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August 14, 2002

RE: ET Docket No. 02-135

Ms. Marlene H. Dortch:

On August 2, I participated on the Spectrum Policy Task Force Panel II – Advanced Technology. Enclosed are the slides that were to be projected during my presentation. Due to audio/visual problems that you were experiencing, this information was not displayed. For this reason, I am submitting this material as an addendum to our original submission.

The majority of the Advanced Technology panelist concurred that current conventional technology cannot, in general, materially alleviate the serious current spectrum issues and problems, and that the exponentially increasing demands for spectrum will further exacerbate these issues. With current technology, policy actions will only serve as a temporary remedy. It will take significant enhancements in performance to provide long-term solutions. Next generation technology has the potential to alleviate or eliminate most, if not all, of these issues.

Several panelists recommended that the Commission proactively and expeditiously support the development of next generation technologies that have the potential of materially affecting these critical issues, and that the Commission ensure that policy development and rule-making support insertion of new technology, enabling new approaches to spectrum management and relieving the current imbalance in spectral efficiency across different services using RF communication. I further suggested meaningful incentives to commercial spectrum users to optimize their spectrum utilization.

The panelist further concurred that, while the FCC has historically focused on the transmit side, the FCC now needs to also consider a more "holistic" approach, and consider the receive side.

The enclosed material is intended to demonstrate the potential of a next-generation technology to eliminate and/or significantly alleviate the critical spectrum issues.

It was a pleasure to serve on the panel and HYPRES looks forward to sharing more information and further discussions with the FCC.

Sincerely,

Jack Rosa
President and CEO

FCC Major Issue
Interference

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Interference

Issue

• Transmitter interference is currently a serious problem and will become worse as wireless communications demand continues to increase.

Solution

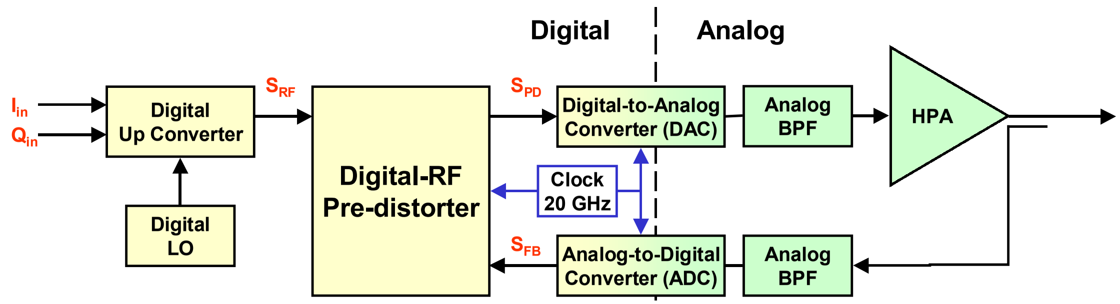
• Next generation technology can eliminate and/or significantly alleviate this major issue.

Text for [Interference]

HYPRES next generation technology has the solutions – outlined in the information to follow.

HYPRES

1. Power Amplifier Linearization



- Near real-time true digital Adaptive Linearization at RF
- Combines the advantages of
  - Digital baseband predistorters (Enhanced DC-to-RF efficiency)
  - Feed-forward amplifiers (Low distortion)
- Frequency (& Data Rate) independent to >0.2 Clock Rate
- Efficiency enhancement up to the inherent limit of the HPA

One HPA Covers Wide Bandwidths Consuming Less Power

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Text for [1. Power Amplifier Linearization]

HYPRES technology can actually realize near real-time true digital adaptive linearization at RF.

The High Power Amplifiers (HPAs) of any system consume a significant part of the cost and power budget. The ability to overcome inherent non-linerarity in the HPA transfer function can not only extend the bandwidth of operation, but can allow for fewer total HPAs, or HPA of lower quality (lower cost) to enable the system to function correctly. While this approach is universally true, only superconductor electronics can actually realize near real-time true digital adaptive linearization at RF. This is accomplished by exploiting the unparalleled high dynamic range and bandwidth for superconductor RSFQ-based ADCs and DACs.

