



DIGITALIZAREA PROCESULUI DE PROIECTARE AL ANTENELOR MULTIFRECVENȚĂ RFID ȘI EVALUAREA EXPUNERII UMANE LA RADIAȚIILE EMISE DE ACESTEA

RAPORT INTERMEDIAR 1

**MODELAREA NUMERICĂ, ANALIZA ȘI OPTIMIZAREA
ANTENELOR RFID CARE FUNCȚIONEAZĂ
LA FRECVENȚE JOASE**

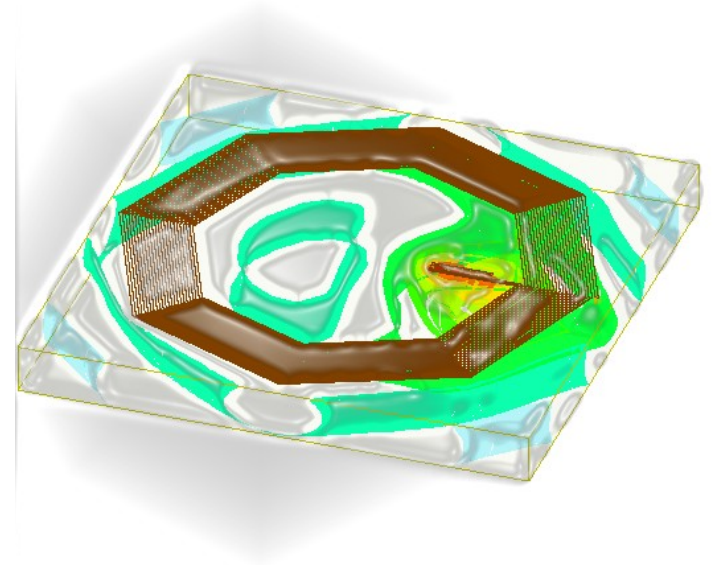
Director: S.I. dr. ing. Constantinescu Claudia Alana

Membrii: Asist. dr. ing. Andreica Sergiu Iulian

Dr. ing. Rapolti Laszlo

CUPRINS

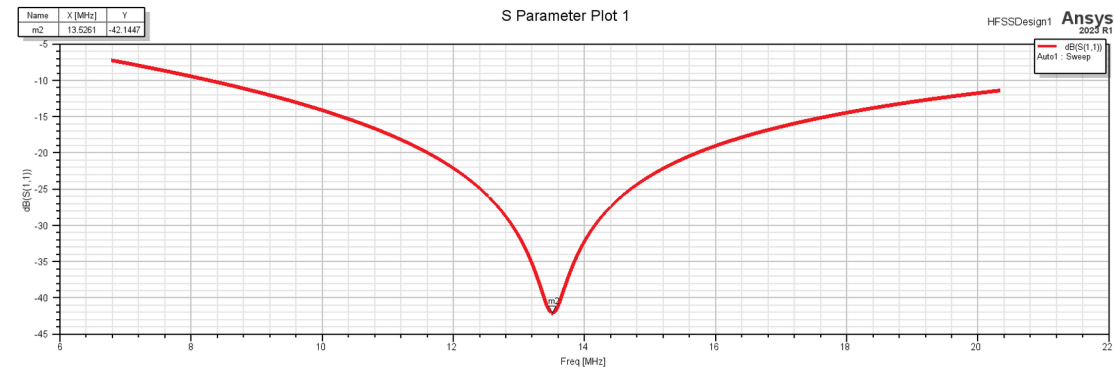
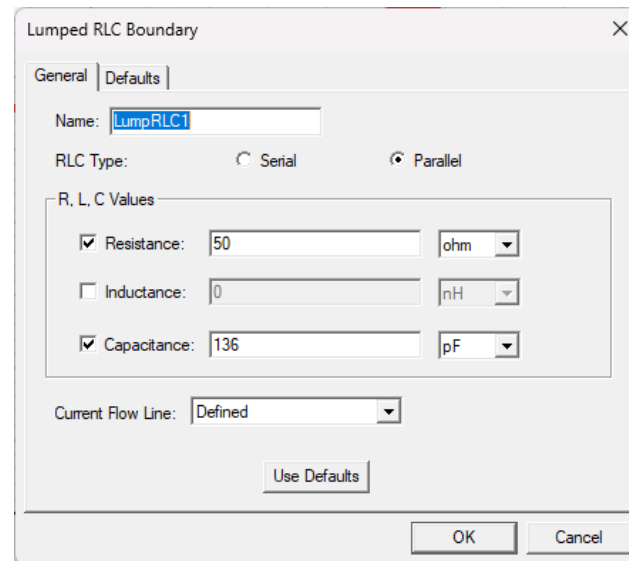
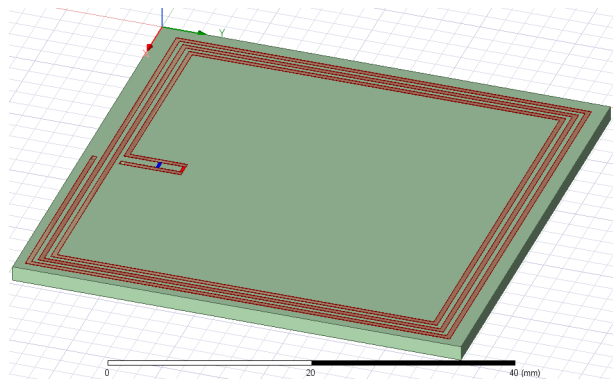
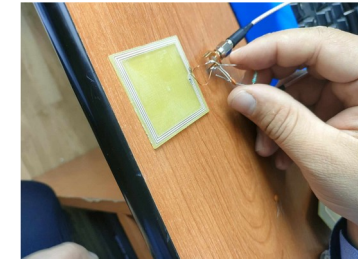
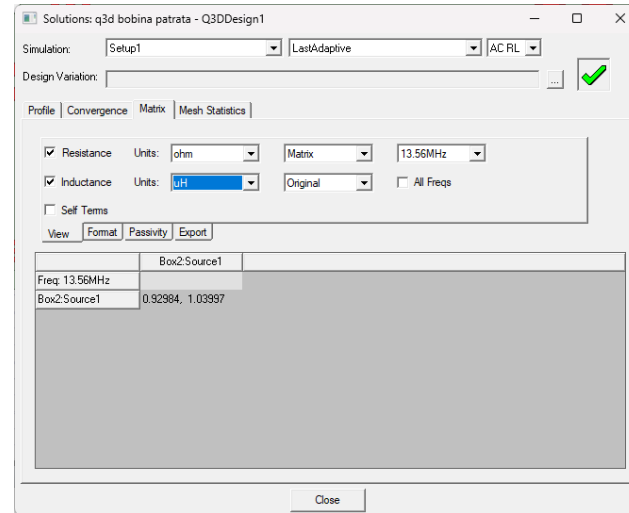
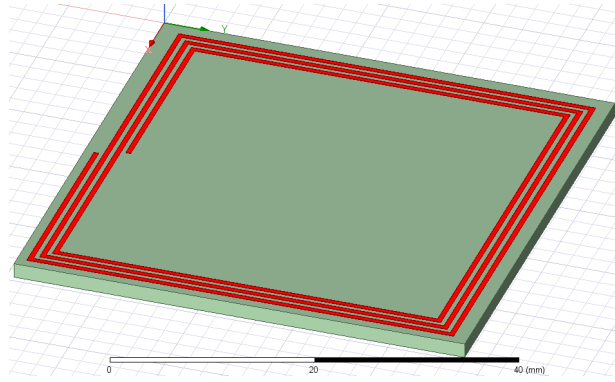
1. Studiu de caz-structură inițială
2. Algoritm pentru determinarea structurilor de interes
3. Influența geometriei asupra parametrilor de interes
4. Influența dielectricului asupra parametrilor de interes
5. Influența grosimii dielectricului asupra parametrilor de interes
6. Analiza termică și mecanică a structurilor optimizate
7. Analiza tag-urilor RFID pătrate proiectate pentru funcționarea la frecvența de 125 kHz





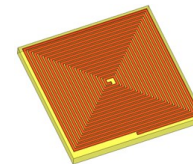
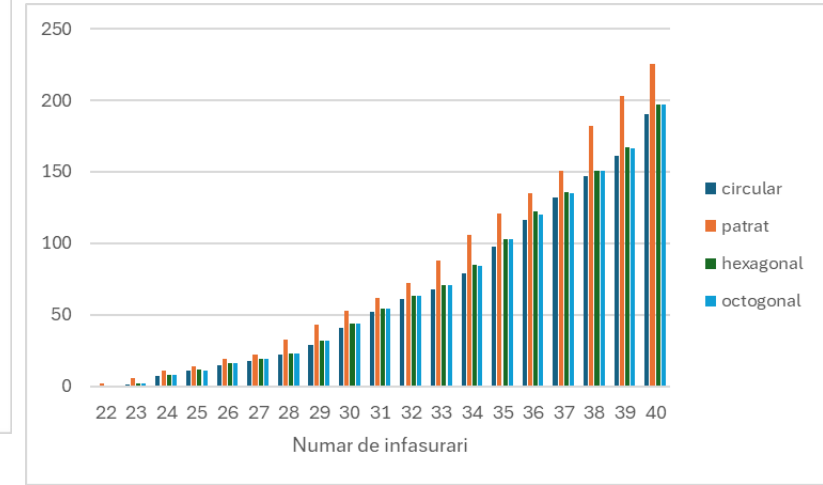
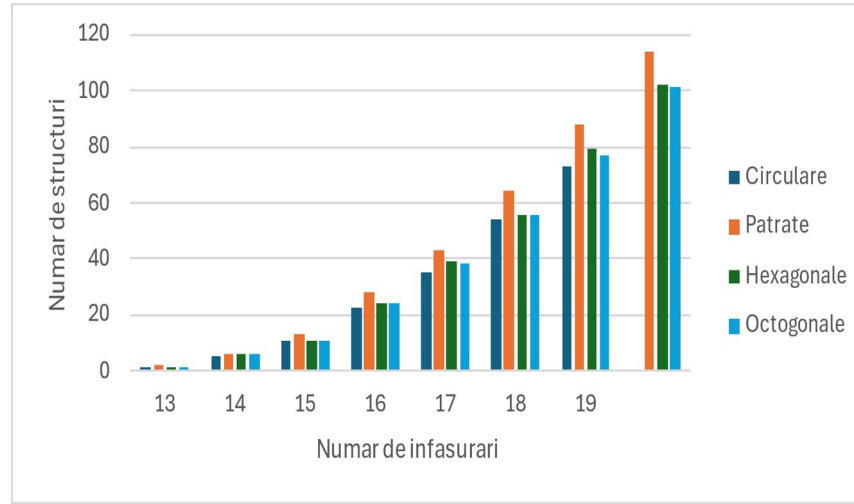
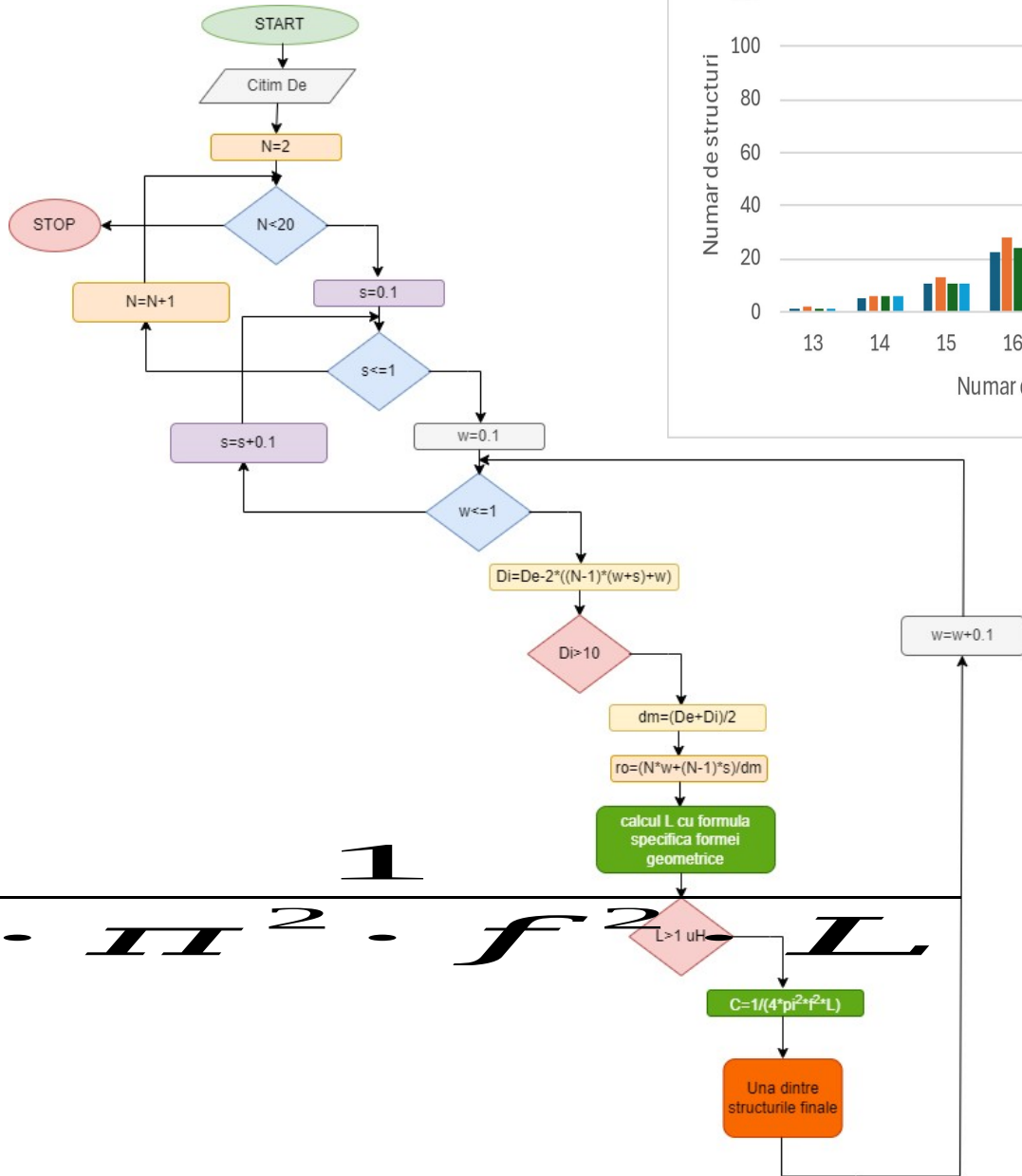
**MODELAREA NUMERICĂ ȘI
ANALIZA MODELELOR
INIȚIALE PENTRU
13.56 MHz**

STUDIU DE CAZ – STRUCTURA INIȚIALĂ

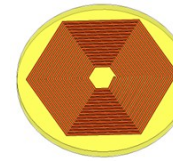


**ALGORITM PENTRU
DETERMINAREA
STRUCTURILOR DE INTERES**

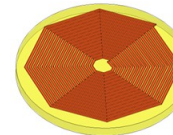
ALGORITM PENTRU DETERMINAREA STRUCTURI DE INTERES



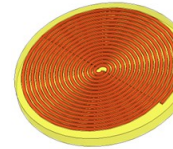
$$L = \left(\frac{u \cdot N \cdot N \cdot dm \cdot 1.27}{2} \right) \cdot (\log(2.07/ro) + 0.18 \cdot ro + 0.13 \cdot ro)$$



$$L = \left(\frac{u \cdot N \cdot N \cdot dm \cdot 1.09}{2} \right) \cdot (\log(2.23/ro) + 0.17 \cdot ro \cdot ro)$$



$$L = \left(\frac{u \cdot N \cdot N \cdot dm \cdot 1.07}{2} \right) \cdot (\log(2.29/ro) + 0.19 \cdot ro \cdot ro)$$



$$L = \left(\frac{u \cdot N \cdot N \cdot dm}{2} \right) \cdot (\log(2.46/ro) + 0.2 \cdot ro \cdot ro)$$

$$4 \cdot \pi^2 \cdot f^2 \cdot L$$

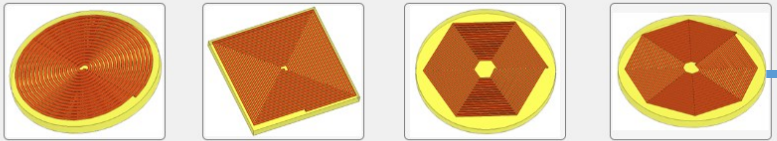
ALGORITM PENTRU DETERMINAREA STRUCTURILOR DE INTERES

MATLAB App

Determinare parametrii caracteristici ai bobinelor spirala de diferite dimensiuni si forme

Frecventa de functionare= 13.56 MHz

Circulare Patrate Hexagonale Octogonale



Blue arrows indicate flow from the Octogonal structure to the right-hand application window. A yellow arrow indicates flow from the Hexagonale structure to the bottom application window.

