One of the most critical elements of Wireless Communication Network is antenna. Antenna represents only a small part of the overall cost of a communication site, but its performance impact is enormous. Its function is to transform conduction current – its this invisible phenomenon that makes radio communications possible. The antenna's impact is determined by choosing appropriate characteristic defined by its specification.

The following information describes and defines the most common parameter used to specify appropriate antenna :

FREQUENCY

Range of frequency from antenna reflect which Range of Frequency Signal Spectrum can be radiated by antenna.

RADIATION PATTERN

The most important requirement is describing where an antenna radiates energy into the space around it. A radiation pattern is a graphical representation of where and how much energy is radiated.

Antenna radiation characteristic are aptly described by only two radiation pattern : horizontal (azimuth) radiation pattern and vertical (elevation) radiation pattern. Radio Network Planner should determine the most suitable radiation pattern to achieve/reach the coverage aim or target.

ANTENNA GAIN

Second most critical parameter in selecting antenna is gain. Gain is proportional to the product of directivity and the antenna's efficiency. Directivity is a measure of how an antenna focuses energy, while the antenna's efficiency accounts for losses associated with the antenna.

$$G = e\,D$$
$$G(dBi) = 10 \operatorname{Log}_{10} (e\,D)$$
$$G(dBi) = D(dBi) - L\,(dB)$$

As G= Gain relative to an isotropic radiator
E= Antenna efficiency
D= Directivity relative to an isotropic radiator
L=Losses due to resistance of conductor., Dielectrics, impedance mismatch, or Polarization

Half Power Beamwidth

Half power beam-width is a parameter that measures the shape of the radiation pattern. It is the angular width of the radiation pattern's main lobe. It is measured between the points where power pattern is one-half (3dB down) the main lobe's peak value.

MATERIALS

The Selection of materials which will be used in an antenna may determine its performance :

- Radiating element and support member
- Radomes
- Feed harness and connectors
- Hardware and mounting

Aluminum alloys which combine high strength, low weight, good resistance to corrosion and good conductivity are natural choice in metals. Pressure cast aluminum is very well suited to certain parts such as basses, sockets, mounts and clamps. It has higher resistance to corrosion than the high strength aluminum alloy while it hardness prevents metal "creep" undesirable in clamps.

Radomes are typically fabricated from high strength, Low RF Loss materials such as fiberglass or ABS. Materials for Outdoor Antenna must be ultraviolet (UV) resistant to avoid deterioration after long exposure to sunlight.

Type N and 7/16 DIN connectors are suitable for use in mobile radio communication. Some users like the connector rigidly attached to the antenna support, while others prefer a flexible lead is desirable between antenna and most transmission lines.

Small hardware such as bolts, nuts and rivets used for attachment of radiating elements or support members should be of sufficient strength and resistant to corrosion.

Below Literature will describe the impact of parameter in selecting antenna towards antenna performance :

Polarization

The Polarization of antenna is a property of the radio wave that is produced by the antenna. Polarization describes how the radio wave varies in space with time. This is important concept because for a radio wave transmitted with a given polarization to be received by another antenna, the received antenna must be able to receive this polarization and be oriented to do so.

INTERMODULATION

A characteristic of passive devices used in radio systems that is becoming increasingly important is inter-modulation distortion (IMD). Nonlinearities within these passive devices cause the appearance of unwanted frequencies equal to the integral multiples and sum of differences of integral multiples of the unwanted frequencies.

POWER RATING

The input power to antenna terminals verifies that antenna can safely handle and deliver its rated performance. Generally, it is limited to the power handling capacity of the feed line. Much digital system will include both average power and peak power requirement.

VSWR

VSWR and Return Loss (RL) are measures of how much energy is reflected from an antenna's input. The amount of energy reflected by the Antenna depends on the antenna's input impedance which consists of two parts : Self-Impedance and mutual impedance.

The Self Impedance is that impedance determined by the antenna on its own, meanwhile mutual impedance is determined by the antenna surroundings i.e. : energy radiated by the antenna that reflected back into the antenna surrounding object.

