AmalgamationofSlotAntenna and FractalAntenna forUWBApplications

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Abstract:Antennaswereproposed with varied methods ofpracticalandtheoreticalsimulations to achieveultrawidebandwidth[UWB]for UWB devices.Thispaperis intended to analyzevarietiesof proposed slot and fractal antennasandtheir methods ofanalysisby availablesoftware andtheirlacunato combinethemtoachieveUWB.

***Key words*:**slot antenna, fractal antenna, HFSS, IE3D,CST.

INTRODUCTION

Aslot antennaconsistsofametalsurface, usuallya flatplate,withaholeorslotcutout.Whent he plate is driven as an antenna by a driving frequency,theslotradiateselectromagn etic waves insimilarway toadipoleantenna.Theshapeand sizeof theslot,aswellasthedrivingfrequency, determine theradiationdistributionpattern.They are usedtypicallyatfrequenciesbetween 300MHz and24GHz.Slotantennasarewidelyuse dinradar antennas,andthesectorantennas areusedforcell phonebasestations,andareoftenfoundi nstandard desktopmicrowave sourcesusedforresearch purposes.Itsmainadvantages areitssize,design simplicity,robustness, andconvenientadaptationto mass productionusingPC boardtechnology.

Afractalantenna isanantenna thatusesafractal, self-similar designtomaximizethelength,or increasetheperimeterofmaterialthatca nreceive or transmit electromagnetic radiation within a giventotalsurfaceareaor volume.Suchfractal antennas arealso referred to as multilevel and spacefilling curves,butthekeyaspectliesintheir repetitionofamotifovertwoormorescal esizesor iterations.Forthisreason,fractalantenn asarevery compact, multibandorwideband,andhave useful applications incellulartelephoneandmicrowave communications. A fractal antenna's response differsmarkedlyfromtraditionalantennadesigns, in that it is capable ofoperatingwith good-to- excellent performance at many different frequenciessimultaneously.Normally standard antennas havetobecutforthefrequencyforwhich they needbeusedandthusthestandardantennas only workwellinthatfrequency.Thismakesthe fractalantennaan excellentdesignforwideband andmultibandapplications.Inaddition thefractal natureof theantenna shrinks itssize,withoutthe useofanycomponents, suchasinductorsor capacitors.

Thispapercompares SlotandFractalantennas proposed byvarious authorsand the simulation methodthattheyhaveadoptedinconcluding the resultsandalsotheircombinationtoprovideUWB.

SLOTANTENNA

Amicrostripantenna composed ofparalleldipole resonatorsof differentlengths fedbyarectangular slotcutinthegroundplaneofamicrostrip lineis analyzedin[1].Multifrequency operationofthis antennaisdemonstratedbyusing twodifferent configurations-smalldipoletobigdipoleandvice versa isused. Theoreticallyobtained valuesare comparedwithmeasuredvaluesforfrequenciesof

5.24GHz,6.1GHzand7.13GHz.The selected parameters aretheratiobetweenthe longestand shortestpairofdipoles,the airgapbetween the dipoles,thesubstratethicknessandthelengthof theslot,which is donetoobtainbestperformance. Application-communication,advancedfrequency radarorscattermeters.Inthispaper[1]study of back lobesandeffectofone dipoleonanotherare notmentionedandalsotheirdesignedprocedure.

Twoparallelslotsareincorporated intothe rectangular microstrippatchantenna,togetE-shapedmicrostrippatchantennain[2]anditisfed bycoaxialprobe.Theuppersubstrate waschosen withhighdielectric constantforcompactsizeand thelowersubstrate isfoamdielectricmaterialto provide groundplane.Anairgapwasusedas the thicknessoffoam materialisfixed,andithelpsin optimizationforwidebandwidth.Parametric study isdonetounderstand -

slotlengthtocontrol frequency, widthto controlimpedance,lengthof patch tocontrol lower frequencyand length of middle armofEplancontrolhigherfrequency.The bandwidth of1.482GHz(4.976–6.458GHz)is obtainedfromsimulationIE3Dandformeasured 1.557GHz (5.557–7.134GHz).This paper[2]has notmentionedanydesigningequations andalsothe methodmentionedforfeediscomplex for simulation.

Antenna consistsofpentagonshapemicrostripslot fedusingmicrostriplineandapentagonstub[3], parametric studyonthepentagonslotprovedthat this dimensiongives good impedancematching. The antennashowsresonancesat3.5GHz,5.4GHz, 7.8GHzand10.5GHz,whichwhenjoins provide theUWBperformance, theimpedancecurveisin thecenterofthe Smithchartwhichprovesgood impedance matchoverawide rangeoffrequency. TheHFSSsimulatorshowsimpedancebandwidth ofthisantennacovers frequenciesfrom2.65GHzto 11.3GHz.Nodesignequationandshape anglesare provided.

