Requirements / Specifications Document

National Institute of Standards and Technology
U.S. Department of Commerce

TITLE: **RFSoC Integrated Microwave Readout Electronics**
PR NUMBER: NB687000-26-02197

Requesting Laboratory / Division / Group: Physical Measurements Laboratory / Applied Physics Division / Quantum Microcalorimeter Group

GENERAL STATEMENT OF NEED:

The Quantum Microcalorimeter Group requires a Radio Frequency System-on-Chip (RFSoC) Integrated Microwave Readout Electronics. The purpose of these electronics will be for the readout and operation of large arrays of x-ray detectors under development at NIST. The electronics must be able to generate, convert to analog, receive and digitize, and process hundreds of sinusoidal tones at frequencies ranging from 1 MHz to 1 GHz. In order to leverage and be compatible with previous NIST work, these electronics must be based on the Xilinx Zynq UltraScale+ RFSoC (Radio Frequency System on Chip). We require an integrated development platform of electronics compatible with a PCI-express interfaces of a PC (Personal Computer) and based on a 3rd Generation (or newer when available) Xilinx RFSoC chip.

BACKGROUND:

NIST develops detector arrays with channel counts in the thousands of detectors. In order to operate and read out data from the detector, each must be electrically interrogated with a unique sinusoidal tone with a frequency at the channel's unique resonant frequency. Specialized electronics are needed in order to simultaneously generate and read hundreds, and up to thousands, of these unique sinusoidal tones. NIST develops its own firmware and software for operating these electronics.

OBJECTIVE:

The electronics must be capable of generating hundreds of frequency tones, convert to analog, receive and digitize returning tones, provide filtering and decimation, and communications to stream results. Each tone must be dynamically programmable based on the needs of the particular detectors. The base frequencies required range from 1 MHz to 1 GHz, which may be upconverted to higher frequencies using separate intermediate frequency (IF) electronics not included or required in this acquisition. NIST has developed its own firmware and software that will be used to operate the electronics.

Item Specifications and Quantities:

Item 1:	**RFSoC Integrated Microwave Readout Electronics**	
Quantity:	**Six (6)**	
Specifications:		
	1.1	8x Radio Frequency Analog to Digital Converters (ADC) at 10 Giga Samples per Second (GSPS) at 14-bit resolution or better.
	1.2	An additional 8x ADCs at 5 GSPS and 14-bit resolution or better.
	1.3	Ability to operate as a standalone electronics board, with support for running an embedded Linux with serial console, 1000Base-T Ethernet Interface, and register read/write access to the FPGA.
	1.4	Ability to operate and interface using PCI-express (PCIe) interface of a computer; PCIe Gen3/Gen4 x4 required.
	1.5	Have ethernet communications at speeds of 10 Gigabit/s or faster, over SFP+/QSFP+ or better supporting passive Direct Attach cabling. The

		connectors might be located on the FPGA card itself, or on an extension card, preferably with an industry standard interface (FMC).
	1.6	"drop in" compatible with NIST-developed firmware and software that will be used to operate the electronics (HTG-ZRF8-R2-48 and HTG-FMC-SFP-OC-E are drop in compatible).
	1.7	Based on a 3rd Generation Xilinx Zync Ultrascale +. RF system-on-chip technology (RFSoC)
	1.8	Support for standalone clocking and running on an external 10 MHz reference clock; support for an external 1PPS like TTL synchronization signal.
	1.9	Support for multi-tile synchronization.
	1.10	Support for at least 16 GByte DDR memory for the Programmable Logic.
	1.11	RFSoC Electronics Development Platform Hardware. Integrated Electronics board that is PCIe and PC compatible. Request delivery of hardware 8 weeks ARO.
	1.12	RFSoC integrated development platform electronics compatibility matching Xillinx ZU48DR chip. Quantity of 3 copies.

PROCUREMENT SUPPORT INFORMATION AND ANCILLARY SERVICES

Section	**Requirements/Specifications**
Planning Considerations ☒ N/A	☐ List any visits required to allow potential vendors to see site specific constraints. ☐ US citizen required on-site (foreign nationals require pre-registration 30 days prior to visit.) ☐ Vendor Representative On-Site more than three (3) days. ☐ Other Considerations:
Shipping & Delivery ☐ N/A	Shipping Address: ☒ NIST-Boulder ATTN: Doug Bennett Mail Stop: 687.12 325 Broadway Boulder, CO 80305 Shipping Criteria: ☐ Partial Delivery Acceptable ☐ [Enter Shipping and Delivery information by item.] ☐ Direct Delivery to OU Building Required [Explain Need for Requirement] Building /Room Number: [Enter Building/Room Number] ☐ Building has Loading Dock Containerization Preference: [Enter Container Type] Other Requirements: [List Any Other Requirement]