MATLAB App

Modul de calcul a inductivitatii bobinelor in functie de diametrul exterior
L [uH] pentru structurile analizate

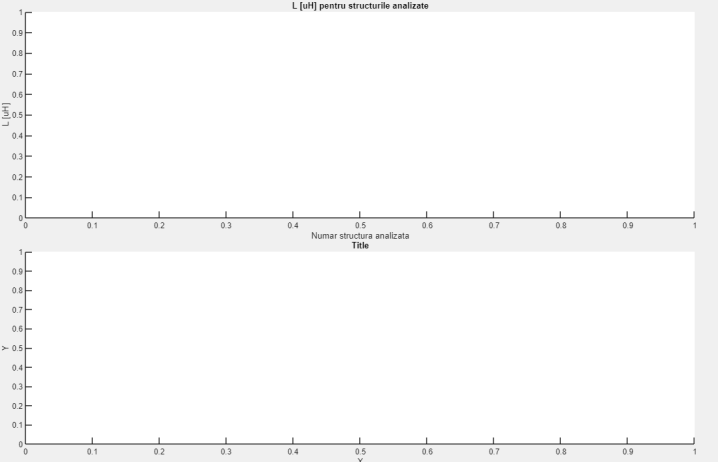
Diametru exterior De

Calcul inductivitate și capacitate corespunzătoare

Exporta in excel

Di	N	s	w	L	C

Reprezentare grafica L[uH] Valori condensatoare necesare [pF]



MATLAB App

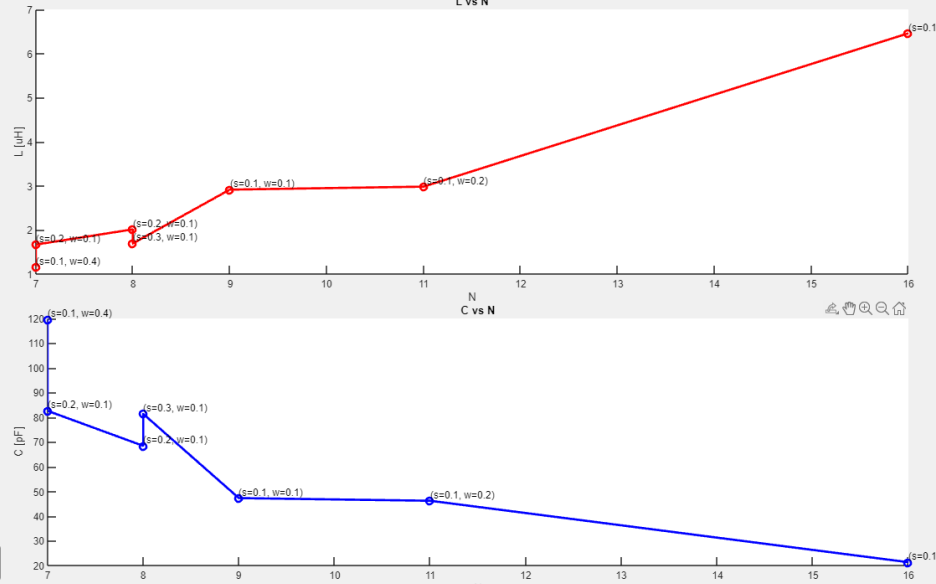
Modul de calcul a inductivitatii bobinelor in functie de diametrul exterior
L vs N

Diametru exterior De

Calcul inductivitate și capacitate corespunzătoare

Exporta in excel

Di	N	s	w	L	C
10.2000	7.0000	0.1000	0.4000	1.1523	11
13.2000	7.0000	0.2000	0.1000	1.6680	8
12.6000	8.0000	0.2000	0.1000	2.0130	6
11.2000	8.0000	0.3000	0.1000	1.6933	8
13.6000	9.0000	0.1000	0.1000	2.9137	4
10.6000	11.0000	0.1000	0.2000	2.9817	4
10.8000	16.0000	0.1000	0.1000	6.4588	2



Reprezentare grafica L[uH] Valori condensatoare necesare [pF]

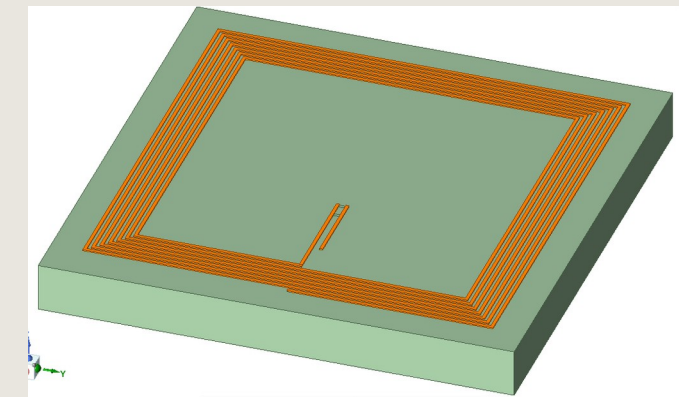
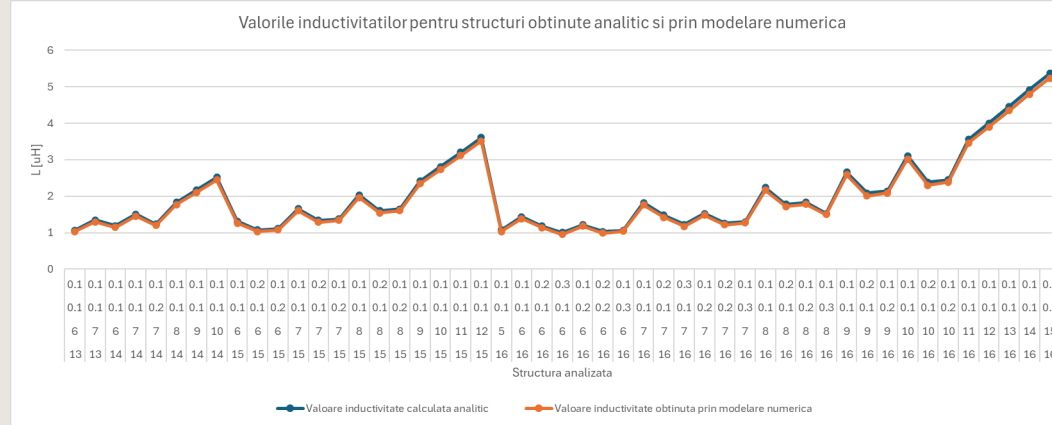
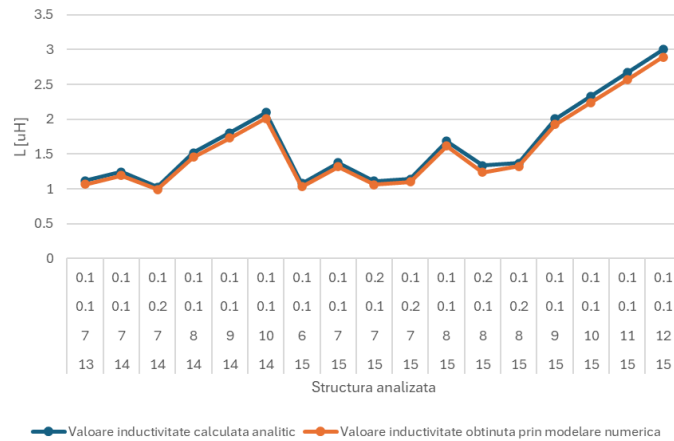


**INFLUENȚA GEOMETRIEI
ASUPRA STRUCTURILOR DE
INTERES**

VALIDAREA REZULTATELOR OBȚINUTE PENTRU INDUCTIVITĂȚI ȘI CAPACITĂȚI ÎN URMA CALCULELOR PENTRU STRUCTURILE CIRCULARE ȘI PĂTRATE

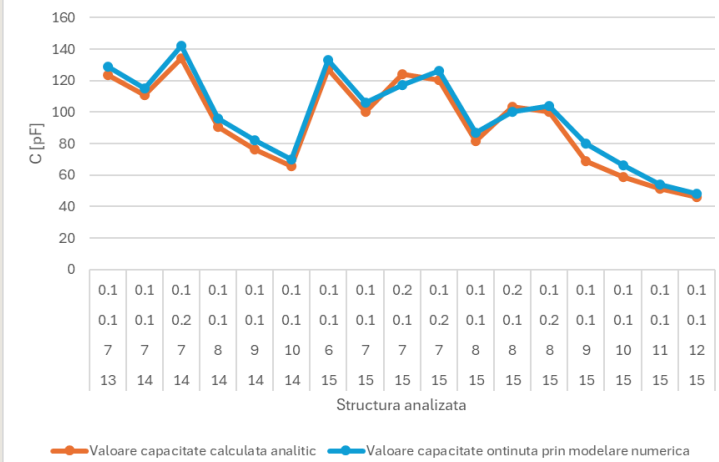
Structuri circulare

Valorile inductivitatilor pentru structuri obtinute analitic si prin modelare numerica

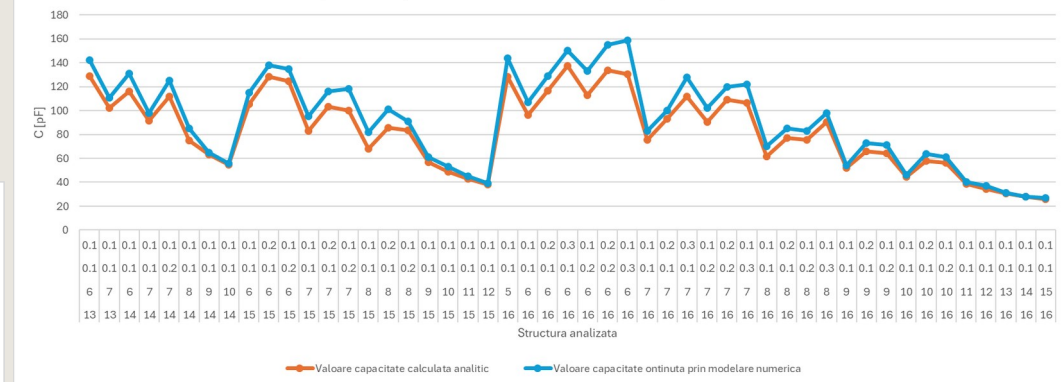


Rezultatele obținute analitic sunt validate prin modelare numerică

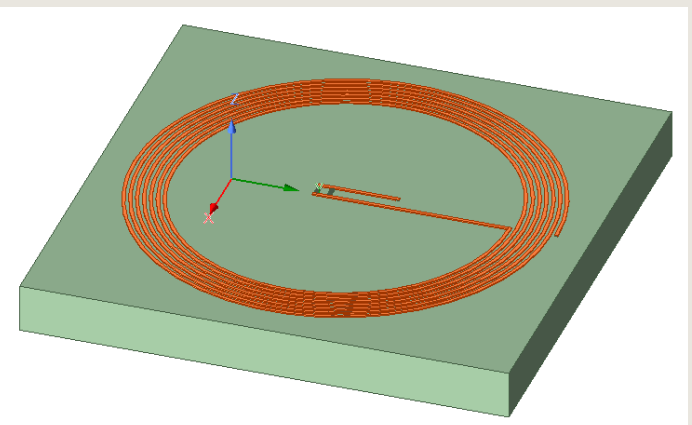
Valorile capacitativitatilor pentru structuri obtinute analitic si prin modelare numerica



Valorile capacitativitatilor pentru structuri obtinute analitic si prin modelare numerica

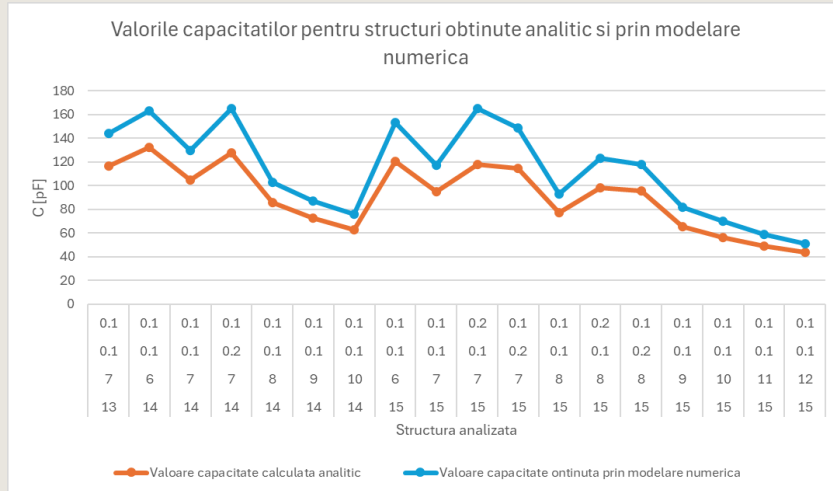
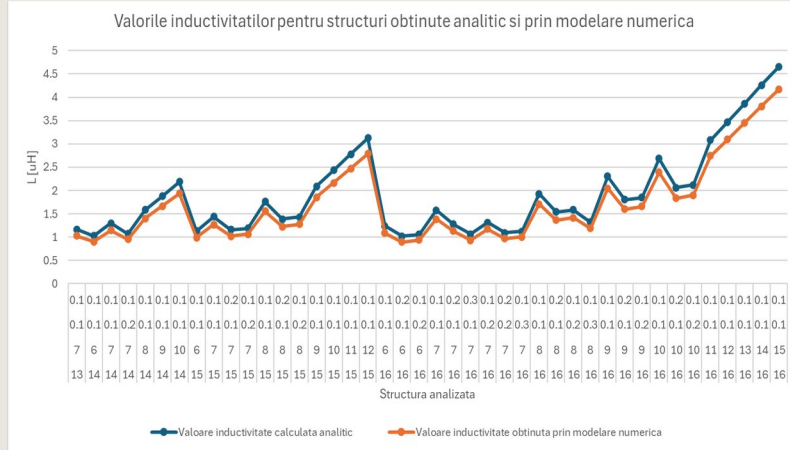
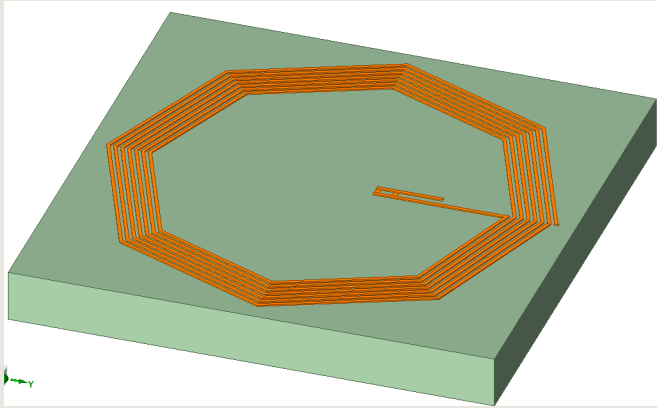


