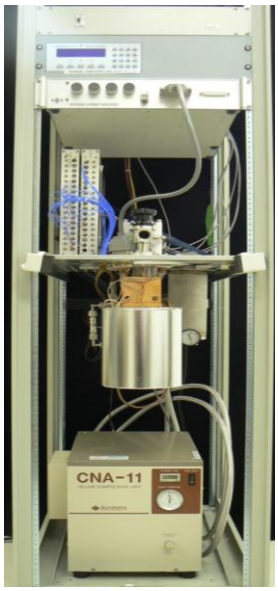
Dual Channel Coherent All Digital Receiver



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PROBLEM STATEMENT

Maintaining high fidelity over a wide frequency band in an interference dominated reception scenario is a longstanding problem in shipboard data collection and direction finding (DF) systems. The best and also the most challenging, solution is to use analog-to-digital converters (ADCs) that directly digitize RF signals with an extremely high spur-free dynamic range (SFDR).

The second problem is to ensure synchronization between signals received from different elements of an antenna array to find direction-of-arrival. The objective is to reinforce signals received by each element of an antenna array from a given direction only. For narrowband analog RF systems,

usually one attempts to achieve phase coherence between the RF outputs of the antenna elements using phase shifters. However, this scheme does not work well with wideband systems, especially with large bandwidth ratios, because phase depends on frequency.

The program of record is the Navy Shipboard Signals Exploitation Equipment (SSEE) future increments beyond Inc. F.

WHO CAN BENEFIT?

HYPRES is on the Argon team for SSEE program as a future technology insertion. It is planned in the FY 11 timeframe that HYPRES All Digital RF will be implemented to resolve many of the topside RF distribution issues (RFDU) now facing the program. HYPRES is one of the niche players as part of the ONR Integrated TopSide program and it is anticipated that this SBIR phase II will be transition to InTop.

A number of programs and platforms are listed below that can benefit from HYPRES All Digital RF solution.

1. **New multi-function ships**
    a. DDG-1000 Zumwalt DD(x) Multi-mission combatant
    b. Littoral Combat Ship
2. **MILSATCOM**
    a. Navy Multi-band Terminal (NMT)
    b. DoD Transformational SATCOM (TSAT)
    c. Army Modernization of Enterprise Terminals (MET)
    d. Army WIN/HC3 programs
3. **JTRS software radio systems**
    a. Navy and Air Force Airborne, Maritime and Fixed (AMF)
    b. DoD and international MIDS (Link-16) networks
    c. Army Ground Mobile Radio's (GMR)
4. **Signal Intelligence and Electronic Warfare**
    a. Navy Shipboard Signals Exploitation Equipment (SSEE) Program
    b. Army/Navy ACS, Prophet, Guardrail
    c. AF TENCAP program

BASELINE TECHNOLOGY

Traditional RF Distribution Sub-System (RFDS) for DF applications lack in dynamic range and utilizing novel architectural variations that are component intensive and expensive. In order to ensure synchronization between signals received from different elements of an antenna array to find direction-of-arrival, current technology usually attempts to achieve phase coherence between the RF outputs of the antenna elements. The objective is to reinforce signals received by each element of an antenna array from a given direction only. For narrowband analog RF systems, usually one attempts to achieve phase coherence between the RF outputs of the antenna elements using phase

shifters. However, this scheme does not work well with wideband systems, especially with large bandwidth ratios, because phase depends on frequency.

The RFDS provides for the wideband distribution, conditioning, and conversion of the received signals between the antennas and the overall system digital processing resources. The conditioning explicitly removes the high level interfering signals encountered on a ship from co-sited emitters and preserves the system capability to detect, identify, DF and geo-locate the signals of interest (SOI). It involves the combination of notch filters, multiplexers, adaptive cancellers, limiters, and extremely linear amplifiers. It removes unwanted energy from the channel spectrum so that conventional A/Ds and processors can be arrayed to support the proven methods of processing and supporting analysis functions.

Implementation of All Digital RF architecture will have a significant impact on performance and cost by elimination the hardware intensive analog components. It is estimated to reduce complexity by more than 50% and cost estimated to be 1/3 of conventional approaches in use today to resolve co-site interference and provide accurate DF for Navy shipboard collection systems.

