Improved Low-Noise Cryogenic Transimpedance Amplifier

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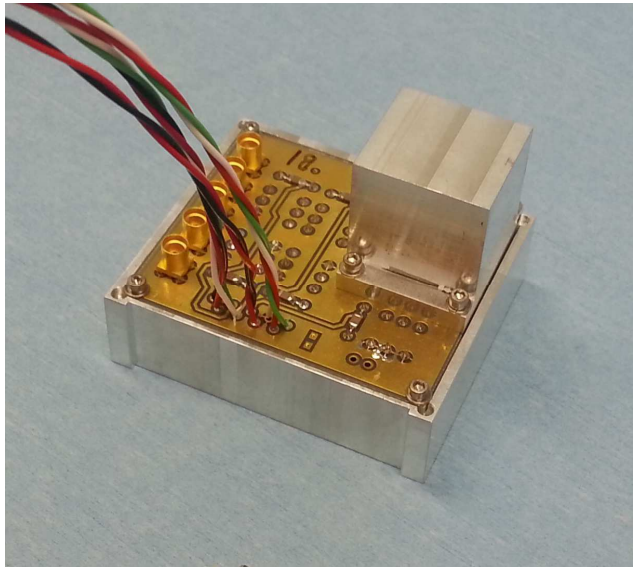

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Characterization and Radiometric Calibration for Remote Sensing
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Design Criteria for New Cryogenic Amplifier

Low Noise

- New amplifier includes shielding enclosure.
- All signal lines are routed on internal PCB layers between ground planes.

Improved Bandwidth

- Smaller PCB size and careful routing reduced stray capacitance. Stray capacitance severely limited the bandwidth of the previous generation amplifier.

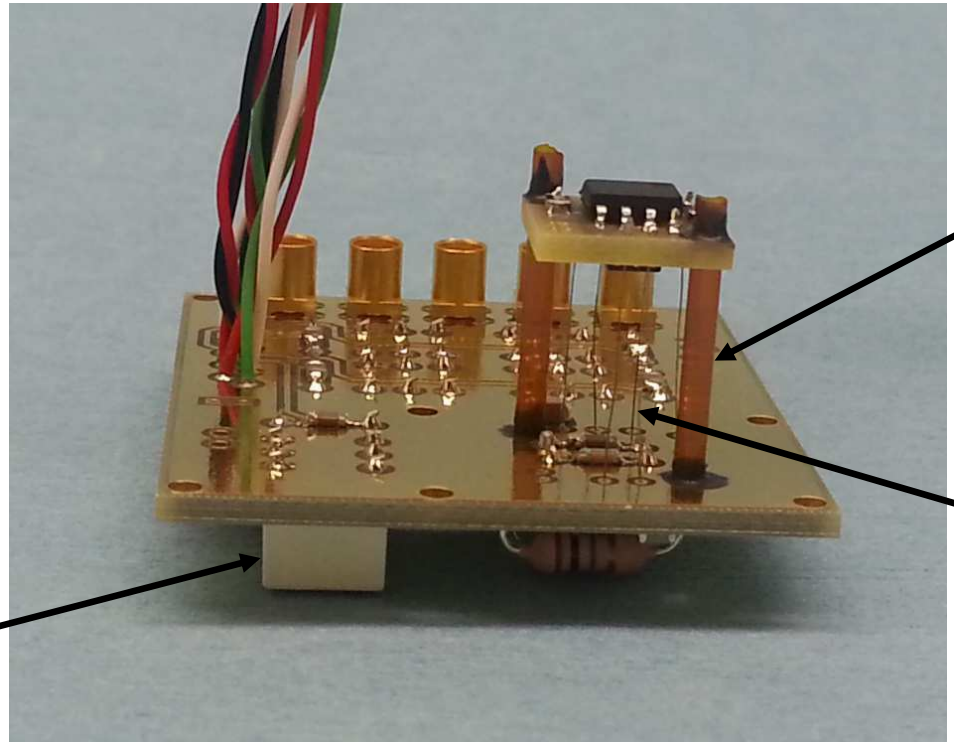
Compact Design

- Eliminated 100 Mohm and 1 Gohm ranges. These were rarely used and had severely limited bandwidth. This also eliminated two (2) electro-mechanical relays.
- Reduced the number of inputs from eight (8) to four (4), eliminating two (2) electro-mechanical relays.

