emphasis on enterprise server-like networking performance measurements.

Our findings conclude that the system is well-optimized for networking throughput platform in the combination that we were sent for several contexts. We offer Background, Features, Testing, Summary, and How We Tested Sections that describe our findings.

Background

The ADLINK COM Express Type 7 architecture uses an ATX-size Type 7 Carrier board with a COM Express module along with varying processor subsystem and memory options that are intended to be used in embedded systems, rather than retail/end-user computing, although the components conceivably fit within the consumer or single board host/server space. ADLINK includes a number of components to make the process of designing embedded designs and reference models possible and maintainable. This open platform starter kit is offered to speed the steps of product life cycles.

ADLINK is a member of the PICMG® committee, and its designs reflect their adherence to several wellknown standards used by applications and design engineers. A listing of the Design Documents flash drive sent to us reflects a considerable measure of both physical description aids, as well as electronics/systems engineering manifests and sources that were used in the board design. This sum of information is dramatically different than those found in commercial server systems from the top two tiers of discrete server systems vendors, and we found the documentation pleasantly reminded us of our own engineering origins.

The COM Express Type 7components, we found, are designed for rapid prototyping, firmware composition, and design engineering prototyping used by designers, applications engineers, and other systems engineers seeking a generic Microsoft (via included UEFI and TPM features) or Linux/xBSD Intel Xeon-based multi-core platform.

We received an evaluation box containing the COM Express Type 7 Starter Kit Plus[1]. The kit is offered for systems architects and product engineering staffs, and the engineering kit allows the ADLINK components to become components of discrete systems. The box contained the chosen processor (Intel Xeon® D-1548 2GHz, 8 core/16 thread) board, carrier board, connecting cables, a MSi 210 Afterburner PCI bus graphics adapter[2], ATX mini power supply, a PCIe riser card adapter, an optional-and requested CPU heatsink, and two flash drives ("Live Linux" and "Design Documentation"), as well as a requested twin port 10 GbE PCIe adapter and appropriate cabling. ADLINK offers different processor, processor cooling, and networking adapters.



The COM Express Type 7 reference carrier board is an ATX form-factor board with integral PS/2 keyboard and mouse ports, twin SATA 6Gb/s ports, four USB 3.0/2.0 ports, a GbE Ethernet port, PCIe riser board, two RS-232C serial ports, as well as a debug board that attaches to the CPU daughterboard via a ribbon cable, which powers the debug board. The carrier board also supports SATA3, along with a long list of header connections for systems use (power on/off, reset, etc.) found in most ATX implementations.

The software sent included a fairly thorough documentation set, as well as a Live Linux flash drive. The Live Linux version is an adapted cut of the Yocto Project Linux edition ("Poky"), along with various Gnome-adapted IU/UX from Intel. The secret sauce, however, is ADLINK's Smart Embedded Management Agent/SEMA, which is in turn addressable/programmable with the included debug board.

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[1] Identified as Part # 50-1J092-1000 see What and How We Tested

[2] The MSi 210 is a 1GB DDR3, PCI-E 2.0, Direct X 10 with NVIDIA Geoforce GPU/integral fan

SEMA

The SEMA agent in turn connects with the Yocto Linux distribution (Broadwell-64 4.4.26 SMP kernel, in our case) and the underlying hardware to provide GUI-based information regarding hardware controls and monitoring, reading and writing the COM Express Type 7's user flash, I2C and GPIO bus monitoring, as well as system health. Although the debug board isn't needed to use the SEMA software, the debug board is a handy addition, we found, and the origins of the information are largely a function of the chosen CPU board.

Through the SEMA software, we found that it's also possible to update BIOS and BMC firmware. This also allows field service personnel to boot an alternate partition that does firmware upgrades where the files are either written to an accessible partition or loaded through the serial port as a remote program load/RPL.

SEMA GNOME-based UI and CLI utilities are available through the SEMA software to interact with pilot platforms and test compatibility (hardware identification, BIOS, Board Management Controller/BMC states, etc) through either the UI or CLI, but we found ourselves using the CLI versions more frequently.

We were also able to force the Xeon CPU into "High Performance" mode, then track performance of the Power Consumption and Temperatures (CPU and board temps) UI. Although we didn't use a maximum amount of bus and peripheral consumption, we were unable to push the temperatures over 42°C during our testing (in free air, and also in an ATX fan-driven case), even under max loads during network performance analysis. We could also watch voltages via the SEMA UI through varying cycles as well, including VCORE, VMEM, 3.3V line, 5VSB, (12V)VIN, 3.3SB, and V5LINE for fluctuations, although not graphically to coincide with other events, like CPU/board temperatures in the SEMA UI version.