Structuri pătrate

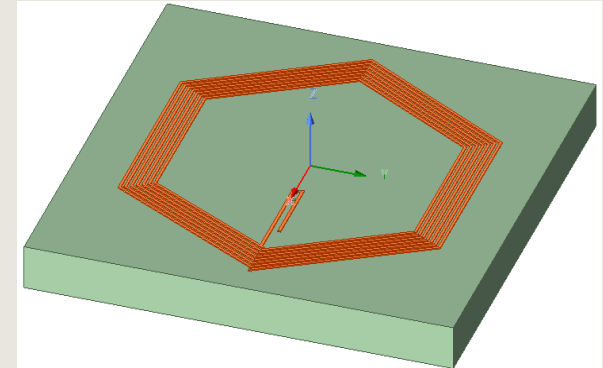
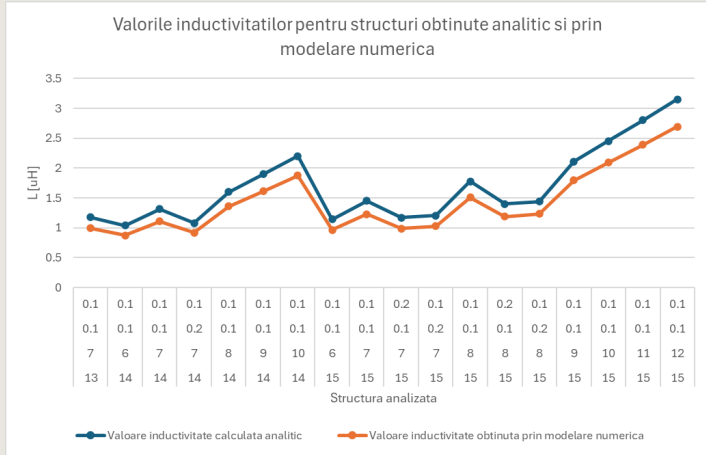
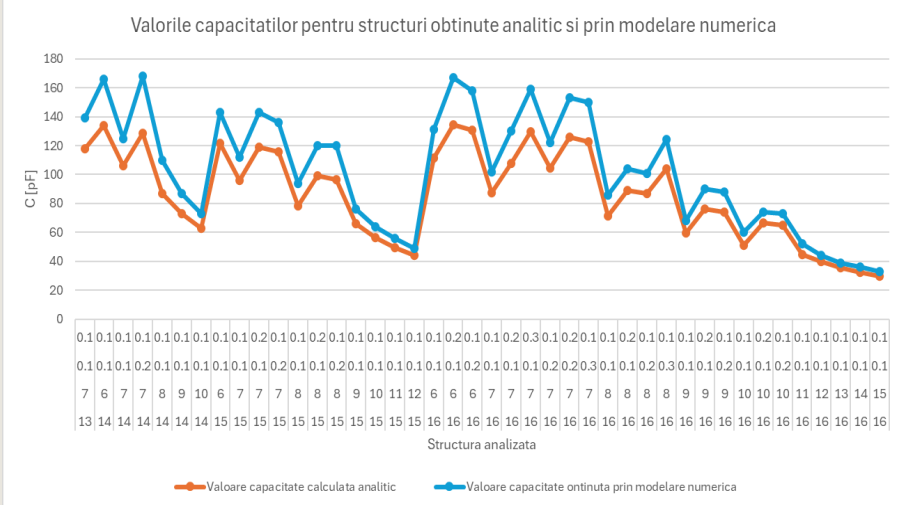


VALIDAREA REZULTATELOR OBȚINUTE PENTRU INDUCTIVITĂȚI ȘI CAPACITĂȚI ÎN URMA CALCULELOR PENTRU STRUCTURILE HEXAGONALE ȘI OCTOGONALE

Structuri octogonale



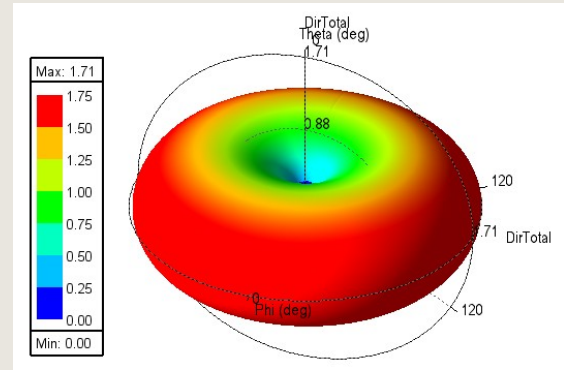
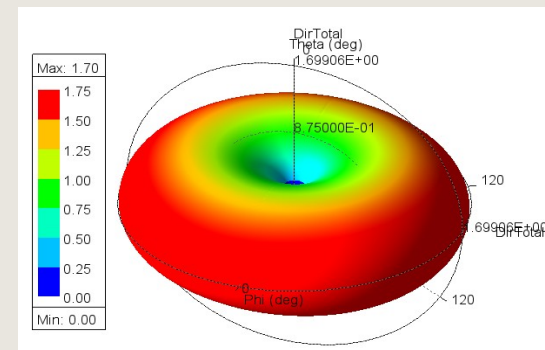
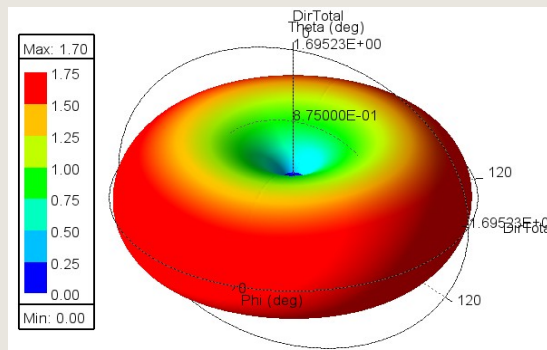
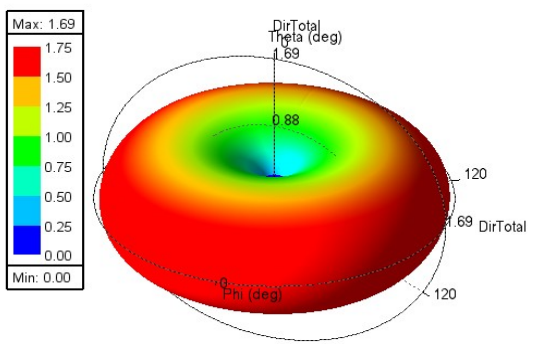
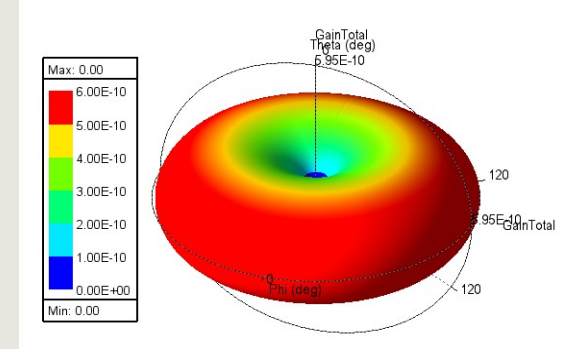
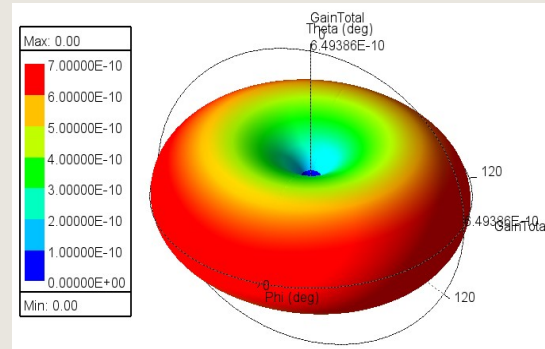
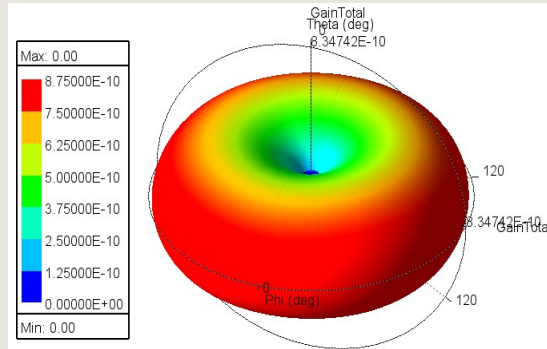
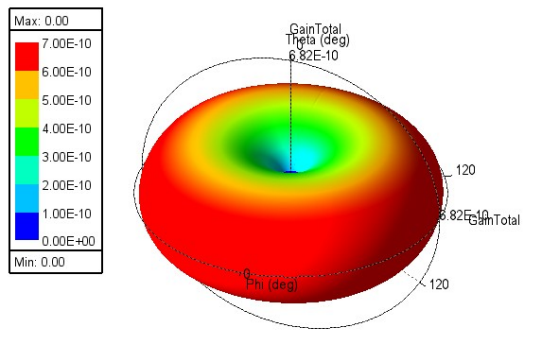
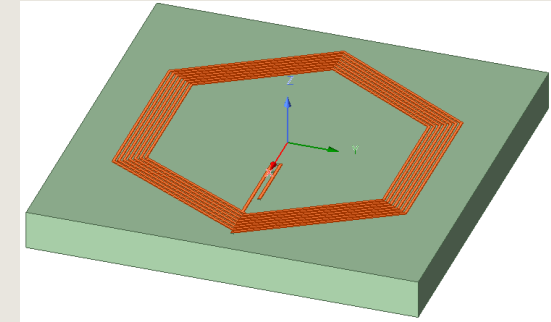
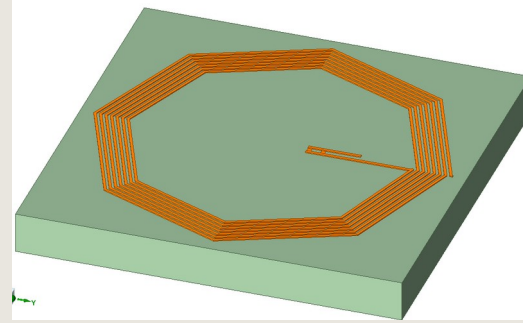
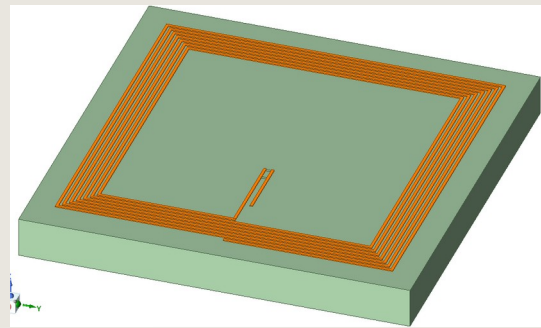
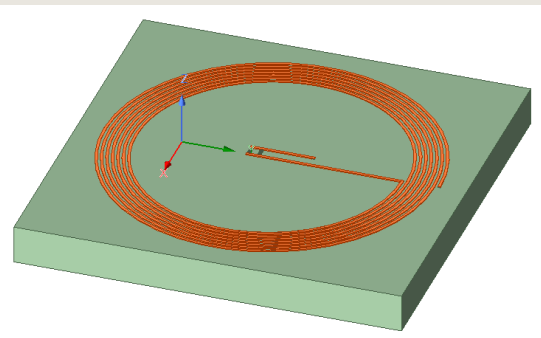
Rezultatele obținute analitic sunt validate prin modelare numerică



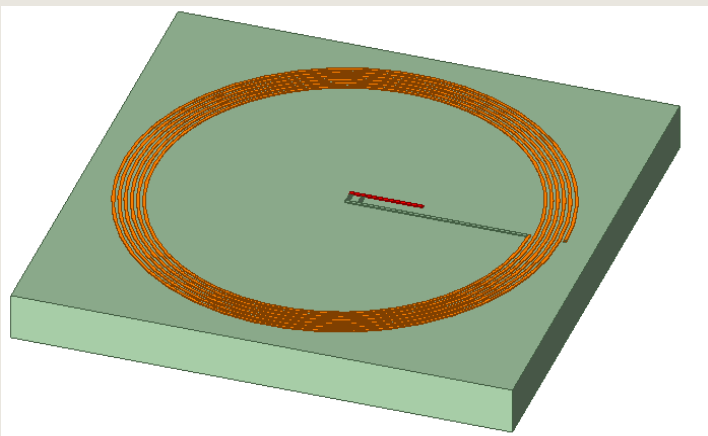
Structuri hexagonale

REPREZENTAREA 3D A CÂȘTIGULUI PENTRU STRUCTURI DE DIFERITE FORME CU ACELAȘI NUMĂR DE ÎNFĂȘURĂRI

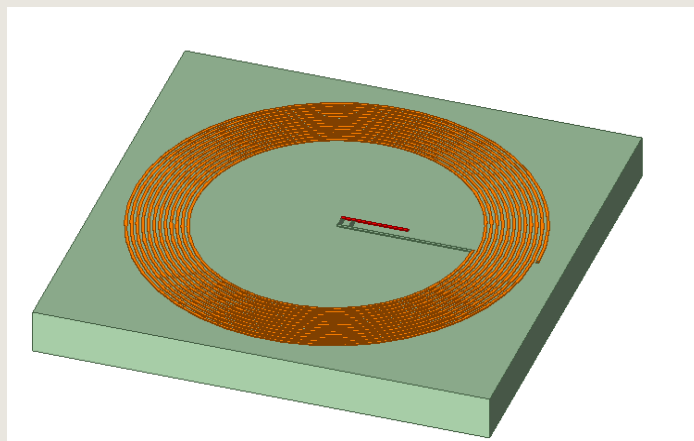
De= 13 mm, N= 7, w=s=0,1 mm



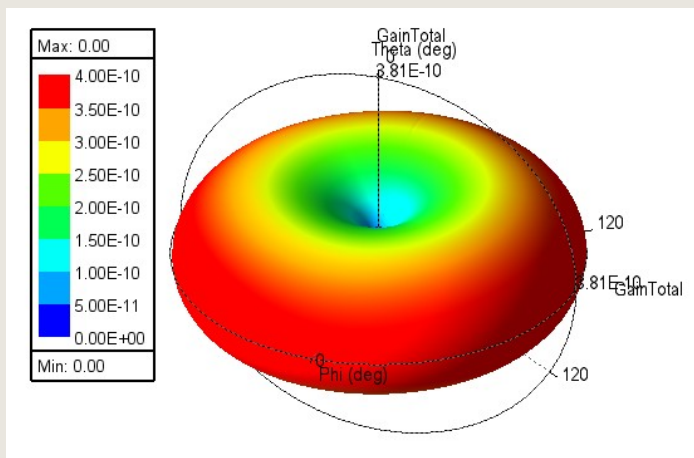
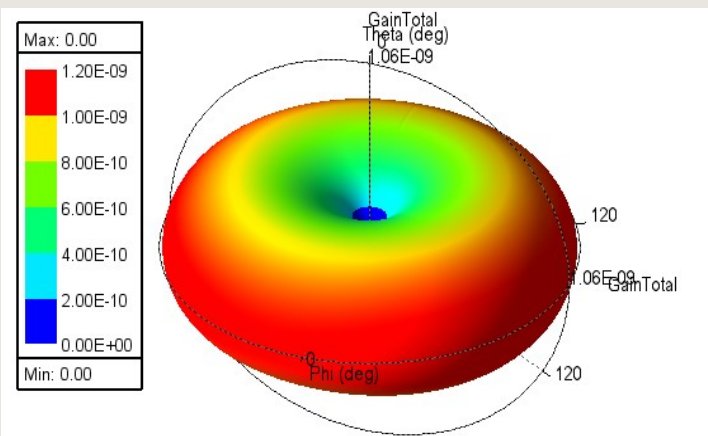
De= 15 mm, N= 7
w=s=0,1 mm



