CST Huygens Box Tutorial

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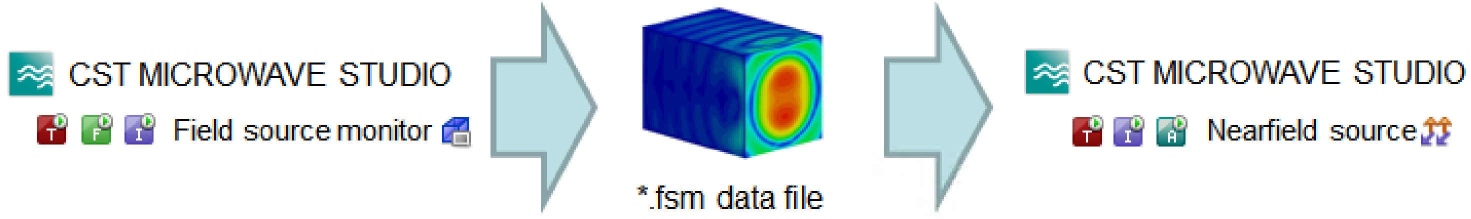
Objective

- A simple tutorial of how to use Huygens-box source in CST, including:
  - How to create a near field source and export the source file
  - How to edit the source file and import it into CST model

FSM File (from CST Help)

FSM nearfield source

FSM nearfield sources can be recorded by the time domain solver, the tetrahedral frequency domain solver, and the integral equation solver of CST MICROWAVE STUDIO by defining a field source monitor. The resulting FSM nearfield source files can be found in the results folder of the original project. The FSM nearfield sources can be imprinted in the CST MICROWAVE STUDIO time domain solver, integral equation solver, and asymptotic solver.



However, FSM file cannot be edited. Instead, it can only be exported from and imported into CST models.

NFS File (from CST Help)

NFS nearfield scan data exchange format

The NFS file format allows the imprint of equivalent surface fields on a box or even on single planes. This format is especially designed for scan data and is able to handle an equidistant as well as a non-equidistant sampled spatial distribution of field data. This format can be imprinted in the CST MICROWAVE STUDIO time domain solver, integral equation solver, and asymptotic solver.

The format is based on the IEC® Technical Report IEC/TR 61967-1-1. In order to describe surface fields on a rectangular box surface, each face and field component has to be defined in a single XML-file and a corresponding DAT-file.

The XML-file contains all meta-data such as field type, field components (Ex, Ey,Ez, Hx, Hy, Hz), frequencies, and a reference to the DAT-file.

The DAT-file contains the actual field data values in the following ASCII pattern:

```
x0 y0 z0 Re(freq1) Im(freq1) Re(freq2) Im(freq2) Re(freq3) Im(freq3) ...
x1 y0 z0 Re(freq1) Im(freq1) Re(freq2) Im(freq2) Re(freq3) Im(freq3) ...
x0 y1 z0 Re(freq1) Im(freq1) Re(freq2) Im(freq2) Re(freq3) Im(freq3) ...
...
```

Where (x_i, y_j, z_k) describe point positions of a cartesian grid and Re(freq1)/Im(freq1) the real/imaginary part of the field value at frequency freq1 and position (x_i, y_j, z_k).

Note: In order to create a supported import file: the arbitrary positions must shape an axis aligned bounding box which is approximately a flat sheet. Additionally, there should be no duplicate points.

