



# Capabilities Brochure

**A Quantum Leap in Digital Communications**  
**Providing real time Digital RF™ Systems**  
**Worldwide**

**The Digital Superconducting Company**

**HYPRES, Inc.**, a complete superconducting electronics company offering design development, fabrication, testing and packaging in a commercial production environment.



# HYPRES HQ

## HYPRES Overview

Founded by researchers from IBM in 1983 --  
a 34 year small business privately held

Location: Elmsford, Westchester County  
30 miles North of New York City.  
19,200 sq. ft. facility.  
Facility cleared for secret level

### Design capabilities:

- VLSI IC computer-aided-design (CAD) workstations
- Niobium (Nb) RSFQ, Si CMOS, SiGe HBT Electrical & Mechanical packaging / modeling and design

Micro-fabrication manufacturing area  
including class 100 clean room.

- 12-level Niobium, 3.0 to 1.0  $\mu\text{m}$  process
  - Silicon micro-machining.
  - **Only commercial superconductor foundry in the world.**

Testing: Multiple 20 GHz to 75 GHz test stations



## Mission

*HYPRES will maintain its world leadership in Superconducting Micro-Electronics (SME), offering design development, fabrication, testing, and packaging by providing Digital RF products for commercial wireless, DoD communications, MILSATCOM and SIGINT systems.*

## Core competencies

*System engineering and design of SME circuits for Communication, EW and SIGINT Systems, Manufacturing and foundry for SME circuits, Program Management, Configuration Management, Logistics Support and Test Engineering*



# The Company

## Objective

To be the world class leader in Advanced Digital RF Systems both for Government, Commercial and Public Safety sectors.

## Company

HYPRES, Inc., Elmsford, NY, develops and commercializes superconductor integrated circuits (ICs) and systems that provide unparalleled performance advantages for government and commercial applications. A flagship product is the Advanced Digital-RF Receiver (ADR), comprising superconducting digital and mixed-signal ICs packaged on a cryocooler. HYPRES also develops custom semiconductor ICs, high-performance analog RF circuits, superconductor digital logic, and operates a complete commercial niobium-based superconducting integrated circuit (IC) foundry. HYPRES recently introduced the Integrated Cryoelectronics Test Bed (ICE-T), a turnkey laboratory test system requiring no liquid cryogen. It provides a complete cryogenic infrastructure for broadband electrical testing of standard and custom high-speed superconducting integrated circuits at 4 K and above.

For more information, visit [www.hypres.com](http://www.hypres.com).





# Company Background

HYPRES was founded in 1983 and has since been active in advanced R&D programs while developing the third/fourth generation IC technologies for superconductive electronics which included a reliable all-refractory niobium IC process that resolved materials related issues 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 that can detect infrared and millimeter wave radiation without cooling.

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.



# The Technology

## **RF CIRCUITS AND SYSTEMS**

HYPRES' Advanced Digital-RF Receiver systems are being fielded for a number of US government customers for a variety of applications, including SIGINT, EW and SATCOM. They feature ultra-wideband, high dynamic range, multi-channel, multi-band operation using superconductor Analog-to-Digital Converter technology. Advanced Digital-RF Receiver (ADR) – Government-tested (TRL 7) units with standard interfaces Integrated Cryogenic Electronics Test bed (ICE-T) – Robust test platform for laboratories Cryogenic Analog RF Module (CARM) – Small, antenna-mounted amplifier units for SATCOM and other RF applications Superconductor Analog-to-Digital Converters (ADCs) – Family of integrated circuits tailored for different applications (Cryogenic Detector Array Readout, Wideband Spectrum Capture) Mixed-signal Application-specific Integrated circuits (ASICs) with ultrafast digital and high-quality analog circuits

## **HIGH PERFORMANCE COMPUTING**

HYPRES is at the center of next-generation, energy-efficient superconductor supercomputer and quantum computer development. Its physicists, engineers and world's premier commercial chip foundry are supporting a number of federally-sponsored and commercially-funded innovative development initiatives. The company is making important contributions in superconductor logic and memory.

