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A Medium Frequency RF Sensor for Detection of Magnetized Quark Nuggets

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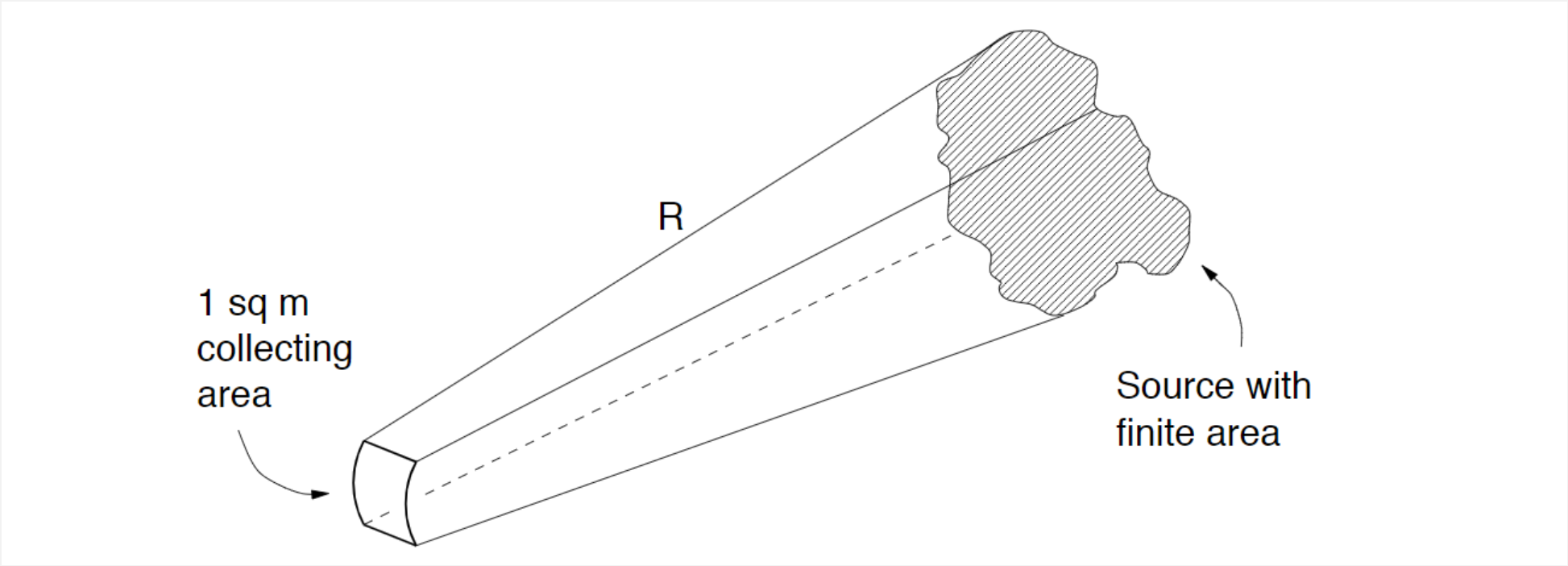
Magnetized Quark Nuggets (MQNs)?

- Quark nuggets are hypothesized objects composed of approximately equal numbers of up, down, and strange quarks
- Dark matter constitutes approximately 85% of the universes mass
- Quark nuggets are a candidate for dark matter

