PER VICES

Defense Markets
White Paper

Per Vices Corporation

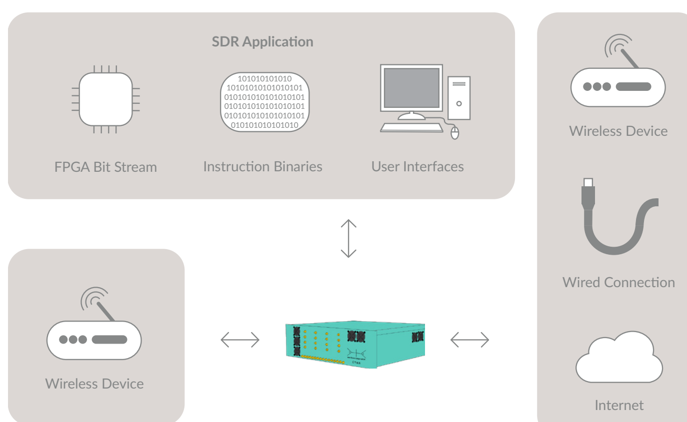
INTRODUCTION

Technology and defense have intersected and grown together since the beginning of time, allowing for communication, intelligence operations, and monitoring. Growing in sophistication from scouts, messengers on horses, and smoke signals in ancient times, to Morse code, rudimentary radar and computing in the past century, to the multi-functional, powerful, and complex systems we have today, we can all agree that it will continue evolving. The defense market is expansive however the key applications in this space can be broken down into the following:

- radar
- spectrum monitoring and recording/signals intelligence
- electronic warfare
- communication/interoperability

Each of these relies on advanced RF and signal processing systems to process large amounts of data quickly and accurately to identify anomalies and relevant information, such as threats and enemy actions. Radios have traditionally been a means of communication for military operations, but have had their shortcomings via reliability and security. JTRS (Joint Tactical Radio System) was a program of the United States military to produce radios that provide flexible and inter-operable communications. What evolved out of this was the concept of software defined radio (SDR); something that was once considered theoretical in nature due to technological limitations. Software defined radios are advanced signal processing devices that combine the functionality of different equipment into one system that is configured through software. SDRs still include components such as filters, oscillators, LNAs, etc., however, the configuration of such components become defined in software, which yields higher utility across a variety of applications. Further, they include an FPGA or ASIC to perform DSP operations on the data once it is converted to/from the analog and digital domains. This versatility allows SDRs to be used for a variety of applications including to provide secure, low latency signal processing and communication. SDRs can transmit and receive a wide variety of different radio frequencies and protocols all on one platform. Another concept that has risen through the evolution and advancements in SDR is cognitive radio. Cognitive radio checks channels for interference and congestion to determine the best available channels to use and can then switch the transmission/reception patterns accordingly. With a wide variety of applications, optimal SWaP, and easy integration, software defined radios are becoming the preferred choice for defense operations. They reduce development time and costs associated when compared to the development and deployment of multiple hardware components while reducing any downtime during maintenance periods by only having a single piece of equipment.

FURTHER DETAILS ON SOFTWARE DEFINED RADIO



Software defined radios are composed of an antenna, a radio front end, an ADC/DAC (analog to digital or digital to analog converter, depending on receive or transmit functionality), and a digital processor such as an FPGA or ASIC. The software/firmware required for each application can then be implemented on the

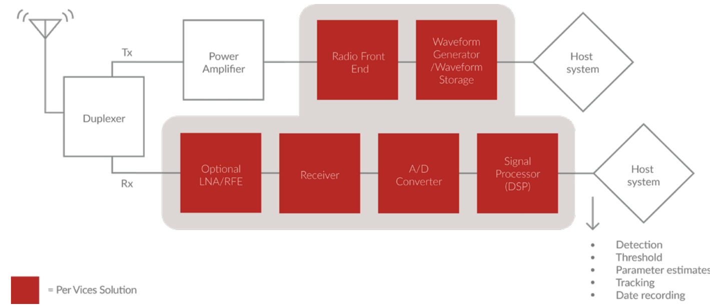
FPGA or ASIC through the use of IP cores or other DSP operations. On the RF receive side, a signal is received and travels through the radio chain, comprised of filters, amplifiers, mixers, upconverters/downconverters before reaching the ADC at which time it is converted to the digital domain. Once the signal is in the digital domain, it is processed by the FPGA which can include a number of DSP operations all configured through software/firmware.

Like most types of equipment, all SDRs are different. Although different specifications may be more important to some applications and less important for others, as a general rule, the following are typically the ones engineers find to be the most relevant for any application.