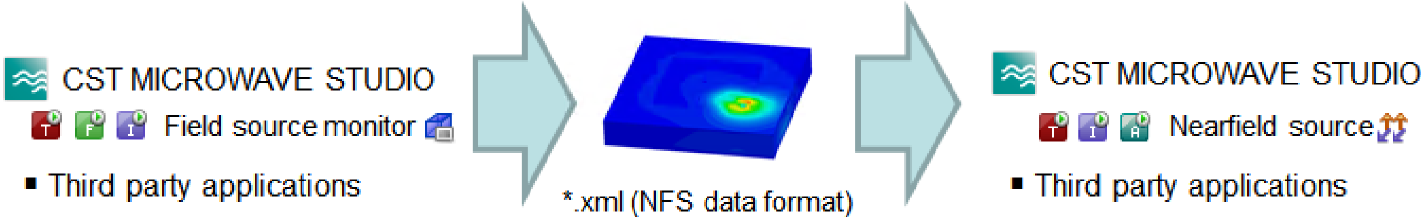
Note: When describing a box using multiple planes, be aware that the plane normal vector is always assumed to point to the positive coordinate axis direction on all box planes. Change the phase of the data on the lower box planes to account for the change of the normal orientation.

Note: While field strength values given in V/m or A/m are interpreted as peak values, data given in logarithmic scale are interpreted as rms. E.g. an electric field strength with peak value x is converted to logarithmic scale according to:

```
xdb = 20 * log( (x/sqr(2)) / (V/m) ) dBV/m
```

Example files for the supported types of the NFS format can be found here.

A detailed description of the file syntax can be found in IEC® Technical Report IEC/TR 61967-1-1.



- FSM file can be converted to NFS file (including xml and dat file), and NFS file can be then edited.

Convert FSM File to NFS File (from CST Help)

FSM export as NFS nearfield scan data exchange format

In order to export data of a field source monitor from a time domain simulation, it is necessary to convert an existing FSM file into the desired NFS nearfield scan data exchange format. This can be achieved in two ways with a VBA command:

1. Directly by absolute path to an existing FSM file:

```
'creates a folder "c:\dummy\my_monitor_file\" in the parent folder of an existing FSM file with a set of NFS files.
With Monitor
    .Reset
    .Export ("nfs" ,"" ,"c:\dummy\my_monitor_file.fsm", True)
End With
```

2. Indirectly by the name of the field source monitor and the excitation name used:

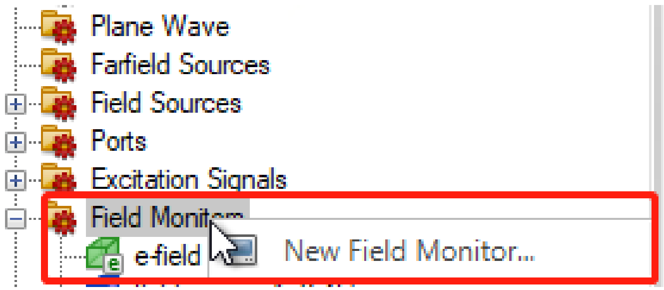
Convert FSM to NFS file through VBA command

```
'creates an additional folder in the result folder of the current project with an existing FSM file: "$PROJECT_RESULT_FOLDER$\$FIELD_SOURCE_MONITOR_NAME$_$EXCITATION_NAME$\".
'E.g. "c:\project_1\Result\field-source (f=4..6(3))_5\": where $FIELD_SOURCE_MONITOR_NAME$ is "field-source (f=4..6(3))", $EXCITATION_NAME$ is "5"  if port "5" was excited and
$PROJECT_RESULT_FOLDER$ is "c:\project_1\Result".
'This folder will contain a set of NFS files.
With Monitor
    .Reset
      .Name ("field-source (f=4..6(3))")
      .Export ("nfs" ,"5" ,"", True)
   End With

'In case of a simultaneous excitation the excitation name is exactly the string in the "Label" field of the Excitation Selection Dialog. E.g. "2[1.0,0.0]+3[1.0,0.0]"
With Monitor
    .Reset
      .Name ("field-source (f=4..6(3))")
      .Export ("nfs" ,"2[1.0,0.0]+3[1.0,0.0]" ,"", True)
   End With
```