With the fastest and most energy-efficient digital ICs available anywhere, HYPRES innovation is at the heart of tomorrow's high energy-efficient computing systems. The company and its partners are currently developing: Energy-efficient computing systems—highly energy-efficient processor and dense, fast memory circuits Quantum computing— support circuits for qubit control and readout.

## **INSTRUMENTATION**

The leader in developing digital superconductor electronics for metrology applications, HYPRES is known worldwide for its signature product, the Primary Voltage Standard (PVS) calibration system, produced in partnership with NIST. It is now producing a new rugged, mobile PVS system designed to US Army specifications for use worldwide. It is also developing very powerful, high resolution but small and mobile Digital MRI systems. They are designed to be easily transported by the military and other agencies to combat and disaster areas and operated in harsh environments that prevent use of conventional MRIs.

## **ANALOG SQUIDS**

HYPRES has a number of programs aimed at sensing and detecting electromagnetic radiation. Using both cryogenic and room temperature materials, our development programs aim to cover the spectrum from ELF (sub-hertz) through infrared and mm-wave and up to X-rays.



# Core advantage

HYPRES is a complete superconducting electronics company offering design development, fabrication, testing, and packaging in a commercial production environment.

HYPRES' design staff provides demonstrated expertise with proven designs. Examples of these include high performance analog-to-digital converters, shift registers, memory, SQUIDs and SQUID amplifiers, IR sensors, SIS mixers, and RSFQ logic gates.

The HYPRES facility includes high speed test equipment, UNIX-based CAD tools, process equipment, 2 and 3 stage closed cycle refrigerators, and clean room space for wafer processing. HYPRES' facility meets all environmental laws and regulations of Federal, State of New York, and local governments for airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

HYPRES is still the only company in the world to have produced and marketed a digital superconducting electronics product to date: the PSP-750 and PSP-1000 digital sampling oscilloscopes. These units, with 70 GHz bandwidth, proved to be the world's highest resolution time domain reflectometers (TDRs). The bandwidth of the sampling head on these scopes was limited by the connector technology, not the sampling circuit. The PSP product line (1987-1990) demonstrated the ability of HYPRES to produce, market, and service a complex digital instrument which utilized superconducting electronics components.

HYPRES is also the only company to have provided state-of-the-art SIS mixers to the radio astronomy community on a commercial basis. The Superconductor-Insulator-Superconductor (SIS) diode is the critical component of the most sensitive radio receivers in the world for frequencies from 65 to 1,000 GHz. HYPRES has provided SIS devices for SIS mixers since 1988. These mixers, developed jointly by the National Radio Astronomy Laboratory and HYPRES, have been sold to radio observatories in Australia, France, and the United States. HYPRES SIS diodes, purchased by University of California - Santa Barbara astronomers, have been to the South Pole where they were used to make extremely accurate measurements of the radiation which was produced by the explosion that started the universe.

HYPRES' SIS mixer customers for radio astronomy include: AT (Australia Telescope), Bell Labs, Bordeaux Observatory (France), CIT-OVRO, Haystack Obs, IRAM, NRAO 12-m Telescope, and UC-Santa Barbara.

HYPRES is currently developing unique products for wireless and optical communications. Leveraging the high performance of its circuits and the established need for higher bandwidth, higher dynamic range, and higher accuracy, HYPRES' new products are intended to facilitate the rollout of higher bandwidth beyond-2G wireless and enhanced optical systems while significantly reducing the capital expenditures and new infrastructure that would otherwise be required. HYPRES' unique technology is unrivaled in this domain and represents the foundation for the new products under development.



