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Laird TECHNOLOGIES®

global solutions :
local support .

Microwave Absorbing Materials

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ABSORB-CAT-2006

global **solutions :**
local **support .**

Laird Technologies is committed to providing the world's leading OEMs with comprehensive solutions for their antenna, EMI shielding, telematics and thermal management requirements.

A world-leader, Laird Technologies has unrivaled product lines, dedication to ongoing R&D and a seamless network of manufacturing and customer support facilities located across the globe - most importantly, near its customers.

The company's philosophy of 'global solutions and local support' coupled with decades of experience and considerable capabilities means it has become a key partner for OEMs manufacturing in the following industries:

Aerospace

Automotive electronics

Computer

Data communications

General electronics

Medical equipment

Military

Network equipment

Telecommunications

global solutions :

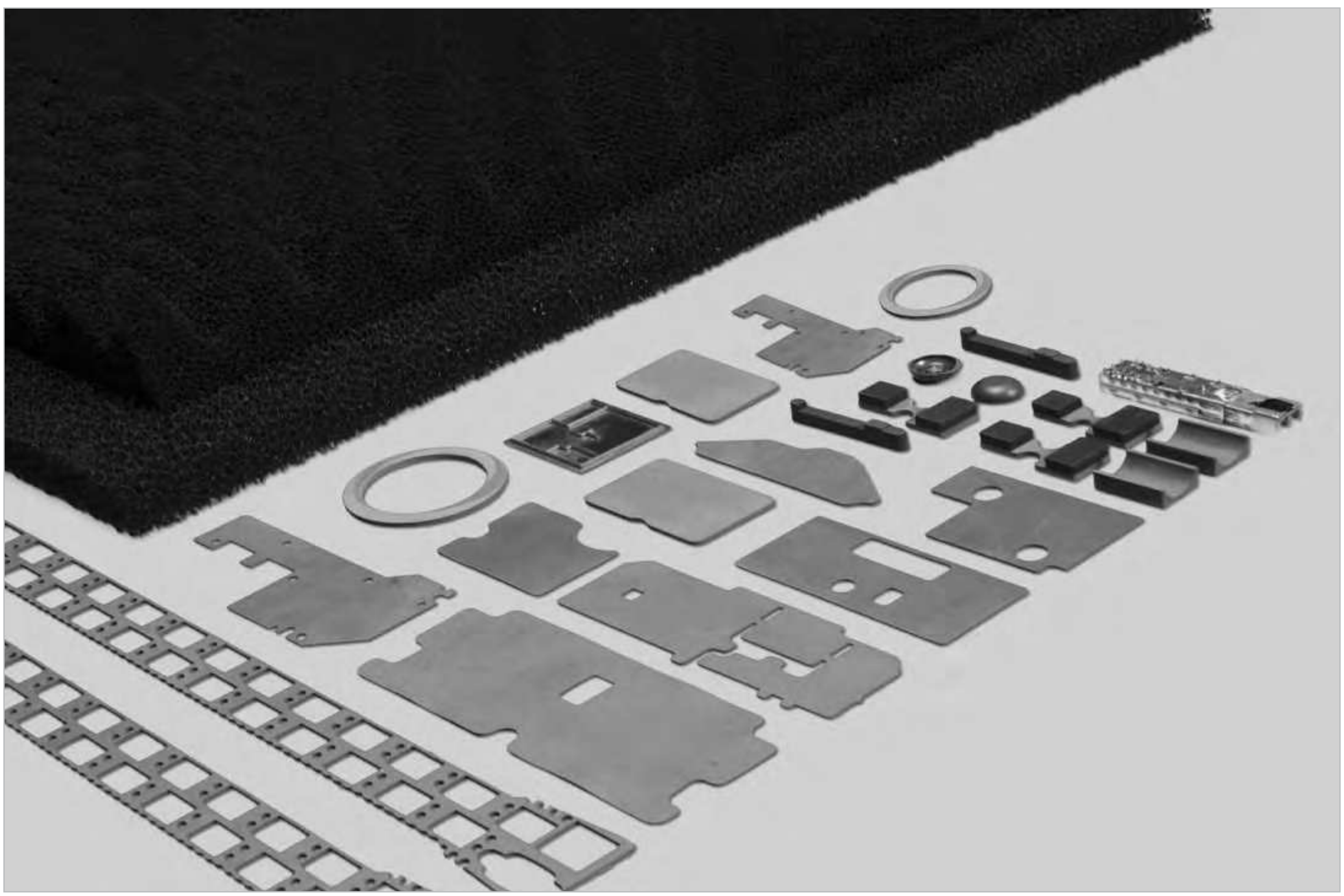
local support

TABLE OF CONTENTS

MATERIAL SELECTION GUIDE

DESIRED PERFORMANCE	ATTRIBUTE	PRODUCT LINE/MATERIAL CHOICE
Frequency	Narrowband	RFSB, RFSS
	Broadband	RFSW, RFRET, RFLS, RFML, RFRET/CV, RFRIGID, RFHC
Absorption Effect	Reflection Loss	RFSB, RFSW, RFRET, RFML, RFRET/CV, RFRIGID
	Radar Cross Section Reduction	RFSB, RFSW, RFRET, RFRIGID
	Surface Current Attenuation	RFSW
	Cavity Resonance Reduction	RFSW, RFLS
	Insertion Loss	RFLS, RFRET, RFRIGID, RFHC
	Free-space attenuation	RFLS, RFRET, RFRIGID, RFHC
	Antenna Pattern Improvement	RFRET, RFRET/CV, RFML, RFHC
Environment	Standard Commercial Use (Low Temp)	Silicone, natural rubber
	High Temperature (>350° F)	Viton or Fluorosilicone elastomer
	Moderate Temperature (220-350° F)	Silicone
	Fuel Resistance	Nitrile, Viton, or Fluorosilicone elastomer
	Outdoor Use	FeSi filler loading
	Fire Retardency (UL-V0 Rating)	Silicone with FR

When ordering, please call our sales department to confirm availability and lead times.



Interest in microwave-absorbing material technology has been growing. As the name implies, microwave-absorbing materials are coatings whose electrical and/or magnetic properties have been altered to allow absorption of microwave energy at discrete or broadband frequencies. There are several techniques to achieve these properties. The goal of the absorber manufacturer is to balance electrical performance, thickness, weight, mechanical properties and cost.

PRINCIPLES OF OPERATION

Altering the dielectric and magnetic properties of existing materials will produce microwave absorbers. For purposes of analysis, the dielectric properties of a material are categorized as its permittivity and the magnetic properties as its permeability. Both are complex numbers with real and imaginary parts. Common dielectric materials used for absorbers, such as foams, plastics and elastomers, have no magnetic properties, giving them permeability of 1. Magnetic materials, such as ferrites, iron and cobalt-nickel alloys, are used to alter the permeability of the base materials. High dielectric materials, such as carbon, graphite and metal flakes, are used to modify the dielectric properties.

When an electromagnetic wave, propagating through a free-space impedance of Z_0, is incident upon a semi-infinite dielectric or magnetic dielectric boundary of impedance Z_1, a partial reflection occurs. The magnitude of the reflection coefficient is governed by the following equation:

$$R = \frac{1 - Z_1/Z_0}{1 + Z_1/Z_0} \qquad [1]$$

Where

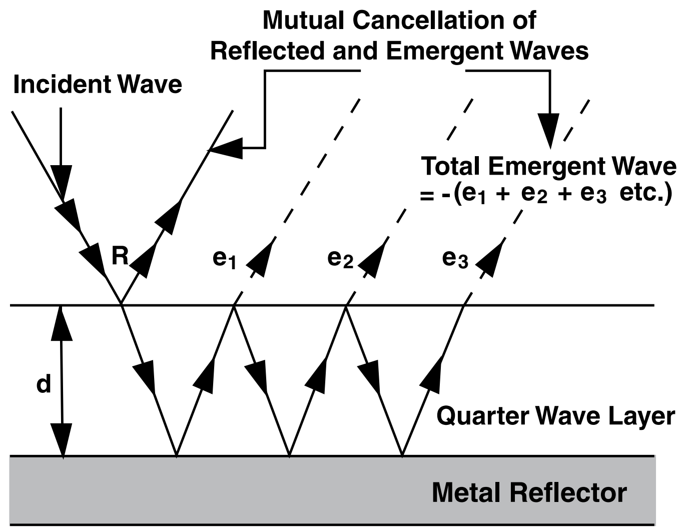
$$Z_0 = \sqrt{\frac{u_0}{e_0}} \qquad Z_1 = \sqrt{\frac{u_1}{e_1}} \qquad [2]$$

To achieve a reflection coefficient of zero: $Z_0 = Z_1$. This condition is achieved when:

$$\frac{u_1}{e_1} = \frac{u_0}{e_0} \qquad [3]$$

The perfect absorber would therefore have u_1 to e_1 and be as large as possible to achieve absorption in the thinnest layer possible. Unfortunately, at microwave frequencies, u_1 generally does not approach the magnitude of e_1. However, other techniques can be used for microwave absorption. In general, practical microwave absorbers are one of two basic types: resonant or graded dielectric.

FIGURE 1.

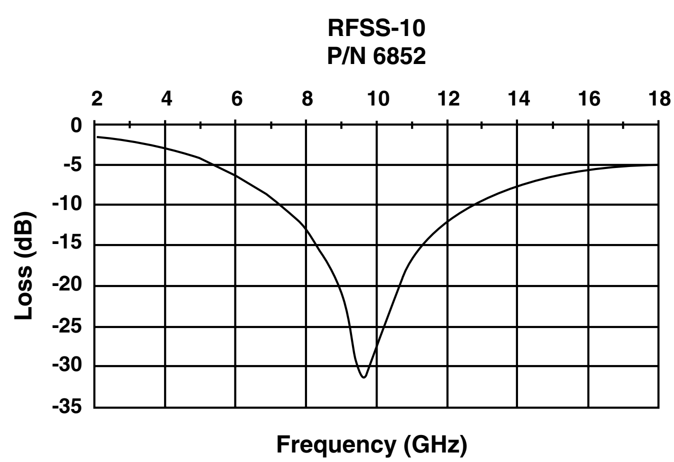


Resonant absorber showing out-of-phase condition existing between reflected and emergent waves.

RESONANT ABSORBERS

The simplest type of resonant absorber is the Salisbury Screen. It consists of a resistive sheet spaced one-quarter wavelength from a conductive ground plane. The resistive sheet is as thin as possible with a resistance of 377 ohms per square matching that of free space. Figure 1 illustrates its operation. A wave incident upon the surface of the screen is partially reflected and partially transmitted. The transmitted portion undergoes multiple internal reflections to give rise to a series of emergent waves. At the design frequency, the sum of the emergent waves is equal in amplitude to, by 180^o out of phase with, the initial reflected portion. In theory, zero reflection takes place at the frequency; in practice, absorption of greater than 30dB (99.9%) may be achieved (see Figure 2).

FIGURE 2.

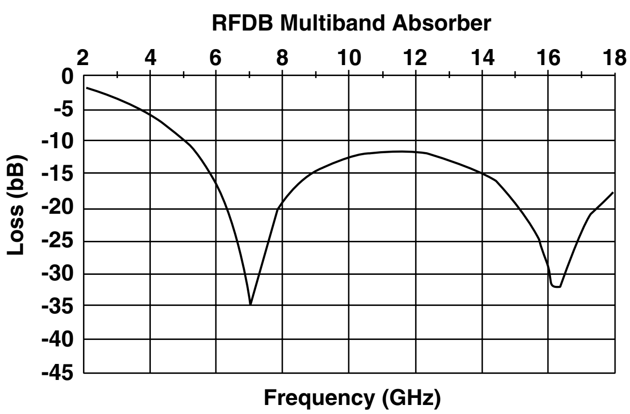


Salisbury Screen resonant absorber at 10GHz.

The inherent problems of the Salisbury Screen are poor flexibility, poor environmental resistance and increased thickness, especially at lower frequencies. Distributing dielectric and/or magnetic fillers into a flexible matrix, such as an elastomer, can produce a more practical absorber. Increasing the permeability and permittivity of the layer increases the refractive index $\sqrt{ue}$, thus decreasing thickness by the relations $1/\sqrt{ue}$. The dramatic difference in thickness achievable can be illustrated by comparing two microwave absorbers. RFSS-10 is a Salisbury Screen-type absorber tuned to 10GHz and is nominally 0.250" (6,4 mm) thick. RFSB-10 is an elastomer loaded with carbonyl iron filler and is 0.068" (1,7 mm) thick. The same electrical performance can be achieved in a material that is 25% as thick (although a weight penalty must be paid). The RFSB absorber is also very flexible and adaptable to outdoor environments.