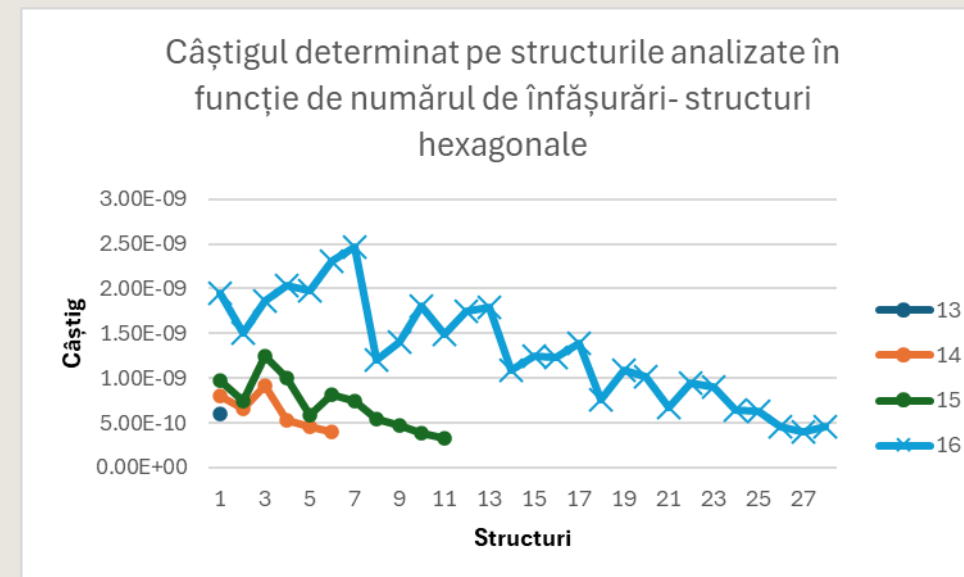
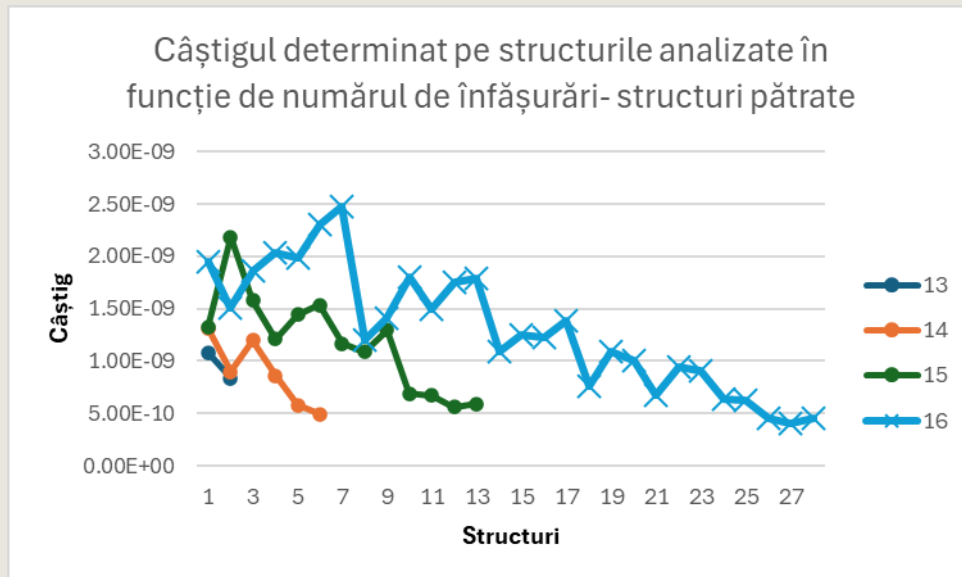
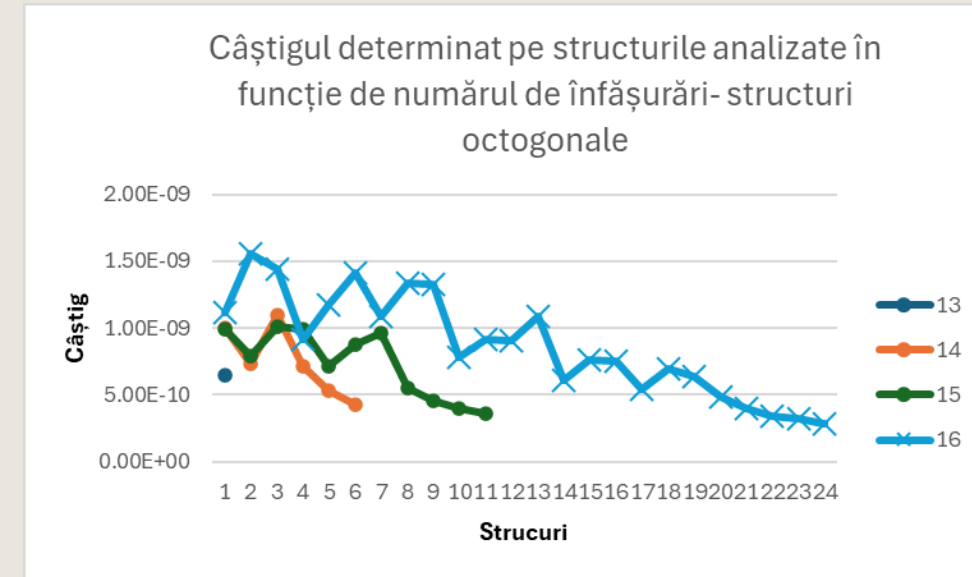
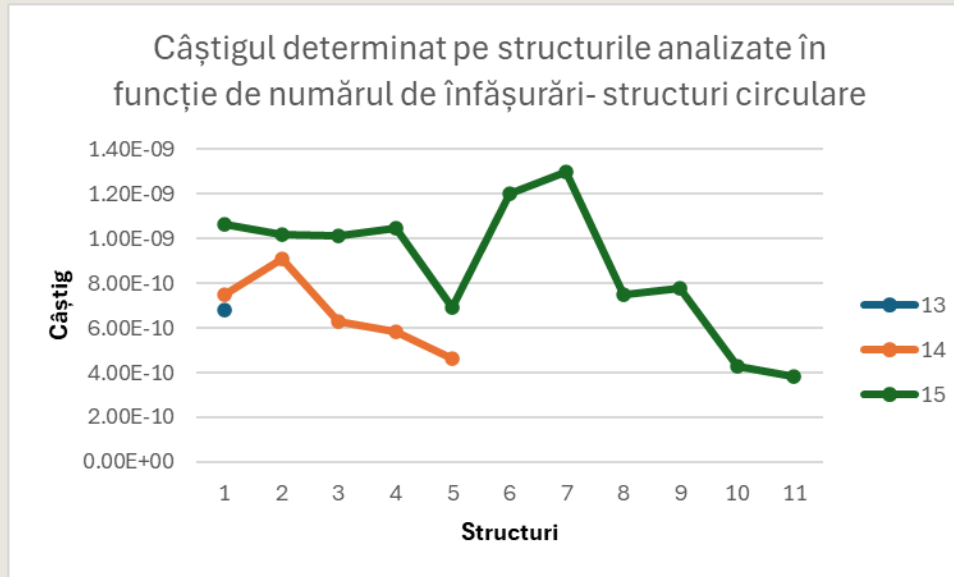
De= 15 mm, N= 12
w=s=0,1 mm



