



Standard Sensors & Accessories for EMAT Applications

© 2023 Innerspec Technologies, Inc.
All Rights Reserved

This Material May Not Be Published, Rewritten,
or Redistributed Without Express Permission

Table of Contents

1. Introduction to Electro Magnetic Acoustic Transducer (EMAT).....	4
1.1. Wave Modes.....	5
2. Applications.....	6
2.1. Normal (Zero Degree) Beam.....	6
2.2. Angled Beam and Phased Array.....	7
2.3. Guided Waves.....	8
3. Equipment Configuration.....	9
4. Instrumentation.....	10
5. Standard Sensors & Accessories.....	10
6. Normal Beam Sensors & Accessories.....	11
6.1.1. Thickness Measurement and Flaw Detection (normal beam) with EMAT.....	15
6.1.1.1. Sensor HT (650C) SH Lorentz w/o Active Cooling – 1.0" D.....	16
6.1.1.2. Sensor HT (650C) SH Butterfly Sensor – 2.38"D.....	17
6.1.1.3. Sensor SH Butterfly Sensor – 1.0"D.....	18
6.1.1.4. Sensor SH Butterfly Sensor – 1.9"L x 1.0"W.....	19
6.1.1.5. Sensor L-Wave Small (HR) for Non-Ferromagnetic Materials – 1" W.....	20
6.1.1.6. Sensor L-Wave Medium (HR) for Non-Ferromagnetic Materials – 1"W.....	21
6.1.1.7. Sensor L-Wave Large (LR) for Non-Ferromagnetic Materials – 1.56"W.....	22
6.1.1.8. Sensor L-Wave X-Large Scanning for Non-Ferromagnetic Materials – 3.5" x 2.5".....	23
6.1.1.9. Sensor SH Flex Coil Scanner.....	24
6.1.2. Corrosion Mapping With EMAT.....	28
6.1.2.1. Sensor SH Spiral Low Profile – 1.5"D.....	29
6.1.2.2. Sensor SH Pitch-Catch Corrosion Mapping.....	30
6.1.2.3. Sensor SH Pitch-Catch Corrosion Mapping.....	31
6.1.3. Bolt Load Measurement with EMAT.....	32
6.1.3.1. Sensor SH Spiral – 0.5"D.....	33
6.1.3.2. Sensor Bolt Load - Piezo + EMAT Dual Mode (L+SH) – 1"D.....	34
6.1.3.3. Sensor SH Spiral – 0.25"D.....	35
6.1.4. Stress Measurement with EMAT.....	36
6.1.4.1. Dual Polarization Sensor – Stress Measurements.....	37
6.1.4.2. Dual Polarization Sensor – Stress Measurements.....	38
6.1.4.3. Stress Measurement Scanner for Train Wheels.....	39
6.1.5. Thickness Measurement and Flaw Detection (normal beam) with DCUT.....	41
6.1.5.1. Contact DCUT Transducer, 2.0 MHz.....	43
6.1.5.2. Contact DCUT Transducer, 3.0 MHz.....	44
6.1.5.3. Contact DCUT Transducer, 4.0 MHz.....	45
6.1.5.4. Flexible DCUT Transducer – Normal Beam, Medium, 3.5 MHz.....	46
6.1.5.5. Flexible DCUT Transducer – Normal Beam, Medium, 3.5 MHz.....	47
6.1.5.6. Flexible DCUT Transducer – Normal Beam, Medium, 3.5 MHz.....	48
6.1.5.7. Wheel DCUT Transducer – 2.0 MHz.....	49
6.1.5.8. Wheel DCUT Transducer – 3.0 MHz.....	50
6.1.5.9. Wheel DCUT Transducer – 4.0 MHz.....	51
6.1.5.10. DCUT Sensor for Pole End.....	52
7. Guided Wave Applications: Sensors & Accessories.....	53
7.1. MRUT (Medium Range Ultrasonics).....	58
7.1.1. MRUT Sensors.....	58
7.1.2. SH Waves.....	59
7.1.2.1. MRUT MS Scanner Circumferential (Shear Horizontal).....	59
7.1.2.2. MRUT MS Scanner Axial (Shear Horizontal).....	60
7.1.2.3. MRUT MS Scanner Axial (Small).....	61
7.1.3. Lamb Waves.....	62
7.1.3.1. MRUT PMX Scanner (Lamb).....	62
7.1.3.2. MRUT PML Scanner (Lamb).....	63
7.1.4. MRUT RF Coils.....	64
7.1.4.1. MRUT SH Coils.....	64

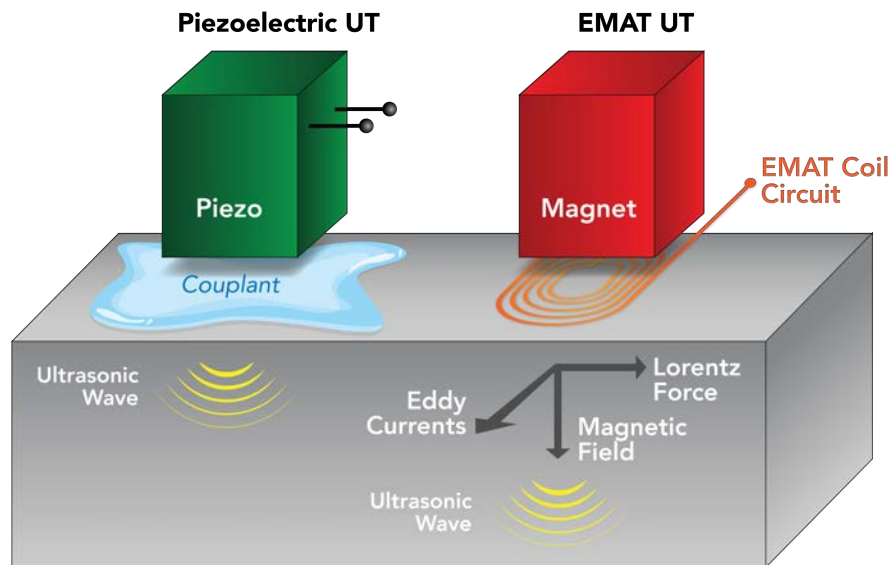
7.1.4.2.	MRUT Lamb Coils for PMX Sensor.....	67
7.1.4.3.	MRUT Lamb Coils for PML Sensor	79
7.2.	LRUT (Long Range Ultrasonics).....	101
7.2.1.	LRUT LITE (Unfocused) Sensor & Accessories	102
7.2.2.	LRUT Tensioner Kit.....	103
7.3.	SH and Surface / Lamb / SV Wave Permanent Magnet Sensors.....	104
7.3.1.	One-Channel SH Wave with Permanent Magnets (Angle Steering with Frequency) - Small	105
7.3.2.	One-Channel SH Wave Permanent Magnets (Angle Steering with Freq.) – Medium Tandem	106
7.3.3.	One-Channel SH Wave with Permanent Magnets (Angle Steering with Frequency) - Large	107
7.3.4.	One-Channel SH Wave with Permanent Magnets – XLarge (LF).....	108
7.3.5.	One-Channel SH Wave with Permanent Magnets – XLarge (HF)	109
7.3.6.	One-Channel Surface/Lamb/SV Wave – Small	110
7.3.7.	Ultra-High Temperature Sensor Surface/Lamb/SV Wave.....	111
7.4.	RF Coils for Angled Beam & Guided Waves (Lamb and Rayleigh) with Permanent Magnet.....	112
7.4.1.	RF Coil: 205C1426-048 Thin-Weld Inspection (2-Channel - Point & Planar)	113
7.4.2.	RF Coil: 205C1426-060 Thin-Weld Inspection (2-Channel - Point & Planar)	114
7.4.3.	RF Coil: 205C1426-080 Thin-Weld Inspection (2-Channel - Point & Planar)	115
7.4.4.	RF Coil: 205C1426-120 Thin-Weld Inspection (2-Channel - Point & Planar)	116
7.4.5.	RF Coils: T-L-M-0.100x7-1.000 & R-L-M-0.100x7-1.000	117
7.4.7.	RF Coils: T-L-M-0.120x5-1.000 & R-L-M-0.120x5-1.000	119
7.4.9.	RF Coils: T-L-M-0.140x6-1.000 & R-L-M-0.140x6-1.000	121
7.4.10.	RF Coils: T-L-M-0.160x5-1.000 & R-L-M-0.160x5-1.000	123
7.4.11.	RF Coils: T-L-M-0.180x5-1.000 & R-L-M-0.180x5-1.000	125
7.4.12.	RF Coils: T-L-M-0.200x4-1.000 & R-L-M-0.200x4-1.000	127
8.	General Sensor Accessories for Normal Beam and Guided Wave.....	129
8.1.1.	Wear Surfaces	129
8.1.1.1.	Metallic	129
8.1.1.2.	Non-Metallic.....	129
8.1.2.	Compliance Spring Foam.....	129
8.1.3.	Coil Backing Tape	130
8.1.4.	Sensor & Magnet Accessories	131
8.1.5.	Thermocouple	132
9.	Software	133
9.1.	GWAT	133
9.2.	BEAM.....	134
10.	Instrument Accessories	135
10.1.	VOLTA 2.....	Error! Bookmark not defined.
10.2.	CODA	137
11.	Calibration Standards.....	138
12.	Appendix	139
12.1.1.	Detachable RF Coils	139
13.	Limited Warranty	140

1. Introduction to Electro Magnetic Acoustic Transducer (EMAT)

EMAT or Electro Magnetic Acoustic Transducer is an Ultrasonic Testing (UT) technique that generates the sound in the part inspected instead of the transducer.

An EMAT induces ultrasonic waves into a test object with two interacting magnetic fields. A relatively high frequency (RF) field generated by electrical coils interacts with a low frequency or static field generated by magnets to generate a Lorentz force in a manner similar to an electric motor. This disturbance is transferred to the lattice of the material, producing an elastic wave. In a reciprocal process, the interaction of elastic waves in the presence of a magnetic field induces currents in the receiving EMAT coil circuit. For ferromagnetic conductors, magnetostriction produces additional stresses that enhance the signals to much higher levels than could be obtained by the Lorentz force alone. Various types of waves can be generated using different combinations of RF Coils and Magnets.

TECHNOLOGY COMPARISON



Because the sound is generated in the part inspected instead of the transducer, EMATs have the following advantages over more conventional piezoelectric transducers:

- Dry inspection. EMAT does not require couplant for transmitting sound, which makes it very well suited for inspection of very hot and very cold parts, and integration in automated environments.
- Impervious to surface conditions. EMAT can inspect through coatings and are not affected by pollutants, oxidation or roughness.
- Easier sensor deployment. Not having wedges or couplant, Snell's law of refraction does not apply, and the angle of the sensor does not affect the direction of propagation. This makes EMAT transducers easier to control and deploy.
- Mode selectivity. The antenna-type construction of the EMAT sensor combined with a multi-cycle excitation provides great specificity in the frequency domain, thus the ability to precisely select the wave mode of interest, which is of great importance for guided wave generation and interpretation.
- Ability to generate SH modes. EMAT is the only practical means for generating shear waves with horizontal polarization (SH waves) without high mechanical pressure or low-density couplant that impede scanning of the part.

1.1. Wave Modes

EMAT is capable of generating all wave modes used in ultrasonic testing, including some modes that are very difficult or impractical with conventional piezoelectric transducers.

The table below provides a summary guide of the type of wave and technique available for different applications.

Bulk/Guided	Beam Orientation	Wave Mode	Technique	Main Applications
Bulk	Normal	Longitudinal	Piezo EMAT	- Thickness and Velocity Measurements - Flaw Detection - Properties Measurement
		Shear Horizontal	EMAT ¹	
	Angled	Shear Vertical	Piezo EMAT	- Flaw Detection
		Shear Horizontal	EMAT ¹	- Flaw Detection, including austenitic materials
Guided	Surface	Rayleigh	Piezo EMAT ²	- Flaw Detection (surface)
	Volumetric	Lamb	Piezo EMAT ²	- Flaw (including Corrosion) Detection - Velocity and Properties Measurements
		Shear Horizontal	EMAT ¹	- Flaw (including Corrosion) Detection - Velocity and Properties Measurements

¹ Generation restricted to EMAT for practical purposes

² Especially well-suited for generation with EMAT

The applications covered in this Catalog include:

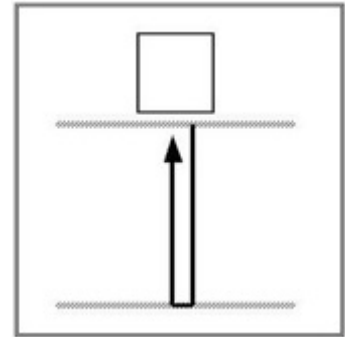
- Bulk, Normal Beam (zero-degree incident angle) with Shear Horizontal and Longitudinal Waves.
- Bulk, Angled Beam Single Channel and Phased Array
- Guided Wave, Surface and Volumetric

2. Applications

2.1. Normal (Zero Degree) Beam

Characteristics

- Direction of Propagation: Perpendicular to the entry wall.
- Sensor Configuration: Pulse-echo (transmitter = receiver) or pitch-catch (transmitter $\neq$ receiver)
- Wave modes: Shear Horizontal and Longitudinal waves in frequencies ranging from 500 kHz to 10 MHz. Whereas EMAT can generate both Shear and Longitudinal waves at 0 degrees, Shear (Horizontal) waves are easier to generate.
- Materials Inspected: Ferromagnetic and non-ferromagnetic metals.



Applications

- Thickness measurement.
- Corrosion and erosion measurement.
- Flaw detection, such as, inclusions, de-laminations and disbond.
- Acoustic velocity measurement.
- Rolling direction recognition.
- Anisotropy and stress measurement.
- Nodularity measurement.
- Bolt-Load measurement.
- Spot-Weld inspection.

EMAT Uniqueness

- Dry and non-contact. Practical working distance from the coil to the part (lift-off) is usually between 0-3mm. Greater lift-off can be achieved (up to 12mm in laboratory settings), depending on material, equipment and type of inspection. Ideal for automated and hot environments.
- Not affected by surface conditions (coatings, oil, oxide).
- Maintains readings even when the sensor face is not parallel to the part. The only restriction in coil/sensor angle is that derived from the loss of signal due to lift-off, so depending on the application the coil/sensor can be angled as much as 30° from the part and still obtain good signals.
- Capable of generating Shear wave energy (Shear Horizontal). Shear waves have approximately half the velocity of Longitudinal waves providing better time resolution (especially important for defects next to walls). Shear waves are also capable of detecting defects perfectly perpendicular to the direction of sound.
- Ability to select the direction of polarization when using Racetrack or Butterfly style coils (see RF Coil section).
- Because EMAT by definition cannot use a delay line (or water column), there is a dead zone of approximately 4μs (equivalent to around 6mm of material). This dead zone can be circumvented when parallel walls are present by relying on the 2nd bounce from the wall to perform the inspection.

2.2. Angled Beam and Phased Array

Characteristics

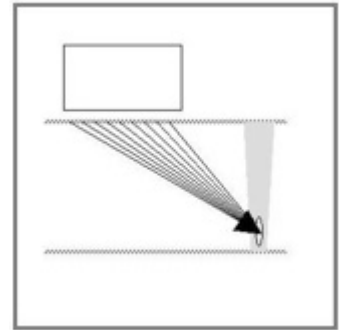
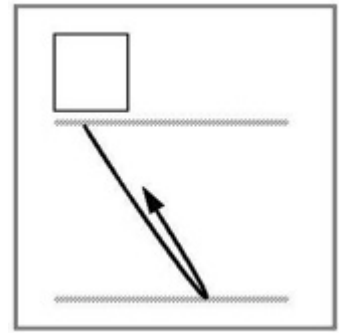
- Direction of Propagation: At an angle from the entry wall.
- Sensor Configuration: Pulse-echo or pitch-catch, including Phased Array
- Wave modes: Shear Horizontal and Shear Vertical at angles from 10° to 80° in frequencies ranging from 500KHz to 10MHz.
- Materials Inspected: Ferromagnetic and non-ferromagnetic metals.

Applications

- Flaw detection, including weld inspection.
- Austenitic weld inspection in heavy walls (>0.5" - 13mm) using SH waves.
- Corrosion and erosion measurement.
- Detection of hydrogen damage and pitting.

EMAT Uniqueness

- Dry and non-contact (up to 2.5mm lift-off depending on application and frequency). Ideal for automated and hot environments.
- Not affected by surface conditions (coatings, oil, oxide). Capable of inspecting on severely pitted surfaces.
- While Angled Beam Shear Vertical energy is easy to generate using refracting angles on piezoelectric transducers (PZT), Shear Horizontal Angled Beams do not travel through low-density couplants, so they are difficult to generate and excluded from applications that require any scanning.
- The polarity of the energy (vertical Vs horizontal) is important since shear waves do not mode convert when striking surfaces that are parallel to the direction of polarization thus Shear Horizontal waves are especially well suited for inspection of austenitic welds and other materials with dendritic grain structures.
- Inspection at temperatures of up to 400°F (200°C).



2.3. Guided Waves

Characteristics

- Direction of Propagation: Parallel to the entry wall and within the boundaries of the top and bottom walls. Limited to approximately 0.5" (12mm) plate thickness for internal flaw detection.
- Sensor Configuration: Pulse-echo or pitch-catch.
- Wave modes: Shear Horizontal at 90°, Lamb waves and Rayleigh waves in frequencies ranging from 50KHz to 10MHz.
- Materials Inspected: Ferromagnetic and non-ferromagnetic metals.

Applications

- Weld inspection in thin plates (<0.5" or 13mm).
- Inspection of welds while welding. For example, inspection of the different layers on submerged arc welds before all the layers have been deposited.
- Flaw detection in plates, tubes and rods.
- Corrosion and erosion measurement.
- Material properties characterization (e.g. acoustic velocity measurement).

EMAT Uniqueness

- Dry and non-contact (up to 2.5mm lift-off depending on frequency and type of application). Ideal for automated environments.
- Not affected by surface conditions (coatings, oil, oxide).
- Ability to normalize the signal for automatic and continuous self-calibration.
- Less sensitive to sensor positioning. Especially well-suited for automated weld inspection.
- Ability to concentrate the energy on the outside boundaries or center of the material to be more or less sensitive to surface or internal defects (e.g. to avoid or ignore root and crown in weld inspection).

3. Equipment Configuration

The picture below shows a common configuration for EMAT equipment.



1. Instrumentation. **Innerspec VOLTA.**
2. Magnet*. Housing containing the magnet (permanent or electromagnet) and the hardware for attaching the RF Coils (when detachable). Many magnets manufactured by Innerspec Technologies can incorporate various types of RF coils for different applications, whereas others have built-in RF coils that cannot be easily exchanged.
3. Coils & Wear Surface. Detachable RF Coils and wear surfaces are listed as separate items in this catalog.
4. Sensor Cables. Connect the magnet and RF Coil to the Signal Conditioning Box and can be up to 12' (3.7 m) in length.

* The combination of Magnet + RF Coil is referred to as a Sensor in this catalog.

4. Instrumentation

Please refer to “Instrumentation for High-Power Ultrasonic Applications” catalog for details.

5. Standard Sensors & Accessories

The Standard Sensors included in this catalog in conjunction with Innerspec **CODA** and **VOLTA 2** instruments or similar are designed to cover a great variety of EMAT inspections. Innerspec Technologies also offers Application Specific instrumentation and sensors and custom designs. Contact Innerspec Technologies for additional information on Sensors and Applications not covered in this Catalog.

The Standard Sensors are divided in two groups:

- Complete Sensors with attached RF Coil. Used on Phased Array and High-Temperature Normal Beam applications.
- Sensor with detachable RF Coil (separate Magnet and RF Coil). Used on ambient temperature Normal Beam, Bulk Angled and all Guided Wave applications.

The Sensors in this Catalog are designed using floating-ground technology that provides optimum performance and immunity to noise. These sensors require three pole connectors, and will not work with standard coaxial cables. On the same token, the standard signal conditioning boxes will not work with non-differential sensors built by other manufacturers. For best results, it is recommended to use sensors, cables and signal conditioning boxes as a set from Innerspec Technologies. Contact Innerspec if you need a custom sensor not available in this Catalog.

The high-voltages and currents generated by EMAT instruments to drive the sensors are not dangerous to humans due to the short duration of the pulses, but it can increase the temperature of some sensors and reduce their life if not cooled properly. To maximize sensor life, it is recommended to avoid pulsing the sensors in the air for long periods of time.

Permanent Magnets Can Create Very Powerful Magnetic Fields Handle With Care

- Can pinch or entrap hands and fingers.
- Pacemaker, Implanted Defibrillator, or other medical aid users: the magnetic field of a permanent magnet 32mm DIA x 25mm thick (1.25" DIA x 1.00" thick) will decrease to 0.05% (< 5 gauss) at a distance of 30 cm (12") from the magnet.
- Can damage credit cards and magnetic ID cards.



6. Normal Beam Sensors & Accessories

Part Number	Wave Mode	Magnet Type	Maximum Temperature and Time	Connector	Dim.	Applications
274A0272	SH Spiral	Permanent Magnet	200°C Unlimited / 650°C – 5s	3 Pin Lemo 0K	1.0" D x 2.4" H (25.4mm D x 61mm H)	Thickness Measurement & Flaw Detection
274A0486	SH Butterfly	Permanent Magnet	200°C Unlimited / 650°C – 5s	3 Pin Lemo 0B	3.25"D x 2.38"H (82.55mm D x 60.45mm H)	Thickness Measurement & Flaw Detection
274A0470	SH Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0B	2.25"D x 1.00"H (57.15mm x 25.40mm)	Thickness Measurement & Flaw Detection
274A0484	SH Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0B	1.875" L x 1.00" W x 1.875" H (47.625mm x 25.4mm x 47.625mm)	Thickness Measurement & Flaw Detection
274A0377	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	1.88" H x 1.00" W x 1.00" L (47.6mm x 25.4mm x 25.4mm)	Thickness Measurement & Flaw Detection
274A0379	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	1.88" H x 1.00" W x 1.00" L (47.6mm x 25.4mm x 25.4mm)	Thickness Measurement & Flaw Detection
274A0381	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	2.00" H x 1.56" W x 1.56" L (50.8mm x 39.7mm x 39.7mm)	Thickness Measurement & Flaw Detection
274A0447	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	2.38" H x 2.50" W x 3.50" L (60.5mm x 63.5mm x 88.9mm)	Thickness Measurement & Flaw Detection
274A0244 Coil: 205C0034	SH Spiral	Permanent Magnet	80°C	6 Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Thickness Measurement & Flaw Detection
274A0244 Coil: 205C0005	SH Butterfly	Permanent Magnet	80°C	6 Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Thickness Measurement & Flaw Detection
274A0244 Coil: 205C0546	SH Butterfly	Permanent Magnet	80°C	6 Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Thickness Measurement & Flaw Detection
274A0334- SPIRAL	SH Spiral	Permanent Magnet	80°C	2 Pin Lemo 0B	1.5" D x 0.63" H (38.1mm D x 15.9mm)	Corrosion Mapping
274A0490	SH Racetrack	Permanent Magnet	80°C	6 Pin Lemo 1B	2.48W" x 5.34L" x 1.94H" (63mm x 135.6mm x 49.3mm)	Corrosion Mapping
274A0244-C Coil: 205C1394	SH Racetrack	Permanent Magnet	80°C	6-Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Corrosion Mapping
274A0409	SH Spiral	Permanent Magnet	80°C	4-Pin Lemo 0K	0.6" D x 1.7" H 15.5mm x 43.2mm	Bolt Load Measurement
274A0477	L + SH (Piezo + EMAT)	Linearly Polarized Spiral	80°C	6-Pin Lemo 1B	1.00" D x 2.00" H (25.4mm D x 50.8mm H)	Bolt Load Measurement

Part Number	Wave Mode	Magnet Type	Maximum Temperature and Time	Connector	Dim.	Applications
274A0479	SH Spiral	Permanent Magnet	80°C	4-Pin Lemo 0K	1.813 H x 0.75 D x 0.28 D (46.05mm H x 19.05mm D x 7.11mm D)	Bolt Load Measurement
274A0157	Dual Linearly Polarized SH Wave @90°	Permanent Magnet	80°C	6 Pin Lemo 1B	1.88" D x 2.31" H (47.6mm D x 58.7mm H)	Stress Measurement
274A0415	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3-Pin Lemo 0K	1.563" W x 2.00"H (39.7 mm W x 50.8 mm H)	Stress Measurement
274A0361 & 187V0028	Dual Linearly Polarized SH Wave @90°	Permanent Magnet	80°C	6 Pin Lemo 1B	1.563" W x 2.00"H (39.7 mm W x 50.8 mm H)	Stress Measurement for Rail Wheels
281A0035-200	Normal Beam-Piezo 2.0 MHz	n/a	50°C or 122°F	Lemo 00 Coax	20 mm – D 27 mm - H	Thickness Measurement
281A0035-300	Normal Beam - Piezo 3.0 MHz	n/a	50°C or 122°F	Lemo 00 Coax	20 mm – D 27 mm - H	Thickness Measurement.
281A0035-400	Normal Beam - Piezo 4.0 MHz	n/a	50°C or 122°F	Lemo 00 Coax	20 mm – D 27 mm - H	Thickness Measurement.
281A0028	Normal Beam Piezo 3.5 MHz	n/a	50°C or 122°F	Lemo 00 Coax	68mm – L 18mm – W 3mm - H	Dry or Wet Thickness Measurement & Spot Flaw Detection
281A0029	Normal Beam Piezo 3.5 MHz	n/a	50°C or 122°F	Lemo 00 Coax	68mm – L 18mm – W 3mm - H	Dry or Wet Thickness Measurement & Spot Flaw Detection
281A0030	Normal Beam Piezo 3.5 MHz	n/a	50°C or 122°F	Lemo 00 Coax	81mm – L 30mm – W 3mm - H	Dry or Wet Thickness Measurement & Spot Flaw Detection
281A0244-200*	Normal Beam Piezo 2.0 MHz	n/a	50°C or 122°F	Lemo 00 Coax	75 mm – D 40 mm -- H	Thickness Measurement & Flaw Detection
281A0244-300	Normal Beam Piezo 3.0 MHz	n/a	50°C or 122°F	Lemo 00 Coax	75 mm – D 40 mm -- H	Thickness Measurement & Flaw Detection
281A0244-400*	Normal Beam Piezo 4.0 MHz	n/a	50°C or 122°F	Lemo 00 Coax	75 mm – D 40 mm -- H	Thickness Measurement & Flaw Detection

Software Options and Upgrades for Normal Beam Applications

Software	Instrument	Applications
Thickness & General A-Scan (default)	CODA (all) VOLTA 2	Thickness Measurement & Flaw Detection with EMAT & DCUT
Thickness Grid	CODA VOLTA 2	Thickness Measurement & Flaw Detection with EMAT & DCUT
Scanning (Line & C-Scan)	CODA+ CODA SM VOLTA 2	Thickness Measurement & Flaw Detection with EMAT & DCUT Corrosion Mapping with EMAT
Bolt Load	CODA SM VOLTA 2	Bolt Load Measurement with EMAT
Stress Measurement	CODA SM VOLTA 2	Stress Measurement with EMAT

- 1 Typical values for aluminum, carbon steel and other conductive materials. Two back walls or more are required for maximum accuracy.
- 2 L-Wave Sensors are only valid for non-ferromagnetic materials (or ferromagnetic above Curie point). All SH probes are valid for magnetic or non-magnetic materials.
- 3 Butterfly Shear Horizontal (SH) sensors have a linearly polarized coil for maximum accuracy on thin and anisotropic materials. Different readings are obtained depending on the orientation of the sensor and the rolling direction. Side marking and red dot point to the direction of the center body of the butterfly coil to help facilitate alignment.

Normal Beam Sensor Cables (VOLTA 2 & CODA)

Part Number	Length	Instrument Connection	Sensor Connection	Description
232A0580	6' (182cm)	1x 6 Pin Lemo 1B	1x 2 Pin Lemo 0B	1 Channel (6 to 2 Pin) Sensor Cable
232A1045	6' (182cm)	1x 6 Pin Lemo 1B	1x 3 Pin Lemo 0K	1 Channel (6 to 3 Pin) Sensor Cable
232A1044	6' (182cm)	1x 6 Pin Lemo 1B	1x 4 Pin Lemo 0B	1 Channel (6 to 4 Pin) Sensor Cable
232A0169	6' (182cm)	1x 6 Pin Lemo 1B	1x 6 Pin Lemo 1B	2 Channel (6 to 6 Pin) Sensor Cable
232A0784	4' (182cm)6'	1x 2 Pin Lemo 0B	Lemo 00 Coax	1 Channel (Lemo 00 Coax to 2 Pin) for Piezo Sensor Cable
232V1434	6' (182cm)	1 x 12 Pin Lemo	1x 4 Pin Lemo 0B	Encoder Cable for 274A0244 (CODA)
232A0709	6' (182cm)	1x 19 Pin Lemo 0B	1x 4 Pin Lemo 0B	Encoder Cable for 274A0244 (VOLTA 2)
				Encoder Cable for 274A0490 (CODA)
232A1075	12' (366cm)	1x 19 Pin Lemo 0B	M12 Encoder Products	Encoder Cable for 274A0490 (VOLTA 2)

- 1 Other lengths up to 6' (182cm) available upon request.
- 2 Other lengths up to 150' (50m) available upon request.
- 3 Other connector angles available upon request

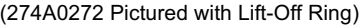
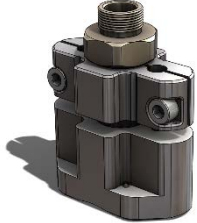
6.1.1. Thickness Measurement and Flaw Detection (normal beam) with EMAT

Part Number	Wave Mode	Magnet Type	Maximum Temperature and Time	Connector	Dim.	Applications
274A0272	SH Spiral	Permanent Magnet	200°C Unlimited / 650°C – 5s	3 Pin Lemo 0K	1.0" D x 2.4" H (25.4mm D x 61mm H)	Thickness Measurement & Flaw Detection
274A0486	SH Butterfly	Permanent Magnet	200°C Unlimited / 650°C – 5s	3 Pin Lemo 0B	3.25"D x 2.38"H (82.55mm D x 60.45mm H)	Thickness Measurement & Flaw Detection
274A0470	SH Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0B	2.25"D x 1.00"H (57.15mm x 25.40mm)	Thickness Measurement & Flaw Detection
274A0484	SH Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0B	1.875" L x 1.00" W x 1.875" H (47.625mm x 25.4mm x 47.625mm)	Thickness Measurement & Flaw Detection
274A0377	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	1.88" H x 1.00" W x 1.00" L (47.6mm x 25.4mm x 25.4mm)	Thickness Measurement & Flaw Detection
274A0379	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	1.88" H x 1.00" W x 1.00" L (47.6mm x 25.4mm x 25.4mm)	Thickness Measurement & Flaw Detection
274A0381	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	2.00" H x 1.56" W x 1.56" L (50.8mm x 39.7mm x 39.7mm)	Thickness Measurement & Flaw Detection
274A0447	L Linearly Polarized Butterfly	Permanent Magnet	80°C	3 Pin Lemo 0K	2.38" H x 2.50" W x 3.50" L (60.5mm x 63.5mm x 88.9mm)	Thickness Measurement & Flaw Detection
274A0244 Coil: 205C0034	SH Spiral	Permanent Magnet	80°C	6 Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Thickness Measurement & Flaw Detection
274A0244 Coil: 205C0005	SH Butterfly	Permanent Magnet	80°C	6 Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Thickness Measurement & Flaw Detection
274A0244 Coil: 205C0546	SH Butterfly	Permanent Magnet	80°C	6 Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Thickness Measurement & Flaw Detection

In order to select the appropriate Magnet and RF Coil,

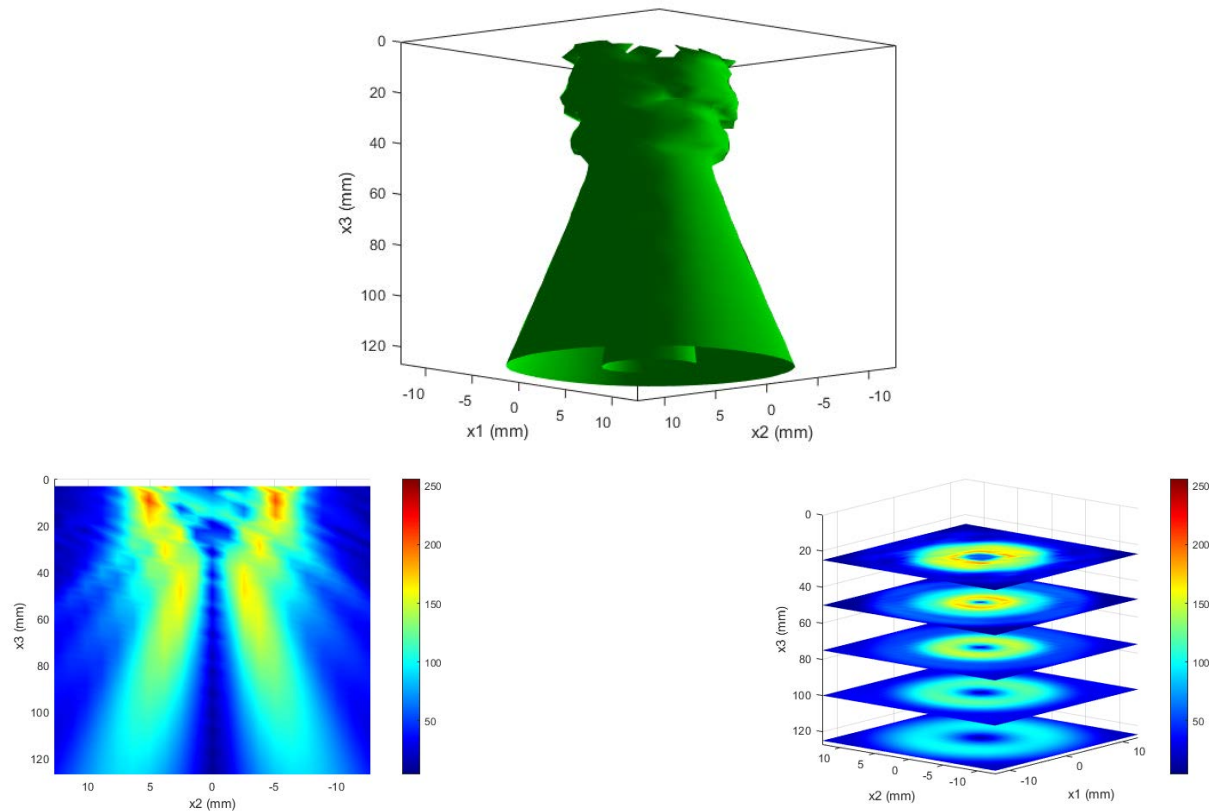
- Larger Magnets provide greater signal-to-noise but can be unwieldy and difficult to move on ferromagnetic parts.
- As with piezoelectric transducers, larger RF Coils concentrate the energy deeper into the material so they have worse near-field sensitivity. Each RF Coil is provided with 3dB plots relative to their point of maximum sensitivity.
- Butterfly Coils provide a linearly polarized wave that is very effective for coverage and sensitivity in flaw detection, but will provide different velocity (and thickness) readings on anisotropic materials depending on the orientation of the sensor magnet.
- Spiral Coils are less affected by anisotropy thus they are easier to use for thickness measurement in anisotropic materials. Flaw detection is limited by their design.
- Permanent Magnet L-Wave coils are only appropriate for non-magnetic materials. Consult Innerspec Technologies for L-Wave generation in ferromagnetic materials.

6.1.1.1. Sensor HT (650C) SH Lorentz w/o Active Cooling – 1.0" D

Part Number		274A0272	
Sensor Type		SH Lorentz Permanent Magnet	
Temperature Ranges		-30°C - 200°C Unlimited 650°C – 5s ¹	
Connector		3 Pin Lemo 0K	
Coil Geometry		Spiral	
Coil ID	Inch	0.25"	
	mm	6.35mm	
Coil OD	Inch	0.75"	
	mm	19.05mm	
Sensor	Inch	1.0 D x 2.4 H	
	mm	25.4 x 61	
Anchor Points		Thread	(274A0272 Pictured with Lift-Off Ring) High-Temp Lift-Off Ring – 187A0020 Handle – 187A0007
Attachments		Lift-Off Ring (for >200°C), Handle	
		Roller Kit	

¹ Temperature of the sensor cannot exceed 200°C. When measuring high temperature materials, active cooling between measurements may be required; e.g. submerging sensor tip in cool water.