Resonant materials can also be produced to absorb at multiple frequencies. By controlling the critical magnetic/dielectric loading and thickness of each layer, two discrete frequencies can be tuned. These flexible dual-band absorbers are standard production products and have the added advantage of broadband absorption. For example, a dual-band absorber with appropriate resonant points will have greater than 15dB absorption over an octave bandwidth (see Figure 3).

FIGURE 3.



Dual-magnetic absorber - nitrile rubber 0.200" (5.1 mm) thick, 1.75 lb. sq.ft.

The performance indicated for resonant absorbers is at normal angles of incidence. The effectiveness of these materials drops off as the angle of incidence increases. Materials have been developed for situations where performance is needed at angles of incidence of 65° and greater. These absorbers are generally thin and heavily loaded with magnetic fillers. Such high-permeability absorbers have a greater than critical impedance at normal angles of incidence, thus resulting in performance that is poorer than the resonant type at normal angles but improves as angle of incidence increases. They are generally tuned for a high angle of incidence and horizontal polarization.

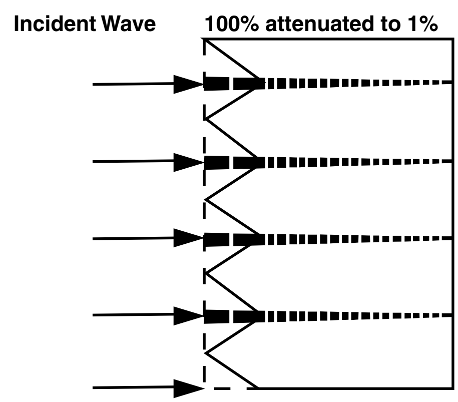
All dimensions shown are in inches (millimeters) unless otherwise specified.

GRADED-DIELECTRIC ABSORBERS

The other absorber category is the graded-dielectric absorber. Its principle of operation is quite different from that of the resonant type. Absorption is achieved by a gradual tapering of impedance from that of free space to a highly "lossy" state. If this transition is done smoothly, little reflection from the front face will result. Anechoic chamber materials accomplish this via the pyramidal shape of the absorber (see Figure 4). The absorbing medium is a conductive carbon in polyurethane foam. Absorption levels of greater than 50dB can be obtained with pyramids many wavelengths thick. These are impractical for electromagnetic interference (EMI) or radar cross-section (RCS) reduction. Good levels of reflectivity reduction (greater than 20dB) can be achieved in materials less than 1/3 wavelength thick. In this case, a very open-celled (10 pores per inch) foam is used. A gradual transition is achieved via a conductive carbon coating. Figure 5 depicts typical performance where reflectivity levels of -20dB are achieved from 4 to 18GHz and above at a thickness of 1.25" (31,8 mm).

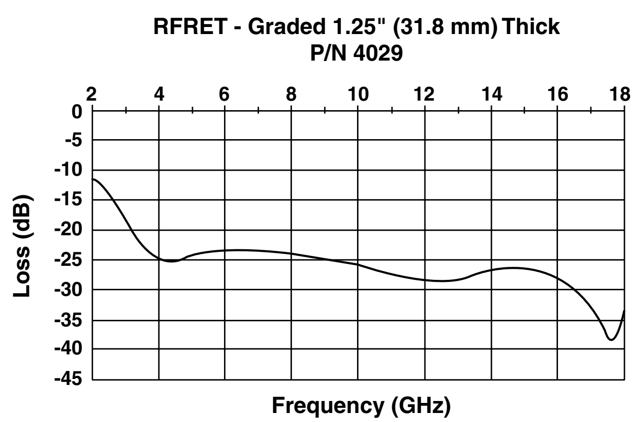
This method of gradual impedance transition can be applied to other materials. Foams, honeycombs and netting are three such matrices where practical absorbers are being produced.

FIGURE 4.



Broadband absorber with tapered impedance. The low loss front face can be obtained by physical tapering or control of dielectric properties.

FIGURE 5.



Broadband-graded reticulated foam absorber 1.25" (31.8 mm) thick.

MATERIAL SELECTION

A wide variety of absorber materials are available for use in EMI and RCS reduction. There are tradeoffs involved in the use of each candidate material. To optimize the use of absorbers in a design, there are three sets of parameters that should be critically analyzed: electrical, physical and application.

Although the "DC to daylight" goal has not been achieved, considerable strides have been made to broaden frequency coverage across the microwave region. In optimizing absorber use, the requirement must be defined as completely as possible. The following questions should be asked:

1. What frequency bands need coverage?
2. Is coverage needed over the entire region or just at specific frequencies? For example, if coverage cannot be achieved over the entire 2 to 18GHz region, will absorption at specific frequencies provide enough protection?
3. What is the order of importance in coverage? Perhaps at F_0, 20dB absorption is needed. However, at F_1, only 12dB is needed; at F_2, 7dB is acceptable. By setting these priorities, a design can be more easily reached.
4. Will the absorber be used to absorb specular energy, or is the application such that high angles of incidence radiation and surface waves must be attenuated?

By answering these questions, the various tradeoffs in electrical performance can be examined and an optimum absorber solution derived.

ELECTRICAL PERFORMANCE GUIDELINES

1. The broader the frequency coverage, the thicker, heavier and more expensive the absorber.
2. The lower the minimum frequency coverage, the thicker and heavier the absorber.
3. Normal incidence performance is better than off-normal performance for most types of absorbers, although they can be designed for off-normal performance.
4. Millimeter-wave materials are now being developed and used.

Of equal importance to the material's electrical performance is its physical performance, which includes environmental characteristics, temperature characteristics and mechanical properties. Again, a series of questions can help clarify the parameters of major importance:

1. What is the application environment? Will the absorber be enclosed or subjected to the outdoor environment?
2. What environmental forces will be degrading the absorber? Some examples are salt, water, ozone, oxygen, ultraviolet light, fuels, oils, chemicals, nuclear and stack gases.
3. Over what temperature range will the material be subjected, and within what thermal range must the material perform?
4. What mechanical stresses will be placed on the absorber? Examples are vibration, thermal shock, elongation or wind.
5. What is the expected lifetime of the absorber? For example, missile applications may not require the same degree of physical integrity as a shipboard application.

PHYSICAL PERFORMANCE GUIDELINES

1. The elastomeric-type (rubber) absorbers have better environmental resistance than the broadband foam types. These types have been used successfully on surface ships for more than 40 years.
2. A variety of elastomers are available to aid in designing for a specific environment. Hypalon® is widely used in naval applications because of superior weather resistance and color fastness. Nitrile is used for fuel and oil resistance. Fluoro-elastomers and silicones have an excellent operating temperature range.
3. Broadband absorption is obtainable with the dual-layer elastomeric absorbers.
4. Broadband foam materials can be used for external environments, but steps must be taken to protect the absorber. Open-cell foams can be filled with low-loss plastics to make rigid panels for use outdoors. Broadband absorbers can be encapsulated in fiber-reinforced plastics to form flexible absorber panels that can be draped over reflectors.
5. The useful temperature range of most absorber material is -65° F to 250° F. Certain materials are available with higher maximum temperatures.

ABSORBER TYPES

Elastomeric Absorbers

These thin, flexible absorbers are best for outdoor use. The method of application is adhesive bonding to a metal substrate. Adhesives vary with the type of elastomer chosen and include: epoxies, urethanes, contact adhesives and pressure-sensitive adhesives (PSA). In general, Hypalon and nitrile are the easiest elastomers to bond and have a variety of compatible adhesive systems available. Bond strengths in excess of 10 pounds per inch are typical. In some cases, it is necessary to cover a tight radius or complex curvature. An alternative to flat sheet material is conformally molded parts. Conformal molds increase the ease of bonding and reduce the likelihood of applying any built-in stresses into the material. For gasket applications, the elastomeric absorber may be extruded.

To improve weather resistance, the absorber is painted. Typically, an epoxy- or urethane-based paint is used. To avoid gaps between sheets, absorptive gap fillers are used to minimize any impedance mismatches from sheet to sheet. This technique also limits the formation of surface waves and reflections. Newer non-corrosive fillers, such as iron silicide, are also available for corrosive environments.

Broadband Absorbers

Open-cell foam absorbers are normally used in a protected environment, i.e. radomes or nacelles. Therefore, application becomes much less critical than for those on the exterior of a vehicle. The typical method of application is adhesive bonding. Again, a wide class of adhesives may be used, including contact cements, epoxies and acrylic PSA. In general, cohesive failure of the material will result before adhesive failure. The front surfaces may be painted or coated to further protect the absorber.

Laird Technologies uses two methods to produce broadband absorbers for external use. The first method involves taking broadband foam or netting absorber and encapsulating it in a reinforced coated fabric. The bagging material is completely enclosed around the absorber making it weather proof. This radar-absorptive cover can then be used in external environments with no physical degradation to the absorbing medium.

A second method uses a closed-cell foam filling technique to produce rigid structural absorptive panels. The absorber, RFRIGID, is lightweight and may be molded to a variety of shapes. It has broadband absorptive characteristics similar to the flexible foam RFRET absorbers. The rigid, closed-cell form may be painted and will be impervious to external environments. A variety of high-strength, lightweight, flexible fillers for RFRIGID are being developed.

RFRIGID and absorptive honeycomb may be used as the inner core for structural panels. The panel would consist of face sheets of fiberglass or Kevlar® facing the radar and graphite or metal as the ground plane. These panels are lightweight and high strength and can be used as structure in certain applications.

APPLICATIONS

The two largest applications for radar-absorbing materials are for EMI and for radar cross section reduction in military and commercial electronics.

Military

Today's modern warship has a wide variety of electronic systems on board. Navigational and target-acquisition radar, countermeasure systems and a wide variety of communication equipment are all mounted on a large metal superstructure. This arrangement creates two major problems: false images from self-reflections and system-to-system interference.

False images or "ghosts" are indirect radar returns resulting from specular reflections of radar energy off the ship's own superstructures. False echoes cause navigation hazards and, if severe enough, can make radar navigation impossible. False returns to target acquisition and fire control systems can cause the system to "lock on" to the false images. These problems can be eliminated through the use of tuned-frequency elastomeric absorbers. Tuned to the frequency of the radar, the absorber is bonded to masts, stacks, yardarms and other reflecting structures. By properly situating the material, false echoes can be reduced by 40dB.

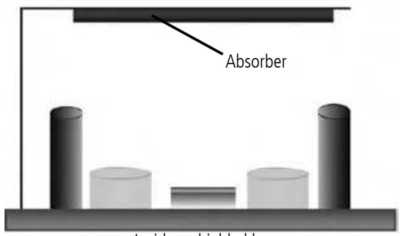
The lack of space available on modern warships causes electronic systems to be placed in close proximity. Often a signal or harmonics from one system will be received by or interfere with an adjacent system. This problem has become especially acute with the powerful broadband jamming equipment currently being deployed, but constructing absorber barriers can alleviate it. Depending on the systems involved, single-frequency, dual-frequency or broadband absorbers will be used.

Antenna pattern improvement is an area of universal application for microwave absorbers. Conductive objects in the near field of an antenna can greatly alter its free-space propagation characteristics. The net effect of this is a wider main beam with increased side lobes. This condition can reduce system discrimination and increase the possibility of side lobe jamming.
The application of absorbing material to the conductive areas will effectively match out radiation propagated in these directions and return the system to its designed free-space characteristics. A variety of antennas use absorber material for this problem, and to coat feeds, struts and mounts, which act as reflectors.

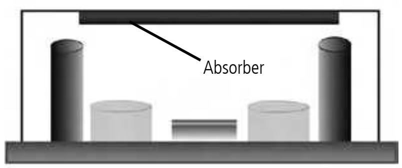
Commercial

There is a growing use of absorbers for reduction of interference in commercial electronics. High-frequency wireless devices often have powerful transmitters and sensitive receivers in close proximity inside a cavity or housing. Spurious signals can cause leakage or system interference, which degrades performance. Magnetic absorbers inside the cavity can reduce the "Q" of the cavity and absorb unwanted reflections. Applications for absorbers can be found in wireless LAN devices, network servers, VSAT transceivers, radios and other high-frequency devices. Custom shapes are die-cut from sheet material with pressure-sensitive adhesive for application inside the noisy cavity.

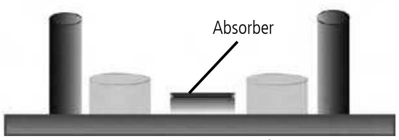
As devices such as computers and cell phones move to higher frequencies and speeds, the need for absorbers or absorbing shields will increase.



