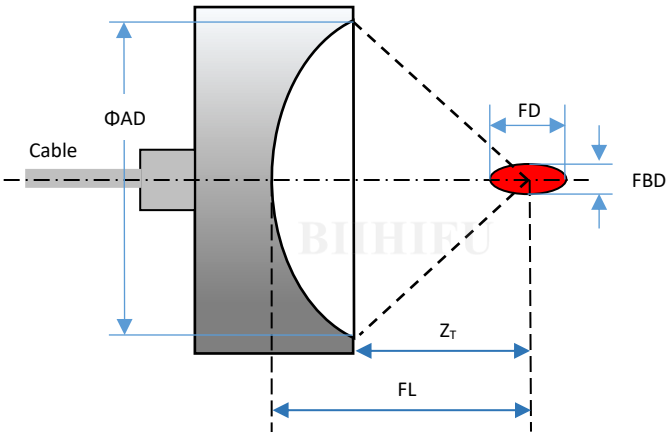
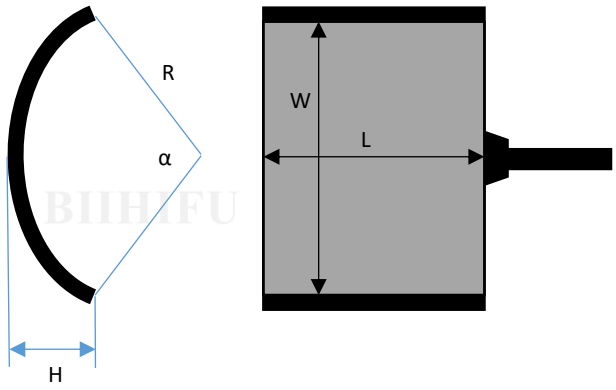
High Intensity Focused Ultrasound (HIFU) Transducer

BII's high intensity focused ultrasound transducers consist of apertures: bowl (concave, with or without a center hole), cylindrical sector, Linear (rectangular) and Annular Array. The energy at focal point or focal line is for physical, chemical, biological, thermal and high-stress uses in nonlinear underwater acoustics: cavitation, streaming, sonic processes and HIFU R&D. The focus of linear array and annular array can be manipulated with technology of array beamforming (beam steering and focusing). The bowl aperture transducers provide the best lateral and axial resolutions. For information on MRI compatibility or safety, please contact BII. To support HIFU R&D, BII provides customized designs on frequency, geometric focus, Fresnel number, focal diameter/length/intensity.

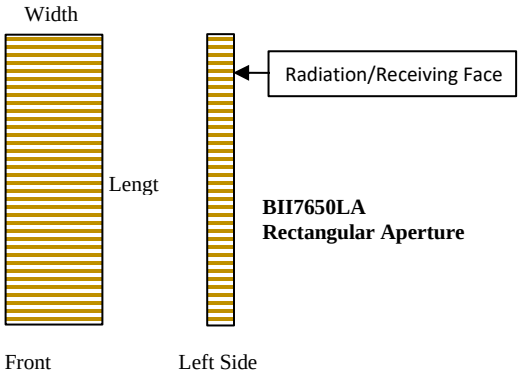
Concave Spherical Sector (Bowl) Aperture with or without Center Hole



Cylindrical Sector Aperture



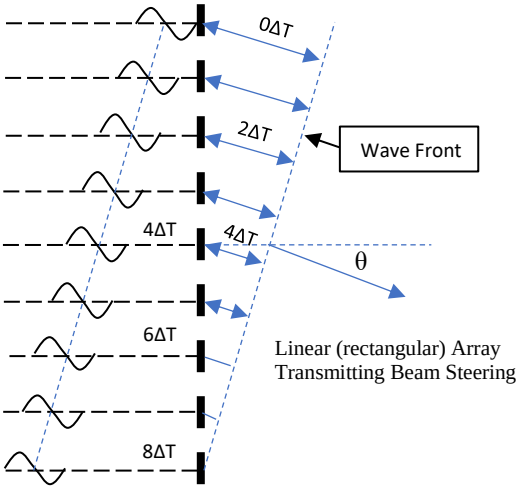
Line Array (Rectangular Aperture, Beam Steering and Focusing)