The relationships between an antenna's input impedance, Z and its VSWR and RL, Γ are :

$$\Gamma = \frac{Z - Z_0}{Z + Z_0} \qquad VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

$$RL = 20 \operatorname{Log}_{10} (\Gamma) = 20 \operatorname{Log}_{10} \frac{VSWR - 1}{VSWR + 1}$$

As : Γ = reflection coefficient
Z = antenna's input impedance
Z_o = Characteristic impedance of system

VSWR or Return Loss is only one component of an antenna. The table below shows how VSWR can increase (RL decrease) without significantly increase the antenna's overall losses.

PRODUCT CHARACTERISTIC

Our IOA has a good performance and pass several criteria such as :

1. ***Wide Frequency Range***.

It covers all type of band of CDMA800, E-TAC, GSM900, GSM1800, PCS1900, UMTS, Wifi. User has no worry if there is plan to utilize antenna for different frequency band.

2. ***High Input Power***.

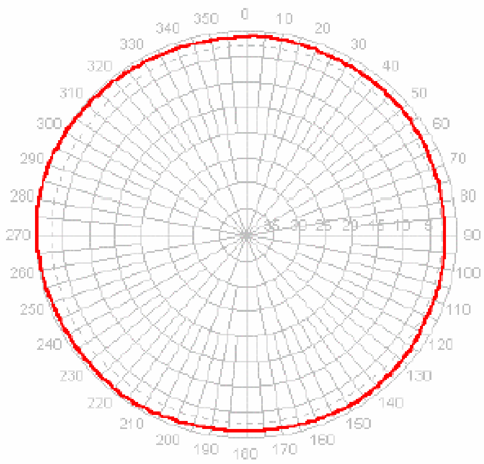
IOA820/2500 can accept input power of CW 100Watts (Continues Wave) which is equal to 50dBm. This consider high for Indoor Antenna.

3. ***Polarization***

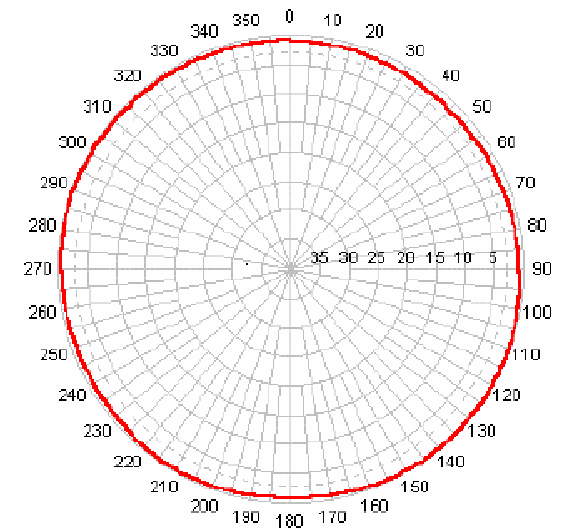
IOA 820/2500 meets the standard polarization for indoor antenna which is Vertical with Horizontal Beamwidth 360^0 and Vertical Beamwidth. 90^0.

Below is Radiation Pattern in Horizontal Plan at various frequency :

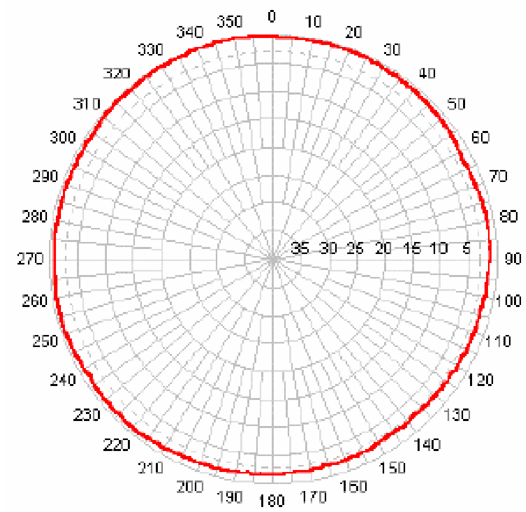
820 MHz, H-plan:



