

# ISR Video Processing System

For Surveillance and Targeting Image Processing

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## Key Features

- High performance image processor
- CHAMP-XD2M DSP
  - + Intel Xeon 16-core D-1587 @ 1.7 GHz
  - + 870 GFLOPs with AVX2
  - + 128 GB DDR4 memory
- VPX6-4941 GPGPUs
  - + NVIDIA Quadro Maxwell-2 GM204
  - + 3.0 TFLOPS, 1536 CUDA Cores
  - + 8 GB GDDR5, 128-bit wide bus
- Xilinx Kintex-7 FPGA Frame Grabber
  - + 4 x HD-SDI digital video inputs
  - + 2 x RS-170 analog video inputs
- RMC
  - + COTS 2.5" SSD Flash to 4 TB
- Fabric40 10GBaud backplane
- Qualified to MIL-STD-810/MIL-STD-461

## Applications

- Aerial Reconnaissance
- 360° Situational Awareness
- Precision Targeting

## Products included in the system:

- 2 x VPX6-483M CHAMP-XD2M DSPs
- 2 x VPX6-4941 GPGPUs
- 2 x XMC-4701 Video I/O XMCs
- 2 x Removable 4 TB SATA SSD drives

## Overview

Curtiss-Wright's ISR Video Processing System (VPS) combines leading edge technologies in Intel® multi-core CPUs, NVIDIA® GPGPUs, and Xilinx® FPGAs to provide users with powerful signal processing capabilities in a compact, embedded 6U VPX format. The VPS processing engine is applicable to a variety of image-based targeting and surveillance systems.

The VPS incorporates two Intel Xeon® D 16-core DSPs, each outfitted with 128 GBytes of DDR4 memory, providing a total of 1740 GFLOPs of AVX2 vector peak performance. There are two graphic processing modules each with a NVIDIA Quadro® Maxwell-2 GPGPU for almost 6 TFLOPS of CUDA® signal processing (option to upgrade to NVIDIA Quadro Pascal GPGPU).

The two Xilinx® Kintex®-7 FPGA Frame Grabber XMCs provide the VPS with flexible image capture interfaces in a variety of digital and analog formats. There are two removable memory cartridges (RMC) with SATA 3.0 interfaces that provide up to 8 TB total solid state disk (SSD) Flash storage. The VPS supports Gigabit Ethernet, serial ports, USB, and a variety of discrete interfaces.

The compact VPS system is packaged in a rugged 5-slot 6U OpenVPX™ MPMC-965x Multi-Platform Modular Computer (MPMC). Besides the GPGPU and DSP modules, there is a spare slot for additional functionality to meet customer application requirements. The MPMC-965x's two fans cool the high performance modules and a top hat holds the two RMC cartridges.

The VPS is a rugged compact high performance image processor with flexibility to interface with multiple simultaneous video input channels in a variety of image formats. It provides teraflops of vector image processing that was not previously available in much larger systems.

## System Description

The Curtiss-Wright ISR Video Processing System (VPS) is packaged in our 6U OpenVPX 5-slot MPMC-965x chassis. It incorporates two CHAMP-XD2M DSPs and two VPX6-4941 GPGPU modules for high performance image processing with a spare slot for additional capabilities. Video input is provided by two XMC-4701 Frame Grabber XMCs hosted on the CHAMP-XD2M. There are two 2.5" SSD removable drives with up to 4 TB storage each in slots provided by the MPMC-935x.

The Frame Grabber XMC, powered by a Xilinx Kintex-7 FPGA, can provide multiple video inputs in a variety of formats. The VPS accepts four digital HD-SDI and two analog RS-170 video inputs. The frames are captured and transferred over the XMC's 4-lane PCI Express® (PCIe) Gen2 data interface to the DSP.