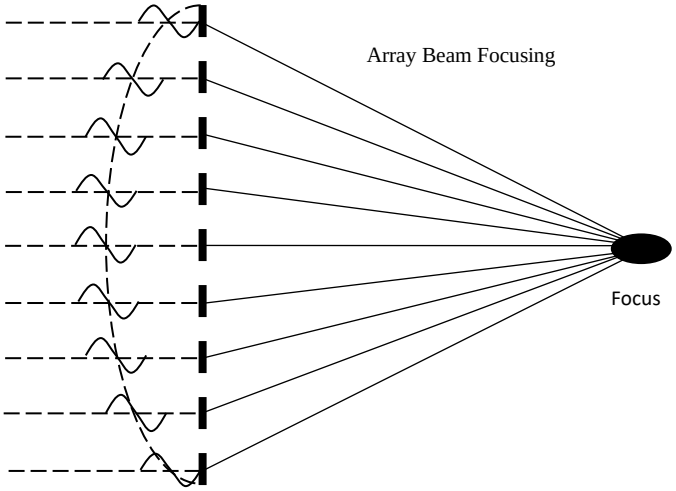
BII7650LA
Rectangular Aperture

Annular Array (Array Focusing)

BII7650AA
Annular Array



Linear (rectangular) Array
Transmitting Beam Steering



Typical Applications	
Cavitation/Streaming/Acoustic Wave Interaction High Frequency Ultrasound Energy Sources Dispersion/Emulsification/Coagulation Sonic Processing/Testing/Analysis	Thermal/Mechanical/Chemical/Biological Effects Sonic Radiation in Sonochemistry/Material Processing/Sonoluminescence Anti-algae & Anti-bacteria, Fluid Dynamics, Nonlinear Acoustics Focused Sound Sources for HIFU R&D
Features	
High Intensity: up to 5000 W/cm²	70 kHz to 2.0 MHz, and the Odd Harmonics

1. Concave or Bowl Aperture
2. Cylindrical Sector Aperture
3. Line Array (Rectangular Aperture, Beam Steering and Focusing)
4. Annular Array (Array Focusing)

IPP: Input Pulse Power (Peak Power); **MIPP**: Maximum Input Pulse Power; **MCIP**: Maximum Continuous Input Power; **D:** Duty Cycle.

MPW: Maximum Pulse Width at MIPP; **η:** HIFU Transducer Efficiency; **FIPIEP**: Focal Intensity per Input Electrical Power, in W/(W*cm²).

How to calculate the maximum acoustic focal intensity the HIFU which transducer can achieve theoretically:
As an example, consider a power amplifier of 40 Watts RMS output power to drive BII7653/2000 at 2MHz, the peak intensity at center of the focus = Input Pulse Power * Efficiency * Focal Intensity per Input Electrical Power = 40W*0.7*175W/(W*cm²) = 4900 W/cm². Depending on the liquid or subject properties, cavitation might occur at much lower intensity and in regions between the transducer face and the focus.

How to determine pulse width, duty cycle and off-time with input pulse power (peak power): Refer to Acoustic Transducers and Measurement Systems.

Concave or Bowl Aperture: Focal point

Focal Intensity:	(Input Electrical Pulse Power) * Transducer Efficiency * (Focal Intensity per Input Electrical Power)
ΦAD:	**Aperture Diameter:** the outside diameter of the piezoelectric concave spherical sector (bowl).
Z_T:	Perpendicular distance from acoustic focus to the imaginary plane of end face of the transducer housing.
FL:	**Focal Length:** Distance from acoustic focus to the center of concave face of the transducer.
FD:	**Focal Depth:** Focal Depth or distance between -3dB points of the focal zone along acoustic axis perpendicular to bowl. **FD** determines the best axial resolution.
FBD:	**Focal Beam Diameter:** the diameter of the beam at -3dB points. **FBD** determines the best lateral resolution.
Customization:	**1. Bespoke**: **HIFU with a center hole whose Diameters is Φ15 mm**. please append **-CH** to the part number. Note: BII7651 series and BII7651Q series are NOT recommended to have a center hole. **2. Minimum HIFU BII can manufacture:** Miniature HIFU Transducer, Aperture ΦD x Focal Length FL = Φ1.5 x 1.5 mm.