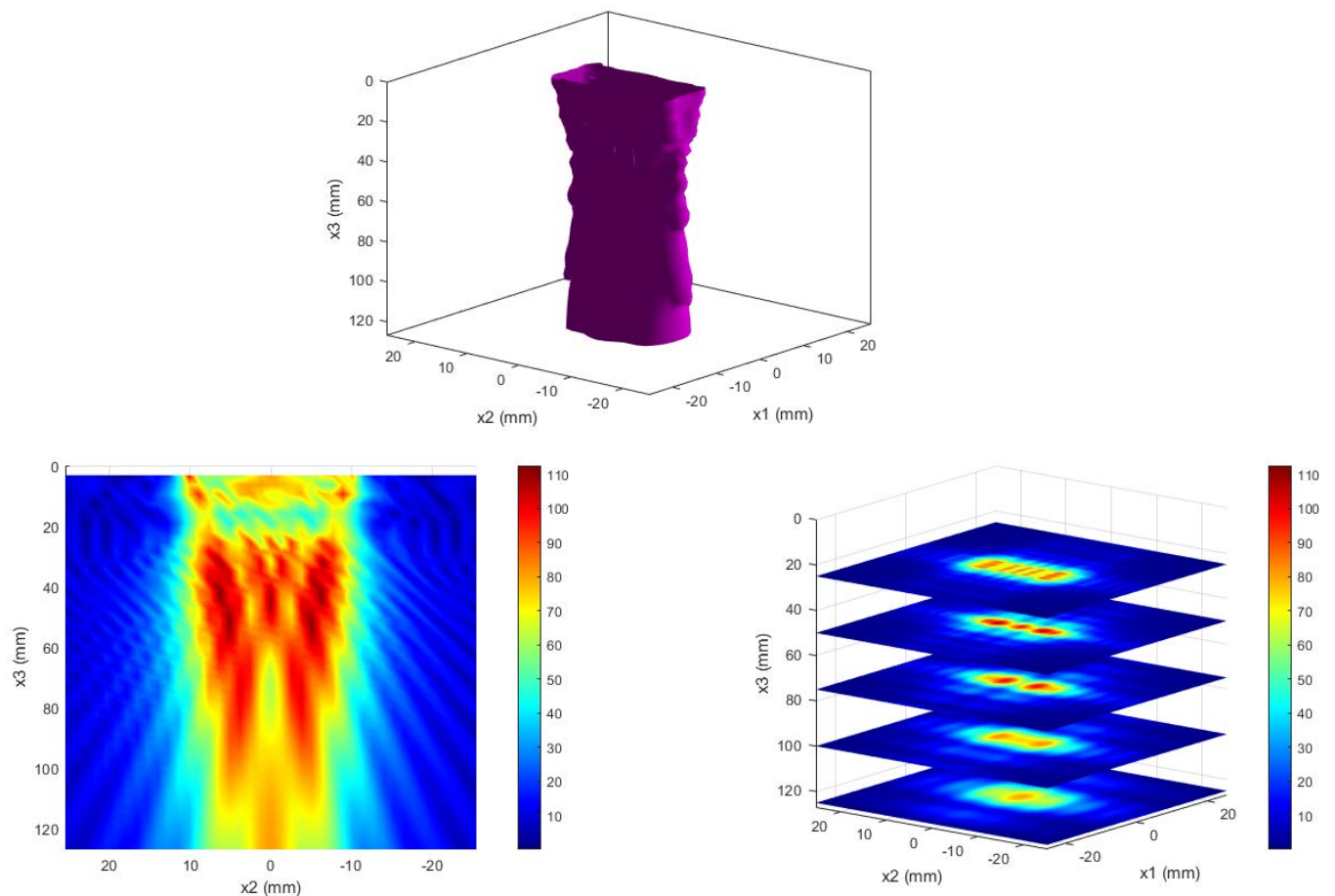
3dB Beam Profiles



6.1.1.2. Sensor HT (650C) SH Butterfly Sensor – 2.38”D

Part Number		274A0486	
Sensor Type		SH Lorentz Permanent Magnet	
Temperature Range		150°C	
Connector		3 Pin Lemo 0B	
Coil Geometry		Butterfly	
Coil Width	Inch	1.000	
	mm	25.40	
Coil Length	Inch	1.386	
	mm	35.20	
Sensor with LO Ring	Inch	3.25 x 2.38 ϕ	
	mm	82.55 x 60.45 ϕ	
Anchor Points		SHCS M4 x 10mm (2X)	High-Temp Lift-Off Ring – 001F4422 Handle – 187A0007
Attachments		Lift-Off Ring (for >200°C), Handle	

3dB Beam Profiles

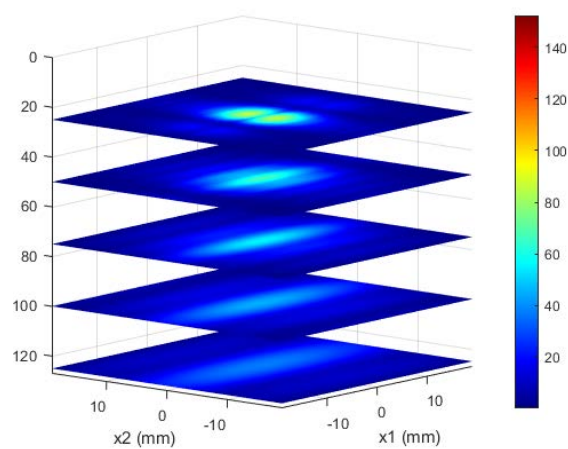
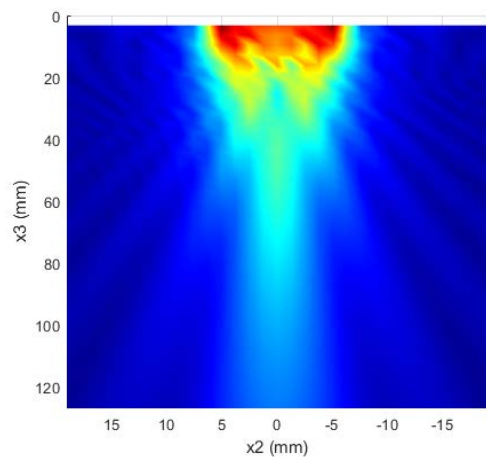
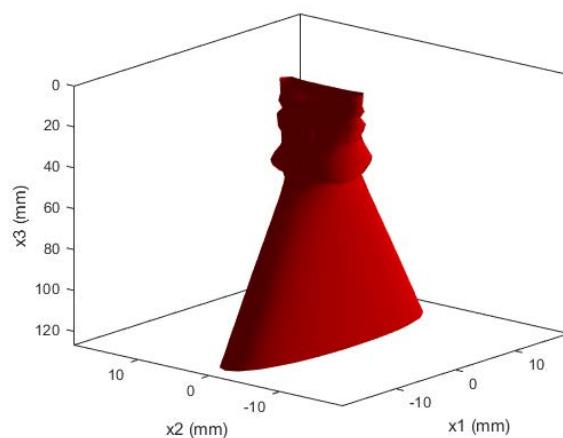


6.1.1.3. Sensor SH Butterfly Sensor – 1.0”D

Part Number		274A0470
Sensor Type		SH Lorentz Permanent Magnet
Temperature Range		80°C
Connector		3 Pin Lemo 0B
Coil Geometry		Butterfly
Coil Width	Inch	0.133
	mm	3.378
Coil Length	Inch	0.701
	mm	17.805
Sensor	Inch	2.25 x 1.00
	mm	57.15 x 25.40



3dB Beam Profiles

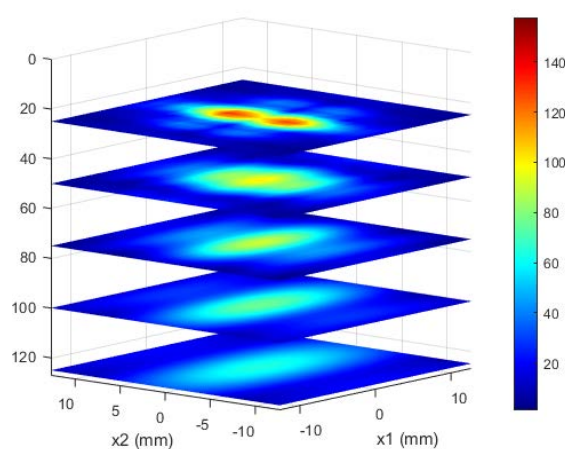
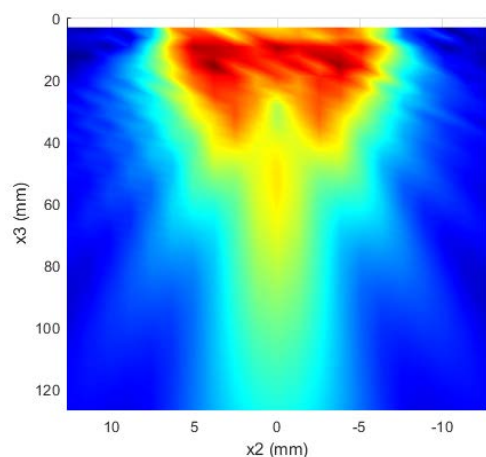
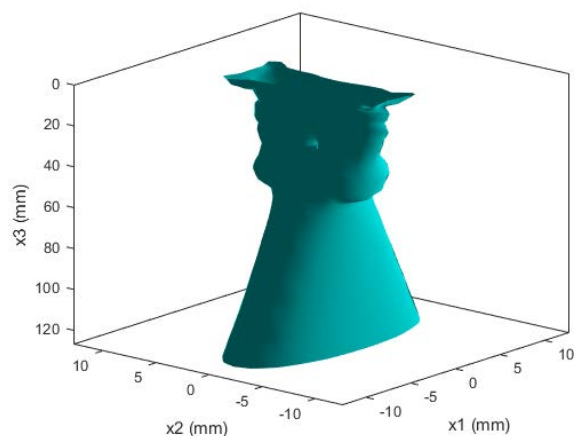


6.1.1.4. Sensor SH Butterfly Sensor – 1.9”L x 1.0”W

Part Number		274A0484
Sensor Type		SH Lorentz Permanent Magnet
Temperature Range		80°C
Connector		3 Pin Lemo 0B
Coil Geometry		Butterfly
Coil Width	Inch	0.217
	mm	5.51
Coil Length	Inch	0.666
	mm	16.92
Sensor	Inch	1.875 x 1.00 x 1.875
	mm	47.625 x 25.4 x 47.625
Anchor Points		2 x M4 x 0.7



3dB Beam Profiles

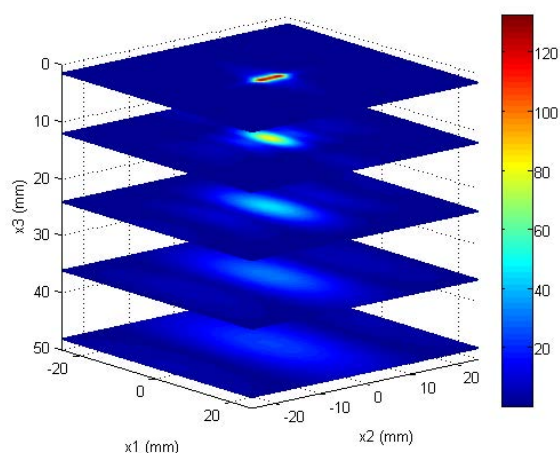
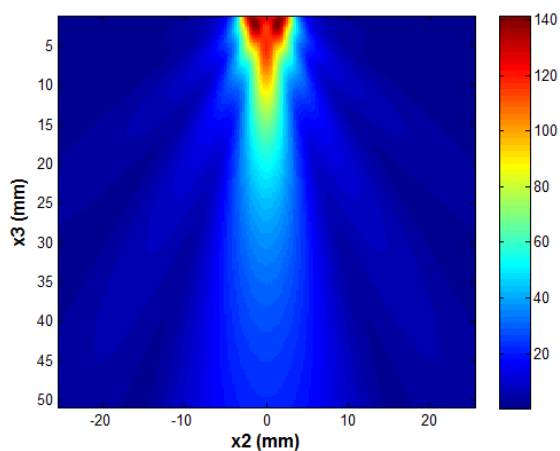
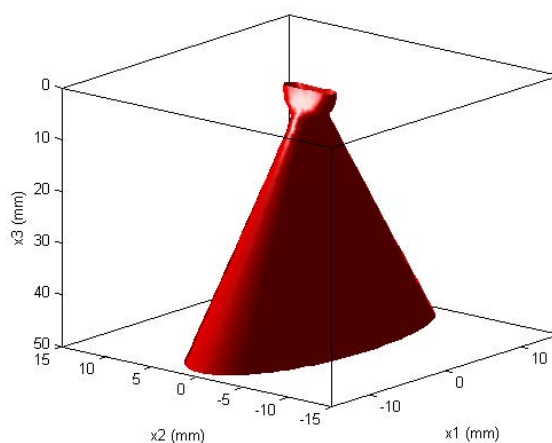


6.1.1.5. Sensor L-Wave Small (HR) for Non-Ferromagnetic Materials – 1" W

Part Number		274A0377
Sensor Type		L - Lorentz Permanent Magnet
Temperature Range		80°C
Connector		3 Pin Lemo 0K
Coil Geometry		Linearly Polarized
Sensor	inch	1.88 H x 1.00 W x 1.00 L
	mm	47.6 x 25.4 x 25.4
Anchor Points		M2 x 5mm Holes (4X)



3dB Beam Profiles

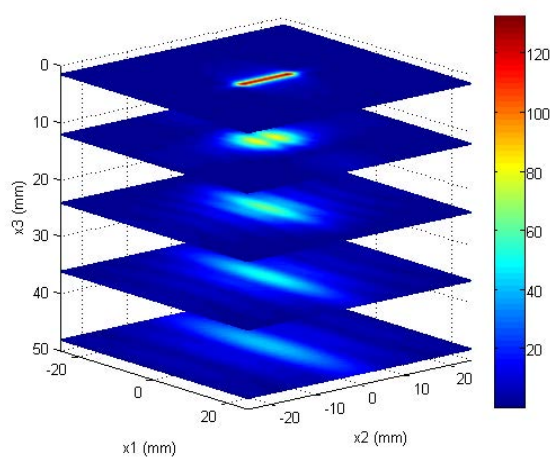
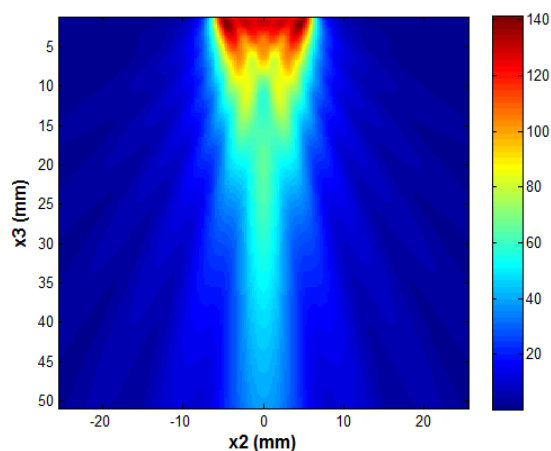
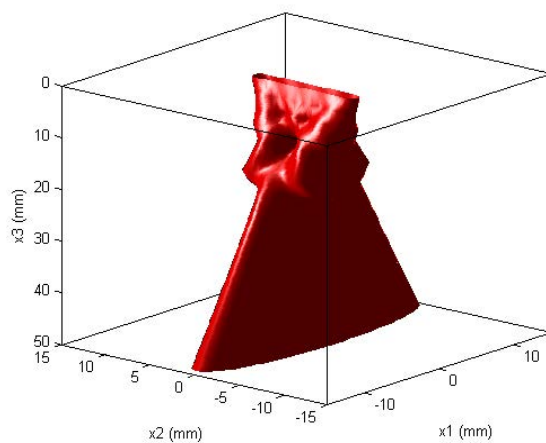


6.1.1.6. Sensor L-Wave Medium (HR) for Non-Ferromagnetic Materials – 1"W

Part Number		274A0379
Sensor Type		L - Lorentz Permanent Magnet
Temperature Range		80°C
Connector		3 Pin Lemo 0K
Coil Geometry		Linearly Polarized
Sensor	inch	1.88 H x 1.00 W x 1.00 L
	mm	47.6 x 25.4 x 25.4
Anchor Points		M2 x 5mm Holes (4X)



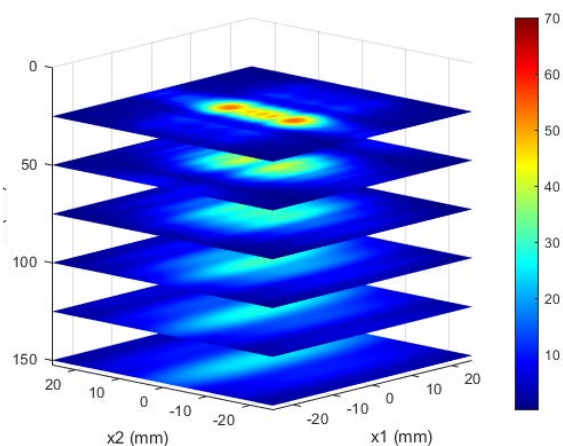
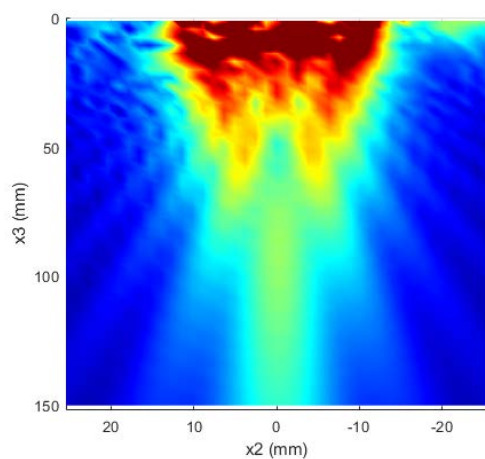
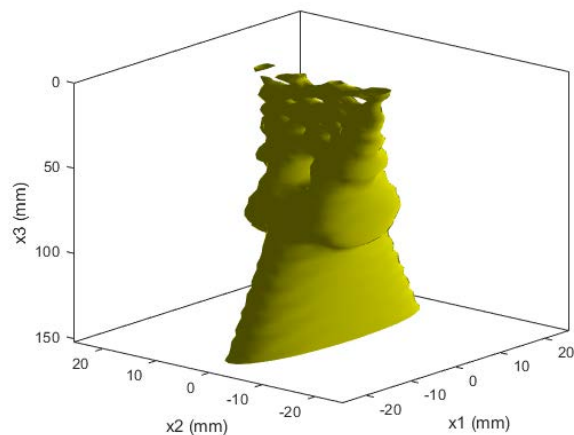
3dB Beam Profiles



6.1.1.7. Sensor L-Wave Large (LR) for Non-Ferromagnetic Materials – 1.56"W

Part Number		274A0381	
Sensor Type		L - Lorentz Permanent Magnet	
Temperature Range		80°C	
Connector		3 Pin Lemo OK	
Coil Geometry		Linearly Polarized	
Sensor	inch	2.00 H x 1.56 W x 1.56 L	
	mm	(50.8mm x 39.7mm x 39.7mm)	
Anchor Points		M3 x 10mm Holes (6X)	
Attachments		High-Temperature Assembly Kit P/N: 274A0416 Lift-Off Case (for > 200 °C) & Handle	
Scanner		160A0225	

3dB Beam Profiles

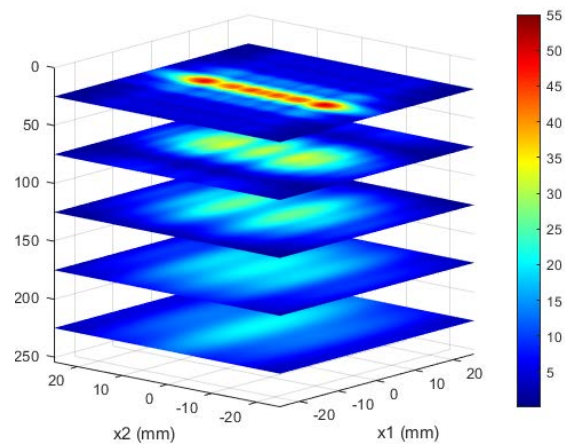
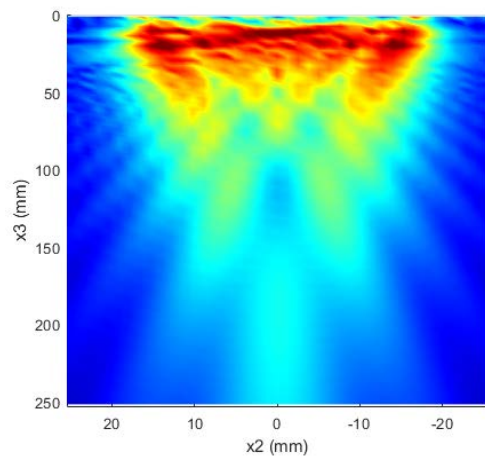
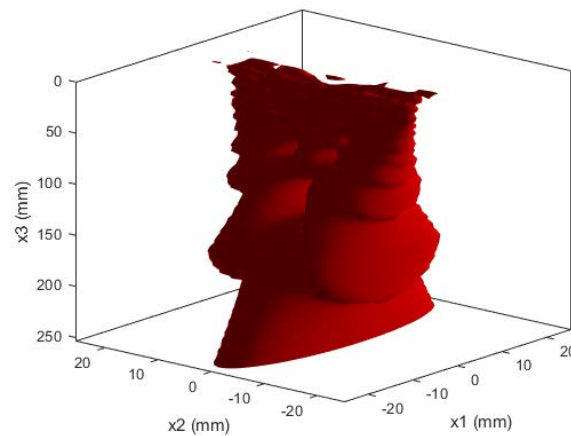


6.1.1.8. Sensor L-Wave X-Large Scanning for Non-Ferromagnetic Materials – 3.5" x 2.5"

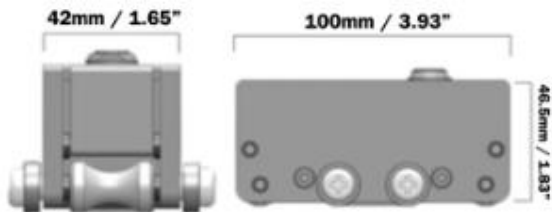
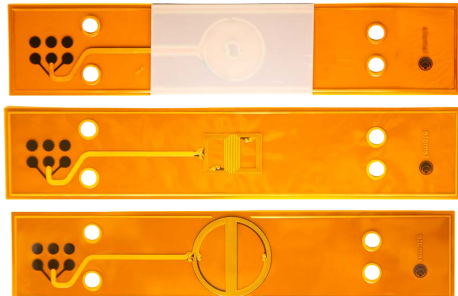
Part Number		274A0447
Sensor Type		L - Lorentz Permanent Magnet
Temperature Range		80°C
Connector		3 Pin Lemo 0K
Coil Geometry		Linearly Polarized
Sensor	inch	2.38 H x 2.50 W x 3.50 L
	mm	(60.5mm x 63.5mm x 88.9mm)
Anchor Points		FHCS, M4 x 10MM (8X)



3dB Beam Profiles



6.1.1.9. Sensor SH Flex Coil Scanner

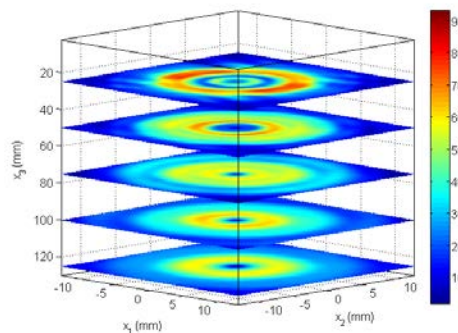
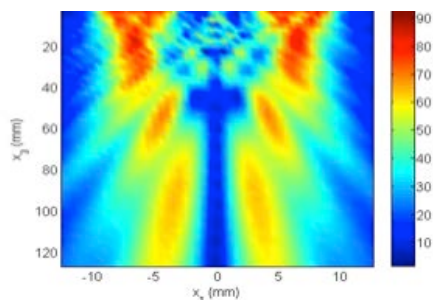
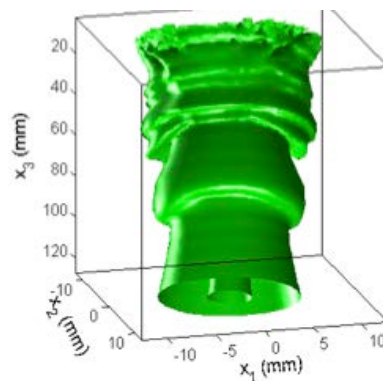
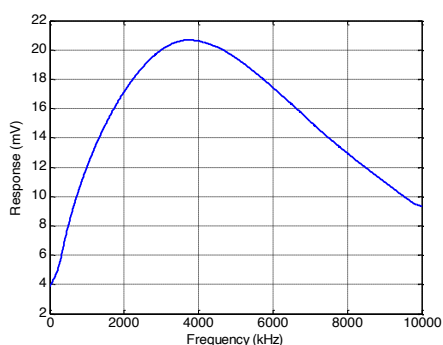
Part Number		274A0244	
Sensor Type		SH Lorentz Permanent Magnet	
Temperature Range		80°C	
Connector		6 Pin Lemo 1B	
Coil Geometry		Spiral & Butterfly	
Sensor	Inch	3.93 x 1.65	
	mm	100 x 42	
Encoder Integrated		001A2174 Cable: 232A0709	
Wear Surface			
EMAT Coil(s)		205C0034 205C0005 205C0546	

*see detailed profile of RF coils for 274A0244 scanner on following pages

6.1.1.9.1. RF Coil: PE-L-S-0.730-0.250-CL

			
Part Number		205C0034	
Connector		2 Pin Lemo 0B	
Coil Function		Transmitter and Receiver	
Compatible Magnet		274A0244	
Coil Geometry		Spiral	
Tuning Module ¹		See Below	
OD	inch	0.730	
	mm	18.25	
ID	inch	0.250	
	mm	6.25	

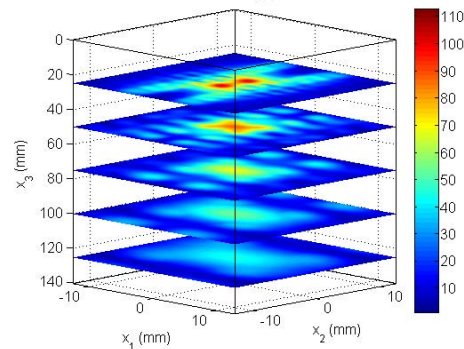
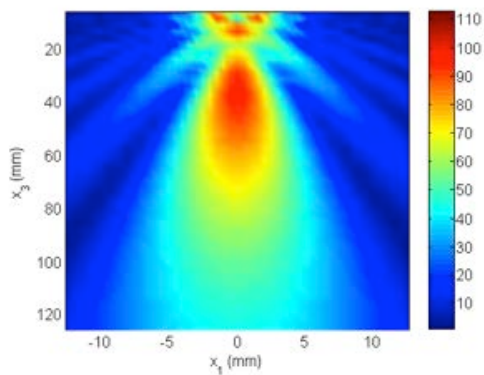
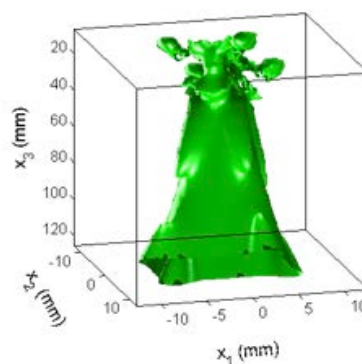
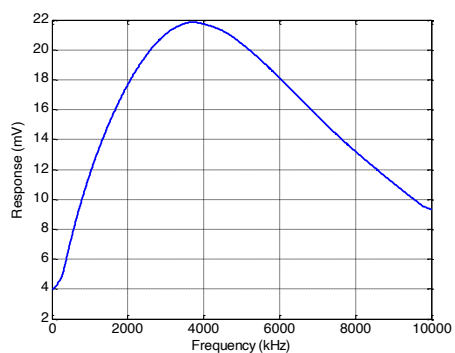
Frequency Spectra & 3dB Beam Profiles



6.1.1.9.2. RF Coils: PE-L-B-0.726-0.492-CL

			
Part Number		205C0005	
Connector		2 Pin Lemo 0B	
Coil Function		Transmitter and Receiver	
Compatible Magnet		274A0244	
Coil Geometry		Butterfly	
Tuning Module¹		See Below	
Width	inch	0.726	
	mm	18.15	
Length	inch	0.492	
	mm	12.30	

Frequency Spectra & 3dB Beam Profiles



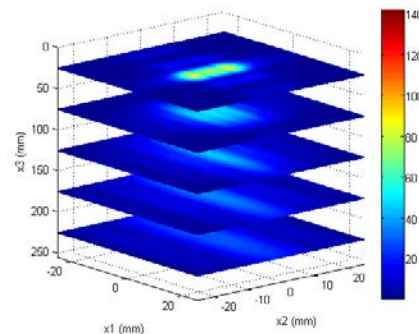
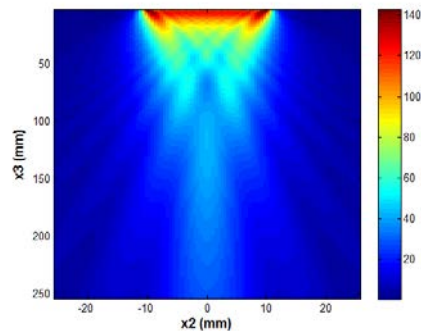
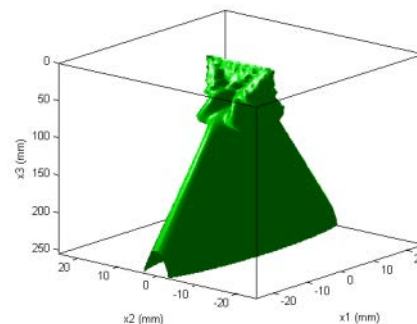
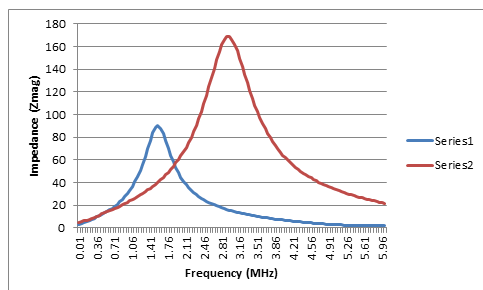
6.1.1.9.3. RF Coils: PE-L-B-1.000-1.000-CL

		
Part Number		205C0546
Connector		2 Pin Lemo 0B
Coil Function		Transmitter and Receiver
Compatible Magnet		274A0244
Coil Geometry		Butterfly
Tuning Module¹		See Below
Width	inch	1.000
	mm	25.4
Length	inch	1.000
	mm	25.4

Tuning Module Data Sheet

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0802	3000	2450	3845
205T0806	1500	1230	1960

Frequency Spectra (on aluminum with 0.25mm lift-off) & 3dB Beam Profiles



6.1.2. Corrosion Mapping With EMAT

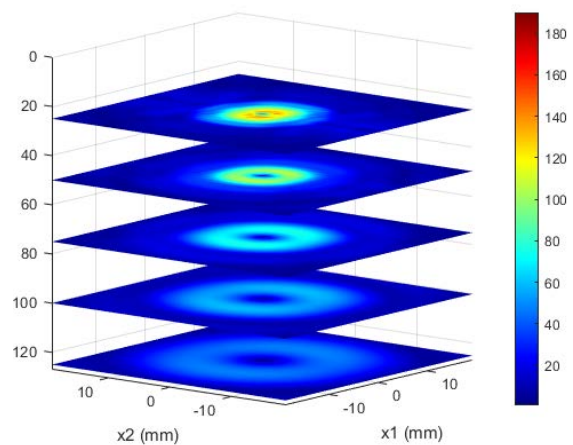
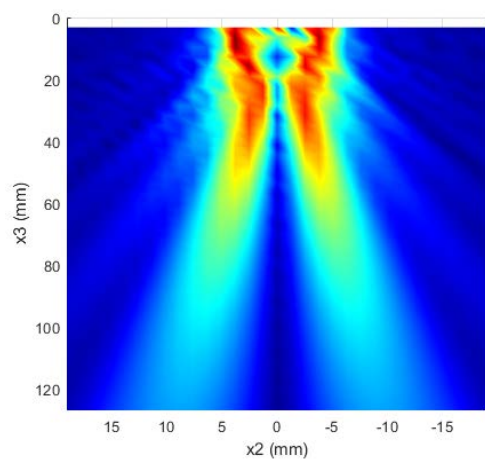
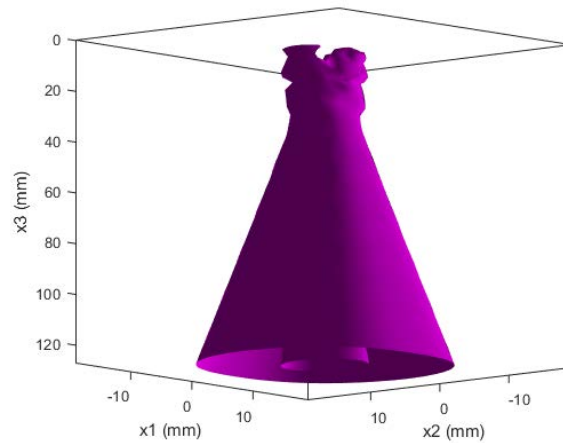
Part Number	Wave Mode	Magnet Type	Maximum Temperature and Time	Connector	Dim.	Applications
274A0334-SPIRAL	SH Spiral	Permanent Magnet	80°C	2 Pin Lemo 0B	1.5" D x 0.63" H (38.1mm D x 15.9mm)	Corrosion Mapping
274A0490	SH Racetrack	Permanent Magnet	80°C	6 Pin Lemo 1B	2.48W" x 5.34L" x 1.94H" (63mm x 135.6mm x 49.3mm)	Corrosion Mapping
274A0244-C Coil: 205C1394	SH Racetrack	Permanent Magnet	80°C	6-Pin Lemo 1B	3.93" x 1.65" x 2" (100mm x 42mm x 51mm)	Corrosion Mapping

6.1.2.1. Sensor SH Spiral Low Profile – 1.5”D

Part Number		274A0334-SPIRAL
Sensor Type		SH Lorentz Permanent Magnet
Temperature Range		80°C
Connector		2 Pin Lemo 0B
Coil Geometry		Spiral
Tuning Module ¹		See Below
Coil Width	Inch	0.250
	mm	6.25
Coil Length	Inch	0.730
	mm	18.25
Sensor	Inch	1.5 D x 0.63 H
	mm	38.1 x 15.9



3dB Beam Profiles

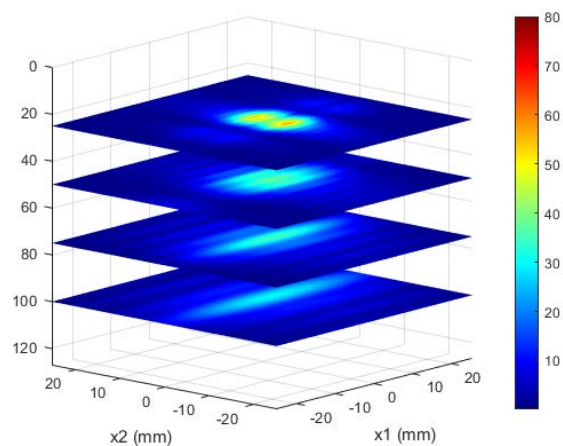
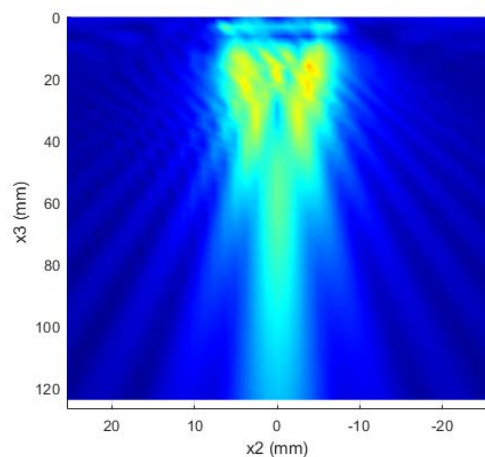
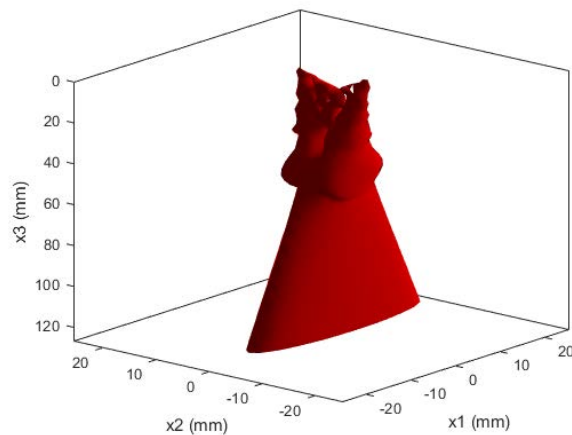


6.1.2.2. Sensor SH Pitch-Catch Corrosion Mapping

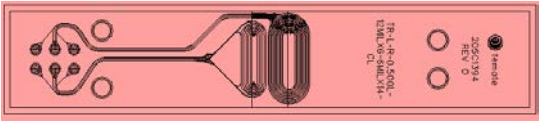
Part Number		274A0490
Sensor Type		SH Lorentz Permanent Magnet
Temperature Range		80°C
Connector		6 Pin Lemo 1B
Coil Geometry		Racetrack (Transmitter & Receiver)
Sensor	Inch	2.48W x 3.25L x 1.94H
	mm	63 x 82.5 x 49.3
Sensor with Encoder	Inch	2.48W x 5.34L x 1.94H
	mm	63 x 135.6 x 49.3
Encoder Cable:		232A1075



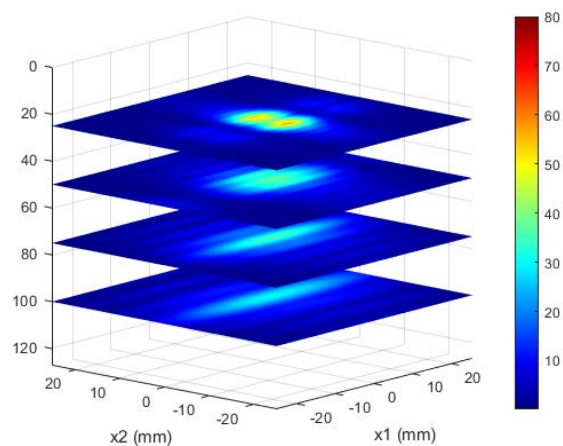
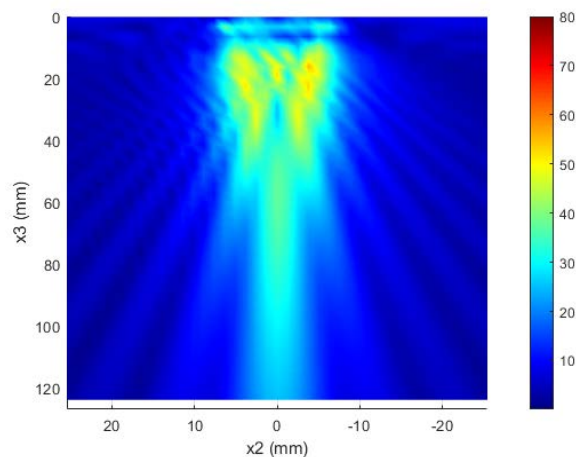
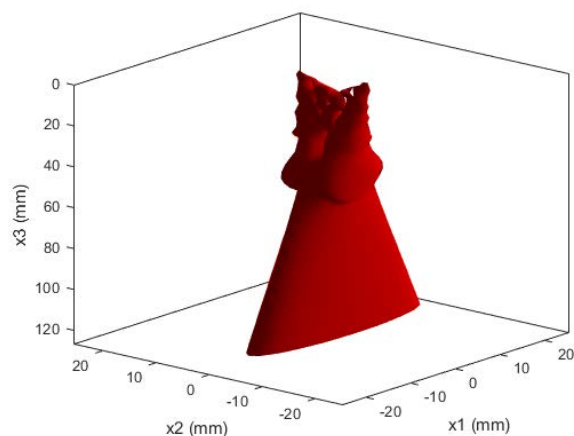
3dB Beam Profiles



6.1.2.3. Sensor SH Pitch-Catch Corrosion Mapping

Part Number		274A0244-C	
Sensor Type		SH Lorentz Permanent Magnet	
Temperature Range		80°C	
Connector		6 Pin Lemo 1B	
Coil Geometry		Racetrack (Transmitter & Receiver)	
Sensor	Inch	3.93 x 1.65	
	mm	100 x 42	
Encoder Integrated		001A2174 Cable: 232A0709	
EMAT Coil		205C1394 Rev0	