# Foundry Services

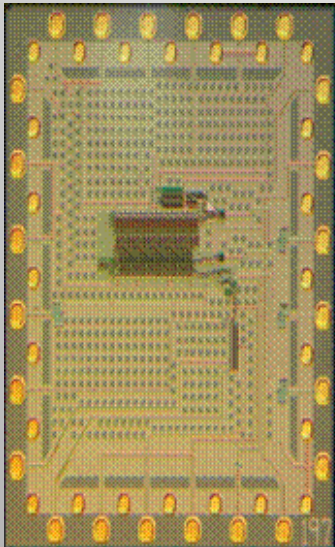
The facility can produce virtually any digital superconductor chip for the U.S. commercial and government markets. The foundry supplies approximately 60 percent of the world's superconducting chips. More than 1,000 lots and more than 5,000 chips have been delivered to a growing number of satisfied customers, including:

## Foundry Customers

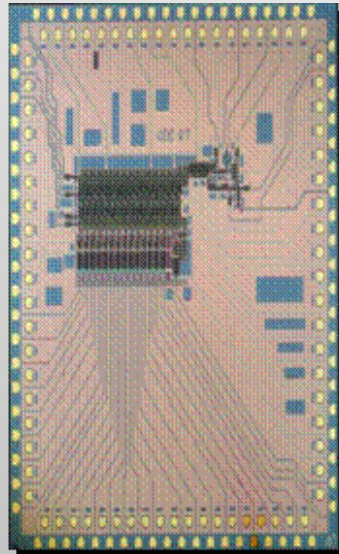
- Agilent Technologies
- BBN Technologies
- Boeing
- California Institute of Technology
- Colgate University
- CEA Grenoble (France)
- HRL Laboratories
- I.B.M.
- Lawrence Berkeley Lab
- Los Alamos National Lab
- Louisiana State University
- M.I.T.
- Moscow University
- NASA
- Northrop Grumman
- Ohio State University
- Physikalisch-Technische Bundesanstalt (Germany)
- Saitama University (Japan)
- Teratec Corp
- U.S. Army Redstone Arsenal
- U.S. Department of Energy
- University of CA, Berkeley
- University of Colorado
- University of Iowa
- University of Karlsruhe
- University of Maryland
- University of North Carolina
- University of Rochester
- University of Stellenbosch
- University of Texas
- University of Tübingen
- University of Twente
- University of Virginia
- University of Waterloo
- Sandia National Labs
- Stanford University
- Stony Brook University
- Tektronix



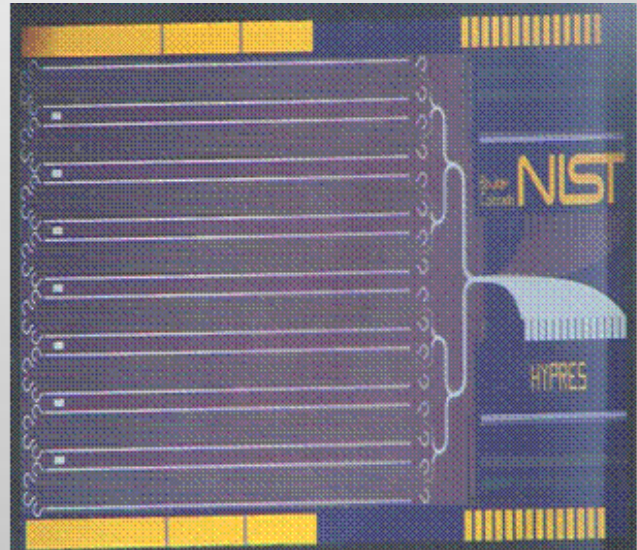
# Examples of Superconductor (Niobium) ICs



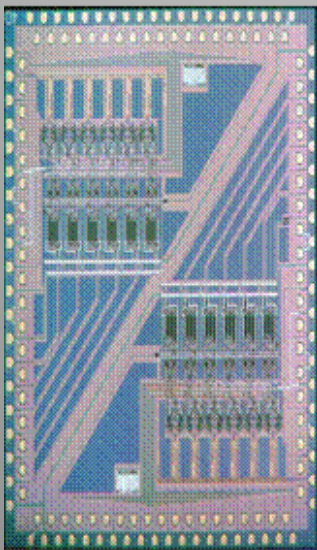
**Time-to-digital  
Converter with on-chip  
40 GHz clock**