HIFU (Bowl)	fs (MHz)	Impedance (Ω)	FIPIEP W/(W*cm²)	Efficiency η	FBD (mm)	FD (mm)	FL (mm)	Z_T (mm)	MIPP (W)	MPW (s)	MCIP (W)	Size:mm ΦDxH
BII7651-2100IM	2.1	50	52.0	0.52	1.31	11.29	30.5	29.1	190	1.8	22	Φ33x26
BII7651Q-300IM	0.3	50	7.1	0.52	3.55	11.85	17.5	10.5	600	10	35	Φ42x30
BII7651Q-500IM	0.5	50	14.0	0.52	2.13	7.11	19.5	12.5	600	6	45	Φ42x30
BII7651Q-1000IM	1.0	50	78.6	0.52	1.07	3.56	20.5	13.5	500	3	50	Φ42x30
BII7651Q-2000IM	2.0	50	314.4	0.52	0.53	1.78	21	14.0	500	2	50	Φ42x30
BII7651H-300IM	0.3	50	4.8	0.52	4.29	17.3	25.0	18.7	600	10	35	Φ48x30
BII7651H-500IM	0.5	50	13.5	0.52	2.58	10.38	27.0	20.7	600	6	45	Φ48x30
BII7651H-1000IM	1.0	50	53.8	0.52	1.29	5.19	29.5	23.2	500	3.5	50	Φ48x30
BII7651H-2000IM	2.0	50	215.4	0.52	0.64	2.60	30.0	23.7	500	2	50	Φ48x30
BII7652-100IM	0.1	50	0.65	0.52	10.8	53	36	26	1100	11	17	Φ60x35
BII7652-150IM	0.15	50	1.46	0.52	7.2	35	36	26	980	7.5	20	Φ60x35
BII7652-200IM	0.2	50	3.0	0.52	5.51	18.97	27.5	17.4	1300	16	70	Φ60x35
BII7652-300IM	0.3	50	6.6	0.52	3.67	12.64	30.0	20.0	1300	10	80	Φ60x35
BII7652-500IM	0.5	50	18.4	0.52	2.20	7.60	32.0	22.0	1200	7	100	Φ60x35
BII7652-1000IM	1.0	50	73.6	0.52	1.10	3.80	32.5	22.4	1200	3	120	Φ60x35
BII7652-2000IM	2.0	50	294.6	0.52	0.55	1.90	33.0	23.0	1200	1.5	130	Φ60x35
BII7653-70IM	0.07	50	0.3	0.52	16.0	81.0	56.0	41.6	2900	16	32	Φ89x45
BII7653-100IM	0.1	50	0.6	0.52	11.2	56.5	56.0	41.6	2400	11	37	Φ89x45
BII7653-150IM	0.15	50	1.3	0.52	7.46	37.68	56.0	41.6	2100	7.5	43	Φ89x38
BII7653-200IM	0.2	50	2.7	0.52	7.00	32.00	43.2	34.5	1500	8	80	Φ89x38
BII7653-300IM	0.3	50	4.0	0.52	4.80	21.00	48.0	39.0	2500	10	190	Φ89x38
BII7653-500IM	0.5	50	11.0	0.52	3.00	13.00	51.0	42.0	2500	7	230	Φ89x38
BII7653-1000IM	1.0	50	44.0	0.52	1.50	6.00	52.5	43.5	800	4	200	Φ89x38
BII7653-2000IM	2.0	50	175.0	0.52	1.00	3.00	53.0	44.0	2500	2	300	Φ89x38
BII7654-70IM	0.07	50	0.165	0.52	21.5	144.85	100.0	86.6	5100	16	57	Φ114x45
BII7654-100IM	0.1	50	0.34	0.52	15	101.4	100.0	86.6	4300	11	65	Φ114x45
BII7654-150IM	0.15	50	0.75	0.52	10.0	67.60	100.0	86.6	3800	7.5	75	Φ114x38
BII7654-200IM	0.2	50	1.53	0.52	7.70	36.60	88.0	74.6	5500	15	280	Φ114x38
BII7654-300IM	0.3	50	3.43	0.52	5.10	24.40	92.5	79.1	4800	10	345	Φ114x38
BII7654-500IM	0.5	50	9.54	0.52	3.06	14.64	95.5	82.1	4800	7	400	Φ114x38

Cylindrical Sector Aperture: Focal Line

Focal Intensity:	(Input Electrical Pulse Power) * Transducer Efficiency * (Focal Intensity per Input Electrical Power)
Z_T:	The vertical distance from acoustic focus to the imaginary plane of end face of the transducer housing.
Z_F:	Acoustic Focus, The vertical distance from acoustic focus to the concave face of the transducer.
FL:	**Focal Length:** Distance between -3dB points of the focal zone along geometrical axis paralleling to curved cylindrical plate.
FW:	**Focal Width:** The width of the beam at -3dB points perpendicular to focal length.