3dB Beam Profiles



6.1.3. Bolt Load Measurement with EMAT

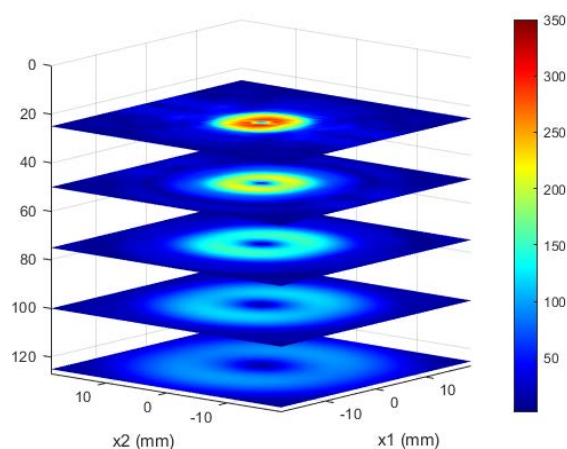
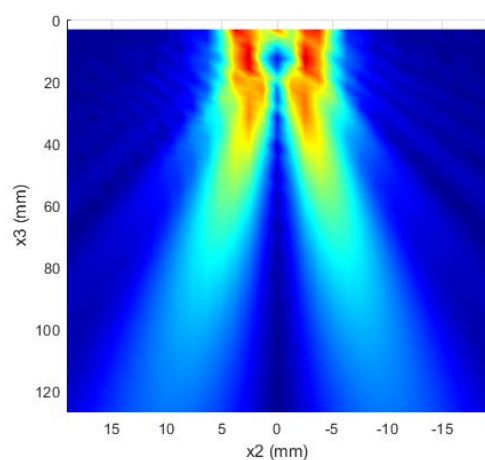
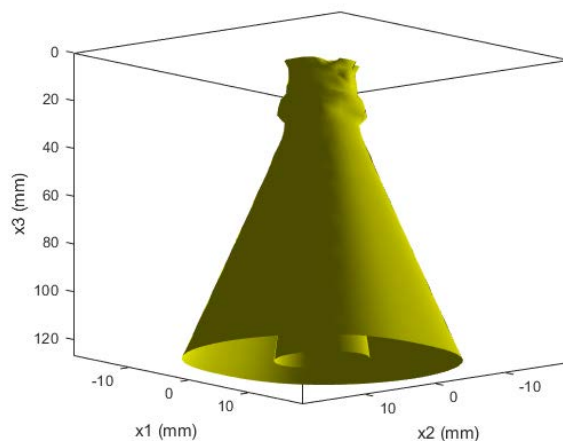
Part Number	Wave Mode	Magnet Type	Maximum Temperature and Time	Connector	Dim.	Applications
274A0409	SH Spiral	Permanent Magnet	80°C	4-Pin Lemo 0K	0.6" D x 1.7" H 15.5mm x 43.2mm	Bolt Load Measurement
274A0477	L + SH (Piezo + EMAT)	Linearly Polarized Spiral	80°C	6-Pin Lemo 1B	1.00" D x 2.00" H (25.4mm D x 50.8mm H)	Bolt Load Measurement
274A0479	SH Spiral	Permanent Magnet	80°C	4-Pin Lemo 0K	1.813 H x 0.75 D x 0.28 D (46.05mm H x 19.05mm D x 7.11mm D)	Bolt Load Measurement

6.1.3.1. Sensor SH Spiral – 0.5”D

Part Number		274A0409
Sensor Type		SH Lorentz Permanent Magnet
Temperature Range		80°C
Connector		4 Pin Lemo 0K
Coil Geometry		Spiral
Coil ID	inch	0.10
	mm	2.54
Coil OD	inch	0.50
	mm	12.7
Sensor	inch	0.6 D x 1.7 H
	mm	15.5 x 43.2



3dB Beam Profiles

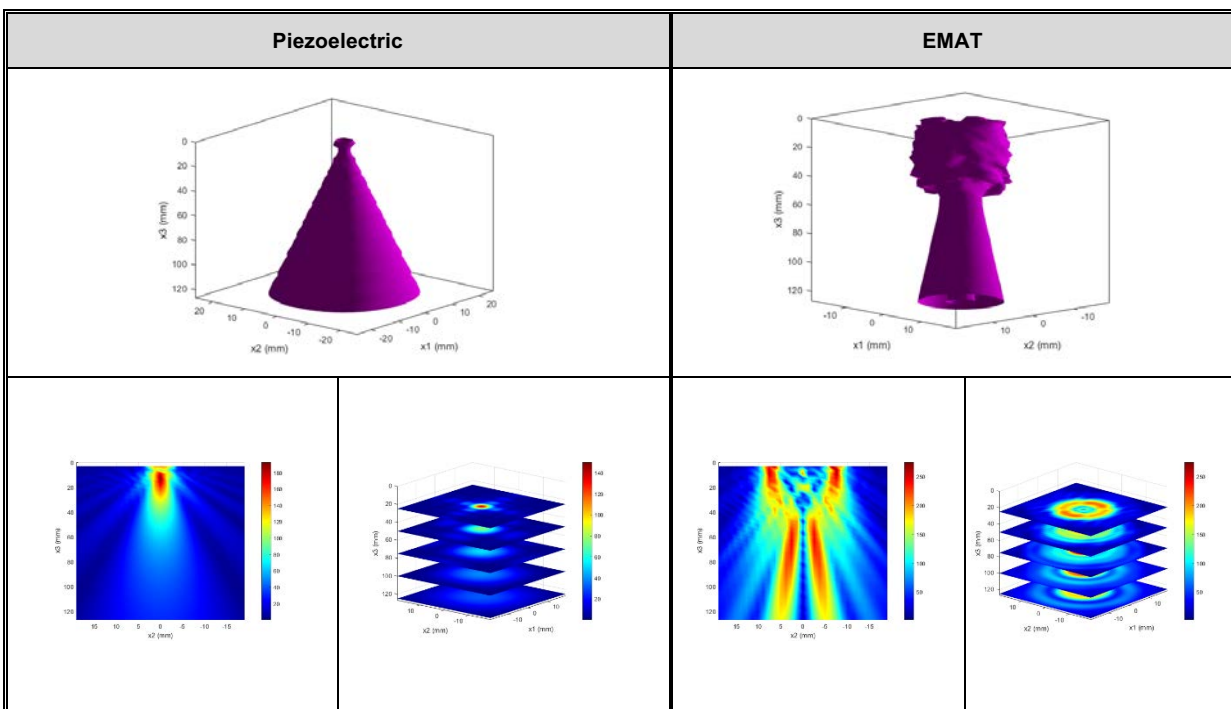


6.1.3.2. Sensor Bolt Load - Piezo + EMAT Dual Mode (L+SH) – 1”D

Part Number		274A0477
Sensor Type		Piezo + EMAT (PEMAT)
Temperature Range		80°C
Applications		Bolt Load
Connector		6 Pin Lemo 1B
Piezoelectric Geometry		6 mm Diameter – 3 MHz
EMAT Coil Geometry		Linearly Polarized – EMAT Spiral
Coil Width	inch	0.730"
	mm	18.25
Coil Length	inch	0.250"
	mm	6.25
Sensor	inch	1.00" D x 2.00" H
	mm	25.4 D x 50.8 H
Mounting Points		2 Ea. M3 Threaded Holes on Top



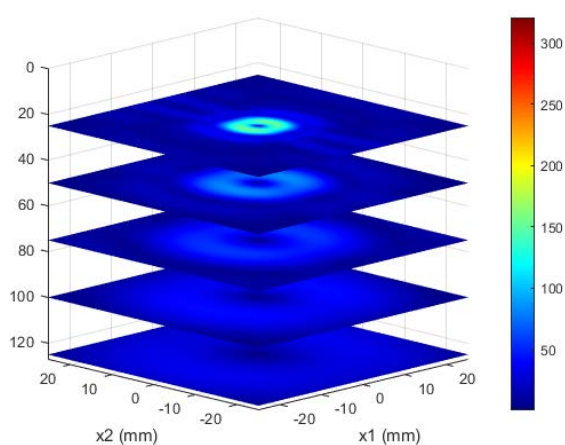
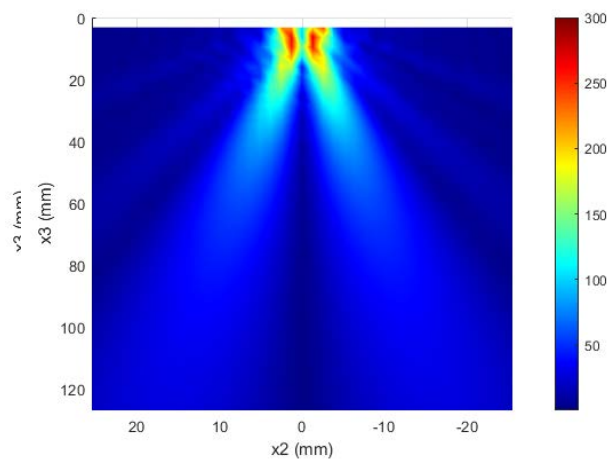
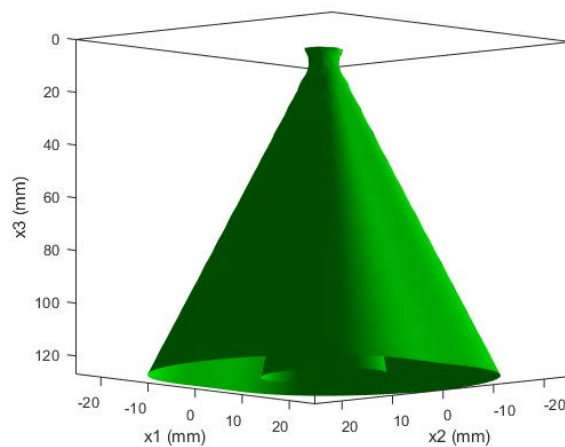
3dB Beam Profiles for PMAT Sensor



6.1.3.3. Sensor SH Spiral – 0.25”D

Part Number		274A0479	
Sensor Type		SH Lorentz Permanent Magnet	
Temperature Range		80°C	
Connector		4 Pin Lemo 0K	
Coil Geometry		Spiral	
Coil ID	inch	0.092	
	mm	2.34	
Coil OD	inch	0.224	
	mm	5.69	
Sensor	inch	1.813 H x 0.75 D x 0.28 D	
	mm	46.05 H x 19.05 D x 7.11 D	

3dB Beam Profiles



6.1.4. Stress Measurement with EMAT

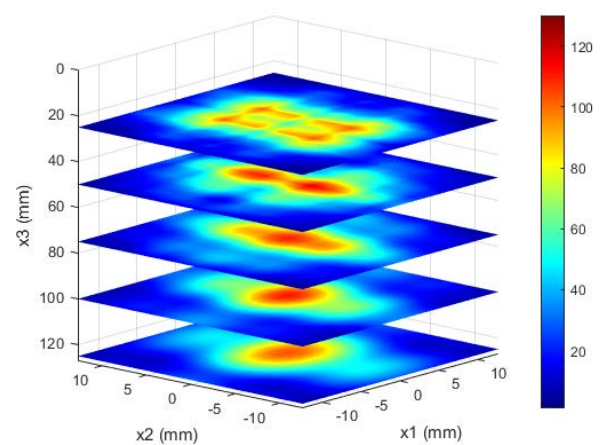
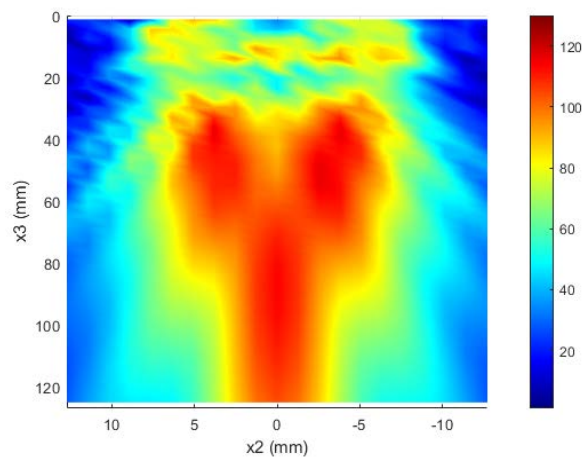
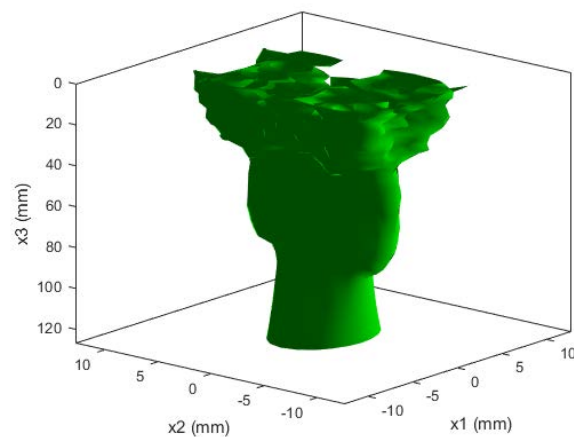
Part Number	Wave Mode	Magnet Type	Maximum Temperature and Time	Connector	Dim.	Applications
274A0157	Dual Linearly Polarized SH Wave @90°	Permanent Magnet	80°C	6 Pin Lemo 1B	1.88" D x 2.31" H (47.6mm D x 58.7mm H)	Stress Measurement
274A0415	Dual Linearly Polarized SH Wave @90°	Permanent Magnet	80°C	3-Pin Lemo 0K	1.563" W x 2.00"H (39.7 mm W x 50.8 mm H)	Stress Measurement
274A0361 & 187V0028	SH	Permanent Magnet	80°C	6 Pin Lemo 1B	1.563" W x 2.00"H (39.7 mm W x 50.8 mm H)	Stress Measurement for Rail Wheels

6.1.4.1. Dual Polarization Sensor – Stress Measurements

Part Number		274A0157
Sensor Type		Dual Linearly Polarized SH Wave @90°
Temperature Range		80°C
Applications		Anisotropy, Stress
Connector		6 Pin Lemo 1B
Coil Geometry		Linearly Polarized Dual
Coil Width	inch	0.42
	mm	10.66
Coil Length	inch	0.90
	mm	22.86
Sensor	inch	1.88" D x 2.31" H
	mm	47.6 D x 58.7 H
Anchor Points		Thread



3dB Beam Profiles for one coil (sensor contains two coils at 90°)

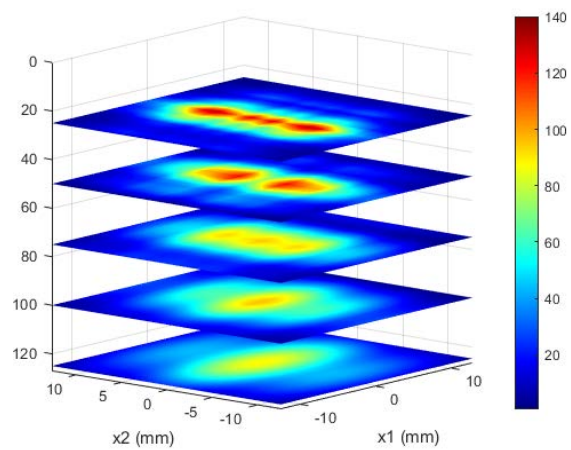
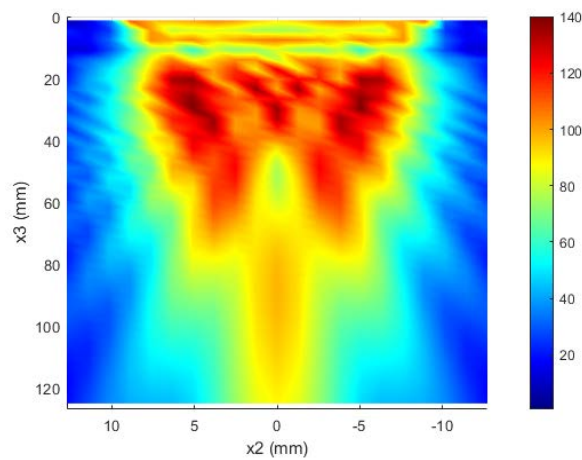
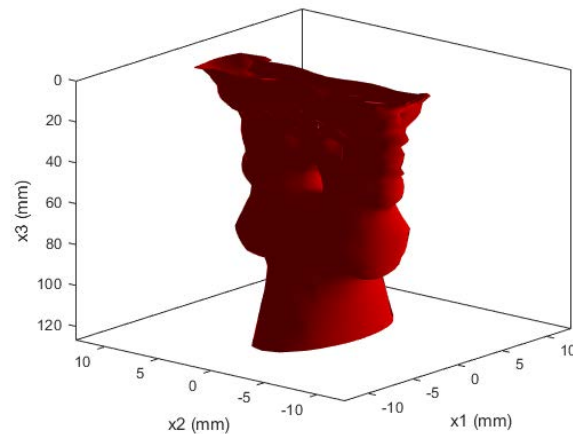


6.1.4.2. Dual Polarization Sensor – Stress Measurements

Part Number		274A0415
Sensor Type		Dual Linearly Polarized SH Wave @90°
Temperature Range		80°C
Applications		Anisotropy, Stress
Connector		6 Pin Lemo 1B
Coil Geometry		Linearly Polarized Dual
Coil Width	inch	0.336"
	mm	8.53
Coil Length	inch	1.192"
	mm	30.28
Sensor	inch	1.57" D x 2.17" H
	mm	40.0 D x 55.1 H
Anchor Points		2 x M3 x 0.5



3dB Beam Profiles for one coil (sensor contains two coils at 90°)



6.1.4.3. Stress Measurement Scanner for Train Wheels

Manual Scanner for Train Wheels

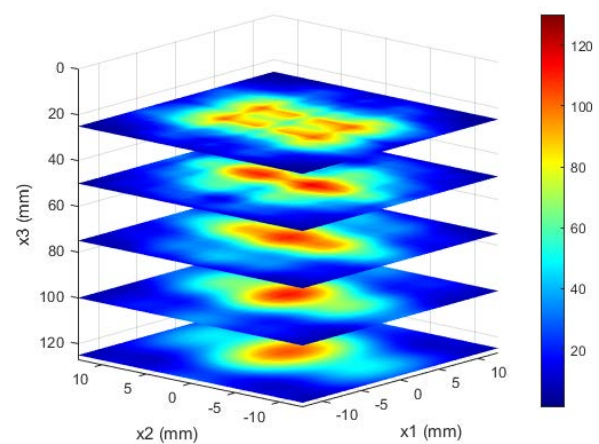
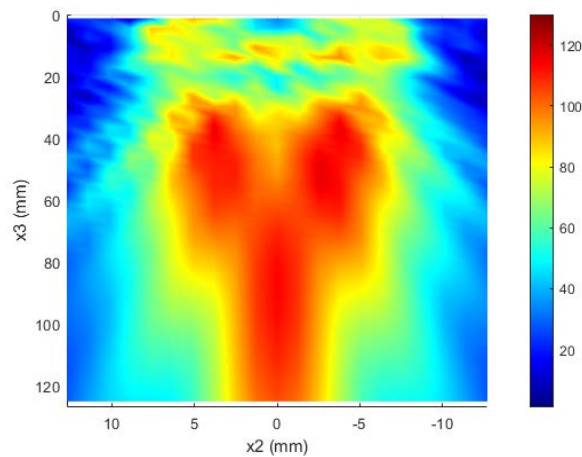
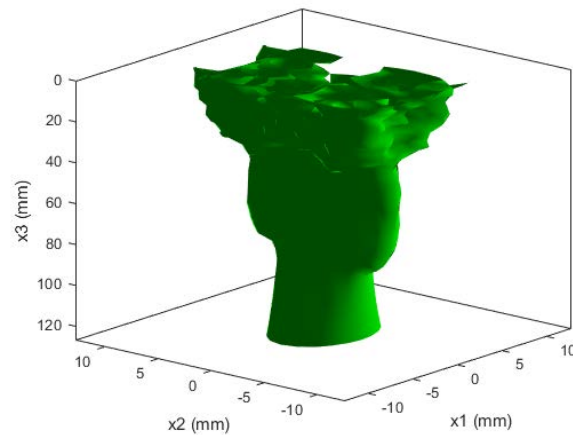


Part Numbers

Scanner: 187V0028
Sensor: 274A0361

6.1.4.3.1. Stress Measurement Sensor for Train Wheel Scanner

Part Number		274A0361
Sensor Type		Dual Linearly Polarized SH Wave @90°
Temperature Range		80°C
Applications		Anisotropy, Stress, Rail Stress
Connector		6 Pin Lemo 1B
Coil Geometry		Linearly Polarized Dual
Coil Width	inch	0.42
	mm	10.66
Coil Length	inch	0.90
	mm	22.86
Sensor	inch	1.57" D x 2.17" H
	mm	40.0 D x 55.1 H
Anchor Points		Thread



6.1.5. Thickness Measurement and Flaw Detection (normal beam) with DCUT

The Piezoelectric transducers and accessories included in this catalog have been designed for use with the Innerspec **CODA** and **VOLTA 2** instruments and other compatible equipment. Contact Innerspec Technologies for additional information on transducers and applications not covered in this Catalog.

The transducers are divided into three groups:

- Contact DCUT Transducers
- Flexible DCUT Transducers
- Wheel DCUT Transducers

Contact DCUT Transducers

Part Number	Operational Frequency	Transducer Size	Maximum Temperature	Connector	Physical Dim.	Applications and Minimum Material Thickness
281A0035-200	2.0 MHz	15 mm or 0.59"	50°C or 122°F	Lemo 00 Coax	20 mm – D 27 mm - H	Thickness Measurement 1mm Various Materials
281A0035-300	3.0 MHz	15 mm or 0.59"	50°C or 122°F	Lemo 00 Coax	20 mm – D 27 mm - H	Thickness Measurement. 1mm Various Materials
281A0035-400	4.0 MHz	15 mm or 0.59"	50°C or 122°F	Lemo 00 Coax	20 mm – D 27 mm - H	Thickness Measurement. 1mm Various Materials

Flexible DCUT Transducers

Part Number	Operational Frequency	Transducer Size	Maximum Temperature	Connector	Physical Dim.	Applications and Minimum Material Thickness
281A0028	3.5 MHz	6mm or 0.24"	50°C or 122°F	Lemo 00 Coax	68mm – L 18mm – W 3mm - H	Dry or Wet Thickness Measurement & Spot Flaw Detection 1mm Other - Varied
281A0029	3.5 MHz	10mm or 0.39"	50°C or 122°F	Lemo 00 Coax	68mm – L 18mm – W 3mm - H	Dry or Wet Thickness Measurement & Spot Flaw Detection 1mm Other - Varied
281A0030	3.5 MHz	20mm or 0.79"	50°C or 122°F	Lemo 00 Coax	81mm – L 30mm – W 3mm - H	Dry or Wet Thickness Measurement & Spot Flaw Detection 1mm Other - Varied

Wheel DCUT Transducers

Part Number	Operational Frequency	Transducer Size	Maximum Temperature	Connector	Physical Dim.	Applications and Minimum Material Thickness
281A0244-200*	2.0 MHz	9.5 mm or 0.375"	50°C or 122°F	Lemo 00 Coax	75 mm – D 40 mm – H	Thickness Measurement & Flaw Detection 1mm Other - Varied
281A0244-300*	3.0 MHz	9.5 mm or 0.375"	50°C or 122°F	Lemo 00 Coax	75 mm – D 40 mm – H	Thickness Measurement & Flaw Detection 1mm Other - Varied
281A0244-400*	4.0 MHz	9.5 mm or 0.375"	50°C or 122°F	Lemo 00 Coax	75 mm – D 40 mm – H	Thickness Measurement & Flaw Detection 1mm Other - Varied

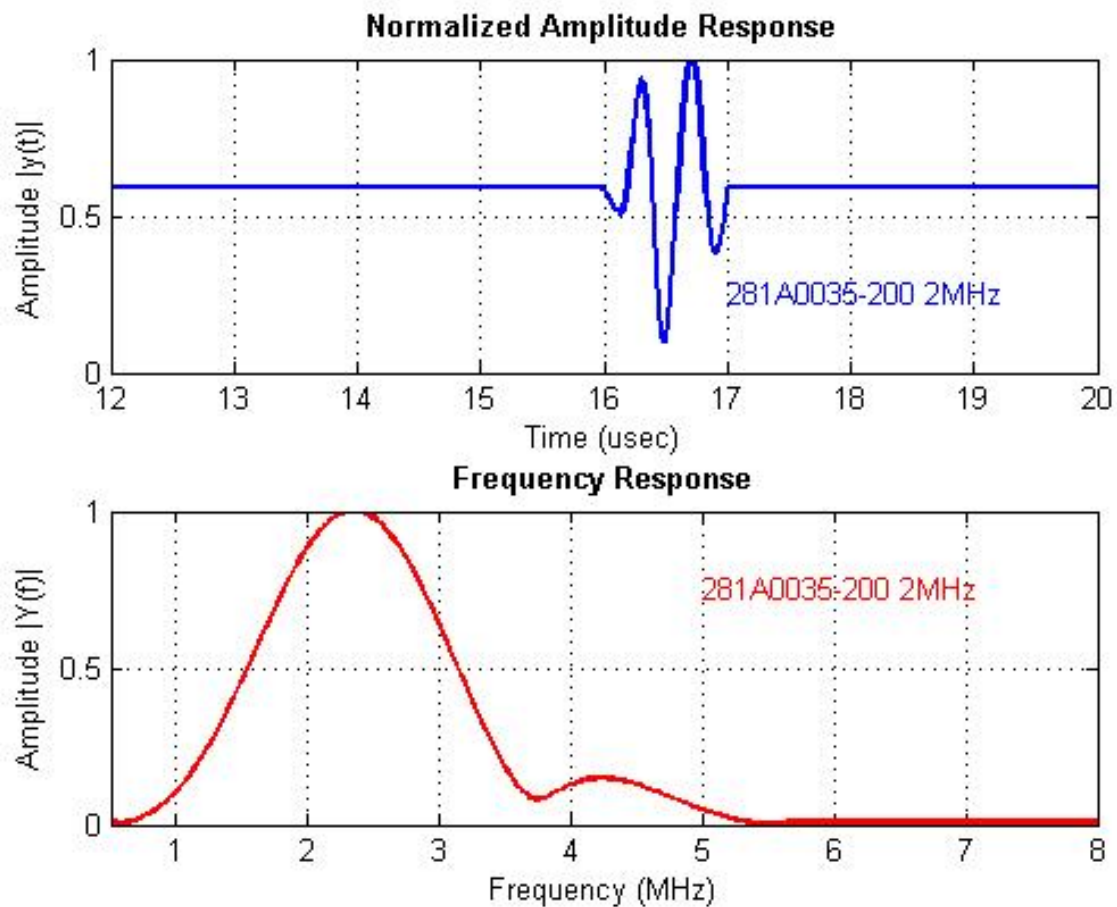
DCUT Accessories

Part Number	Required Hardware	Connector	Description	Picture
281A0040-250	281A0035-200 281A0035-300 281A0035-400	Threaded M18 x 1.0	25mm Delay Line for Contact DCUT Transducers	
281A0040-150	281A0035-200 281A0035-300 281A0035-400	Threaded M18 x 1.0	15mm Delay Line for Contact DCUT Transducers	
800A0283	281A0244-200 281A0244-300 281A0244-400	Lemo 00 BNC Coaxial	DCUT Hand Scanner for Wheeled DCUT Sensors	

6.1.5.1. Contact DCUT Transducer, 2.0 MHz

Part Number	281A0035-200	
Part Description	Contact DCUT Transducer – 2 MHz	
System Connection Type	Single Pin Lemo 00 Coax	
Wave Mode	Normal Beam	
Dimensions	15mm Diameter	
Recommended Power	1200 Vpp	
Supported Transducer Configurations	Pulse-Echo	
Compatible Cable	232A0678	

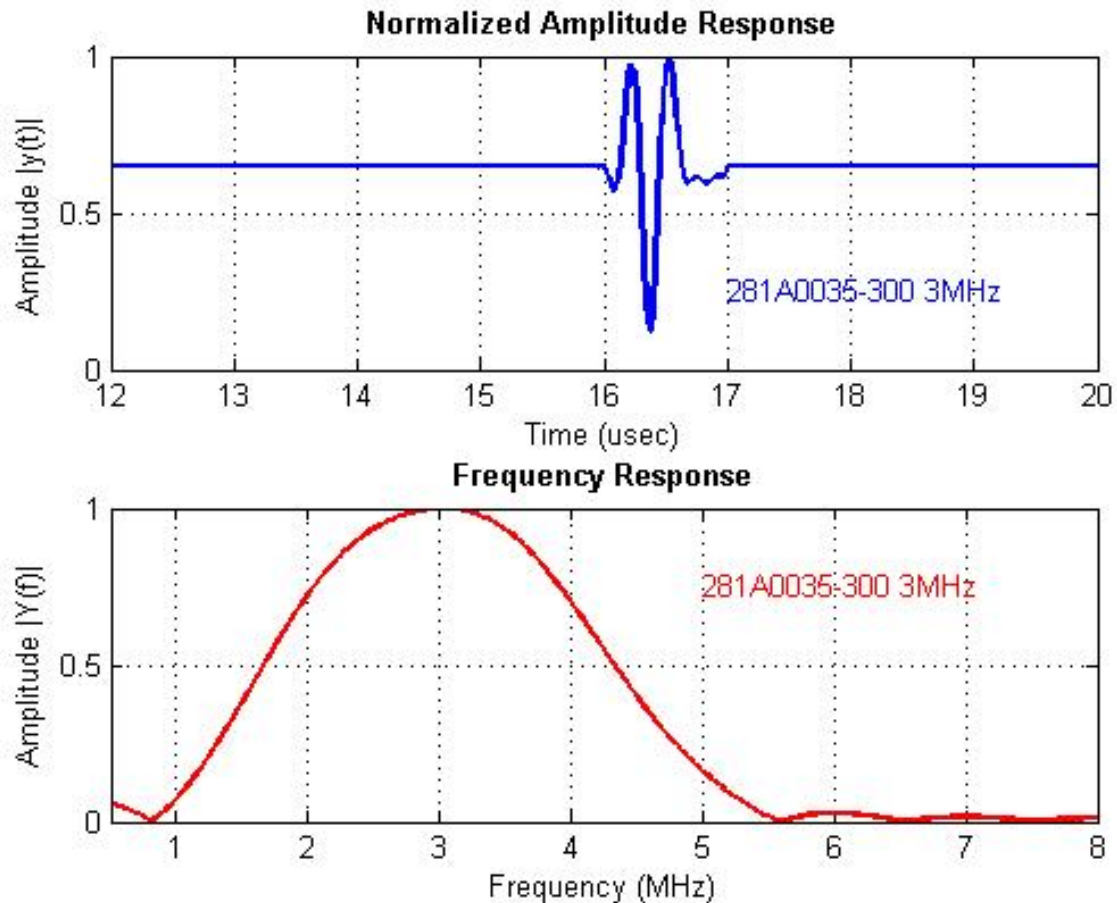
Frequency Spectra & 3dB Beam Profiles



6.1.5.2. Contact DCUT Transducer, 3.0 MHz

Part Number	281A0035-300	
Part Description	Contact DCUT Transducer – 3 MHz	
System Connection Type	Single Pin Lemo 00 Coax	
Wave Mode	Normal Beam	
Dimensions	15mm Diameter	
Recommended Power	1200 Vpp	
Supported Transducer Configurations	Pulse-Echo	
Compatible Cable	232A0678	

Frequency Spectra & 3dB Beam Profiles

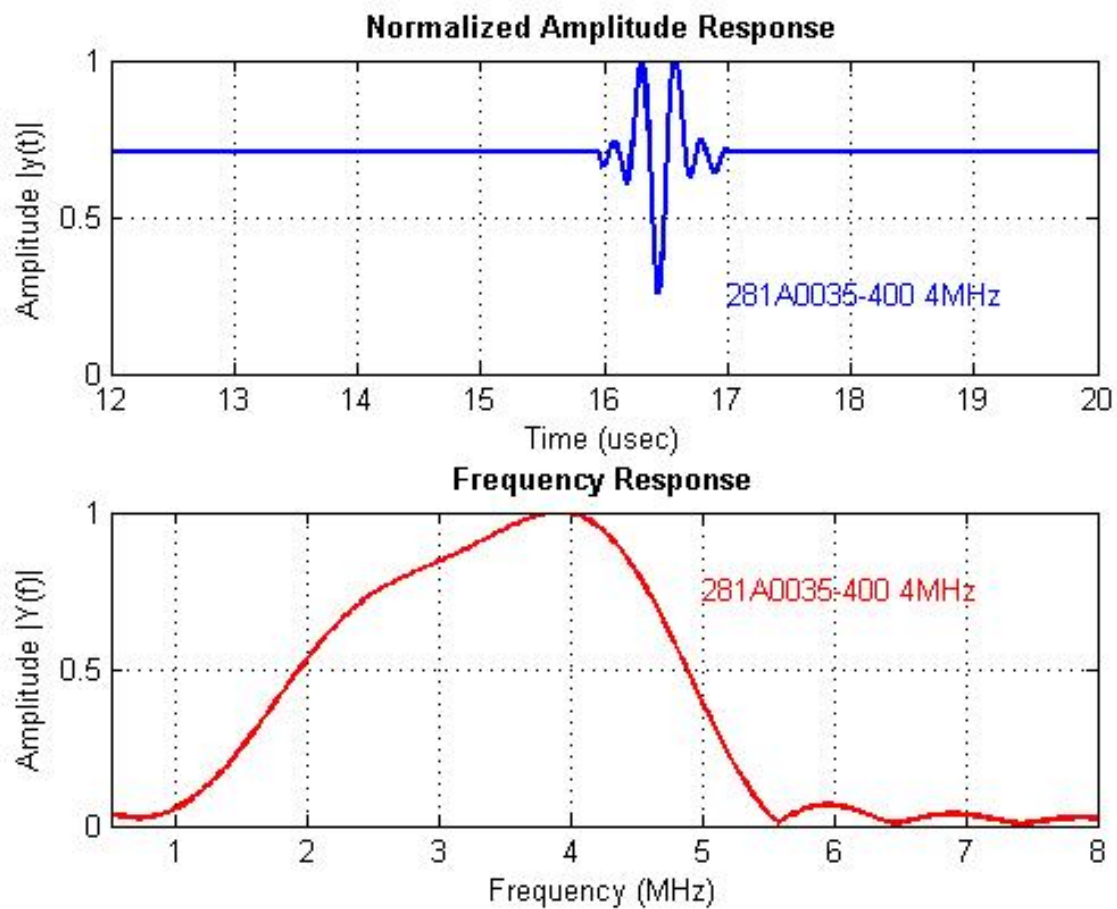


6.1.5.3. Contact DCUT Transducer, 4.0 MHz

Part Number	281A0035-400
Part Description	Contact DCUT Transducer – 4 MHz
System Connection Type	Single Pin Lemo 00 Coax
Wave Mode	Normal Beam
Dimensions	15mm Diameter
Recommended Power	1200 Vpp
Supported Transducer Configurations	Pulse-Echo
Compatible Cable	232A0678



Frequency Spectra & 3dB Beam Profiles

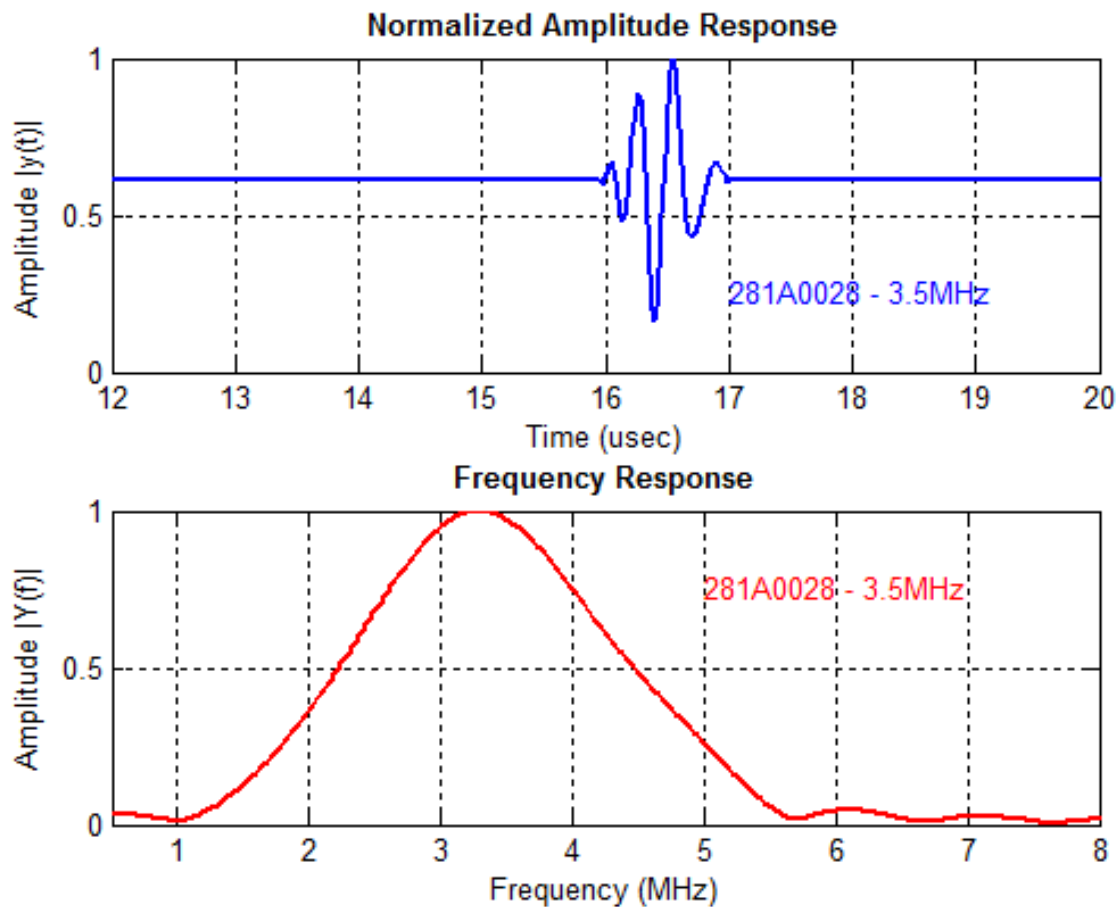


6.1.5.4. Flexible DCUT Transducer – Normal Beam, Medium, 3.5 MHz

Part Number	281A0028
Part Description	Flexible DCUT Transducer - Small
System Connection Type	Single Pin Lemo 00 Coax
Transducer Size	6mm
Wave Mode	Normal Beam
Physical Dimensions	68mm – L, 18mm – W, 3mm – H
Recommended Power	1200 Vpp
Supported Transducer Configurations	Pulse-Echo
Compatible Cable	232A0784