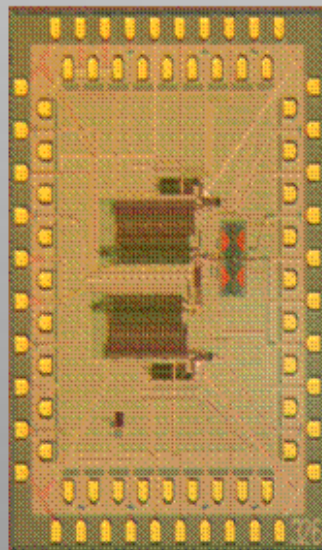
**15-bit Analog-to-digital  
Converter with 20 GHz  
clock (98dB SFDR @ 10  
MHz)**



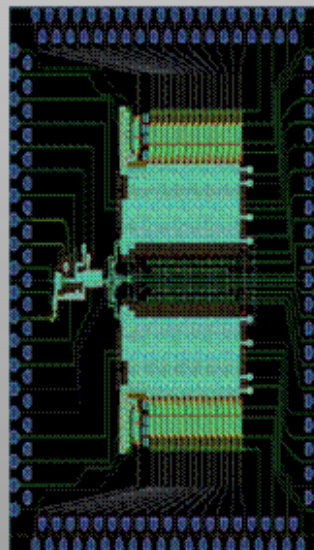
**1cm x 2 cm 10 Volt Chip with 5ppb accuracy  
(>20,000 Josephson junctions)**



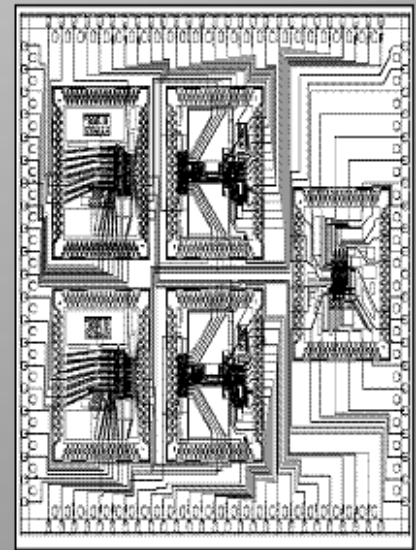
**Transient Digitizer:  
Two 6-bit 20 GSa/s  
Flash ADCs with 32-  
word memory**