An Example of Using Huygens Box in CST

Field Source Monitor

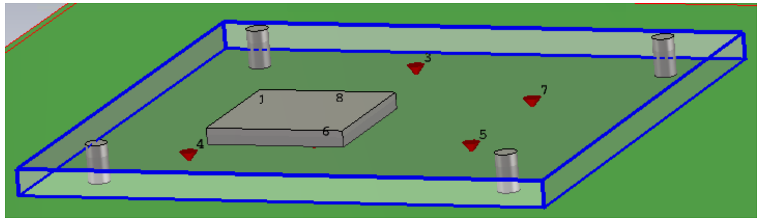


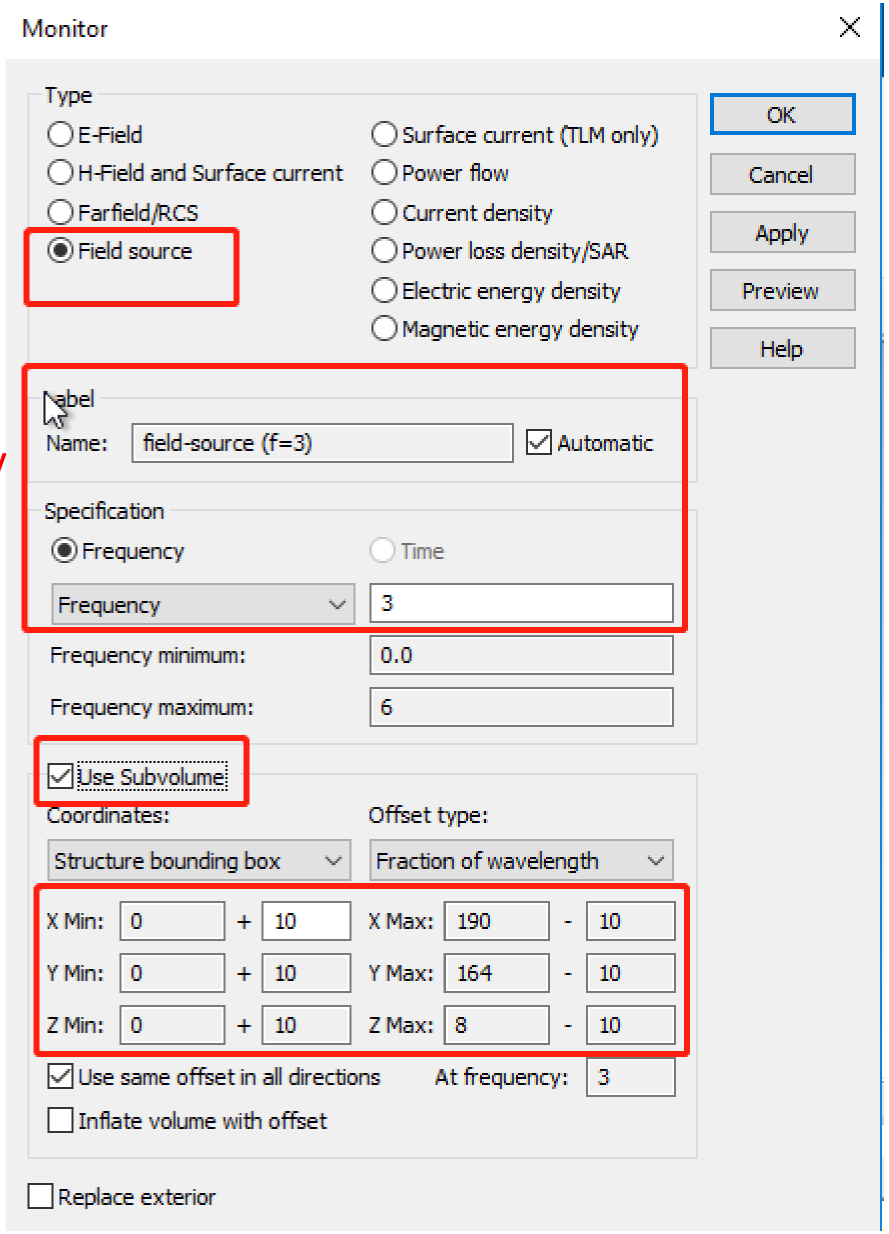
Create a new field monitor

Choose Field source

Define frequency of interest

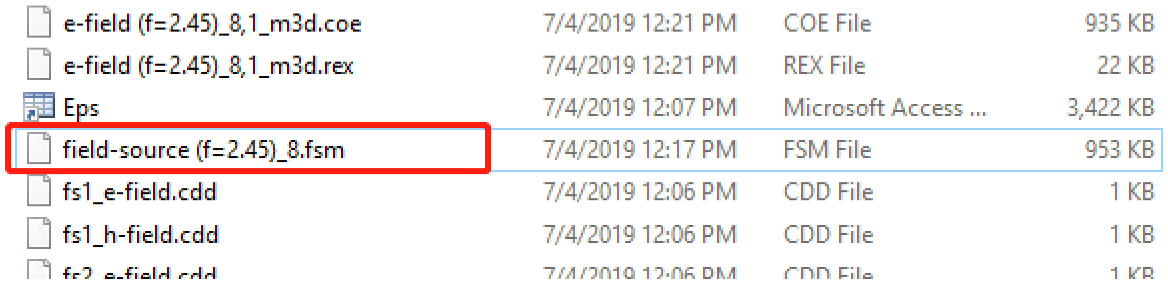