Frequency Spectra & 3dB Beam Profiles

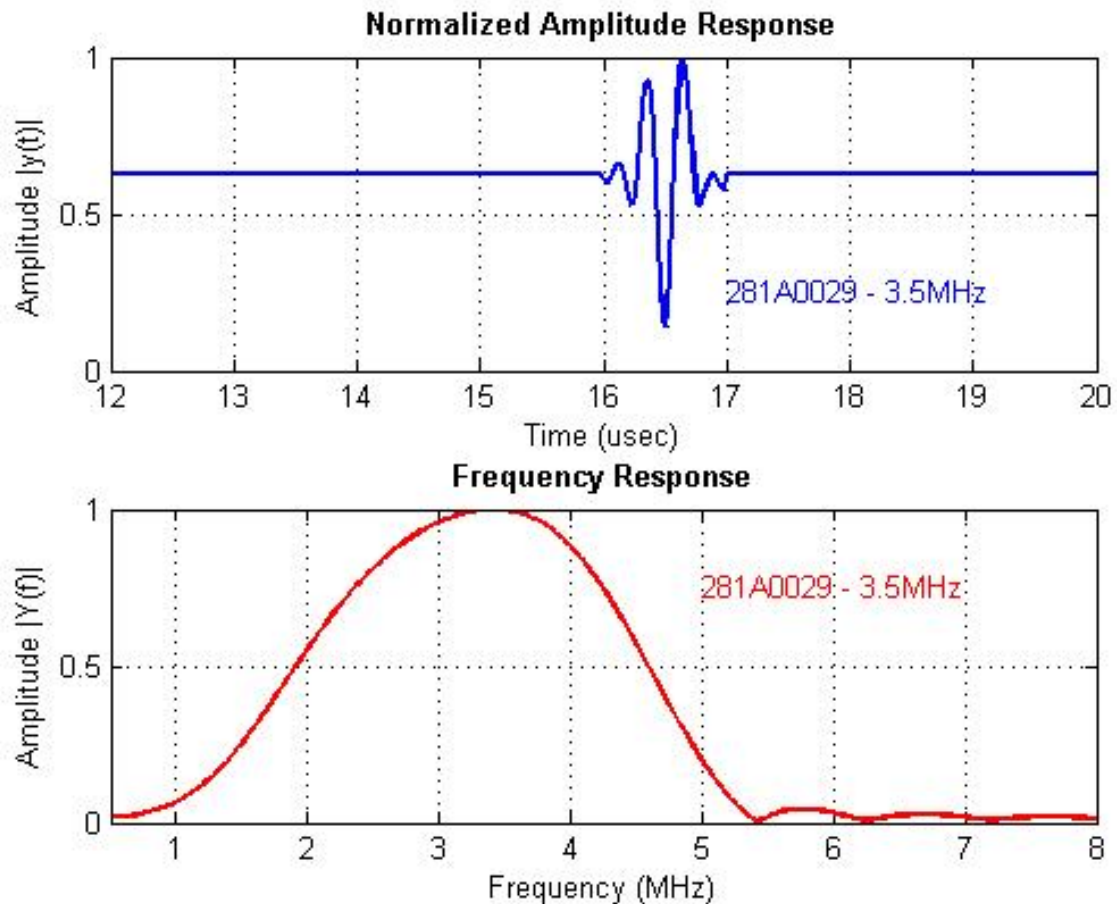


6.1.5.5. Flexible DCUT Transducer – Normal Beam, Medium, 3.5 MHz

Part Number	281A0029
Part Description	Flexible DCUT Transducer - Medium
System Connection Type	Single Pin Lemo 00 Coax
Transducer Size	10mm
Wave Mode	Normal Beam
Physical Dimensions	68mm – L, 18mm – W, 3mm – H
Recommended Power	1200 Vpp
Supported Transducer Configurations	Pulse-Echo
Compatible Cable	232A0784

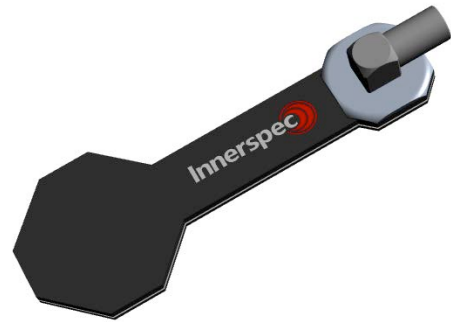


Frequency Spectra & 3dB Beam Profiles

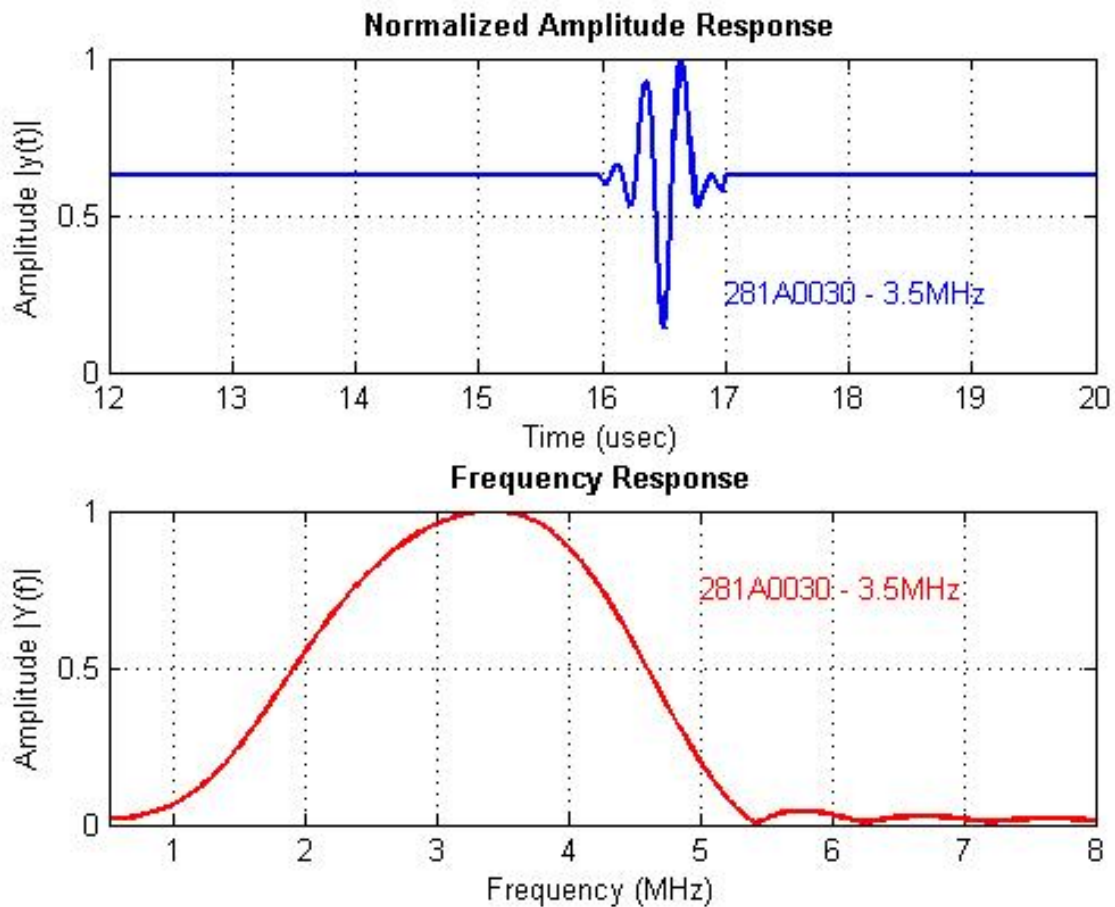


6.1.5.6. Flexible DCUT Transducer – Normal Beam, Medium, 3.5 MHz

Part Number	281A0030
Part Description	Flexible DCUT Transducer - Large
System Connection Type	Single Pin Lemo 00 Coax
Transducer Size	20mm
Wave Mode	Normal Beam
Physical Dimensions	81mm – L, 30mm – W, 3mm – H
Recommended Power	1200 Vpp
Supported Transducer Configurations	Pulse-Echo
Compatible Cable	232A0784



Frequency Spectra & 3dB Beam Profiles

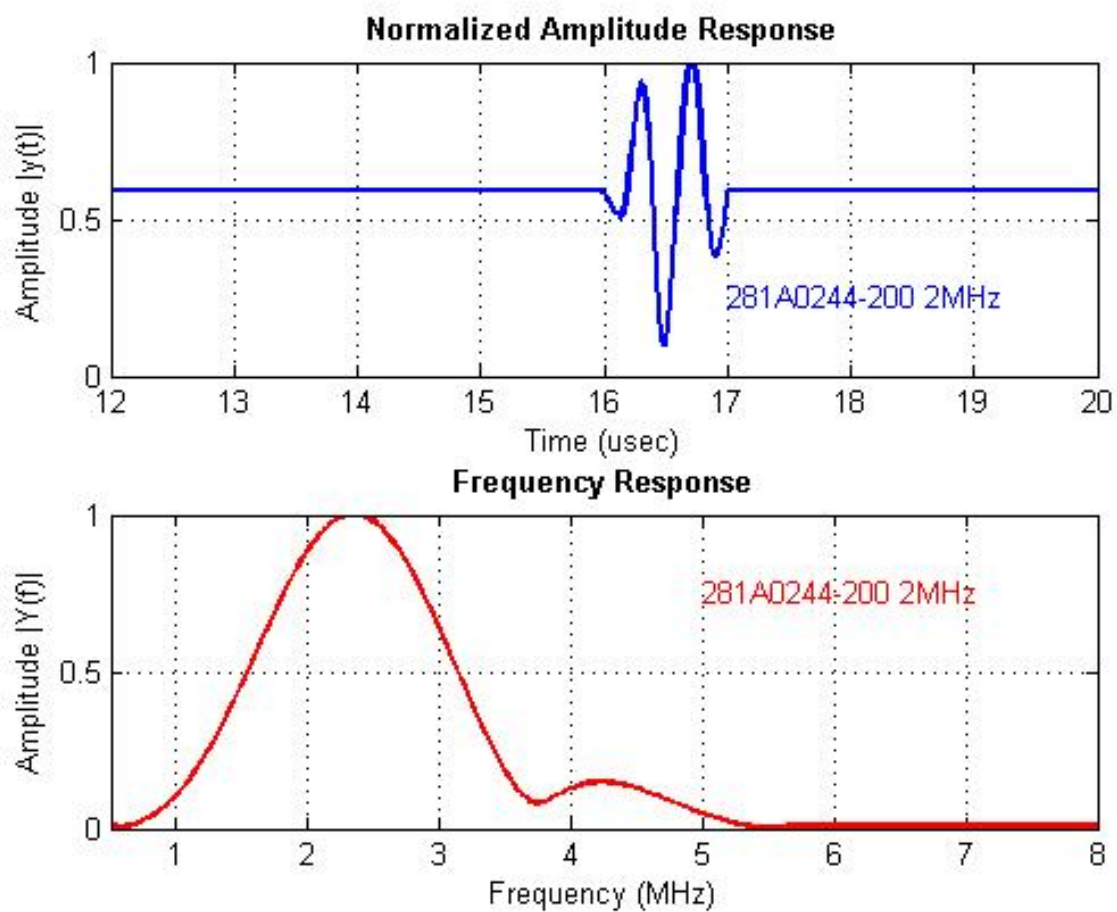


6.1.5.7. Wheel DCUT Transducer – 2.0 MHz

Part Number	281A0244-200
Part Description	DCUT Wheel Transducer
System Connection Type	Lemo 00 Coax
Transducer Size	9.5mm
Wave Mode	Normal Beam
Physical Dimensions	73mm Diameter
Recommended Power	1200 Vpp
Compatible Cable	232A0817



Frequency Spectra & 3dB Beam Profiles

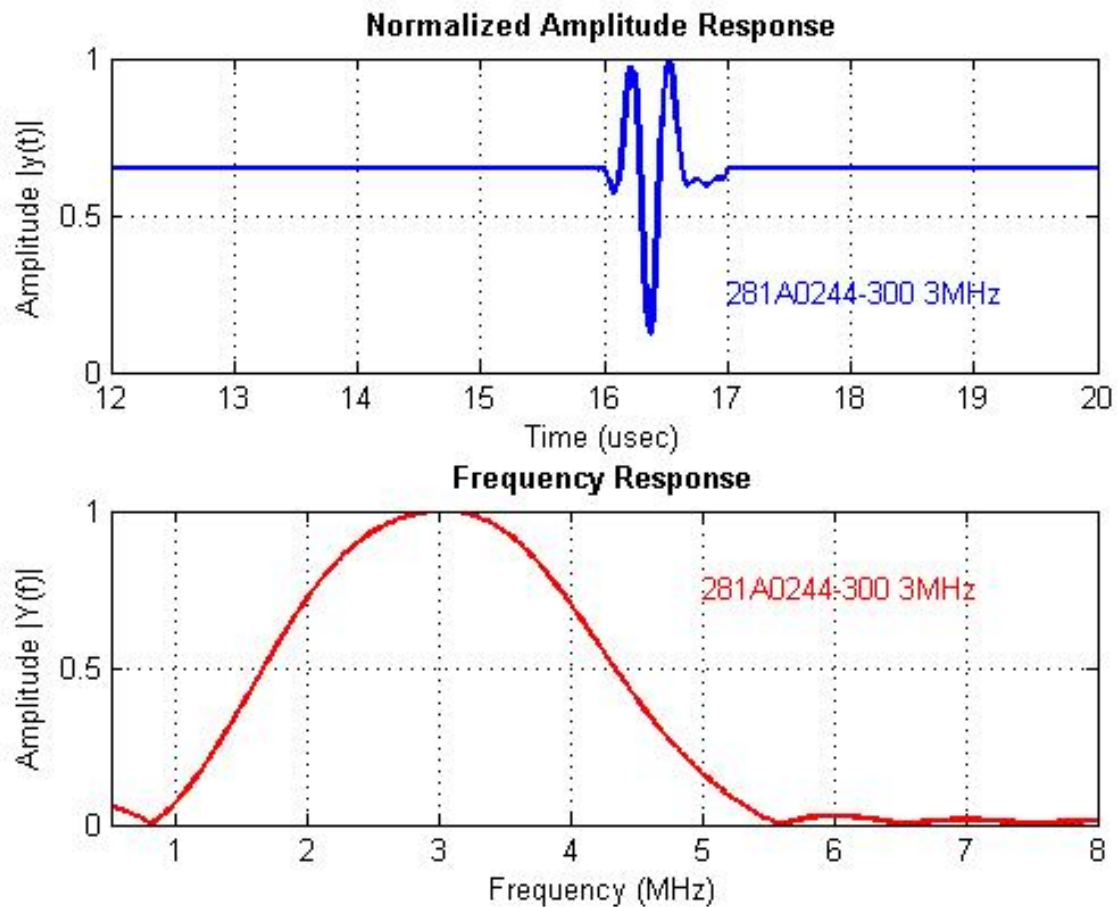


6.1.5.8. Wheel DCUT Transducer – 3.0 MHz

Part Number	281A0244-300
Part Description	DCUT Wheel Transducer
System Connection Type	Lemo 00 Coax
Transducer Size	9.5mm
Wave Mode	Normal Beam
Physical Dimensions	73mm Diameter
Recommended Power	1200 Vpp
Compatible Cable	232A0817



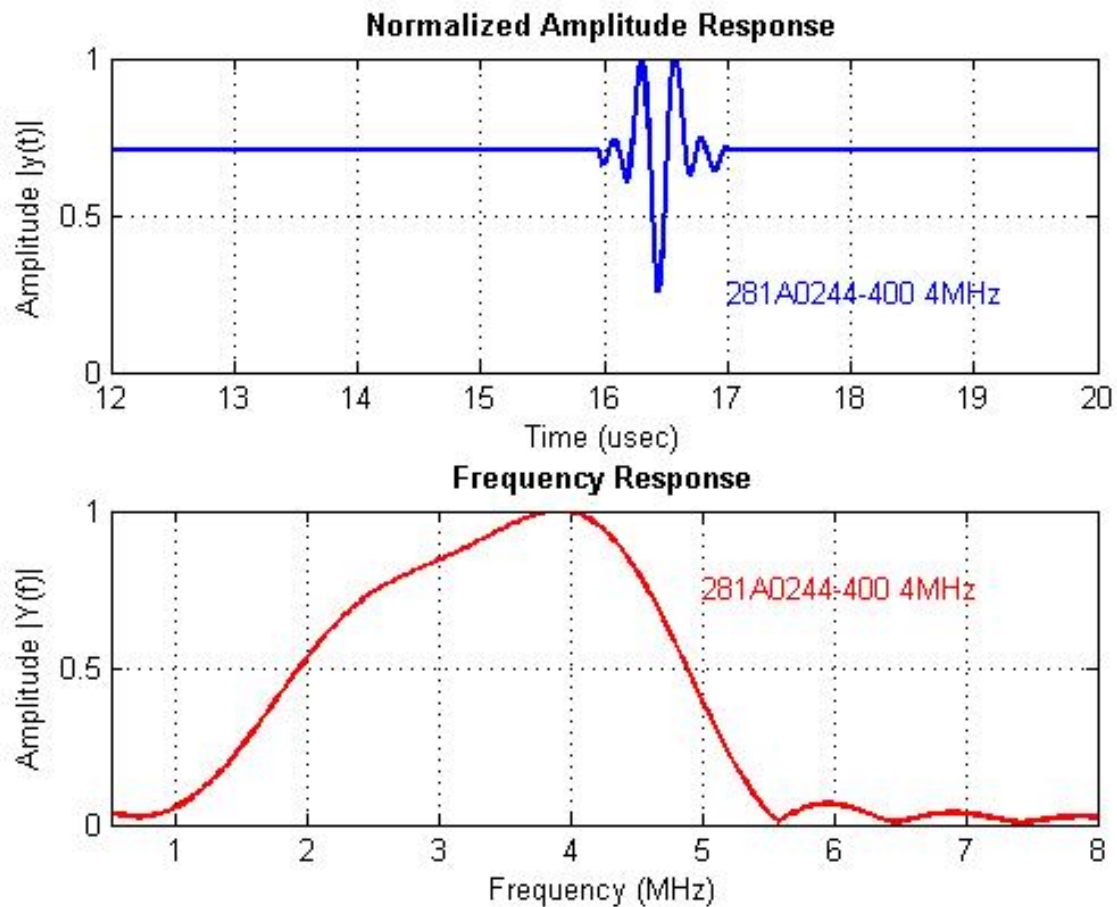
Frequency Spectra & 3dB Beam Profiles



6.1.5.9. Wheel DCUT Transducer – 4.0 MHz

Part Number	281A0244-400	
Part Description	DCUT Wheel Transducer	
System Connection Type	Lemo 00 Coax	
Transducer Size	9.5mm	
Wave Mode	Normal Beam	
Physical Dimensions	73mm Diameter	
Recommended Power	1200 Vpp	
Compatible Cable	232A0817	

Frequency Spectra & 3dB Beam Profiles



6.1.5.10. DCUT Sensor for Pole End

Part Number		281A0297
Sensor Type		DCUT: Piezo
Temperature Range		80°C
Applications		Thickness, Flaw Detection
Connector		Lemo 00 Coax
Sensor	inch	0.75" W x 2.75" H
	mm	19mm x 70mm



Pole Attachment:



7. Guided Wave Applications: Sensors & Accessories

***See section 2.3 for an explanation of guided wave applications**

Guided Waves have different motion distribution depending on the geometry and characteristics of the material that “guides” the sound. The introduction of boundary conditions makes guided wave problems inherently more difficult than bulk waves. Unlike the finite number of modes present in a bulk wave problem, there are generally an infinite number of modes associated with a given guided wave problem. That is, a finite body can support an infinite number of different guided wave modes.

This Catalog provides an example of the steps required in designing a guided wave inspection, and the Dispersion Curves in a **Steel Plate**.

The Dispersion Curves provided are **NOT** intended for:

- Other materials (other than steel)
- Anisotropic materials
- Multiple layered structures
- Tube, pipe, bar or other geometries
- Other wave modes

Contact Innerspec Technologies for additional assistance*

* Innerspec Technologies offers a comprehensive software package designed to provide dispersion curves for plates, tubes and rods in different materials (see **temate® GWAT** in the Software section of this Catalog). In addition to the dispersion curves, the software includes all the RF Coils available in this Catalog and can reference the right RF Coil for a specific mode thus considerably simplifying the setup process.

Setup Process:

- a. Determine Thickness of Test Sample (h).
- b. Select Appropriate Mode. The user will need to determine the desired mode to be excited based on wave mode analysis, finite element analysis (FEA), or empirical evidence. Mode selection depends on the type and geometry of defects, geometry of the part and other variables (e.g. environmental conditions of the sample).
- c. Go to Phase Velocity Dispersion Curve (C_p Vs fh) and Group Velocity dispersion curve (C_g Vs fh) for that material and confirm the adequacy of the mode.
 - The Phase Velocity curve shows the mode separation for a given frequency-thickness. The more separate a mode is from others, the easier it will be to generate without interferences.
 - The Group Velocity curve determines how that mode will travel in time with other modes. This is important to know when designing the experiment since modes of different speeds could interfere with each other at the time when the reading is to be taken.
- d. Determine the EMAT Coil to use. Using the information from the Phase Velocity Dispersion Curve, calculate the targeted wavelength for the specific mode.

$$\lambda = \frac{C_p}{f} = \left(\frac{C_p}{fh} \right) h$$

- e. Select from the Catalog an RF Coil with a Period equal or close to the targeted wavelength.

f. Hardware Setup

- Frequency Selection. Once the mode is selected, frequency, phase velocity and group velocity can be easily derived from the tables.
 - i. Using the (f, h) curve provided for each coil to determine the test frequency f_0
 - ii. Using the (C_g, h) curve provided for each coil to determine the group velocity of the mode C_{g0}
 - iii. Phase velocity $C_{p0} = f_0 \lambda_0$
- Tuning Module Selection.
 - i. Select the tuning module for that particular RF Coil that covers the particular frequency selected f_0
 - ii. Insert Tuning Module in Signal Conditioning Box.
 - iii. Experienced users may also pick up the tuning module based on the frequency spectrum provided in this catalog, or from their own experience.

Other Setup Tips:

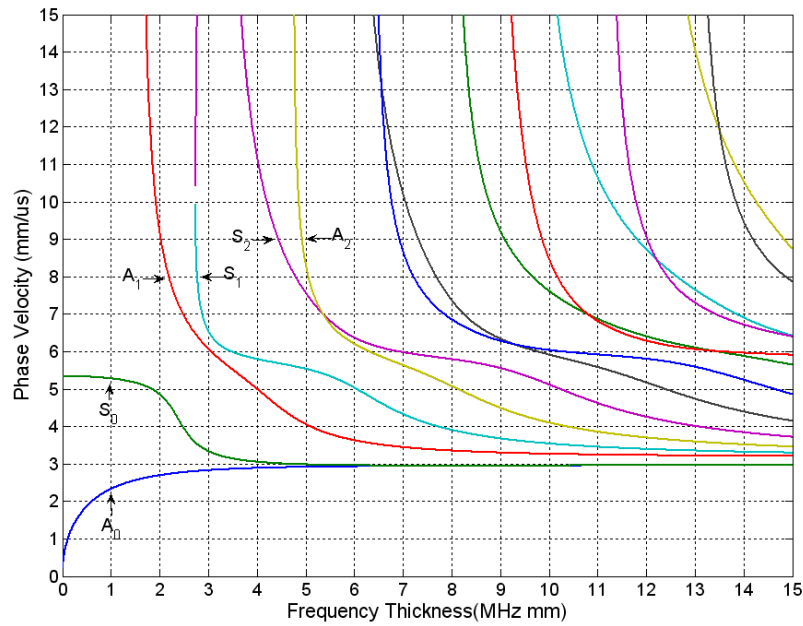
- a. The excitation is achieved with a tone burst signal of center frequency f_0 .
- b. Number of cycles of the excitation signal can be changed depending on the inspection requirement.
 - Time domain: More cycles result in longer pulse time which could affect resolution for Time-Of-Flight calculations.
 - Frequency domain: More cycles means narrower band and better mode selectivity.
 - Amplitude: For non-dispersive and weak dispersive modes, more cycles typically result in stronger signal. The peak amplitude of the signal will increase up to a point when $N_t = N_T + N_R - 1$. Here N_t , N_T , and N_R are number of cycles in the excitation signal, number of periods in the transmission coil, and the number of cycles in the receiving coil respectively. For strongly dispersive modes, this rule is not applicable.
- c. Time of expected signal package
 - Estimate the distance of expected sound path l .
 - i. In through transmission, this is the distance between transmitter and receiver.
 - ii. In reflection, this is the distance of transmitter to reflector plus the distance of the reflector to the receiver.
 - Calculate the expected time of flight (TOF) of the signal:

$$t = C_{g0} \times l$$
 - Set detection gate based on the expected TOF and/or its range.
- d. For some steel products, the material property may vary from the standard property used in the catalog. The test designer might need to change the test frequency around the theoretical value f_0 to optimize the test result.
- e. A_0 and S_0 Lamb wave modes converges to Rayleigh wave at high frequency. Therefore, the Rayleigh surface wave velocity can also be read from the dispersion curves shown here.

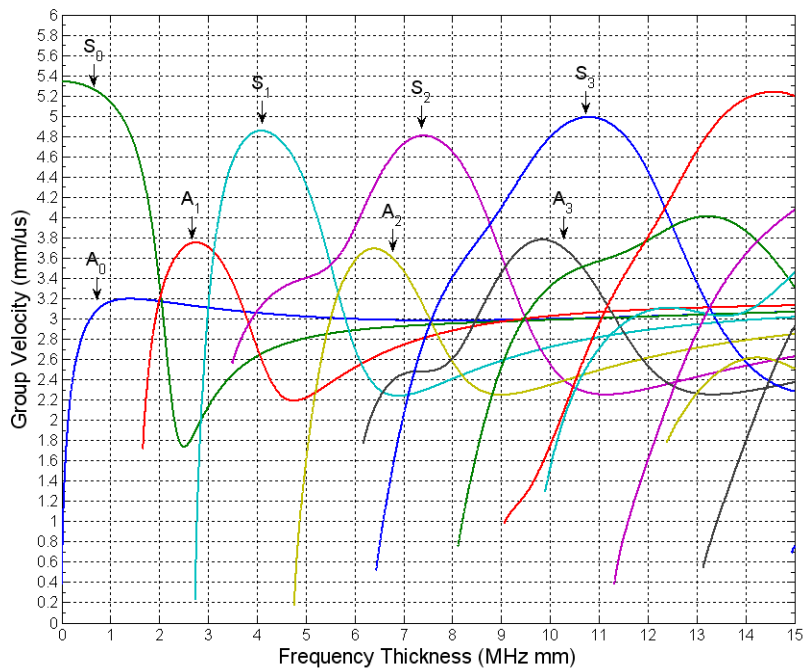
Phase Velocity and Group Velocity Dispersion Curves in Steel Plate (Generic)

Lamb & Rayleigh Wave Dispersion Curves

Phase Velocity

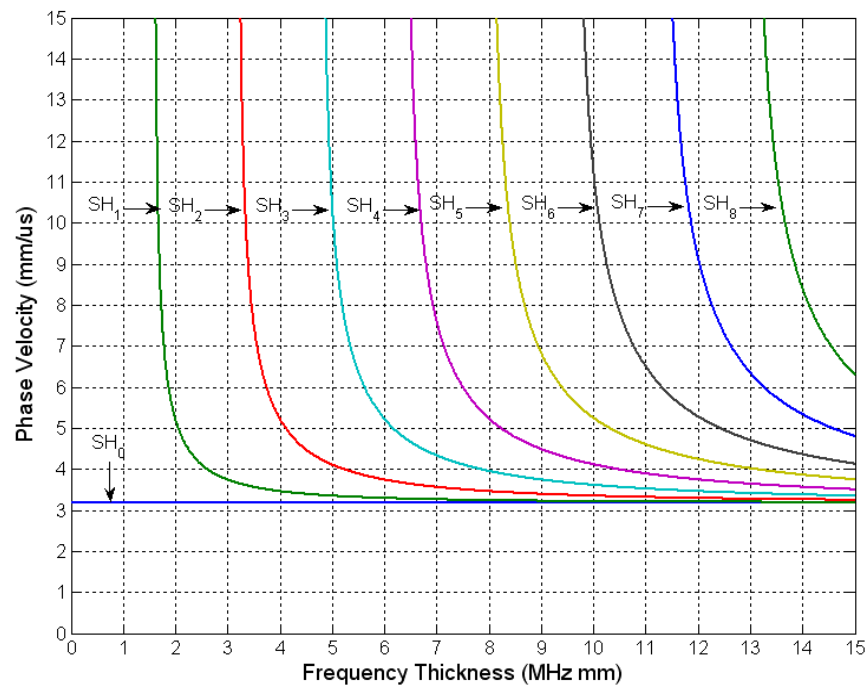


Group Velocity

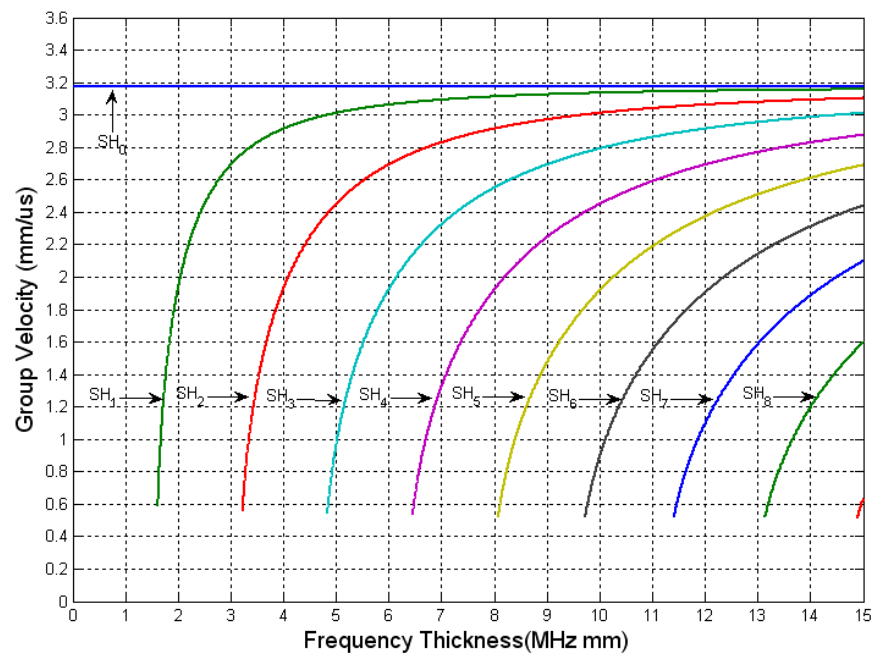


Shear Horizontal Wave Dispersion Curves

Phase Velocity

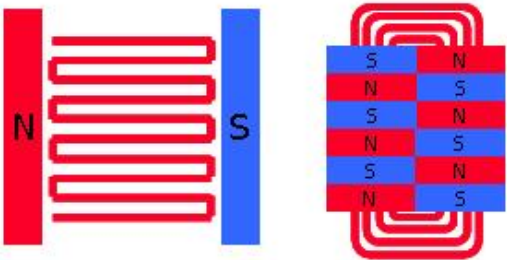
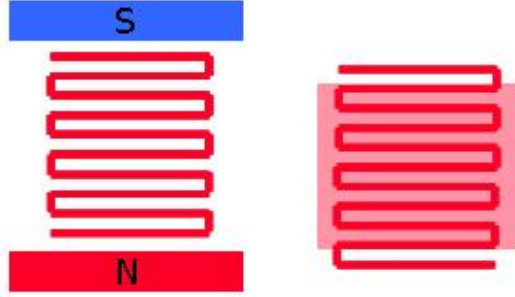


Group Velocity



Angled Beam and Guided Wave RF Coils

Angled Beam Bulk Waves and Guided Waves are generated using alternating magnetic fields created by either a meander RF Coil or a set of periodic magnets on a racetrack or spiral RF coil. The table below shows examples of Guided Wave magnet and RF Coil configurations.

RF Coil Geometry	Wave Mode	Wavelength	Configuration
Meander and Racetrack (spiral)	Shear Horizontal	RF Coil spacing or magnet size determine wavelength	
Meander	Rayleigh Lamb	Meander spacing determines wavelength	

Because of its mode-selection and non-contact characteristics, EMAT is by design very well suited to efficiently generate all the Guided Wave modes including Rayleigh, Shear Horizontal, and Lamb waves.

7.1. MRUT (Medium Range Ultrasonics)

MRUT (Medium Range UT) describes a suite of techniques that permit covering an area between approximately 25mm to 3000mm from the location where the inspection is performed. MRUT uses guided wave and/or bulk wave techniques and complements LRUT (Long Range UT) by covering the near field area where LRUT cannot be used. MRUT techniques are mainly designed for fast scanning and detection (qualitative assessment), although in some circumstances they can provide relatively accurate measurements (quantitative assessment via defect sizing). Innerspec's MRUT techniques are all based on EMAT. MRUT characteristics are that it will detect cracks, pits and corrosion on pipes and tank. Axial scans provide circumferential and volumetric inspection of pipelines (including under supports) at fast inspection speeds (25 mm/s). Circumferential scans permit inspection of supports and soil interfaces up to 3 m deep. In a tank inspection configuration, the system scans up to 1 m per pass.

Applications include:

- General Flaw Detection
- Defect/Flaw Sizing
- Inspection of Light-Coated Free-Standing Pipes
- Inspection of Pipe Supports from Top
- Inspection of Inaccessible Areas from Side
- Plate and Tank Volumetric Inspection
- Rail Head Inspection
- Inspection of Thin Materials
- Surface Inspections



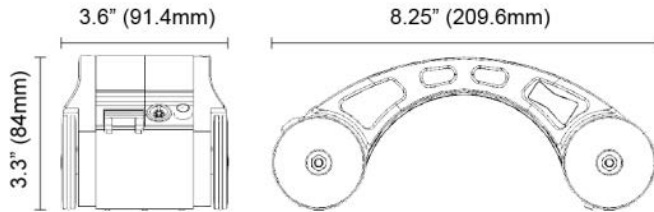
7.1.1. MRUT Sensors

Part Number	System Name	Operation Mode	Scanning Configuration	Magnet Options	System Requirement	Application
280A0384	MRUT-SH MS Scanner Circumferential	Manual	Circumferential Axial	N/A	VOLTA 2	Inspection of Pipes, Tubes, & Plates
160A0264	MRUT-SH MS Scanner Axial (Large)	Manual	Axial	N/A	VOLTA 2	Inspection of Pipes, Tubes, & Plates; MRUT Sizing
274A0432	MRUT-SH MS Scanner Axial (Small)	Manual	Axial	N/A	VOLTA 2	Inspection of Pipes, Tubes, & Plates
800A0375	MRUT-Lamb PMX Scanner	Manual	Axial Flat Circumferential	Permanent	VOLTA 2	Inspection of Exposed Pipes, Tubes, & Plates
800A0243	MRUT-Lamb PML Scanner	Manual	Axial Flat	Permanent	VOLTA 2	Inspection of Exposed Pipes, Tubes, & Plates

7.1.2. SH Waves

7.1.2.1. MRUT MS Scanner Circumferential (Shear Horizontal)

Guided wave reflection technique to inspect flats or tubes. Sound is sent along the plate or tube and reflects from defects ahead or behind the sensors. This system uses Shear Horizontal (SH) wave modes with a magnetostrictive strip applied to the surface of the material.

MRUT MS Scanner Circumferential		
		
Minimum OD Inspected	4" (102 mm)	
		
Part Numbers (SH Wave)		
SH Wave	Scanner: 280A0384	Kit: 800A1352 (VOLTA) 800A0424 (for VOLTA 2) Accessories: 800A0332 (for VOLTA) 800A0358 (Consumables) 232A0169-012 (Cable) 232A1016 (Encoder Cable) Coils: 205C0468 (for 128 kHz) 205C0470 (for 64 kHz)

7.1.2.2. MRUT MS Scanner Axial (Shear Horizontal)

Guided wave reflection and attenuation technique to inspect flats or tubes. Sound is sent along the plate or around the tube and reflects from defects around sensor. This system uses Shear Horizontal (SH) wave modes with a magnetostrictive strip applied to the surface of the material.

MRUT MS Scanner Axial (Large)		
		
Minimum OD Inspected	4" (102 mm)	
Dimensions	8" x 3.5" x 1.5"	
Part Numbers (SH Wave)		
SH Wave	Scanner: 160A0264	Kit: 800A0425 (VOLTA 2) Accessories: 800A0358 (Consumables) 232A1102 (Cables) Coils: 205C1197 (for 128 kHz) 205C1198 (for 64 kHz)

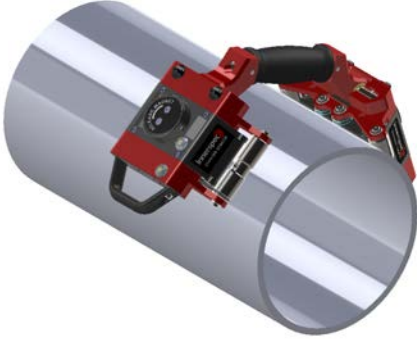
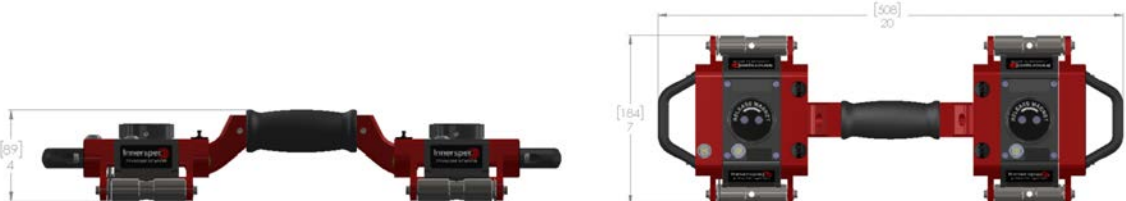
7.1.2.3. MRUT MS Scanner Axial (Small)

MRUT MS Scanner Axial (Small)		
		
Minimum OD Inspected	4" (102 mm)	
Dimensions	8" x 3.5" x 1.5"	
Part Numbers (SH Wave)		
SH Wave	Scanner: 274A0432	Kit: 800A0422 (VOLTA 2) Accessories: 800A0358 (Consumables) 232A0169-RAC-012 (Cable) 232A1046-012 (Encoder Cables) Coils: 800A0424 (VOLTA 2)

7.1.3. Lamb Waves

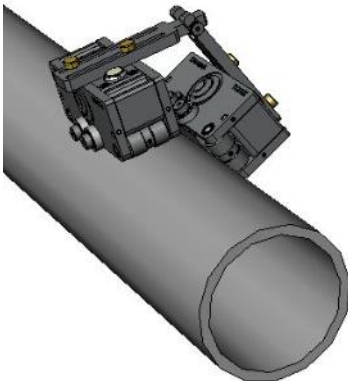
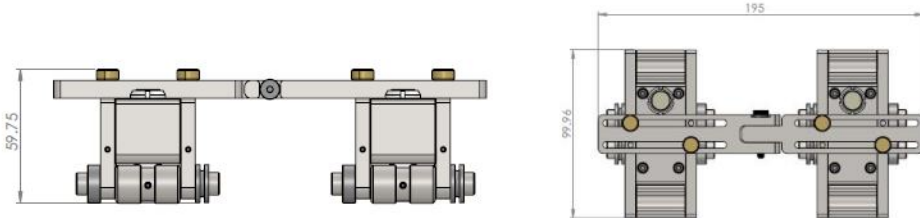
7.1.3.1. MRUT PMX Scanner (Lamb)

Guided wave technique is used to inspect flat, convex (e.g. pipe ID), or concave surfaces (e.g. pipe OD). Sound is sent either in Pitch-Catch mode (one sensor as the transmitter, and another sensor as the receiver), or Pulse-Echo mode (one sensor as both the transmitter and receiver). This system uses Lamb wave modes with permanent magnets.

