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WHITE PAPER

SBC8 - A Radiation Tolerant Single Board Computer That Adapts For All Your Satellite Mission Needs

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Abstract— *The Satellite and Space Industry has changed dramatically in the last 5-10 years and continues to evolve at a rapid pace. Launch costs are declining, satellites are getting smaller, and many more satellites are being launched every year. At the same time, development times are being drastically cut and budgets are being slashed. The days of taking 10 years to develop a large, GEO, billion-dollar satellite, are all but replaced by 2-year cycles of development with only incremental feature growth in future generations of a similar satellite.*

So, how can your company keep up with the demand for functionality and deal with compression of schedules and budgets?

One powerful way is to focus less on hardware development and focus on your company's area of expertise, your "special sauce". Focus your engineering effort on the firmware and software that gives your satellite or mission a distinct edge over your competition and reuse as much of that as is possible for future missions. This may best be achieved by employing the same hardware platform across many projects throughout your company. To do this you need to have a powerful and stable hardware platform that meets your immediate needs but has the adaptability to evolve as your missions mature.

With that in mind, Frontgrade Technologies has developed our Generation 8 Single Board Computer (SBC8) to be a powerful and extensible computing platform in a small and industry standardized form factor. This allows you to use SBC8 for many projects and missions, allowing your engineering team to really understand the hardware and reuse your special software and firmware to the greatest extent possible. SBC8 is packed with interfaces and features, but also allows the development of mission ready mezzanine cards to personalize the hardware capabilities of the SBC without redesigning the core processing element, the base SBC.

Keywords—*Single Board Computer, SBC, SpaceVPX, VPX, XMC, Mezzanine, GR740, CertusPro-NX, FPGA*

INTRODUCTION

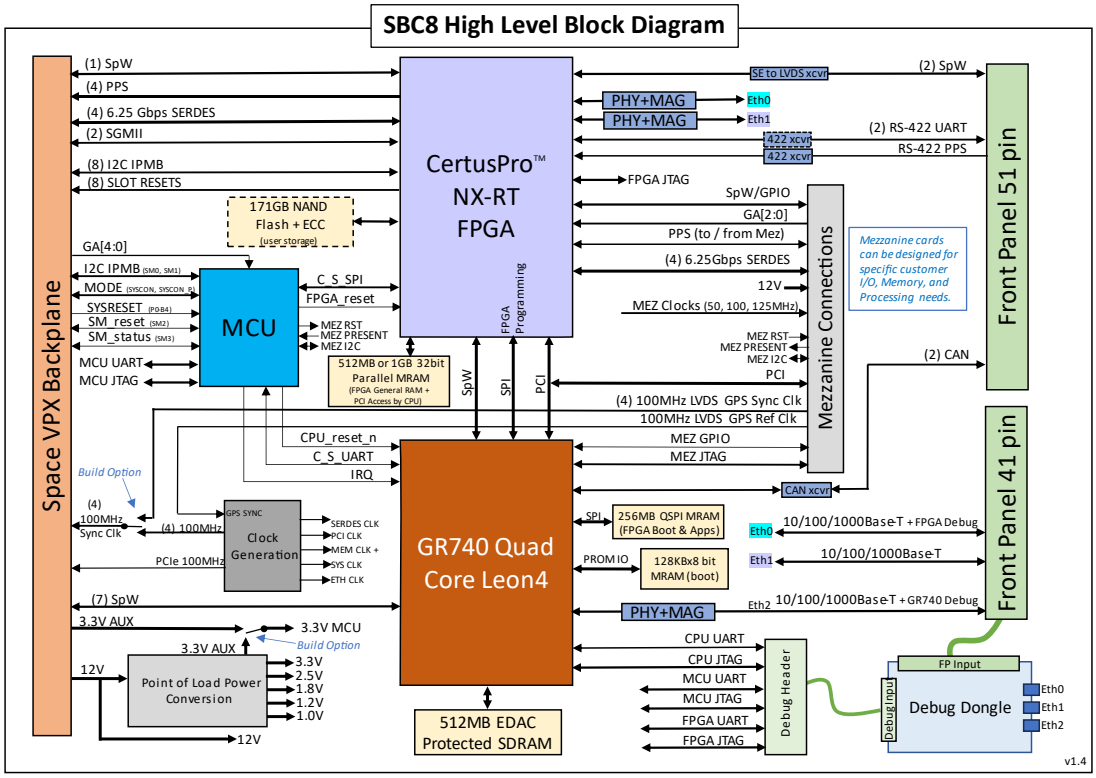
The Frontgrade Generation 8 Single Board Computer (SBC8) is anchored by the latest, fault tolerant, flight proven, quad-core SPARC V8 Processor that can provide up to 1800 DMIPS of processing power (Gaisler GR740). This powerful processing engine is paired with our latest Low Power, High Performance, Radiation Tolerant CertusPro-NX-RT FPGA. SBC8 provides 512MB of Reed-Solomon EDAC protected SDRAM directly connected to the GR740 processor along with 256MB of Dual-QSPI MRAM for application and user storage. Additionally, SBC8 provides up to 1GB of expansion persistent RAM (MRAM) available via PCI transactions from the GR740 through the Frontgrade CertusPro-NX-RT FPGA. All told, the SBC8 implements a robust memory architecture based on highly reliable, space assured memories, yielding a total of 512MB volatile SDRAM and up to 1.25GB of non-volatile MRAM. SBC8 also optionally includes up to 171GB of EDAC Corrected Non-Volatile User Data Storage.