SPEC	WHAT IT DOES	TOP OF THE LINE RANGE
Tuning Range	This is the lower and upper frequencies that the device can tune into	DC to 18GHz
Number of channels	Enables receiving or transmitting at different frequencies or having multiple radio chains tuned to the same frequency to allow for TOA or other calculations	Up to 16 independent radio chains
Bandwidth	The amount of data captured within the tuning range by each channel	Up to 3 GHz
Digital backlog	The interface between the SDR and other digital systems such as a host/server system or recorder	Up to 400Gbps

I - RADAR

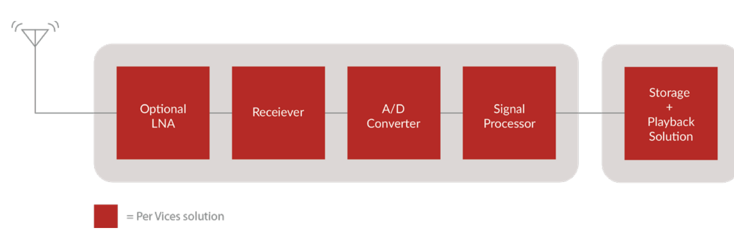
With the recent advancements in SDR technology such as ease of integration, increased number of channels, higher speeds, and higher reliability, they have become an important consideration for radar systems. The ease of maintenance and set up of SDR's allow for seamless integration into any system.



The figure displayed (above) shows a typical set up for a radar system where SDRs are incorporated. By integrating SDRs into your system, you have a fully integrated product that contains both the transmit and receive functionality required with the phase coherency and stability needed. The setup involves either a single or multiple host systems with the ability to send arbitrary waveforms or trigger pre-stored waveforms, on the SDR, with the output to either a single or multiple 50Ω SMA connections. This can be directly connected to your required power amplifier and transmitted. With the same SDR, you can also receive the reflected data, over multiple receive SMA ports, with optional increased low noise amplification, and convert the RF data into the digital domain. The FPGA on the SDR can further perform additional DSP or pass the data through to a host system for further analysis with your radar software.

II - SPECTRUM MONITORING & RECORDING/ SIGNALS INTELLIGENCE

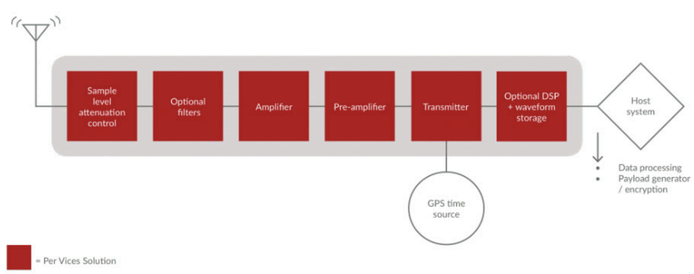
Spectrum monitoring is used to capture slices of the spectrum for analysis and storage. Although conventional radios can be designed to capture specific regions of the spectrum, it is more efficient to utilize a SDR as it can do it all, and be reprogrammed, supporting dynamic and wideband requirements. SDRs can serve in many applications including: interference detection, enforcing spectrum policy, monitoring restricted areas, and intercepting signals.



The system architecture (see diagram) shows a typical network for spectrum monitoring and recording. Everything starts with the radio chain. With SDRs, this offers 1 to 16 independent radio chains, each offering adjustable bandwidths up to 1GHz, where the higher bandwidth would be useful for wideband monitoring and a narrow bandwidth would be used for better SNR for specific signal analysis. The data is sent to the FPGA which allows for real-time analysis and streaming. It is also possible to upconvert and/or downconvert the signal if desired. Following any other DSP performed using the FPGA, the data is sent over 4 x 40Gbps ports to a Recording and Playback Solution where the ability to process the data from a greater number of channels allows for better IODT, geolocation and mapping with the use of software. The more channels, the more accurate geolocation positioning is, therefore allowing you to deploy resources to a location with confidence and save valuable time by not having to extensively search and approximate a signals' location.

III - ELECTRONIC WARFARE

SDRs provide significant advantages and advancements in the field of electronic warfare. By offering a wide tuning range and very high channel count, and associated bandwidths, SDRs provide unmatched utility for applications requiring the transmission of high and low powered signals simultaneously across multiple bands and channels.

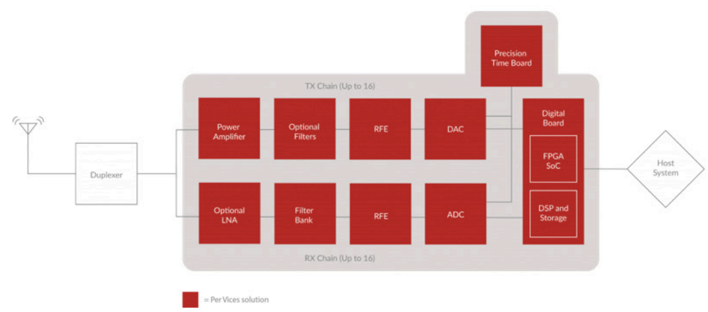


The system architecture (see diagram) shows a typical transmit radio chain of an SDR. In this particular architecture the SDR is connected to a host system where data processing and payload generation/encryption all take place in software, however, it is also possible to implement this functionality on the FPGA if enough resources are available. This block diagram can be repeated as many times as there are channels available, enabling significant advantages when combining high power and low power outputs at varying radio bands.