Arectangular patchwithfeedline withgapfrom ground planeononesideofsubstrateanda truncated ground plane with two slots and H- shapedconductor-backed planeisproposedin[4]. Twoslots in the ground plane are adjusted for length and width (parametric study) to get maximum bandwidthwhichdetermines upper operating frequency,impedance bandwidthand impedancematching, Hshapebackedplane conductorpositionfromgroundplane determines the bandnotchcharacteristicsanditsbandwidthis determined byitswidth.Theproposedmonopole antennahas thefrequencybandof3.1toover13.9 GHzwitha rejectionbandaround5.1to6GHz usingHFSSwassimulated. FloatingHplaneand theslotconsideredisinthemiddleofgroundplane andnoton thepatch.

Generally slotdone inradiatingpatchorground planwillbecomplex ifitisusedinstacked configurations. Somedesignisformultifrequency applications andsomeforbroadbandwithband notch characteristicsbetween5to6GHz,maximum bandwidth reportedisupto16GHz. Different shapesaredoneinradiatingpatchlike-dipole,U slotandLprobe,Eshape,halfellipse withTstubs, Cslotandmanymore. Insomedesign,ground planeismodifiedtogetwidebandresponseand thatwillbeincorporated toobtainbandnotch characteristics. Generally simulationofslot antennasaredone eitherbyIE3D,HFSSandCST, else experimentaldataarecollected.

FRACTALANTENNA

Thebaseshapeofhexagonalfractalanditsfirst and seconditerations are used to obtain the proposedantenna[5].Simulatedby using microwaveoffice(MOMmethod)withresultof thisantenna inbroadbandrangeandappliedinall frequencies 0.1GHz–24GHz.Thisantennais designed usingADS2005andthefractalis generatedbyprogram writteninAEL.Feeding types andstudy of basic, first iteration is not studied.

A5-iternation,Pythagoreantreeisproposed in[6], whichisusedastheradiation part.The couplingof groundplanenearthetree structureandtaperingof thefeedlinecansignificantly increasethe bandwidthof theproposed antenna. When theantennaisconstructed,thecurveshows thatthe antennamaintainsbandwidthinbetweenfrom4to 5GHz,6.2GHzto6.8GHzand7.5to8.2GHzand 8.5to10GHz.Thiscanbeapproximatedas6.2to 10GHzbandwidth becausebytuning some variables,itisquiteeasytoachievethesame.Only approximation isdonetoshowwidebandwidth.In theexperiment,bandwidthvariesbetween 4to 5GHztwice,6oddto8oddGHzandfrom 10GHz itisbelow-10dB.Simulator usedisFDTD algorithm andtuningofvariablesismentionedbut notperformedandstudied.

The Sierpinskigasket antennaisconstructedafter5 iterationsandcompared with5bow-tieantennasof differentsizesimilar togasketiterationin[7]. Frequency isvariedfrom1to16GHztoseethe response,5bandsareobtainedinboth experiment andsimulation.Effectofgroundplane,feedgap is not mentioned. For bow-tie VSWR is not mentionedproperly andallaremeasured experimentallyandFDTDsimulator.

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Acircularfractalmonopole designbasedon modifiedDescartescircletheorem (DCT)is presented in[8].Measured returnlosswith referenceto−15dBisfrom2.65GHztoover20GHzexceptfrom5.4to6.5GHwhereit'saround−14dB.Measuredandsimulated using CSTisnot tallyingcompletely.No designproceduresandwhy ellipticalshapeholeforfractalisnotspecifiedand ifthereturnlossisconsideredas-10dBthen the bandwidthobtainedwillbebeyond20GHz.Different shapes-Hexagonal, Triangle, Square, Star,Treewithdifferentlevelofiteration saredone togetfractalantennaandthecomplexity increases withnumberofiterations withloosingofrequired characteristics for high eriteration.

Maximum bandwidth reportedis23.9GHzandfindsmain applicationinmultifrequencyoperation.Generally simulation isdonewithMWO,FTDT,else experimentaldata arecollected.