This combination of processing, storage, and programable logic makes the SBC8 a powerful and flexible Single Board Computer that can easily handle your Command and Data Handling mission needs. The

"superpower" of the SBC8 is the inclusion of an XMC Mezzannine connector set with direct interface capabilities to the GR740 processor and the CertusPro-NX-RT FPGA. The ability to include mission specific mezzanine cards on the SBC8 platform gives SBC8 the ability to adapt to mission needs that are not directly handled on the base SBC with minimal hardware development. Do you need more or different interfaces? Do you need more processing power? Any mezzanine you can envision can be directly accessed from the GR740 via the PCI bus or via SpaceWire and SERDES connections to the CertusPro-NX-RT FPGA that also is accessed over the PCI bus. Reuse your Firmware and Software base code across many satellite missions but give yourself the ability to add precise mission features without extensive hardware development.

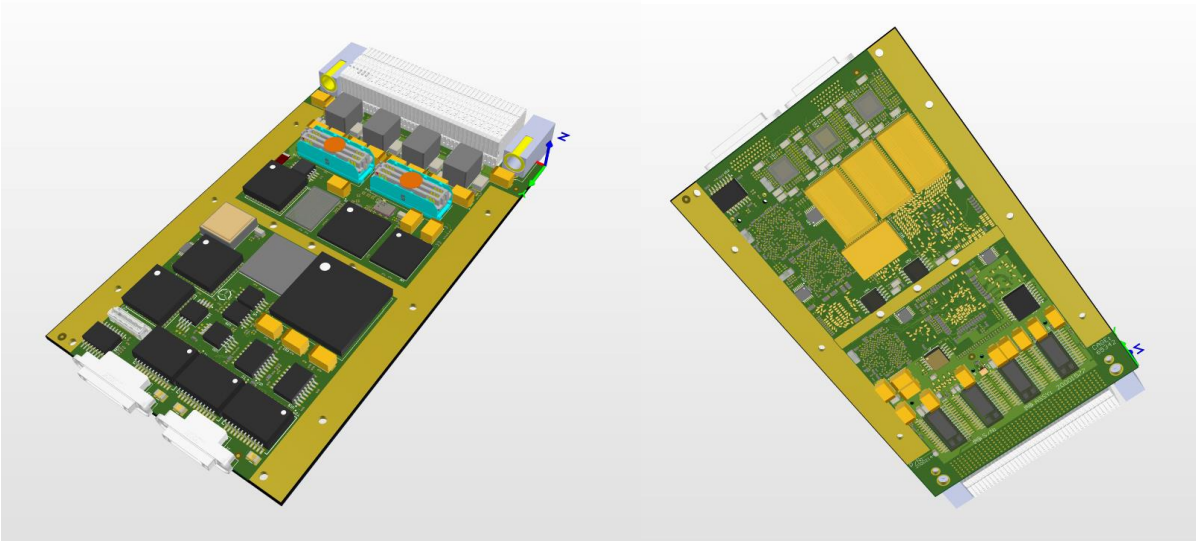
BASE SBC8

The Generation 8 Single Board Computer (SBC8) was designed to fit into a compact 3U SpaceVPX form factor targeted at a SpaceVPX Controller profile (Slot Profile: SLT3-CON-8T-14.6.2 and Module Profile: MOD3-CON-8T8U-16.6.2-1-16.12). As shown in the Block Diagram below, SBC8 has the ability to control (via the SpaceVPX IPMB Bus and Resets) up to 8 other cards in the same chassis and can communicate to the spacecraft bus or other peripherals via Spacewire, 1000Base-T Ethernet, RS-422 UART or CAN Bus on



the front panel. SBC8 also has 4 lanes of 6.25Gbps SERDES, 8x Spacewire, and SGMII Interfaces on the Backplane to communicate or pass data to other cards in the box. The Backplane SERDES originates from the CertusPro FPGA and so you can implement many protocols including PCIe to communicate to items

