**Lab 12：Horn Antennas**

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| **Introduction**  Horn antennas represent a fundamental component of microwave and millimeter-wave communication systems, valued for their efficient radiation characteristics and versatile applications. Operating based on fundamental electromagnetic principles, horn antennas serve as crucial elements in transmitting and receiving electromagnetic waves across a wide frequency range.  At its core, a horn antenna consists of a flared metal structure resembling a horn, with a feed element located at its narrowest section. This feed element, often connected to a transmission line, launches or receives electromagnetic waves into or from the horn structure. The gradual expansion of the horn allows for impedance matching and efficient radiation of electromagnetic waves.  Mathematically, the radiation pattern of a horn antenna can be described using the aperture theory, which relates the radiated electric field to the aperture distribution of the antenna. Additionally, the gain of a horn antenna, a measure of its directivity, can be calculated using the Friis transmission equation, considering factors such as aperture size and operating frequency.  In the realm of communication, horn antennas play a pivotal role in various applications. They are widely employed in radar systems for their ability to provide directive and high-gain radiation patterns, enabling precise target detection and tracking. In wireless communication systems, horn antennas facilitate long-distance communication with minimal signal loss and interference, making them indispensable in point-to-point microwave links and satellite communication.  Beyond communication, horn antennas find applications in scientific research, such as radio astronomy for capturing faint signals from celestial bodies, and in medical imaging for microwave imaging techniques like microwave tomography.  **Lab results & Analysis**：  Design a Pyramidal Horn Antenna with frequency range from 4.64GHz~7.05GHz. The horn is fed by a WR-159 rectangular waveguide. The gain at 5.8GHz is at least 20dB.  Plot its S11, radiation pattern (4.64, 5.8, 7.04GHz or their adjacent frequency) and gain vs. frequency.    G(5.8GHz) > 20dB(100)  WR159, a = 40.386mm, b = 20.193mm    f=5.8\*10^9;  c=3\*10^8;  lamda=c/f;  G=100;  a=0.040386;  b=0.020193;  epsilon\_ap=0.51;  syms a1  eqn=(a1)^4-a\*(a1)^3+(3\*b\*G\*(lamda)^2)/(9\*pi\*epsilon\_ap)\*a1-(3\*G^2\*(lamda)^4)/(32\*pi^2\*(epsilon\_ap)^2)==0;  a1=solve(eqn,a1);  a1=double(a1);  We get:    a1=231.1mm  a1=0.2311;  syms b1  b1=solve(G==(4\*pi\*epsilon\_ap\*a1\*b1)/(lamda^2),b1);  b1=double(b1)  And we get b1=180.6mm  syms rou1  rou1=solve(b1==sqrt(2\*lamda\*rou1),rou1);  syms rou2  rou2=solve(a1==sqrt(3\*lamda\*rou2),rou2);  rou1=double(rou1)  rou2=double(rou2)  We get: rou1=315.3mm, rou2=344.2mm;  syms L  L=solve(rou1/L==b1/(b1-b),L);  syms L  L=solve(rou2/L==a1/(a1-a),L);  We get L= 282mm  So: a1=231.1mm, b1=180.6mm, L=282mm, a = 40.386mm, b = 20.193mm, lrec=3/4\*lamda=38.79mm  lf=1/2\*lamda=25.86mm, lp=1/2\*b=10.1mm, rp=1.3mm, rout=3mm  Modeling using the above parameters leads to:    (1) S11    So we need to tunning the lp.    After tuning, new lp=11.1mm  (2) Radiation pattern  a. 4.64GHz    b. 5.8GHz    c. 7.04GHz    (3) gain vs frequency | |
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| **Score** | 95 |