The two sets of DSPs and GPGPUs work in tandem on the image input. Data is transferred between the processors over a 16-lane PCIe Gen3 expansion plane interconnect. Each pair has 870 GFLOPs and 3.0 TFLOPs of AVX2 and CUDA peak parallel processing available respectively, as well as hardware accelerators for video encode. The VPS has no video output though both the XMC and GPGPU are capable of supplying outputs in a variety of formats.

The two CHAMP-XD2Ms are interconnected on the data plane with 40GBase-KR4 Ethernet. The control plane between the two is 10GBase-KR. Each DSP has an additional 40G and 10G interface that could be routed to the module in the spare slot. There is a SATA 3.0 interface to a RMC SSD data drive for each DSP. Different COTS SSD hard drive products can be incorporated to support a variety of capacities and features such as encryption and secure erase.

System power is provided by a COTS VITA 62 28V 800W power supply. It is MIL-STD-704 and MIL-STD-461 compliant with input EMI filtering, in-rush current limiting, reverse polarity protection, and current, voltage, and temperature protection.

The VPS provides Ethernet, serial, and USB communications as well as discrete interfaces. On the front panel each of the DSPs has one 10/1000/1000Base-T, EIA-232, EIA-422, and USB 2.0 interface.

Each CHAMP-XD2M has sixteen general purpose digital I/Os. The VPS front panel supports a variety of discrete interfaces that can be customized for specific systems. Curtiss-Wright's VPS provides the conversion, conditioning, isolation, feedback, and BIT test circuitry for 1PPS, 28V, open/ground, normal closed or open switches, and TTL interfaces.