like a Mass Memory Unit (MMU) across the backplane. Following is a full list of standard interfaces on the SBC8 backplane and front panel connectors.



SBC8 Top & Bottom Views

Front Panel Interfaces

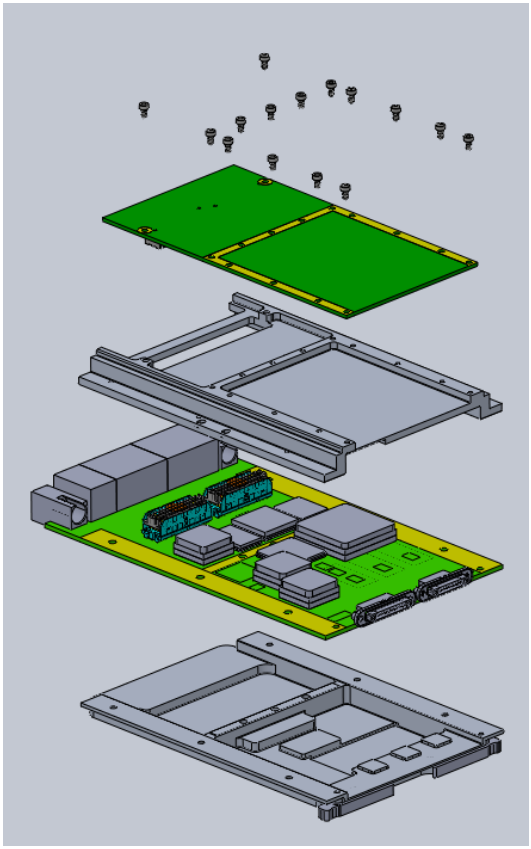
- 2x SpW
- 3x 10/100/1000Base-T Ethernet Ports
  - 2x FPGA connected with 1 that also operates as an Ethernet Debug Port
  - 1x CPU connected (user + debug)
- 2x RS-422 UARTs
- 2x CAN
- PPS Input (RS-422)

Backplane Panel Interfaces

- 8x SpW
- 4 lanes multi-purpose SERDES (6.25Gbps)
- 2 lanes of SGMII SERDES
- 8x I2C for IPMB
- 8x Slot Resets for other boards in the chassis
- 4x PPS Outputs
- 4x 100MHz Sync Clk Outputs (can come from on board clock or GPS Reference clock implemented on a Mezannine)
- PCIe 100MHz Clk Output
- SpaceVPX Controller (Slot Profile: SLT3-CON-8T-14.6.2 Module Profile: MOD3-CON-8T8U-16.6.2-1-16.12)
- 12V Power Input (with optional 3.3V Aux usage)

MEZZANINE CAPABILITIES

Like the Backplane, the XMC+ mezzanine has 4 lanes of 6.25Gbps SERDES that can be used to communicate to a mission specific backplane, but it has much more. The mezzanine has the same shared PCI bus that the GR740 uses to communicate with the CertusPro FPGA, allowing the mezzanine to implement another PCI device and be directly controlled by the CPU. The mezzanine interface has also been designed to allow a Precision GPS clock generation circuit to feed sync clocks to up to 4 backplane slots. The possibilities are almost endless. Below is a list of the Mezzanine interfaces available, followed by some mezzanine concepts our customers have asked for or are in development already.