MRUT PMX Scanner		
		
Extension Arm		Minimum OD Inspected
7.88" (200 mm)		5" (127 mm)
		
Part Numbers (Lamb Wave)		
Lamb	Scanners: 800A0375 Magnets: 274A0398	Accessories: 800A0383 (VOLTA) 800A0423 (VOLTA 2)

7.1.3.2. MRUT PML Scanner (Lamb)

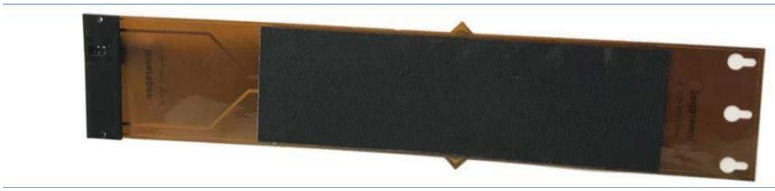
Guided wave technique is used to inspect flat, convex (e.g. pipe ID), or concave surfaces (e.g. pipe OD). Sound is sent either in Pitch-Catch mode (one sensor as the transmitter, and another sensor as the receiver), or Pulse-Echo mode (one sensor as both the transmitter and receiver). This system uses Lamb wave modes with permanent magnets.

MRUT PML Scanner		
		
Extension Arm		Minimum OD Inspected
7.68" (195 mm)		1" (25 mm)
		
Part Numbers (Lamb Wave)		
Lamb	Scanner: 800A0243 Magnets: 274A0244 (x2) 187A0017: Connecting Bracket for 2 - 274A0244 Magnets for MRUT Operation.	Accessories: 800A1329 (for VOLTA) 800A0421 (for VOLTA 2) Wear Surface: 001F2201

7.1.4. MRUT RF Coils**7.1.4.1. MRUT SH Coils**

Part Number	Compatible Sensor	Function	Coil Period (inch)	Number of Periods
205C0468	280A0383	Transmitter & Receiver	1.0	2
205C0470	280A0383	Transmitter & Receiver	2.0	2
205C1197	160A0264	Transmitter & Receiver	1.0	2
205C1198	160A0264	Transmitter & Receiver	2.0	2

7.1.4.1.1. RF Coils: PE-MSS-M-1.000X2-6.000-R

		
Part Number		205C0468
Connector		6 pin Lemo
Coil Function		Transmitter/Receiver
Compatible Sensor		274A0398
Coil Geometry		Meander
Meander Period	inch	1.0
	mm	25.4
Number of Periods		2

7.1.4.1.2. RF Coils: PE-MSS-M-2.000X2-6.000-R

		
Part Number		205C0470
Connector		6 pin Lemo
Coil Function		Transmitter/Receiver
Compatible Sensor		274A0398
Coil Geometry		Meander
Meander Period	inch	2.0
	mm	50.8
Number of Periods		2

7.1.4.1.3. RF Coils: PE-MSS-M-1.000X2-6.000-R



Part Number		205C1197
Connector		6 pin Lemo
Coil Function		Transmitter/Receiver
Compatible Sensor		160A0264
Coil Geometry		Meander
Meander Period	inch	1
	mm	25.4
Number of Periods		2

7.1.4.1.4. RF Coils: PE-MSS-M-1.000X2-6.000-R



Part Number		205C1198
Connector		6 pin Lemo
Coil Function		Transmitter/Receiver
Compatible Sensor		160A0264
Coil Geometry		Meander
Meander Period	inch	2
	mm	50.8
Number of Periods		2

7.1.4.2. MRUT Lamb Coils for PMX Sensor

Part Number	Compatible Magnet	Function*	Coil Period (inch)	Number of Periods	Aperture (inch)
205C0788	274A0398	Transmitter	0.200	7	2.000
205C0799	274A0398	Receiver	0.200	7	2.000
205C0789	274A0398	Transmitter	0.250	6	2.000
205C0804	274A0398	Receiver	0.250	6	2.000
205C0790	274A0398	Transmitter	0.300	5	2.000
205C0805	274A0398	Receiver	0.300	5	2.000
205C0791	274A0398	Transmitter	0.400	4	2.000
205C0806	274A0398	Receiver	0.400	4	2.000
205C0792	274A0398	Transmitter	0.520	3	2.000
205C0807	274A0398	Receiver	0.520	3	2.000
205C0793	274A0398	Transmitter	0.640	3	2.000
205C0808	274A0398	Receiver	0.640	3	2.000
205C0794	274A0398	Transmitter	0.720	2	2.000
205C0809	274A0398	Receiver	0.720	2	2.000
205C0795	274A0398	Transmitter	0.880	2	2.000
205C0800	274A0398	Receiver	0.880	2	2.000
205C0796	274A0398	Transmitter	0.960	2	2.000
205C0801	274A0398	Receiver	0.960	2	2.000
205C0797	274A0398	Transmitter	1.040	2	2.000
205C0802	274A0398	Receiver	1.040	2	2.000
205C0798	274A0398	Transmitter	1.120	2	2.000
205C0803	274A0398	Receiver	1.120	2	2.000

7.1.4.2.1. RF Coils: VOLTA-T-ME-M-0.200x7-2.000 & VOLTA-R-ME-M-0.200x7-2.000

			
Part Number		205C0788	205C0799
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.200	0.200
	mm	5.08	5.08
Number of Periods		7	7
Overall Depth	inch	1.337	1.324
	mm	33.95	33.63
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1154	400	100-500	250-670	240-740
205T1152	1000	500-1200	500-1890	440-2000*
205T1153	2000	1200-4000	730-4000*	550-4000*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	4302	3571	4963
205T0802	2918	2410	3358
205T0803	2574	2116	2964
205T0804	2142	1746	2467
205T0805	1847	1492	2132
205T0806	1583	1266	1836
205T0807	1273	994	1486
205T0808	1042	786	1226
205T0809-LF	825	584	984
205T0810-LF	689	442	830
205T0811-LF	542	459	725
205T0812-LF	425	357	596
205T0813-LF	323	269	485
205T0814-LF	254	211	414
205T0815-LF	293	194	390

7.1.4.2.2. RF Coils: VOLTA-T-ME-M-0.250x6-2.000 & VOLTA-R2-ME-M-0.250x6-2.000

			
Part Number		205C0789	205C0804
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.250	0.250
	mm	6.35	6.35
Number of Periods		6	6
Overall Depth	inch	1.437	1.493
	mm	34.50	37.92
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1156	400	100-500	260-640	160-710
205T1157	800	500-1000	450-1350	300-1600*
205T1155	1500	1000-3000	690-2930	410-3000*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	2221	1726	2666
205T0802	1632	1264	1944
205T0803	1466	1129	1745
205T0804	1244	951	1481
205T0805	1084	819	1293
205T0806-LF	939	700	1120
205T0807-LF	761	549	913
205T0808-LF	624	429	755
205T0809-LF	497	300	607
205T0810-LF	413	347	561
205T0811-LF	323	270	457
205T0812-LF	251	209	376
205T0813-LF	189	156	305
205T0814-LF	146	120	259
205T0815-LF	133	109	246

7.1.4.2.3. RF Coils: VOLTA-T-ME-M-0.300x5-2.000 & VOLTA-R2-ME-M-0.300x5-2.000

			
Part Number		205C0790	205C0805
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.300	0.300
	mm	7.62	7.62
Number of Periods		5	5
Overall Depth	inch	1.412	1.481
	mm	35.86	37.62
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1159	300	100-400	190-500	160-590
205T1160	650	400-800	340-1210	300-1500
205T1158	1250	800-2500	510-2410	410-3000

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	2477	1920	2995
205T0802	1773	1368	2116
205T0803	1581	1216	1885
205T0804	1331	1019	1588
205T0805	1156	877	1379
205T0806-LF	996	748	1191
205T0807-LF	804	588	966
205T0808-LF	659	467	795
205T0809-LF	523	344	637
205T0810-LF	436	250	536
205T0811-LF	342	286	472
205T0812-LF	268	222	387
205T0813-LF	203	168	314
205T0814-LF	161	132	265
205T0815-LF	148	121	252

7.1.4.2.4. RF Coils: VOLTA-T-ME-M-0.400x4-2.000 & VOLTA-R2-ME-M-0.400x4-2.000

			
Part Number		205C0791	205C0806
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.400	0.400
	mm	10.2	10.2
Number of Periods		4	4
Overall Depth	inch	1.487	1.588
	mm	37.77	40.34
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1162	250	100-300	160-420	140-490
205T1163	500	300-600	280-920	230-1000*
205T1161	1000	600-2000	450-2000*	330-2000*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	2058	1501	2593
205T0802	1451	1059	1783
205T0803	1290	939	1581
205T0804	1080	782	1325
205T0805-LF	935	671	1144
205T0806-LF	804	570	985
205T0807-LF	646	449	794
205T0808-LF	527	354	651
205T0809-LF	418	261	518
205T0810-LF	347	193	434
205T0811-LF	272	224	382
205T0812-LF	213	175	310
205T0813-LF	162	132	251
205T0814-LF	129	105	210
205T0815-LF	119	96	199

7.1.4.2.5. RF Coils: VOLTA-T-ME-M-0.520x3-2.000 & VOLTA-R-ME-M-0.520x3-2.000

			
Part Number		205C0792	205C0807
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.520	0.520
	mm	13.2	13.2
Number of Periods		3	3
Overall Depth	inch	1.412	1.550
	mm	35.86	39.37
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1164	150	50-200	100-240	90-250
205T1166	400	200-500	210-760	210-760
205T1167	750	500-1500	330-1500*	320-1500*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1828	1334	2269
205T0802	1294	938	1586
205T0803	1150	829	1409
205T0804-LF	964	689	1182
205T0805-LF	834	591	1023
205T0806-LF	716	502	880
205T0807-LF	575	393	709
205T0808-LF	469	310	582
205T0809-LF	371	229	463
205T0810-LF	308	172	387
205T0811-LF	241	197	341
205T0812-LF	189	154	274
205T0813-LF	144	117	221
205T0814-LF	115	93	185
205T0815-LF	106	86	175

7.1.4.2.6. RF Coils: VOLTA-T-ME-M-0.640x3-2.000 & VOLTA-R2-ME-M-0.640x3-2.000

			
Part Number		205C0793	205C0808
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.640	0.640
	mm	16.3	16.3
Number of Periods		3	3
Overall Depth	inch	1.737	1.912
	mm	44.12	48.56
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1168	150	50-200	80-270	80-280
205T1170	300	200-350	150-600*	150-600*
205T1171	500	350-1200	220-1000*	210-1000*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1363	959	1712
205T0802-LF	996	695	1239
205T0803-LF	891	620	1109
205T0804-LF	754	519	939
205T0805-LF	655	449	816
205T0806-LF	565	380	704
205T0807-LF	455	300	569
205T0808-LF	372	304	505
205T0809-LF	294	175	372
205T0810-LF	244	131	311
205T0811-LF	191	156	275
205T0812-LF	150	121	222
205T0813-LF	114	92	177
205T0814-LF	91	73	148
205T0815-LF	84	68	140

7.1.4.2.7. RF Coils: VOLTA-T-ME-M-0.720x2-2.000 & VOLTA-R2-ME-M-0.720x2-2.000

			
Part Number		205C0794	205C0809
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.720	0.720
	mm	18.3	18.3
Number of Periods		2	2
Overall Depth	inch	1.242	1.412
	mm	31.55	35.86
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1172	125	50-150	70-220	60-250*
205T1173	250	150-300	140-460	100-500*
205T1174	500	300-1000	230-1000*	150-1000*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1877	1315	2349
205T0802	1298	903	1615
205T0803	1149	795	1429
205T0804-LF	957	657	1191
205T0805-LF	823	560	1027
205T0806-LF	704	473	880
205T0807-LF	562	370	705
205T0808-LF	457	291	575
205T0809-LF	359	217	453
205T0810-LF	297	168	379
205T0811-LF	232	187	331
205T0812-LF	182	147	266
205T0813-LF	139	112	211
205T0814-LF	112	89	176
205T0815-LF	104	83	166

7.1.4.2.8. RF Coils: VOLTA-T-ME-M-0.880x2-2.000 & VOLTA-R-ME-M-0.880x2-2.000

			
Part Number		205C0795	205C0800
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.880	0.880
	mm	22.35	22.35
Number of Periods		2	2
Overall Depth	inch	1.532	1.536
	mm	38.91	39.01
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1179	100	30-120	60-180	40-200*
205T1180	140	120-160	80-260	60-280*
205T1182	250	160-500	130-500*	80-500*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1273	799	1652
205T0802-LF	915	570	1185
205T0803-LF	815	506	1055
205T0804-LF	684	419	887
205T0805-LF	592	361	767
205T0806-LF	508	307	657
205T0807-LF	406	239	527
205T0808-LF	330	188	430
205T0809-LF	259	138	339
205T0810-LF	215	103	282
205T0811-LF	167	132	248
205T0812-LF	131	103	198
205T0813-LF	100	79	157
205T0814-LF	80	62	130
205T0815-LF	74	58	123

7.1.4.2.9. RF Coils: VOLTA-T-ME-M-0.960x2-2.000 & VOLTA-R-ME-M-0.960x2-2.000

			
Part Number		205C0796	205C0801
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	0.960	0.960
	mm	24.38	24.38
Number of Periods		2	2
Overall Depth	inch	1.677	1.656
	mm	42.60	42.06
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1183	100	20-115	60-180	40-200*
205T1184	130	115-150	70-240	50-310
205T1185	220	150-500	110-410	70-510

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1242	779	1614
205T0802-LF	894	556	1160
205T0803-LF	797	492	1035
205T0804-LF	670	411	869
205T0805-LF	580	351	752
205T0806-LF	498	298	646
205T0807-LF	398	232	518
205T0808-LF	326	184	425
205T0809-LF	254	132	333
205T0810-LF	210	97	277
205T0811-LF	164	129	244
205T0812-LF	128	100	195
205T0813-LF	97	76	154
205T0814-LF	78	61	128
205T0815-LF	72	56	120

7.1.4.2.10. RF Coils: VOLTA-T-ME-M-1.040x2-2.000 & VOLTA-R-ME-M-1.040x2-2.000

			
Part Number		205C0797	205C0802
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	1.040	1.040
	mm	26.416	26.416
Number of Periods		2	2
Overall Depth	inch	1.798	1.808
	mm	45.67	45.92
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1188	80	20-100	40-150	30-160
205T1186	120	100-140	60-230	40-240*
205T1187	200	140-400	100-400*	60-400*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1098	671	1429
205T0802-LF	792	480	1033
205T0803-LF	707	424	921
205T0804-LF	595	351	775
205T0805-LF	514	299	670
205T0806-LF	441	251	576
205T0807-LF	360	198	471
205T0808-LF	289	150	379
205T0809-LF	224	99	298
205T0810-LF	185	145	277
205T0811-LF	144	113	220
205T0812-LF	112	87	176
205T0813-LF	85	66	139
205T0814-LF	67	52	115
205T0815-LF	62	48	108

7.1.4.2.11. RF Coils: VOLTA-T-ME-M-1.120x2-2.000 & VOLTA-R-ME-M-1.120x2-2.000

			
Part Number		205C0798	205C0803
Connector		RF Coil directly to FPC	RF Coil directly to FPC
Coil Function		Transmitter	Receiver, bi-directional
Compatible Magnet		274A0398	274A0398
Coil Geometry		Meander	Meander
Meander Period	inch	1.120	1.120
	mm	28.45	28.45
Number of Periods		2	2
Overall Depth	inch	1.892	1.896
	mm	48.06	48.16
Aperture	inch	2.000	2.000
	mm	50.8	50.8

* Hourglass shaped RF Coil is designed to conform to tubular products when scanning axially.

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1191	80	20-90	50-150	30-160*
205T1189	110	90-140	60-200*	40-220*
205T1190	180	140-360	90-360*	60-360*

* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	1220	750	1587
205T0802-LF	877	532	1134
205T0803-LF	777	470	1011
205T0804-LF	651	388	847
205T0805-LF	562	331	732
205T0806-LF	482	279	627
205T0807-LF	391	220	512
205T0808-LF	314	167	412
205T0809-LF	244	116	323
205T0810-LF	202	159	300
205T0811-LF	157	123	238
205T0812-LF	122	96	190
205T0813-LF	92	72	150
205T0814-LF	73	57	124
205T0815-LF	68	53	117

7.1.4.3. MRUT Lamb Coils for PML Sensor

Part Number	Compatible Magnet	Function	Coil Period (inch)	Number of Periods	Aperture (inch)
205C0310	274A0244	Transmitter	0.060	12	1.000
205C0106	274A0244	Receiver	0.060	12	1.000
205C0319	274A0244	Transmitter	0.080	8	1.000
205C0115	274A0244	Receiver	0.080	8	1.000
205C0327	274A0244	Transmitter	0.120	5	1.000
205C0121	274A0244	Receiver	0.120	5	1.000
205C0333	274A0244	Transmitter	0.160	5	1.000
205C0127	274A0244	Receiver	0.160	5	1.000
205C0339	274A0244	Transmitter	0.200	4	1.000
205C0133	274A0244	Receiver	0.200	4	1.000
205C0342	274A0244	Transmitter	0.250	4	1.000
205C0136	274A0244	Receiver	0.250	4	1.000
205C0345	274A0244	Transmitter	0.300	3	1.000
205C0139	274A0244	Receiver	0.300	3	1.000
205C0348	274A0244	Transmitter	0.400	2	1.000
205C0142	274A0244	Receiver	0.400	2	1.000
205C0351	274A0244	Transmitter	0.500	2	1.000
205C0145	274A0244	Receiver	0.500	2	1.000

7.1.4.3.1. RF Coils: T-L-M-0.060x12-1.000 & R-L-M-0.060x12-1.000

			
Part Number		205C0310	205C0106
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.060	0.060
	mm	1.524	1.524
Number of Periods		12	12
Overall Depth	inch	0.705	0.705
	mm	17.9	17.9
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0916	1600	600-1800	1198-2143	951-2527
205T0917	2000	1800-2400	1485-2707	1185-3339
205T0918	3500	2400-6000	2347-5206	1772-6706

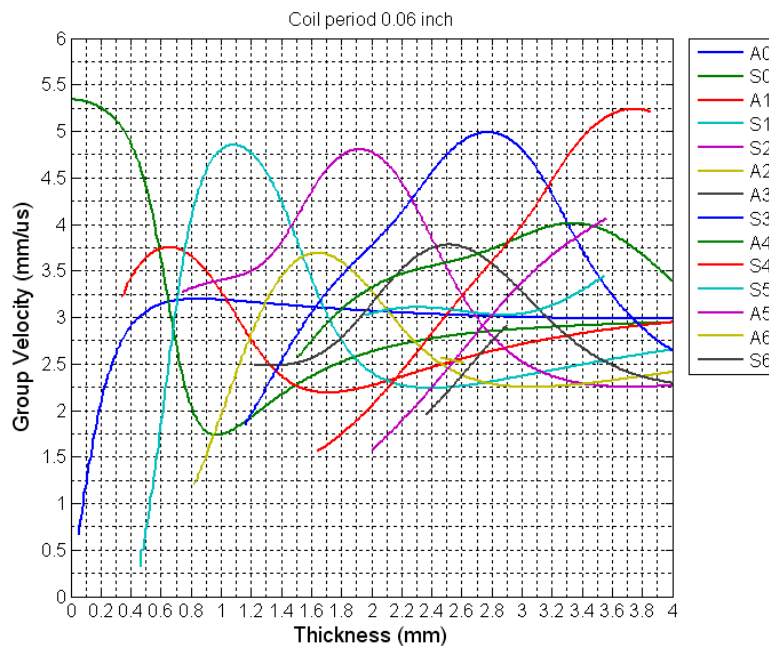
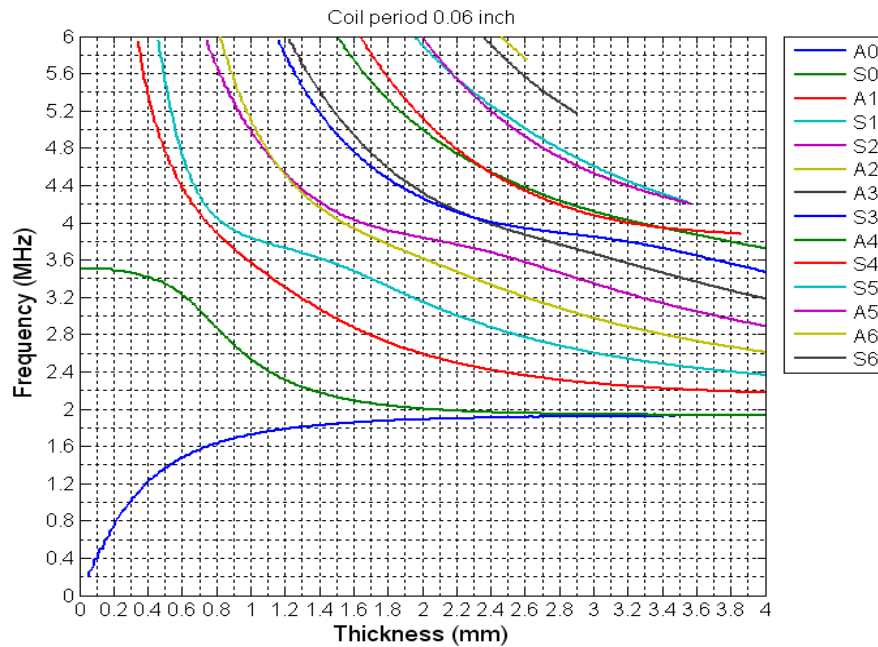
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	6790	6129	7403
205T0802	4425	3910	4861
205T0803	3912	3425	4312
205T0804	3172	2718	3527
205T0805	2754	2313	3083
205T0806	2338	1901	2644
205T0807	1926	1471	2210
205T0808	1549	989	1815
205T0809	1215	881	1805
205T0810-LF	986	674	1572
205T0811-LF	752	466	1326
205T0812-LF	558	283	1129
205T0813-LF	368	21	946
205T0814-LF	118	10	791

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.06" (1.52mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.2. RF Coils: T-L-M-0.080x8-1.000 & R-L-M-0.080x8-1.000

			
Part Number		205C0319	205C0115
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.080	0.080
	mm	2.03	2.03
Number of Periods		8	8
Overall Depth	inch	0.62	0.62
	mm	15.75	15.75
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Tuning Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0922	1000	500-1200	778-1303	698-1472
205T0924	1500	1200-1800	1132-1997	990-2168
205T0926	2600	1800-6000	1864-3607	1494-4237

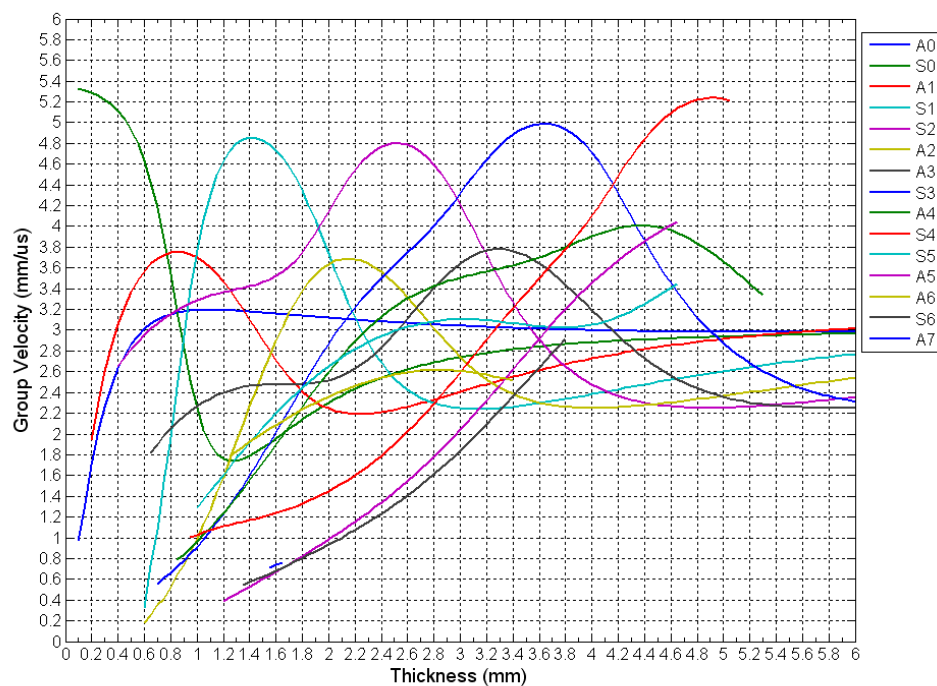
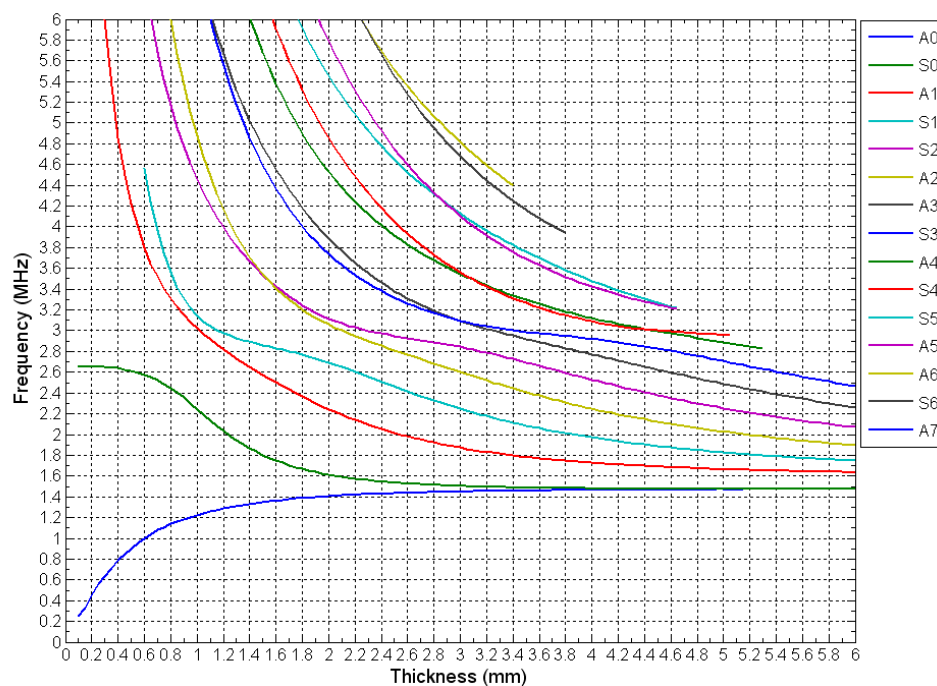
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	7687	7142	8227
205T0802	5015	4615	5379
205T0803	4431	4061	4760
205T0804	3594	3265	3880
205T0805	3121	2815	3383
205T0806	2656	2372	2894
205T0807	2198	1932	2413
205T0808	1784	1533	1980
205T0809	1425	1179	1602
205T0810	1184	933	1350
205T0811-LF	944	672	1099
205T0812-LF	757	556	1087
205T0813-LF	591	411	911
205T0814-LF	463	296	774

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.08" (2mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.3. RF Coils: T-L-M-0.120x5-1.000 & R-L-M-0.120x5-1.000

			
Part Number		205C0327	205C0121
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.120	0.120
	mm	3.05	3.05
Number of Periods		7	5
Overall Depth	inch	0.570	0.570
	mm	14.48	14.48
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0937	500	300-600	346-681	297-773
205T0934	1000	600-1200	680-1412	568-1648
205T0935	2000	1200-2500	1232-3196	896-3856
205T0936	5000	2500-9000	2240-8870	1370-10000*

* The +3dB range is greater than twice of the tuning frequency

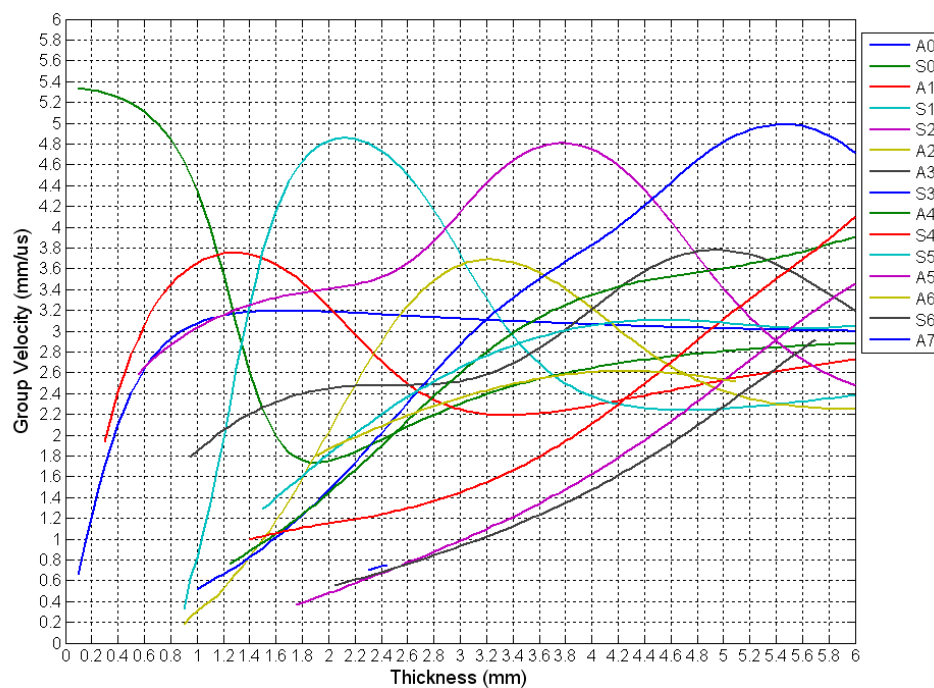
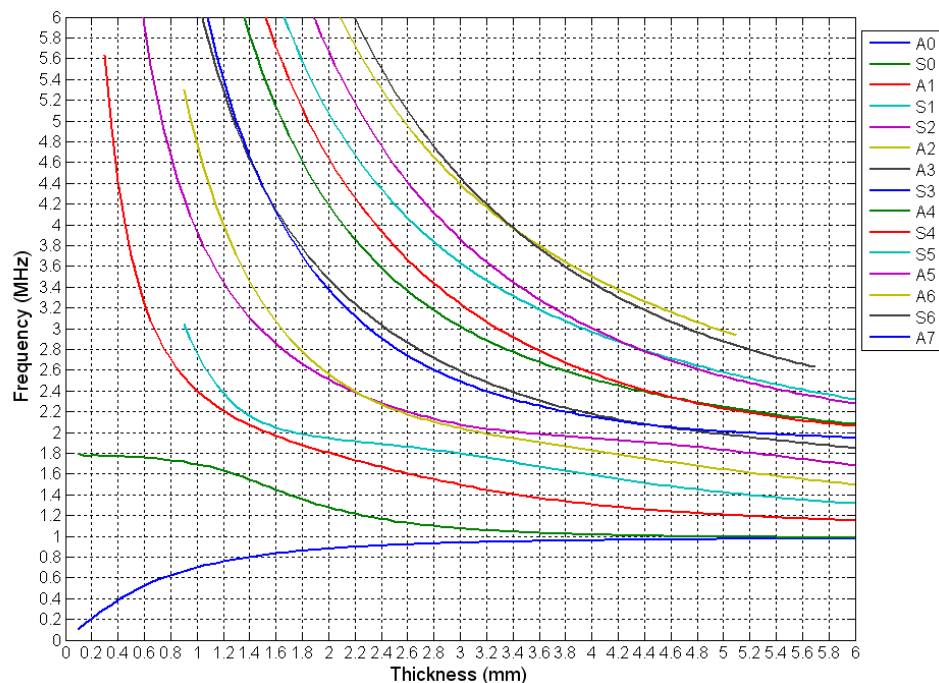
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	5303	4676	5894
205T0802	3617	3169	4015
205T0803	3223	2813	2582
205T0804	2641	2289	2942
205T0805	2305	1986	2572
205T0806	1968	1678	2205
205T0807	1631	1368	1840
205T0808	1324	1080	1506
205T0809	1056	822	1217
205T0810-LF	875	642	1022
205T0811-LF	695	415	830
205T0812-LF	555	392	850
205T0813-LF	430	286	712
205T0814-LF	336	210	611

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.120" (3mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.4. RF Coils: T-L-MF-0.120x5-1.000-7.000R & R-L-MF-0.120x5-1.000-1.000R

			
Part Number		205C0364	205C0160
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		2274A0244	274A0244
Coil Geometry		Meander Focused	Meander Focused
Meander Period	inch	0.120	0.120
	mm	3.04	3.04
Number of Periods		5	5
Overall Depth	inch	0.6	0.6
	mm	15.24	15.24
Aperture	inch	1.000	1.000
	mm	25.4	25.4
Focal Distance	Inch	1	1
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

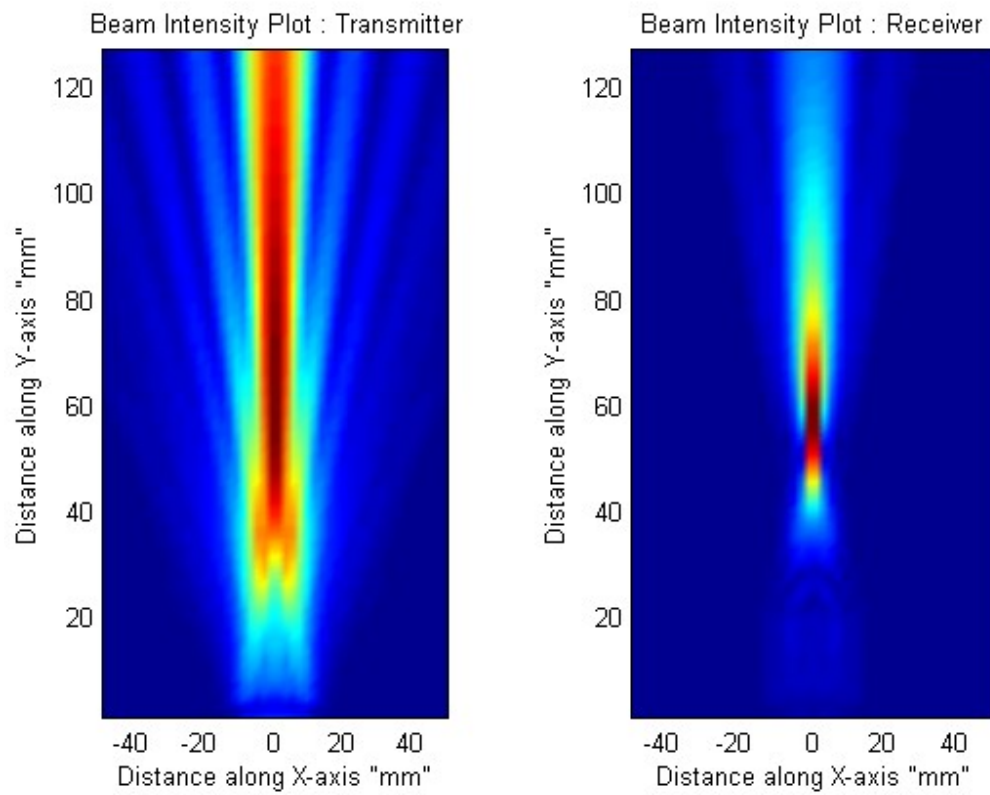
Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0975	500	350 - 650	145 – 208	167 - 246
205T0972	1000	650 - 1350	528 – 540	296 - 404
205T0973	2000	1350 - 2650	912 - 1116	688 - 1180
205T0974	5000	2650 - 7350	2620 - 3930	2660 - 3720