Beyond the benefits of increased bandwidth and efficiency improvements, ultra-linear power amplifiers are becoming increasingly more important for the both the military and commercial wireless systems. Systems, particularly multi-channel systems such as JTRS, will greatly benefit from the significantly-reduced spurious signals (which cause serious system-degrading interference) generated by the power amplifiers. Also, the FCC has heightened interest in similar performance due to the developing spectrum utilization issues caused by increased wireless communication demand [FCC ET Docket No. 02-135].

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Linearization of RF Power Amplifiers

HYPRES Real-Time Digital RF Pre-Distorter

Digital pre-distortion is a well-known technique for linearization of amplifiers. Many military communications systems use digital baseband pre-distortion. These techniques change the digital baseband signal – either by mapping an input in-phase and quadrature signal vector into an output signal vector or by multiplying the signal with a level-dependent complex gain – but not the RF waveform, in an attempt to compensate for the amplifiers non-linear gain and phase characteristics. Many commercial communication systems use feed-forward techniques to linearize multi-carrier power amplifiers (MCPA), which results in marginal linearity and very low efficiencies (typically 5 to 10 % at commercial wireless frequencies).These conventional approaches are very limited in performance and bandwidth.

Fast digital circuits, using superconductor technology, enable digital pre-distortion on the multi-GHz RF waveform itself, greatly simplifying the algorithms and the complexity of signal processing. HYPRES high-speed digital-circuit capability (HYPRES **Digital RF** pre-distortion) implements the pre-distortion techniques at multi-GHz frequencies.

Superior linearization results in broadband, low-distortion, multi-carrier transmitters --utilizing cheaper and more efficient high power amplifiers (HPAs). This results in a major enhancement of system performance as well as lower cost and operating expenses of communication signal transmitters. The technology has a major impact on US military and commercial wireless communication systems.

Beyond the benefits of increased bandwidth and efficiency improvements, ultra-linear power amplifiers are becoming increasingly more important for the both the military and commercial wireless systems. Systems, particularly multi-channel systems such as JTRS, will greatly benefit from the significantly-reduced spurious signals (which cause serious system-degrading interference) generated by the power amplifiers. Also, the FCC has heightened interest in similar performance due to the developing spectrum utilization issues caused by increased wireless communication demand [FCC ET Docket No. 02-135].

Note: These schemes cannot be implemented by fast semiconductor device technology, such as SiGe, InP, GaAs, SOS, SOI, etc. (in any form – high electron mobility, heterojunction bipolar transistors, etc.). The fundamental drawback of relatively long interconnect delays in semiconductor integrated circuits limits the speed of these circuits to well below that needed to achieve the required high-speed circuit operation and the integration levels that are needed to affect this functionality.