Inside a shielded box



Inside a board level shield



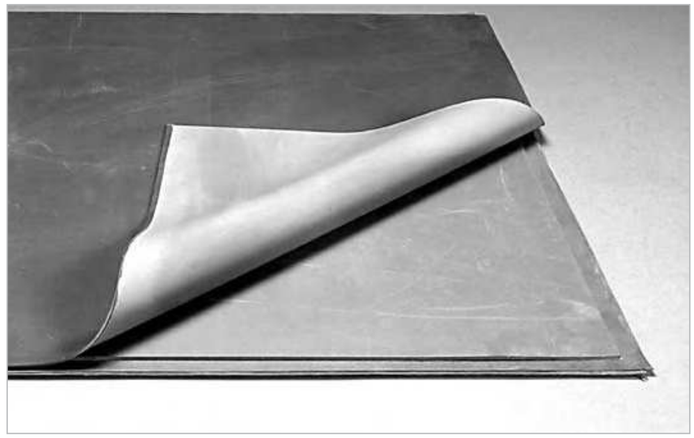
Applied directly to the top of an IC

AVAILABLE IN MULTIPLE WAYS TO FIT INDIVIDUAL APPLICATIONS
APPLICATION NOTES
- Inside a shielded box:
  Internal EMI reduction, cavity resonace reduction, used in conjunction with a board level shield
- Applied directly to the top of high speed CPUs, LSIs, and ICs
- Suppress surface currents on the rear of an LCD
- Surface wave suppression
- Crosstalk superssion
- Improves antenna gain in RFID applications
- To avoid re-spinning a PCB due to EMI issues
- To absorb noise generated between PC boards
- To absorb noise radiated through openings in shielded cavities

APPLICATION METHODS
- Microwave absorbers are most commonly applied using pressure sensitive adhesive (PSA).
- RFSW materials are most effective when used in conjunction with a reflective ground plane. This ground plane can be a metal shield, housing, or chassis. Laird Technologies can also provide these materials with an integral ground plane.
- RFLS materials are commonly used in applications where space is limited. These materials are most effective when used in conjunction with a reflective ground plane, but may also be effective when used in a plastic housing.

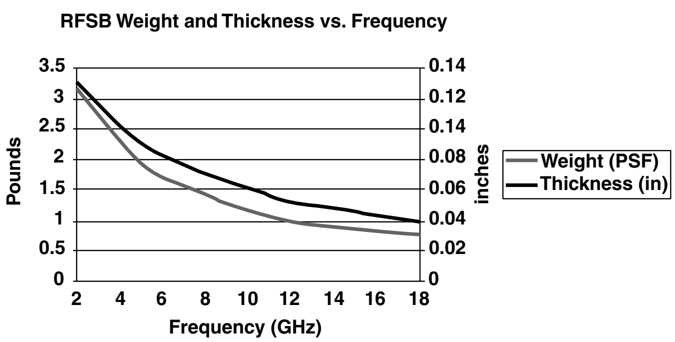
Q-Zorb RFSB absorbers are resonantly tuned to discrete frequencies between 500MHz and 100GHz. They are designed to reduce energy reflections off of a conductive ground plane by > 99% (-20dB) at normal angles of incidence. The performance is based upon the principle of phase cancellation by the incident energy reflection being out of phase with the ground plane reflection. For further discussion on resonant absorbers see "Introduction to Microwave Absorbers" on page 3.

The materials are thin, flexible and easy to cut and install. They are elastomer based with a variety of choices available. For example, silicone is chosen for high-temperature applications, nitrile for fuel and oil resistance and natural rubber for commercial applications. Several magnetic fillers are available; carbonyl iron powder is standard, but other materials such as iron silicide (FeSi) are used for corrosion-resistant applications. The density of the materials is based on the volume percentage of magnetic filler. Table 1 gives the relationship between resonant frequency, weight and thickness.



RFSB absorbers require a conductive backing to achieve the reflectivity results shown. For applications where a conductive backing is not available, Laird Technologies can supply a ground plane bonded to the sheet. Pressure-sensitive adhesives can also be provided for ease of installation.

TABLE 1: RFSB WEIGHT AND THICKNESS VS. FREQUENCY



APPLICATIONS

Single band absorbers are used for maximum normal incidence attenuation at a discrete frequency. They are commonly used to minimize antenna reflections off of a structure or for antenna pattern shaping. They are also used for discrete frequency test chambers for devices such as transceivers, wireless devices and antenna test hoods. They are typically molded in flat sheets, but can be molded into conformal shapes or extruded into tape, gaskets and tubing.

FIGURE 1.

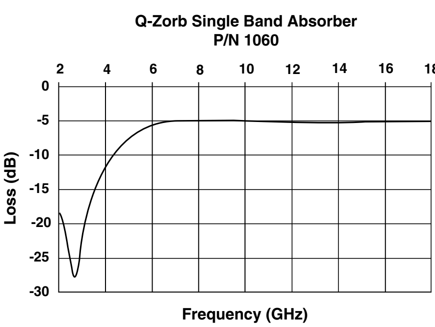


FIGURE 3.

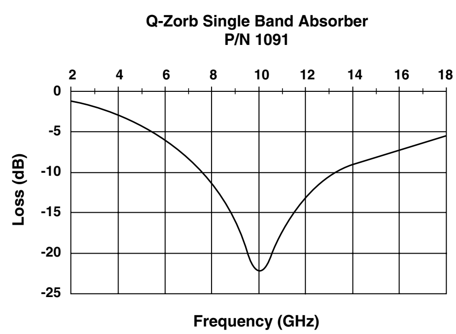


FIGURE 2.

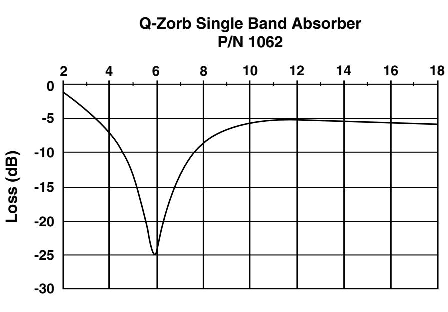
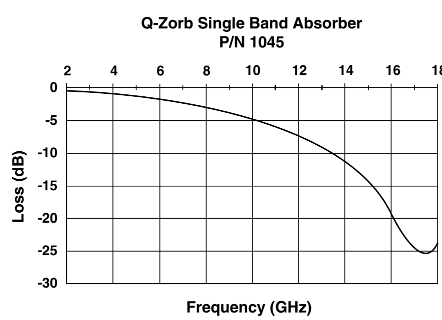


FIGURE 4.



All dimensions shown are in inches (millimeters) unless otherwise specified.

ORDERING INFORMATION

Select the desired frequency of operation (listed in ascending order) from Table 2. This selection will govern dB loss and thickness. Then choose the material type and other options including flame retardant (FR), pressure-sensitive adhesive (PSA), ground plane (GP), or iron silicide (FeSi) and select a part number.

Material Types Available:

FS - Fluorosilicone
H - Hypalon®
N - Nitrile
R- Natural Rubber
S- Silicone
U - Urethane
V - Viton
W - Neoprene

PART NUMBER	MATERIAL TYPE	FREQ (GHZ)	DB LOSS	THICKNESS IN (MM)	OTHER
1122	R	1.000	-15.0	0.250 (6,4)	
1019	N	1.400	-15.0	0.165 (4,2)	
1065	R	1.500	-15.0	0.150 (3.8)	PSA
1048	R	1.500	-15.0	0.150 (3,8)	
1039	N	1.575	-20.0	0.148 (3,8)	PSA
1049	R	1.880	-20.0	0.140 (3,6)	PSA
1031	N	1.960	-17.0	0.132 (3,4)	PSA
1007	N	1.960	-17.0	0.132 (3,4)	
1236	S	2.000	-20.0	0.132 (3,4)	PSA
1027	S	2.100	-20.0	0.105 (2,7)	
1125	N	2.250	-20.0	0.115 (2,9)	PSA
1124	N	2.250	-20.0	0.115 (2,9)	
1060	R	2.400	-20.0	0.100 (2,5)	PSA
1059	R	2.400	-20.0	0.100 (2,5)	
1267	S	3.000	-20.0	0.105 (2,7)	PSA
1084	N	3.000	-20.0	0.115 (2,9)	GP
1083	N	3.000	-20.0	0.115 (2,9)	
1044	N	3.200	-20.0	0.105 (2,7)	PSA
1043	N	3.200	-20.0	0.105 (2,7)	
1042	S	3.500	-20.0	0.095 (2,4)	PSA
1040	S	3.500	-20.0	0.095 (2,4)	
1167	S	4.000	-20.0	0.078 (2,0)	PSA
1101	S	4.000	-20.0	0.095 (2,4)	
1086	N	4.000	-20.0	0.110 (2,8)	GP
1085	N	4.000	-20.0	0.110 (2,8)	
1071	R	4.500	-20.0	0.095 (2,4)	PSA
1070	R	4.500	-20.0	0.095 (2,4)	
1268	S	5.000	-20.0	0.095 (2,4)	PSA
1104	S	5.000	-20.0	0.095 (2,4)	
1126	N	5.200	-20.0	0.095 (2,4)	PSA
1073	N	5.200	-20.0	0.095 (2,4)	
1016	R	5.600	-20.0	0.075 (1,9)	PSA
1164	S	6.000	-20.0	0.082 (2,1)	PSA
1062	S	6.000	-20.0	0.082 (2,1)	PSA
1061	S	6.000	-20.0	0.082 (2,1)	
1088	N	6.000	-20.0	0.085 (2,2)	GP
1087	N	6.000	-20.0	0.085 (2,2)	
1008	R	6.175	-20.0	0.080 (2,0)	PSA
1105	S	6.500	-20.0	0.075 (1,9)	
1021	R	6.500	-20.0	0.075 (1,9)	PSA
1056	N	6.500	-20.0	0.085 (2,2)	PSA
1269	S	7.000	-20.0	0.070 (1,8)	PSA
1106	S	7.500	-20.0	0.075 (1,9)	
1033	N	7.500	-20.0	0.075 (1,9)	PSA
1032	N	7.500	-20.0	0.075 (1,9)	
1080	S	7.750	-20.0	0.066 (1,7)	PSA
1079	S	7.750	-20.0	0.066 (1,7)	
1107	S	8.000	-20.0	0.070 (1,8)	
1270	S	8.000	-20.0	0.070 (1,8)	PSA
1057	N	8.000	-20.0	0.070 (1,8)	PSA

PART NUMBER	MATERIAL TYPE	TYPE FREQ (GHZ)	DB LOSS	THICKNESS IN (MM)	OTHER
1090	N	8.000	-20.0	0.070 (1,8)	GP
1089	N	8.000	-20.0	0.070 (1,8)	
1137	N	8.150	-20.0	0.090 (2,3)	
1130	S	8.400	-20.0	0.070 (1,8)	
1034	N	8.400	-20.0	0.065 (1,7)	PSA
1005	N	8.400	-20.0	0.065 (1,7)	
1271	S	9.000	-20.0	0.680 (1,7)	PSA
1017	N	9.375	-20.0	0.063 (1,6)	PSA
1118	N	9.400	-20.0	0.063 (1,6)	GP-PSA
1013	N	9.400	-20.0	0.063 (1,6)	
1068	S	9.500	-20.0	0.060 (1,5)	
1078	N	9.500	-20.0	0.062 (1,6)	PSA
1077	N	9.500	-20.0	0.062 (1,6)	
1025	S	9.700	-20.0	0.060 (1,5)	
1092	N	10.000	-20.0	0.060 (1,5)	GP
1091	N	10.000	-20.0	0.060 (1,5)	PSA
1259	S	10.000	-20.0	0.060 (1,5)	PSA
1018	N	10.100	-20.0	0.060 (1,5)	PSA
1024	N	10.200	-20.0	0.065 (1,7)	
1063	N	10.525	-20.0	0.065 (1,7)	PSA
1109	S	11.000	-20.0	0.055 (1,4)	
1009	R	11.200	-20.0	0.055 (1,4)	PSA
1029	R	11.200	-20.0	0.055 (1,4)	GP-PSA
1023	R	11.200	-20.0	0.055 (1,4)	GP
1115	S	12.000	-20.0	0.052 (1,3)	
1161	S	12.000	-20.0	0.052 (1,3)	PSA
1006	R	12.000	-20.0	0.060 (1,5)	
1110	S	13.000	-20.0	0.050 (1,3)	
1094	N	13.000	-20.0	0.050 (1,3)	GP
1093	N	13.000	-20.0	0.050 (1,3)	
1067	S	14.000	-20.0	0.045 (1,1)	
1168	S	14.000	-20.0	0.045 (1,1)	PSA
1022	N	14.000	-20.0	0.050 (1,3)	PSA
1010	R	14.375	-20.0	0.056 (1,4)	PSA
1096	N	15.000	-20.0	0.045 (1,1)	GP
1097	N	15.000	-20.0	0.045 (1,1)	
1160	S	16.000	-20.0	0.040 (1,0)	PSA
1045	N	16.700	-20.0	0.035 (0,9)	PSA
1111	S	18.000	-20.0	0.040 (1,0)	
1272	S	18.000	-20.0	0.045 (1,1)	PSA
1014	R	18.200	-20.0	0.040 (1,0)	PSA
1038	R	18.200	-20.0	0.040 (1,0)	
1112	S	22.000	-20.0	0.035 (0,9)	GP
1116	S	22.400	-20.0	0.035 (0,9)	
1015	R	22.400	-20.0	0.035 (0,9)	PSA
1117	S	22.000	-20.0	0.045 (1,1)	PSA
1273	S	24.000	-20.0	0.035 (0,9)	PSA
1132	N	35.000	-20.0	0.035 (0,9)	
1274	S	38.000	-20.0	0.030 (0,8)	PSA

All dimensions shown are in inches (millimeters) unless otherwise specified.

