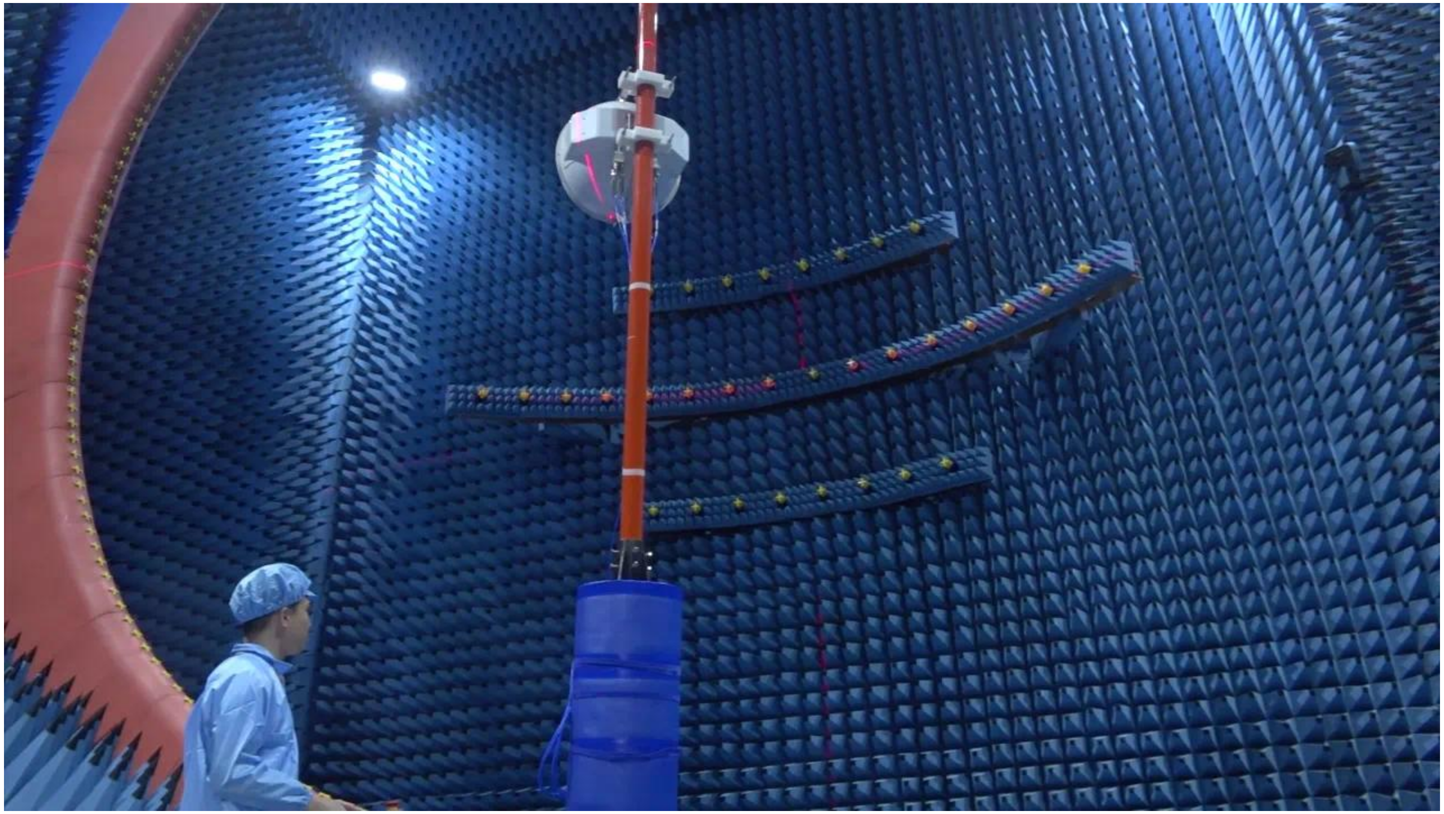
Luneburg Lens Reflector

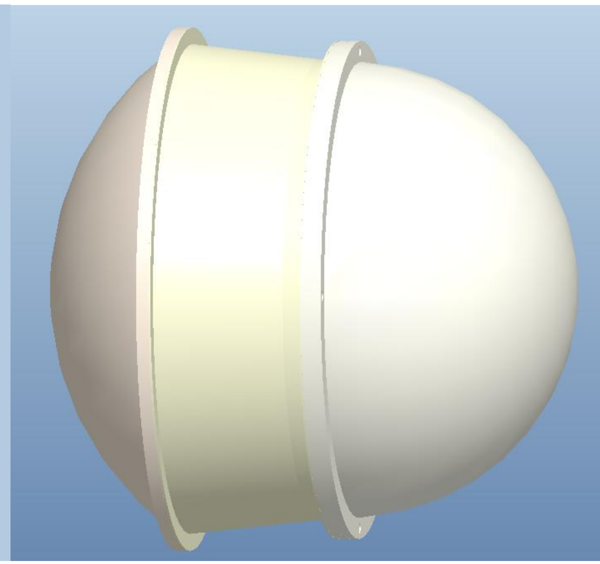
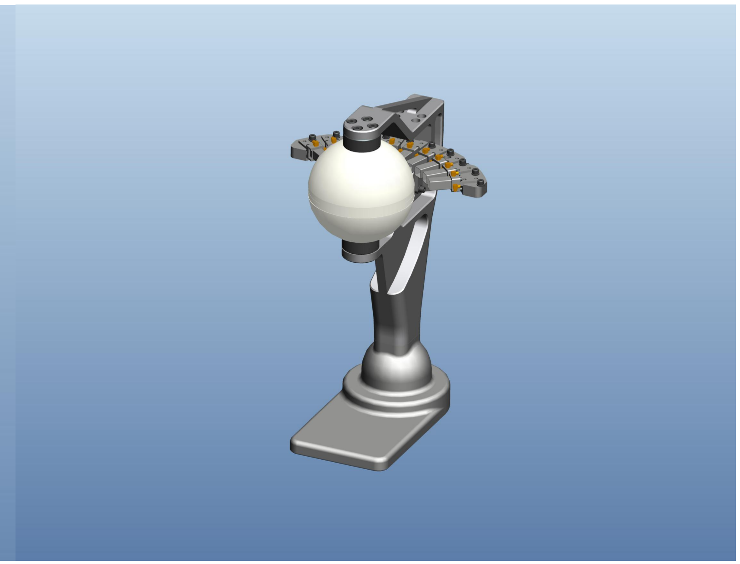
Technical Manual

LXA & LXB & LXE_Ver1.5.0

Test Site



Product Photos (ref.)

Overview

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The Luneburg lens reflector is meticulously designed based on the principles of electromagnetic wave refraction and reflection.
It uses microwave low-loss dielectric materials and precisely controls the distribution of the refractive index within the sphere.
The reflector is formed using high-precision tooling and advanced manufacturing processes, making it a new type of passive echo enhancer.

Advantages

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- Compact size and lightweight, with extremely high reflection efficiency and a wide response angle. Its radar cross-section is hundreds of times larger than that of a metal sphere of the same diameter.

- Low cost, easy to install, maintain, and use, with a long lifespan and no need for a power supply.

- No electromagnetic radiation, harmless and non-interfering with personnel and equipment, and not affected by electromagnetic interference. It has a very low failure rate and high reliability.

Typical Applications

- In the Air: Can be installed on airplanes, missiles, and targets, serving as a radar echo enhancer or an electronic warfare decoy.

- On the Ground: Can be installed in ports, airports, serving as navigational identification equipment, and can also be used to camouflage artillery vehicles, tanks, field stations, bridges, etc.