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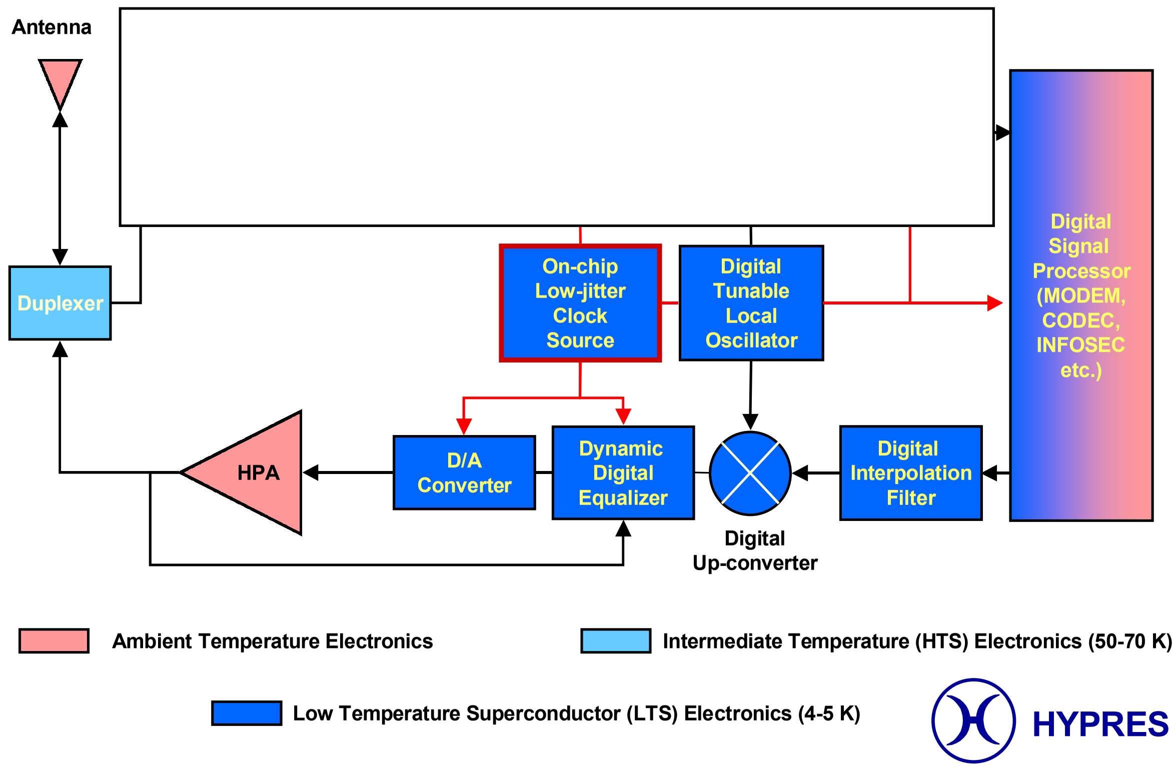
Digital-RF Transceiver



Text for [Digital-RF Transceiver]

A radio performs a variety of functions in the process of converting voice or data information to and from a Radio Frequency (RF) signal. Nominally, these functions include:

- Processing the analog RF signal (e.g., amplification/deamplification, converting to/from Intermediate Frequencies (IFs, filtering, etc.);
- Waveform modulation/demodulation (including error correction, interleaving, etc.); and
- Processing of the baseband signal (e.g., adding networking protocols, routing to output devices, etc.).

Emphasized on this chart is the transmitter side of the HYPRES transceiver. The waveforms are generated as sampled digital signals, converted from digital to analog via a wideband Digital-to-Analog Converter (DAC), and then sent to the (previously discussed) ultra linearized HPA.

Note that the entire process is done digitally before being converted to analog form for amplification and transmission through the antenna(s).

The accuracy, precision, and speed of an all-digital approach using HYPRES technology to generate the signals is orders of magnitude better than an analog or mixed signal approach. **It is virtually without any intermod/spur products and is essentially noise free (=~"0" transmitter noise).**

The key component using HYPRES technology are discussed on the next charts**.**

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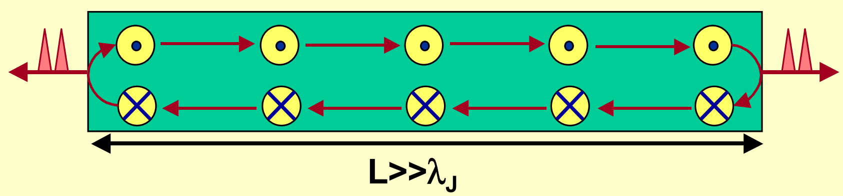
Resonant Solitons in LJJ