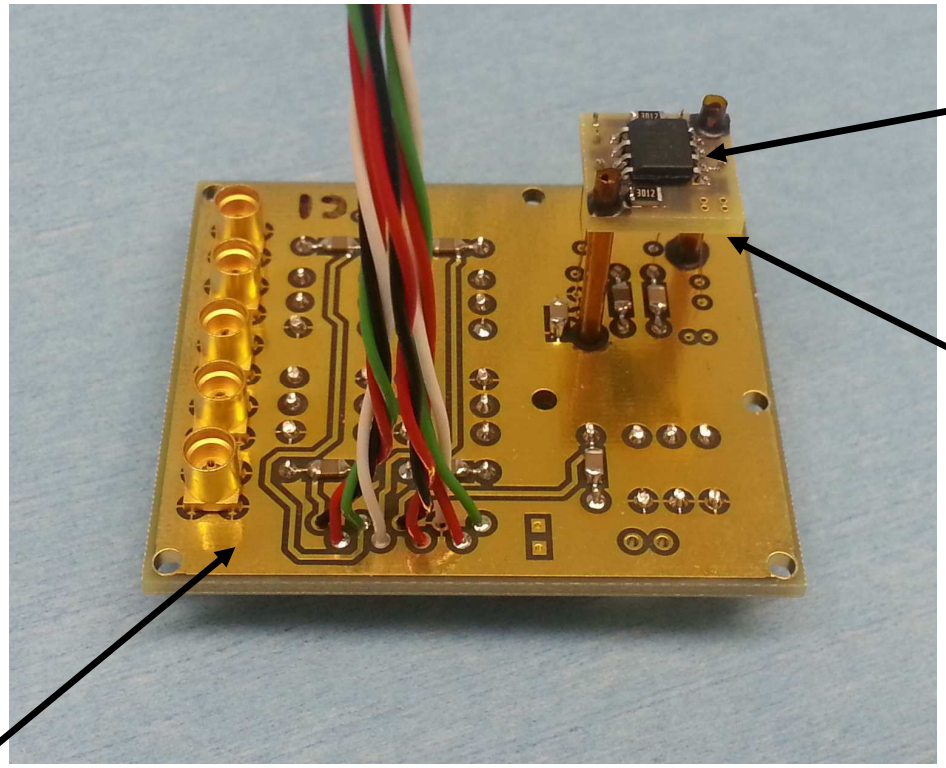
Improved Cryogen Hold Time

- The cryogenic amplifier dissipates 4 mW.
- The silicon diode temperature sensor on the BIB detector package dissipates 17 uW.
- Separating the amplifier from the detector package significantly reduces the heat load on the detector cryostat, improving cryogen hold time.