Pulse Echo

Receiver Coil

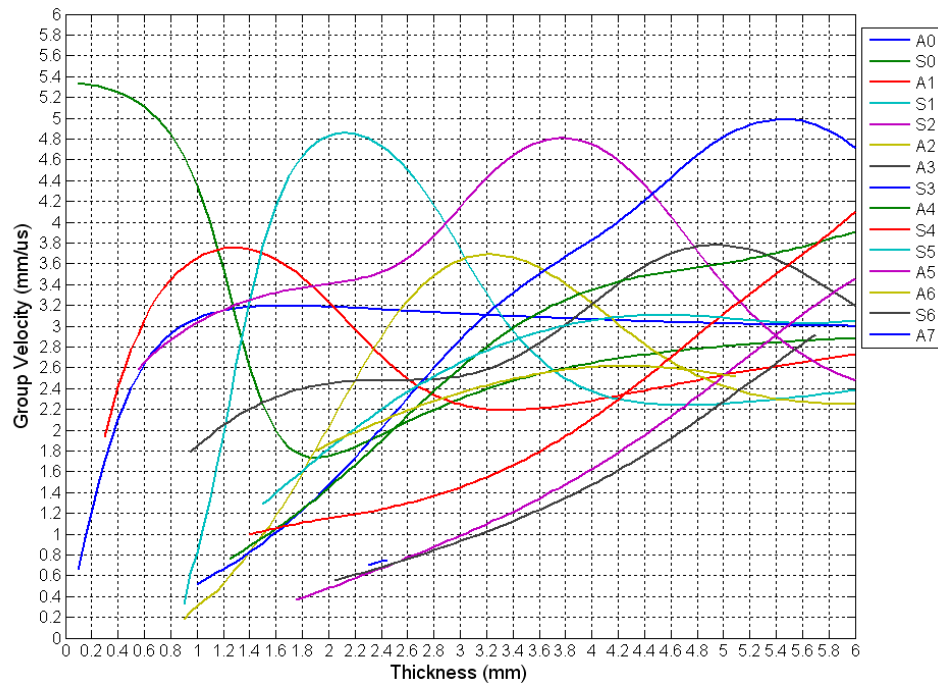
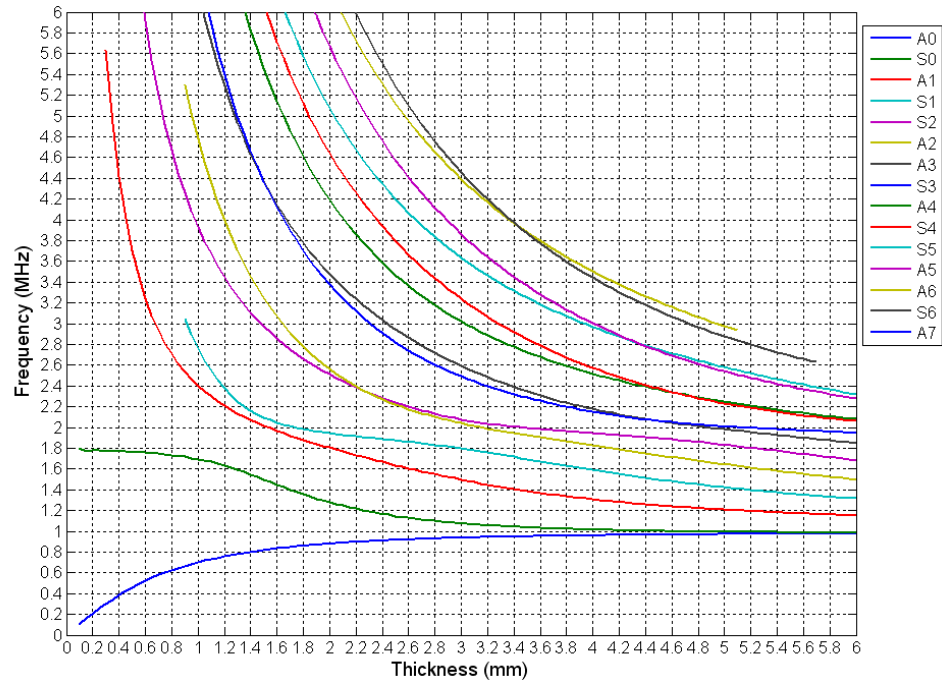
Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	8887	8197	8561
205T0802	5517	5081	5921
205T0803	4838	4447	5196
205T0804	3892	3560	4190
205T0805	3368	3067	3636
205T0806	2859	2587	3095
205T0807	2362	2117	2571
205T0808	1916	1689	2102
205T0809	1531	1320	1696
205T0810	1275	1072	1428
205T0811	1023	812	1165
205T0812-LF	826	618	954
205T0813-LF	656	486	910
205T0814-LF	528	372	776

Illustration of Focusing Effect



Lamb & Rayleigh Dispersion Curves for RF Coils with 0.12" (3.04mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.5. RF Coils: T-L-M-0.160x5-1.000 & R-L-M-0.160x5-1.000

			
Part Number		205C0333	205C0127
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.160	0.160
	mm	4.06	4.06
Number of Periods		5	5
Overall Depth	inch	0.760	0.760
	mm	19.30	19.30
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0943	500	200-600	359-697	287-815
205T0944	750	600-800	522-1066	404-1283
205T0941	1250	800-1500	810-1882	588-2500*
205T0942	3000	1500-5000	1542-4980	883-6000*

* The +3dB range is greater than twice of the tuning frequency

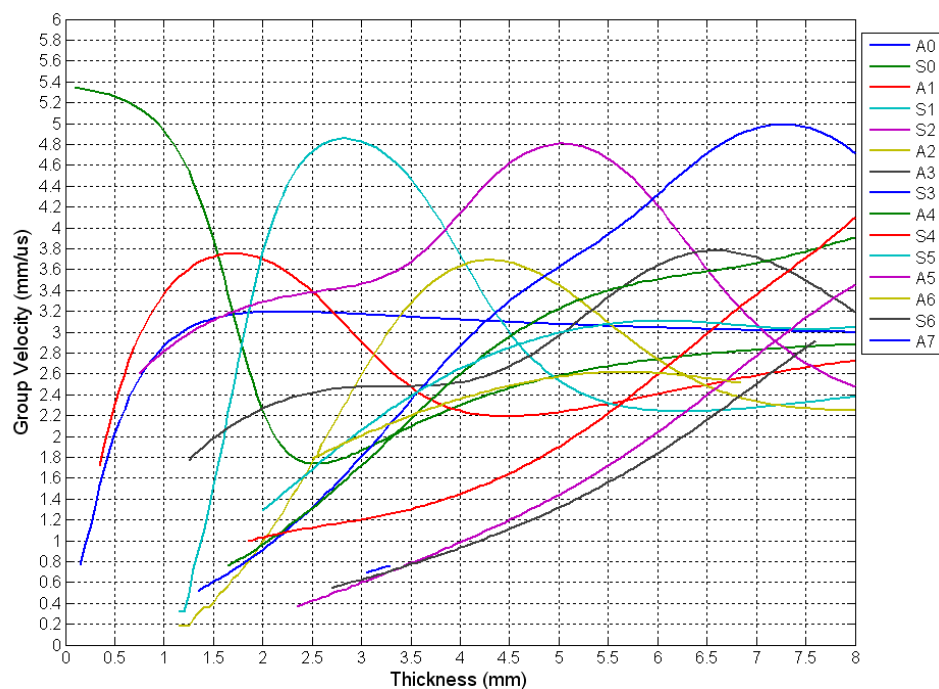
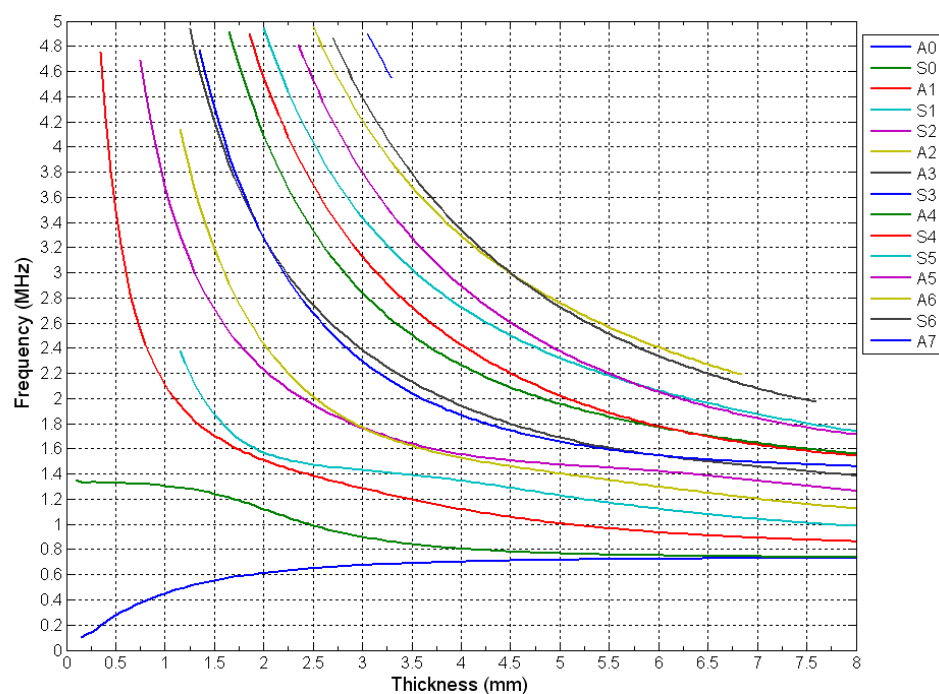
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	4670	4040	5259
205T0802	3182	2741	3575
205T0803	2838	2440	3188
205T0804	2328	1989	2619
205T0805	2032	1725	2289
205T0806	1735	1460	1961
205T0807	1439	1192	1635
205T0808	1168	943	1338
205T0809-LF	932	716	1081
205T0810-LF	772	555	907
205T0811-LF	614	355	736
205T0812-LF	489	346	762
205T0813-LF	373	249	634
205T0814-LF	297	185	544

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.160" (4mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.6. RF Coils: T-L-M-0.200x4-1.000 & R-L-M-0.200x4-1.000

			
Part Number		205C0339	205C0133
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.200	0.200
	mm	5.08	5.08
Number of Periods		4	4
Overall Depth	inch	0.750	0.750
	mm	19.05	19.05
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0950	500	200-600	330-730	251-953
205T0948	1000	600-1200	582-1646	395-2000*
205T0949	2000	1200-4000	916-3664	521-4000*

* The +3dB range is greater than twice of the tuning frequency

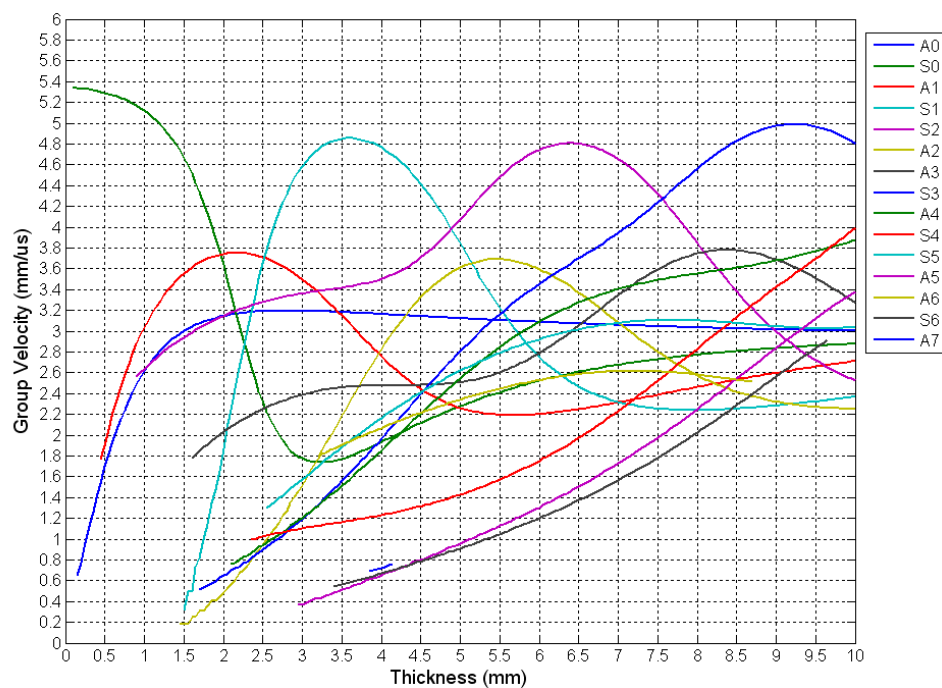
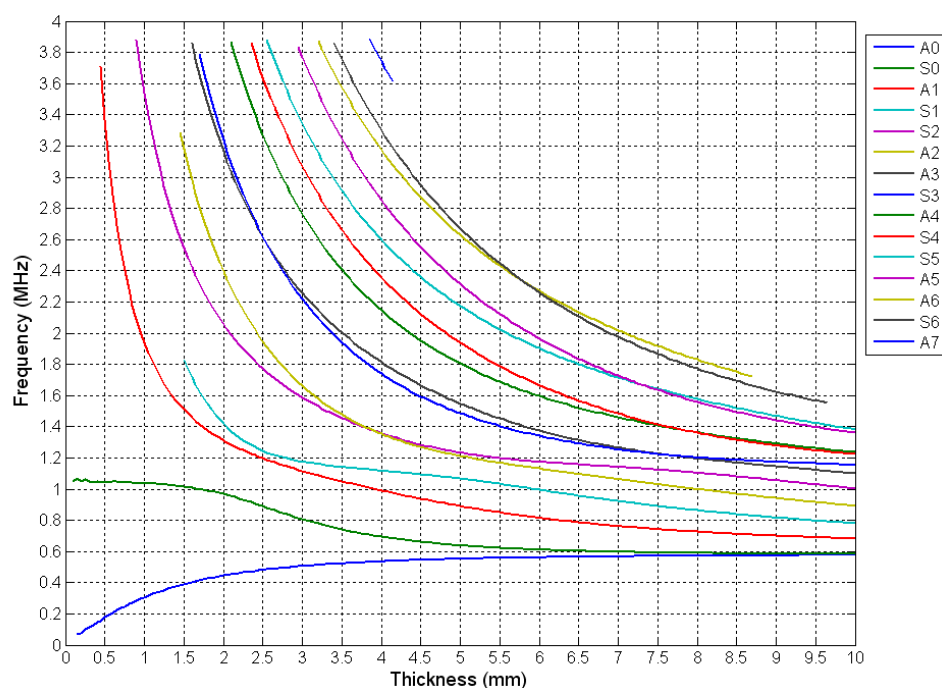
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	5258	4485	5980
205T0802	3458	2940	3918
205T0803	3062	2594	3470
205T0804	2487	2099	2821
205T0805	2161	1811	2453
205T0806	1837	1524	2093
205T0807	1516	1239	1736
205T0808	1227	979	1415
205T0809-LF	976	747	1138
205T0810-LF	808	588	950
205T0811-LF	642	402	770
205T0812-LF	512	360	780
205T0813-LF	394	261	644
205T0814-LF	315	196	554

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.200" (5mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.7. RF Coils: T-L-M-0.250x4-1.000 & R-L-M-0.250x4-1.000

			
Part Number		205C0342	205C0136
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.250	0.250
	mm	6.35	6.35
Number of Periods		4	4
Overall Depth	inch	0.938	0.938
	mm	23.81	23.81
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0952	400	100-500	251-621	222-725
205T0953	800	500-1000	429-1350	366-1600*
205T0951	2000	1000-4000	740-3872	569-4000*

* The +3dB range is greater than twice of the tuning frequency

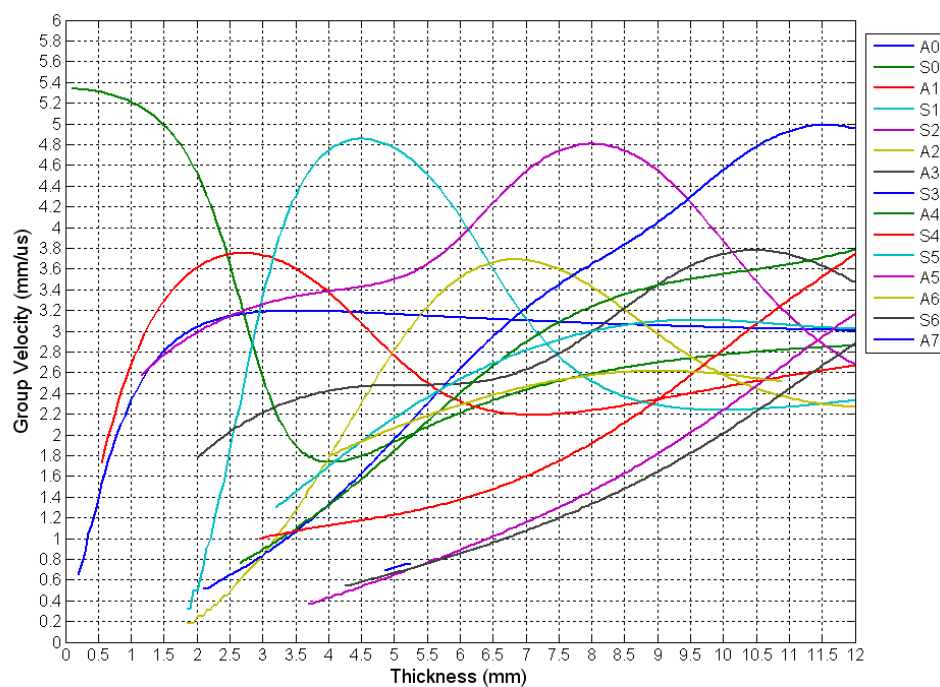
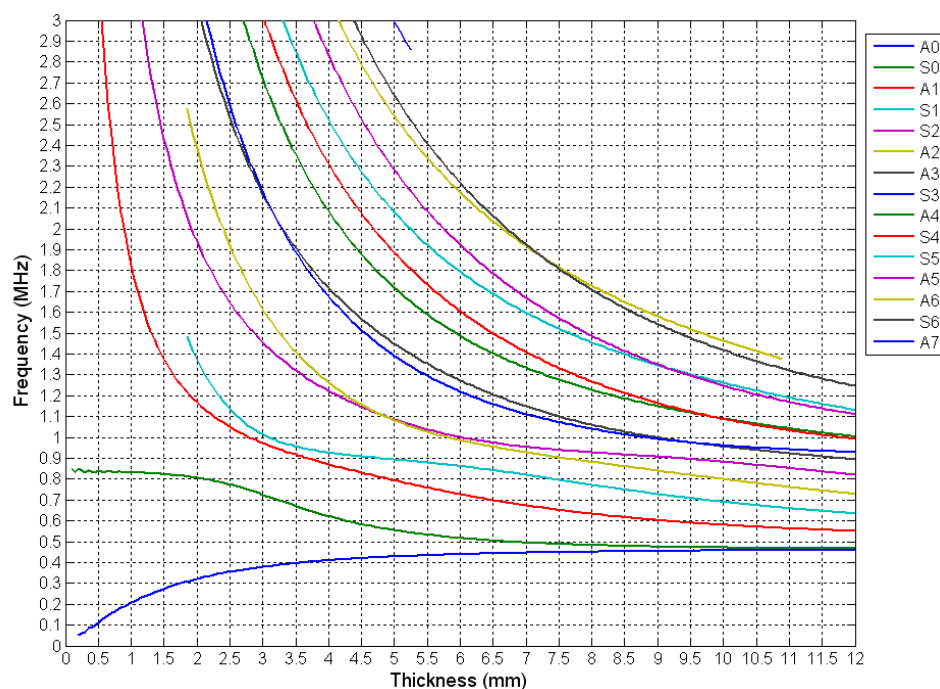
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	3553	2966	4079
205T0802	2453	2042	2805
205T0803	2194	1817	2510
205T0804	1805	1480	2071
205T0805	1576	1281	1814
205T0806	1346	1079	1555
205T0807	1115	872	1296
205T0808-LF	903	677	1060
205T0809-LF	717	498	853
205T0810-LF	591	333	715
205T0811-LF	467	328	732
205T0812-LF	368	247	615
205T0813-LF	277	173	510
205T0814-LF	215	115	438

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.250" (6.35mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.8. RF Coils: T-L-M-0.300x3-1.000 & R-L-M-0.300x3-1.000

			
Part Number		205C0345	205C0139
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.300	0.300
	mm	7.62	7.62
Number of Periods		3	3
Overall Depth	inch	0.825	0.825
	mm	20.96	20.96
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0955	300	100-350	198-460	147-600*
205T0956	700	350-800	393-1165	363-1400*
205T0954	1500	800-2500	658-3000*	373-3000*

* The +3dB range is greater than twice of the tuning frequency

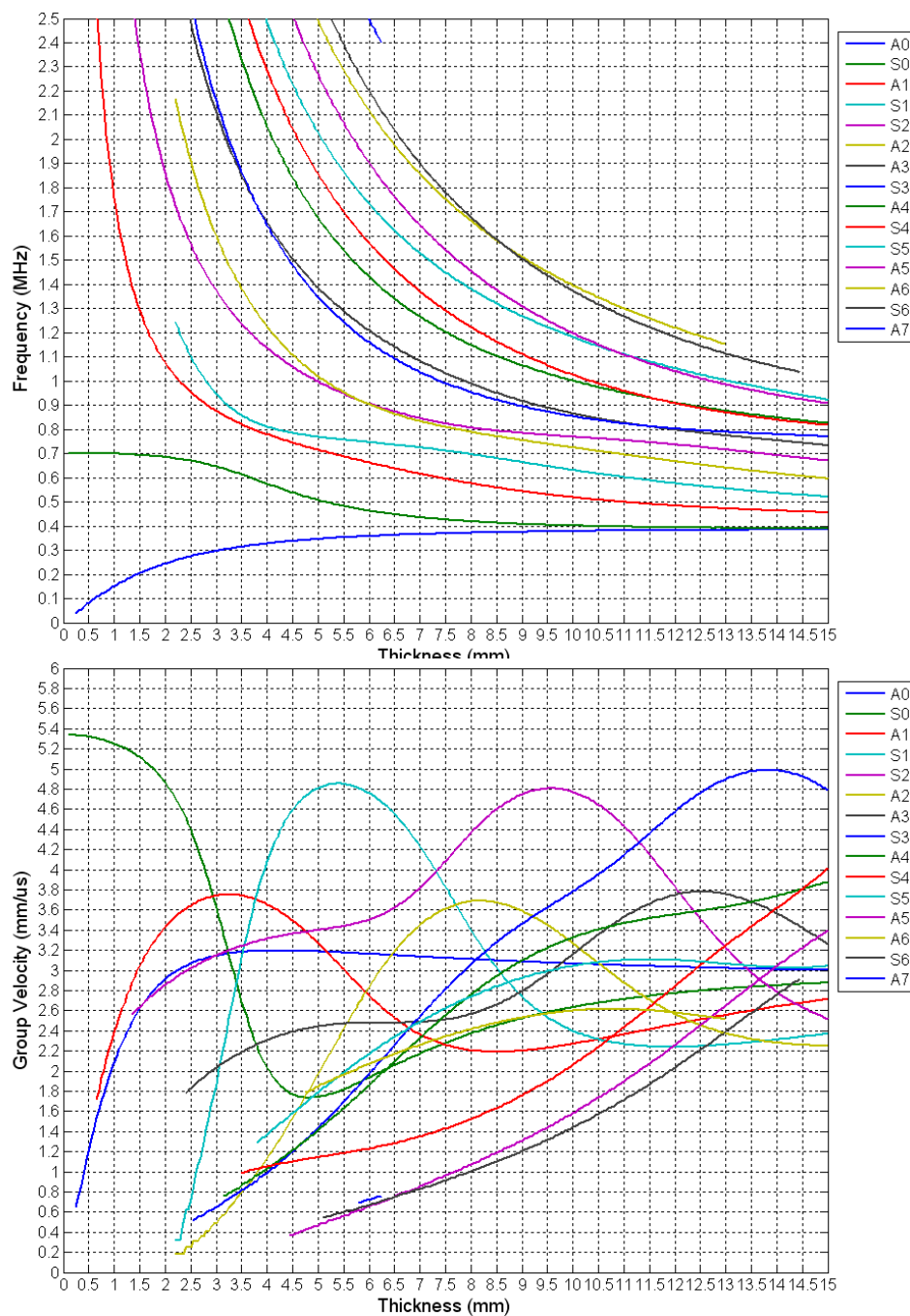
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	4418	3614	5142
205T0802	2903	2357	3371
205T0803	2570	2081	2985
205T0804	2087	1676	2426
205T0805	1811	1443	2110
205T0806	1536	1211	1795
205T0807	1265	978	1486
205T0808	1020	766	1205
205T0809-LF	808	574	965
205T0810-LF	666	434	804
205T0811-LF	527	373	811
205T0812-LF	417	286	675
205T0813-LF	319	207	556
205T0814-LF	252	154	475

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.300" (7.62mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.9. RF Coils: T-L-M-0.400x2-1.000 & R-L-M-0.400x2-1.000

			
Part Number		205C0348	205C0142
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.400	0.400
	mm	10.2	10.2
Number of Periods		2	2
Overall Depth	inch	0.700	0.700
	mm	17.78	17.78
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0958	200	100-250	120-312	114-400*
205T0959	500	250-550	275-855	231-1000*
205T0957	1000	550-2000	431-1647	343-2000*

* The +3dB range is greater than twice of the tuning frequency

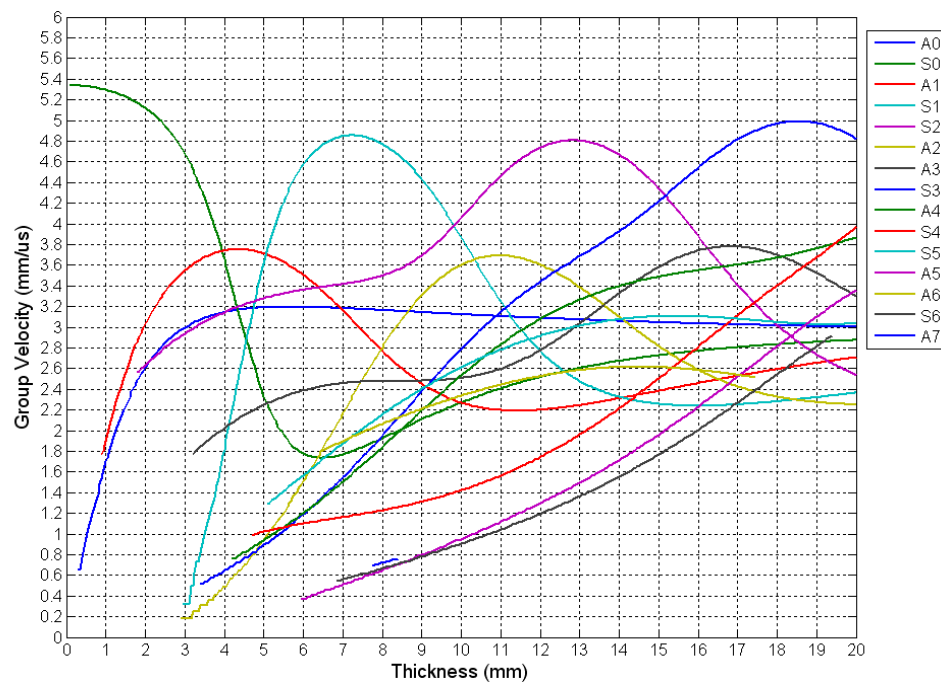
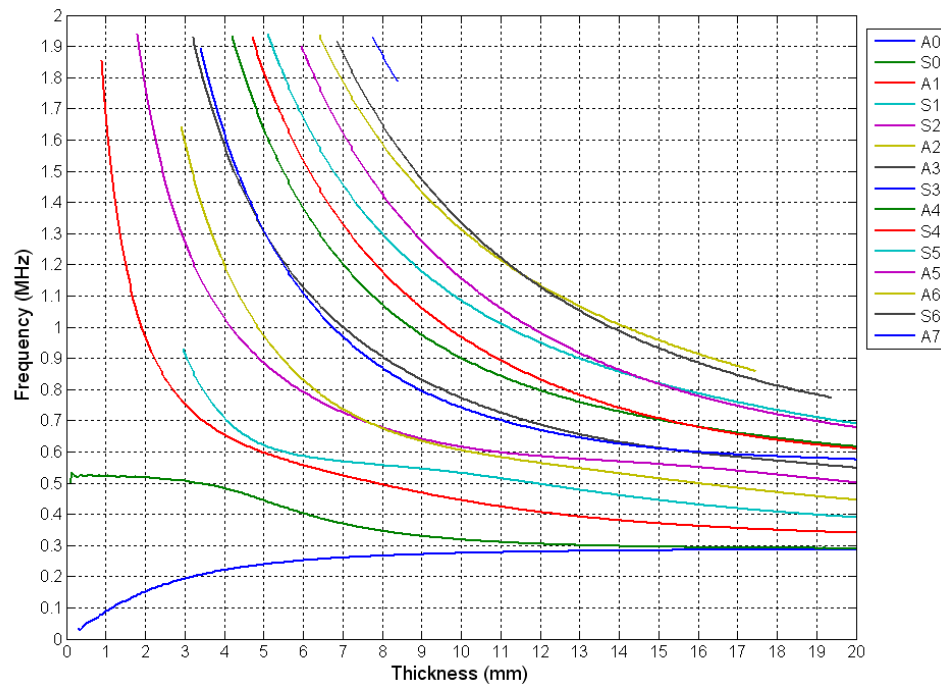
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	3328	2463	4082
205T0802	2212	1637	2698
205T0803	1961	1452	2389
205T0804	1592	1176	1938
205T0805	1380	1016	1680
205T0806	1169	856	1423
205T0807-LF	961	695	1174
205T0808-LF	772	546	946
205T0809-LF	610	411	751
205T0810-LF	503	323	624
205T0811-LF	399	225	497
205T0812-LF	316	210	513
205T0813-LF	243	155	419
205T0814-LF	196	117	359

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.400" (10.2mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.1.4.3.10. RF Coils: T-L-M-0.500x2-1.000 & R-L-M-0.500x2-1.000

			
Part Number		205C0351	205C0145
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.500	0.500
	mm	12.7	12.7
Number of Periods		2	2
Overall Depth	inch	0.875	0.875
	mm	22.2	22.2
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0961	200	20-250	136-296	72-400*
205T0962	400	250-500	257-604	130-800*
205T0960	1000	500-1500	541-1607	201-2000*

* The +3dB range is greater than twice of the tuning frequency

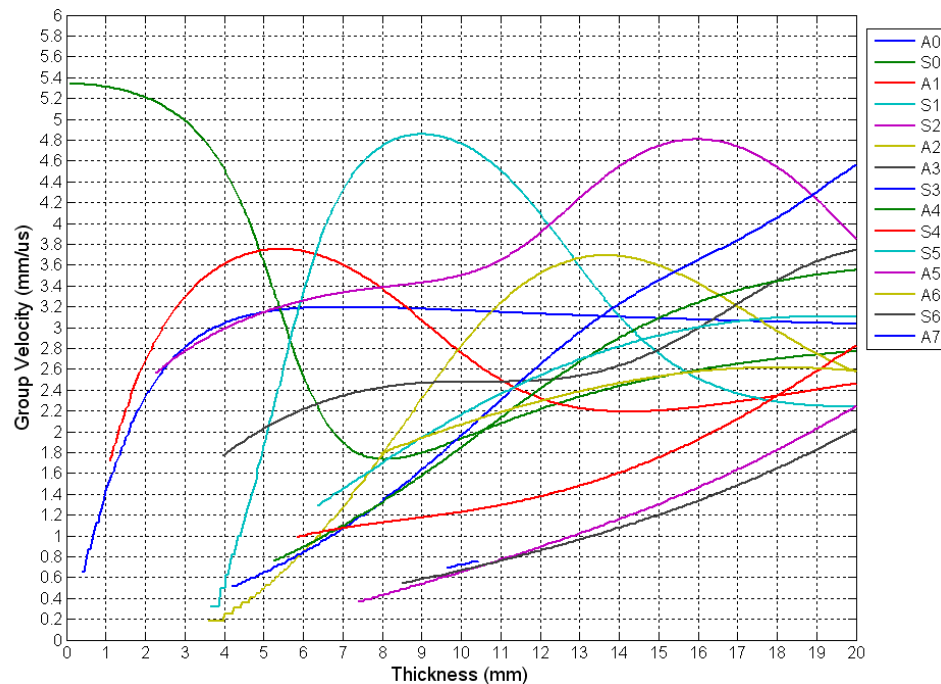
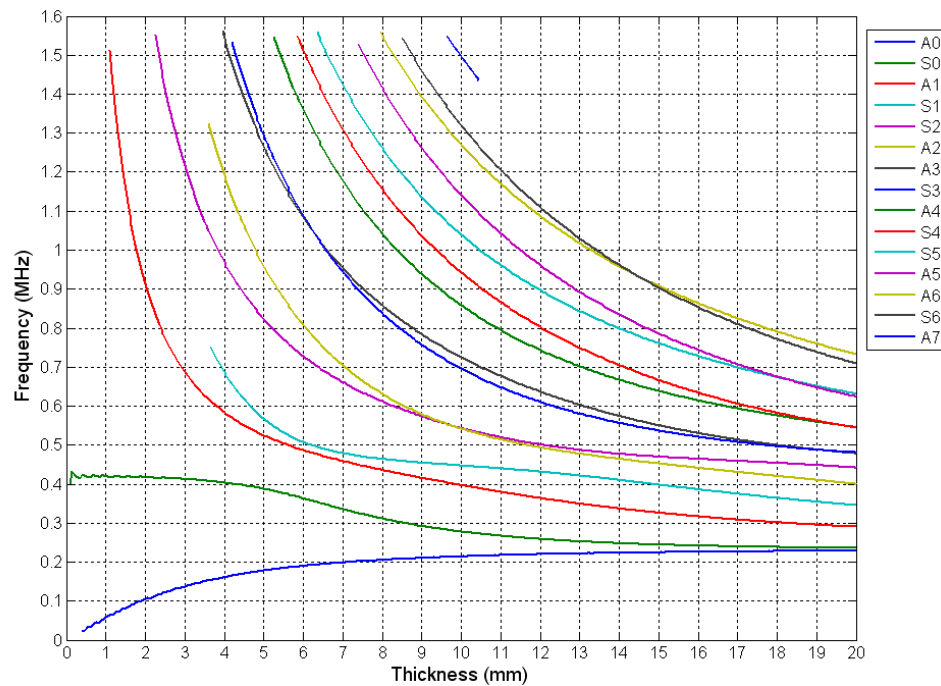
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	2540	1827	3148
205T0802	1744	1253	2154
205T0803	1554	1119	1917
205T0804	1272	914	1567
205T0805	1106	794	1362
205T0806-LF	940	672	1157
205T0807-LF	773	550	952
205T0808-LF	622	435	769
205T0809-LF	492	334	610
205T0810-LF	406	264	504
205T0811-LF	320	216	512
205T0812-LF	255	173	429
205T0813-LF	197	123	342
205T0814-LF	159	100	295

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.500" (12.7mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.2. LRUT (Long Range Ultrasonics)

With the aid of a magnetostrictive material attached to the surface of a pipe, a low-profile collar can cover 100 meters from the inspection location in both directions of the sensor.

Wave cancelation allows for unidirectional propagation.

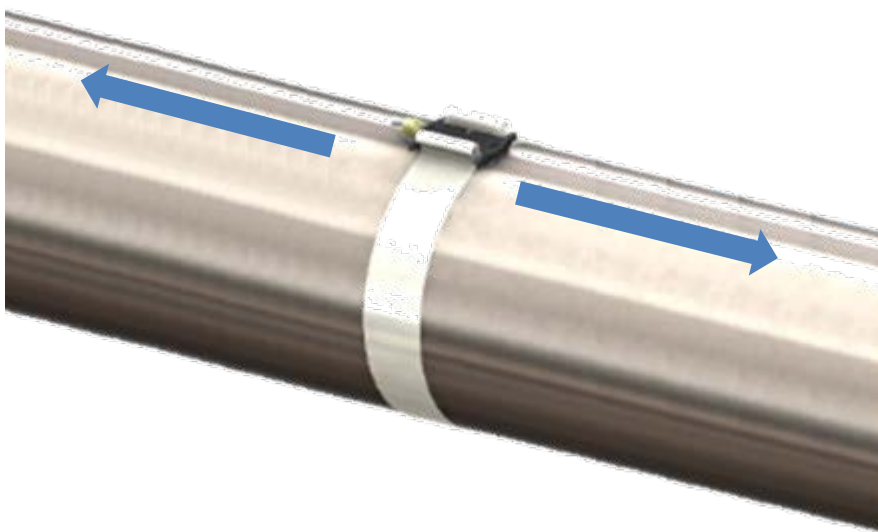
Dead-zone does not allow detection of defects close to the sensor

Used for:

- Corrosion fast-screening
- Inspection under insulation and welded supports
- Inspection of through-walls
- Inspection of buried segments



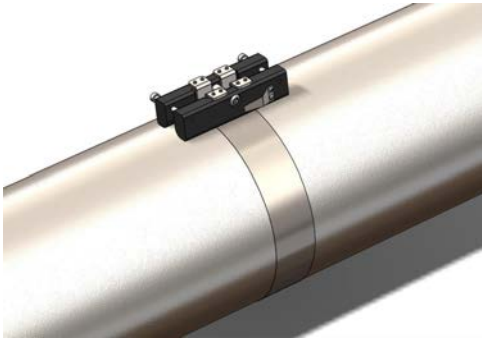
7.2.1. LRUT LITE (Unfocused) Sensor & Accessories

LRUT Sensor		
		
Minimum OD Inspected	4" (102 mm)	
Temperature Rating: 200C° (400F°)		
Part Numbers (SH Wave)		
SH Wave	Ribbons for Pipe Sizes:	
	232A1019-4	40 CONDUCTOR 14.14" RIBBON CABLE FOR NPS-4
	232A1019-8	40 CONDUCTOR 27.10" RIBBON CABLE FOR NPS-8
	232A1019-12	40 CONDUCTOR 40.06" RIBBON CABLE FOR NPS-12
	232A1019-16	40 CONDUCTOR 50.27" RIBBON CABLE FOR NPS-16
	232A1019-20	40 CONDUCTOR 62.84" RIBBON CABLE FOR NPS-20
	232A1019-24	40 CONDUCTOR 75.40" RIBBON CABLE FOR NPS-24
	232A1019-28	40 CONDUCTOR 88.0" RIBBON CABLE FOR NPS-28
	232A1019-36	40 CONDUCTOR 113.10" RIBBON CABLE FOR NPS-36
	232A1019-48	40 CONDUCTOR 150.80" RIBBON CABLE FOR NPS-48
		Accessories: 800A0358 (Consumables) Frequency Adapters:: 205A0665 (32kHz Adapter) 205A0666 (64kHz Adapter) 205A0667 (128kHz Adapter) 232V1133 (clip for loose cable)

7.2.2. LRUT Tensioner Kit

The tensioner kit is designed to be used without the need for coupling the magnetostrictive material to a pipe with double sided tape or epoxy thus simplifying and expanding inspection capabilities.

MS Strip with Welded Clips

Part Number	Nominal Pipe Size (NPS)	Tensioner Clamp Assembly
027A0100-4	4	
027A0100-5	5	
027A0100-6	6	
027A0100-8	8	
027A0100-10	10	
027A0100-12	12	
027A0100-14	14	
027A0100-16	16	
027A0100-18	18	
027A0100-20	20	
027A0100-22	22	
027A0100-24	24	
027A0100-26	26	
027A0100-28	28	
027A0100-48	48	

7.3. SH and Surface / Lamb / SV Wave Permanent Magnet Sensors

SH sensors are mainly used for inspection of austenitic materials and generation of SH guided waves. Steering is achieved by changing the frequency of the instrument. Only used in pitch-catch configuration with two sensors.