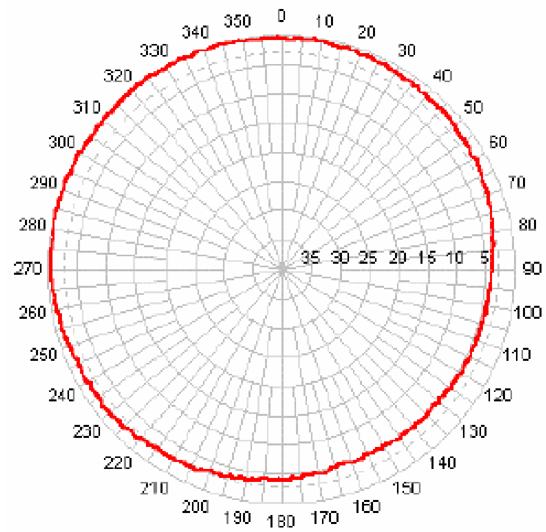
960 MHz, H-plan:



1700Mhz : H-Plan :

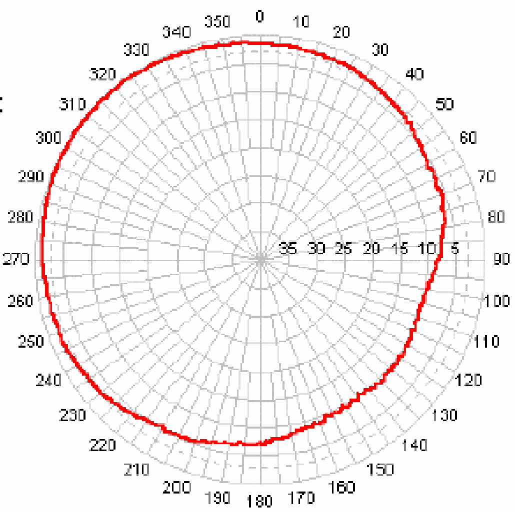


2100Mhz : H-Plan :



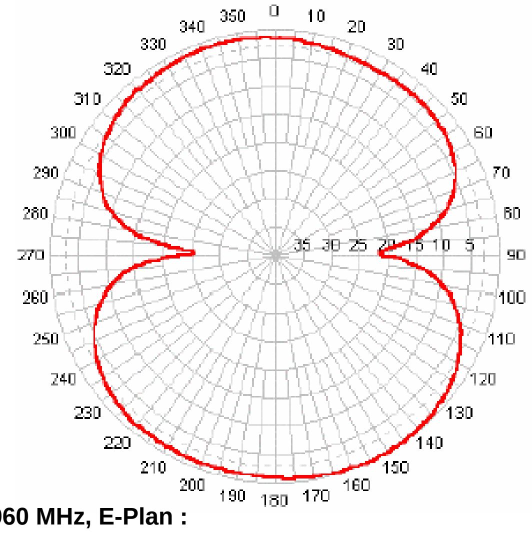
2500Mhz : H-Plan

:

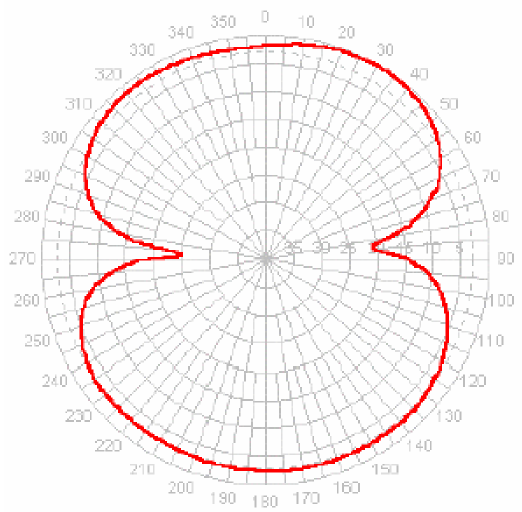


Below is Radiation Pattern in Elevation Plan at various frequency :