Cylindrical Sector	fs (MHz)	Impedance (Ω)	FIPIEP W/(W*cm²)	Efficiency η	FW (mm)	FL (mm)	Z_F (mm)	Z_T (mm)	MIPP (W)	MPW (s)	MCIP (W)	Size: mm LxWxH
BII7650H/2000CS	2.0	50	18.0	0.6	0.65	16	4.5	2.3	100	2	10	25x16x10
BII7650Q/2000CS	2.0	50	12.8	0.6	0.65	22.3	7.5	4.4	200	2	20	32x21x12
BII7651/2000CS	2.0	50	10.4	0.6	0.65	27.6	10	6.2	300	2	35	38x25x14
BII7651Q/2000CS	2.0	50	7.5	0.6	0.65	38.2	15	9.7	500	2	60	45x30x16
BII7651Q/1000CS	1.0	50	3.7	0.6	1.3	38.2	15	10	500	3.5	60	45x30x16
BII7651H/2000CS	2.0	50	6.7	0.6	0.65	42.4	17	11	700	2	80	52x35x18
BII7651H/1000CS	1.0	50	3.4	0.6	1.3	42.4	17	11	700	3.5	70	52x35x18
BII7652/2000CS	2.0	50	5.2	0.6	0.65	55	23	15	1200	2	140	65x45x20
BII7652/1000CS	1.0	50	2.6	0.6	1.3	55	23	15	1200	3.5	120	65x45x20
BII7652/500CS	0.5	50	1.3	0.6	2.6	55	23	15	1200	7	100	65x45x20
BII7653/1000CS	1.0	50	1.8	0.6	1.3	82	35.5	24	2500	3.5	280	90x63x25
BII7653/500CS	0.5	50	0.9	0.6	2.6	82	35.5	24	2500	7.5	230	90x63x25
BII7653/300CS	0.3	50	0.5	0.6	4.3	82	35.5	24	3000	10	190	90x63x25
BII7654/500CS	0.5	50	0.7	0.6	2.6	108	48	33	4500	7	400	118x80x30
BII7654/300CS	0.3	50	0.4	0.6	4.3	108	48	33	5500	10	340	118x80x30
BII7654/200CS	0.2	50	0.3	0.6	6.5	108	48	33	5500	15	280	118x80x30

Line Array: Rectangular Aperture, Beam Steering and Focusing

Customized, please specify element spacing, element size, element quantity, operating frequency, etc…	
Frequency:	50 kHz to 1 MHz
Array Geometry:	Linear (Rectangular)
Beamforming:	Beam Focusing and Steering.

Annular Array: Array Focusing

Customized, please specify element spacing, element size, element quantity, operating frequency, etc…	
Frequency:	50 kHz to 1 MHz
Array Geometry:	Annular.
Beamforming:	Beam Focusing.

Warning: the loading medium which the transducer is immersed in MUST be non-corrosive and non-flammable.

fs Tolerance:	±5% Typical
Third Harmonic:	2.9fs ~ 3.2fs; Transducers can operate at 3fs and an impedance matching network at 3fs should be ordered.
Pulse Driving Signal:	Pulse and burst SINE/Square/Chirp excitation. To avoid overheating transducer, DO NOT use high power continuous signal to drive HIFU transducer.
	How to determine pulse width, duty cycle and off-time with input pulse power (peak power): 1. Determine the input pulse power (IPP, peak power) with sound intensity required by the project. IPP MUST be less than MIPP. 2. Pulse Width ≤ (MIPP * MPW*(120°c-T)/103°c)/IPP. T: Water Temperature in °c. 3. Duty Cycle D ≤ MCIP*(120°c-T)/103°c)/IPP. 4. Off-time ≥ PW*(1-D)/D.
Quality Factor Q_m:	≥ 6. Note: -3dB bandwidth Δf = fs/Q_m.
SPL at fs:	$Sound\ Pressure\ Level\ SPL = \sqrt{Focal\ Inensity * \rho C}$, ρC = Characteristic Impedance of loading medium.
Free Capacitance:	Listed in the datasheet of a specific HIFU transducer.
Dissipation:	Listed in the datasheet of a specific HIFU transducer.
Admittance:	Listed in the datasheet of a specific HIFU transducer.
Driving Voltage:	Listed in the datasheet of a specific HIFU transducer.
Operating Depth:	Maximum, 20 m and Limited by the cable length if the cable has wire leads or a non-waterproof connector.
Mounting Options:	1. Default: Free Hanging (FH) 2. Thru-hole Mounting with Single O-ring (THSO) 3. Thru-hole Mounting with Double O-ring (THDO) 4. Bolt Fastening Mounting (Stainless Steel) (BFMSS) 5. End-face Mounting (EFM) 6. Flange Mounting (FGM) 7. Flush Mounting (FSM) Please refer to online document **AcousticSystem.pdf** for a complete list of Mounting Options and more details.
Cable-Out:	By default, the cable goes out of the device from the end face. To save space and have the device shorter, the cable can go out of the device from the side wall. Specify when ordering.
Cable:	1. 50 Ω RG58 Coax (RG58) 2. Two Conductor Shielded Cable (SC)
Cable Length:	1. Default: 1 m. 2. Custom.
Connector:	1. Default: Wire Leads (WL) 2. 50 Ω BNC Male (BNC) 3. Underwater Mateable Connector (UMC) 4. MIL-5015 Style (5015) 5. Custom (custom) Note: Underwater Mateable Connector is for underwater uses. Other connectors and wire leads are for dry uses and are non-waterproof.
Size:	Listed in the datasheet of a specific HIFU transducer.
Weight:	≥ 0.1 kg with 1 m cable. Actual weight depends on Mounting Parts, Cable Types and Length.
Operation Temperature:	1. Default: -10 °C to +60 °C or 14 °F to 140 °F. 2. Bespoke High Temperature Transducer: -10 °C to 120 °C, or 14 °F to 248 °F. Append HT to part number.