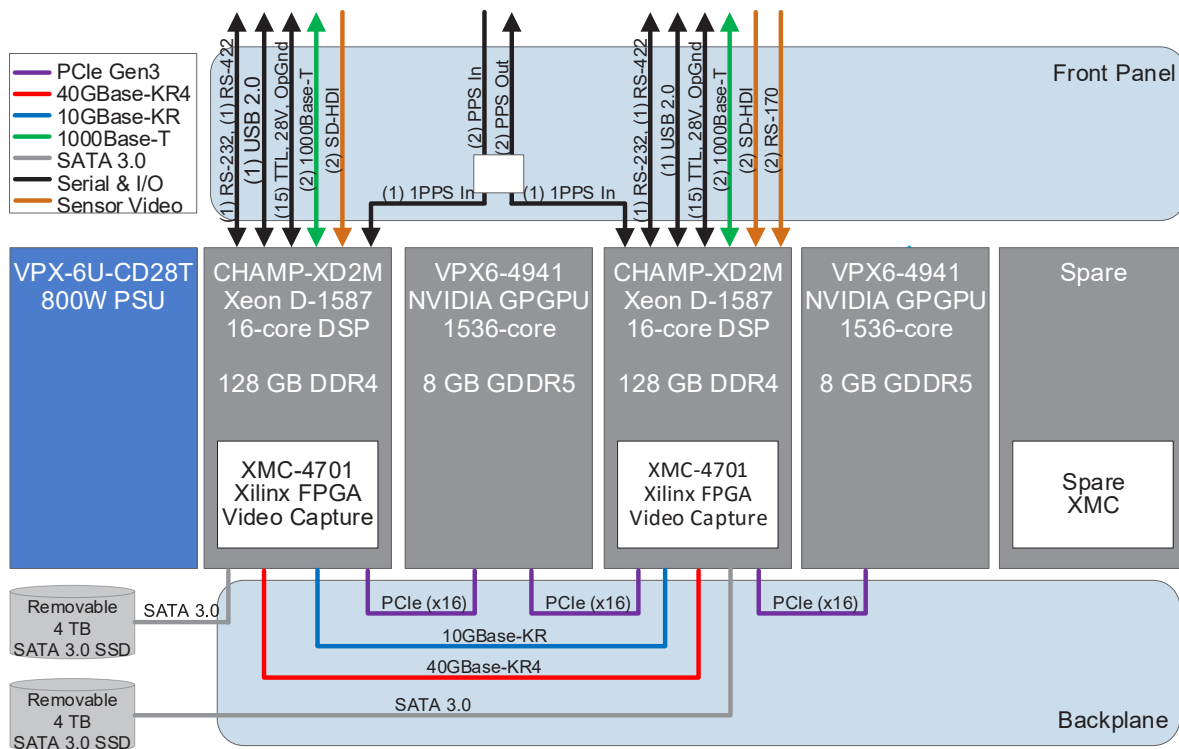


Figure 1: VPS System Diagram

## CHAMP-XD2M DSP (VPX6-483M)

The CHAMP-XD2M DSP card is designed for High Performance Embedded Computer (HPEC) systems. It has a 16-core Intel Xeon D-1587 processor operating at 1.7 GHz with peak AVX2 peak performance of 870 GFLOPs. It comes configured with up to 128 GBytes of ECC DDR4 dual channel memory with >34 GBytes per second bandwidth. Non-volatile memory includes 16 or 32 GBytes SATA NAND Flash, 16 MBytes SPI Flash, and 512 Kbytes NVRAM.

The CHAMP-XD2M features cutting edge bandwidth that includes the following interfaces: four 40GBase-KR4 or InfiniBand® data plane, two 10GBase-KR or 1GBase-KX control plane, one 1000Base-T Ethernet, two SATA 3.0, two USB 2.0/3.0, and PCIe Gen3 expansion plane. Its core function FPGA provides serial UARTs, discrete interfaces, a watchdog timer, and six general-purpose timers. The module's XMC mezzanine site is designed for up to 25 watts of thermal dissipation.

It is supported by a suite of firmware, Operating Systems (OS), communication APIs, and signal processing libraries. Operating systems include CentOS Linux and Red Hat® Enterprise Linux®. Communications support includes MPI and OFED. Available vector math libraries include VSIPL, FFTW, and others. Curtiss-Wright's OpenHPEC™ integrates proven supercomputer industry tools in a development suite to simplify application deployment.

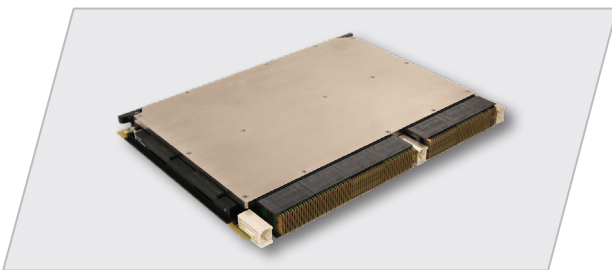


Figure 2: 6U OpenVPX High Memory Capacity Intel Xeon D Processor Card

### Processor

- Intel Xeon D 16-core with AVX2
- 870 GFLOPs @ 1.7 GHz
- Integrated Platform Controller Hub (PCH)
- Intelligent Platform Management Interface (IPMI)

### Memory

- 128 GBytes DDR4 @ 2133 MTs (34 GBytes/sec)
- 16 to 32 GBytes NAND FLASH
- 16 Mbytes SPI BIOS Flash / 512K NVRAM

### Interfaces

- (4) 40G/10G Ethernet or InfiniBand data plane
- (2) 10GBase-KR or (2) 1GBase-KX control plane
- (2) x16-lane PCIe Generation 3 backplane fabric
- (1) 1GBase-T, (4) EIA-232, (2) EIA-422/485
- (2) SATA 3.0, (2) USB 3.0/2.0, (16) GPIO
- (1) VITA 46.9 XMC site with x8 PCIe Gen3

### Software

- CentOS and Red Hat Enterprise Linux
- TrustedCOTS Security
- OpenHPEC Accelerator Suite

## VPX6-4941 GPGPU

The VPX6-4941 graphic processor, developed by our GPU graphics solution partner Wolf Advanced Technology, brings impressive performance for imaging applications. It incorporates one or two NVIDIA Quadro Maxwell-2 1536-core GPGPUs (VPS configuration is a single GPGPU) each providing 2995 GFLOPs peak parallel processing performance. The Maxwell-2 includes a dedicated NVIDIA NVENC (H.265) and (H.264) hardware accelerator for independent video compression encode.