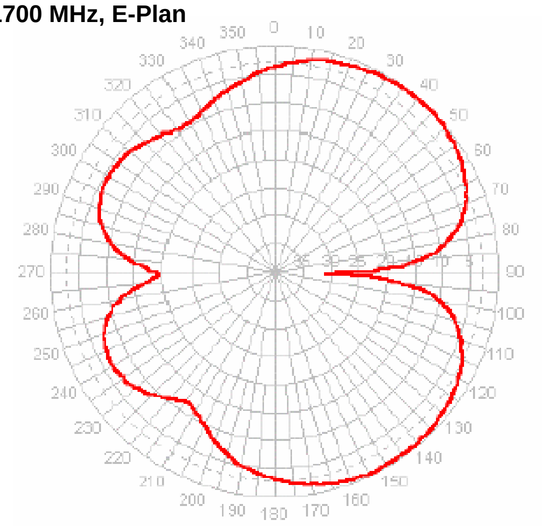
820 MHz, E-Plan :



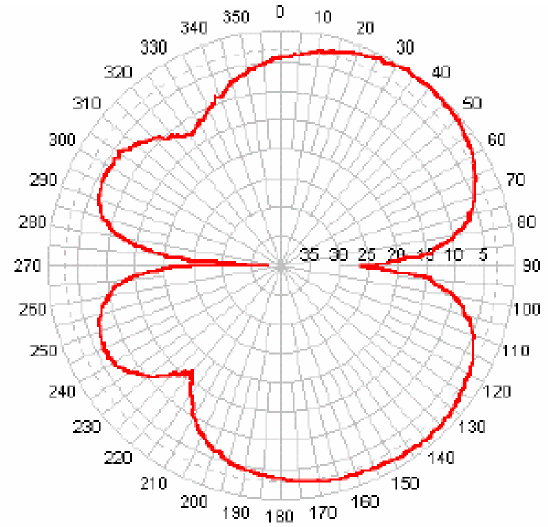
960 MHz, E-Plan :



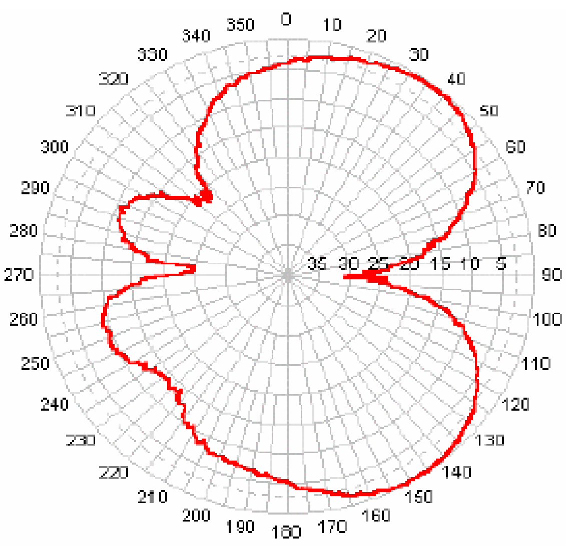
1700 MHz, E-Plan



2100 MHz, E-Plan



2500 MHz, E-Plan



4. Type of Connector

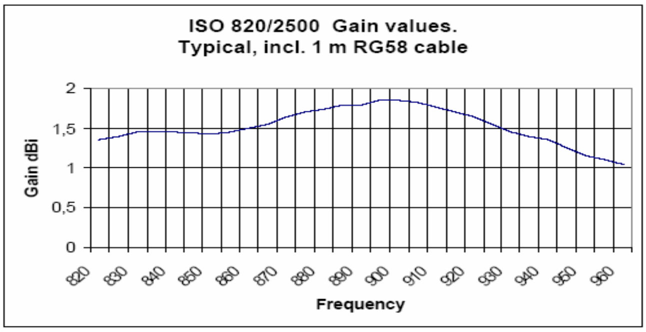
IOA 820/2500 use Nfemale connector which is widely accepted in Cellular industry. Connector is located on top of antenna to ease installation.