Q-ZORB® RFSW - SURFACE WAVE ABSORBERS

Q-Zorb RFSW surface wave absorbers are thin, magnetically loaded elastomeric sheets designed to provide attenuation at high angles of incidence for surface wave attenuation. They are nominally manufactured in the thickness range of 0.015" to 0.125" (0,4 mm to 3,2 mm). They are elastomer-based with a variety of choices available. For example, silicone is chosen for high-temperature applications, nitrile for fuel and oil resistance and natural rubber for commercial applications. Several magnetic fillers are available; carbonyl iron powder is standard, but other materials such as iron silicide (FeSi) are used for corrosion-resistant applications. The materials are available in UL fire retardant versions for use in commercial devices. Laird Technologies can provide the material die-cut and with a pressure-sensitive adhesive for ease of installations. Sheets are offered in nominal sizes of 24" x 24" (609,6 mm x 609,6 mm), although custom sizes and molded components are available.

APPLICATIONS

The material can be used inside of microwave housings to reduce internal resonance and to lower the "Q" of the microwave cavity. They are also effective in isolating antennas from ground plane reflections. Q-Zorb can be used with board level shielding and other types of EMI shielding to enhance the shielding effectiveness at frequencies from 2-40GHz.

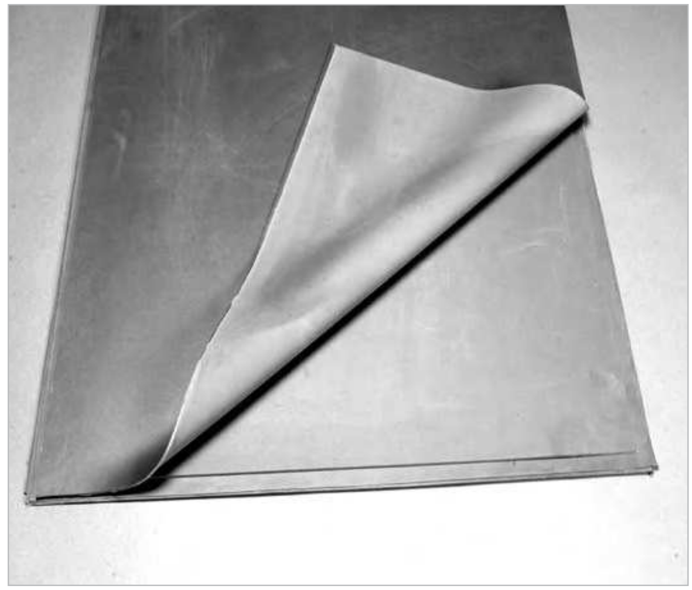


FIGURE 1.

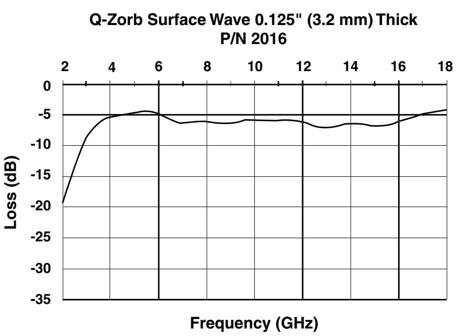


FIGURE 2.

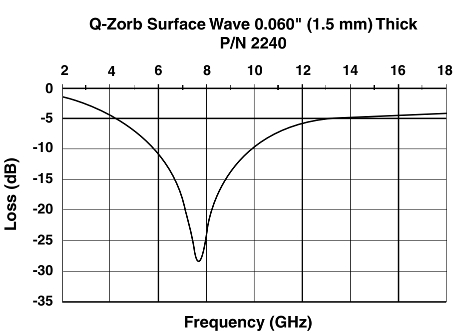


FIGURE 3.

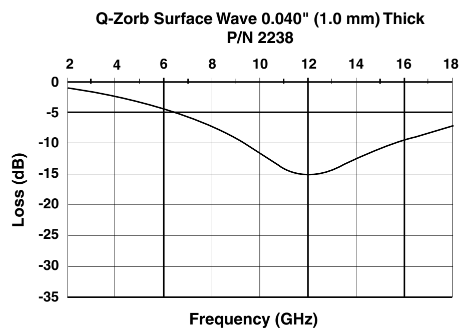
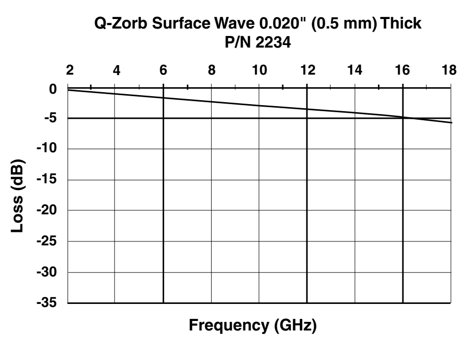


FIGURE 4.



Q-ZORB® RFSW - SURFACE WAVE ABSORBERS (CON'T)

ORDERING INFORMATION

Select desired frequency of operation (listed in ascending order) from Table 1 on the next page. This selection will govern dB loss and thickness. Then choose material type and other options including flame retardant (FR), pressure-sensitive adhesive (PSA), ground plane (GP), or iron silicide (FeSi) and select a part number.

Material Types Available:

FS - Fluorosilicone
H - Hypalon®
N - Nitrile
R - Natural Rubber
S - Silicone
U - Urethane
V - Viton®
W - Neoprene

TABLE 1: RFSW - SURFACE WAVE ABSORBER PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

2000 - 2999 RFSW - SURFACE WAVE ABSORBERS

PART NUMBER	MATERIAL TYPE	THICKNESS IN (MM)	OPT. FREQ. RANGE (GHZ)*	OTHER
2138	S	0.187 (4,7)	< 2	
2130	N	0.180 (4,6)	< 2	
2062	R	0.180 (4,6)	< 2	PSA
2178	R	0.180 (4,6)	< 2	
2049	R	0.175 (4,4)	< 2	PSA
2247	R	0.175 (4,4)	< 2	
2032	R	0.170 (4,3)	< 2	
2222	S	0.138 (3,5)	< 2	
2129	N	0.125 (3,2)	2-4	PSA
2171	N	0.125 (3,2)	2-4	GP
2170	N	0.125 (3,2)	2-4	
2016	R	0.125 (3,2)	2-4	PSA
2196	R	0.125 (3,2)	2-4	
2142	S	0.125 (3,2)	2-4	PSA
2242	S	0.125 (3,2)	2-4	FR-PSA
2264	S	0.125 (3,2)	2-4	
2162	N	0.115 (2,9)	2-4	PSA
2161	N	0.115 (2,9)	2-4	
2041	N	0.110 (2,8)	2-4	PSA
2044	R	0.110 (2,8)	2-4	PSA
2258	R	0.110 (2,8)	2-4	
2021	N	0.100 (2,5)	2-4	
2220	R	0.100 (2,5)	2-4	PSA
2094	R	0.100 (2,5)	2-4	
2272	S	0.100 (2,5)	2-4	FR-PSA
2230	S	0.100 (2,5)	2-4	
2167	N	0.095 (2,4)	4-8	
2034	R	0.095 (2,4)	4-8	PSA
2190	S	0.093 (2,4)	4-8	
2068	R	0.090 (2,3)	4-8	PSA
2087	R	0.090 (2,3)	4-8	
2042	N	0.085 (2,2)	4-8	PSA
2002	N	0.085 (2,2)	4-8	
2123	N	0.080 (2,0)	4-8	PSA
2122	N	0.080 (2,0)	4-8	
2023	R	0.080 (2,0)	4-8	PSA
2095	S	0.080 (2,0)	4-8	PSA
2257	S	0.080 (2,0)	4-8	FR-PSA
2256	S	0.080 (2,0)	4-8	FR
2141	S	0.078 (2,0)	4-8	PSA
2231	S	0.078 (2,0)	4-8	
2248	N	0.075 (1,9)	4-8	
2047	R	0.075 (1,9)	4-8	
2225	R	0.072 (1,8)	4-8	
2266	N	0.072 (1,8)	4-8	PSA
2265	N	0.072 (1,8)	4-8	
2080	N	0.065 (1,7)	8-12	PSA
2082	N	0.065 (1,7)	8-12	GP-PSA
2081	N	0.065 (1,7)	8-12	GP
2097	N	0.065 (1,7)	8-12	
2005	R	0.062 (1,6)	8-12	PSA
2039	N	0.060 (1,5)	8-12	PSA
2147	N	0.060 (1,5)	8-12	

PART NUMBER	MATERIAL TYPE	THICKNESS IN (MM)	OPT. FREQ RANGE (GHZ)"	OTHER
2038	R	0.060 (1,5)	8-12	PSA
2263	R	0.060 (1,5)	8-12	
2261	S	0.060 (1,5)	8-12	PSA
2240	S	0.060 (1,5)	8-12	FR-PSA
2239	S	0.060 (1,5)	8-12	FR
2221	S	0.060 (1,5)	8-12	
2134	R	0.055 (1,4)	8-12	PSA
2133	R	0.055 (1,4)	8-12	
2113	N	0.052 (1,3)	8-12	PSA
2169	N	0.052 (1,3)	8-12	
2056	N	0.050 (1,3)	8-12	PSA
2296	s	0.050 (1,3)	8-12	FR-PSA
2057	N	0.050 (1,3)	8-12	GP-PSA
2093	N	0.045 (1,1)	8-12	
2105	R	0.044 (1,1)	8-12	
2153	S	0.044 (1,1)	8-12	
2168	N	0.043 (1,1)	8-12	
2143	N	0.040 (1,0)	8-12	PSA
2099	N	0.040 (1,0)	8-12	
2031	R	0.040 (1,0)	8-12	PSA
2146	R	0.040 (1,0)	8-12	
2218	S	0.040 (1,0)	8-12	PSA
2238	S	0.040 (1,0)	8-12	FR-PSA
2237	S	0.040 (1,0)	8-12	FR
2270	S	0.038 (1,0)	8-12	
2028	N	0.036 (0,9)	12-18	GP
2252	S	0.036 (0,9)	12-18	FR-PSA
2251	S	0.035 (0,9)	12-18	FR
2204	N	0.035 (0,9)	12-18	PSA
2260	N	0.030 (0,8)	12-18	
2045	N	0.030 (0,8)	12-18	PSA
2191	N	0.030 (0,8)	12-18	GP
2181	N	0.030 (0,8)	12-18	
2151	R	0.030 (0,8)	12-18	
2152	S	0.030 (0,8)	12-18	PSA
2236	S	0.030 (0,8)	12-18	FR-PSA
2235	S	0.030 (0,8)	12-18	FR
2046	S	0.028 (0,7)	12-18	
2144	R	0.028 (0,7)	12-18	PSA
2119	S	0.027 (0,6)	12-18	
2140	N	0.025 (0,6)	12-18	
2078	N	0.025 (0,6)	12-18	
2136	S	0.025 (0,6)	12-18	
2053	N	0.020 (0,5)	12-18	PSA
2201	R	0.020 (0,5)	12-18	PSA
2112	R	0.020 (0,5)	12-18	
2120	S	0.020 (0,5)	12-18	PSA
2234	S	0.020 (0,5)	12-18	FR-PSA
2233	S	0.020 (0,5)	12-18	FR
2075	S	0.020 (0,5)	12-18	
2966	S	0.015 (0,4)	12-18	PSA
2963	S	0.012 (0,3)	12-18	PSA
2960	S	0.010 (0,3)	12-18	PSA

* Adequate surface wave performance may be achieved by using thinner materials. Consult Laird Technologies applications engineers for assistance.

All dimensions shown are in inches (millimeters) unless otherwise specified.

RFRET - RETICULATED FOAM ABSORBERS

RFRET is a reticulated foam absorber. Reticulated foam is an urethane-based foam with a well-defined open-cell structure. The cell size can be chosen to optimize penetration of the conductive coating to which it is adhered. Laird Technologies uses two separate processes to produce its reticulated foam absorber. This unique spray process applies a coating that is graded through the thickness of the foam. The grading of the coating also produces an electrical grading that results in a material with excellent broadband reflectivity reduction.