The SEMA controller can additionally read S.M.A.R.T. hard drive information, although a S.M.A.R.T. drive needs to be attached; the solid state drives we used do not support S.M.A.R.T. drive API calls and so this functionality wasn't tested. Monitoring S.M.A.R.T. information can provide indications that drive subsystems are healthy or indicate possible failure via differing errors and accumulations of errors. Some engineers feel drive failure warnings (or alternately, indications of drive health) are useful for field deployed systems.

Those seeking to use SEMA information via an API or library call can be rewarded: Retrieving the messages through a daemon, then writing them to a syslog or remote syslog can be accomplished. It's up to other management application logic to deal with error conditions, or to separate information errors by elevating them to critical Windows Events, syslog errors, etc.

Yocto

The COM Express Type 7 system supplies the Yocto Linux's Poky distribution with the kit we were sent. The Yocto Project is an organization producing several Linux distributions. The Poky release includes is designed to be used with SBC/SBH as Poky includes OpenEmbedded Build System, which is designed to allow systems engineers use of GitHub-based OEBS layers and recipes, or port existing OEBS code to new platforms. The Yocto builds are also maintained at GitHub, and serves as the basis for the SEMA executables.

Applications engineers seeking to integrate the COM Express Type 7 into their designs can also take advantage of Yocto Project recipes, which are formulations of scripts to build both software layers, or entire images to be used with embedded systems solutions distributions; this also provides a pathway and methodology to patch/fix/update/port/maintain SBC/SBH infrastructure across a fleet of deployed systems.

Testing

We underwent three test sequences, general compatibility, host performance, and network performance tests. The Starter Kit in our arrived configuration (see How We Tested) scored as expected in basic performance, better than expected in network throughput, and was found to have average to good compatibility with various operating systems and hardware peripherals/boards/USB devices.

General Compatibility

We tested the COM Express Type 7 with the following operating systems for suitability in a nonexhaustive test, where all components of the ADLINK COM Express Type 7 were required to recognized by the hosted OS[3]:

Windows 7 SP2 Enterprise, Windows 10 Professional, Windows Server 2008 SP3/2016 CentOS 7, Ubuntu 16.04 (server editions), Live Linux/Yocto, NetBSD 7.1, VMware ESXi 6.5, FreeBSD 11.1

Windows drivers are contained on the supplied Design Documents flash drive. Windows 7 and Windows 2012 drivers that were supplied were unnecessary for Windows 10 Professional and Windows 2016 Data Center editions, respectively. Information regarding UEFI considerations are contained in the Design Documentation, along with the COM Express Type 7 TPM module, as well.

We mounted the COM Express Type 7 board both freely on our workbench, but also into two random ATX cases we had on hand. The supplied documents annotated the exact dimensions of the board and its mounting components, including drawings. Although

[3] The host OS was patched to all possible updates between October 25-27, 2017

we don't have robotic manufacturing equipment, we noted that the processor mounting as well as chassis mounting were repeatable in terms of screw torque needed. Mechanical drawings (often in 2D or 3D formats) are included for chassis designers.

The docs include board ORCAD design materials, mechanical drawings, images, bills of material, and layout info, Board Management Controller manual, SEMA-related manuals, and much more.

The motherboard contained all of the usual plugs that we'd expect for chassis use in a header located at one corner of the board. Both the debug board (itself connected via a 40 conductor flat cable) and the chassis have LED displays, as well as discrete LEDs indicating various states. The 10 GbE/SFP+ board also has LED indicators for various SFP+ module states.

The debug board LED module follows and displays codes specific to the board state from power-up through to a resting condition. LEDs include: circuit board reset pushed, circuit board power ok, We also tried common USB 2 devices to the board, as well as three SATAIII devices, and all were correctly found with Windows 10 and Ubuntu Linux 16.04.

Basic Compatibility

The Intel® Broadwell-DE chipset has eight cores, and sixteen threads, and is found in a number of ATX motherboard form factors; each SBC/SBH vendor implements chipsets in different ways resulting in similar results. HPE, as an example, uses the same Intel D-1548 chipset in its Proliant M510 chassis cartridge. The processor has a "turbo" mode, rising as high as 2.5ghz clock during our testing, when allowed to do so. The CPU has conservative power states, as well as power conservation states available as well. Whatever the speed/power state, all cores in this processor behave according to a single power attribute state attribute; there is no slowing down some cores over others. Power consumption natively is quite small, but will vary with differing peripheral card mixtures and user application options.

We used the maximum memory available, 8GB, for our tests. Ambient temperature/humidity/sinusoidal vibration testing was not performed, nor FCC/UL/CE or other compliance testing. Our lab is temperature and humidity controlled (20-30C, >78%relhum). Power source was 118-121VAC 60Hz as the US standard. NOC testing was performed in a highly controlled environment (23C, >30%relhum) at 121VAC/60Hz.