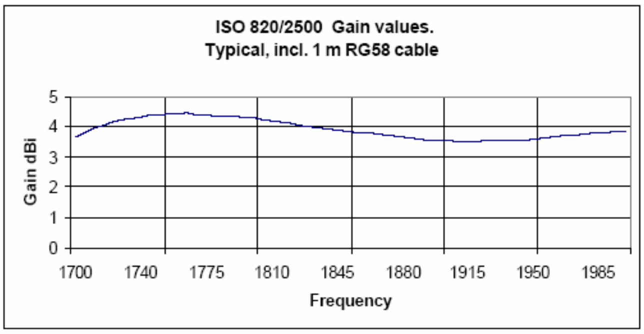
5. ***Material and Dimension***.

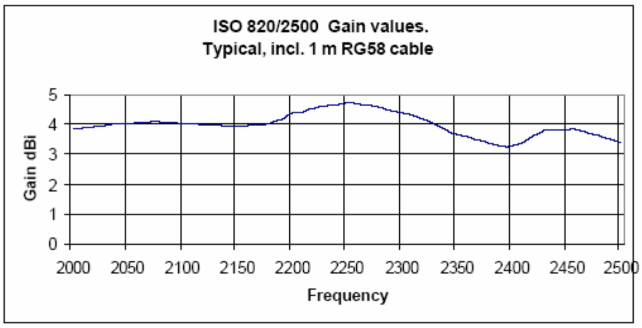
Nice size and Smooth shape of IOA820/2500 make itself suit or match to the building ceiling. With White color ABS Radome material, IOA looks similar to the Building surrounding equipment such as light, smoke detector, Dome Camera, etc. Radiating Material is Aluminum which combines high strength, low weight, good resistance to corrosion and good conductivity

6. ***Gain.***

Unlike other Omni Directional Indoor Antenna, IOA 820-2500 has variable gain from 2dBi at 820-960 Mhz and 4dBi at 1710-2500Mhz as shown by graph below :

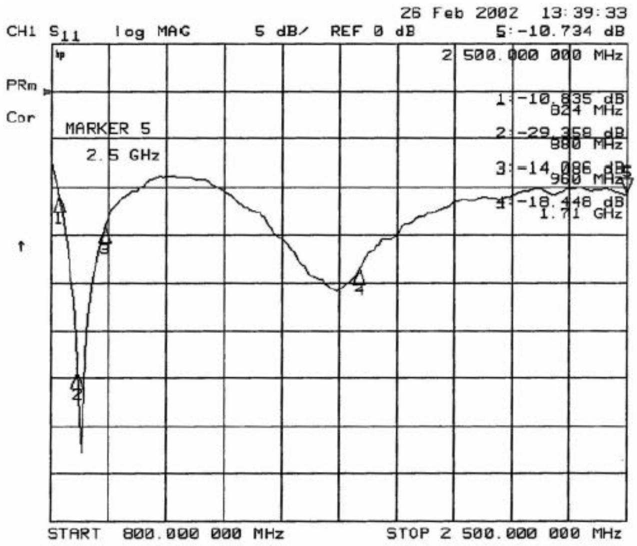






7. *VSWR*

IOA820/2500 has various VSWR at each the frequency as shown by below Graph :



It is high at the beginning (824 Mhz) and get better after 880Mhz, which is :

- at 824 Mhz RL is -10.83dB or VSWR 1.8
- at 880 Mhz RL is -29.35dB or VSWR 1.07
- at 960 Mhz RL is -14.08dB or VSWR 1.5
- at 1710 Mhz RL is -18,44dB or VSWR 1.27

In General Practice, Cellular Operator verify the acceptance of network performance by using VSWR criteria. This is relevant with Theory that higher VSWR deliver higher Reflected power which cause higher Transmission loss and Lower Percentage of Power Transmitted.