INFLUENȚA NUMĂRULUI DE
INFĂȘURĂRI ASUPRA
DISTRIBUȚIEI CÂȘTIGULUI

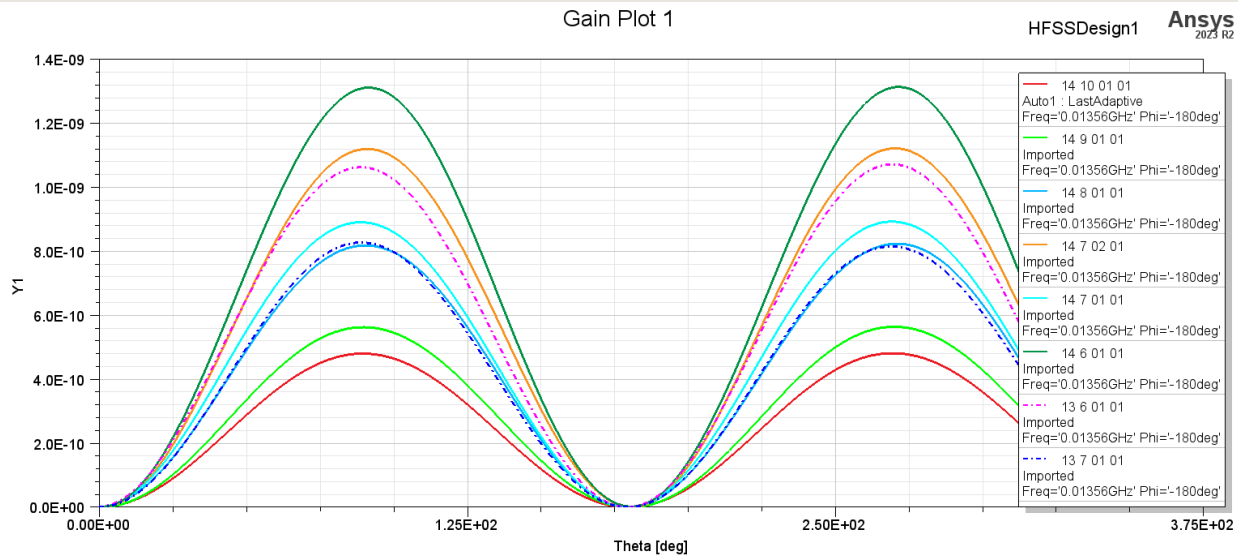


INFLUENȚA NUMĂRULUI DE ÎNFĂȘURĂRI ASUPRA CÂȘTIGULUI

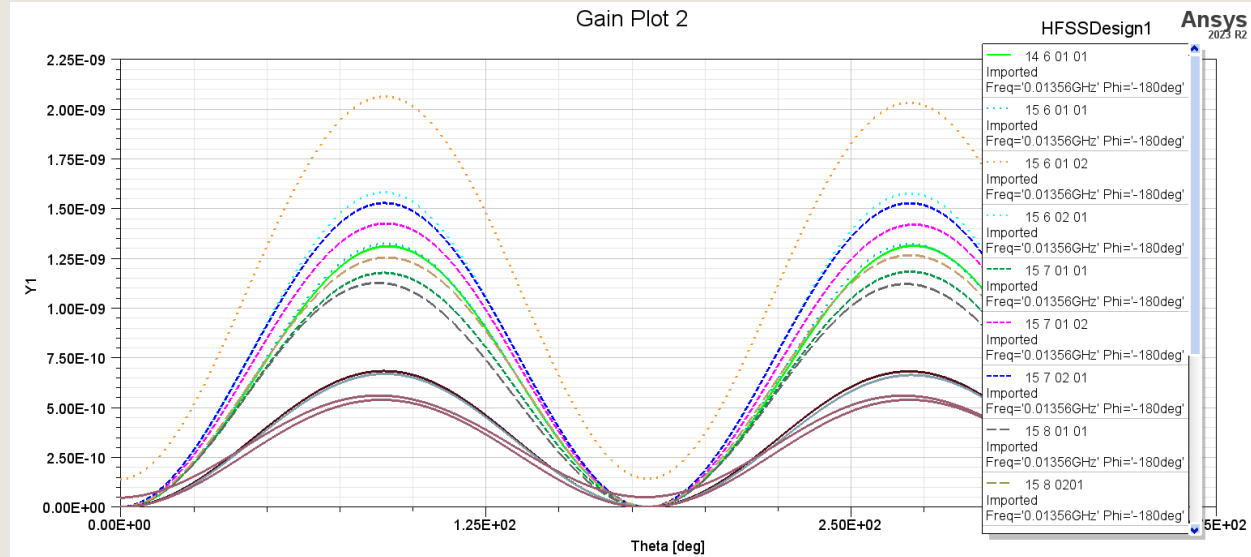


VARIAȚIA CÂȘTIGULUI ȘI AL DIRECTIVITĂȚII PENTRU STRUCTURILE PĂTRATE CU 13,14 ȘI 15 ÎNFĂȘURĂRI

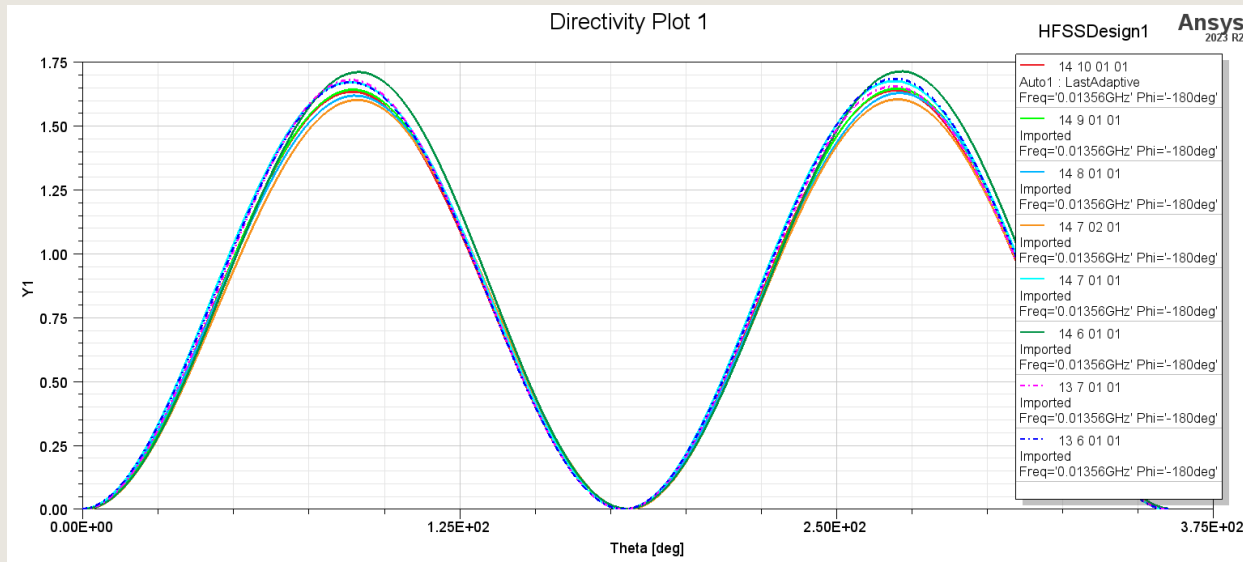
Gain Plot 1



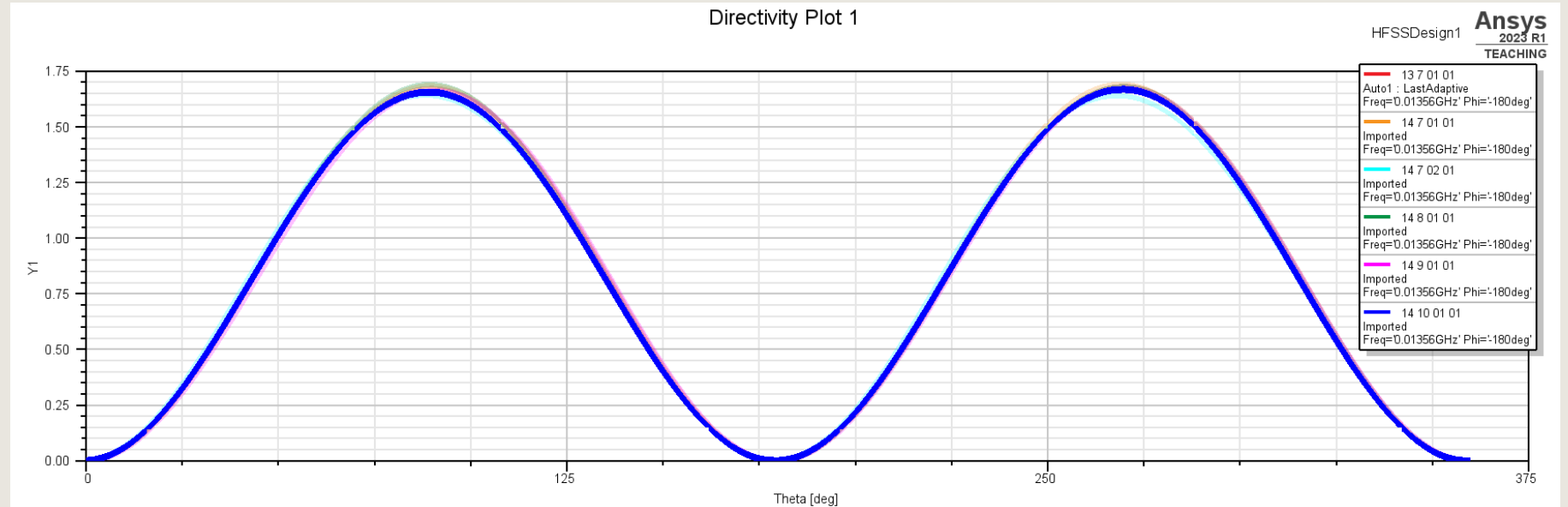
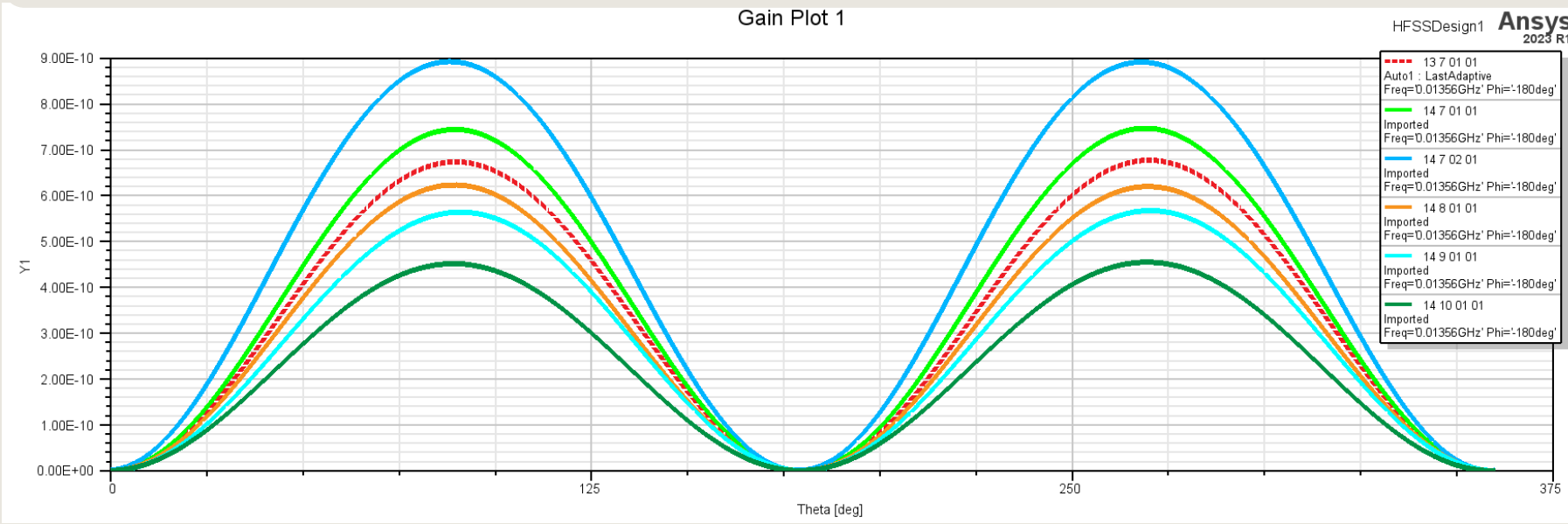
Gain Plot 2



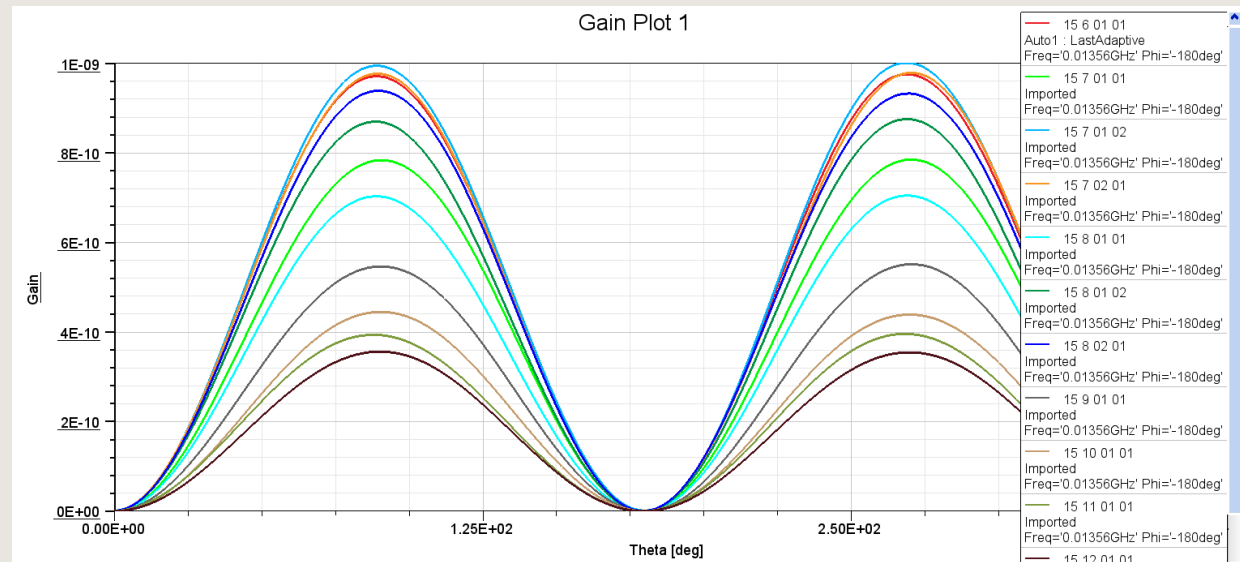
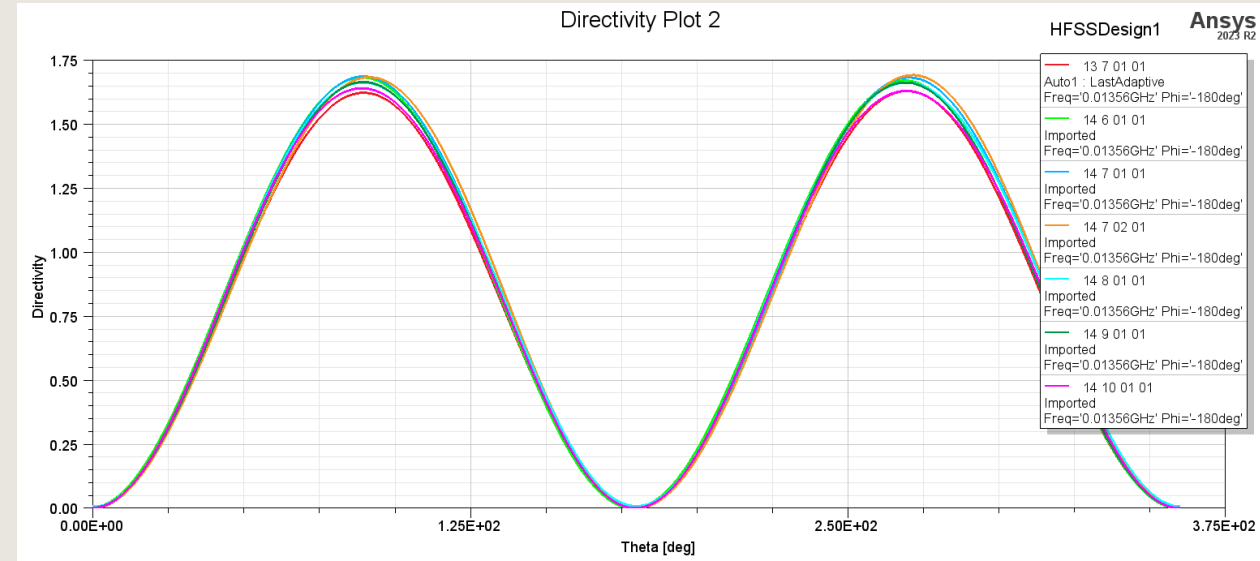
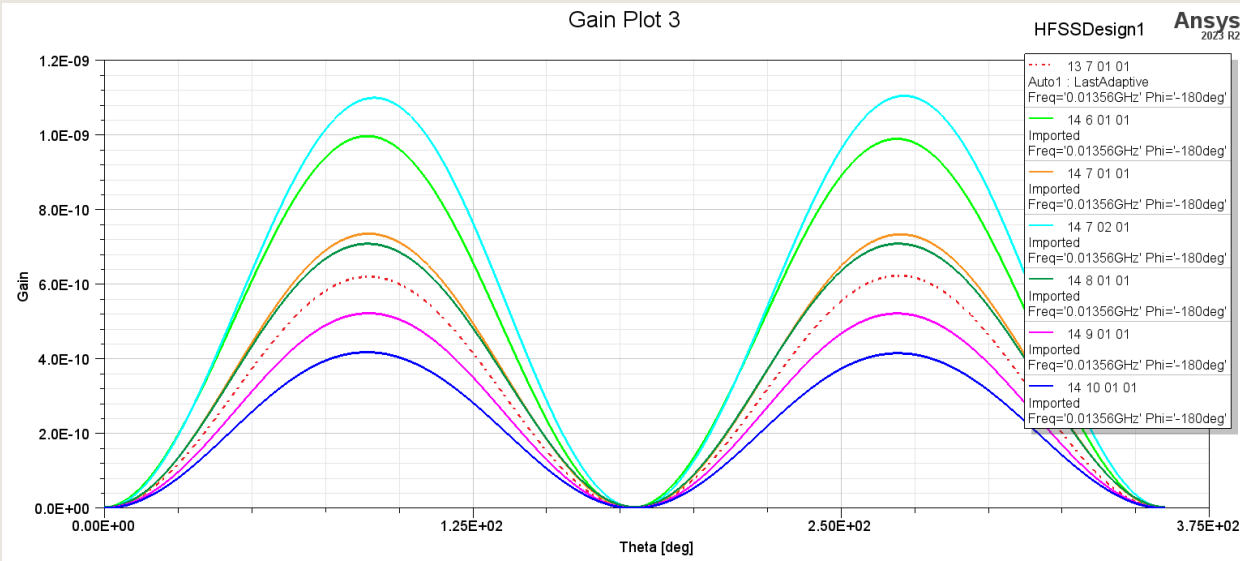
Directivity Plot 1