**Two-channel Dual-  
function Digitizer (TDC  
& ADC)**



**Two-channel Digital  
Channelizer (>12,000  
JJs)**



**Multi-chip Module  
(20 Gbps interchip data  
rate)**





# Advanced Digital RF Receiver

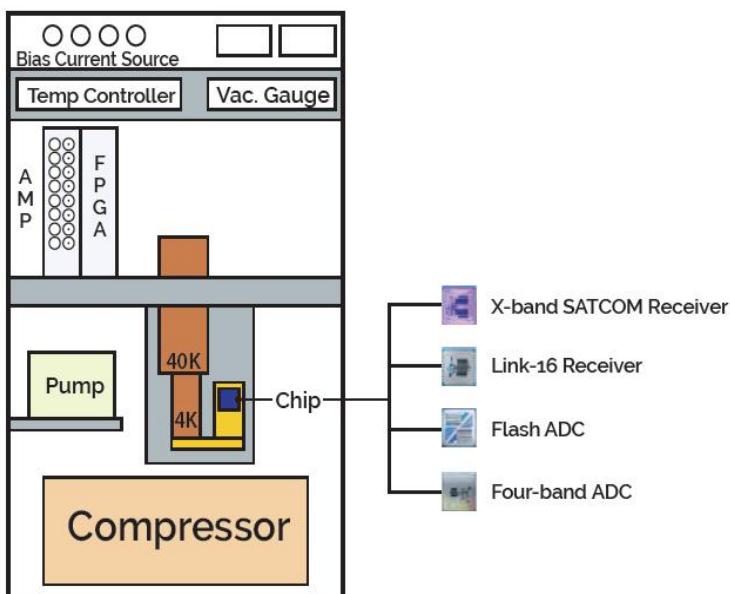
## Description

Using state-of-the-art superconductor analog-to-digital converter (ADC) technology, the HYDR-01 can go directly from RF to digital. This modular cryocooled 19-inch rack-mounted system is completely free of liquid cryogen, capable of digitizing multi-GHz bandwidth with center frequency up to 21 GHz.

The HYDR-01 is completely customizable and upgradable. In its basic configuration, HYDR-01 includes one user-selected superconductor chip. HYDR-01 can be upgraded and reconfigured by purchasing additional chip modules. Additional cryogenic electronics, such as a low-noise amplifier and an analog filter, may be incorporated within HYDR-01.



Exterior View



## Features

- Directly digitize RF (no analog down-conversion)
- Ultra-wide bandwidth
- Multi-band, multi-carrier operation
- Compatible with any digital processor
- Turnkey operation
- Modular upgrades with new chips as they become available

## Applications

- Software Radio
- Spectrum monitoring
- Satellite communication
- Wireless communication
- Electronic communication
- Electronic Warfare
- Radar
- Digital dehopping
- Channelizing receiver



# Cryogenic Analog RF Module Low Noise Amplifier

## Features

- Extremely low noise amplification
- Light and compact
- High gain
- Ka-band
- Turnkey operation
- Various customization options available

## Applications

- Satellite communication
- Line-of-sight datalinks
- Signals Intelligence
- Electronic Warfare
- Radar
- Channelizing receiver
- Transient digitizer
- Software Radio
- Spectrum monitoring



CARM-02 module

## Description

HYPRES is proud to announce an Analog-RF Amplifier product. Using state-of-the-art low noise amplifier and compact cryogenic cooler, the Cryogenic Analog RF Module (CARM-02) provides amplification with extremely low noise.

Its compactness allows the module to be used directly after an antenna in place of a traditional LNA or LNB. Initially developed for Ka-Band, different frequency bands will soon be available. Customization of the mechanical interface, formfactor or additional filtering are also possible.





# ICE-T

## Integrated Cryogenic Test Bed

### Description

The Integrated Cryogenic Electronics Test-bed (ICE-T) is designed for rapid and convenient testing of low-temperature electronics, especially for superconductor electronics (SCE), integrated circuits (ICs) and multi-chip modules (MCMs).

When properly configured, it provides the entire cryocooled infrastructure required to test a wide variety of devices and ICs.

Modular in design, ICE-T can be reconfigured through user-specified Electrical Inserts, ranging from standard to fully customized ones.

ICE-T is completely cryogen-free and requires 3-phase power supply. The versatile, modular design allows inserts to function as liquid helium immersion cryoprobes, without the associated high cost of liquid helium. ICE-T can pay for itself in helium savings alone in fewer than two years.

### Features

- ICE-T accommodates two interchangeable Electrical Inserts with a standard vacuum flange.
- Modular design of Electrical Inserts allows maximum flexibility and convenience for experiments.
- Turnkey operation with two native temperature stages: the low-temperature stage (4K to 15K) and high-temperature stage (30K to 40K), and controlled variable temperature test capability in custom Electrical Inserts.
- Quick and convenient superconductor IC mounting capability



### Applications

- High-speed superconducting electronics chips for supercomputing applications
- Process control monitors and digital diagnostics
- High-performance cryogenic analog-to-digital converters (ADCs) for RF receivers
- Analog low-noise measurements for SQUIDs and SQIFs
- Cryogenic semiconductor devices

ICE-T





# The Future of Magnetic Resonance Imaging



## The Solution—Digital-RF Technology

To date, improvements in MRI images have been possible primarily with more powerful, better designed magnets, and to a lesser degree with advanced electronics and software. The industry continues to pursue even more powerful magnets and refinements based on multiple sensors and processors. However, the resulting gains are forecasted to be marginal overall with little improvement in basic operation or patient experience. HYPRES offers a new solution based on its patented Digital-RF technology that brings, for the first time, the full power of digital processing to MRI.