Surface / Lamb / SV type sensors are used for surface wave measurements (up to 850 °C) and lamb wave measurements. It can also be used for generation of Shear Vertical waves.

Part Number	Wave Mode	Magnet Type	Maximum Temp.	Connector	Dim.	Applications
274A0166 (T) / 274A0167 (R) (Small SH)	SH Pitch Catch	Periodic Magnet	80°C	2 Pin Lemo 0B	0.63" x 2.00" x 1.25" 15.9 x 50.8 x 31.8mm	SH Wave Generation from 0°- 90° Guided Waves: Thin Plates (<6mm)
274A0201 (Medium SH Tandem)	SH Pitch Catch	Periodic Magnet	80°C	2 Pin Lemo 0B	1.57" x 1.84" x 2.95" 39.9 x 46.7 x 74.9mm	Austenitic Weld Inspection (<25mm)
274A0168 (Large SH)	SH Pitch Catch	Periodic Magnet	80°C	2 Pin Lemo 0B	1.25" x 2.25" x 2.25" 31.8 x 57.2 x 57.2mm	SH Wave Generation from 0°- 90° Guided Waves: Thin Plates (<6mm)
274A0222 (T) / 274A0223 (R) (XLarge SH)	SH Pitch Catch	Periodic Magnet (.250")	80°C	2 Pin Lemo 0B	1.63" x 2.75" x 1.75" 41.4 x 69.8 x 44.4mm	Guided Waves: Thick Plates (>6mm)
274A0169 (T) / 274A0170 (R) (XLarge SH)	SH Pitch Catch	Periodic Magnet (.500")	80°C	2 Pin Lemo 0B	1.63" x 2.75" x 1.75" 41.3 x 69.8 x 44.5mm	Guided Waves: Thick Plates (>6mm)
274A0220 (T) / 274A0221 (R) (SV / Surface / Lamb Waves)	SV Pitch Catch	Permanent Magnet	80°C	2 Pin Lemo 0B	0.63" x 2.00" x 1.25" 15.9 x 50.8 x 31.8mm	Rayleigh Wave Generation Surface Inspection Plate Inspection
274A0141 (Ultra-High Temperature Surface/Lamb)	Rayleigh Lamb Pulse/Echo Pitch/Catch	Permanent Magnet	850°C Air Cooled	2 Pin Lemo 0B	3.25" x 3.00" x 2.75" 82.6 x 76.2 x 69.8mm	Surface Wave Inspections at Very High Temperatures

7.3.1. One-Channel SH Wave with Permanent Magnets (Angle Steering with Frequency) - Small

Guided waves (SH₀) can be excited using 500 kHz. Check dispersion curves for 0.25" wavelength.

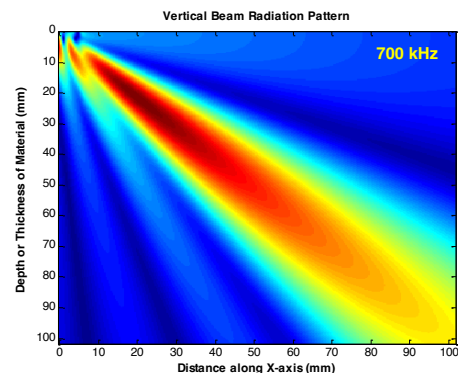
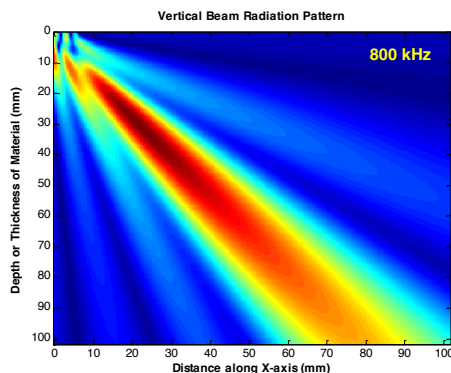
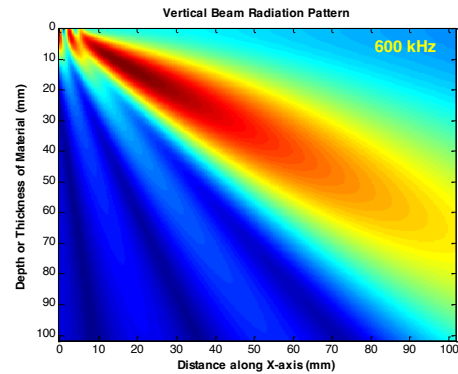
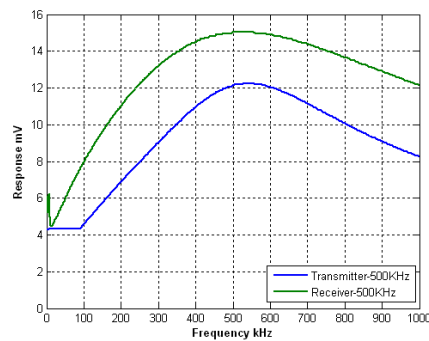
Part Number		274A0166 (T) and 274A0167 (R)
Sensor Type		SH Lorentz Periodic Magnets
Temperature Ranges		80°C
Connector		2 Pin Lemo 0B
Coil Geometry		Racetrack 280A0269(T) – 280A0270(R)
Wavelength		0.25"
Frequency		500 to 800 kHz
Coil Width	inch	1.00"
	mm	25.4mm
Coil Length	inch	1.00"
	mm	25.4mm
Sensor	inch	0.63 x 2.00 x 1.25
	mm	15.9 x 50.8 x 31.8
Anchor Points		4 ea. #6-32, 0.63" x 1.25" (15.9mm x 1.8mm) Pattern



Tuning Module Data Sheet

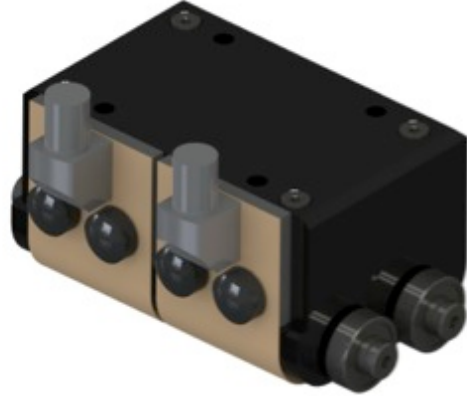
Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
SP-R1-0.250-500kHz	500	500 – 800	288 – 797	217 – 1000

Frequency Spectra & 3dB Beam Profiles



7.3.2. One-Channel SH Wave Permanent Magnets (Angle Steering with Freq.) – Medium Tandem

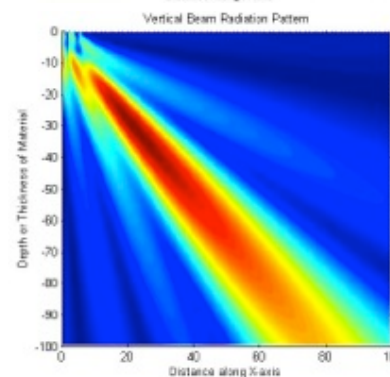
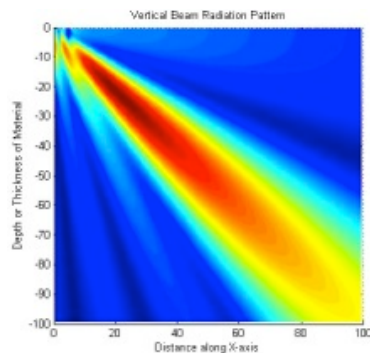
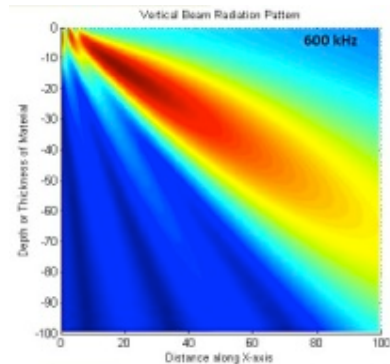
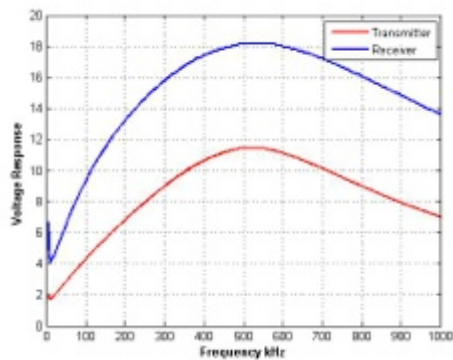
Part Number		274A0201
Sensor Type		SH Tandem Magnet Sensor
Sensor Arrangement		Pitch-Catch in Tandem (one sensor)
Temperature Ranges		80°C
Coil Geometry		Racetrack 280A0242(T) Rev A 280A0243(R) Rev A
Wavelength		0.250"
Frequency		500 – 800 kHz
Connector		2 ea. Cables w/ 2-pin Lemo 0B
Coil Width	inch	1.18"
	mm	30mm
Coil Length	inch	0.94"
	mm	24mm
Sensor Dimensions	inch	1.57 x 1.84 x 2.95
	mm	39.9 x 46.7 x 74.9
Anchor Points		4 ea. #M5 (40mm x 35mm apart)
Wheels		Optimized for 100mm Diameter Tubes (remove for larger diameters to minimize lift-off)



Tuning Module Data Sheet

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
SP-R2-0.250-500kHz	500	500 - 800	356-713	330-742

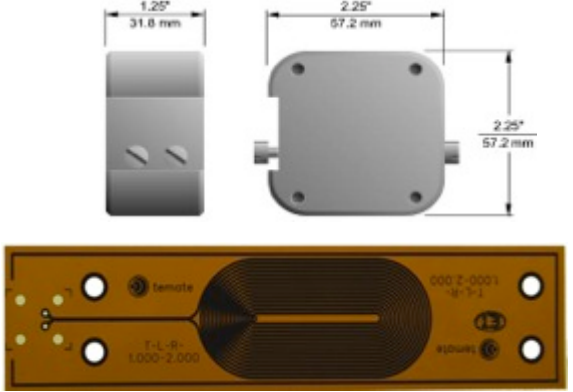
Frequency Spectra & 3dB Beam Profiles



7.3.3. One-Channel SH Wave with Permanent Magnets (Angle Steering with Frequency) - Large

Guided waves (SH₀) can be excited using 500 kHz. Check dispersion curves for 0.25" wavelength.

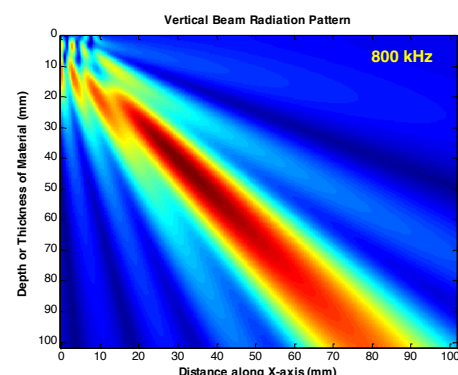
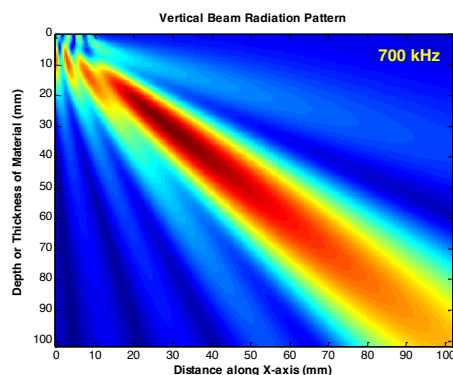
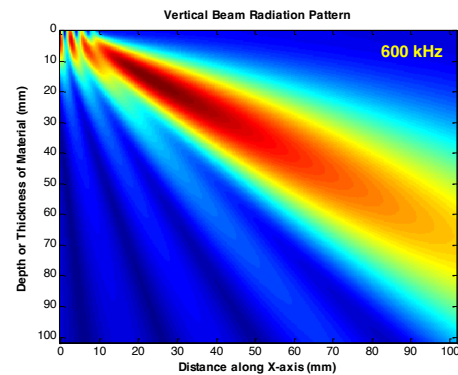
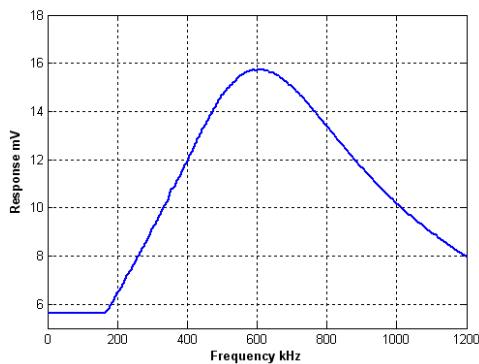
Part Number		274A0168
Sensor Type		SH Lorentz Periodic Magnets
Temperature Ranges		80°C
Connector		2 Pin Lemo 0B
Coil Geometry		Racetrack PC-LA-R-1.000-2.000
Wavelength		0.250"
Frequency		500 - 800 kHz
Coil Width	inch	1.000"
	mm	25.4mm
Coil Length	inch	2.000"
	mm	50mm
Sensor	inch	1.25"x2.25"x2.25"
	mm	31.8x57.2x57.2mm
Anchor Points		4 ea. #10-32, 1.75" x 1.50" (44.5mm x 38.1mm) Pattern



Tuning Module Data Sheet

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
LP-R-0.250-600kHz	600	500-800	372-945	383-961

Frequency Spectra & 3dB Beam Profiles



7.3.4. One-Channel SH Wave with Permanent Magnets – XLarge (LF)

Guided waves (SH₀) can be excited using 250 kHz. Check dispersion curves for 0.500" wavelength.

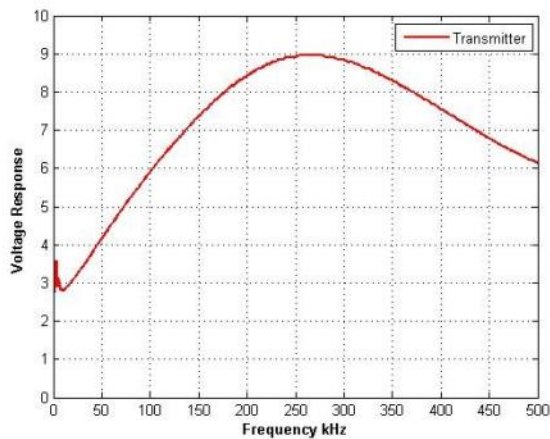
Part Number		274A0169 (T) / 274A0170 (R)
Sensor Type		SH Lorentz Periodic Magnets
Temperature Ranges		80°C
Connector		2 Pin Lemo 0B
Coil Geometry		Racetrack - T-XLP-R-1.500-1.250 Rev A & R-XLP-R-1.500-1.250 Rev A
Wavelength		0.500"
Frequency		250kHz to 500 kHz
Coil Width	inch	1.00"
	mm	25.4mm
Coil Length	inch	1.00"
	mm	25.4mm
Sensor	inch	1.63" x 2.75" x 1.75"
	mm	41.3 x 69.8 x 44.5mm
Anchor Points		2 ea. #M5 (50.8mm apart)



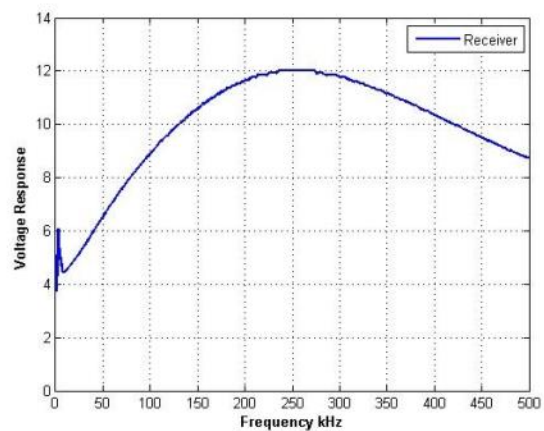
Tuning Module Data Sheet

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1242	250	250 - 500	112 – 492	88 - 514

Frequency Spectra



Transmitter



Receiver

7.3.5. One-Channel SH Wave with Permanent Magnets – XLarge (HF)

Guided waves (SH₀) can be excited using 500 kHz. Check dispersion curves for 0.250" wavelength.

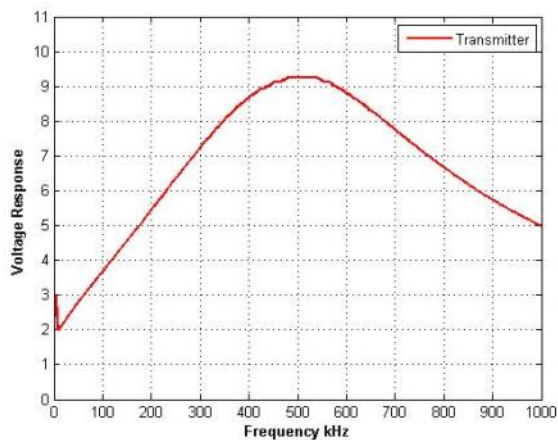
Part Number		274A0222 (T) / 274A0223 (R)
Sensor Type		SH Lorentz Periodic Magnets
Temperature Ranges		80°C
Connector		2 Pin Lemo 0B
Coil Geometry		Racetrack T-XLP-R-1.500-1.000 Rev A & R-XLP-R-1.500-1.000 Rev A
Wavelength		0.250"
Frequency		500 kHz – 800 kHz
Coil Width	inch	1.00"
	mm	25.4mm
Coil Length	inch	1.00"
	mm	25.4mm
Sensor	inch	1.63" x 2.75" x 1.75"
	mm	41.3 x 69.8 x 44.5mm
Anchor Points		2 ea. #M5 (50.8mm apart)



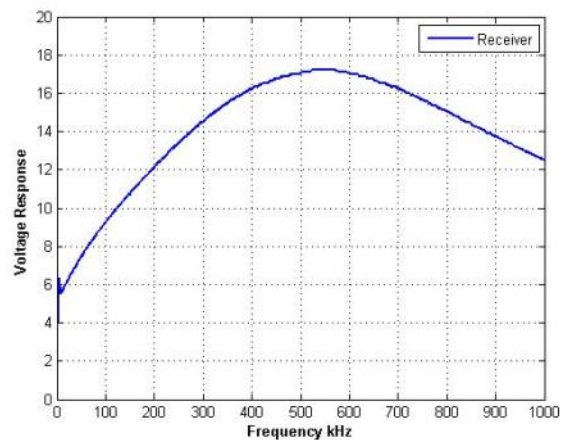

Tuning Module Data Sheet

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T1241	500	500 – 700	240 – 312	306 - 545

Frequency Spectra



Transmitter



Receiver

7.3.6. One-Channel Surface/Lamb/SV Wave – Small

Generates Rayleigh Waves using 720 kHz.

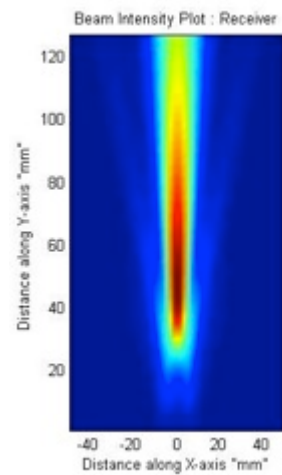
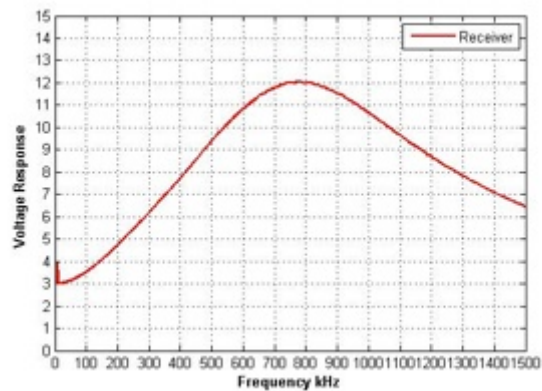
Part Number		274A0220 (T) and 274A0221 (R)
Sensor Type		Rayleigh / Lamb / SV
Temperature Ranges		80°C
Connector		2 Pin Lemo 0B
Coil Geometry		Meander – 280A271(T) & 280A0272(R)
Wavelength		0.16"
Frequency		720 kHz
Coil Width	inch	0.86"
	mm	22mm
Coil Length	inch	0.78"
	mm	20mm
Sensor	inch	1.25" L x 2.00" W x 0.63" H
	mm	31.8 x 50.8 x 15.9mm
Anchor Points		4 ea. #6-32, 0.63" x 1.25" (15.9mm x 1.8mm) Pattern



Tuning Module Data Sheet

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)
205T0944	750	700 - 800

Frequency Spectra & 3dB Beam Profile



7.3.7. Ultra-High Temperature Sensor Surface/Lamb/SV Wave

Part Number		274A0141
Sensor Type		Rayleigh/Lamb Lorentz
Temperature Range		850°C continuous with air 1mm (lift-off)
Connector		2 Pin Lemo 0B
Coil Function		Transmitter/Receiver, bi-directional
Coil Geometry		Meander
Meander Period	inch	0.250
	mm	6.35
Number of Periods		4
Overall Depth	inch	0.938
	mm	23.81
Aperture	inch	1.000
	mm	25.4
Sensor	inch	3.25" H x 3.00" W x 2.75" D
	mm	82.6 x 76.2 x 69.8mm
Air Coupling		1/4" NPT M14 x 1.5 male adapter provided
Anchor Points		4 ea. M8 threaded holes 2"x2" (50.8mm x 50.8mm) Pattern



Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0952	400	100-500	251-621	222-725
205T0953	800	500-1000	429-1350	366-1600*
205T0951	2000	1000-4000	740-3872	569-4000*

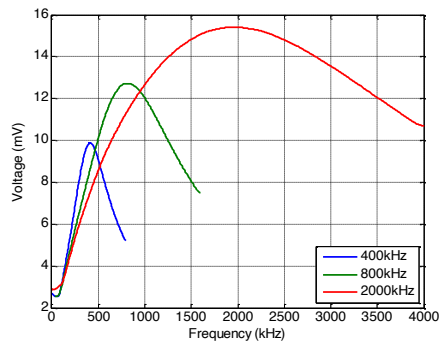
* The +3dB range is greater than twice of the tuning frequency

Pulse Echo

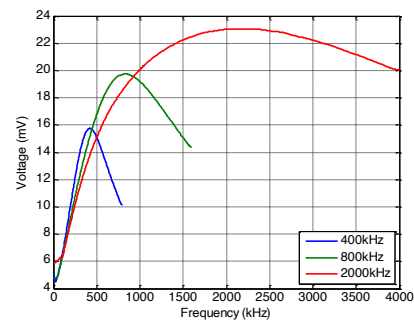
Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	
		Min	Max
205T0805	3220	2000	4000
205T0808	1690	1000	2000

Frequency Spectra (see coil R-L-M-0.250x4-1.000 for Dispersion Curves)

Transmitter



Receiver



7.4. RF Coils for Angled Beam & Guided Waves (Lamb and Rayleigh) with Permanent Magnet

Part Number	Compatible Magnet	Function	Coil Period (inch)	Number of Periods	Aperture (inch)
205C1426-048	274A0244	PE	0.048	12	0.875
205C1426-060	274A0244	PE	0.060	10	0.875
205C1426-080	274A0244	PE	0.080	8	0.875
205C1426-120	274A0244	PE	0.120	6	0.875
205C0323	274A0244	Transmitter	0.100	7	1.000
205C0118	274A0244	Receiver	0.100	7	1.000
205C0327	274A0244	Transmitter	0.120	5	1.000
205C0121	274A0244	Receiver	0.120	5	1.000
205C0330	274A0244	Transmitter	0.140	6	1.000
205C0124	274A0244	Receiver	0.140	6	1.000
205C0333	274A0244	Transmitter	0.160	5	1.000
205C0127	274A0244	Receiver	0.160	5	1.000
205C0336	274A0244	Transmitter	0.180	5	1.000
205C0130	274A0244	Receiver	0.180	5	1.000
205C0339	274A0244	Transmitter	0.200	4	1.000
205C0133	274A0244	Receiver	0.200	4	1.000

7.4.1. RF Coil: 205C1426-048 Thin-Weld Inspection (2-Channel - Point & Planar)

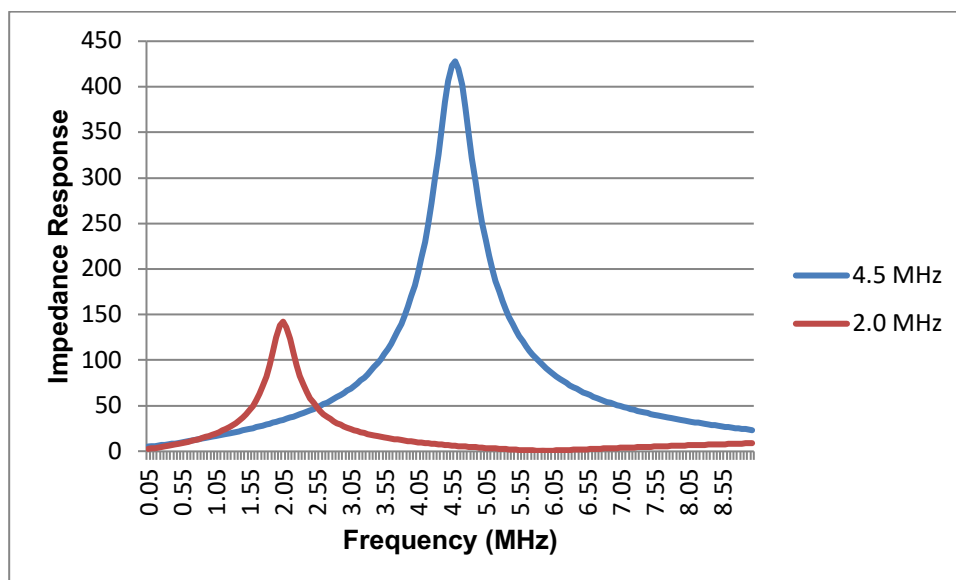
		
Geometry		Planar – Straight Coil, Point – Angled Coil
Connector		NA
Coil Function		Transmitter/Receiver
Compatible Magnet		274A0244
Coil Geometry		Meander Focused
Meander Period	inch	0.048
	mm	1.22
Number of Periods		10
Overall Depth	inch	0.456
	mm	11.6
Aperture	inch	0.875
	mm	22.2
Focal Distance	Inch	2.500
	mm	63.5

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pulse Echo

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range
			Transmitter/Receiver (kHz)
205T0808	2000	1850-2200	1829-2202
205T0804	4500	4250-4850	4271-4867

Frequency Spectra



7.4.2. RF Coil: 205C1426-060 Thin-Weld Inspection (2-Channel - Point & Planar)

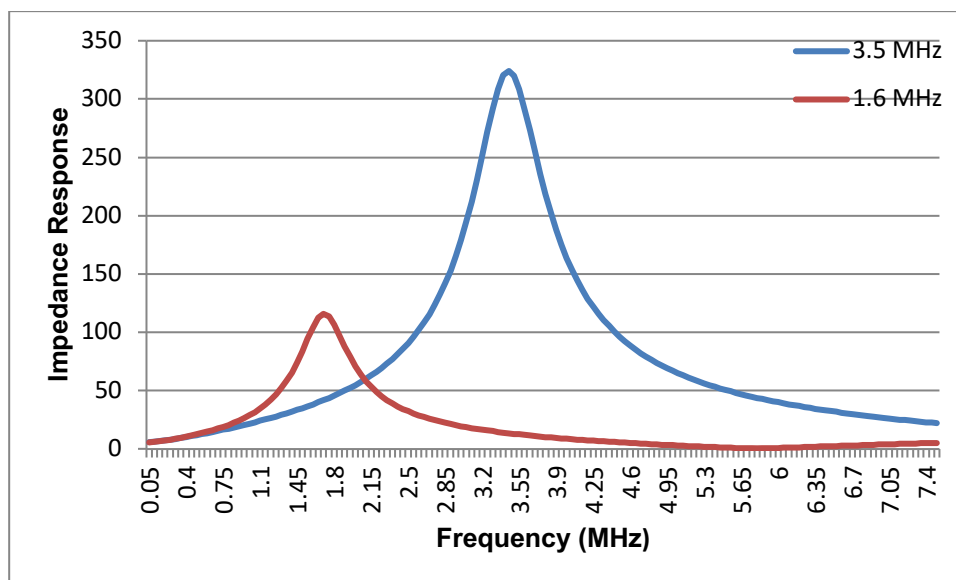
			
Geometry		Planar – Straight Coil, Point – Angled Coil	
Connector		NA	
Coil Function		Transmitter/Receiver	
Compatible Magnet		274A0244	
Coil Geometry		Meander Focused	
Meander Period	inch	0.060	
	mm	1.52	
Number of Periods		8	
Overall Depth	inch	0.450	
	mm	11.4	
Aperture	inch	0.875	
	mm	22.2	
Focal Distance	Inch	2.500	
	mm	63.5	

Tuning Module Data Sheet (Modules shaded in red are the minimum recommended)

Pulse Echo

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range
			Transmitter/Receiver (kHz)
205T0808	1600	1400-1850	1385-1878
205T0804	3500	3050-3700	3089-3731

Frequency Spectra



7.4.3. RF Coil: 205C1426-080 Thin-Weld Inspection (2-Channel - Point & Planar)

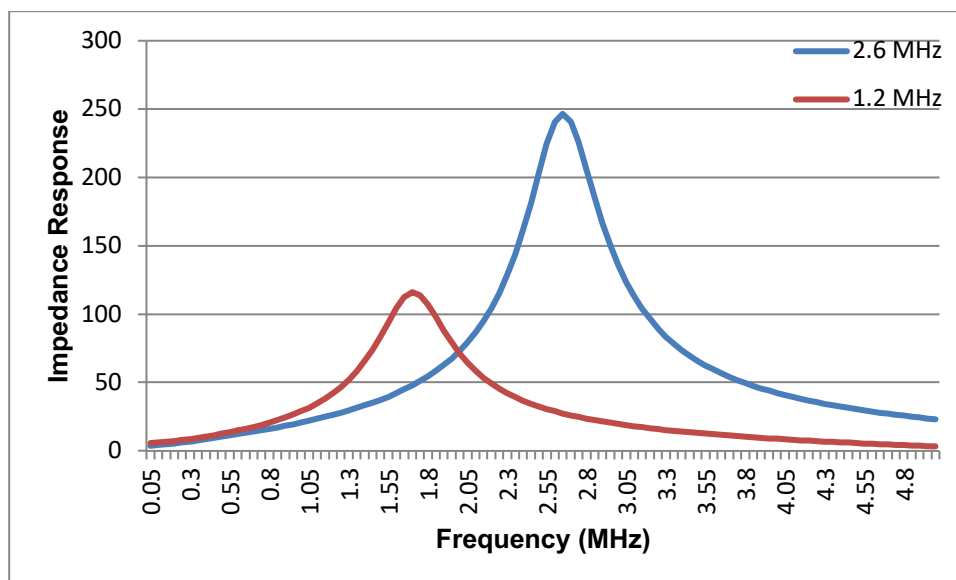
			
Geometry		Planar – Straight Coil, Point – Angled Coil	
Connector		NA	
Coil Function		Transmitter/Receiver	
Compatible Magnet		274A0244	
Coil Geometry		Meander Focused	
Meander Period	inch	0.080	
	mm	2.03	
Number of Periods		6	
Overall Depth	inch	0.440	
	mm	11.2	
Aperture	inch	0.875	
	mm	22.2	
Focal Distance	Inch	2.500	
	mm	63.5	

Tuning Module Data Sheet (Modules shaded in red are the minimum recommended)

Pulse Echo

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range
			Transmitter/Receiver (kHz)
205T0810	1200	1100-1400	1086-1437
205T0806	2600	2400-2800	2385-2846

Frequency Spectra



7.4.4. RF Coil: 205C1426-120 Thin-Weld Inspection (2-Channel - Point & Planar)

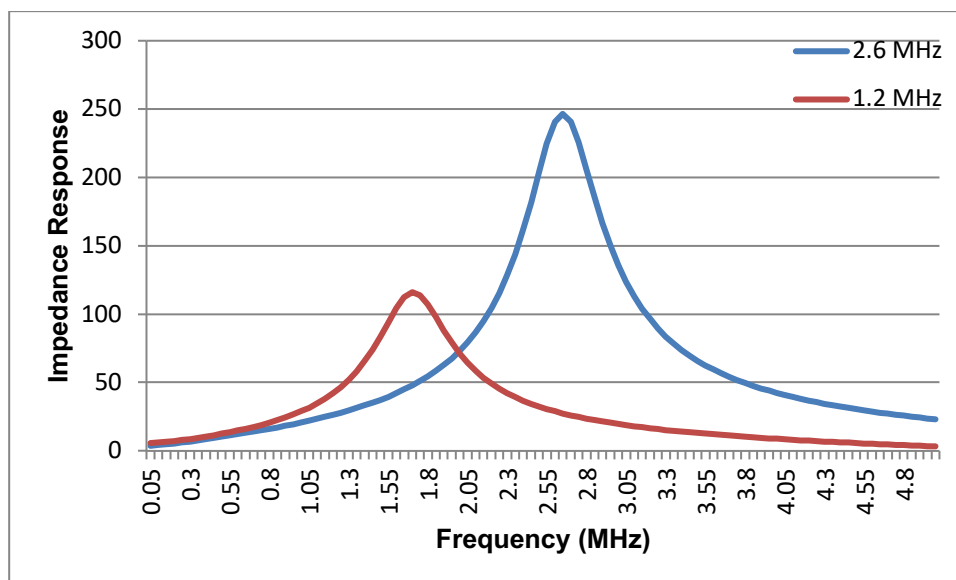
		
Geometry		Planar – Straight Coil, Point – Angled Coil
Connector		NA
Coil Function		Transmitter/Receiver
Compatible Magnet		274A0244
Coil Geometry		Meander Focused
Meander Period	inch	0.120
	mm	3.05
Number of Periods		6
Overall Depth	inch	0.440
	mm	11.2
Aperture	inch	0.875
	mm	22.2
Focal Distance	Inch	2.500
	mm	63.5

Tuning Module Data Sheet (Modules shaded in red are the minimum recommended)

Pulse Echo

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range
			Transmitter/Receiver (kHz)
205T0810	1200	1100-1400	1086-1437
205T0806	2600	2400-2800	2385-2846

Frequency Spectra



7.4.5. RF Coils: T-L-M-0.100x7-1.000 & R-L-M-0.100x7-1.000

			
Part Number		205C0323	205C0118
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.100	0.100
	mm	2.54	2.54
Number of Periods		7	7
Overall Depth	inch	0.675	0.675
	mm	17.15	17.15
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0933	900	500-1000	691-1162	632-1317
205T0930	1250	1000-1400	930-1616	858-1874
205T0931	2000	1400-4000	1421-2630	1253-3207

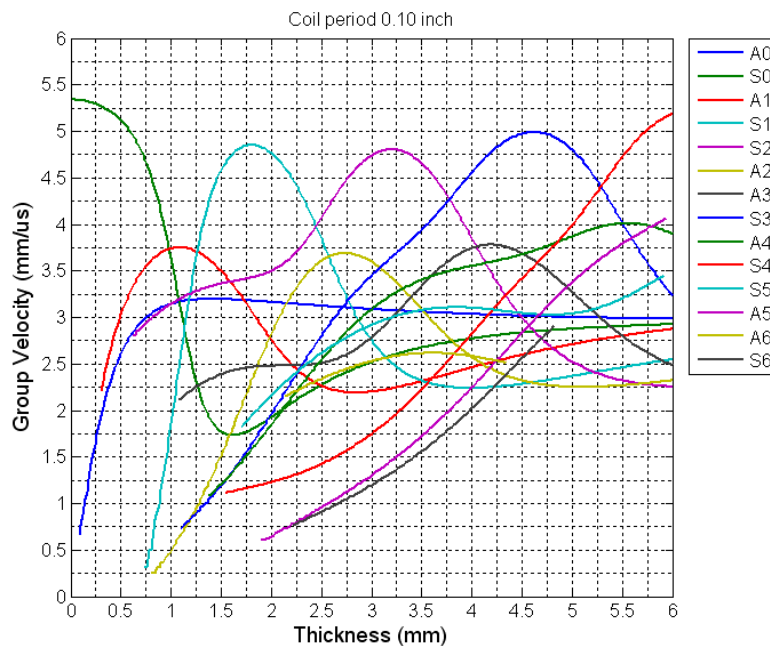
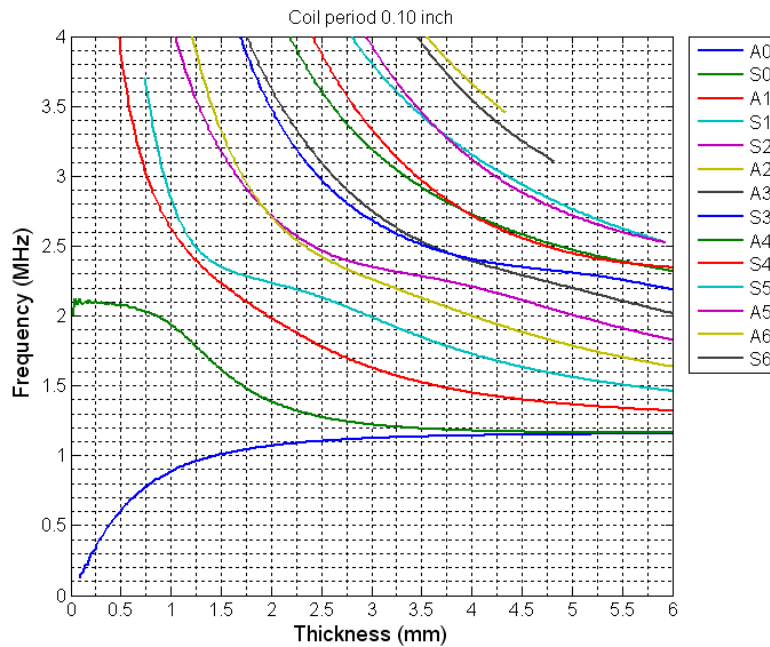
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	7782	7243	8316
205T0802	5015	4632	5365
205T0803	4424	4073	4740
205T0804	3584	3275	3855
205T0805	3112	2826	3359
205T0806	2648	2383	2873
205T0807	2192	1945	2395
205T0808	1779	1546	1962
205T0809	1422	1196	1590
205T0810	1183	957	1340
205T0811-LF	946	682	1095
205T0812-LF	761	567	1064
205T0813-LF	597	418	892
205T0814-LF	474	307	764

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.10" (2.54mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.4.7. RF Coils: T-L-M-0.120x5-1.000 & R-L-M-0.120x5-1.000