Performance [4]

We performed tests from OpenBenchmarking.org, also known as the Phoronix Test Suite using a booted image on a SATAIII Patriot Ignite 480GB SSD, running LinuxMint xfce 18.2 as a base operating system. We ran Phoronix DBench and SciMark2 tests; results are cross-posted to OpenBenchmarking.org at *https://openbenchmarking.org/result/1711015-TY-DBENCHALL63*.

Phoronix DBench Results

Client Count 1	70.28
Client Count 6	237.91
Client Count 12	442.29
Client Count 48	1094.57
Client Count 128	1616.27
Client Count 256	1464.43

The DBench benchmark is a test that in our way of thinking, combines a graduated number of network calls, per client against a single "tbench" server over a period of time, timing their results. Graduating the client count will reach a saturation for the server, as shown at Client Count 128. The score is very good for a 8-core (Linux counts them as 16 core, because it counts threads, not cores) processor.

Phoronix SciMark2 Computational Test Results

Composite	423.40
Monte Carlo	89.77
FFT	134.86
Sparse Matrix	448.55
Dense Factorization	584.61
Jacobi Relaxation	859.21

The SciMark2 benchmark tracks how a processor does math in a famous suite of complex math problems. It tests how fast the CPU and memory interact, as well as the floating point processing power of the CPU. It tests no disk or peripheral I/O. The results are good and typical for this family of Xeon processor at this speed. Rarely are the results for this combination faster.

These are good results overall, and not beyond the realm of expectation for the processor, CPU clock, and implementation. They are otherwise unoptimized, run at "performance CPU settings", and represent the first of several trials, all of which fell within a standard deviation of 1.5%.

Ethernet SFP+ Board Tests

The COM Express Type 7 kit supplied to us contained a 10 GbE ADLINK SFP+ card, which integrates two full duplex 10 GbE links. We inserted two 10GB fiber SFP+ fiber connectors to the board and proceeded to test it against our Extreme Summit Series 10 GbE Full Duplex Switch fabric. The Extreme Switch was then connected to our NOC infrastructure, consisting of several Ubuntu 16.04 Server VMs running under VMware 6.5.

[4] See How We Tested

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There are two 10 GbE FDX connections and we tested them independently, and then we tested them together under both the Yocto Linux and Ubuntu Server 16.04. The chipset used, the Inphi CS4227, is known for low latency, and four channel (two out, two in) operation via its two connectors.

As a single board host/SBH, the COM Express Type 7 system fits in a confined, ATX-form factor, and it's capacity for networking throughput is gargantuan compared to its comparatively small DD3 memory maximum size. Matching the networking throughput (2x 10 GbE + 1x mainboard GbE), we thought of NFV applications. This is could be possible through combinations of Openstack with applications like Docker container-based Quagga and NVF containers.

We tested and found connection latencies as low as 8ns where the circuit was a 10m link of fiber, through the switch, and back to the COM Express board as evidenced by a GNU/Linux ping test.

Netperf was used to perform optimized traffic analysis tests on the board. We disabled the Linux firewall using the Live Linux/ Yocto implementation we received from ADLINK, and connected the interfaces through the aforementioned Extreme Switch to a Lenovo x3550 M5 server via direct IPv4- IPv4 addressing, each 10 GbE port having a separate IPv4 address, for 10 seconds.