The VPX6-4941 supports GPUDirect DMA technology which allows devices to write directly into the GPGPU's memory. Each GPGPU has 8 GBytes of 256-bit wide GDDR5 graphics memory providing 147.2 GBytes/second bandwidth.

Each module has four x8 PCIe Gen3 data interfaces configurable to x16. There are 4 DisplayPort™ 1.2 outputs supporting video of 4K at 60 Hz with 10-bit color.

The VPX6-4941 is supported by the CUDA Toolkit 9.0 parallel processing development environment with support

### Processor

- Single or dual NVIDIA Quadro Maxwell-2 GPGPU
- 1536 CUDA cores, 2995 GFLOPs
- NVIDIA NVENC (H.265)/(H.264) hardware encode
- Configurable operating power

### Memory

- 8 GBytes 256-bit wide GDDR5 ECC memory
- 147.2 GBytes/second with NVIDIA GPU Direct DMA

### Interfaces (VPS does not bring out video outputs)

- (2) x16 or (4) x8 PCIe Gen3 data interfaces
- (2) DisplayPort 1.2, (1) DVI, (1) VGA video outputs

### Software

- Windows and Linux drivers with Compute Capability 5.0
- With support for OpenCL 1.2



Figure 3: VPX6-4941 – 6U VPX GPGPU Processor with NVIDIA Quadro M5000SE

## Upgradeable to VPX6-4943 GPGPU

Curtiss-Wright is planning to upgrade the VPS's VPX6-4941 graphics processor to its VPX6-4943 GPGPU product. The VPX6-4943 incorporates NVIDIA Quadro Pascal P5000 GPGPUs, an enormous leap in processing power compared to the previous generation Maxwell M5000SE GPGPU. The VPX6-4943 provides twice the processing performance with its 2048 CUDA cores, twice the GDDR5 memory with increased bandwidth, and twice the number of video outputs with the capability to support high dynamic range (HDR) video.

### Processor

- Single or dual NVIDIA Quadro Pascal P5000 GPGPU
- 2048 CUDA cores, 6200 GFLOPs each
- NVIDIA NVENC (H.265) and AVC (H.264) encode/decode
- Configurable operating power

### Memory

- 16 GBytes 256-bit wide GDDR5 ECC memory each
- 192 GBytes/second with NVIDIA GPUDirect DMA

### Interfaces (VPS does not bring out video outputs)

- (2) x16 or (4) x8 PCIe Gen3 data interfaces
- (8) DisplayPort 1.4, High Dynamic Range (HDR) support
- 4K @120 Hz or 5K @ 60 Hz 10-bit color

### Software

- Windows and Linux drivers with Compute Capability 6.0
- With support for OpenCL 1.2



Figure 4: VPX6-4943 - 6U VPX GPGPU Processor with NVIDIA Quadro Pascal P5000

## MPMC-965x 6U VPX Rugged Enclosure

The MPMC-965x Multi-Platform Modular Computer (MPMC) has five 6U VPX slots (two populated with CHAMP-XD2Ms, two with VPX6-4941 GPGPUs, and one spare) with up to three XMC sites. The enclosure is designed to meet the temperature, altitude, voltage spikes, shock, vibration, and other harsh requirements of military computing applications environments.

The enclosure's design incorporates several unique features optimized to allow VPS modules to be able to run at full performance. Circuit cards have custom adaptor heat frames mounted with a structural and thermal adhesive to the COTS heat frame. Two lightweight 3.5" brushless fans, with finger guards, provide the forced airflow through cooling. VITA 46 multigig connectors interface to the backplane and SATA cables connect the two RMC SSDs located in the enclosure top hat. All slots are uniquely keyed per module.