Laird Technologies also uses a dip process to produce foam with uniform electrical properties. This type of foam is described in more detail in the Lossy foam section on page 13. RFRETĐLS is produced to a specific insertion loss (dB/in.) at a specific insertion loss (dB/in.) at a specific frequency (generally 3 or 10GHz).

Laird Technologies also dips RFRET-CV, a convoluted egg-crate shaped foam. This shaping allows for graded impedance, which provides broadband reflectivity reduction. RFRET-CV is produced in thicknesses from 1.5" to 4" (38,1 mm to 101,6 mm) and is used when broadband performance from 2 to 18GHz is required. The product can be supplied with a bonded-on ground plane and pressure-sensitive adhesive.

APPLICATIONS

RFRET broadband foam is commonly used around antennas to provide isolation or side lobe reduction. It can be die-cut into components for EMI reduction inside microwave cavities and is used to manufacture antenna hats and test boxes. It can be encapsulated into a textile cover for use outdoors and fabricated into blankets, covers and other components. Recently, it has been used for a combination air/EMI filter in networking equipment. The product can be made UL94 HF1 for such applications.

FIGURE 1.

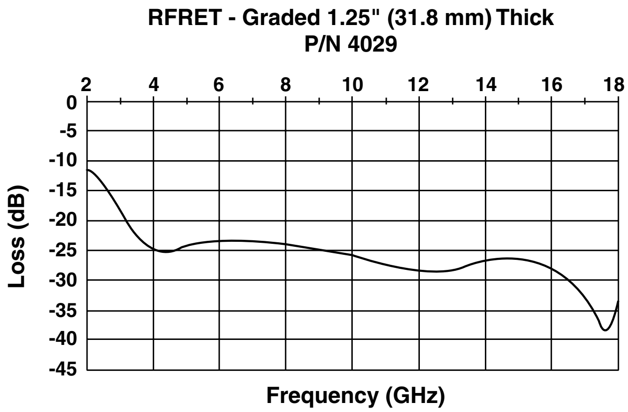


FIGURE 2.

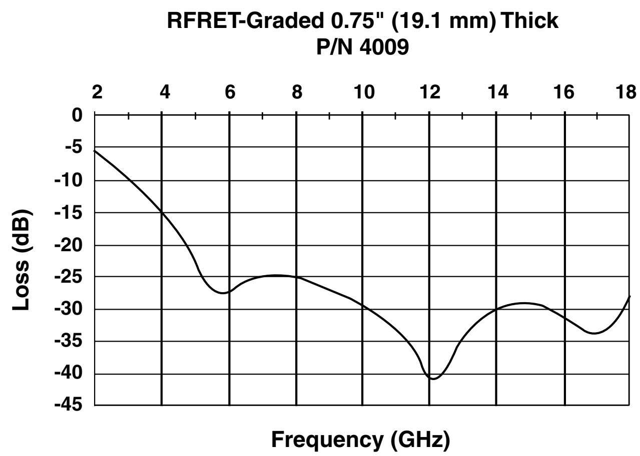
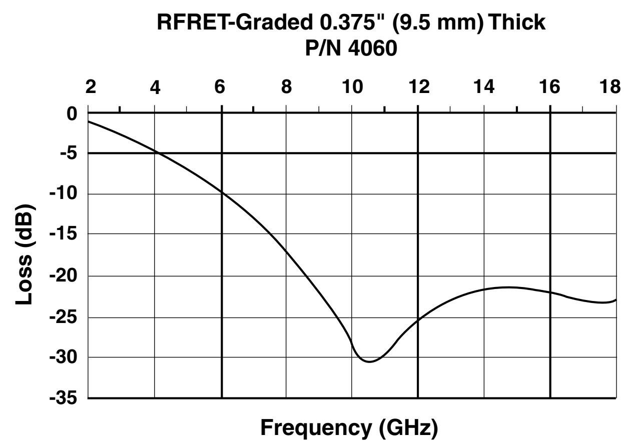


FIGURE 3.



ORDERING INFORMATION

Tables 1-3, on page 12, provide ordering information and existing part numbers for three types of reticulated foam absorbers: RFRET-Graded Coating, RFRET-Uniform Coating and RFRET/CV Convoluted Reticulated Foam.

RFRET - GRADED COATING

Select desired frequency range, noting thickness (in ascending order) from Table 1. The base part number determines the length, width and frequency range. The other options column indicates flame retardant (FR), pressure-sensitive adhesive (PSA) or ground plane (GP).

All dimensions shown are in inches (millimeters) unless otherwise specified.

TABLE 1: RFRET - GRADED COATING PART NUMBERS

Note: Other combinations of attributes or materials are available; please contact sales for assistance.

4000 - 4299 RFRET - GRADED COATING

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	FREQ. RANGE (GHZ) 20DB	OTHER
4044	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	12-18	FR
4032	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	12-18	
4054	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	10-18	
4050	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	10-18	FR
4000	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	10-18	
4078	0.375 (9,5)	48.0 (1219,2)	24.0 (609,6)	10-18	GP
4058	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	10-18	GP-PSA
4060	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	10-18	PSA
4074	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	8-18	
4001	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	8-18	
4014	0.500 (12,7)	96.0 (2438,4)	24.0 (609,6)	8-18	
4056	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	8-18	GP
4002	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	
4012	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	
4006	0.750 (19,1)	96.0 (2438,4)	24.0 (609,6)	6-18	
4009	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	
4038	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	
4022	0.750 (19,1)	59.0 (1498,6)	24.0 (609,6)	6-18	
4043	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	GP
4059	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	PSA
4062	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	5-18	
4036	1.125 (28,6)	60.0 (1524,0)	30.0 (762,0)	4-18	
4037	1.125 (28,6)	96.0 (2438,4)	30.0 (762,0)	4-18	
4003	1.125 (28,6)	24.0 (609,6)	24.0 (609,6)	4-18	
4015	1.125 (28,6)	24.0 (609,6)	24.0 (609,6)	4-18	GP
4029	1.250 (31,8)	24.0 (609,6)	24.0 (609,6)	4-18	
4071	1.250 (31,8)	24.0 (609,6)	24.0 (609,6)	4-18	GP-PSA
4076	1.250 (31,8)	24.0 (609,6)	24.0 (609,6)	4-18	PSA
4021	1.500 (38,1)	24.0 (609,6)	24.0 (609,6)	4-18	
4073	2.000 (50,8)	40.0 (1016,0)	30.0 (762,0)	2-18	
4020	2.000 (50,8)	24.0 (609,6)	24.0 (609,6)	2-18	
4051	2.000 (50,8)	24.0 (609,6)	24.0 (609,6)	2-18	FR
4024	2.000 (50,8)	24.0 (609,6)	24.0 (609,6)	2-18	
4026	2.000 (50,8)	60.0 (1524,0)	30.0 (762,0)	2-18	
4077	2.000 (50,8)	24.0 (609,6)	24.0 (609,6)	2-18	GP
4040	3.000 (76,2)	24.0 (609,6)	24.0 (609,6)	2-18	

RFRET-UNIFORM COATING

Table 2 shows existing part numbers for uniform reticulated foam materials. Select the desired thickness and part number. Within a given thickness, the insertion loss can be tailored by the addition of more conductive carbon coating. Performance is measured in dB insertion loss compared to air either at 3 or 10GHz. The other column indicates flame retardancy (FR), pressure-sensitive adhesive (PSA) or ground plane (GP).

Standard sheet size is 24" x 24" (609,6 mm x 609,6 mm); other sizes are also available.

All dimensions shown are in inches (millimeters) unless otherwise specified.

TABLE 2: RFRET - UNIFORM COATING RETICULATED FOAM PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

4300 - 4399 RFRET - UNIFORM COATING

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	INSERTION LOSS AT 3GHZ (DB/IN)	INSERTION LOSS AT 10GHZ (DB/IN)	OTHER
4312	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)		-8.0	
4313	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)		-12.0	
4341	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)		-49.0	PSA
4308	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)		-68.0	
4340	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)		-76.0	
4314	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)		-18.0	
4315	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	-40.0		
4316	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	-20.0		
4318	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	-40.0		
4347	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	-10.5		
4320	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	-11.5		
4346	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	-5.0		

RFRET/CV - CONVOLUTED RETICULATED FOAM

Table 3 lists existing part numbers for convoluted reticulated foam materials. Select the desired frequency range and thickness and determine the part number. The thicker the foam material, the broader the frequency ranges of coverage. Performance is nominally -20dB reflectivity reduction over the frequency range listed. Standard sheet size is 24 x 24"(609,6 x 609,6 mm); other sizes are also available.

TABLE 3: RFRET/CV - CONVOLUTED RETICULATED FOAM PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

4500-4599 RFRET/CV - CONVOLUTED RETICULATED FOAM

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	FREQ. RANGE (GHZ)-20DB	OTHER
4506	1.500 (38,1)	24.0 (609,6)	24.0 (609,6)	4-18	
4507	1.500 (38,1)	24.0 (609,6)	48.0 (1219,2)	4-18	
4511	1.500 (38,1)	24.0 (609,6)	24.0 (609,6)	2-18	FR
4513	2.000 (50,8)	24.0 (609,6)	24.0 (609,6)	2-18	
4514	2.000 (50,8)	24.0 (609,6)	24.0 (609,6)	2-18	GP
4500	2.500 (63,5)	24.0 (609,6)	24.0 (609,6)	2-18	
4509	2.500 (63,5)	24.0 (609,6)	24.0 (609,6)	2-18	
4503	2.750 (69,9)	24.0 (609,6)	24.0 (609,6)	2-18	
4501	3.000 (76,2)	24.0 (609,6)	24.0 (609,6)	2-18	
4504	3.000 (76,2)	24.0 (609,6)	24.0 (609,6)	2-18	
4512	3.000 (76,2)	24.0 (609,6)	24.0 (609,6)	2-18	PSA
4502	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	2-18	
4505	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	2-18	PSA
4510	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	2-18	GP

RFLS - SINGLE LAYER "LOSSY" FOAM ABSORBERS

RFLS is a series of single layer "lossy" sheets produced by dipping lightweight open-celled urethane foam into a resistive solution. The end product is a uniform, lightweight, loaded sheet material with a specified insertion loss at a given frequency. RFLS offers the lowest cost in microwave absorber products. Thickness of the sheets range from 0.125" to 1.5" (3,2 mm to 38,1 mm) and are generally 24" x 24" (609,6 mm x 609,6 mm). Custom sizes and components can be fabricated. The insertion loss of the product is measured in an insertion tunnel over the 2 to 18GHz frequency range. Specifications are generally given at 3 or 10GHz. The material can be die-cut into components and supplied with a pressure-sensitive adhesive for ease of application.

APPLICATIONS

RFLS sheets are used to lower noise or cavity Q's in microwave components such as amplifiers, oscillators, computer housings and wireless equipment. Fire retardant versions to UL94 HF1 are also available.

FIGURE 1.

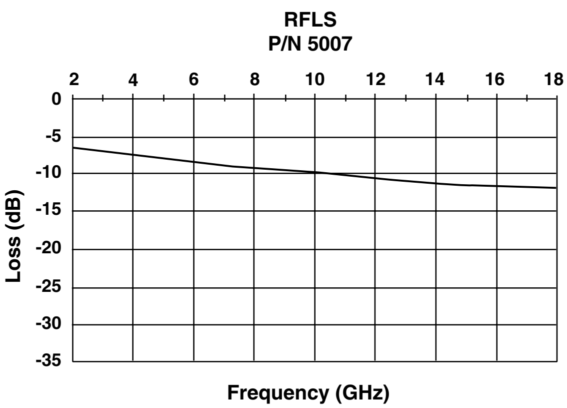
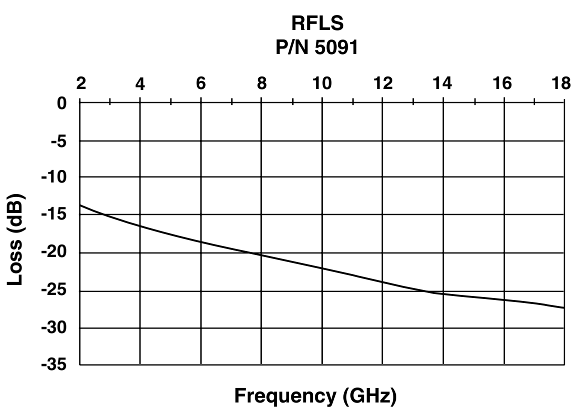


FIGURE 2.



ORDERING INFORMATION

Table 1 lists existing part numbers for uniform Lossy foam materials. Select the thickness (in ascending order) and the part number. Within a given thickness, the insertion loss can be tailored by the addition of more of the conductive carbon coating. The other columns indicate flame retardant (FR), pressure-sensitive adhesive (PSA) or ground plane (GP). Performance is measured in dB insertion loss compared to air at 3GHz. Standard sheet size is 24" x 24" (609,6 mm x 609,6 mm); other sizes are also available.