Cryoampilfier Photo 1: Side View



Cryoamplifier Photo 2: Top View



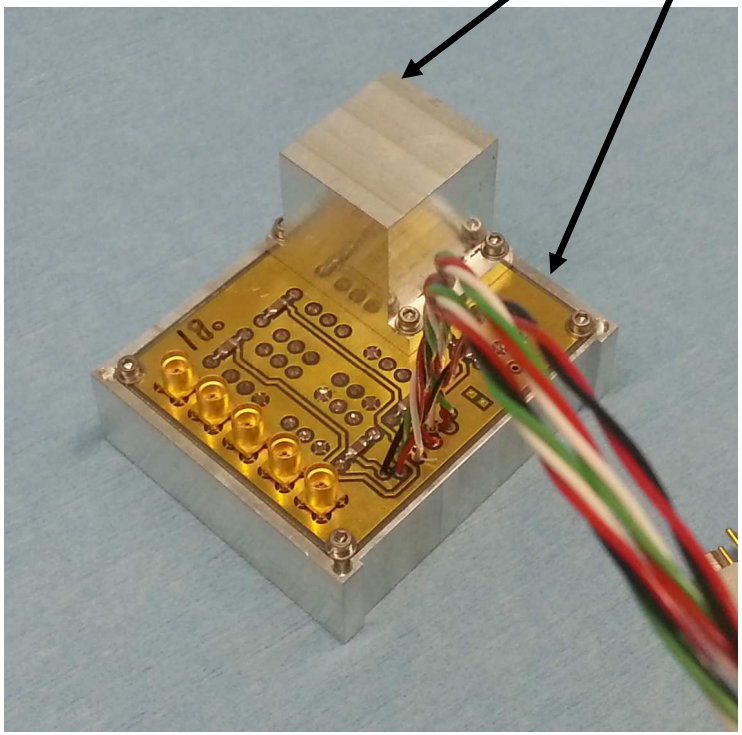
TLC271B OpAmp

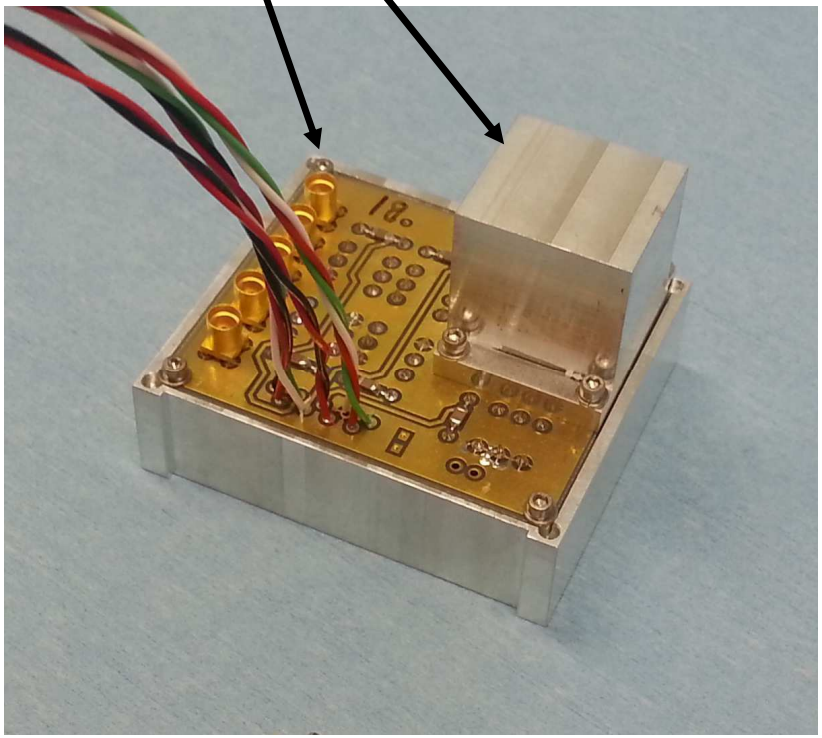
LS844 Preamp (on underside)

Signal traces are on internal PCB layers between upper and lower ground planes for shielding.

Cryoamplifier Photo 3: Enclosure

Amplifier cover provides electrical shielding as well as containment of thermal radiation from warm amplifier components.