The MPMC-965x has been designed to meet or surpass MIL-STD-810 Qualifications for Military Equipment for Airborne Equipment. Circuit cards installed in the sealed chassis are completely isolated from external environmental conditions such as humidity, dust and sand. Proper bonding design and the use of isolation materials such as EMI gaskets are used to ensure EMI / EMC compatibility to MIL-STD-461E. See the environmental and EMI tables for qualification test details.



Figure 5: ISR Video Processing System

### Chassis features

- 5-slots 6U VPX, 3 XMC sites
- Two lightweight 3.5" fans
- Integrated handle
- SSD SATA RMC top hat

### SWaP

- Size (L x W x H) : 14.83" x 14.38" x 10.68"
- Weight: 59.32 lbs.
- Power: 575 watts

### Power

- COTS 28V 800 watts power supply
- MIL-STD-704 Aircraft Electrical Power

### Interfaces

- Front panel I/O conversion, relays, drivers, isolation
- MIL-DTL-38999 I/O connectors

### Environmental / Electromagnetic

- MIL-STD-810F Environmental Engineering
- MIL-STD-461E Electromagnetic Compatibility
- MIL-STD-1472 Human Factors Engineering



## Environmental Qualifications

TABLE 1		EMI Qualification Tests
TEST		MIL-SPEC
28V Power		MIL-STD-704
Bonding test		< 2.5 milliohms
Emissions	Conducted	Power leads, 10 KHz to 10 MHz > MIL-STD-461E, CE102
	Radiated	Electric field, 2 MHz to 18 GHz > MIL-STD-461E, RE102
Susceptibility	Conducted	Power leads 800 Hz to 150 KHz > MIL-STD-461E, CS101
		Bulk cable injection, 10 KHz to 200 MHz > MIL-STD-461E, CS114
		Bulk cable injection, impulse excitation > MIL-STD-461E, CS115
	Damped sinusoidal transients, cables and power leads, 10 KHz to 100 MHz > MIL-STD-461E, CS116	
Radiated	> MIL-STD-461E, RS103	
Electrostatic Discharge Protection		> MIL-STD-1686C

TABLE 2		ENV Qualification Tests
TEST		MIL-SPEC
Temperature	Operating	-29°C to +12°C at 8000 ft.
	Storage	-40°C to +71°C
Altitude	Operating	Sea level to 16,000 ft.
	Storage	Sea level to 35,000 ft.
Shock	Crash Hazard	MIL-STD-810G, Method 516.6 Procedure V
	Bench Handling	MIL-STD-810G, Method 516.6 Procedure VI
Vibration		C72-1100-110 for Zone 4
Humidity		MIL-STD-810G, Method 507.5 Procedure I, Cycle B1
Waterproof		MIL-STD-810G Method 506.5 Procedure III
Salt Spray		5% NaCl per ASTM B117 500 Guidebook Spiral 3 appendix D
Sand and Dust		MIL-STD-810G Method 510.5 Procedure I
Fungus		MIL-STD-810G, Method 508.6

## XMC-4701 Frame Grabber XMC

The XMC-4701 is a versatile video Frame Grabber eXtreme (FGX) XMC developed by our graphics solution partner, Wolf Advanced Technology. The XMC-4701 is powered by a Xilinx Kintex-7 programmable FPGA. Combined with Wolf video IP, it provides the performance and flexibility to interface with multiple video standards.

The XMC-4701 can capture four HD-SDI (or two 3G-SDI) and four analog (CVBS, STANAG 3350, or VGA) independent channels while simultaneously providing four HD-SDI (or two 3G-SDI) and two analog outputs.

Input channel video can be streamed with sub-frame latency to its host processor for storage, analysis, or encode over a 4-lane PCIe Gen2 interface with 2 GBytes/second bandwidth. The XMC can perform real-time conversion and output to SDI or analog output from GPU DisplayPort or PCIe video sources.

The XMC-4701 is supported by Windows® and Linux® drivers as well as a variety of real-time operating systems including VxWorks®, INTEGRITY®, LynxOS®, and others.