Storage Temperature:	-20 °C to +60 °C or -4 °F to 140 °F.
Power Amplifier:	BII5000 Series Power Amplifier, Order Separately, or Third-party's power amplifiers such as 50Ω RF power amplifiers.
Impedance Matching:	BII6000 Bespoke Impedance Matching between transducers and power amplifiers. Order Separately. Append **IM** to the part number for integrating BII6000 in the transducer, and specify impedance in Ω. For example, BIIxxxxIM50Ω: BIIxxxx transducer with built-in Impedance Matching unit as a 50 Ω load.
Temperature Sensor:	1. Default: No built-in temperature sensor. 2. Built-in temperature sensor. Append **TS** to part number (BIIxxxxTS) for integrating a temperature sensor in the transducer. Click Temperature Characteristics for more information.

WARNING: DANGER — HIGH VOLTAGE on wires. Wires shall be insulated for safety. DO NOT TOUCH THE WIRES BEFORE THE DRIVING SIGNAL IS SHUT DOWN. Cable shield must be grounded firmly for safety.

for 50Ω BNC Male connector, it is buyer's sole responsibility to make sure that the (female) BNC shield of the signal source is firmly grounded for operating safety before hooking up transducer/hydrophone to the signal source. Coax with BNC is not intended for hand-held use at voltages above 30Vac/60Vdc.

Wiring:	**Two Conductor Shielded Cable**	**Coax/BNC**	**Underwater Connector**	**MIL-5015 Connector**
Signal	White or Red	Center Contact	Contact 2	Contact C
Signal Common	Black	Shield	Contact 1	Contact B
Shielding and Grounding	Shield	Shield	Contact 3	Contact A

Maintenance and Operations of BII HIFU Transducers.

Cooling Transducer:	To avoid overheating the HIFU transducers during high power applications, pulse driving signal MUST be used to allow HIFU transducers to cool down in water or liquid. Effective cooling is necessary by liquid circulation and keep water/liquid in specified temperature range.
Remove Air Bubbles on Radiation Surface:	To increase power efficiency, the air bubbles on transducer radiation face developed during operation must be removed with soft cloth before driving the transducer. An flashlight is a useful aid to check the situation of the transducer surface underwater. It is a good routine to rub the transducer radiation surface lightly with soft cloth before operating the transducer each time. Do NOT touch the water/liquid and transducer when the system is powered.

Testing before shipment: BII carries out the cavitation test in water to HIFU transducers.

Disclaimer: The Focal Intensity, Focal Diameter and Focal Length in the specs are tested with low intensity sound level at BII or are calculated with electrical and physical parameters of the transducers. BII DOES NOT GUARANTEE THEIR ACCURACY. To get accurate data of these parameters, the buyer shall have the transducer tested at the buyer's cost by National Metrology Institutes or other organizations who provide calibration services.

General Operating Guide of BII HIFU Transducer

To produce the cavitation in liquids, please choose carefully the liquid (surface tension, viscosity, temperature), hydrostatic pressure, pulse length, operating frequency and driving voltage level or driving power. As a general guide, the cavitation threshold of the liquid increases as the operating frequency increases.

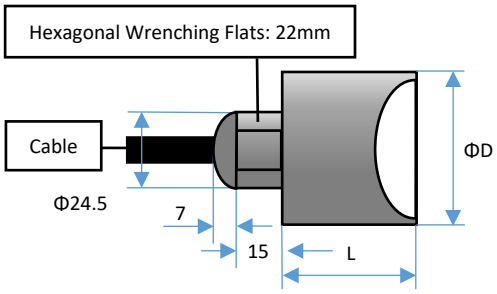
Driving HIFU Transducer	**Phenomenon on Water Surface at Room Temperature: Mist, Fog and Fountain.**
1 to 10 watt	Fountain occurs; Mist and Fog start to occur.
15 to 60 watt	Strong Fountain, Mist and Fog.
Cool down transducer	Refer to **How to determine pulse width, duty cycle and off-time with input pulse power (peak power)**.
Remove air bubbles	Air bubbles will develop on the radiation surface especially in fresh water or liquids. Rub the radiation surface lightly with soft cloth in water before driving HIFU transducer each time. Warning: Do NOT touch water and transducer when the system is powered.
Case Study:	
1MHz HIFU Transducer: (BII7653/1000)	**System Setup**: Pulse Signal Generator -> BII5121 -> BII6010 -> BII7653/1000 -> Water Tank. **Driving Signal**: SINE Pulse, 1MHz, Pulse Width=0.1mS, Duty Cycle=10%. **Electrical Power delivered to Transducer**: 5W **Phenomenon on Water Surface at Room Temperature**: Mist, Fog and Tiny Fountain with height of 8 to 10 mm.
2MHz HIFU Transducer: (BII7652/2000)	**System Setup**: Pulse Signal Generator -> BII5111 -> BII6010 -> BII7652/2000 -> Water Tank. **Driving Signal**: Pulsed/Burst Pulse Train, 2MHz, Pulse Width =10mS, Duty Cycle=10%. **Electrical Power delivered to Transducer**: 1.5 W. **Phenomenon on Water Surface at Room Temperature**: Mist, Fog and Tiny Fountain with height of 8 cm.