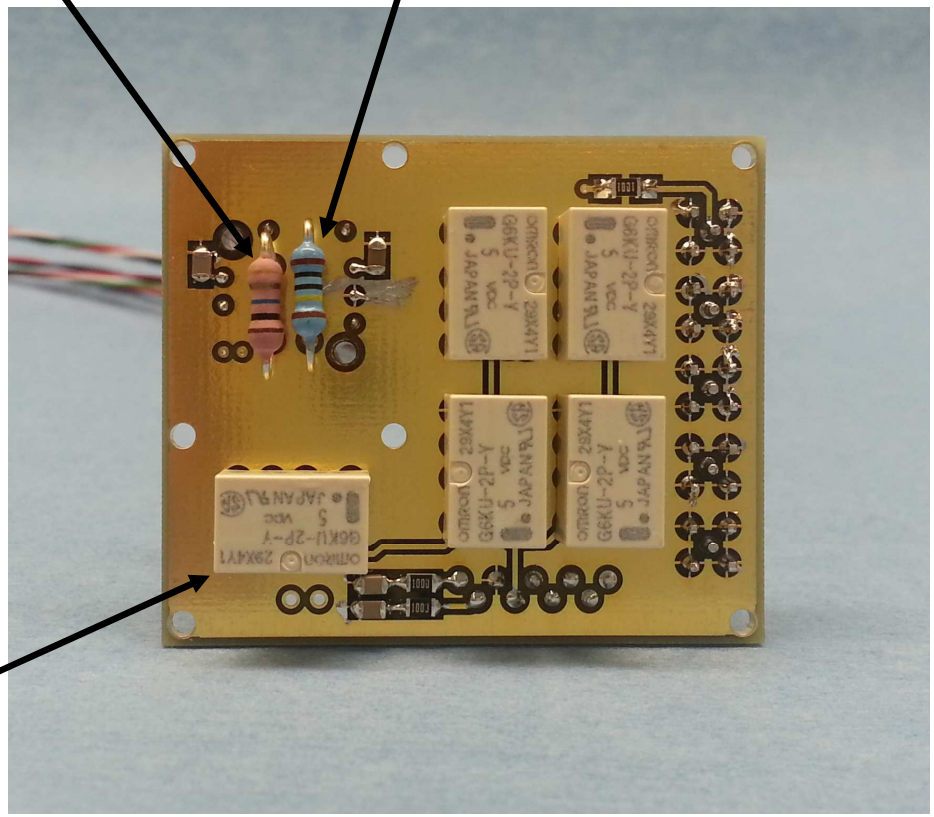




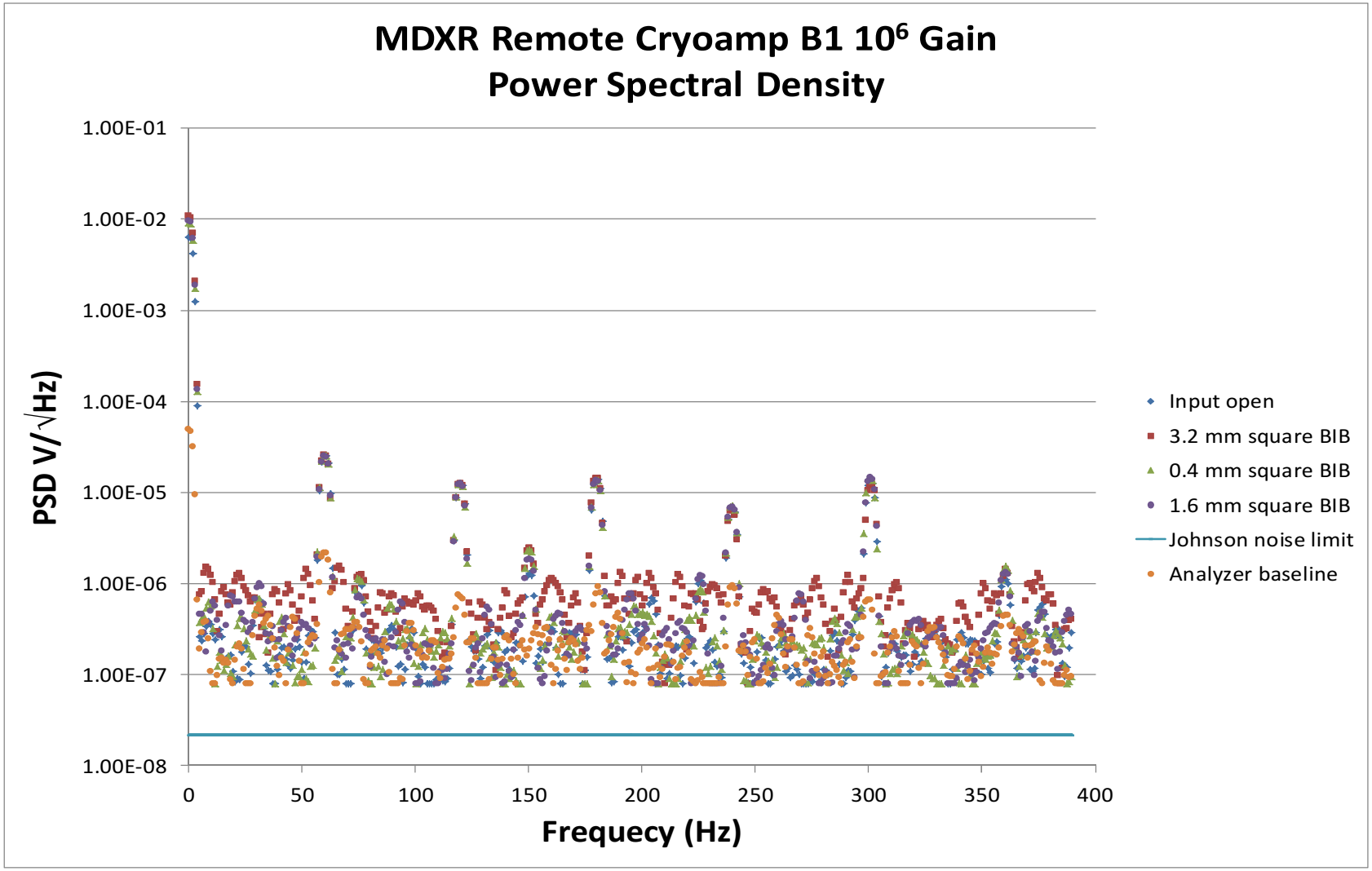
Cryoamplifier Photo 4: Bottom View

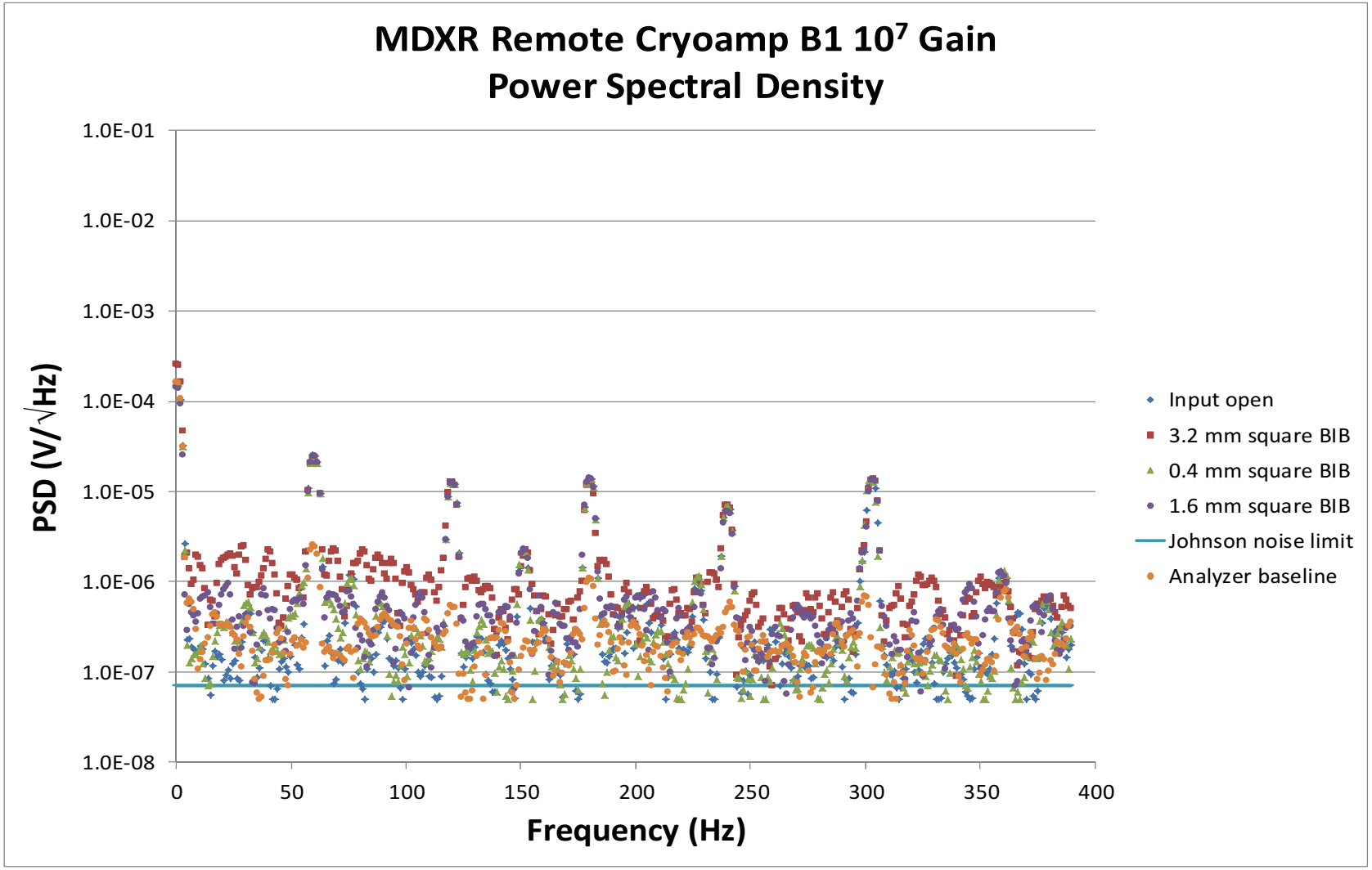
10 Megaohm feedback resistor

1 Megaohm feedback resistor



Dual coil latching relay


MDXR Remote Cryoamp B1 10^6 Gain
Power Spectral Density
PSD V/√Hz)
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
0
50
100
150
200
250
300
350
400
Frequecy (Hz)
Input open
3.2 mm square BIB
0.4 mm square BIB
1.6 mm square BIB
Johnson noise limit
Analyzer baseline


MDXR Remote Cryoamp B1 10^7 Gain
Power Spectral Density
PSD (V/√Hz)
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
0
50
100
150
200
250
300
350
400
Frequency (Hz)
Input open
3.2 mm square BIB
0.4 mm square BIB
1.6 mm square BIB
Johnson noise limit
Analyzer baseline

MDXR Remote Cryoamplifier - DC noise performance

Output signal measured using a commercially available digital multimeter.

Single measurement integration time: 1.667 seconds (100 power line cycles at 60 Hz)