The VPS brings in just a subset of the possible video, four HD-SDI digital and two RS-170 analog video inputs, and does not bring out any video outputs.

### XMC Features

- Xilinx Kintex-7 FPGA
- x4 PCIe Gen2 interface
- VITA 46.9 VPX I/O compliant

### Video Inputs

- (4) HD-SDI or (2) 3G-SDI digital video inputs
- (4) Analog video outputs (STANAG 3350 or CVBS)

### Video Outputs

- (4) HD-SDI or (2) 3G-SDI digital video outputs
- (2) Analog video outputs (STANAG 3350 or RS-170)

### Software

- Windows or Linux drivers available
- VxWorks, INTEGRITY, and LynxOS drivers available

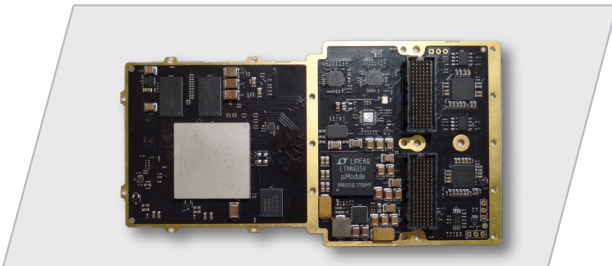


Figure 6: XMC-4701 Video Frame Grabber XMC with Xilinx Kintex-7 FPGA

## Removable Memory Cartridge (RMC)

The Removable Memory Cartridge (RMC) is a rugged housing for SATA 2.5" SSD drivers. The RMC was specifically designed for durability in high-insertion applications that require data storage plus transport to other locations. For reliable long-term usage, the RMC features a 100,000 insertion cycle connector. It comes with a special handle to allow gloved-hand removal.

The VPS RMC connector has been upgraded to a SATA 3.0 interface. The high-bandwidth SATA 3.0 interface can provide up to 500 Mbytes/second read/write bandwidth.

A large variety of SSD types, capacities, and capabilities can be supported. COTS 2.5" SSD hard drives provide reliable and power-efficient NAND flash solid-state drive for data and video storage. Storage can be either SLC or MLC with capacity up to four TB.

The SSD drives come with Error Correcting Code (ECC), wear level and bad block management, and can support capabilities such as write protect, AES-256 encryption, and secure erase to protect sensitive data.

### RMC Hardware

- 2.5" SATA SSD Flash hard drives
- Programmable LED indicators
- Handle for gloved-hand removal

### Interfaces

- 1000K cycle connector
- SATA 3.0 interface
- 500 Mbytes/second read/write bandwidth

### SATA SSD Storage

- COTS 2.5" MLC or SLC NAND Flash
- Up to 4 terabytes storage
- ECC, bad block, and wear level monitoring
- Data encryption and secure erase

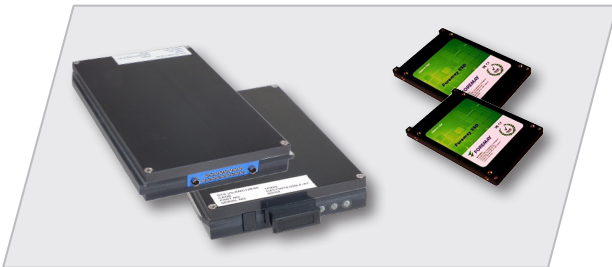
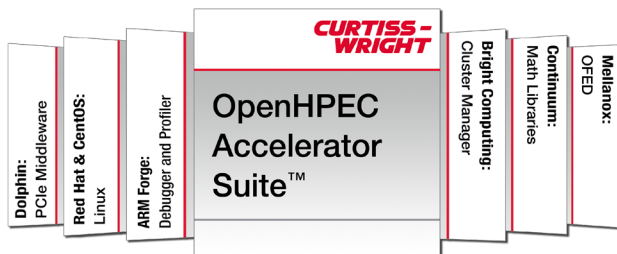


Figure 7: Removable Memory Cartridges with SSD Drives



## OpenHPEC

Curtiss-Wright supports its high performance processors with an OpenHPEC Accelerator Suite, a software development environment that integrates proven development tools from the supercomputing industry into a turnkey development suite that improves customers' time-to-deployment. Our premium suite of embedded software tools provide users with proven, fast, and standards-based tools to build multi-processor embedded applications. Features of the OpenHPEC suite are shown below.