- On the Water: Can be installed on fishing boats, ships, lifeboats, to increase radar detection range and probability, prevent collisions, and facilitate rescue operations. It can also be installed around marine aquaculture areas, offshore exploration areas, construction areas, and military test zones as warning signs for approaching vessels.

Note* According to different applications, please carefully choose the appropriate diameter, reflector shape, and size of the spherical lens reflector.

Principle

- The Luneberg Lens antenna, proposed by R.K. Luneberg in 1944, has a history of over 60 years.

- With continuous updates and improvements by engineers, this dielectric lens antenna technology is now widely used to manufacture low-cost, high-gain, and easy-to-operate microwave antennas, primarily for satellite tracking by mobile receiving stations.

- The Luneberg Lens reflector is used to enhance the effective radar cross-section of targets, applicable in radar target identification and as decoys for target drones.

- The Luneberg lens is a dielectric sphere with a layered structure. The dielectric constant of its outer layer is similar to that of air and increases towards the center of the sphere. This configuration allows the Luneberg lens to converge captured electromagnetic waves. When a plane wave enters the lens, it is focused to the point on the opposite side of the sphere's diameter, perpendicular to the plane wavefront. Similarly, placing a feed source at this focal point will generate a plane wave that is emitted from the aperture of the spherical antenna. By moving the feed source along the surface of the sphere, the beam can be scanned 360 degrees.

- The Luneberg lens reflector is created by coating half (or part) of the surface of a Luneberg lens sphere with a metallic reflective layer. This design allows the lens reflector to gather intercepted electromagnetic waves and reflect them back with significant gain, resulting in a large effective reflective area. The radar effective reflective area is proportional to the fourth power of the edge length and inversely proportional to the square of the wavelength.

Structure

▪ The lens reflector is made from low-loss dielectric materials, with its structure layered according to different dielectric constant distributions. Each layer consists of two hemispheres, and the outer shell is a fiberglass protective layer coated with paint. This design provides sealing, corrosion resistance, and weatherproofing.

▪ According to the azimuth design requirements of the Luneberg lens reflector, a conical metal reflecting with a 120-degree reflection angle is designed on one side, and a circular metal reflecting is radially designed for the full 360-degree azimuth.

Specifications

YCLXA					
Band	**Model #**	**Max. RCS (㎡)**	**Diameters (mm)**	**Reflection Characteristics**	**Weight (g)**
X	**YCLXA061**	0.18	61	Cone Angle>120°	50
X	**YCLXA076**	0.25	76	Cone Angle>120°	85
X	**YCLXA090**	0.50	90	Cone Angle>120°	133
X	**YCLXA1036**	0.75	103.6	Cone Angle>120°	200
X	**YCLXA122**	1.46	122	Cone Angle>120°	350
X	**YCLXA132**	1.80	132	Cone Angle>120°	410
X	**YCLXA146**	2.29	146	Cone Angle>120°	550
X	**YCLXA156**	3.00	156	Cone Angle>120°	680
X	**YCLXA162**	3.30	162	Cone Angle>120°	740
X	**YCLXA178**	5.00	178	Cone Angle>120°	972
X	**YCLXA1905**	6.50	190.5	Cone Angle>120°	1260
X	**YCLXA195**	7.00	195	Cone Angle>120°	1275
X	**YCLXA207**	9.00	207	Cone Angle>120°	1620
X	**YCLXA227**	13.00	227	Cone Angle>120°	2100
X	**YCLXA259**	20.00	259	Cone Angle>120°	3100
X	**YCLXA307**	40.00	307	Cone Angle>120°	5200
X	**YCLXA395**	45.00	395	Cone Angle>120°	10600

Table 1: Technical Parameters of YCLXA Luneberg Lens Reflector (RCS @ 9375 MHz)