Software defined radios can be integrated into future cognitive electronic warfare systems to assist in air defense, through its multispectrum capabilities, advanced algorithmic processing, easy integration and scalabilty.

IV - COMMUNICATIONS

Accurate, secure, and fast communications in defense settings is imperative for the success of general operations, missions, and emergency situations. Software defined radio provides reliable, low latency, and high bandwidth communications across different frequencies for the most robust communication networks. With digital backhaul speeds reaching 400Gbps and RF bandwidths of up to 3GHz per channel, SDRs can meet the most demanding requirements.



Advantages:

- Ability to communicate in real time across multiple platforms
- Scalable and flexible network structure
- Transmit, receive and process all signal on one fully integrated, modular platform
- Spectrum slicing capabilities due to onboard DSP
- Tuning to multiple frequencies and protocols simultaneously
- Filtering/Adjacent Channel Rejection to proactively deal with cluttered airways
- Signal beamforming, Signal Accuracy/RTK

An example of where this utility can be further realized is through the accurate communication from a command ground station to airborne units to a naval ship. There are multiple latency and reliability configurations that can be easily implemented due to the software defined architecture of these systems. With filters such as RTK, LNA, etc., the signals are processed with high phase coherence and accuracy, giving you confidence in your testing results and outcomes. A customizable and high quality radio front end allows for integration of various antennas and links while still locking signals, quickly digitizing them, and providing you with a long term asset and tool, that can be upgraded through software alone.

CONCLUSION

Per Vices is a leading designer and manufacturer of high performance software defined radios for mission critical applications. Per Vices offers both COTS stock products and tailored solutions to meet customer requirements and works with customers every step of the way, from discovery, to a trial phase, to enterprise integration. With Crimson TNG and Cyan, a reliable, long lasting defense system is possible with configuration and updates done entirely in software. With input from clients and evaluating the evolving needs of the markets, they are a step ahead, offering the highest performing SDRs available.
Their product range includes Crimson TNG and the recently expanded Cyan family of products, which include Cyan EC (Extended Channel), Cyan High Bandwidth, and host/server and recording systems that can accompany each product. A brief overview of the products are listed in the chart below.

TECHNOLOGY READINESS LEVELS

1. Basic Research
2. Tech Formulation
3. Proof of Concept
4. Lab Validation
5. Simulated Validation
6. Prototype System
7. Pilot System
8. Qualified System
9. Operational System

Technology Readiness Levels (TRLs) were established by NASA, and are used by government institutions and companies globally to enable uniform discussions of technical development and maturity across different technologies. Per Vices makes the only customer-validated SDR platform that supports manufacturers from ideation through full production.

WORKING TOGETHER

Please contact us at solutions@pervices.com to learn more about how we can help you. Following our initial discussion, our team will support you throughout the whole process, from a trial with a stock product, to developing out specific requirements for a statement of work, all the way to the volume integration and certification stage. Our engineers work with you each step of the way to ensure it's a smooth and easy integration of our product into your systems.

Device	Ideal for	Key specs	FPGA	COTS or Custom
Crimson TNG	All markets	**Channels:** 4 Rx, 4 Tx **Op Freq:** DC to 6GHz **Backhaul:** 20 Gbps **Bandwidth:** 325MHz per chain; over 1200 MHz total	Altera Arria V ST FPGA SoC	COTS or Custom
Cyan	All markets	**Channels:** Up to 16 **Op Freq:** DC to 18GHz **Backhaul:** 160 or 400 Gbps **Bandwidth:** 1GHz per chain; 16 GHz total	Intel Stratix 10 FPGA SoC	COTS or Custom
Cyan EC (extended channel)	All markets	**Channels:** Up to 64 DSP channels on 16 receive chains **Op Freq:** DC to 18GHz **Backhaul:** 160 or 400 Gbps **Bandwidth:** 1 GHz per channel	Intel Stratix 10 FPGA SoC	COTS or Custom
Cyan High Bandwidth	All markets	**Channels:** 8 Rx/Tx **Op Freq:** DC to 18GHz **Backhaul:** 400 Gbps **Bandwidth:** 3 GHz per channel; total system capture 18 GHz	Intel Stratix 10 FPGA SoC	COTS or Custom