Frequency	**Aerated (tap) Water: Cavitation Threshold.**	**RMS Pressure MPa**	**Degassed Water: Cavitation Threshold.**	**RMS Pressure MPa**
70 kHz	0.8 W/cm²	0.035	8 W/cm²	0.110
100 kHz	1 W/cm²	0.039	9 W/cm²	0.116
150 kHz	1.6 W/cm²	0.049	11 W/cm²	0.128
200 kHz	2 W/cm²	0.055	13 W/cm²	0.140
300 kHz	7 W/cm²	0.102	25 W/cm²	0.194
400 kHz	8 W/cm²	0.110	40 W/cm²	0.245
500 kHz	10 W/cm²	0.122	60 W/cm²	0.300
1 MHz	600 W/cm²	0.949	600 W/cm²	0.949
2 MHz	1000 W/cm²	1.225	1000 W/cm²	1.225
3 MHz	5000 W/cm²	2.739	5000 W/cm²	2.739
4 MHz	10000 W/cm²	3.873	10000 W/cm²	3.873
5 MHz	80000 W/cm²	10.954	80000 W/cm²	10.954

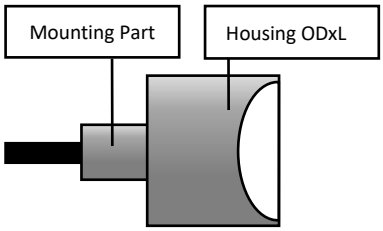
Package Types of HIFU Transducers

Physical Size of Bowl or Concave Spherical Sector without Center Hole (Dimensional Unit: mm):
The overall length varies with the length of mounting parts. Please refer to online information of mounting options.

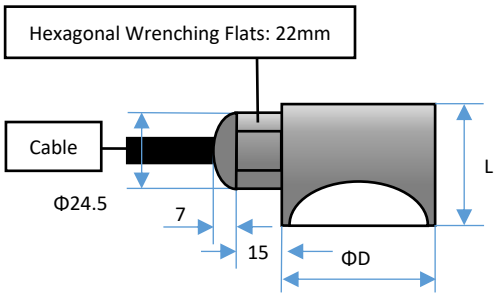
1. Cable goes out of the device from the end face.
a. Size information of Free Hanging.



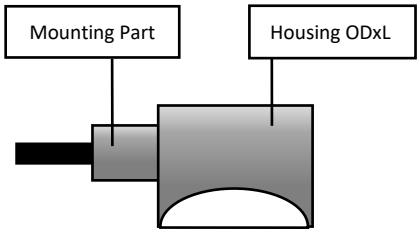
b. General Size information.



2. Cable goes out of the device from the side wall.
a. Size information of Free Hanging.

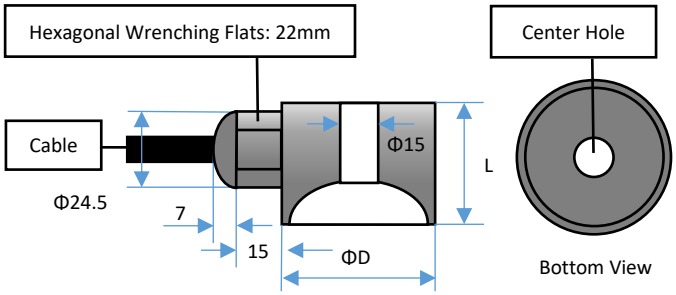


b. General Size information.

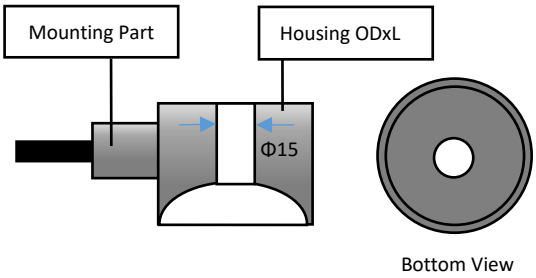


Physical Size of Bowl or Concave Spherical Sector with Center Hole (Dimensional Unit: mm):
The overall length varies with the length of mounting parts. Please refer to online information of mounting options.
Cable goes out of the device from the end face.