All dimensions shown are in inches (millimeters) unless otherwise specified.

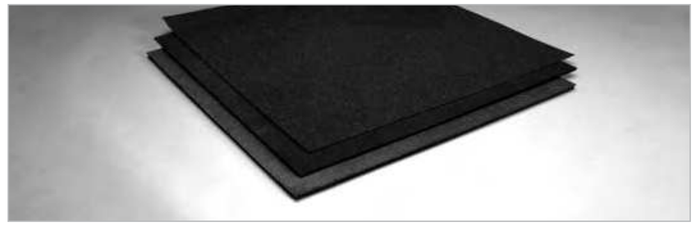


TABLE 1: RFLS - SINGLE LAYER "LOSSY" SHEETS PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

5000 - 5299 RFLS - SINGLE LAYER "LOSSY" SHEETS

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	INSERTION LOSS PER IN AT 3GHZ (DB/IN)	OTHER
5020	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-7.8	
5047	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-10.0	
5072	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-15.0	
5093	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-15.0	PSA
5049	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-32.0	
5073	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-38.0	PSA
5040	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-46.0	
5099	0.125 (3,2)	24.0 (609,6)	24.0 (609,6)	-46.0	
5002	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-1.1	
5007	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-1.7	
5006	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-2.5	
5005	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-3.8	
5082	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-4.1	
5008	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-5.9	
5009	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-7.8	
5081	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-10.0	
5003	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-32.0	
5079	0.250 (6,4)	108.0 (24743,2)	24.0 (609,6)	-32.0	
5004	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-39.0	
5010	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-46.0	
5016	0.250 (6,4)	110.0 (2794,0)	24.0 (609,6)	-49.0	
5092	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-49.0	
5011	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	-58.0	PSA
5048	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	-10.0	
5017	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	-15.0	
5060	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	-32.0	
5078	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	-39.0	
5021	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	-46.0	
5095	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	-6.5	
5089	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	-25.0	
5090	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	-25.0	PSA
5014	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	-13.0	
5091	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	-15.0	
5086	1.000 (25,4)	24.0 (609,6)	24.0 (609,6)	-30.0	
5059	1.250 (31,8)	24.0 (609,6)	24.0 (609,6)	-10.0	PSA
5068	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	-1.5	
5069	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	-2.0	
5070	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	-3.0	
5071	4.000 (101,6)	24.0 (609,6)	24.0 (609,6)	-4.0	

RFML - MULTILAYER FOAM ABSORBERS

RFML is a multilayer foam absorber consisting of three sheets of RFLS material. The layers vary in insertion loss from the front to the back of the material. For example, RFML-75 is 0.75" (19,1 mm) thick and consists of three layers of RFLS 0.25" (6,4 mm) bonded together. The top layer is very lightly loaded to provide a good impedance match to free space. This matching layer reduces the energy reflected off the surface of the material. The second and third layers have increasing loss and the net effect is a material that has broadband reflectivity reduction.

The thickness range of the RFML product is 0.375" to 4.5" (9,5 mm x 114,3 mm), and the standard sheet size is 24" x 24" (609,6 mm x 609,6 mm). The foam can be cut with a band saw or electric knife into final shape.

The material can be supplied with a bonded-on ground plane and pressure-sensitive adhesive. It can also be supplied weatherproof by bonding a neoprene or vinyl fabric to the material.

APPLICATIONS

RFML is used to reduce cross talk between antennas and reduce antenna side lobes. It can also be used in chambers to minimize reflections from test equipment and other objects in the field of measurement. While the attenuation is not as deep and flat as the RFRET graded product, its higher density makes it the absorber of choice in many applications.

FIGURE 1.

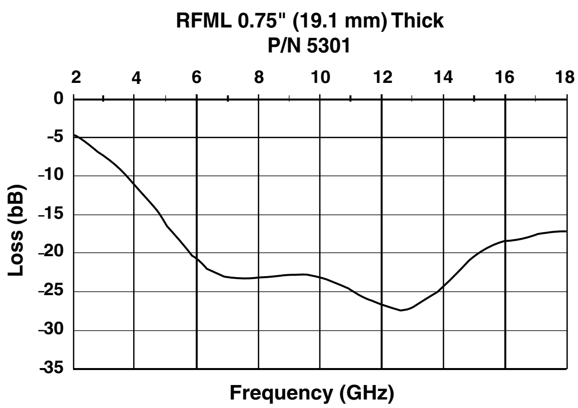
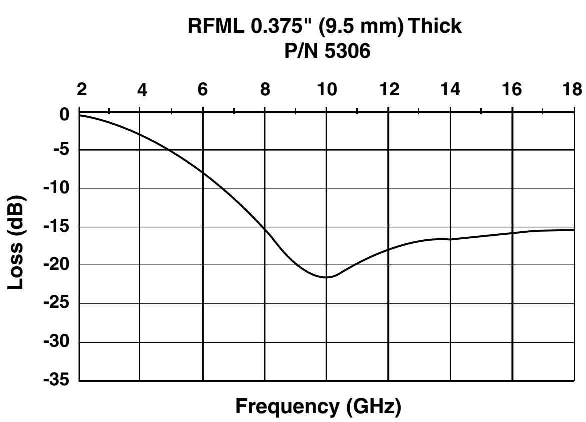
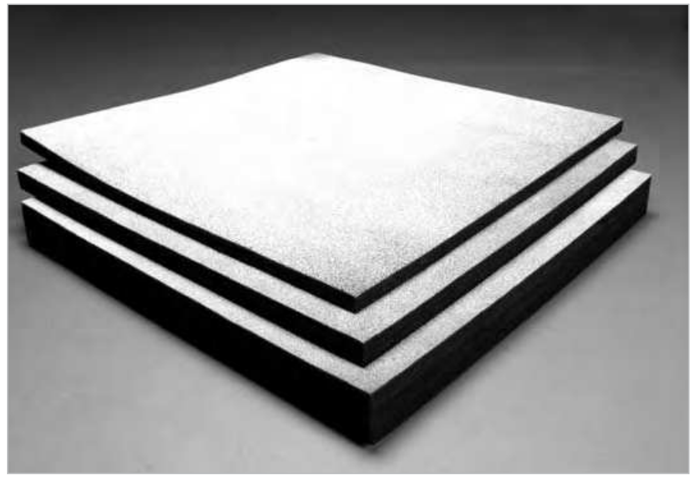


FIGURE 2.





ORDERING INFORMATION

Table 1 lists the existing part numbers for broadband multilayer absorbers. Select the desired frequency range, noting thickness (in ascending order). The base part number determines the length, width and frequency range. The other column indicates pressure-sensitive adhesive (PSA) and ground plane (GP).

Performance is nominally >-15dB reflectivity reduction over the frequency range listed. Standard sheet size is 24" x 24" (609,6 mm x 609,6 mm).

TABLE 1: RFML - MULTILAYER ABSORBER PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

5300 - 5599 RFML - MULTILAYER ABSORBERS

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	FREQ RANGE (GHZ)	DB LOSS	OTHER
5305	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	12-18	-15	
5311	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	8-18	-15	PSA
5309	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	8-18	-15	GP-PSA
5314	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	8-18	-15	FR
5306	0.375 (9,5)	24.0 (609,6)	24.0 (609,6)	8-18	-15	
5312	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	-15	PSA
5310	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	-15	GP-PSA
5313	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	-15	GP
5301	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	6-18	-15	
5307	1.125 (28,6)	24.0 (609,6)	24.0 (609,6)	4-18	-15	PSA
5303	1.125 (28,6)	24.0 (609,6)	24.0 (609,6)	4-18	-15	
5300	2.250 (57,2)	24.0 (609,6)	24.0 (609,6)	2-18	-15	
5308	4.500 (114,3)	24.0 (609,6)	24.0 (609,6)	< 2-18	-15	

All dimensions shown are in inches (millimeters) unless otherwise specified.

RFRIGID - STRUCTURAL MICROWAVE ABSORBING FOAM

Laird Technologies manufactures a structural foam family with microwave absorbing properties. It is based on the RFRET reticulated foam absorber. RFRET is an excellent free-space absorber, but lacks toughness and environmental resistance. Because RFRET is open-celled, it can be filled with closed-celled structural foam to form RFRIGID. Three standard fillers are used: rigid urethane, flexible urethane and epoxy. The resulting products range from 10 to 20 pounds per cubic foot density and offer a structural, environmentally tough panel. The materials can be molded to shape, machined or bonded into complex covers and shapes. If skins are applied, rigid lightweight structural panels are formed.

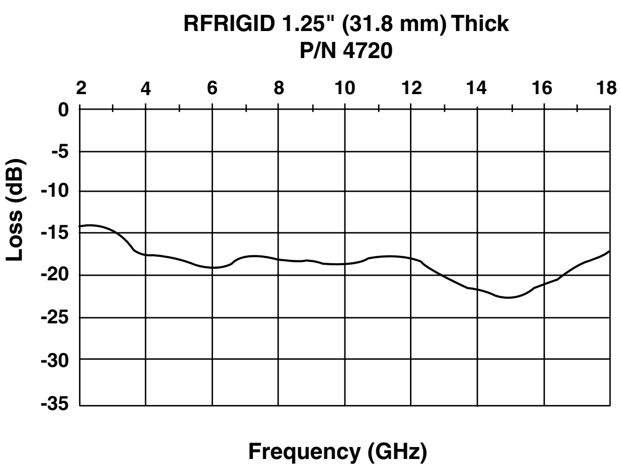
Laird Technologies has developed new types of foam, including syntactic foam and phenolic foams. Contact an applications engineer for more details.

APPLICATIONS

The ability to customize the mechanical and electrical properties of the foam allow for a wide range of applications including:

- Absorptive pucks for spiral antenna cavities
- Fairings for vehicles and radars
- Antenna housings
- Lightweight microwave absorbing barriers

FIGURE 1.



ORDERING INFORMATION

Table 1 shows existing standard part numbers for RFRIGID products. From the table, select desired thickness (in ascending order). The part number determines the material type, length, width and frequency range of operation. The other column lists the closed-cell foam that is used to fill the reticulated foam. The thicker the foam material, the broader the frequency ranges of coverage. Performance is nominally -17 to -20dB reflectivity reduction over the frequency range listed.

Available Fill Foam Materials are:

E - Epoxy

FU - Flexible Urethane

RU - Rigid Urethane

S - Syntactic Urethane

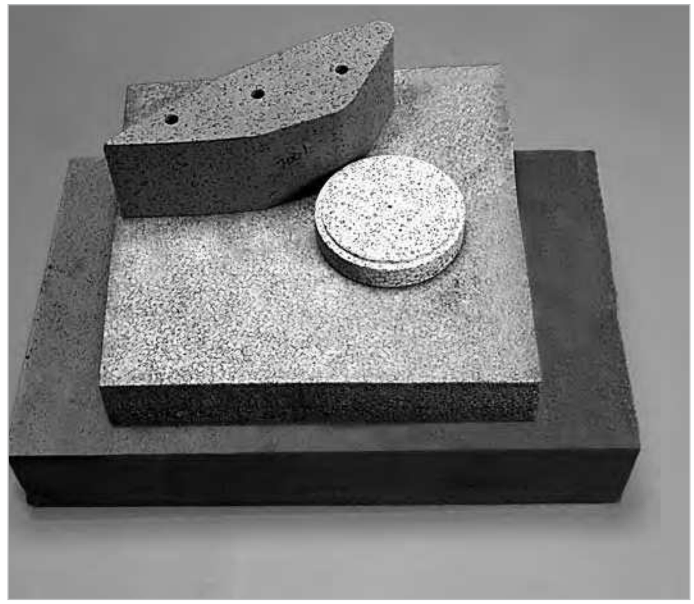


TABLE 1: RFRIGID - STRUCTURAL MICROWAVE ABSORBING FOAM PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

4700 - 4799 RFRIGID - STRUCTURAL MICROWAVE ABSORBING FOAM

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	FREQ. RANGE (GHZ) - 17DB	MATERIAL
4738	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	7-18	E
4739	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	7-18	E
4701	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	5-18	RU
4710	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	5-18	RU
4703	1.000 (25,4)	12.0 (304,8)	12.0 (304,8)	3-18	RU
4746	1.000 (25,4)	48.0 (1219,2)	36.0 (914,4)	3-18	E
4711	1.250 (31,8)	24.0 (609,6)	24.0 (609,6)	3-18	RU
4712	1.250 (31,8)	24.0 (609,6)	24.0 (609,6)	3-18	RU
4720	1.250 (31,8)	48.0 (1219,2)	36.0 (914,4)	3-18	E
4730	1.250 (31,8)	24.0 (609,6)	36.0 (914,4)	3-18	RU

All dimensions shown are in inches (millimeters) unless otherwise specified.

