Opportunity Title: Superconducting Implementations of Signals Processing Techniques
Opportunity Reference Code: ICPD-2021-20

Organization Office of the Director of National Intelligence (ODNI)

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Complete your application – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant.

Additional information about the IC Postdoctoral Research Fellowship Program is available on the program website located at: https://orise.orau.gov/icpostdoc/index.html.

If you have questions, send an email to ICPostdoc@orau.org. Please include the reference code for this opportunity in your email.

Application Deadline 2/26/2021 6:00:00 PM Eastern Time Zone

Description **Research Topic Description, including Problem Statement:**

Superconducting electronics (SCE) offer the possibility of digital electronics with gate speeds in the range of many tens of gigahertz with very low power consumption that is also intrinsically radiation hard. However, the design principles are somewhat different than for traditional semiconductor electronics. Integrating high-speed and low-noise analog-to-digital converters with very fast digital signals processing back end is very attractive and would put software-defined radio on a whole new plane. L-band (1-2 GHz) should be easily achievable, but it is already within reach of semiconductors. C-band (4-8 GHz) should also be directly within reach of SCE. More interesting is what might happen at X-band (8-12 GHz), which is well within gate speeds of all the SCE logic families, and would allow development of a variant of software-defined radio that could be called "software-defined radar." On the transmit side, with high-speed and low-noise digital-to-analog converters, the possibilities for software-defined beamforming in phased array applications needs to be explored. The goal of such a project would be to develop designs for such signals processing algorithms that are implementable in SCE using newly developed suites of computer-aided design tools specifically targeted to SCE technologies.

Example Approaches:

There are a lot of ideas that are not easily realizable in the analog world that might be accessible in a high-speed digital word, such as transmitters based on complementary binary series of sequences known as Golay series, based on pairs of Golay codes having nonperiodic autocorrelation functions with null sidelobe levels. Very high-speed digital-to-analog and analog-to-digital converters are also possible in SCE with digitization rates approaching 60 gigahertz and noise levels 20 dB below what can be achieved in room-temperature semiconductor electronics. A simpler initial project could be to design a programmable suite of digital filters of 100 stages with 8 bits of quantization in SCE technology and model its performance. An interesting follow-on project could be to create SCE designs and models for high-speed frequency agile modulator/demodulators for quadrature amplitude modulated (QAM) or trellis coded modulation (TCM) modems.

Relevance to the Intelligence Community:

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The Intelligence Community needs to be able to search for and process new signals in frequency ranges that exceed the gate speeds of semiconductor electronics. This has forced approaches that break the frequency spectrum into narrow bands that are then basebanded, digitized, and then processed. Wide band signal can be lost, and digitally defined phased-array beamforming is nearly impossible, leading to potential problems with sidelobe interference. Being able to process L-band, X-band, and possibly even K-band signals at speed with software-defined radio would offer unprecedented flexibility in both spectrum search for emitters and demodulation of known high-frequency signals.

Key Words: Superconducting Electronics, SCE, Signals Processing, Quadrature Amplitude Modulated, QAM, Trellis Coded Modulation, TCM, Modems

Qualifications

Postdoc Eligibility

- U.S. citizens only
- Ph.D. in a relevant field must be completed before beginning the appointment and within five years of the application deadline
- Proposal must be associated with an accredited U.S. university, college, or U.S. government laboratory
- Eligible candidates may only receive one award from the IC Postdoctoral Research Fellowship Program

Research Advisor Eligibility

- Must be an employee of an accredited U.S. university, college or U.S. government laboratory
- Are not required to be U.S. citizens

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12)
  - **Communications and Graphics Design** (2)
  - **Computer, Information, and Data Sciences** (17)
  - **Earth and Geosciences** (21)
  - **Engineering** (27)
  - **Environmental and Marine Sciences** (14)
  - **Life Health and Medical Sciences** (45)
  - **Mathematics and Statistics** (10)
  - **Other Non-Science & Engineering** (2)
  - **Physics** (16)
  - **Science & Engineering-related** (1)
  - **Social and Behavioral Sciences** (27)