For example : VSWR 1.0 has 0 dB Transmission Loss and 100% Power Transmitted, meanwhile VSWR 1.3 has 0.075dB Transmission Loss and 98.3% Power Transmitted. Normally Max VSWR is 1.5 as it has 0.177dB Transmission Loss and 96% Power Transmitted.

We can get better VSWR with certain length of Feeder Cable., For instance : direct VSWR sweep to antenna at 824 Mhz RL is 10.9dB and VSWR is 1.8, and with 50m 7/8" Feeder (loss is 4.1dB/100m) RL is 15dB and VSWR 1.44.

The Effect of VSWR on Transmission Power

VSWR	VSWR [dB]	Return Loss [dB]	Trans. Loss [dB]	Volt. Refl. Coeff.	Power Trans. [%]	Power Refl. [%]
1.00	.0	∞	.000	.00	100.0	.0
1.01	.1	46.1	.000	.00	100.0	.0
1.02	.2	40.1	.000	.01	100.0	.0
1.03	.3	36.6	.001	.01	100.0	.0
1.04	.3	34.2	.002	.02	100.0	.0
1.05	.4	32.3	.003	.02	99.9	.1
1.06	.5	30.7	.004	.03	99.9	.1
1.07	.6	29.4	.005	.03	99.9	.1
1.08	.7	28.3	.006	.04	99.9	.1
1.09	.7	27.3	.008	.04	99.8	.2
1.10	.8	26.4	.010	.05	99.8	.2
1.11	.9	25.7	.012	.05	99.7	.3
1.12	1.0	24.9	.014	.06	99.7	.3
1.13	1.1	24.3	.016	.06	99.6	.4
1.14	1.1	23.7	.019	.07	99.6	.4
1.15	1.2	23.1	.021	.07	99.5	.5
1.16	1.3	22.6	.024	.07	99.5	.5
1.17	1.4	22.1	.027	.08	99.4	.6
1.18	1.4	21.7	.030	.08	99.3	.7
1.19	1.5	21.2	.033	.09	99.2	.8
1.20	1.6	20.8	.036	.09	99.2	.8
1.21	1.7	20.4	.039	.10	99.1	.9
1.22	1.7	20.1	.043	.10	99.0	1.0
1.23	1.8	19.7	.046	.10	98.9	1.1
1.24	1.9	19.4	.050	.11	98.9	1.1
1.25	1.9	19.1	.054	.11	98.8	1.2
1.26	2.0	18.8	.058	.12	98.7	1.3
1.27	2.1	18.5	.062	.12	98.6	1.4
1.28	2.1	18.2	.066	.12	98.5	1.5
1.29	2.2	17.9	.070	.13	98.4	1.6
1.30	2.3	17.7	.075	.13	98.3	1.7
1.32	2.4	17.2	.083	.14	98.1	1.9
1.34	2.5	16.8	.093	.15	97.9	2.1
1.36	2.7	16.3	.102	.15	97.7	2.3
1.38	2.8	15.9	.112	.16	97.5	2.5
1.40	2.9	15.6	.122	.17	97.2	2.8
1.42	3.0	15.2	.133	.17	97.0	3.0
1.44	3.2	14.9	.144	.18	96.7	3.3
1.46	3.3	14.6	.155	.19	96.5	3.5
1.48	3.4	14.3	.166	.19	96.3	3.7
1.50	3.5	14.0	.177	.20	96.0	4.0
1.52	3.6	13.7	.189	.21	95.7	4.3
1.54	3.8	13.4	.201	.21	95.5	4.6
1.56	3.9	13.2	.213	.22	95.2	4.8
1.58	4.0	13.0	.225	.22	94.9	5.1
1.60	4.1	12.7	.238	.23	94.7	5.3
1.62	4.2	12.5	.250	.24	94.4	5.6