Back-and-forth propagation of Fluxons (solitons) in LJJ



- Long JJ (LJJ) Oscillators exhibit the highest quality (Q) factor and the lowest time jitter among all integrated circuit clock sources
- Highest quality clock source can be integrated on the same chips with high-performance ADC and DAC modulators to preserve excellent time jitter

Text for [Resonant Solitons in LJJ]

Interference is reduced with the use of spectrally pure carriers and ultra-linear power amplifiers. Spectrally pure carriers begin with multi-GHz clocks with clock jitters measured in sub-picoseconds, to generate the **"near-perfect sine wave".**

Long JJ (LJJ) Oscillators exhibit the highest quality (Q) factor and the lowest time jitter among all integrated circuit clock sources -- by orders of magnitude.

This LJJ (highest quality clock source) can be integrated on the same chips with high-performance ADC and DAC modulators to preserve excellent time jitter.

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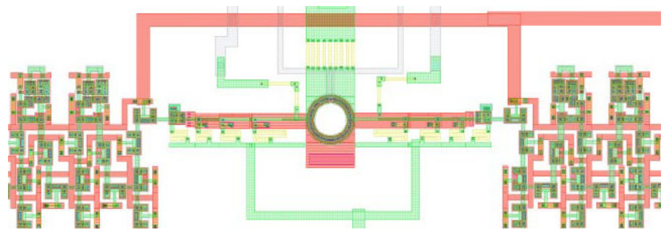
LJJ Clock Sources



Measured time jitter of 60 femtoseconds (0.06 picoseconds) includes the clock, LJJ-to-RSFQ interface and JTLs.

LJJ Clock Sources from 8 GHz to 50 GHz Demonstrated

HYPRES

Text for [LJJ Clock Sources]

Interference is reduced with the use of spectrally pure carriers and ultra-linear power amplifiers. Spectrally pure carriers begin with multi-GHz clocks with clock jitters measured in sub-picoseconds, to generate the **"near-perfect sine wave".**

Measured time jitter **of 60 femtoseconds (0.06 picoseconds) includes the oscillator, LJJ-to-RSFQ interface and JTLs.**

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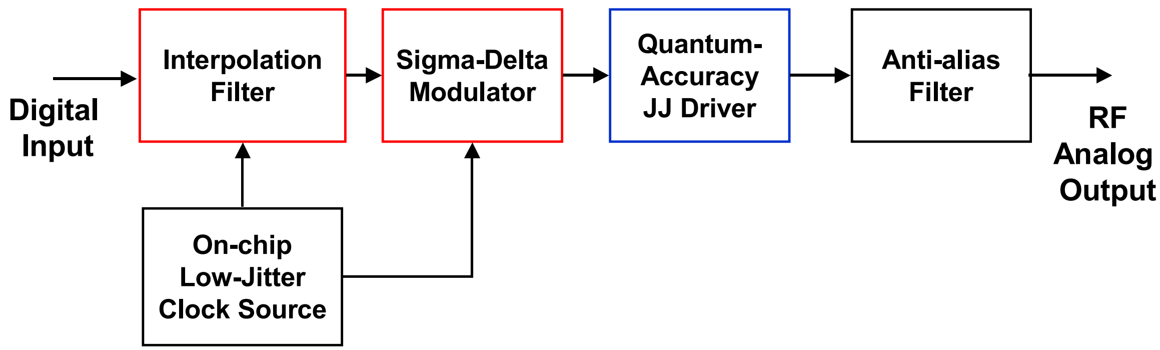
Sigma-Delta Digital-to-Analog Converter



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Text for [Sigma-Delta Digital-to-Analog Converter]

Shown are some of the details of the DAC.

Note that the filter and the modulator are keyed to the on-chip ultra low jitter clock source.