VARIAȚIA CÂȘTIGULUI ȘI AL DIRECTIVITĂȚII PENTRU STRUCTURILE CIRCULARE CU 13 ȘI 14 ÎNFĂȘURĂRI

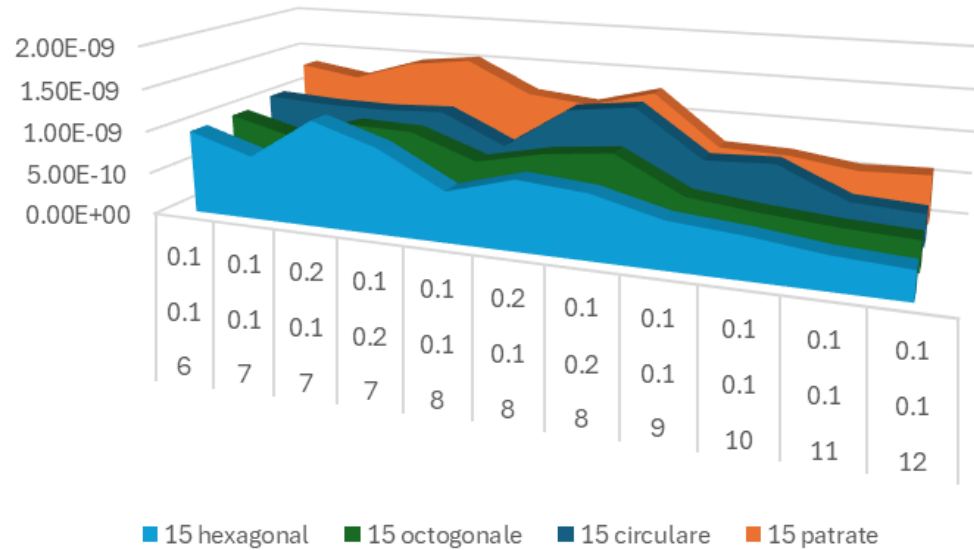


VARIAȚIA CÂȘTIGULUI ȘI AL DIRECTIVITĂȚII PENTRU STRUCTURILE OCTOGONALE CU 13,14 ȘI 15 ÎNFĂȘURĂRI

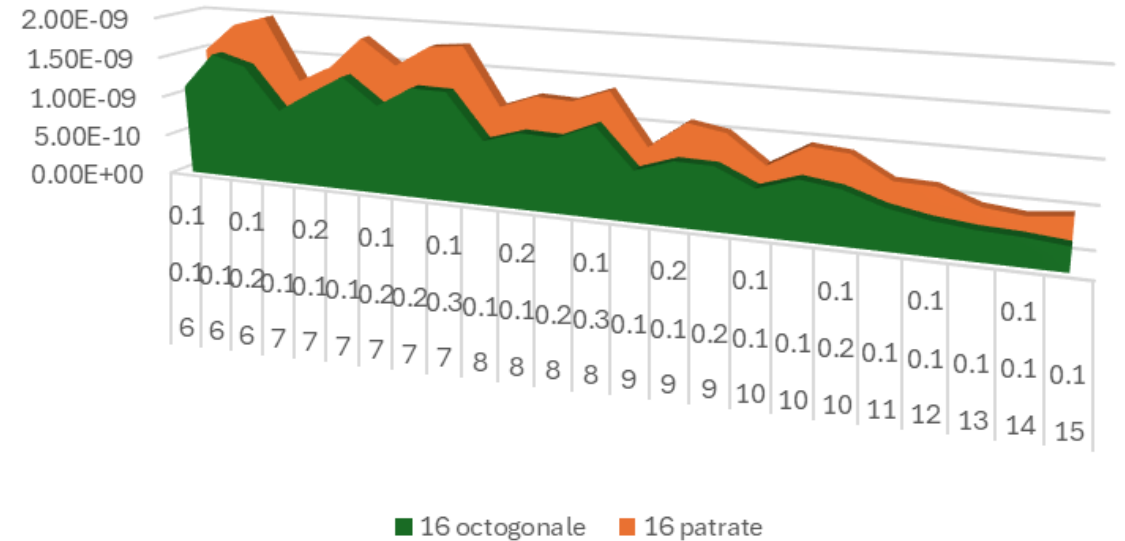


COMPARAȚIE ÎNTRE CÂȘTIGUL ȘI DIRECTIVITATEA STRUCTURILOR CU DIFERITE FORME PENTRU MAI MULTE DIMENSIUNI

Castig pentru structurile cu 15 infasurari



Castig pentru structurile cu 16 infasurari

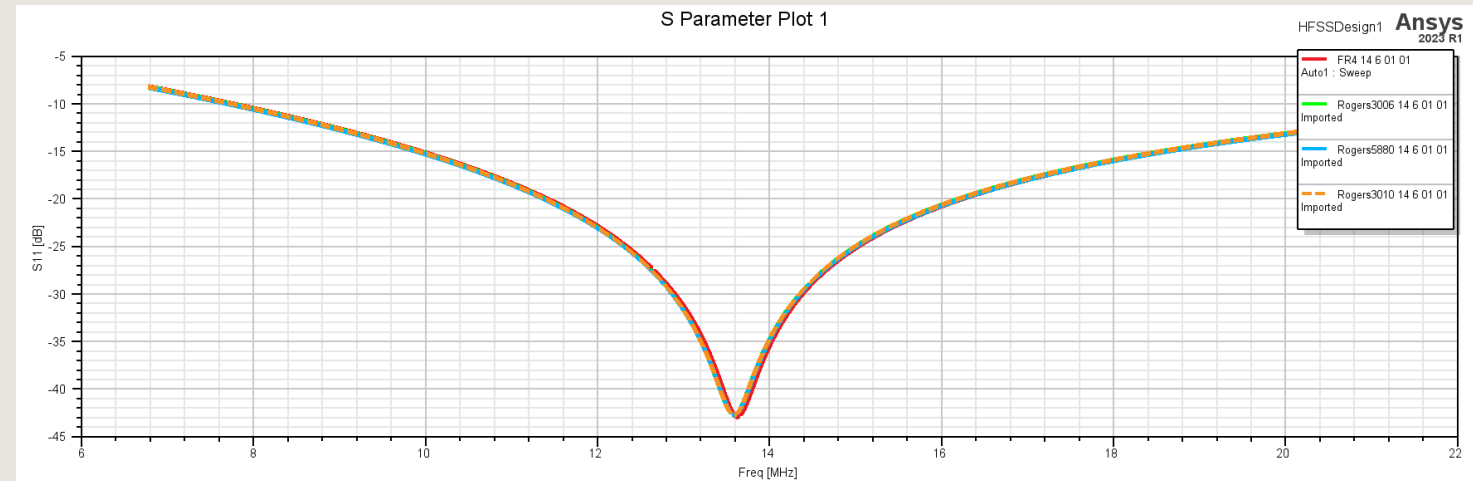
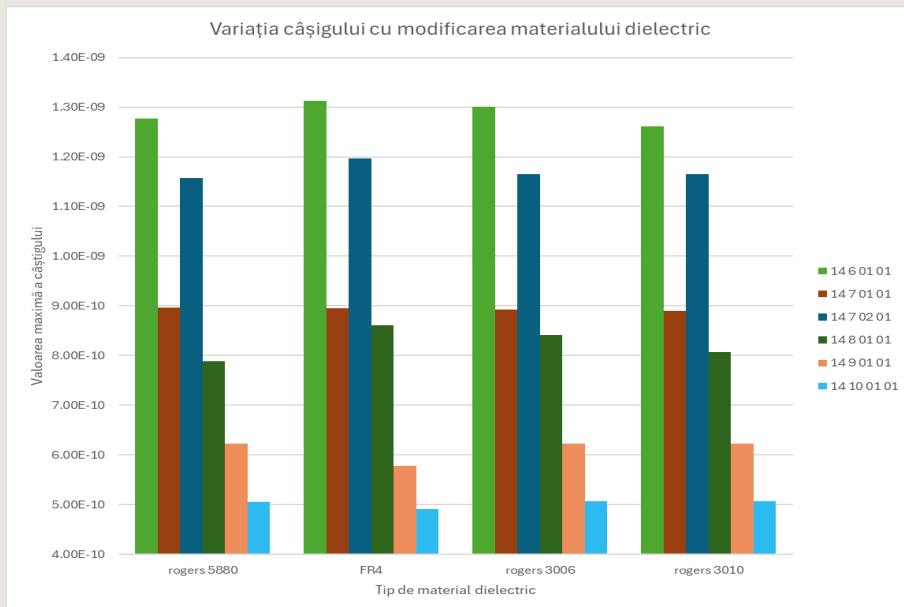
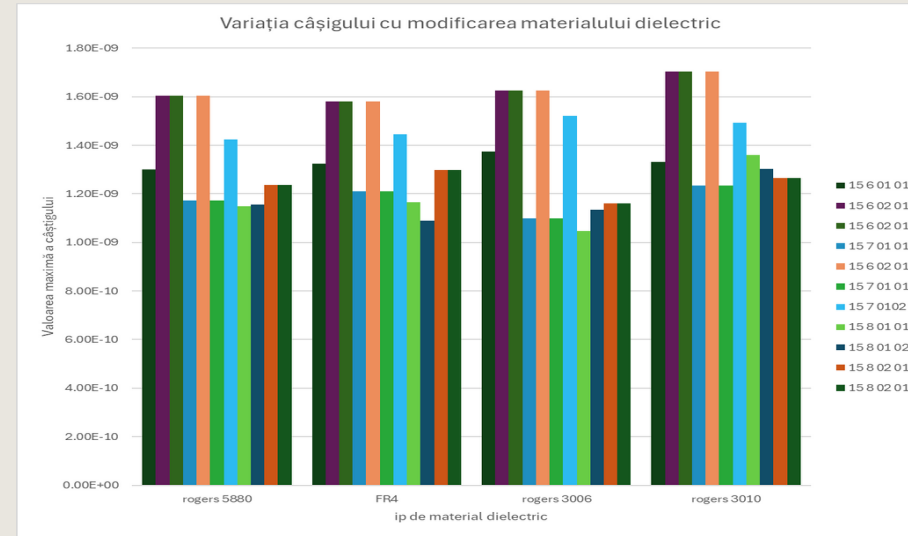




**INFLUENȚA MATERIALULUI
DIELECTRIC ASUPRA
CÂȘTIGULUI ȘI A FRECVENȚEI
DE REZONANȚĂ**

INFLUENȚA MATERIALULUI DIELECTRIC ASUPRA CÂȘTIGULUI ȘI A FRECVENȚEI DE REZONANȚĂ PENTRU STRUCTURILE PĂTRATE

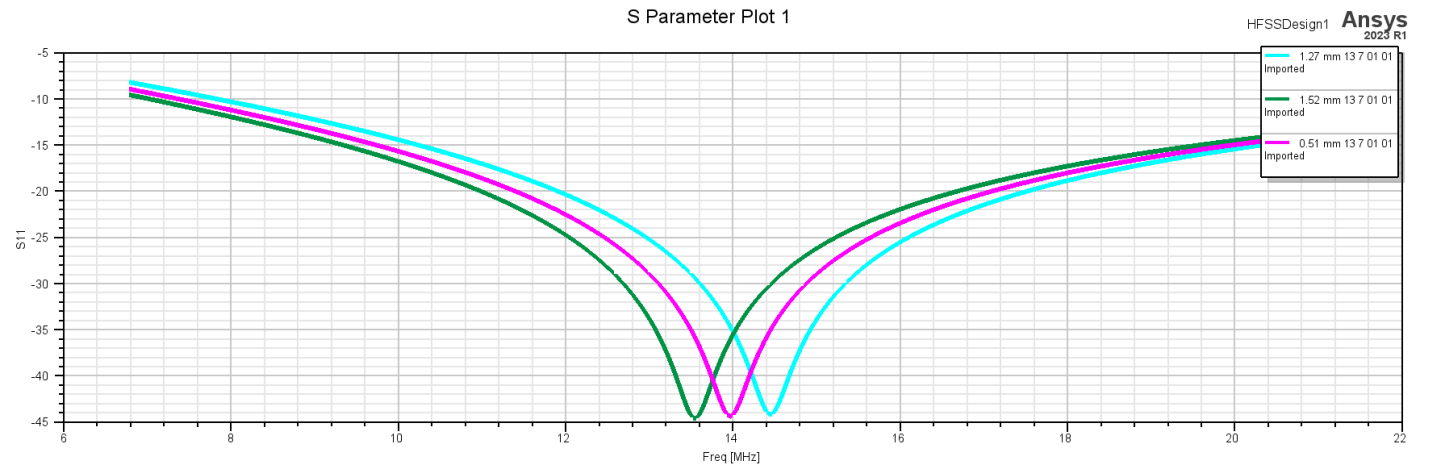
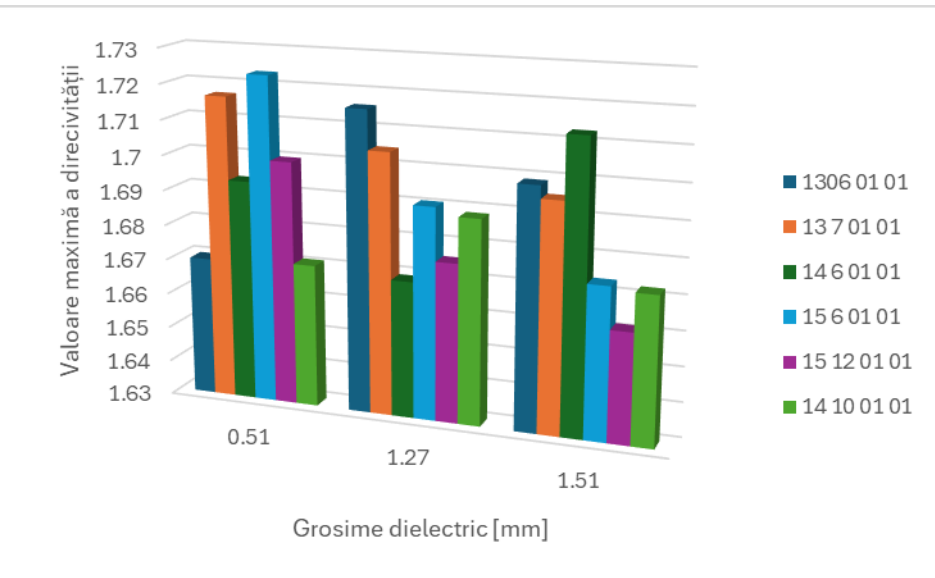
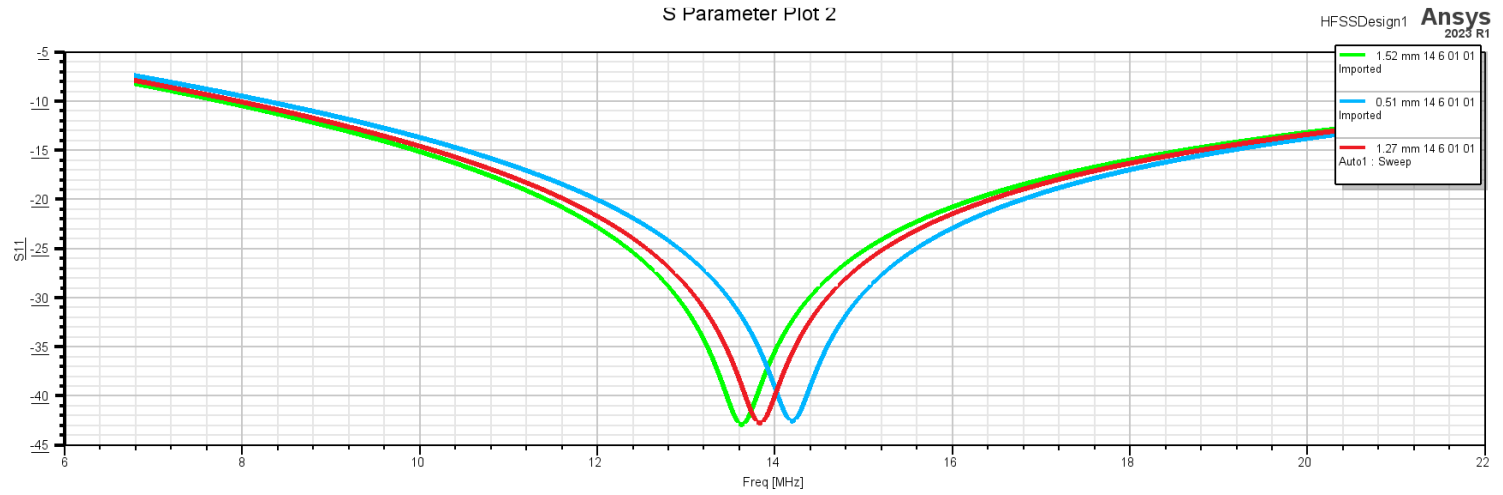
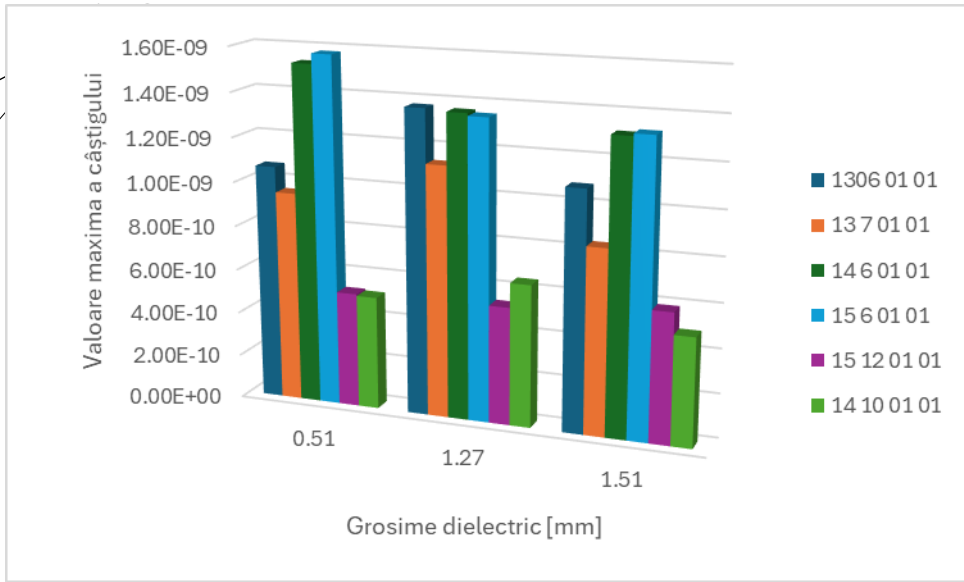
Dielectric		Tangenta de pierderi
Rogers 5880	2.2	0.0009
FR4 Epoxy	4.4	0.02
Rogers 3006	6.15	0.0025
Rogers 3010	10.2	0.0035