Exploded SBC8 / Blank Mezzanine View

Mezzanine Interfaces

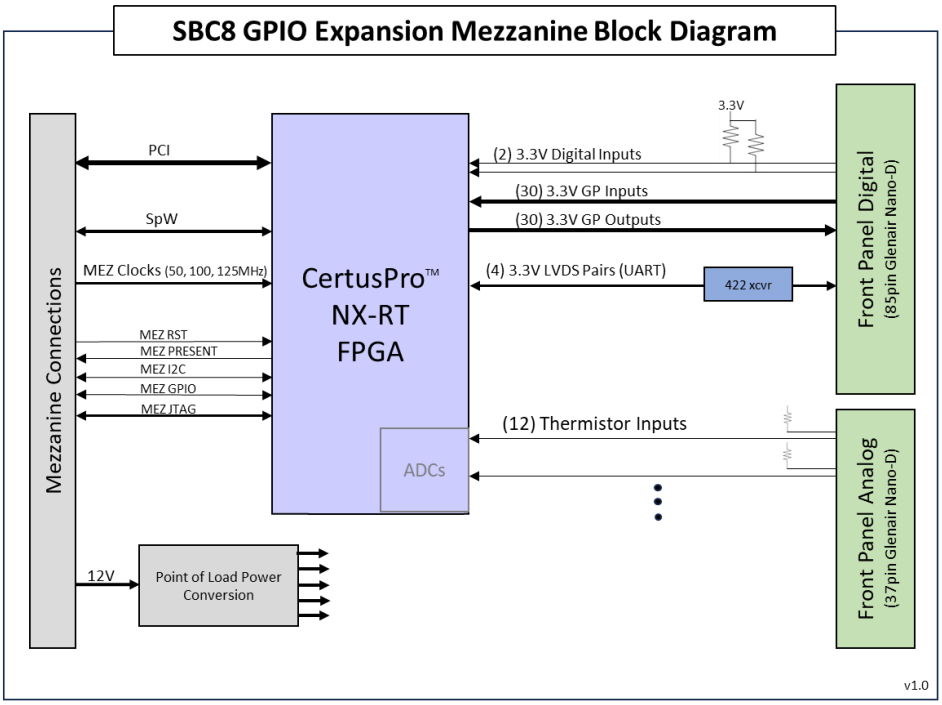
- PCI
- 4 lanes multi-purpose SERDES (6.25Gbps)
- SpW (can also be used as 4x LVDS GPIO or 8 SE GPIO)
- 1x GR740 GPIO
- PPS to/from Mez
- 4x Differential 100MHz Sync Clk from Mez + 1x Differential from Mez to Clock Network Manager
- 50MHz, 100MHz and 125MHz Clocks to Mez
- Mezzanine JTAG (to program FPGAs on Mez) – can be used as GPIO

MEZZANINE EXAMPLE: GENERAL PURPOSE I/O EXPANSION

Maybe the simplest and most useful mezzanine for SBC8 is one that easily expands the interfaces available to personalize them to your mission specific needs. Below is a concept block diagram of such an expansion card. The FPGA is directly connected on thee GR740 PCI bus allowing direct control of the interfaces. A variation of this card with different interfaces for your mission can be easily developed from our base mezzanine design template by your engineers or Frontgrade's team.