Brightness: Thinking About Units

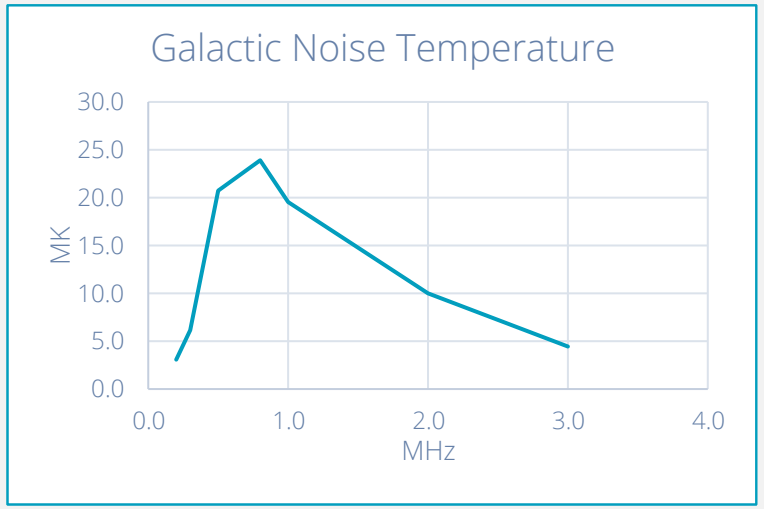
$$Brightness: W/m^2/sr/Hz$$



Working Toward Design Requirements

Noise Temperature → Rayleigh-Jeans Law → Brightness

$Kelvin$ $W/m^2/sr/Hz$