			
Part Number		205C0327	205C0121
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.120	0.120
	mm	3.05	3.05
Number of Periods		7	5
Overall Depth	inch	0.570	0.570
	mm	14.48	14.48
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0937	500	300-600	346-681	297-773
205T0934	1000	600-1200	680-1412	568-1648
205T0935	2000	1200-2500	1232-3196	896-3856
205T0936	5000	2500-9000	2240-8870	1370-10000*

* The +3dB range is greater than twice of the tuning frequency

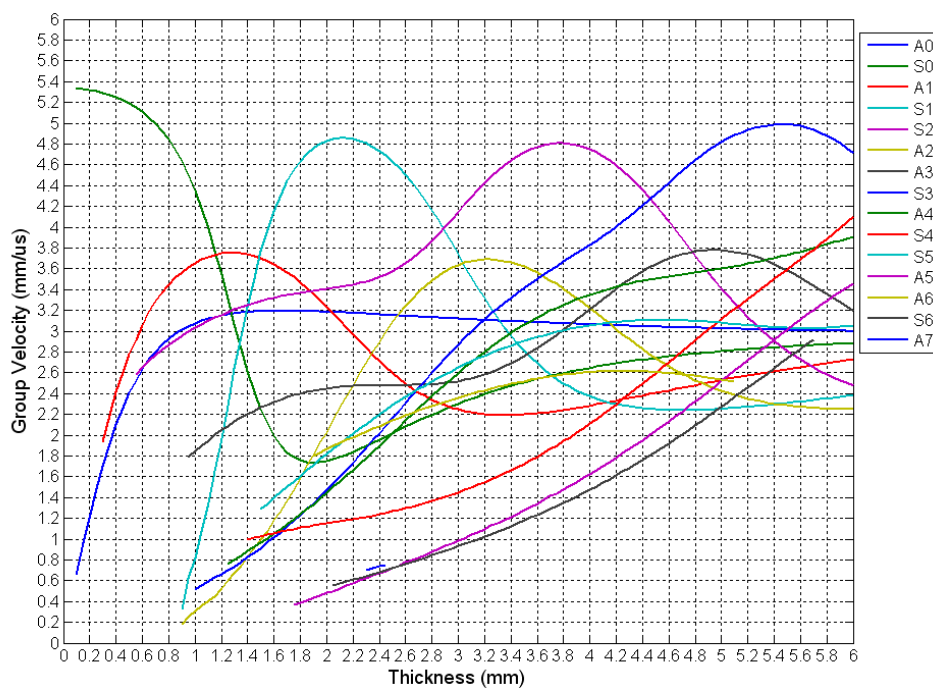
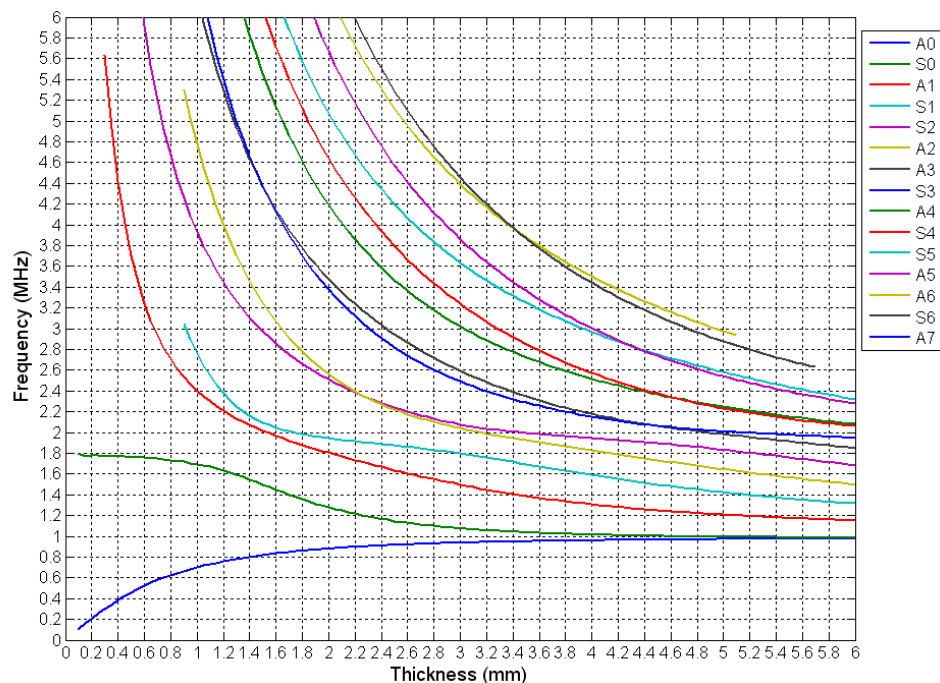
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	5303	4676	5894
205T0802	3617	3169	4015
205T0803	3223	2813	2582
205T0804	2641	2289	2942
205T0805	2305	1986	2572
205T0806	1968	1678	2205
205T0807	1631	1368	1840
205T0808	1324	1080	1506
205T0809	1056	822	1217
205T0810-LF	875	642	1022
205T0811-LF	695	415	830
205T0812-LF	555	392	850
205T0813-LF	430	286	712
205T0814-LF	336	210	611

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.120" (3mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.4.9. RF Coils: T-L-M-0.140x6-1.000 & R-L-M-0.140x6-1.000

			
Part Number		205C0330	205C0124
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.140	0.140
	mm	3.556	3.556
Number of Periods		6	6
Overall Depth	inch	0.805	0.805
	mm	20.45	20.45
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0939	500	200-600	345-695	296-815
205T0940	900	600-1100	612-1344	502-1587
205T0938	1500	1100-3000	951-2399	684-3000

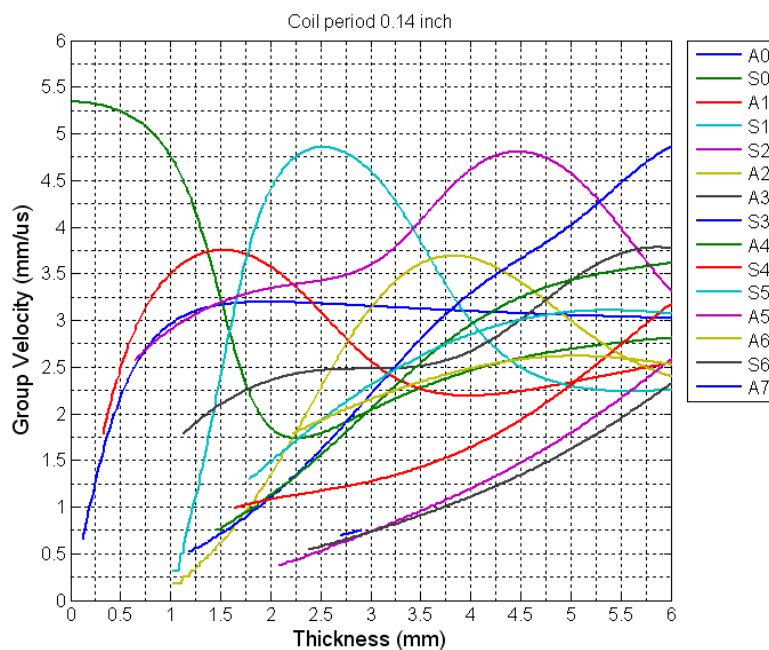
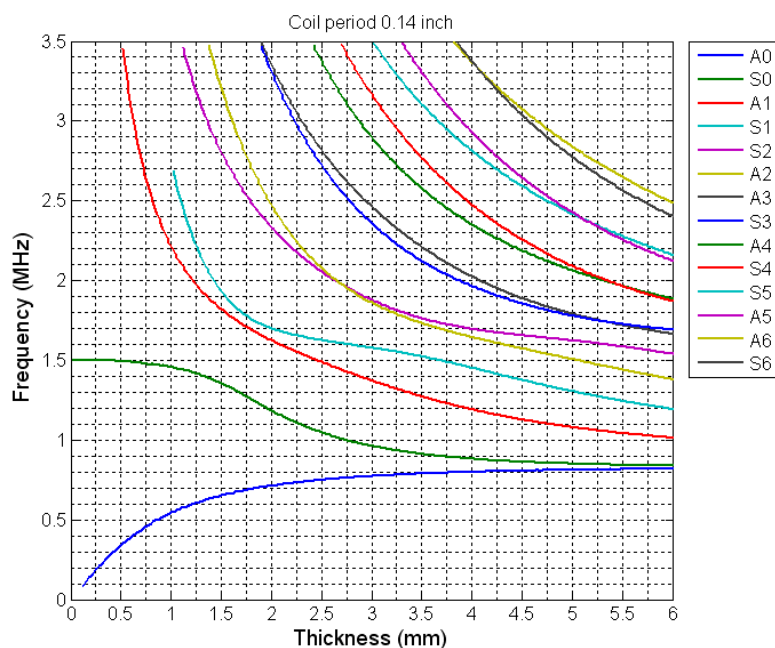
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	4467	3901	4989
205T0802	3035	2628	3390
205T0803	2706	2334	3026
205T0804	2220	1894	2489
205T0805	1938	1637	2181
205T0806	1656	1376	1873
205T0807	1372	1112	1564
205T0808	1112	861	1284
205T0809-LF	884	619	1039
205T0810-LF	728	535	1074
205T0811-LF	573	405	900
205T0812-LF	451	304	762
205T0813-LF	333	203	638
205T0814-LF	253	121	556

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.140" (3.56mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.4.10. RF Coils: T-L-M-0.160x5-1.000 & R-L-M-0.160x5-1.000

			
Part Number		205C0333	205C0127
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.160	0.160
	mm	4.06	4.06
Number of Periods		5	5
Overall Depth	inch	0.760	0.760
	mm	19.30	19.30
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0943	500	200-600	359-697	287-815
205T0944	750	600-800	522-1066	404-1283
205T0941	1250	800-1500	810-1882	588-2500*
205T0942	3000	1500-5000	1542-4980	883-6000*

* The +3dB range is greater than twice of the tuning frequency

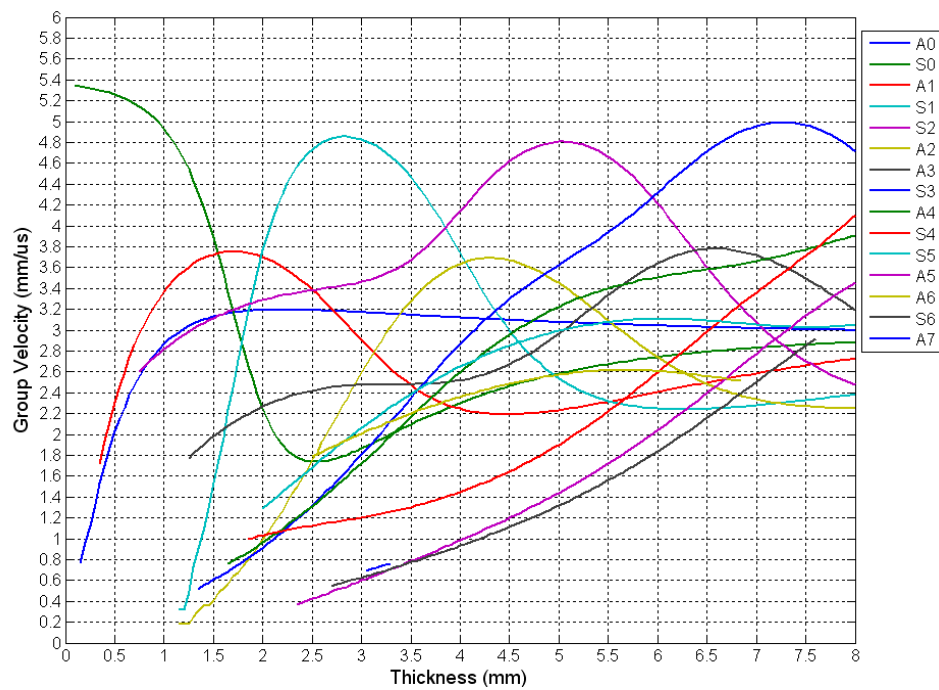
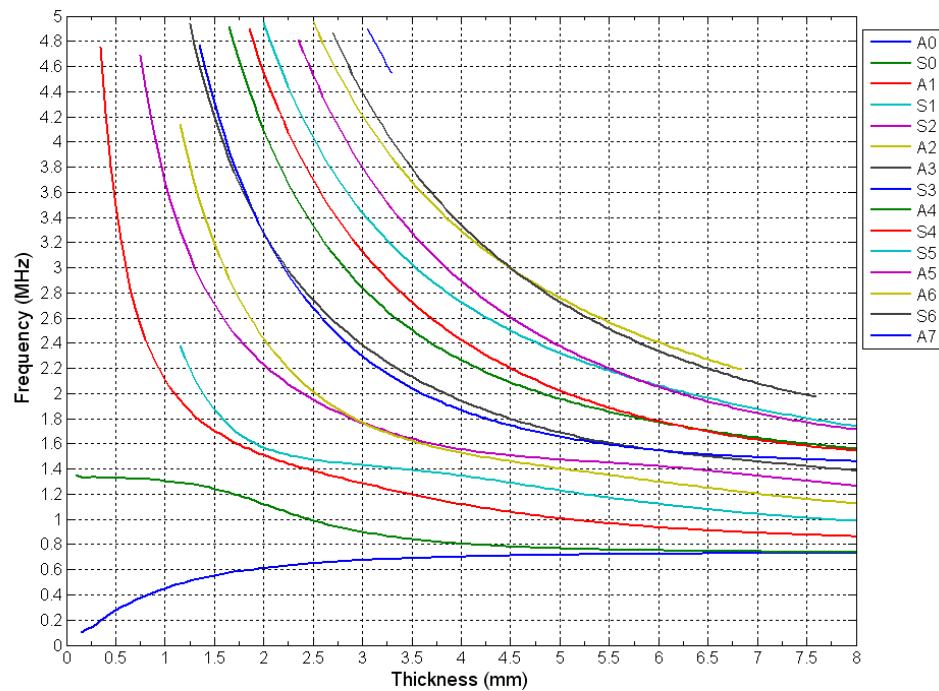
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	4670	4040	5259
205T0802	3182	2741	3575
205T0803	2838	2440	3188
205T0804	2328	1989	2619
205T0805	2032	1725	2289
205T0806	1735	1460	1961
205T0807	1439	1192	1635
205T0808	1168	943	1338
205T0809-LF	932	716	1081
205T0810-LF	772	555	907
205T0811-LF	614	355	736
205T0812-LF	489	346	762
205T0813-LF	373	249	634
205T0814-LF	297	185	544

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.160" (4mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.4.11. RF Coils: T-L-M-0.180x5-1.000 & R-L-M-0.180x5-1.000

			
Part Number		205C0336	205C0130
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.180	0.180
	mm	4.57	4.57
Number of Periods		5	5
Overall Depth	inch	0.855	0.855
	mm	21.72	21.72
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0946	400	150-500	273-607	241-639
205T0947	700	500-800	437-1102	402-1177
205T0945	1200	800-2500	658-2054	605-2323

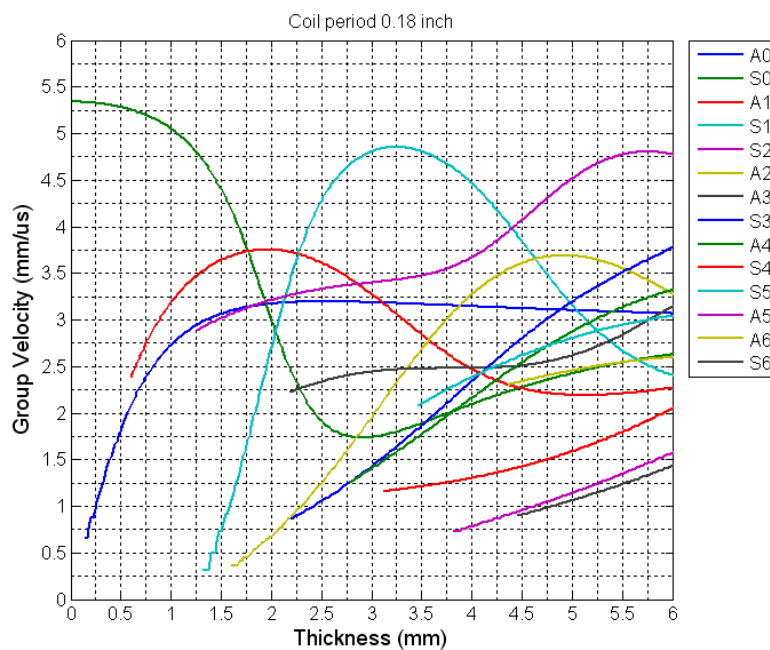
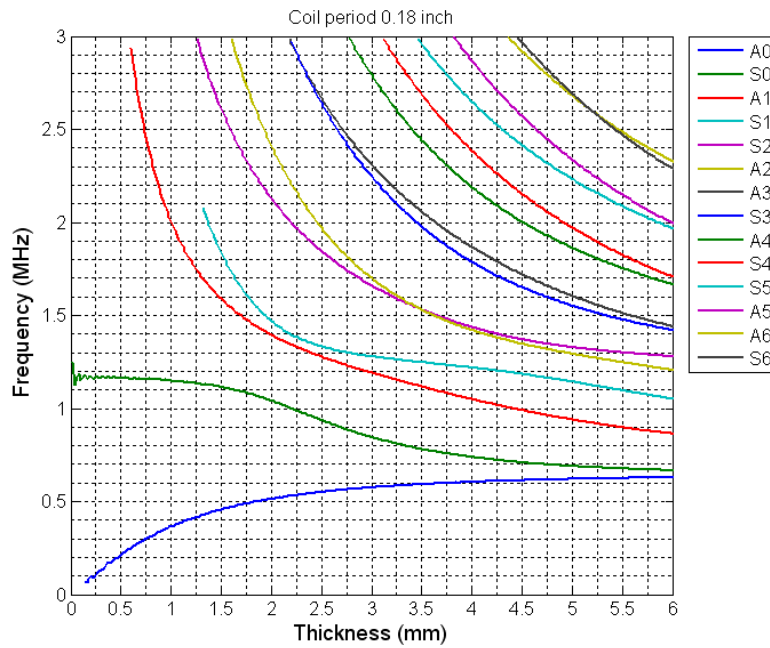
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	
		Min	Max
205T0801	4669	3971	5324
205T0802	3133	2662	3553
205T0803	2785	2365	3158
205T0804	2276	1924	2581
205T0805	1983	1668	2249
205T0806	1691	1413	1923
205T0807	1400	1154	1598
205T0808	1136	916	1304
205T0809-LF	906	708	1048
205T0810-LF	752	561	880
205T0811-LF	599	400	713
205T0812-LF	477	344	724
205T0813-LF	368	254	596
205T0814-LF	296	189	519

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.18" (4.57mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



7.4.12. RF Coils: T-L-M-0.200x4-1.000 & R-L-M-0.200x4-1.000

			
Part Number		205C0339	205C0133
Connector		2 Pin Lemo 0B	2 Pin Lemo 0B
Coil Function		Transmitter, bi-directional	Receiver
Compatible Magnet		274A0244	274A0244
Coil Geometry		Meander	Meander
Meander Period	inch	0.200	0.200
	mm	5.08	5.08
Number of Periods		4	4
Overall Depth	inch	0.750	0.750
	mm	19.05	19.05
Aperture	inch	1.000	1.000
	mm	25.4	25.4

Tuning Module Data Sheet (Modules shaded in red are recommended for standard applications)

Pitch-Catch

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range	3dB Range	
			Transmitter (kHz)	Receiver (kHz)
205T0950	500	200-600	330-730	251-953
205T0948	1000	600-1200	582-1646	395-2000*
205T0949	2000	1200-4000	916-3664	521-4000*

* The +3dB range is greater than twice of the tuning frequency

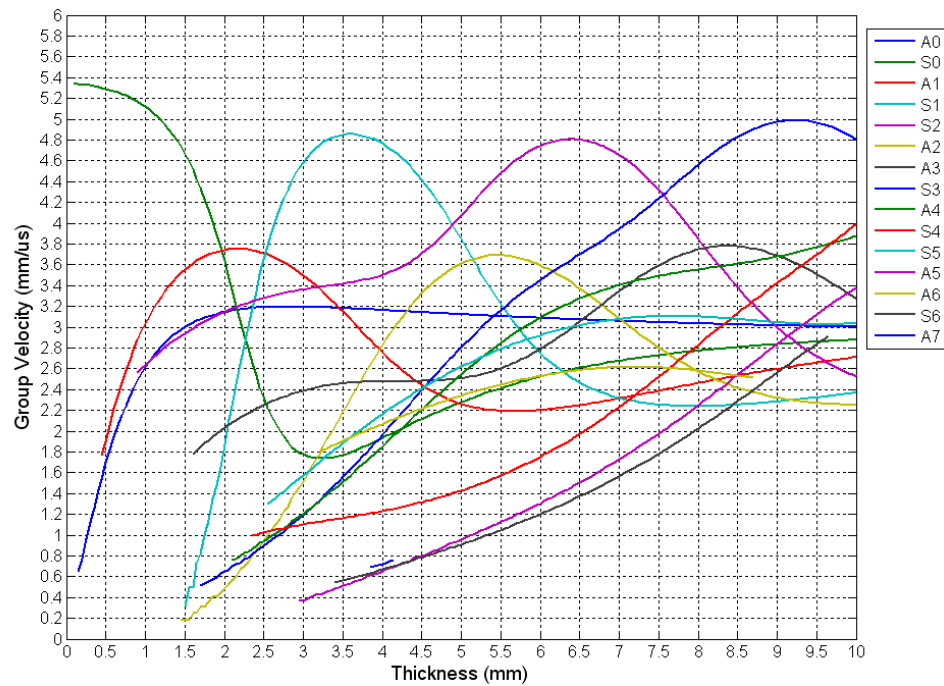
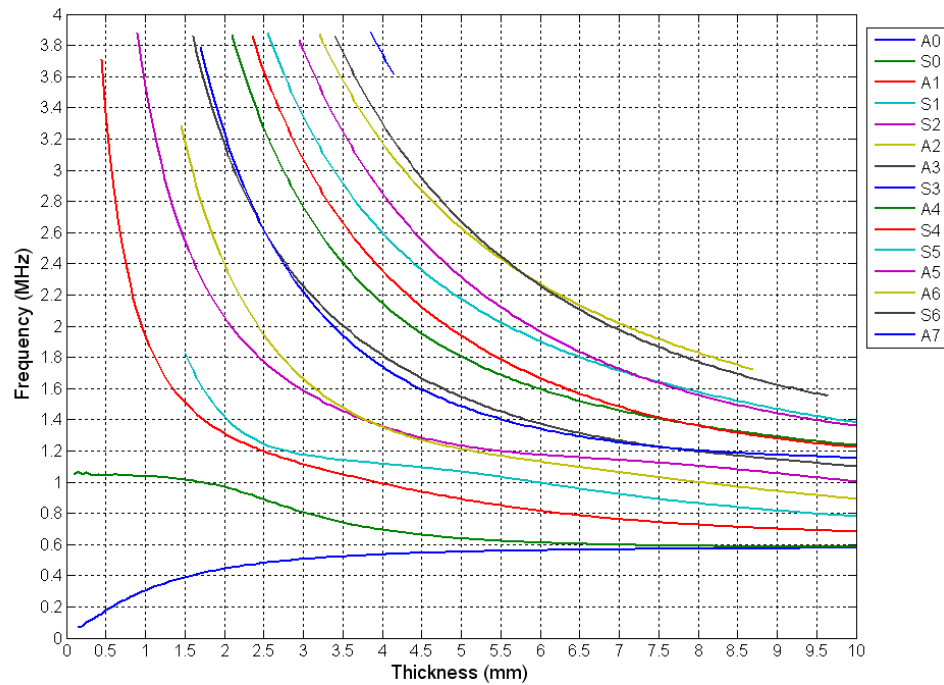
Pulse Echo

Receiver Coil

Tuning Setting Module Name	Tuning Frequency (kHz)	Recommended Frequency Range (kHz)	
		Min	Max
205T0801	5258	4485	5980
205T0802	3458	2940	3918
205T0803	3062	2594	3470
205T0804	2487	2099	2821
205T0805	2161	1811	2453
205T0806	1837	1524	2093
205T0807	1516	1239	1736
205T0808	1227	979	1415
205T0809-LF	976	747	1138
205T0810-LF	808	588	950
205T0811-LF	642	402	770
205T0812-LF	512	360	780
205T0813-LF	394	261	644
205T0814-LF	315	196	554

Lamb & Rayleigh Dispersion Curves for RF Coils with 0.200" (5mm) Coil Period

The following sets of curves provide the Frequency and Corresponding Group Velocity for a given thickness of **Steel Plate**.



8. General Sensor Accessories for Normal Beam and Guided Wave

8.1.1. Wear Surfaces

Standard RF coil wear surfaces protect the RF coil against abrasion and puncture. The wear surfaces should be replaced if they are torn, worn out or wrinkled to avoid damage to the RF coil. For optimum performance use only the wear surface suggested by this document.

8.1.1.1. Metallic

Metallic Wear Surfaces are recommended only for Magnetostrictive applications.

Part Number	Magnet	Dimensions
001F2201	274A0244	Rectangular 4.0" L x 1.125" W 98mm L x 28mm W

* Hourglass shaped wear surface is designed to conform to tubular products when scanning along the tube (axial direction).

8.1.1.2. Non-Metallic

Non-Metallic Wear Surfaces are recommended for Normal Beam Applications and High Temperature Angled Beam, Guided Waves and Phased Array (Lorentz).

Part Number	Application	Dimensions & Length
510V0005	Normal Beam up to 200°C	High Resistance Wear Surface Tape Roll 0.010" Thick 2" x 5 yds
510V0006	Guided Waves, Angled Beam and SV Phased Array at up to 200°C	High Resistance Wear Surface Tape Roll 0.005" Thick 2" x 5 yds
510V0008	Single Channel and Phased Array Sensors up to 200°C	High Resistance Wear Surface Tape Roll 0.002" Thick 2" x 5 yds

8.1.2. Compliance Spring Foam

Compliance spring foam is used to maintain flexible RF coils close to the part. The foam is engineered to maintain its shape in dirty or wet environments and apply very low pressure on the coil to minimize wear.

Part Number	Description	Order Quantity	Magnets
033V0032	1/16" White High-Temperature Foam (200°C)	12" x 12" Sheet	274A0244
001F4025	Shaped White Foam for PMX Sensor	Unit	274A0398
001F4026	Shaped Gray High Temperature Foam for PMX Sensor	Unit	274A0398

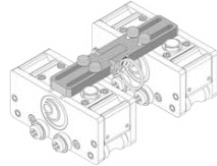
8.1.3. Coil Backing Tape

Tape is applied to the back of receive coils to protect the coil from damage and improve signal quality.

Part Number	Description	Order Quantity	Magnets
027V0039	Backing tape for standard temperatures (<80°C)	Unit	274A0244 274A0398
027V0029	Backing tape for high temperatures (80°C – 200°C)	Unit	274A0244 274A0398

8.1.4. Sensor & Magnet Accessories

Roller-Kit assemblies are recommended for scanning ferromagnetic parts with Permanent Magnets, and handles are used for spot checking through insulation inspection holes with our high-temperature sensors. Lift-Assist devices are also available to scan and dislodge Permanent Magnets from a ferromagnetic part. The SH Sensor Positioning Fixture permits setting angles and distances to facilitate setups in automated scanning.

Part Number	Description	Magnets	Picture
187A0007	High-Temperature Sensor Handle 1" D x 12" L 25mm D x 300mm L	274A0272 274A0268	
187A0020	High-Temperature Sensor Lift-Off Ring and Adapter Kit	274A0272	
187A0017	Connecting Bracket for 2 - 274A0244 Magnets for MRUT Operation.	274A0244	
800A0358	MS Strip Kit for MRUT	NA	
027V0105	Double-Sided Tape for MRUT MS Strip	NA	
116V0052	2-Part Epoxy for MRUT MS Strip	NA	

8.1.5. Thermocouple

Designed to be integrated seamlessly with the appropriate instrumentation.

Part Number	Description	Connector	Magnets	Instrument	Picture
281A0001	Thermocouple	Type K Mini	NA	VOLTA 2 CODA	

9. Software

Software	Instrument	Applications
MRUT	VOLTA 2	Pipes, Tubes, Plates, etc. Required Software for VOLTA 2 Applications
MRUT Sizing	VOLTA 2	Defect Sizing
LRUT Lite (Unfocused)	VOLTA 2	Long Range Ultrasonic Inspection of Pipes & Tubes
LRUT FOCUS	VOLTA 2	Long Range Ultrasonic Inspection of Pipes & Tubes with Focus for location determination circumferentially of defects
Thickness & General A-Scan (default)	CODA (all) VOLTA 2	Thickness Measurement & Flaw Detection with EMAT & DCUT
Thickness Grid	CODA VOLTA 2	Thickness Measurement & Flaw Detection with EMAT & DCUT
Scanning (Line & C-Scan)	CODA+ CODA SM VOLTA 2	Thickness Measurement & Flaw Detection with EMAT & DCUT Corrosion Mapping with EMAT
Bolt Load	CODA SM VOLTA 2	Bolt Load Measurement with EMAT
Stress Measurement	CODA SM VOLTA 2	Stress Measurement with EMAT

9.1. GWAT

The **temate® GWAT (Guided Wave Analysis Tool)** provides an advanced mathematical analysis tool in an easy-to-use interface to generate and evaluate dispersion curves and other wave propagation features in a variety of geometries, including plates, tubes and rods.

Part Number	Software Name	Geometry
400S0002	temate® GWAT-FS	Full Suite (Plates, Rods, Tubes)
400S0003	temate® GWAT-P	Plates
400S0005	temate® GWAT-T	Tubes (Circumferential Propagation)

Each **Temate® GWAT** product covers the following Wave Modes, Materials and Features:

Wave Modes	Materials*	Analysis Features	Other Features
• Rayleigh (Surface) • Lamb • Shear Horizontal	• Steel • Aluminum • Copper • Titanium • Ductile Iron	• Phase Velocity Vs Frequency • Group Velocity Vs Frequency • Frequency Vs Product Thickness (for a given EMAT coil) • Group Velocity Vs Product Thickness (for a given EMAT coil) • Phase Velocity Vs Product Thickness (for a given EMAT coil) • Wave Structure for a Given Mode • Wave Excitability and Sensitivity	• Built-in standard pipe schedule • Built-in material library • International and US units

* Other materials available upon request. Contact Innerspec for details.

9.2. BEAM

Beam steering software permits calculating angle of incidence and beam profiles for different wavelengths and frequencies in different materials.

Part Number	Software Name	Geometry
400S0007	temate® BEAM	Plates

10. Instrument Accessories

10.1. VOLTA 2



Part Number	Description	Dimensions	Good For	Picture
135V0029	Transport Case Small 26" L x 17.5" W x 12" D	26" L x 17.5" W x 12" D (66.0 x 44.5 x 30.5 cm)	1 x Innerspec VOLTA (with Jetpack) 1 x Innerspec VOLTA Accessories Bag	
135A0420	VOLTA 2 Backpack	24" L x 14.5" W x 8" D (61.0 x 37 x 20.5 cm)	1 x VOLTA 2	
135A0030	Accessories Backpack	24" L x 14.5" W x 8" D (61.0 x 37 x 20.5 cm)	1 x VOLTA 2 Accessories	

Part Number	Description	Dimensions	Good For	Picture
210V0011	Spare Battery	n/a	1 x VOLTA 2	
211V0182	External Charger	n/a	1 x VOLTA 2 Battery	

10.2. CODA



Part Number	Description	Dimensions (cm)	Good For	Picture
241V0211	Transport Case Small	48 x 37 x 17	1 x CODA + Accessories	
241A0199	Belt	23 x 16 x 8	1 x CODA	
187V0098	Wrist Band	13 x 8 x 4.5	1 x CODA	
210V0018	Spare Battery	8.5 x 7.8 x 2.3	1 x CODA	
107V0018	External Charger & Power Supply	12 x 5 x 3.5	1 x CODA	

11. Calibration Standards

These calibration blocks have been designed for use with the complete line of portable equipment offerings available from Innerspec Technologies. Please see the item descriptions for more information on the specification application for each calibration standard.

Part Number	Description	Application
019F0008	CAL. STD. STEEL SEMICIRCULAR STEP BLOCK 0.050" - 0.5"	Used for TG-IS(B) calibration for standard boiler tube.
019F0010	CAL. STD. CLAD STEEL SEMICIRCULAR STEP BLOCK 0.050" - 0.5"	Used for TG-IS(B) calibration for clad pipe (typical of recovery boilers)
019F0034	CAL. STD. SS 4 STEP BLOCK 2.5MM-12MM	Step wedge for thickness measurement
019F0035	CAL. STD. STEEL 4 STEP BLOCK 2.5MM-12MM	Step wedge for thickness measurement
019F0036	CAL. STD. AL 4 STEP BLOCK 6.25MM-25MM	Step wedge for thickness measurement
019F0037	CAL. STD. AL 5 STEP BLOCK 2.5MM-12.5MM	Step wedge for thickness measurement
019F0038	CAL. STD. STEEL 12MM THICK. 3MM FBH	FBH for Normal beam defect detection
019F0039	CAL. STD. STEEL 12MM THICK. 5MM FBH	FBH for Normal beam defect detection
019F0040	CAL. STD. STEEL 25MM THICK. 3MM FBH	FBH for Normal beam defect detection
019F0041	CAL. STD. STEEL 25MM THICK. 5MM FBH	FBH for Normal beam defect detection
019F0042	CAL. STD. STEEL 50MM THICK. 3MM FBH	FBH for Normal beam defect detection
019F0043	CAL. STD. STEEL 50MM THICK. 5MM FBH	FBH for Normal beam defect detection
019F0044	CAL. STD. STEEL 6MM THICK. 5%-10% NOTCH. 1/16" THOLE	Notch and hole for bulk wave angle beam, and surface wave
019F0045	CAL. STD. STEEL 12MM THICK. 5%-10% NOTCH. 1/16" THOLE	Notch and hole for bulk wave angle beam, and surface wave
019F0046	CAL. STD. STEEL 25MM THICK. 5%-10% NOTCH. 1/16" THOLE	Notch and hole for bulk wave angle beam, and surface wave
019F0047	CAL. STD. STEEL 1MM THICK. 5%-20% NOTCH. T/4-2T THOLE	Notch and hole for guided wave
019F0048	CAL. STD. STEEL 3MM THICK. 5%-20% NOTCH. T/4-2T THOLE	Notch and hole for guided wave
019F0049	CAL. STD. STEEL 6MM THICK. 5%-20% NOTCH. T/4-2T THOLE	Notch and hole for guided wave
019F0050	CAL. STD. STEEL 10MM THICK. 5%-20% NOTCH. T/4-2T THOLE	Notch and hole for guided wave

12. Appendix

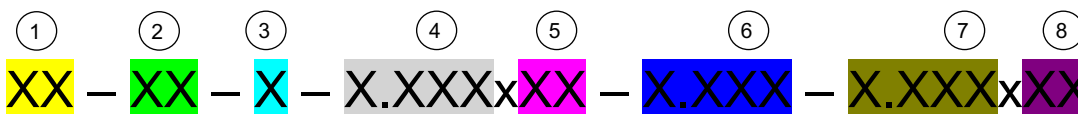
12.1.1. Detachable RF Coils

In addition to complete Sensors with embedded RF Coils, Innerspec Technologies offers a wide range of freestanding RF Coils to mount on the Standard Magnets. These RF coils offer the following advantages:

- Low cost means of having several EMAT Sensors at a fraction of the expense of embedded versions.
- Inexpensive and easy to replace if damaged.
- Flexible coil substrate adapts to the undulations of the material thus reducing lift-off and improving signal-to-noise (especially important for guided waves).
- Different wear surfaces can be adapted for unique applications.

All flexible RF Coils in this catalog have a maximum operating temperature of 200°C (400°F) without active cooling

The coil description printed on each RF Coil shows its unique characteristics in 8 separate fields.



- **Field 1.** Coil Function. The options are:
 - T: Transmitter
 - R: Receiver
 - T2: Unidirectional Transmitter. Two transmitter coils separated at approx. $\frac{1}{4}$ of a wavelength
 - PE: Pulse-Echo. One coil in which the Transmitter is the same as Receiver
 - PC: Pitch-Catch. Separate Transmitter and Receiver coils built in one flexible RF coil package
- **Field 2.** Compatible Standard Magnet. The options are:
 - M: Medium Permanent Magnet (PN 274A0106)
 - L: Large Permanent Magnet (PN 274A0244, 274A0107, 274A0144 & 274A0120)
 - XL: Extra Large (PN 274A0108)
 - LW: L-Wave (PN 274A0381)
 - SP, LP, XLP: Small, Large and XL Periodic Magnet Array
 - SN (Number): Special + Number (e.g. 1). Used for special magnets
 - SE: Pulsed Electromagnet Small (PN 160A0062 & 160A0049)
 - ME: Pulsed Electromagnet Medium (PN 274A0076 & 274A0119)
- **Field 3.** Coil Geometry. The options are:
 - S: Spiral
 - B: Butterfly
 - R: Racetrack
 - M, MF: Meander and Meander Focused coil
 - PA, PAF: Phased Array and Phased Array Focused coil
- Fields 4, 5, 6, 7 & 8. Other relevant parameters particular to each RF Coil (different for each geometry). 7 & 8 are only applicable to Phased Array. The options are:

Coil Geometry	Field 4	Field 5	Field 6	Field 7	Field 8
S	OD	-	ID	-	-
B	Coil Width	-	Coil Length	-	-
R	Coil Width	-	Coil Length	-	-
M(F)	Coil Period*	No. Coil Periods	Aperture	-	-
PA(F)	Coil Period	No. Coil Periods	Elevation	Pitch	No. Channels

* On Meander Coils, Coil Period is usually referred to as the wavelength of the most efficiently excited guided wave modes for that particular RF Coil.

13. Limited Warranty

Innerspec Technologies warrants these products to be free of defects in Material and Workmanship for a period of **one year** from date of purchase by end user. **Innerspec Technologies** will, at its choice, replace or repair parts found defective and return equipment or parts to the purchaser.

The above stated warranty does not apply to expendable or consumable parts (*e.g., coils, transducers, cables, and batteries*), and to products that have failed due to misuse, alteration, unauthorized repair or modification. The purchaser is responsible for transportation costs of the equipment to and from the factory for warranty replacement or repair. The above warranty does not include incidental or consequential damages.

Innerspec Technologies is not responsible for damage to or loss of any programs, data, or removable storage media and for the restoration or reinstallation of any programs or data other than software installed by **Innerspec Technologies** when the product is manufactured.