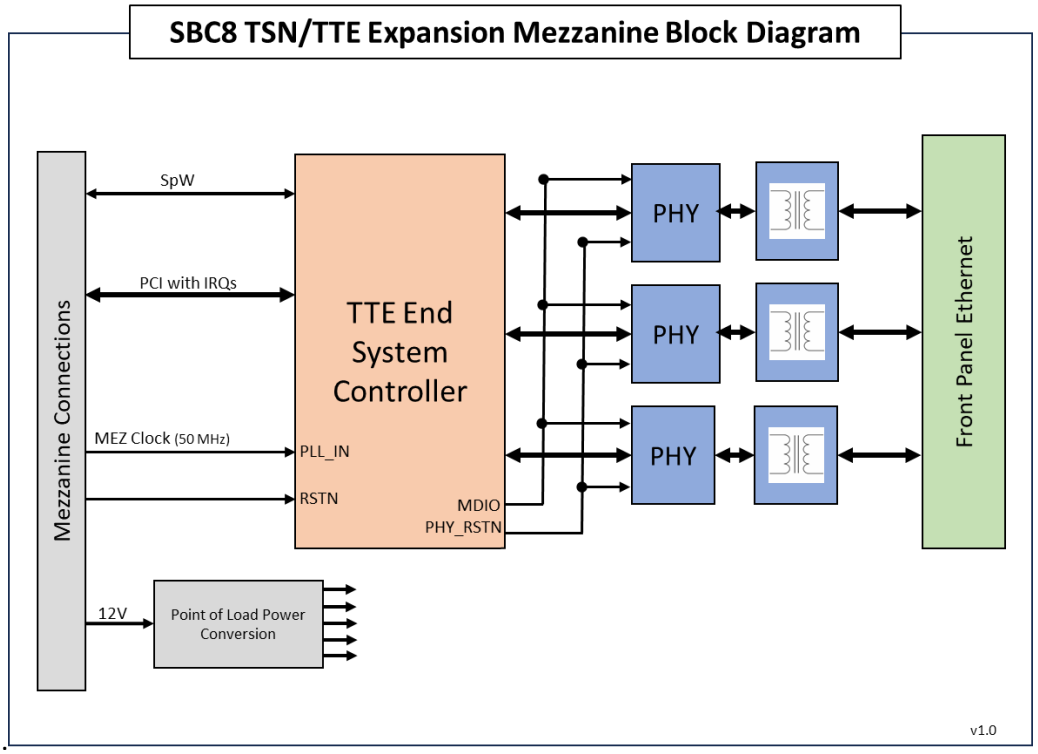
Front Panel IO
(2) 3.3V Digital Inputs
(active low – 10K pull-up)
(30) 3.3V GP Outputs
(30) 3.3V GP Inputs
(4) RS-422 LVDS Pairs
(12) Thermistor Inputs

Mezzanine Interface to SBC8
PCI
12V Power



MEZZANINE EXAMPLE: TSN/TTE ETHERNET EXPANSION

Does your satellite C&DH computer need to employ Time-Sensitive Networking (TSN; IEEE 802.1Qbv and others) or Time-Triggered Ethernet (TTE; SAE AS6802) to add determinism to the on-board ethernet network operations? The Frontgrade SBC8 Single Board Computer was designed to easily integrate a TTE-End System Controller ASIC from a leading authority on TSN/TTE on to a mezzanine that will provide three TSN/TTE Ethernet ports capable of up to 1Gbps. The SBC8 mezzanine connections were expressly configured to directly interface with this ASIC over our PCI bus with the GR740 to expand the SBC8 Ethernet capabilities to be a true TSN//TTE Endpoint.



MEZZANINE EXAMPLE: GPS SYNC/PRECISION TIMING MODULE

Does your mission design require synchronization of operations throughout a constellation or even just among the systems on the satellite? The SBC8 has been designed to allow for a mezzanine card that can accept PPS and 10MHz GPS references and generate a high precision synchronization clock to trigger or synchronize the operation of anything that is in the box or external. The mezzanine has access to 4 differential clock pairs that can be driven with a reference/sync clock and it also has the capability to synchronize its internal clocks to a reference from a mezzanine. PPS can be shared with the FPGA and that device can create up to 4 separate PPS signals to be used by backplane cards also. Alternatively, if your system is only looking for a reference/sync clock inside the box and not needing that to be directly tied to a GPS reference, that is already built into the base SBC8. The on-board clock system has up to four 100Mhz clocks that can be sent to the backplane to be used by other slots as needed.

CONCLUSION

To maintain pace with your customer needs, including short schedules and budgets, it may sense for your company spend less time on developing hardware and focus your team's skills on those things you do so well and that can set you apart from your competition. The SBC8 and other hardware developments ongoing at Frontgrade Technologies might be great off-the-shelf building blocks that you can use for your current and future products.

If you would like more information on SBC8 or any other Mission Processing Building Blocks that Frontgrade offers, contact Tim Meade, Product Manager Mission Processing, 719-235-0842 Tim.L.Meade@Frontgrade.com.