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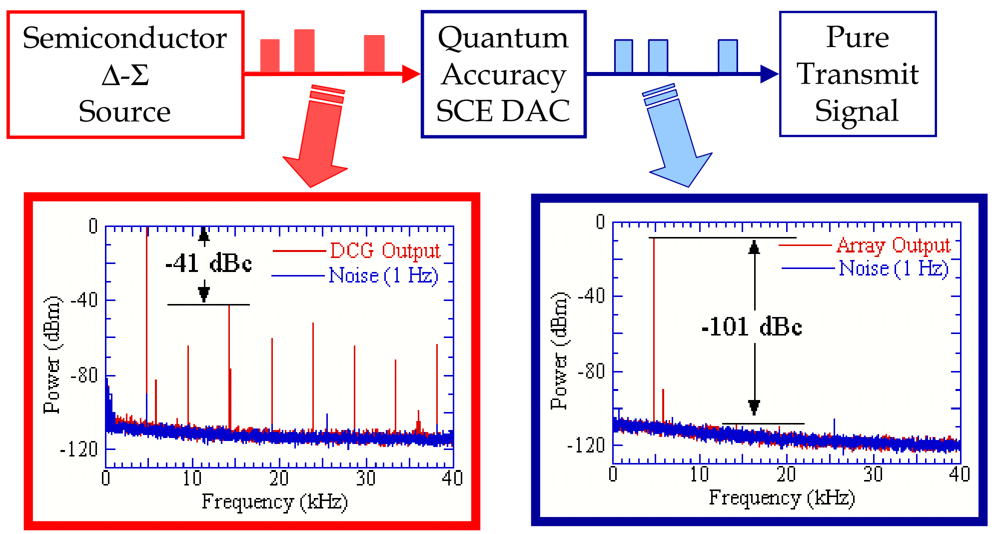
Quantum Accuracy of DAC



Before SCE

After SCE

SCE = SuperConductor Electronics

Demonstrated and Certified by N.I.S.T.

HYPRES

Text for [Quantum Accuracy of DAC]

Interference is reduced with the use of spectrally pure carriers and ultra-linear power amplifiers. Spectrally pure carriers begin with multi-GHz clocks with clock jitter measured in sub-picoseconds, **followed by inherently-perfect DACs*, to generate the "near-perfect sine wave".**

This chart shows the basic performance of superconductive DACs -- note that the signal is cleaned up to over 100 dB below the carrier. This is measurements by NIST (formerly Bureau of Standards).
[The red and blue spikes present in the "before and after" pictures are "artifacts" of the test setup]

*HYPRES DACs are derived from our "Voltage Standard" products, and hence are "inherently perfect". The technology is so accurate that it defines the volt. HYPRES produces Voltage Standard products for worldwide customers – it is the worldwide standard used to calibrate secondary standards.

HYPRES

2. DSP Interference Mitigation

- **Interference has three main forms:**
  - **Small signal of interest in the presence of large interfering signal**
  - **Small signal of interest in the presence of a large number of equal strength signals**
  - **Impulsive interference from hoppers**

Solution:
High-SFDR ADC Front-end followed by
Correlation-based Digital Signal Processing

Text for [2. DSP Interference Mitigation]

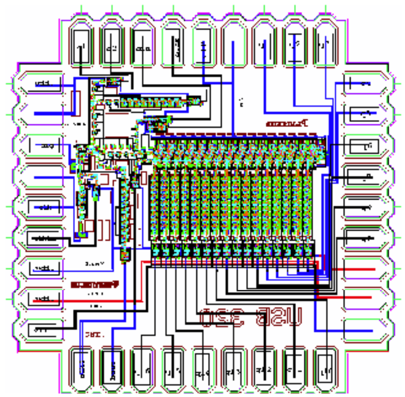
Interference has three main forms. First are small signal of interest in the presence of large interfering signals, e.g., trying to receive a weak spread spectrum signal while transmitting a strong one. This often blocks the military's use of CDMA. Another issue is when a small signal of interest is in the presence of a large number of equal strength signals where multi-path confusion is possible. To counter this, wide guard bands are employed, resulting in fewer usable channels. Finally, there is the impulsive interference from hoppers and other sources.