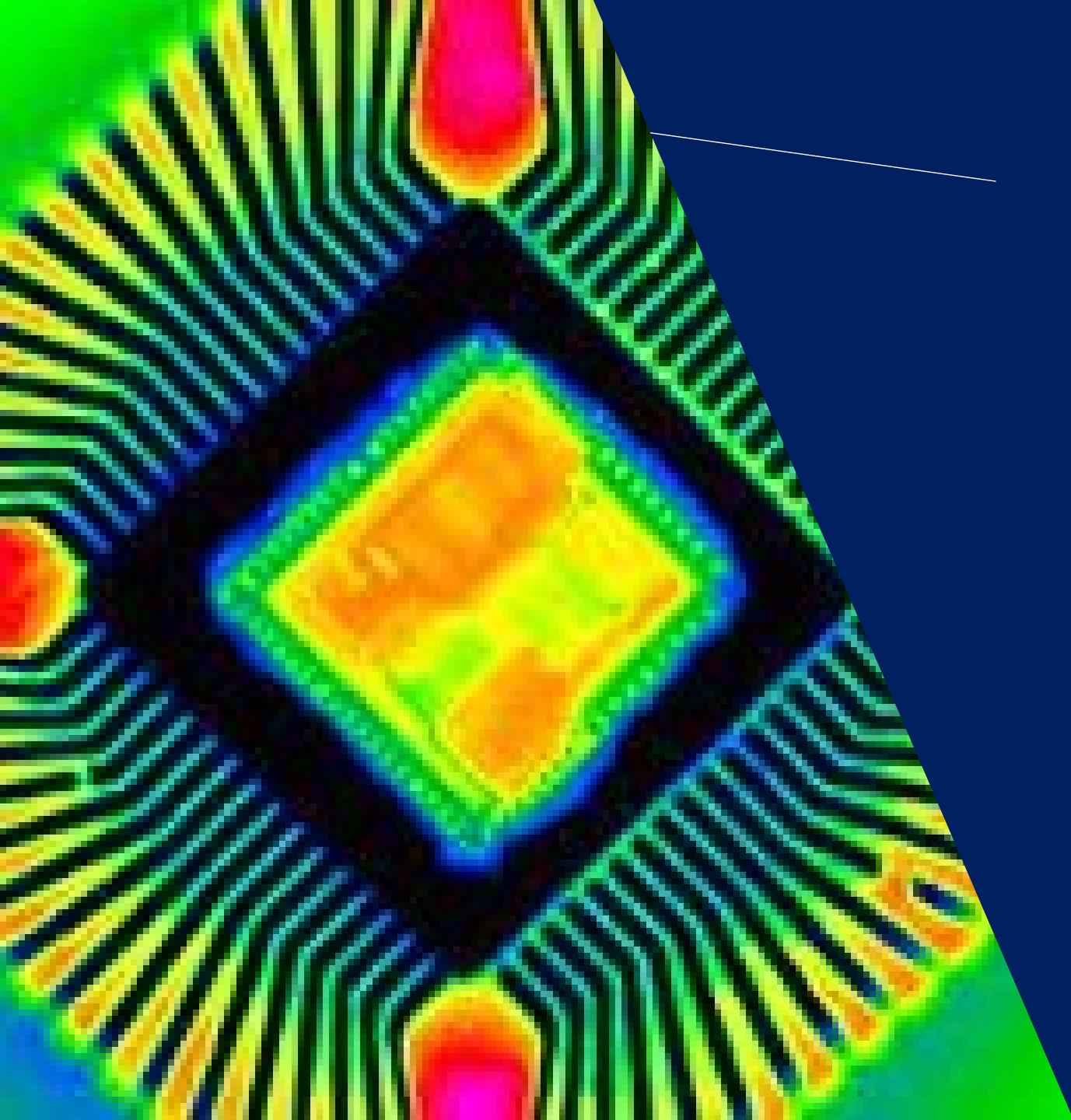




**INFLUENȚA GROSIMII
DIELECTRICULUI ASUPRA
PARAMETRILOR DE
INTERES**

INFLUENȚA GROSIMII DIELECTRICULUI ASUPRA PARAMETRILOR DE INTERES

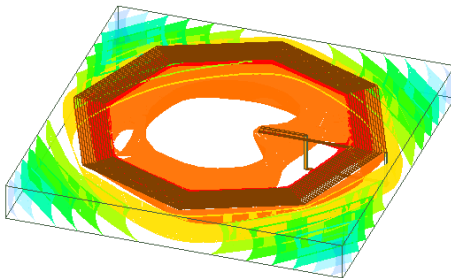
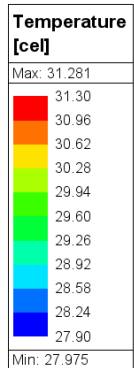
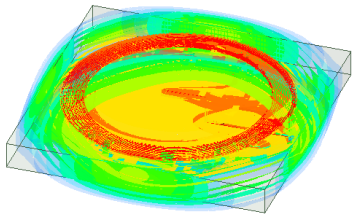
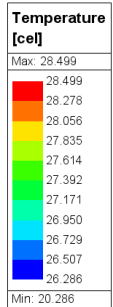
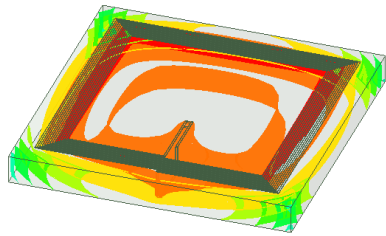
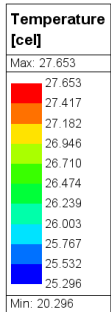




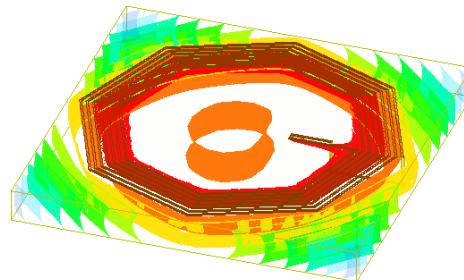
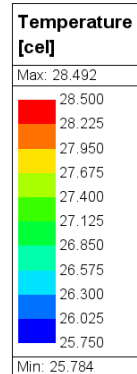
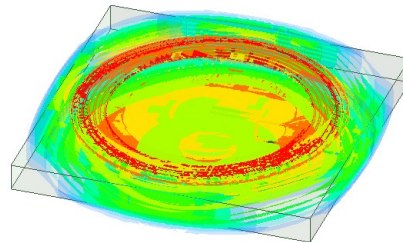
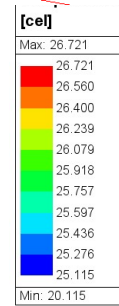
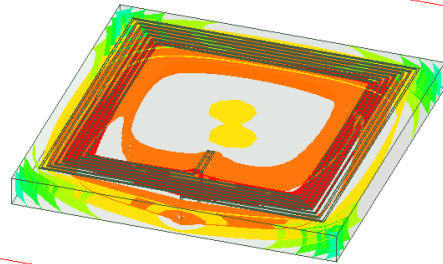
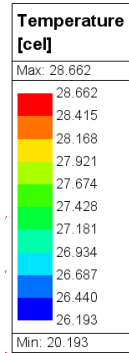
ANALIZA TERMICĂ ȘI
MECANICĂ A STRUCTURILOR
OPTIMIZATE

VARIAȚIA TEMPERATURII ÎN STRUCTURILE ANALIZATE

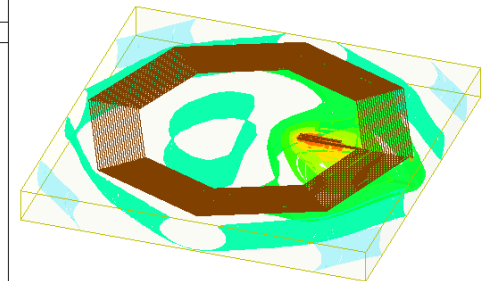
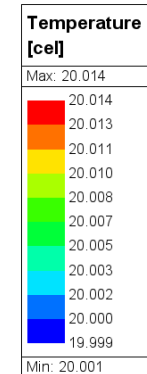
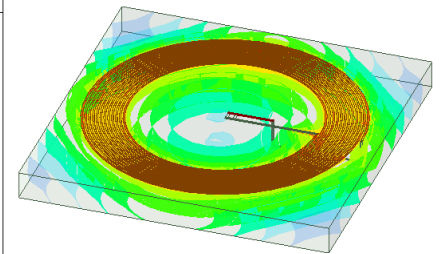
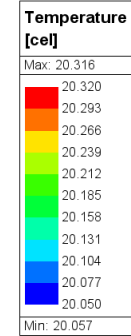
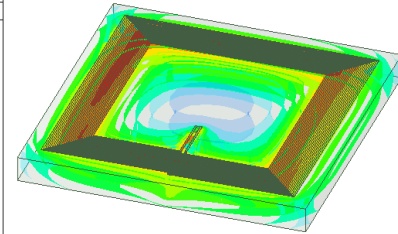
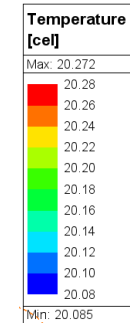
De= 13, N=7,
w=s=0.1 mm

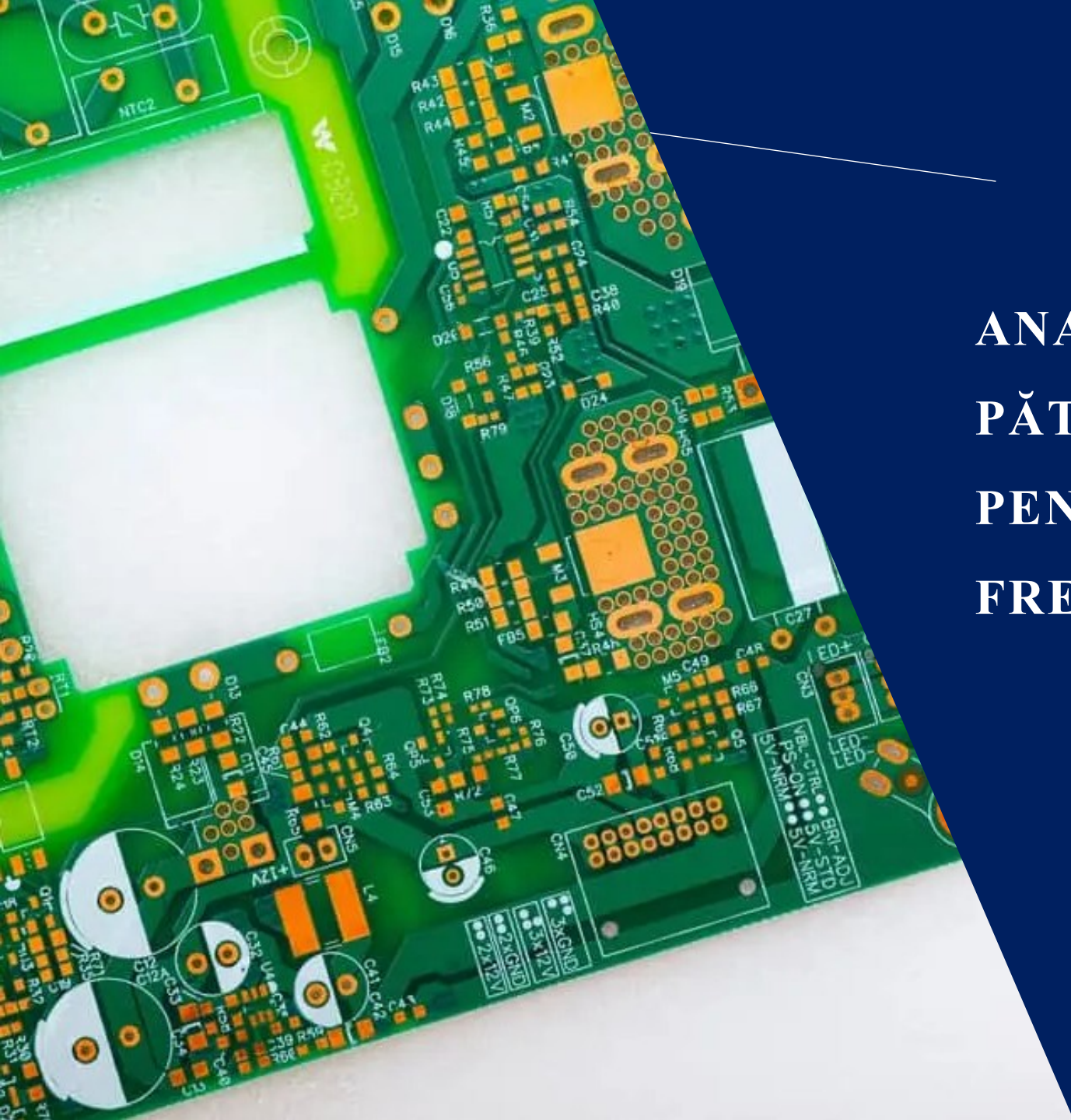


De= 15, N=7,
w=0.2 mm, s=0.1 mm



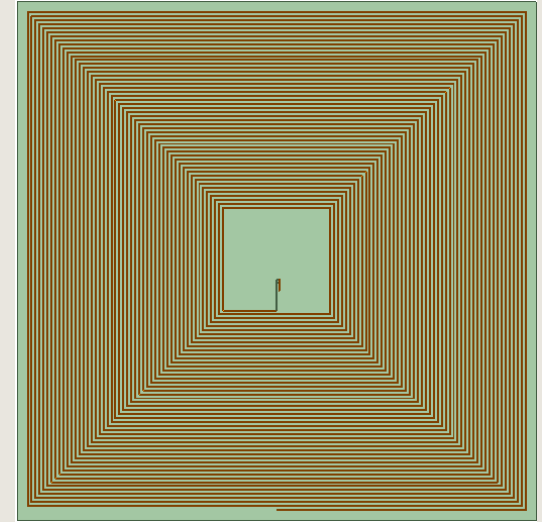
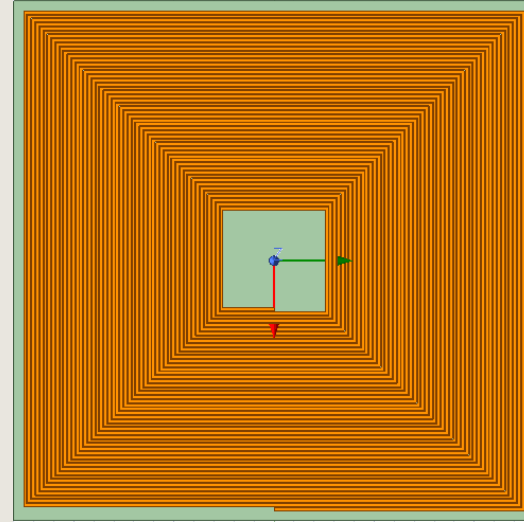
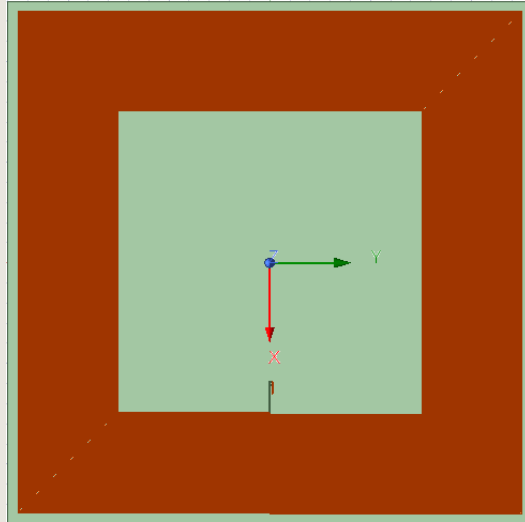
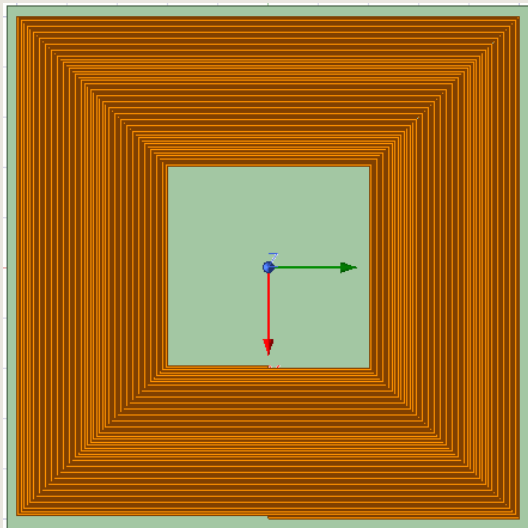
De= 15, N=12,
w=0.1 mm, s=0.1 mm



