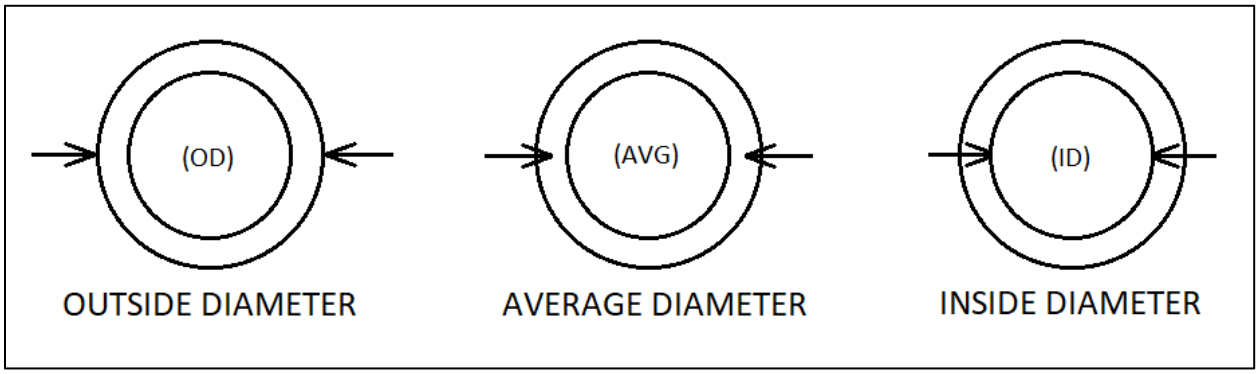
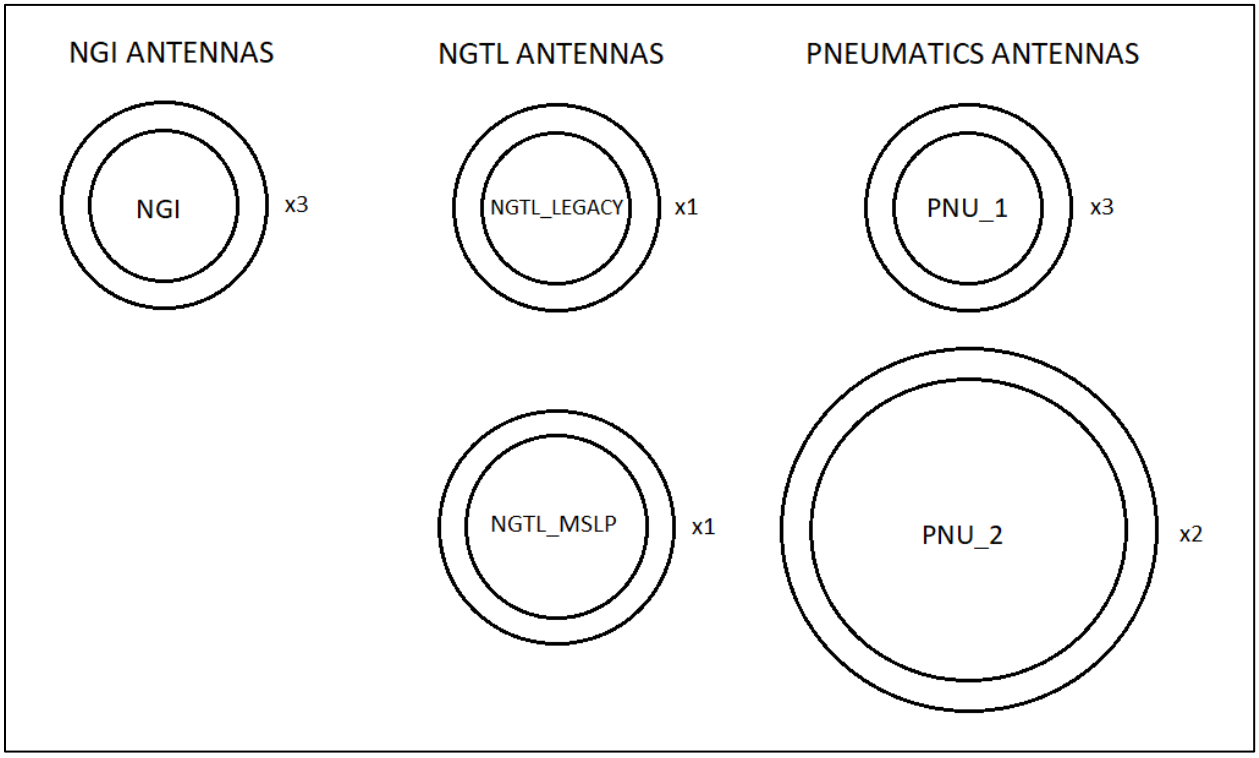
ANTENNA GAIN CALCULATION FOR THE 300038501, 300035274 & 300036797 PCBAs