### Tool: Function

- **Bright Computing Cluster Manager:** System build, management, operation, and maintenance
- **ARM Allinea Debugger / Profiler:** Debug, profile, edit, build, and version control
- **Industry Math Libraries:** VSIPL, FFTW, and Continuum vector libraries (AVX/AVX2)
- **Curtiss-Wright Data Flow:** Throughput, latency, and processor loading benchmark tool
- **Mellanox OFED:** Mellanox ConnectX-3 high performance 40 GB Ethernet drivers
- **Dolphin eXpressWare PCIe:** High-speed, low-latency PCIe Gen3 fabric middleware

The Bright Cluster Manager tool builds, manages, operates, and maintains HPEC processing resources. It simplifies the configuration of new systems and its revision-control gives developers the power to track changes and roll back to previous software revisions.

ARM's Allinea Forge provides debugging, profiling, editing, building, and version control integration. It provides a best-in-class debugger and profiler used in more than 70% of the world's supercomputers. Its MAP profiler provides in-depth instrumentation software with adaptive sampling techniques.

Curtiss-Wright products provide a number of transport mechanisms and protocols for data transfer. Our OpenHPEC Dataflow measures data movement throughput, latency, and processor loading.

OpenHPEC Math Libraries provide a comprehensive set of functions optimized to exploit the performance of Intel AVX/AVX2 processors. The OpenHPEC Math Libraries are supported on all our Intel processor products and the APIs are compatible with Vector Signal Image Processing Library (VSIPL), Fastest Fourier Transform in the West (FFTW), and legacy Continuum™ Vector libraries.

## Software and Built-in-Test

The CHAMP-XD2M is supported by the Red Hat Enterprise Linux 64-bit BSP. Drivers are provided for all devices in the unit with user-level APIs. Modules include hardware such as watchdog timers and thermal sensors for users' application test software.

Curtiss-Wright VPS supports diagnostic tests, each available with a detailed coverage analysis, at three levels: Start-Up (SBIT), Initiated (IBIT), and Periodic (PBIT). The user configurable test software is based on module and automatic test software for VPS functionality used in ATP/DVT/QPT/ESS testing and ensures a high degree of confidence in the health of the hardware.

### BIT Functional Test

- Gigabit Ethernet interfaces
- EIA-232 / EIA-422 serial and USB 2.0 interfaces
- 1PPS and other multi-function I/O
- HD-SDI and RS-170 video interfaces
- SATA 3.0 interface and SDD storage status
- Fans and power temperatures and voltages monitor
- CCA temperatures and status

## VPS Interfaces

The CHAMP-XD2M DSPs include the Ethernet, serial, and USB external interfaces. The XMC-4701 frame grabber XMC has the digital and analog video interfaces. The VPS front panel provides conversion, drivers, isolation, and test for discrete interfaces to the CHAMP-XD2M DSPs. VPS interface types and numbers are shown below.

## Ordering information

Contact your local sales representative for additional information.

**TABLE 3** System interfaces

TYPE	SIGNAL	COUNT
Communications	1000Base-T Ethernet	4
	EIA-232 Serial	2
	EIA-422 Serial	2
	USB 2.0	2
Discrete I/O	28V Output	12
	28V Input	2
	NC/NO Switched I/O	8
	28V Open DIO	4
	Open / Ground Input	4
	Open / Ground Output	2
	TTL Digital I/O	2
	1PPS 5V Input	2
	1PPS 5V Output	2
Video	HD-SDI Video Input	4
	RS-170 Video Input	2