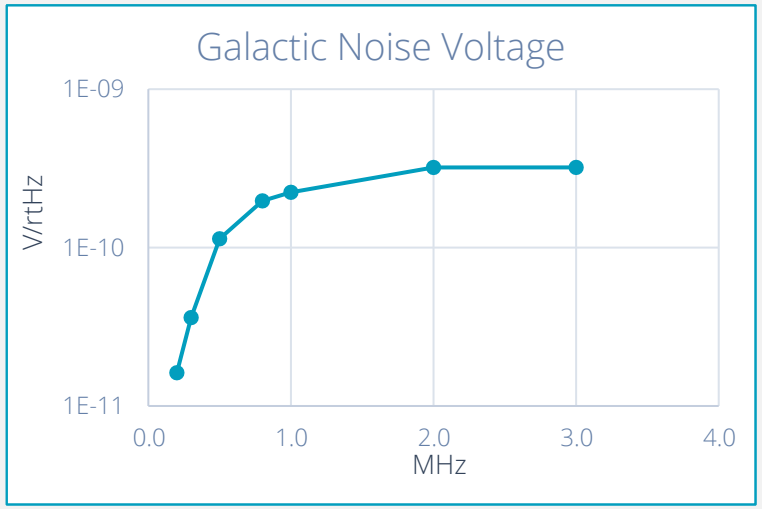
$$B_v(T) = \frac{2v^2 k_B T}{c^2}$$

Working Toward Design Requirements

Brightness
$W/m^2/sr/Hz$

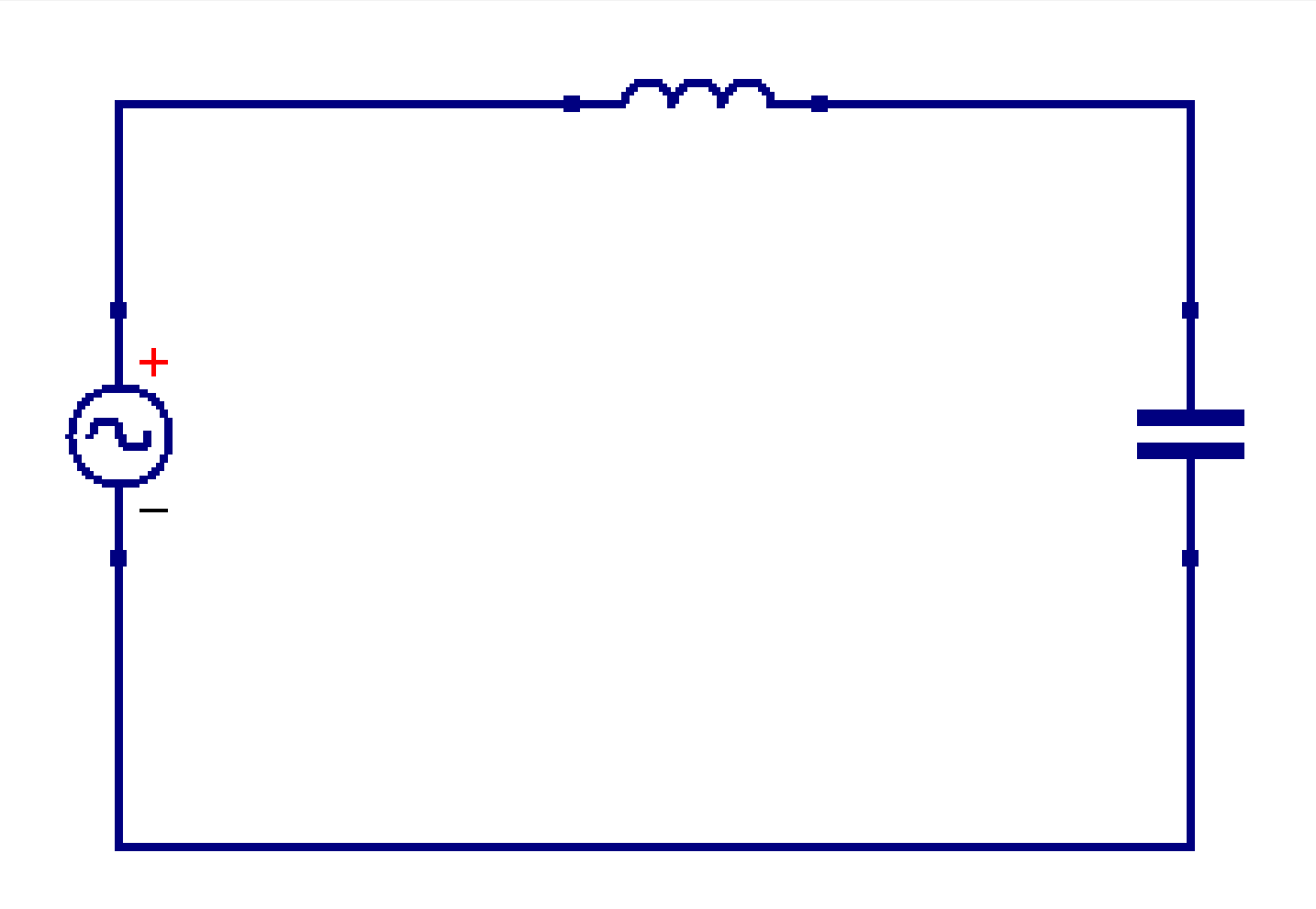
Magnetic Field
$T/\sqrt{Hz}$

Noise Voltage
$V/\sqrt{Hz}$