The NGI RFID PCBA (300038501) has three antennas, all identical in size (marked NGI above). The NGTL RFID PCBA (300035274) has two antennas, one smaller in size (marked NGTL_LEGACY above) and one larger in size (marked NGTL_MSLP above). The Pneumatics RFID PCBA (300036797) has five antennas, three smaller identical in size (marked PNU_1 above) and two larger in size (marked PNU_2 above).

Antenna Gain was calculated for each of the five antenna sizes using three different lengths for D (diameter): OD, AVG, ID. The equation used to calculate gain:

$$G = \eta\left(\frac{\pi DF}{c}\right)^2$$

Where η = net efficiency and for a typical antenna = 0.55

Where D = diameter in meters

Where F = is frequency, or 13.56MHz

Where c = speed of light, or $3(10)^8$

Diameter calculations:

INCHES	OD	AVG	ID
NGI	0.930	0.860	0.790
NGTL_MSLP	1.044	0.987	0.930
NGTL_LEGACY	0.950	0.895	0.840
PNU_1	0.990	0.920	0.850
PNU_2	1.540	1.470	1.400

METERS	OD	AVG	ID
NGI	0.024	0.022	0.020
NGTL_LEGACY	0.027	0.026	0.024
NGTL_MSLP	0.024	0.023	0.021
PNU_1	0.025	0.024	0.022
PNU_2	0.040	0.038	0.036

From the table we can show that $G = D^2(1.109)10^{-2}$, which provides:

GAIN	OD	AVG	ID
NGI	6.388E-06	5.368E-06	4.436E-06
NGTL_MSLP	8.085E-06	7.497E-06	6.388E-06
NGTL_LEGACY	6.388E-06	5.867E-06	4.891E-06
PNU_1	6.931E-06	6.388E-06	5.368E-06
PNU_2	17.744E-06	16.014E-06	14.373E-06

Using $10\log\left(\frac{Po}{Pi}\right) = dB$, we plug the values from the gain table in for $\frac{Po}{Pi}$ to get:

GAIN (dBD)	OD	AVG	ID
NGI	-51.946	-52.702	-53.530
NGTL_MSLP	-50.923	-51.251	-51.946
NGTL_LEGACY	-51.946	-52.316	-53.106
PNU_1	-51.592	-51.946	-52.702
PNU_2	-47.509	-47.955	-48.425

now, if we assume that the equation $\boldsymbol{G = \eta\left(\frac{\pi DF}{c}\right)^2}$ assumes that dB gain is with respect to a halfwave diploe (dBD), then to express the gain (dB) in dBi (with respect to an isotropol radiator) we must add 2.14 to the value to get:

GAIN (dBi)	OD	AVG	ID
NGI	-49.806	-50.562	-51.390
NGTL_MSLP	-48.783	-49.111	-49.806
NGTL_LEGACY	-49.806	-50.176	-50.966
PNU_1	-49.452	-49.806	-50.562
PNU_2	-45.369	-45.815	-46.285

Based on the above, we can use a theoretical antenna gain of ~-50 dBi as an average for the different antennas.

Reference:
http://www.aticourses.com/antennas tutorial.htm