TECHNOLOGY DESCRIPTION

Tolerating high levels of interference, including those from co-located RF transmitters, is a longstanding problem for building wideband and sensitive naval signals intelligence (SIGINT) and DF receivers. ADCs are the critical elements that define the architecture and the performance capabilities of the interference-tolerant digital receiver. Ultrafast switching speed, low power, natural quantization of magnetic flux, quantum accuracy, and low noise of cryogenic superconductor circuits enable fast and accurate data conversion between the analog and digital domains. Based on rapid single-flux quantum (RSFQ) logic, these integrated circuits are capable of achieving performance levels unattainable by any other technology. Dynamic ranges in excessive of 120dBM are achievable with All Digital RF technology. The result is substantial reduction in size, weight, power and cost estimated to be in excess of 50%. The feature and benefit table below summarizes the advantages of All Digital RF technology.

Table 1Featur/Benefits of All Digital RF Technology

Features	Benefits		
	Communications	SIGINT/EW	Surveillance
Wideband receiver with programmable channel locations and bandwidth	➢Simultaneous reception of multiple waveforms, emitter signatures and radar signatures		
	➢Dynamic Reallocation of channel BW for voice/data	➢Refinement of freq. resolution for precision ID	➢Simultaneous probing of different length scales
Reduced receiver noise figure	➢Higher Data Rate ➢Higher spectral efficiency ➢Lower TX power	➢Earlier warning ➢Enhanced range	➢Detection of smaller targets ➢Enhanced Range
Nonlinear analog replaced with high-fidelity digital components	➢Discrimination against interferors ➢Mitigation of co-site problem	➢Reduction of false targets	➢Reduction of false targets
Modular Receiver Chip-set (Comms +EW+Radar)	Synthesis of different receivers using modular channelizer chips and interchangeable ADC front-ends. Provides programmability and reconfigurability of hardware.		

CURRENT STATE OF DEVELOPMENT

The work on the funded (base, $500K) part of the project is complete, over six months ahead of schedule. The project was to build a digital-RF receiver system and demonstrate with a dual-ADC chip (two low pass ADCs with common clock). This was completed and the prototype was demonstrated to the technical monitor, Ms. Anna Leese de Escobar on July 29 2010. The only remaining item at that time was to mount an additional temperature controlled stage for housing HTS filters, LNAs etc. which has now been mounted. The Phase II option ($250K) has been requested for additional work, including delivery, installation and testing at SPAWAR Systems center.

Completion of the phase II is expected by March 2011 and it is anticipated that the resulting testing and demonstration will qualify for TRL-4 at the end of the phase II option.

REFERENCES

The references provided are all very familiar with HYPRES thru regular visits and briefings and are the decision makers for MILSATCOM and SIGINT (DF) programs.

1. SPAWAR PMW/A 170 PM
   619-524-7930

2. SPAWAR PMW 120 PM
   619-524-7373

3. SPAWAR PMW 150
   858-537-0260

4. SPAWAR SSC
   619-553-5987

5. US Army CERDEC Tech Director
   732-427-3967

6. US AF Space Warfare Center PM TENCAP
   719-567-9187

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ABOUT THE COMPANY

HYPRES Corporate Headquarters

Since 1983, HYPRES has been engaged in advanced R&D programs and commercialization of superconducting microelectronics (SME). SME represent a significant advancement over existing semiconductor technologies by uniquely converting radio waves to digital at or near the antenna. HYPRES is the world leader in superconducting technology and has *the only commercial foundry in the United States*. HYPRES is developing an All Digital RF product-line to support its customers both for government and commercial wireless markets. HYPRES has developed second-generation Superconducting IC technology for its All Digital RF product line. This includes a reliable all-refractory niobium IC process that resolves the materials-related issues that had limited progress in the IBM Josephson computer program. In addition, a new logic family is now applied that takes full advantage of the intrinsic properties of superconductors and enables gate speeds approaching 1,000 GHz (770 GHz demonstrated in the laboratory).

The company is located in Elmsford, NY and includes a complete superconducting integrated circuit fabrication line. The facility is totally self-sufficient and includes thin film and photolithography processing and support functions covering CAD, device testing, and cryogenics development. Our staff is expert in circuit design, circuit fabrication, packaging, and cryogenics. In addition to capabilities in superconductivity, other HYPRES technologies enable advanced micro-fabrication processes which lead to unique micro-machined sensors for the detection of infrared and millimeter wave radiation without cooling.

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Our staff includes a management team with proven performance, world experts in superconductivity and cryogenics with advanced degrees, an experienced engineering and operations team, and an efficient administrative team. At HYPRES, our mission is to develop and market products with performance significantly exceeding current technology for a comparable price and in a comparable package. We are dedicated and committed to complete customer satisfaction in the products and services we deliver.

Notes: The technology discussed is in the public domain and is on the HYPRES website. www.hypres.com

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