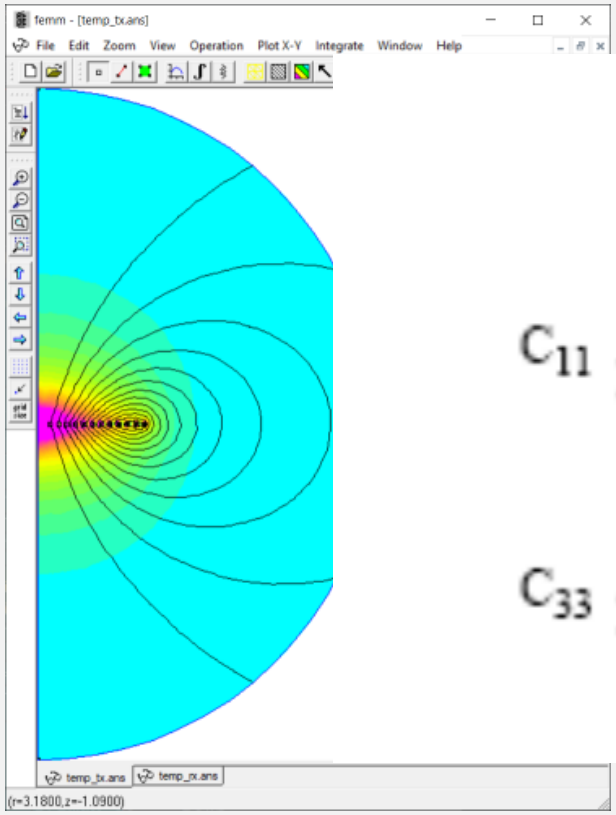


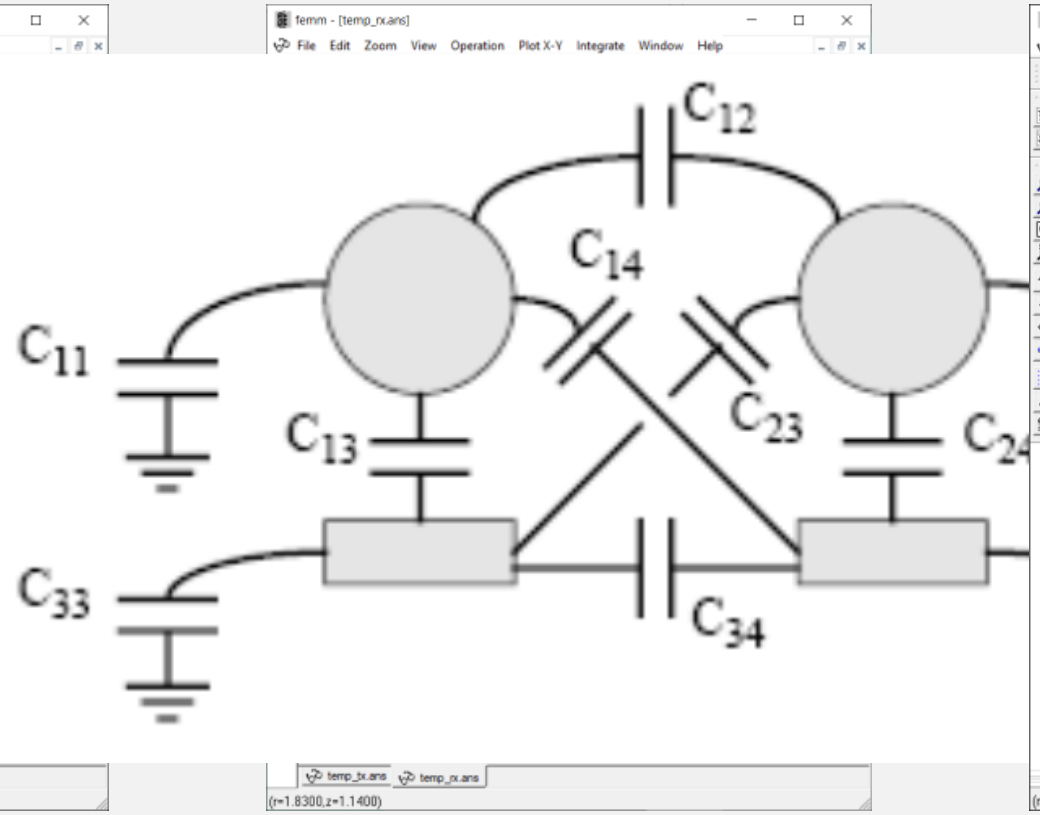
Transfer Function:
$10^8\ V/T$

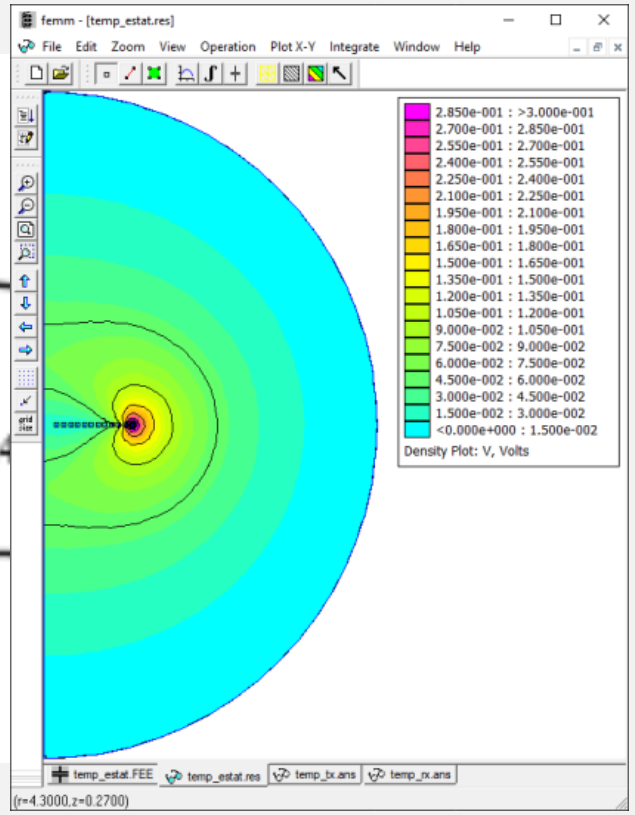
Inductive Loop Antennas Are Limited by Capacitance



Calculating A Self-Resonant Frequency (SRF)