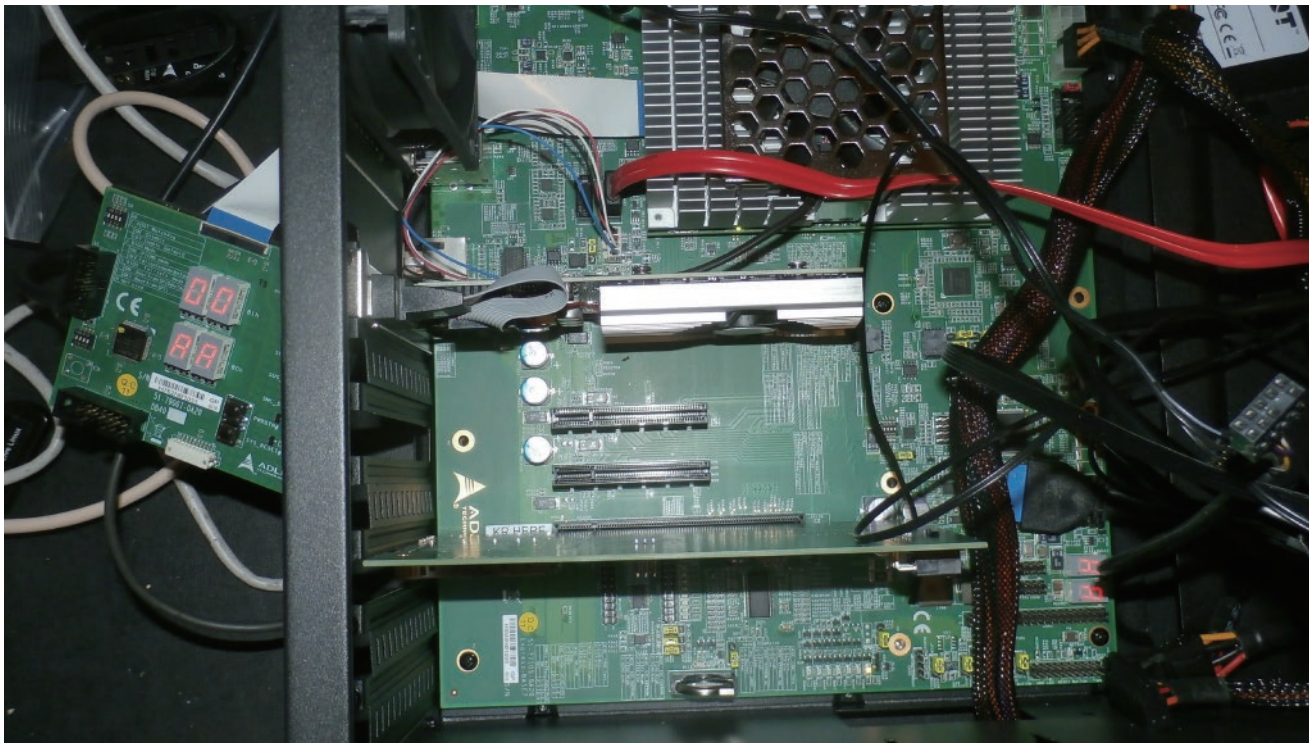
Netperf Results

TCP_STREAM	THROUGHPUT	681,372,828 BYTES/sec
UDP_STREAM	THROUGHPUT	622,691,230 BYTES/sec

We caution the reader that these are optimized throughput numbers, and do not reflect other important network qualities/qualifications, but are impressive nonetheless. Much network throughput is contingent on other device and OS/OS configuration qualities.

Applications Observations

The strong performance of networking, coupled to a well-documented, Xeon-based COM Express Type 7 system, lends itself to possible medical, telecom, industrial, server farm, and other applications where the limitations of the board can be accommodated. These limitations are in maximum user memory (8GB), PCIe bus architecture, SATAIII ports (fast, but not SAS), along with the mix of system boardbased standard IO ports. With the addition of an ASIC, FPGA, or GPU board, block chain is easily possible, as well. For many, these limitations won't be confining.



This is the COM Express Type 7 Module we tested, inside and ATX case. Please forgive our spaghetti.
We hope systems developed from this starter kit will be designed with cleanliness in mind - TH

Summary

ADLINK supplies many tools with the COM Express Type 7 Starter Kit to enable systems designers to do their job, including a very reasonably performing COM Express/ATX-based systems, and industry standard components. Their secret sauce is the SEMA software, Yocto prototyping and provisioning environment, ease of initial provisioning and firmware modifications, coupled to the ability to keep up with a wide variance of network challenges. The supplied documentation was strong and complete for the needs of applications and design engineers, we felt. We found the system to be highly compatible with mainstream OS platforms, and chassis mounting. It's a surprisingly open system, enhanced by thorough documentation.

As an embedded system single board computer/single host computer, there are few limitations, including maximum system memory, a maximum of CPU sixteen threads, and lack of Serial Attached SCSI (SAS), and perhaps, too few full-lane PCIe bus slots (although there is a riser/extender included). There's a lot to the COM Express Type 7 System, and much is crammed into the system's density. The tools to do the job are included, and ADLINK engineers were available to assist.

How We Tested

We tested the COM Express Type 7 Starter Kit in our lab in Bloomington Indiana, and at our NOC at Expedient, in Carmel Indiana. The lab contains a wide amount of consumer and server hardware in a 10 GbE network. The NOC is in a data center connected through a 10 GbE switch fabric, including four 24-port Extreme Summit Series switches.

OS Compatibility tests were performed using flash drives containing bootable ISOs of each of the images tested. We booted each OS, noting any unfound or misidentified hardware (there was none). Where necessary, we used a Ignite Patriot 480GB SATAIII SSD as the target hard drive for the OS under test.

About ExtremeLabs, Inc.

At ExtremeLabs, Inc. our engineers test systems software and hardware in the enterprise computing systems space for public and private consumption (search term: "henderson extremelabs -nv"). We also perform product QA and first article testing, investor technical due diligence, and publish technical essays and product reviews. Located in Bloomington Indiana, USA, ExtremeLabs also covers systems infrastructure, networking, mobile networks, systems security, cloud infrastructure, blockchain, and community communications infrastructure.

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