RFHC - TREATED HONEYCOMB CORE ABSORBERS

RFHC is a broadband microwave absorbing honeycomb core material. Laird Technologies uses either Nomex® or fiberglass honeycomb core and applies a "lossy" coating to it. The RF core can have a uniform coating to optimize insertion loss or a graded coating to optimize reflection loss. The cell sizes generally used are 0.125" to 0.187" (3,2 mm to 4,8 mm) thick with densities of 3 to 4 lb./ft^3. The performance curve in Figure 1 shows the typical performance of a 0.5" (12,7 mm) thick core, providing good attenuation over a broad frequency range. We can optimize the performance to account for laminated skins or core and can assist in selecting the right materials to minimize performance degradation.

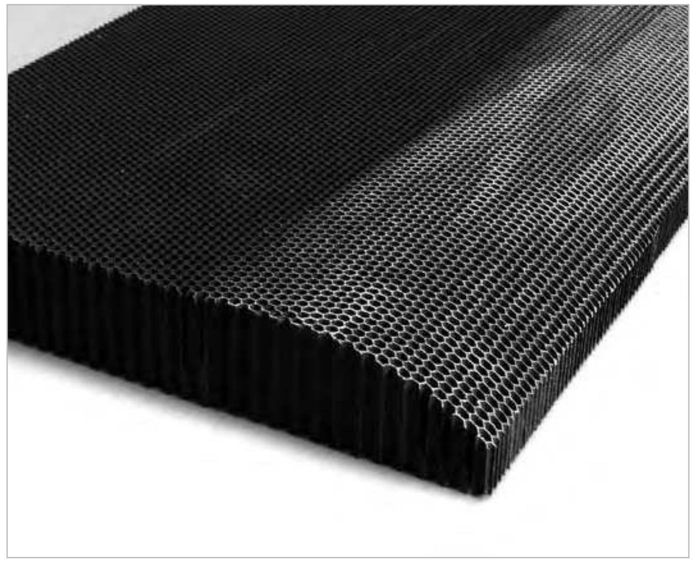
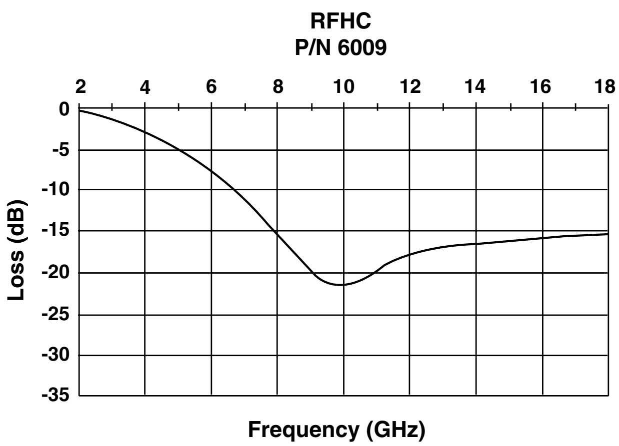


FIGURE 1.



APPLICATIONS

RFHC materials are used as "lossy" loads in spiral antennas and high-power antenna couplers. They are used with laminated skins to manufacture radar absorbing structural (RAS) panels and components. Our engineering staff can design a material that meets your special requirements.

ORDERING INFORMATION

Table 1 lists the existing part numbers for broadband microwave absorbing honeycomb core material. Select the desired thickness (in ascending order), noting the desired frequency range. Select a cell size and density and the base part number. The base part number determines the length, width, density in terms of pounds per cubic foot (PCF), cell size and frequency range.

The thicker the core material, the broader the frequency ranges of coverage. Performance is nominally -17dB reflectivity reduction over the frequency range listed. The cell size of the honeycomb core is generally 0.125" to 0.187" (3,2 mm to 4,8 mm) with a core type of either Nomex or fiberglass.

TABLE 1: RFHC - TREATED HONEYCOMB CORE PART NUMBERS

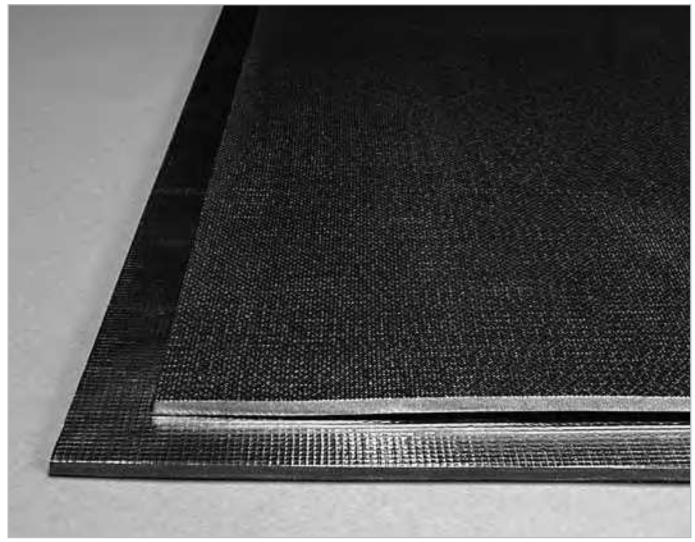
Note: Other materials or combinations of attributes are available; please contact sales for assistance.

6000 - 6799 RFHC - TREATED HONEYCOMB CORE

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	DENSITY (PSF)	CELL SIZE IN (MM)	FREQ
6017	0.500 (12,7)	24.0 (609,6)	24.0 (609,6)	3	0.187 (4,8)	8-18
6003	0.500 (12,7)	12.0 (304,8)	12.0 (304,8)	3	0.250 (6,4)	8-18
6009	0.500 (12,7)	12.0 (304,8)	12.0 (304,8)	4	0.125 (3,2)	8-18
6000	0.500 (12,7)	12.0 (304,8)	12.0 (304,8)	3	0.187 (4,8)	8-18
6007	0.500 (12,7)	16.0 (406,4)	18.0 (457,2)	4	0.187 (4,8)	8-18
6008	0.500 (12,7)	12.0 (304,8)	12.0 (304,8)	4	0.187 (4,8)	8-18
6011	0.500 (12,7)	12.0 (304,8)	12.0 (304,8)	4	0.187 (4,8)	8-18
6050	0.625 (15,9)	24.0 (609,6)	24.0 (609,6)	4	0.187 (4,8)	8-18
6005	0.670 (17,0)	12.0 (304,8)	12.0 (304,8)	4	0.187 (4,8)	6-18
6049	0.750 (19,1)	24.0 (609,6)	24.0 (609,6)	4	0.187 (4,8)	6-18
6002	0.750 (19,1)	12.0 (304,8)	12.0 (304,8)	3	0.125 (3,2)	6-18
6021	0.813 (20,7)	12.0 (304,8)	12.0 (304,8)	3	0.187 (4,8)	6-18
6004	0.877 (22,3)	12.0 (304,8)	12.0 (304,8)	3	0.187 (4,8)	6-18
6013	1.200 (30,5)	24.0 (609,6)	24.0 (609,6)	4	0.125 (3,2)	6-18
6010	1.250 (31,8)	12.0 (304,8)	12.0 (304,8)	4	0.125 (3,2)	4-18
6051	1.750 (44,5)	13.0 (330,2)	13.0 (330,2)	3	0.187 (4,8)	4-18
6006	2.000 (50,8)	30.0 (762,0)	30.0 (762,0)	1.8	0.125 (3,2)	2-18
6037	2.065 (52,5)	10.0 (254,0)	15.0 (381,0)	3	0.187 (4,8)	2-18
6025	2.500 (63,5)	24.0 (609,6)	24.0 (609,6)	2	0.187 (4,8)	2-18
6038	3.500 (88,9)	12.0 (304,8)	12.0 (304,8)	3	0.187 (4,8)	2-18

All dimensions shown are in inches (millimeters) unless otherwise specified.

RFSS - SALISBURY SCREENS

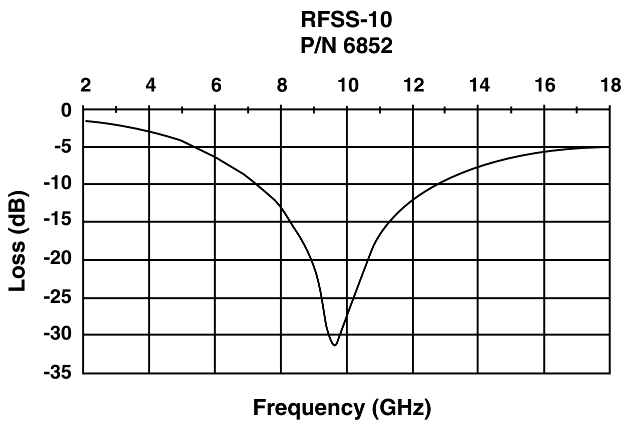


RFSS screen absorbers are thin, extremely lightweight absorbers that are optimized to provide a high degree of absorption for specific frequencies in the range of 1 to 18GHz.

Construction consists of a conductive carbon coated "lossy" fabric, separated from a conductive ground plane by a low dielectric foam core. As a tuned (narrowband) absorber, the material must have an electrical thickness of 1/4 of a wavelength at the frequency of operation. This promotes signal attenuation by both energy dissipation within the "lossy" fabric material, as well as cancellation of the incoming and emerging signals at the surface, where they are 180° out of phase.

Through accurate control of the coating process used for the "lossy" fabric, absorption levels of greater than 20dB are easily and consistently achieved with a 10% bandwidth at the specified operating frequency.

FIGURE 1.



APPLICATIONS

This material is primarily used in airborne applications where weight savings are essential. It is used to reduce the interfering reflections in airborne radar applications or any antenna or signal environment that requires the suppression of random reflections at specified frequencies.

To facilitate installation in application-specific areas, this material is readily supplied die-cut to specific shapes and sizes.

ORDERING INFORMATION

Table 1 shows existing standard part number configurations. Select the desired frequency and part number. The part number designates the thickness, length, width and frequency range. The other column indicates the use of pressure-sensitive adhesive.

TABLE 1: RFSS - SALISBURY SCREEN PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

6800 - 6999 RFSS - SALISBURY SCREENS

PART NUMBER	THICKNESS IN (MM)	LENGTH IN (MM)	WIDTH IN (MM)	FREQ. RANGE (GHz) -20dB	OTHER
6827	0.540 (13,7)	24.0 (609,6)	24.0 (609,6)	5.4	
6802	0.250 (6,4)	96.0 (2438,4)	48.0 (1219,2)	9	
6803	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	9	
6847	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	9.4	
6848	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	9.4	PSA
6852	0.250 (6,4)	24.0 (609,6)	24.0 (609,6)	10	
6814	0.180 (4,6)	24.0 (609,6)	24.0 (609,6)	16.7	

All dimensions shown are in inches (millimeters) unless otherwise specified.

MICROWAVE ABSORBING TEXTILE COVERS

Absorbing textile antenna covers.

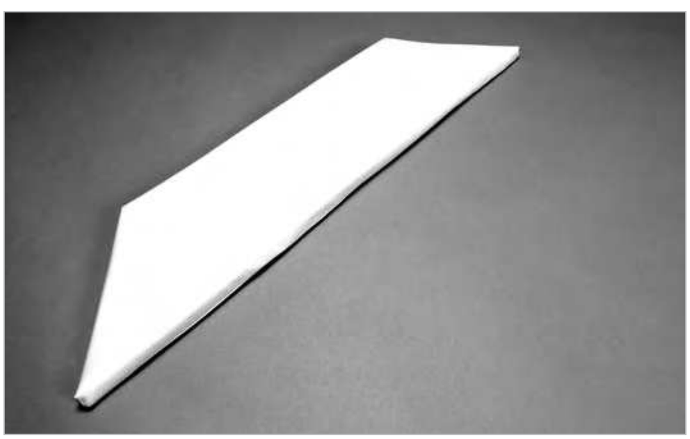
Complete capability for manufacturing microwave absorbing textiles.