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	Delivery Date Criteria: ☒ Delivery Shall Be Competed No Later Than: 16 Weeks ARO ☐ Delivery Shall Be Made No Earlier Than: Click or tap to enter a date. ☐ Scheduled Deliveries:
Electronic Media ☒ N/A	☐ Software ☐ Electronic Manuals; All manuals shall be provided electronically. ☐ License Key ☐ Other: [List Any Other Electronic Media Requirements] ☐ US Government Email Address for Software Delivery: [Enter Address]
Installation ☒ N/A	☐ Vendor Technician on Site ☐ Rigging ☐ Uncrating / Unpackaging ☐ Removal of Packaging Material ☐ Equipment Set Up ☐ Start-Up Services ☐ Turnkey Installation ☐ Other: [Enter Details] NOTE: TPOC shall be the coordination POC.
Facility / Utility Considerations ☒ N/A	[List Site Specific Utility Considerations by Item] ☐ OFPM Work Order Numbers [List Work Order Numbers] ☐ Power Available Voltage: [Enter voltage] (V) Maximum Current: [Enter max current draw] (A) Phase: [Choose Phase] Frequency: [Typically 60Hz] (Hz) NEMA Plug Type: [Enter Plug Type] (i.e.: NEMA L5-20P) Environment: [Choose Environment] Other Power Considerations: [List Any Other Power Considerations.] ☐ Utility Connections: [List Relevant Available Utilities, Pressure(s) and Flowrate(s).] ☐ Other Considerations: [List Other Considerations to Ensure an Accurate Quote.]

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Inspection and Acceptance ☐ N/A	[Inspection Requirements Per Item (Who, When, What, Where)] ☐ On-Site ☒ Acceptance Expected to Not to Exceed 7 Business Days ☐ Acceptance Expected to Exceed 7 Business Days: [Duration] ☐ Inspection and Acceptance Plan: [Explanation] ☐ Other: [Enter Other Requirements]
Training ☒ N/A	Training Requirements (Who, When, What, Where) ☐ Number of Trainees: [Enter Number of Trainees] ☐ On-Site ☐ Off-Site Location: [Enter Location(s)] Is Trainee Travel Required: [Choose Answer] Scope of Training ☐ Operation ☐ Maintenance ☐ Troubleshooting ☐ Safety ☐ Other [Enter Other Scope of Training Requirements] ☐ Training Materials to be Provided by Government: [Describe Materials] ☐ Training Materials to be Provided by Vendor: [Describe Materials] ☐ Other [Enter Other Training Requirements] NOTE: TPOC shall be coordination POC.
Warranty ☐ N/A	Base Manufacturer Warranty is acceptable Warranty Length: 1 - year What is included? ☐ Labor ☐ Parts ☐ Travel ☐ Cost and Liability for Returns ☐ Other The cryostat system shall have a 1-year warranty. ☐ 1 Option Period ☐ 2 Option Periods ☐ 3 Option Periods ☐ 4 Option Periods (Maximum)

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Maintenance ☒ N/A	[Describe Maintenance Requirements Per Item] Maintenance Plan Length: [i.e. 3 - Years] What is Included? ☐ Labor ☐ Spare Parts ☐ Consumables ☐ Travel ☐ Cost and Liability for Shipment ☐ Software Updates ☐ Manuals ☐ Other Requirements: ☐ [Enter Requirements] (i.e.: On-Site Within 72 hours, etc.) 1 Option Period Length: [i.e. 1 – Year / 6 - Months] ☐ 2 Option Periods ☐ 3 Option Periods ☐ 4 Option Periods (Maximum) ☐ 4 Option Periods (Maximum)
Government Furnished Material / Equipment ☒ N/A	List Any Government Furnished Material / Equipment Per Item] ☐ Equipment which will leave Government Site ☐ Description: Serial Number: NIST Property Number: Other: [Enter Description] [Enter Serial Number] [Enter NIST Property Number] ☐ Other: [Enter Other Details]
Travel ☒ N/A	[Describe any Travel Requirements Per Item] ☐ [Enter Justification / Requirement] Other: ☐ [Enter Other Requirements] [Enter Other Requirements] NOTE TO VENDOR: To the maximum extent possible, include travel requirement estimates as part of pertinent sections above (Installation, Maintenance, Repair, etc.). Otherwise, Travel will be a separate line item, reimbursable per the Federal Travel Regulation.