## Digital Superconductor Electronics

Digital superconductor electronics, proven in metrology and wireless communications, provide significant benefits for medical imaging. Digital-RF transitions MRI to fully digital MRI with reduced scan times, improved image resolution, lower cost, enhanced safety, and improved accessibility to people worldwide. HYPRES all-digital receivers and processors are at the core of Digital MRI. They feature the world's fastest digital circuits, 100 times faster than today's MRI processors. Digital-RF technology can be used to both modify existing MRI systems and develop new small, portable machines that can be operated safely in any environment. These portable MRIs could be taken to the patient in the doctor's office, emergency room, or even on the battlefield in a military field hospital.



# Customer Base

## Government Customers

- |   |  |
|---|--|
| <input type="checkbox"/> ONR                        | <input type="checkbox"/> NASA Goddard/GRC    |
| <input type="checkbox"/> DOC/NIST                   | <input type="checkbox"/> ARL                 |
| <input type="checkbox"/> DARPA                      | <input type="checkbox"/> NSA                 |
| <input type="checkbox"/> NRL                        | <input type="checkbox"/> AF Rome Labs        |
| <input type="checkbox"/> NIH                        | <input type="checkbox"/> Las Alamos          |
| <input type="checkbox"/> SPAWAR                     | <input type="checkbox"/> SMDC                |
| <input type="checkbox"/> CECOM                      | <input type="checkbox"/> NSWC                |
| <input type="checkbox"/> NSF                        | <input type="checkbox"/> AF SWC              |
| <input type="checkbox"/> MDA                        | <input type="checkbox"/> AF ESC              |
| <input type="checkbox"/> DOE                        | <input type="checkbox"/> AF Kirkland Labs    |
| <input type="checkbox"/> NAVAIR                     | <input type="checkbox"/> AF Wright Patterson |
| <input type="checkbox"/> US Army PM DCATS and WIN-T | <input type="checkbox"/> IARPA               |

## Prime Customers

- |   |   |
|---|---|
| <input type="checkbox"/> Raytheon         | <input type="checkbox"/> Rockwell/Collins |
| <input type="checkbox"/> Northrop/Grumman | <input type="checkbox"/> Harris           |
| <input type="checkbox"/> Argon ST         | <input type="checkbox"/> SwRI             |
| <input type="checkbox"/> Lockheed/Martin  | <input type="checkbox"/> STI              |
| <input type="checkbox"/> BAE              | <input type="checkbox"/> L-3              |
| <input type="checkbox"/> Cubic            | <input type="checkbox"/> Thales           |
| <input type="checkbox"/> L-3              | <input type="checkbox"/> Sarnoff Labs     |
| <input type="checkbox"/> ViaSat           | <input type="checkbox"/> Ball Areospace   |
| <input type="checkbox"/> Boeing           | <input type="checkbox"/> General Dynamics |

## Commercial Customers

- |   |                                      |
|---|--------------------------------------|
| <input type="checkbox"/> SUNY Stonybrook      | <input type="checkbox"/> Sprint      |
| <input type="checkbox"/> Rochester University | <input type="checkbox"/> Nokia       |
| <input type="checkbox"/> RPI                  | <input type="checkbox"/> Eriksson    |
| <input type="checkbox"/> USC                  | <input type="checkbox"/> Orange UK   |
| <input type="checkbox"/> Tristan Tech         | <input type="checkbox"/> Sunpower    |
| <input type="checkbox"/> Sumitomo             | <input type="checkbox"/> TAI         |
| <input type="checkbox"/> Create               | <input type="checkbox"/> Air Liquide |



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