12-Turn Coil “Transmit” Sim

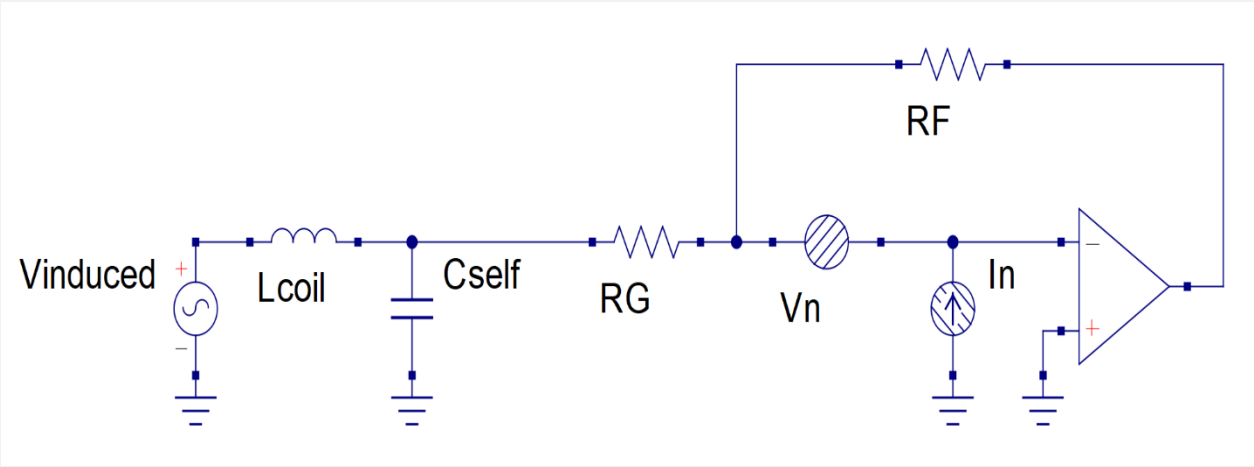
12-Turn Coil “Receive” Sim

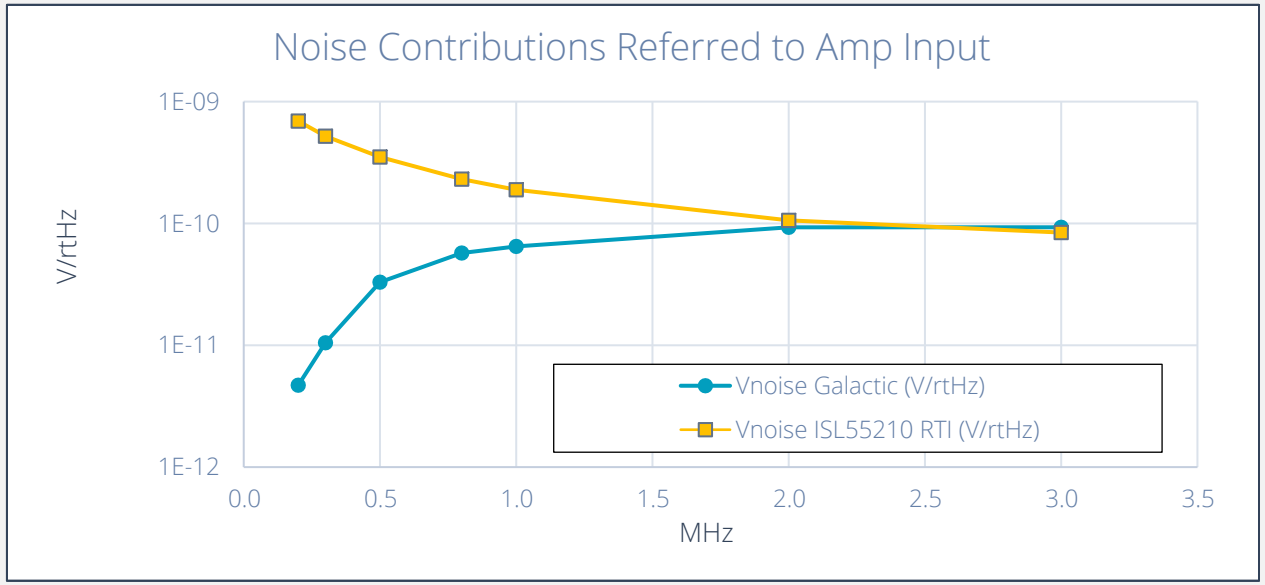
12-Turn Coil “Electrostatic” Sim

We Built The Sensor…

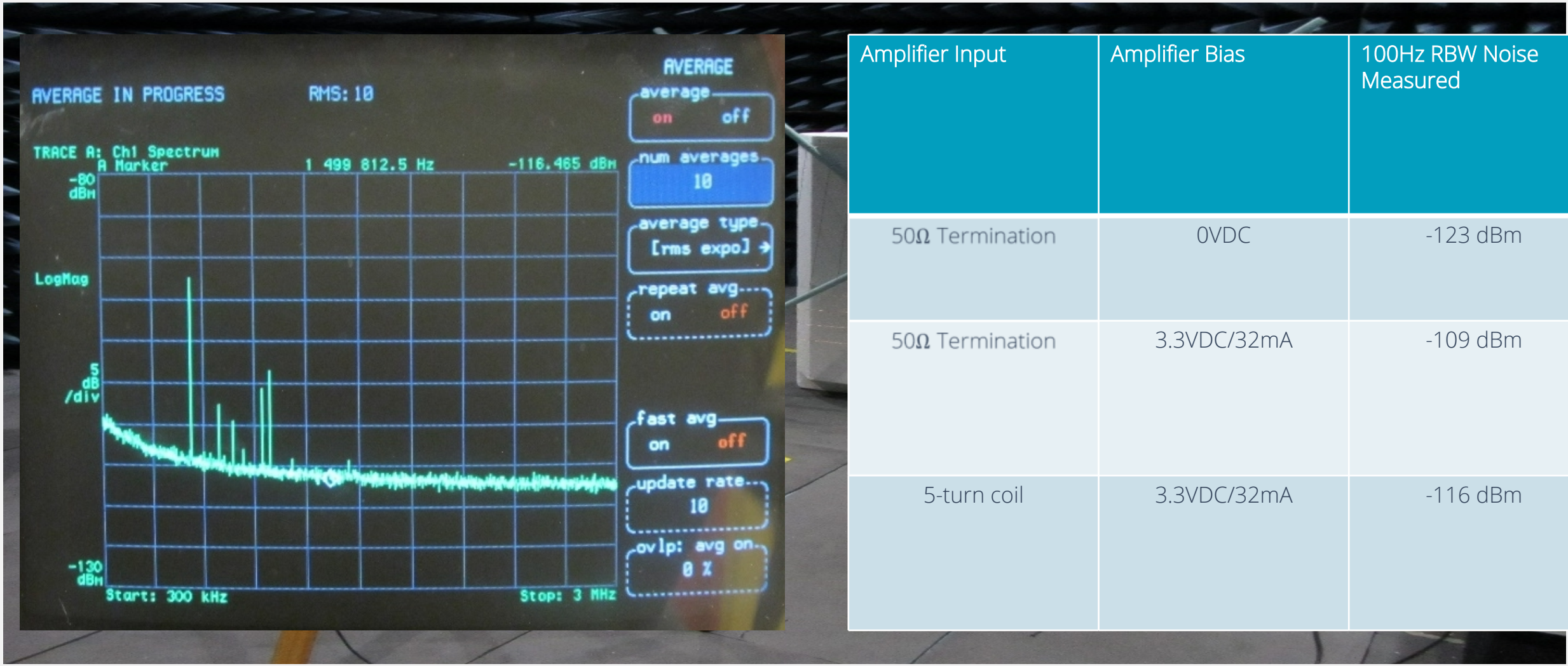
Parameters	12-turn Coil (Predicted)	12-turn Coil (Measured)	5-turn Coil (Measured)	5-turn Coil (Measured)
Inductance	$130\ \mu H$	$160\ \mu H$	$43.0\ \mu H$	$36.0\ \mu H$
SRF	$6.00\ MHz$	$1.00\ MHz$	–	$4.50\ MHz$
Transfer Function	$51.6\ MV/T$	–	$29.0\ MV/T$	–