Number of readings averaged: 36

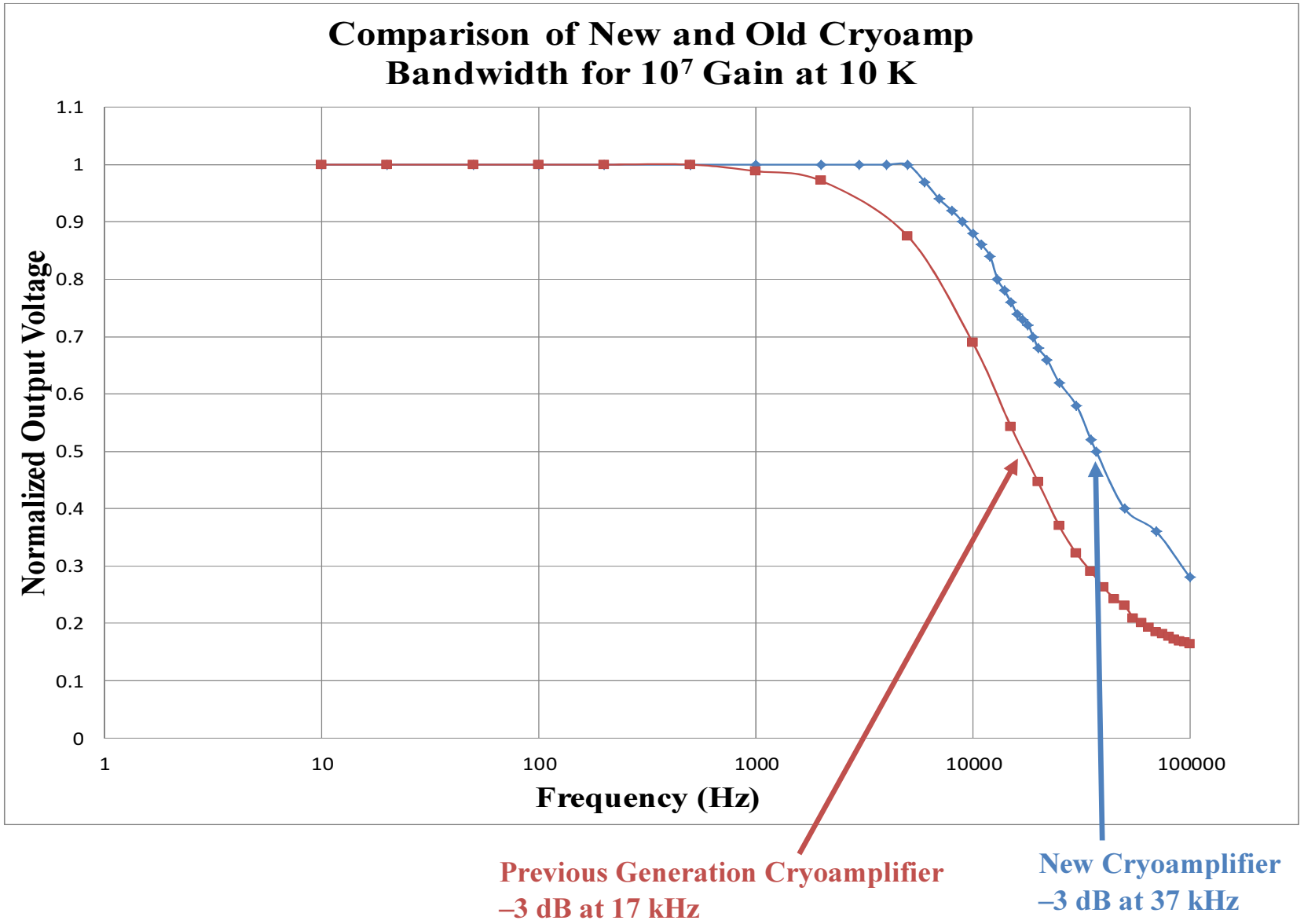
Total effective measurement integration time: 60 seconds

1 Mohm range

Amplifier Input	Signal Mean (V)	Signal Standard Deviation (V)	Std Dev / Mean
Open	3.68×10^{-3}	2.23×10^{-7}	0.000061
3.2 mm square BIB	4.46×10^{-3}	1.57×10^{-5}	0.003529
1.6 mm square BIB	4.47×10^{-3}	2.58×10^{-6}	0.000578
0.4 mm square BIB	3.64×10^{-3}	2.46×10^{-7}	0.000067