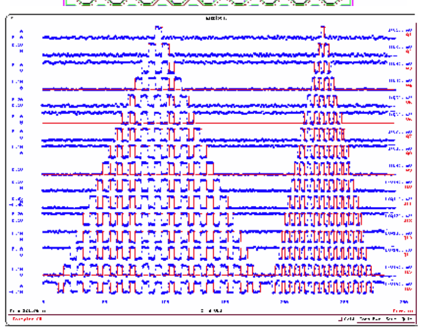
Superconductor electronics and the high dynamic range, wideband ADCs and DACs overcome these problems by employing unprecedented fidelity and speed to resolve the issues. The end result is that the interference solution offered by HYPRES' Digital-RF technology is method-driven and does not have to be individually tailored to specific applications.

With dynamic ranges >120 dB, HYPRES wideband ADCs and DACs overcome interference problems by employing uniquely high fidelity and speed. Specifically, an ultra-linear front-end ADC can be used in concert with an ultra-fast correlation-based receiver. The effect is to create a matched digital filter convolving the waveform samples with a known template of the desired signal. Use of many simultaneous protocols is enabled by simply updating this template in real-time. The ability to digitally process signals at >40 GHz allows this simple and very effective approach.

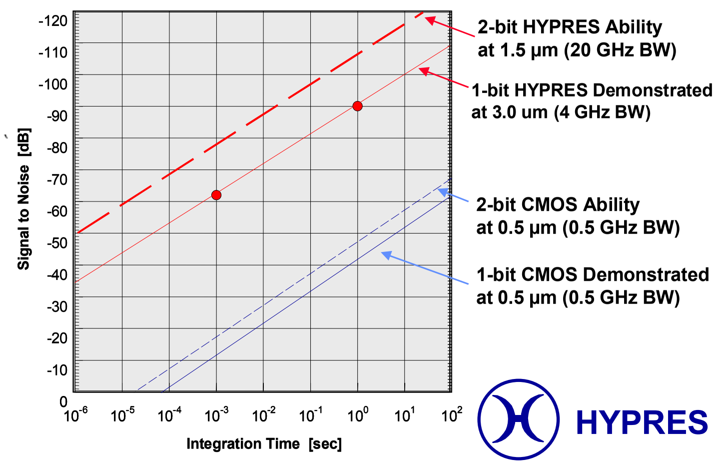
HYPRES

4-GHz Bandwidth All-Digital Autocorrelator





- ❑ 16 channels
- ❑ 4 GHz bandwidth / 16 GHz clock
- ❑ 9-bit output values
- ❑ 1600 devices



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Text for [4-GHz Bandwidth All-Digital Autocorrelator]

The correlator-based maximum likelihood demodulator de-correlates interferors down as it does noise. However, the strategy would be to design the correlation time to drive the interferors below the noise floor level.

Assume that after you have “cleaned up” the transmitter (as previously described) about <u>another 60 to 70 dB</u> of suppression is needed to get below the noise floor.

This chart shows the performance of one of our autocorrelator prototypes. As this chart depicts, it would take about 2 minutes with the best semiconductor-based circuits (clearly unacceptable for a communication system), but only about 0.01 ms (10 microseconds) to achieve this level using our superconducting technology.

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Summary

In summary, the answer is:

Ultra-linear power amplifiers, Spectrally-pure carriers, and Correlator-based/maximum-likelihood-demodulator receivers.

Using HYPRES next generation technology
to eliminate the critical interference issue.

Text for [Summary]

This the HYPRES "1-2" (next-generation technology) punch.

1. Reduce the transmitter "splatter" (intermods/spurs and noise) to very low levels -- far beyond what is achievable with conventional technologies.
2. Use the correlation based receivers to remove the remaining to below the basic noise floor. Using HYPRES technology, this can be accomplished in microseconds (vs minutes for conventional technologies), which is more than adequate for communication systems.

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