VSWR	VSWR [dB]	Return Loss [dB]	Trans. Loss [dB]	Volt. Refl. Coeff.	Power Trans. [%]	Power Refl. [%]
1.64	4.3	12.3	.263	.24	94.1	5.9
1.66	4.4	12.1	.276	.25	93.8	6.2
1.68	4.5	11.9	.289	.25	93.6	6.4
1.70	4.6	11.7	.302	.26	93.3	6.7
1.72	4.7	11.5	.315	.26	93.0	7.0
1.74	4.8	11.4	.329	.27	92.7	7.3
1.76	4.9	11.2	.342	.28	92.4	7.6
1.78	5.0	11.0	.356	.28	92.1	7.9
1.80	5.1	10.9	.370	.29	91.8	8.2
1.82	5.2	10.7	.384	.29	91.5	8.5
1.84	5.3	10.6	.398	.30	91.3	8.7
1.86	5.4	10.4	.412	.30	91.0	9.0
1.88	5.5	10.3	.426	.31	90.7	9.3
1.90	5.6	10.2	.440	.31	90.4	9.6
1.92	5.7	10.0	.454	.32	90.1	9.9
1.94	5.8	9.9	.468	.32	89.8	10.2
1.96	5.8	9.8	.483	.32	89.5	10.5
1.98	5.9	9.7	.497	.33	89.2	10.8
2.00	6.0	9.5	.512	.33	88.9	11.1
2.50	8.0	7.4	.881	.43	81.6	18.4
3.00	9.5	6.0	1.249	.50	75.0	25.0
3.50	10.9	5.1	1.603	.56	69.1	30.9
4.00	12.0	4.4	1.938	.60	64.0	36.0
4.50	13.1	3.9	2.255	.64	59.5	40.5
5.00	14.0	3.5	2.553	.67	55.6	44.4
5.50	14.8	3.2	2.834	.69	52.1	47.9
6.00	15.6	2.9	3.100	.71	49.0	51.0
6.50	16.3	2.7	3.351	.73	46.2	53.8
7.00	16.9	2.5	3.590	.75	43.7	56.3
7.50	17.5	2.3	3.817	.76	41.5	58.5
8.00	18.1	2.2	4.033	.78	39.5	60.5
8.50	18.6	2.1	4.240	.79	37.7	62.3
9.00	19.1	1.9	4.437	.80	36.0	64.0
9.50	19.6	1.8	4.626	.81	34.5	65.5
10.00	20.0	1.7	4.807	.82	33.1	66.9
11.00	20.8	1.6	5.149	.83	30.6	69.4
12.00	21.6	1.5	5.466	.85	28.4	71.6
13.00	22.3	1.3	5.762	.86	26.5	73.5
14.00	22.9	1.2	6.040	.87	24.9	75.1
15.00	23.5	1.2	6.301	.88	23.4	76.6
16.00	24.1	1.1	6.547	.88	22.1	77.9
17.00	24.6	1.0	6.780	.89	21.0	79.0
18.00	25.1	1.0	7.002	.89	19.9	80.1
19.00	25.6	.9	7.212	.90	19.0	81.0
20.00	26.0	.9	7.413	.90	18.1	81.9
25.00	28.0	.7	8.299	.92	14.8	85.2
30.00	29.5	.6	9.036	.94	12.5	87.5

For In-Building design, there will be few dB margin included for link budget (perhaps 3, 5 or 10 dB). Therefore, the additional transmission loss of 0.3dB should be <u>negligible/easily compensated by the margin added in link</u>

For instance :
- With VSWR 1.3, transmission loss is 0.075dB and reflected power is 98.3 %
- With VSWR 1.8, transmission loss is 0.370dB and reflected power is 91.8 %

Meanings : there is additional transmission loss of 0.295dB and reflected power reduce by 6.5%.

Meanwhile in InBuilding Design, we only cater for small RF Power at antenna such as 2dBm till 5dBm equal to 1.6mWatt till 3.2 mWatt. With the above sample, additional loss 0.295dB equal to 0.1475% till 0.059% compare to Rf power at antenna and reflected power reduce by 6.5% equal to 0.1mWatt till 0.2 mWatt from 1.6mWatt till 3.2 mWatt.