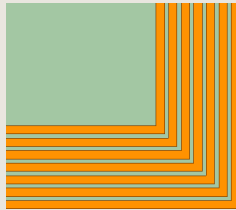


**ANALIZA TAG-URILOR RFID
PĂTRATE PROIECTATE
PENTRU FUNCȚIONAREA LA
FRECVENȚA DE 125 KHZ**

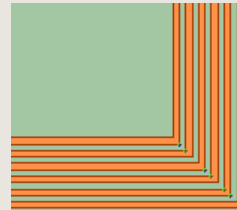
ANALIZA STRUCTURILOR CU 50 DE ÎNFĂȘURĂRI



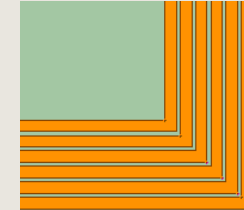
$S=0.1$ mm,
 $W=0.2$ mm



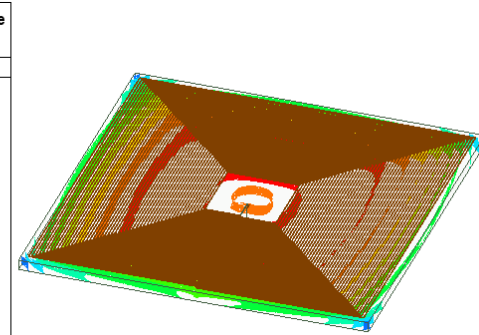
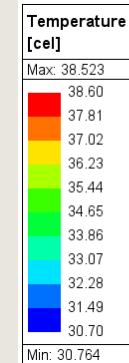
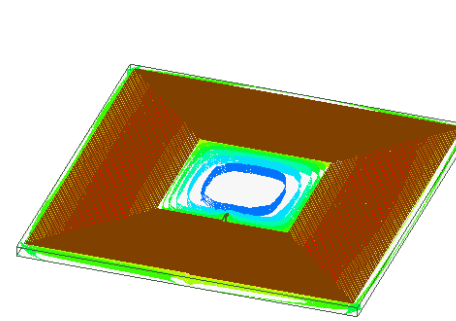
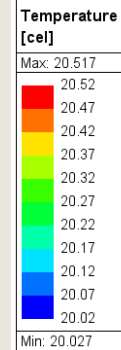
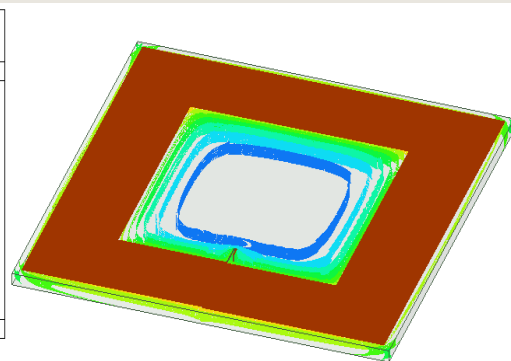
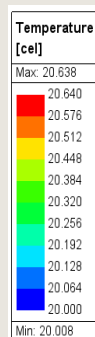
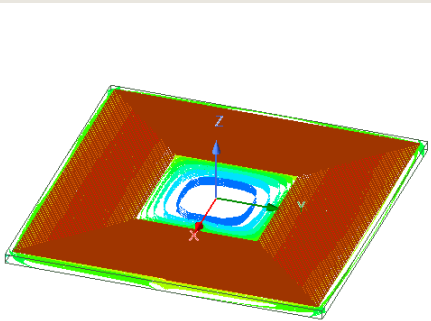
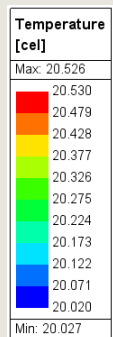
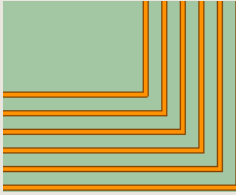
$S=0.1$ mm,
 $W=0.1$ mm



$S=0.1$ mm,
 $W=0.3$ mm



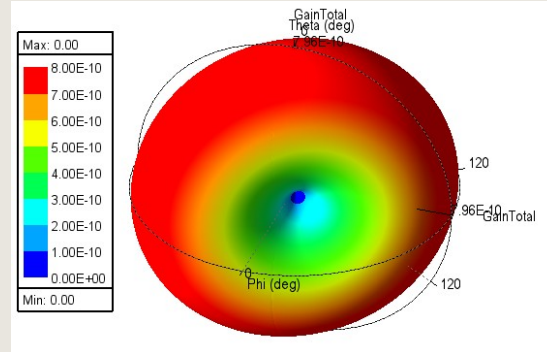
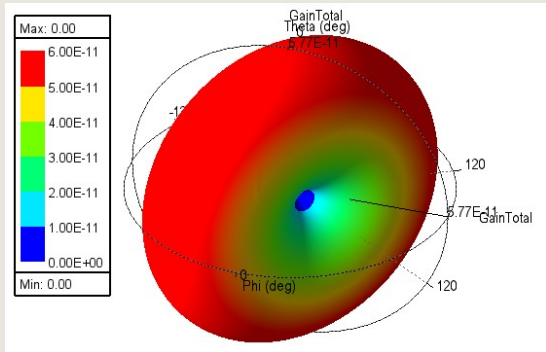
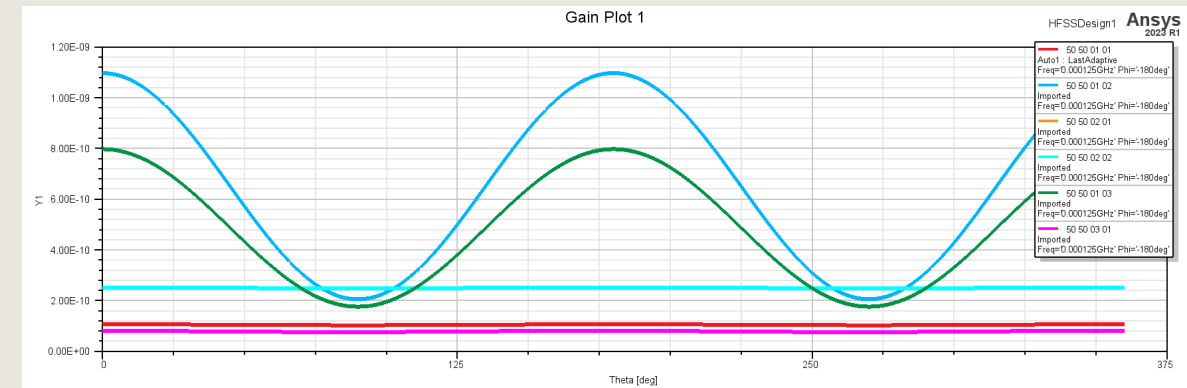
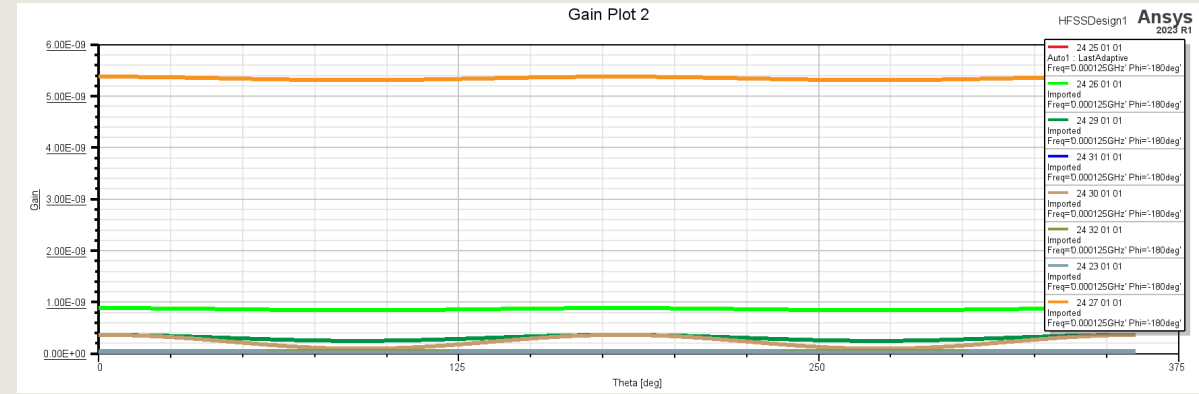
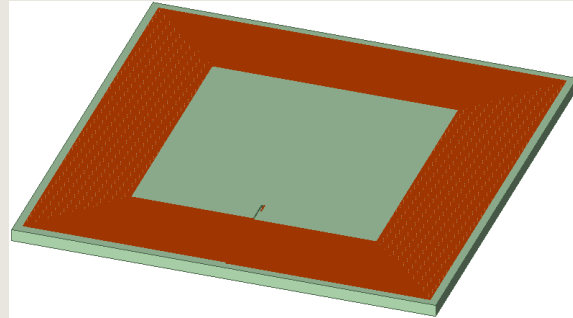
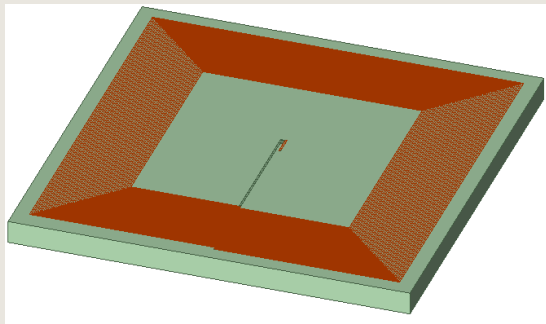
$S=0.3$ mm,
 $W=0.1$ mm



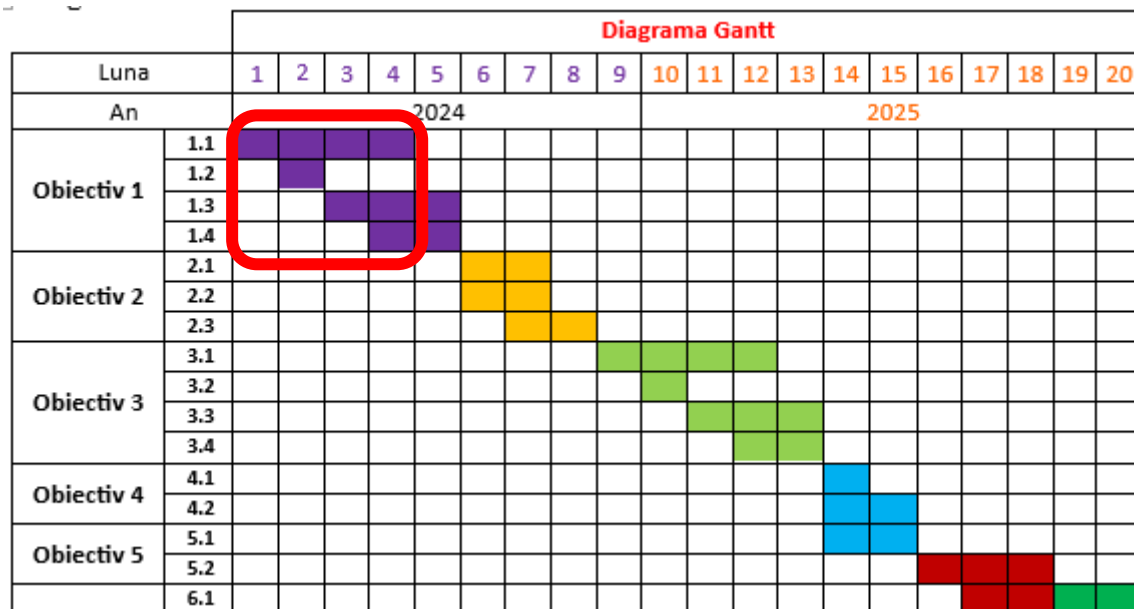
CÂȘTIGUL STRUCTURILOR PROIECTATE PENTRU FUNCȚIONAREA LA 125 KHZ

De= 24, N=25,
w=s=0.1 mm

De= 50, N=50,
w=s=0.1 mm



RAPORT 1- OBIECTIVE, ACTIVITĂȚI ASOCIATE



An	Obiective	Activități asociate	Livrabile
2024	1. Modelarea numerică, analiza și optimizarea antenelor RFID care funcționează la frecvențe joase (structuri inductive).	1. Studiul sistematic al literaturii de specialitate	- seturi de date obținute pentru diferite structuri în vederea utilizării machine learning pentru optimizare - crearea unui mod de lucru complex și etapizat de determinare unor antenelor RFID optime pentru aplicații specifice
		2. Modelarea numerică și analiza modelelor inițiale pentru frecvențele 125 kHz, 13.56 MHz	
		3. Optimizarea structurii prin modelare numerică (variația dimensiunii, formei, materialului dielectricului) și machine learning	
		4. Analiza termică și mecanică a structurilor optimizate	

CONCLUZII

- ❏ S-a creat un program pentru determinarea structurilor care îndeplinesc condițiile de proiectare ($L > 1 \mu\text{H}$, diametrul interior mai mare de 10 mm) în vederea determinării mai ușoare a geometriei structurilor RFID tag-urilor și a capacităților necesare în vederea funcționării la frecvențele de interes
- ❏ S-a observat că valoarea maximă a câștigului se obține pentru structurile cu un diametru exterior mai mare
- ❏ Cu cât numărul de înfășurări crește cu atât valoarea maximă a câștigului scade, dar câștigul este mai bine dispersat pe toată suprafața tag-ului
- ❏ Cele mai bune rezultate din punct de vedere al câștigului, respectiv al distanței de transmitere al datelor, dar și din punct de vedere al numărului de structuri conforme cerințelor de proiectare îl reprezintă structurile pătrate
- ❏ La frecvențele analizate tipul de dielectric nu influențează parametrii de interes al tag-ului
- ❏ Grosimea dielectricului face ca frecvența de rezonanță să se modifice, dar având în vedere domeniul de frecvențe mare la care tag-ul funcționează, nu influențează în mod semnificativ
- ❏ Valorile temperaturii în structurile analizate sunt mici, în consecință nu duc la modificarea geometriei și aspectului structurii

**Va multumesc pentru
atentia acordata**