Sensor Noise Determined by Amplifier/Coil Interaction



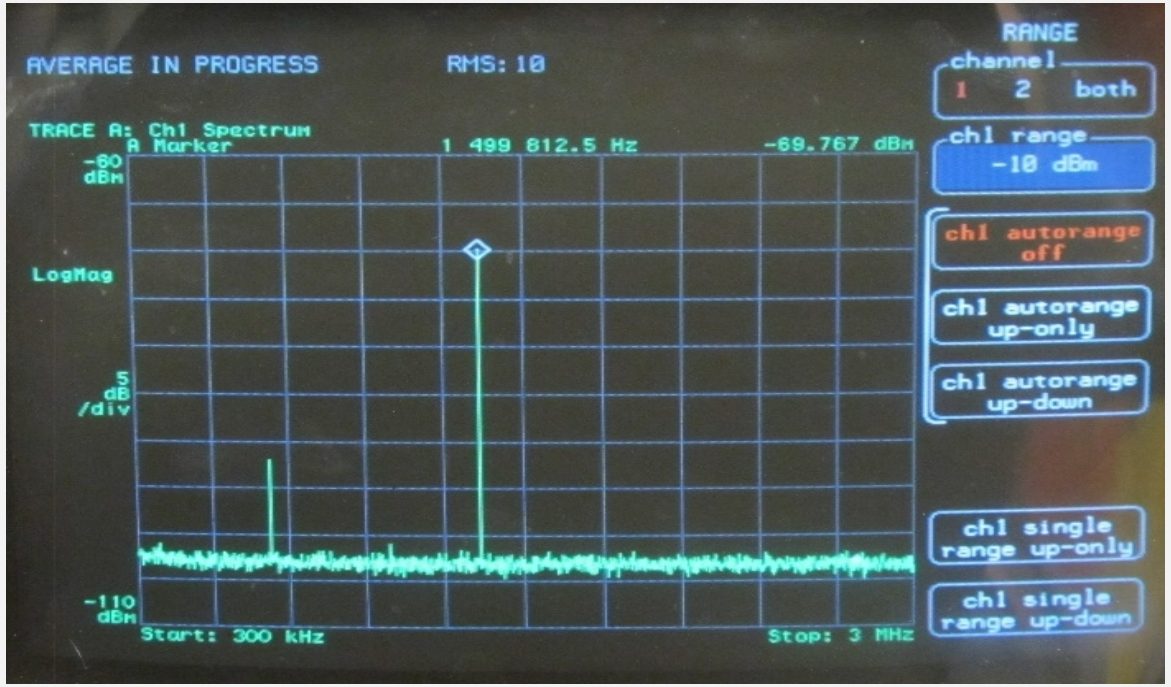


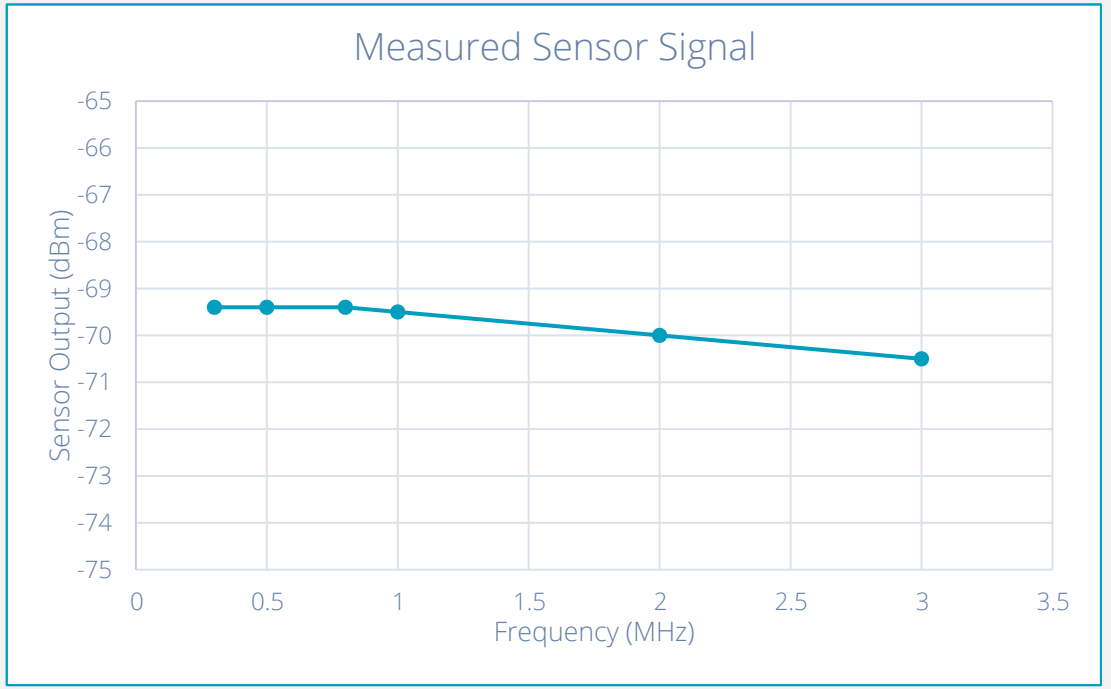
Testing & Our Workable Solution



Amplifier Input	Amplifier Bias	100Hz RBW Noise Measured
50Ω Termination	0VDC	-123 dBm
50Ω Termination	3.3VDC/32mA	-109 dBm
5-turn coil	3.3VDC/32mA	-116 dBm

Sensor Signal





Conclusion

- Brightness
- Capacitance
- Amplifier/Coil Interaction