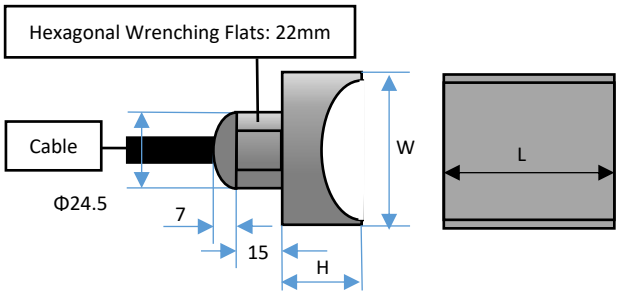
a. Size information of Free Hanging.



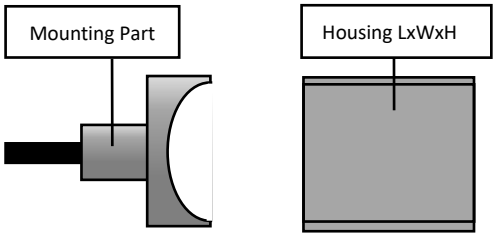
b. General Size information.



Cylindrical Sector Aperture (Dimensional Unit: mm):
1. Cable goes out of the device from the rear.
a. Size information of Free Hanging.

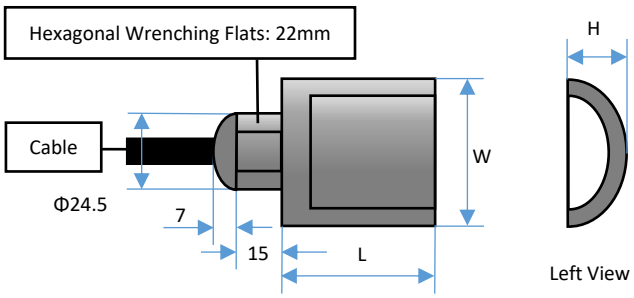


b. General Size information.

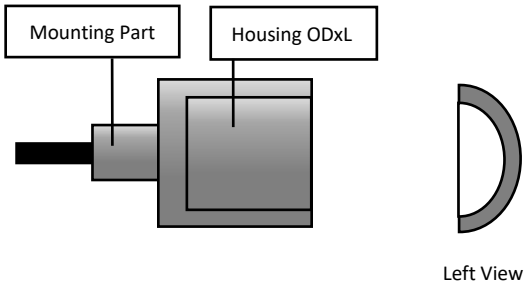


2. Cable goes out of the device from the end face.

a. Size information of Free Hanging.



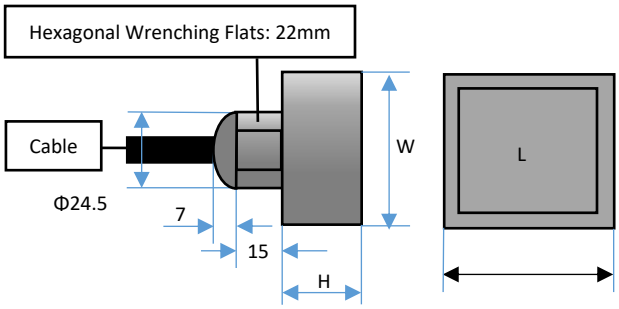
b. General Size information.



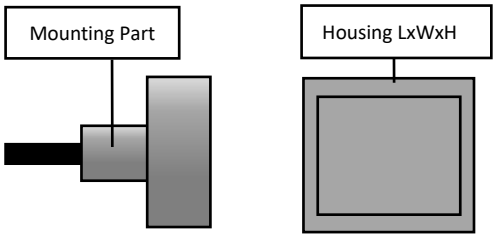
Line Array (Rectangular Aperture) (Dimensional Unit: mm):

1. Cable goes out of the device from the Rear.

a. Size information of Free Hanging.

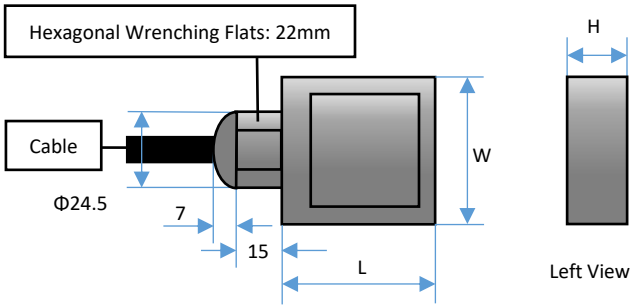


b. General Size information.

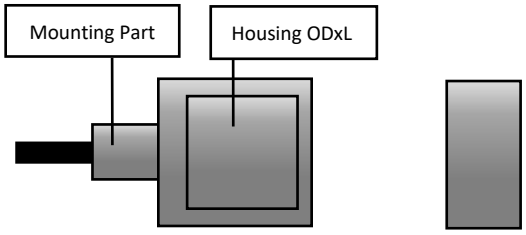


2. Cable goes out of the device from the end face.

a. Size information of Free Hanging.