MERGINGTHESLOTANTENNAAND FRACTALANTENNA

Aslotantenna having higherbandwidthwhen combinedwitha fractalantennaofsimilartype should resultinanantenna withtheconsolidated bandwidth havingUWBcharacteristics.Inthis paper,I haveconsideredsquarepatchheldparallel togroundplanewith9slotsto implementfractal Sierpinskicarpet geometrywhichisinvestigated extensively formonopoleanddipoleantenna configurations [9,10,11and12],thisisdoneto avoid the effect of substrate in terms of its thicknessandaffectingthefrequencybandwidth.In thisapproach, onestartswitha largesquare encompassingtheentiregeometrywhich isdivided at themiddleto obtaineightsquares ofscaleddownsizeoforiginal(1/4th forfirstiterationand 1/8th forseconditeration) samedivisionisdoneon eachofthecopytoobtainmultipleiterations,I haveconsideredtwoiterationsforstudy and simulatedit.Thelowerfrequency forsquare monopole isgiven by:

$$f_L = \frac{7.2}{L+r}\ GHz$$

Where L= length in cm, $r = \frac{w}{2\pi}$

W= width in cm. For L=W=4.5 mm, fl is found to be 13.8GHz. The inner one square is of area 1mm2 and eight small squares is of area 0.25mm2, these two areas are cut from main square to obtain Sierpinski carpet as shown in figure

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1 FIGURE

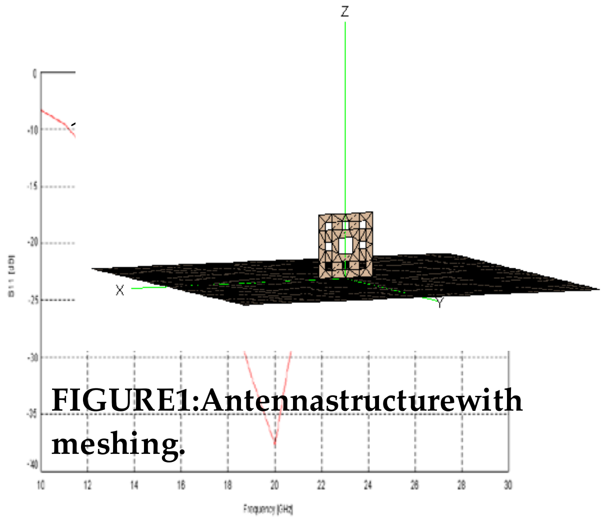
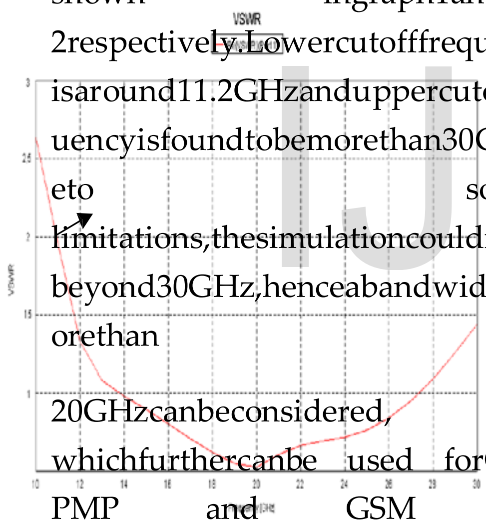


FIGURE1:Antennastructurewith meshing.

GRAPH 1: S11 versus frequency

ThesimulatedresultforS11andVSWRis shown ingraph1andgraph 2respectively.Lowercutofffrequency isaround11.2GHzanduppercutofffreq uencyisfoundtobemorethan30GHz,du eto software limitations,thesimulationcouldnotgo beyond30GHz,henceabandwidthofm orethan

20GHzcanbeconsidered, whichfurthercanbe used forC-DOT PMP and GSM (DCS) applicationsasbaseantennas.Itisclearfr om the simulation that the slot fractal antenna has widebandbehaviour;thishasto becheckedwith practically constructedone.Morefractal-slot antennatypeslikeSierpinskitriangle, monopolecircular type,Kochcurve,Koch loopandHilbert loopcanbeconsidered for widebandapplications.



GRAPH 2: VSWR versus frequency arrow indicates 10.9 GHz

CONCLUSION

UWBoperationofslotfractalantenna hasbeen demonstratedwithsquareslot fractal antennato coverabandwidthofmorethan20GHz,t heS11 andVSWRplotarefoundsatisfactorytot herange with good impedancematching. Moreiterationcan beconsideredtoseetheperformance ofantenna in termsofimpedance/VSWR/S11 bandwidth.Such antenna canberealized practicaltoseeits performance. Application of such antenna is limited tobasestationasthestructure islike monopole antenna and canbeusedindeviceswherespacecons traintsarenotpresent.

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