Specifications

YCLXB					
Band	**Model #**	**Max. RCS (㎡)**	**Diameters (mm)**	**Reflection Characteristics**	**Weight (g)**
X	**YCLXB178**	1.00	178	Horizontal: 360° Vertical: ±15°	970
	YCLXB1905	2.50	190.5		1260
	YCLXB195	3.00	195		1275
	YCLXB207	4.40	207		1620
	YCLXB227	5.50	227		2100
	YCLXB259	8.00	259		3100
	YCLXB291	10.00	291		4300
	YCLXB307	15.00	307		5200

Table 2: Technical Parameters of YCLXB Luneberg Lens Reflector (RCS @ 9375 MHz)

- The lens reflector can be used over several octaves with wavelengths greater than 2 cm. Its radar cross-section is inversely proportional to the square of the wavelength, while the reflection angle response remains constant.
- Working Temperature: -40℃ to +55℃.
- Relative Humidity: no more than 98%.

- Based on the principle that parallel waves converge on the opposite side of the sphere, the entire Luneberg lens is a fully symmetrical structure. To meet the effective response coverage range, specific angles of circular reflective metal surfaces can be selected. For example, the YCLXA model with a conical response angle provides a specific angle of spatial reflection coverage, where the effective RCS (Radar Cross Section) remains almost constant within this range. The YCLXB model with an omnidirectional response angle offers a horizontal 360-degree and vertical ±15-degree spatial reflection coverage, where the effective RCS is also almost constant.

- YCLXB have an effective reflective area that is only 1/3 to 1/4 of the reflective area of the same size in YCLXA models due to the incident beam being blocked by the same-side reflective membrane. Based on the Luneberg lens RCS calculation formula, $\sigma=\frac{4\pi^3 R^4}{\lambda^2}10^{-13.37\frac{R}{\lambda}\tau\gamma\delta}$, it can be deduced that RCS is proportional to the square of the frequency and the fourth power of the size. Therefore, the principles for selecting a Luneberg lens reflector are as follows:

  i. Determine the spatial response requirement, deciding whether to use the 120-degree conical angle model or the 360-degree ring model.
  ii. Choose the appropriate model based on an RCS greater than YY square meters at the frequency of XX.
  iii. Select the suitable size according to installation dimensions and load capacity requirements.

YCLXE								
RCS (㎡)								
Freq. / Model #	3G	5G	8G	9G	10G	12.5G	15G	18G
YCLXE061	0.02	0.04	0.12	0.16	0.18	0.27	0.32	0.37
YCLXE076	0.03	0.06	0.16	0.23	0.25	0.35	0.43	0.50
YCLXE090	0.05	0.12	0.33	0.46	0.50	0.70	0.85	1.00
YCLXE1036	0.08	0.18	0.50	0.70	0.75	1.10	1.30	1.50
YCLXE122	0.16	0.35	0.97	1.30	1.46	2.14	2.53	2.92
YCLXE132	0.18	0.48	1.20	1.68	1.80	2.41	3.01	3.61
YCLXE146	0.23	0.61	1.53	2.10	2.29	3.06	3.82	4.59
YCLXE156	0.30	0.80	2.00	2.80	3.00	4.00	5.00	6.00
YCLXE162	0.35	0.93	2.33	3.00	3.30	4.66	5.50	6.99
YCLXE178	0.50	1.20	3.30	4.60	5.00	6.50	8.50	10.00
YCLXE195	0.80	1.80	5.00	6.40	7.00	9.10	11.00	14.00
YCLXE207	1.00	2.20	6.00	8.30	9.00	12.00	15.00	18.00
YCLXE259	2.30	5.00	13.00	18.40	20.00	24.00	27.00	27.00
YCLXE307	4.50	10.00	26.00	36.80	40.00	45.00	40.00	35.00
YCLXE395	-	-	-	-	45.00	-	60.00	-

Table 3: Radar Cross Section (RCS) of YCLXA Luneberg Lens Reflector (@3-18 GHz)