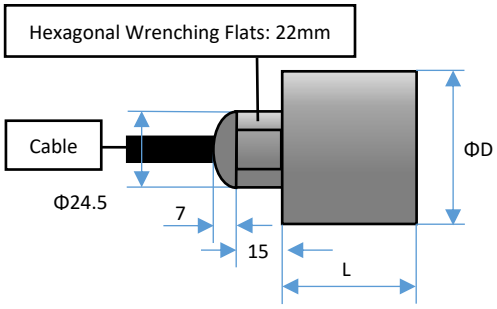


b. General Size information.

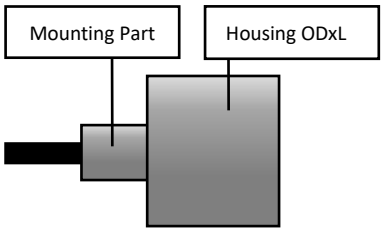


Annular Array (Dimensional Unit: mm):

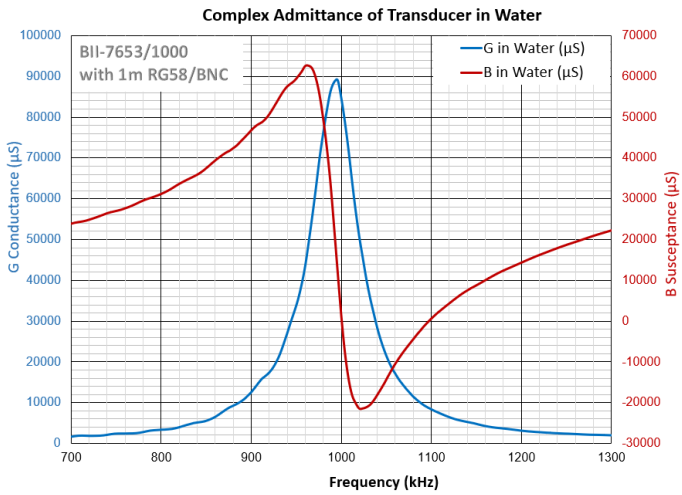
a. Size information of Free Hanging.

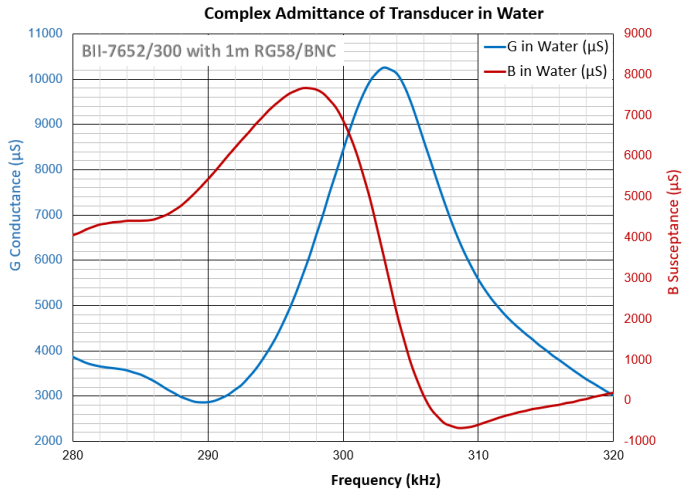


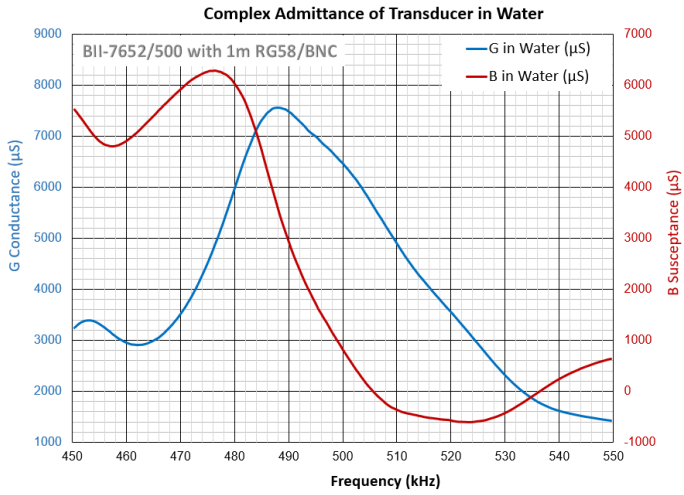
b. General Size information.



Admittance in Water without BII6010 Impedance Matching







Impedance in Water with BII6010 Impedance Matching to BII Amplifier or 50Ω