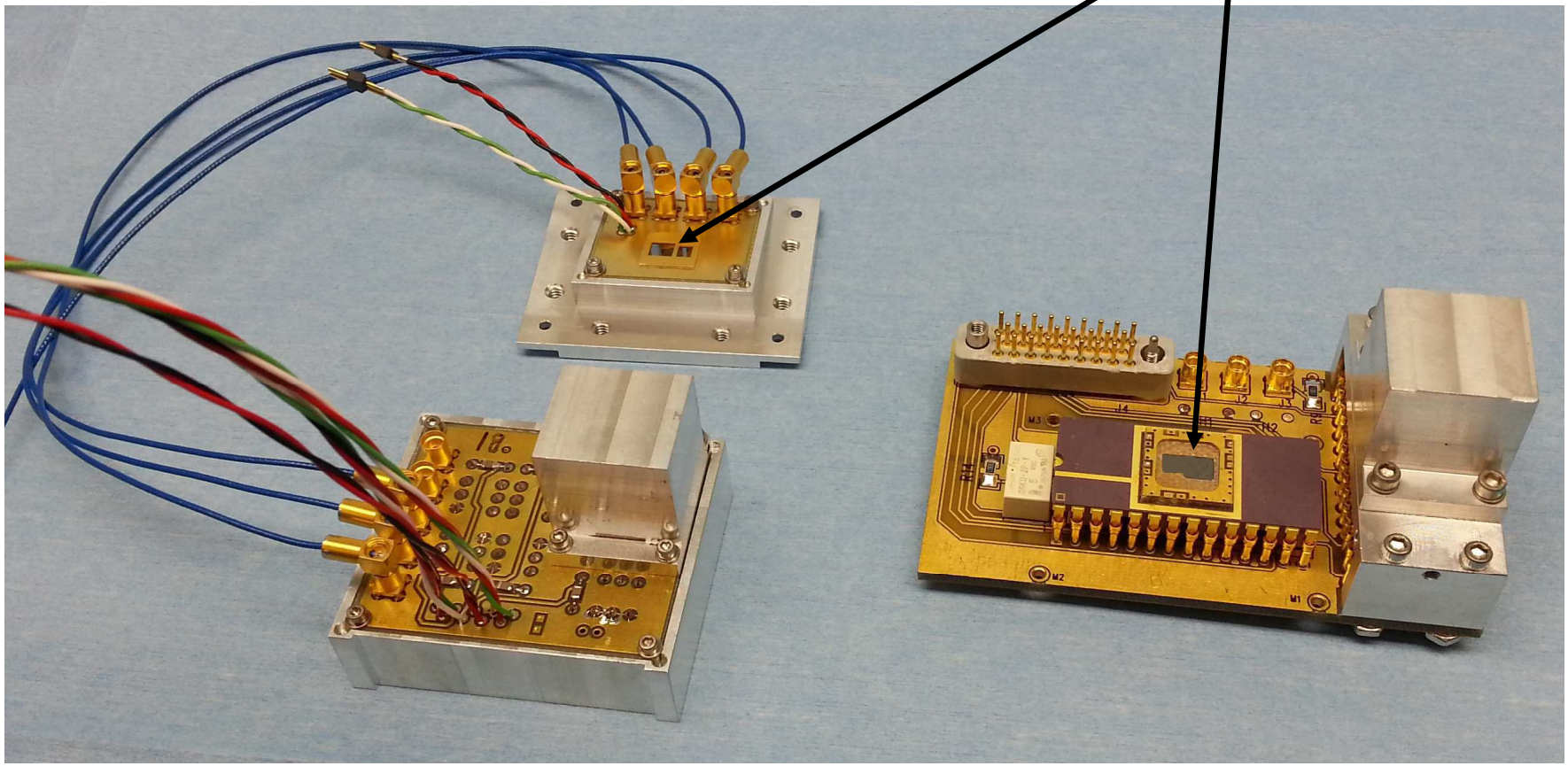
10 Mohm range

Amplifier Input	Signal Mean (V)	Signal Standard Deviation (V)	Std Dev / Mean
Open	3.02×10^{-3}	1.16×10^{-7}	0.000038
3.2 mm square BIB	1.12×10^{-2}	7.73×10^{-5}	0.006931
1.6 mm square BIB	1.17×10^{-2}	1.69×10^{-5}	0.001450
0.4 mm square BIB	3.10×10^{-3}	3.89×10^{-7}	0.000125


Comparison of New and Old Cryoamp
Bandwidth for 10^7 Gain at 10 K
Normalized Output Voltage
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
10
100
1000
10000
100000
Frequency (Hz)
Previous Generation Cryoamplifier
–3 dB at 17 kHz
New Cryoamplifier
–3 dB at 37 kHz

New and Previous Generation Cryoamplifiers

New package reduces heat load on cryogen reservoir by approximately two orders of magnitude



Power Dissipation:

BIB Package: < 20 uW to Liquid He reservoir

Amplifier: ~ 4 mW to test chamber cooling system

Power Dissipation:

BIB/Cryoamp Package: ~ 4 mW to Liquid He reservoir

Benefits of the new MDXR Remote Cryoamplifier

Amplifier power dissipation is removed from detector cryogen reservoir, significantly increasing measurement time between refilling operations.

Improved bandwidth, -3 dB at 37 kHz compared to 17 kHz for previous generation cryoamplifier.

Near Johnson noise limited performance on 10^7 gain range

New cryoamplifier has "bypass" setting that feeds selected detector directly out on the calibration line, bypassing the cryoamplifier, allowing measurement of the signal using external instruments.

Better containment of thermal radiation from warm amplifier components

Detector package is simpler and more compact, saving critical space in the optical path.