Laird Technologies integrates microwave absorbing or reflecting properties into custom covers, screens and other textile products to fit different application needs. Applications for these products include:

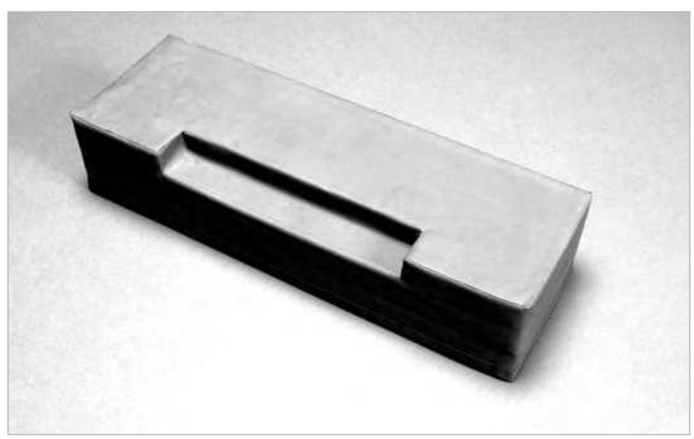
- Test blankets for shipboard EMI
- Diagnostics for PCS antenna installations
- Covers for radomes, hangar doors or other ship articles
- Covers for guns, turrets or other vehicle articles
- Tents and equipment housings
- Personnel clothing and covers
- Cushions and boat articles

Many of these products are based upon Laird Technologies RFRET foam material. RFRET is open-celled lightweight foam, which is flexible and provides excellent broadband microwave absorption. The absorber can be sewn or RF welded into different textile materials. The textile cover is chosen based upon the environmental properties desired. Vinyl, neoprene, silicone and Hypalon® are commonly used materials. Reinforcements include nylon, fiberglass, polyester and Kevlar®. A variety of attachment schemes can be used including Velcro®, zippers, buckles, tie downs and other standard attachments.

Camouflage materials can also be used to provide both RF and visual protection. The foam works equally well at millimeter wave frequencies. Laird Technologies is working with other companies to provide infrared protection and integrate conductive materials into fabric coatings. A variety of conductive materials are available including Flectron nickel/copper coated fabric, aluminized glass mat, lightweight scrims and wire screens.



Fabric covered foam for weatherproof applications.



Custom fabric coated RFML absorber.

Laird Technologies is the leader in the compression molding of elastomeric magnetic sheet materials. The single band, surface wave and multiband types of absorbers have magnetic fillers mixed into gum elastomers and are subsequently compression molded into flat sheets or conformal shapes. The end product is tightly controlled for electrical properties and is a very robust material capable of being die-cut into a variety of shapes.

To meet our customers' ever-expanding needs, Laird Technologies has developed other magnetically loaded materials, which can be used and applied in different ways.

THERMOPLASTIC EXTRUDING

Traditional elastomers are thermoset materials. Once the materials go through a curing process they cannot be re-melted or re-formulated. Thermoplastic materials are resins that will melt at a specific temperature and be solid at temperatures below that temperature. The material will continue to become viscous at temperatures above its melt temperature. Laird Technologies has used different types of thermoplastic materials and loaded them with different magnetic fillers. These include carbonyl iron powder, iron silicide and ferrites. A twin-screw extruder is used to melt the thermoplastic, mix in the magnetic filler and extrude the loaded compound to a specific shape.

Laird Technologies has used polyamide and thermoplastic urethane resins to produce several products including microwave absorbing thermoplastic string, hot-melt glue sticks and thermoplastic tape.

The customer can achieve similar electrical properties in the thermoplastic matrix, as can be seen in elastomeric sheets, but be able to manufacture in roll form instead of sheet form.

Thermoplastic products include microwave absorbing tapes, string and hot-melt glue sticks.

LIQUID RESIN SYSTEMS

Laird Technologies loads liquid resin systems with magnetic fillers. Resins used include silicone, urethane, polysulfide and epoxy. Several products are produced from these resins including:

Doctor Bladed Sheets and Tape

Laird Technologies is limited in thickness of compression-molded elastomers to 0.015" (0,4 mm). By pulling a liquid film under a precision blade, magnetic films from 0.002" to 0.020" (0,05 mm to 0,5 mm) in thickness can be produced in lengths up to 144" (3657,6 mm). Both urethane and silicone have been used to make these thin magnetic films.

Cast Components

Laird Technologies can cast absorbers from silicone and urethane loaded liquid compounds. The casting process allows the use of aluminum tooling for lighter weight and lower cost. Sheet material can be cast as well, or the customer can cast their own components by procuring the loaded resin systems.

Paints

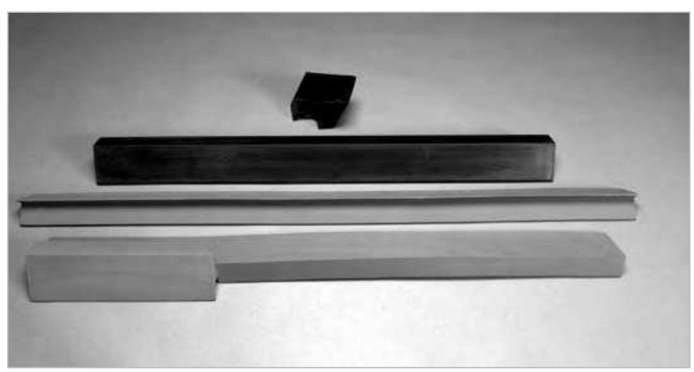
Laird Technologies can supply an epoxy- or urethane-loaded resin that can be diluted and sprayed onto a surface with standard spray equipment.

EXTRUDED ELASTOMERS

Laird Technologies, routinely extrudes several geometries of conductive elastomers. Laird Technologies uses this capability to extrude tubing, gaskets and other geometries of its magnetically loaded material.

Laird Technologies continually works to expand our products and processes to meet your specifications. Please contact an applications specialist at Laird Technologies with your specific requirements.

Thermoplastic extruder for microwave absorbing thermoplastic products.



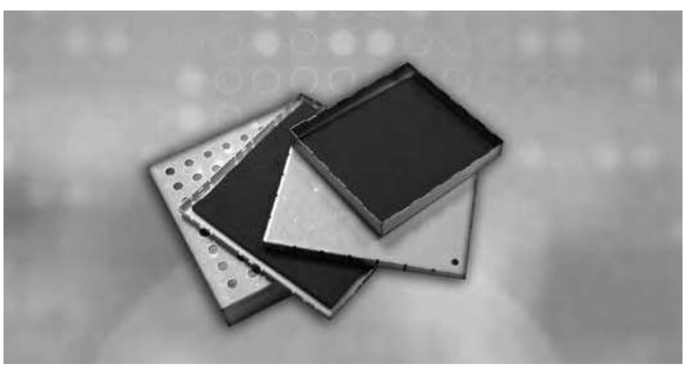
Conformally molded elastomeric components.

Transmission tunnel and microwave test equipment for material property measurement.

Computer controlled network analyzer provides amplitude and phase measurements on microwave absorbers.

Laird Technologies, has exceptionally strong research and development capabilities. Staying at the forefront of microwave absorber technology requires the ability to perform accurate measurements of absorber performance and material properties, the ability to perform computer analysis of new absorber designs and, finally, the ability to build and test prototype absorbers and components.

Laird Technologies works on internal product development programs to combine absorbers with EMI shielding.



Absorber Board Level Shield (ABLS)

Absorber Board Level Shielding (ABLS)

Increasing use of printed circuit boards in complex electronics requires unique shielding solutions. Laird Technologies has developed a near field measurement to accurately determine the effectiveness of board level shielding. Several Laird Technologies board level shields have been characterized using this technique. Laird Technologies has further enhanced performance at greater than 2 GHz by adding a microwave absorber to the board level shield.

Further work has been completed on Flomerics™ FLO-EMC to analytically investigate board level shields performance improvement using absorbers at high frequency.

Absorber/Thermal Materials

Laird Technologies has enhanced the thermal conductivity of magnetic absorbers by adding thermally conductive fillers. These fillers do not degrade the microwave absorbing property of the material while enhancing the thermal conductivity for use as a thermal pad.

Laird Technologies continues to do a significant amount of military product development for its customer base.

Structural Absorbers

In addition to its product line of structural foams and treated honeycomb core, Laird Technologies designs and produces structural composite absorbers. Using resistive films, magnetic layers and different dielectric constant reinforcing layers, Laird Technologies can manufacture structures with excellent mechanical properties, broadband electrical properties and good environmental capabilities. Laird Technologies is experienced in the electrical and mechanical properties of a variety of reinforcing materials including: Kevlar®, Spectra, E and S glass, graphite and other materials.

Millimeter Wave Absorbers

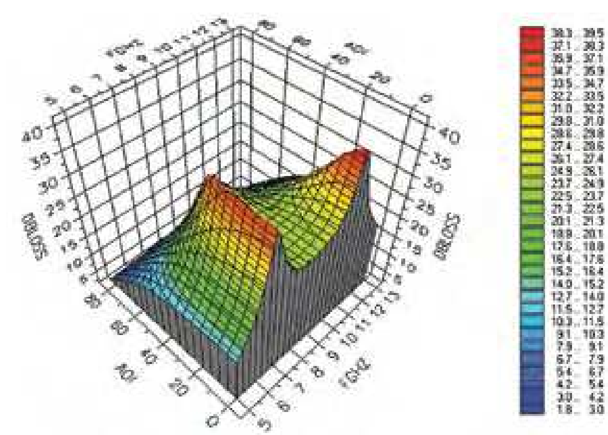
As both military and commercial systems move to higher frequencies, there is a growing need for absorbers that work to 100GHz. Laird Technologies has designs for specific resonant frequencies in the millimeter wave band, as well as broadband designs. Laird Technologies is working on several military programs at these frequencies, as well as automotive radars and millimeter wave communications programs.

Resistive Film Development

Laird Technologies provides design and fabrication work with frequency selective surfaces (FSS) and resistive films. Laird Technologies can spray carbon-based resistive films on a variety of substrates. Laird Technologies also silk-screens both resistive and conductive inks on plastic films. Laird Technologies can silk-screen continuous films or dots, squares, crosses and other shapes. Laird Technologies can provide design services for antenna terminations, FSS or R-films.

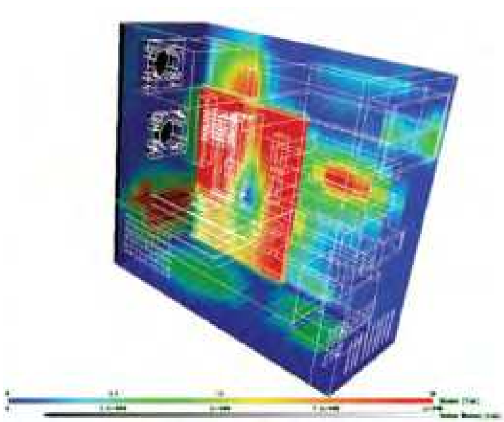
Laird Technologies has excellent design, test and analysis capability for absorber materials.

FIGURE 1.



VBROP can optimize absorber performance at various frequencies and angles of incidence.

FIGURE 2.



FLO-EMC can analyze areas of high field intensity for treatment with microwave absorbers.

Mu Epsilon Measurement Capabilities

Laird Technologies has a network analyzer to make amplitude and phase measurements from 130MHz to 20GHz. Laird Technologies also has a reflectivity arch, transmission tunnel and a variety of coaxial, wave-guide and other test equipment to determine intrinsic electrical properties of absorber materials. This ability has enabled Laird Technologies to build a database that customers can use to design new absorbers and analyze their performance in different situations.

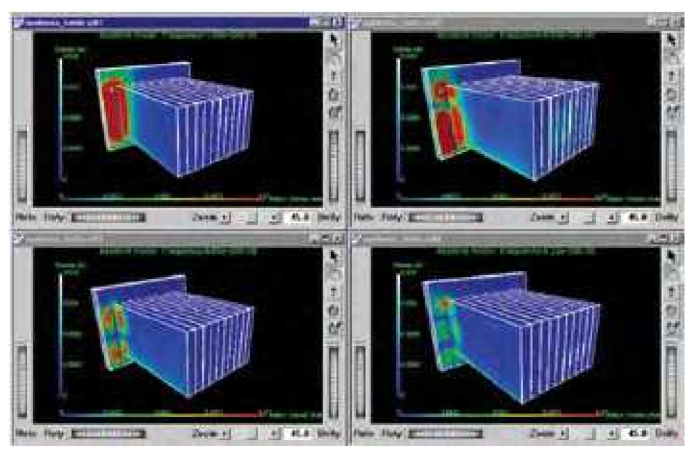
Analytical Software VBROP

VBROP is a versatile Windows® 95/98/NT-based optimizer of multi-layered stacks for reflection or maximum transmission at specified frequencies, angle of incidence and polarization. The visual basic front-end makes the software extremely user friendly, with interactive analysis of layer properties versus performance. It is useful for the design, optimization and detailed performance analysis of RAM, RAS, radomes and microwave windows.

Analytical Software FLO-EMC

This Flomerics™ software package allows the user to analyze component, subsystem and system level EMI problems. Laird Technologies is working with Flomerics to make its mu epsilon database available to FLO-EMC users. It is possible for designers to put microwave absorbers in their models to understand the effect of microwave absorbers on their system, prior to manufacture. Whether it's prototype development for commercial application, military application or design and analysis needs, Laird Technologies can supply valuable engineering assistance to customers.

FIGURE 3.



Unwanted currents on PCBs can be characterized and reduced with microwave absorbers.