A subvolume box can be defined. Then the source file will include the field on the outer surface of the box



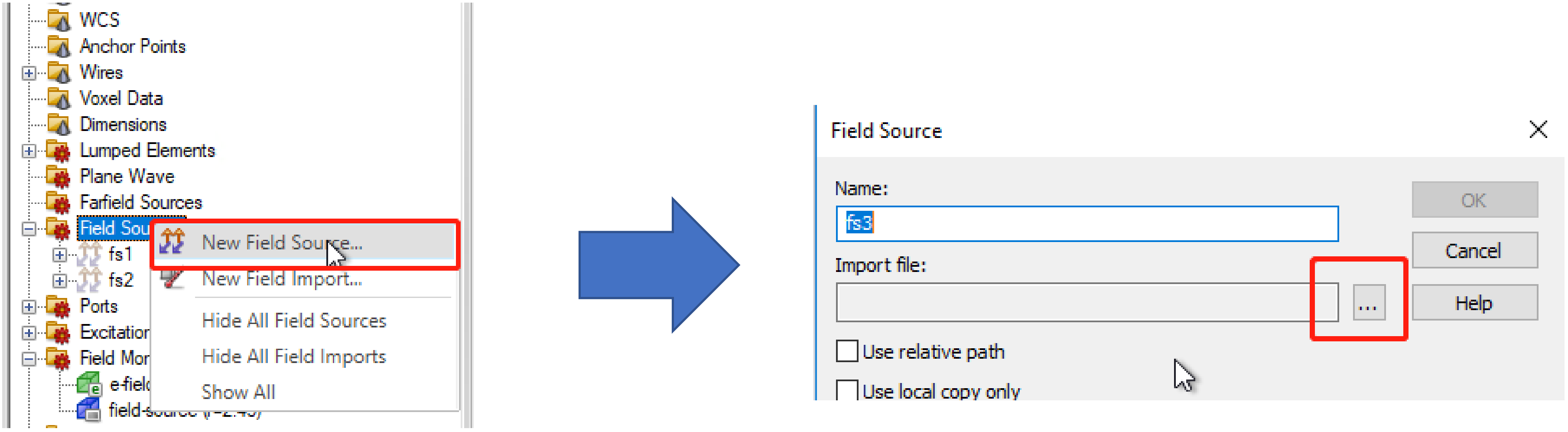


FSM File

After simulation is done, there will be a FSM file in the ‘Result’ folder



The FSM file can be directly imported into CST through ‘Field Sources’:



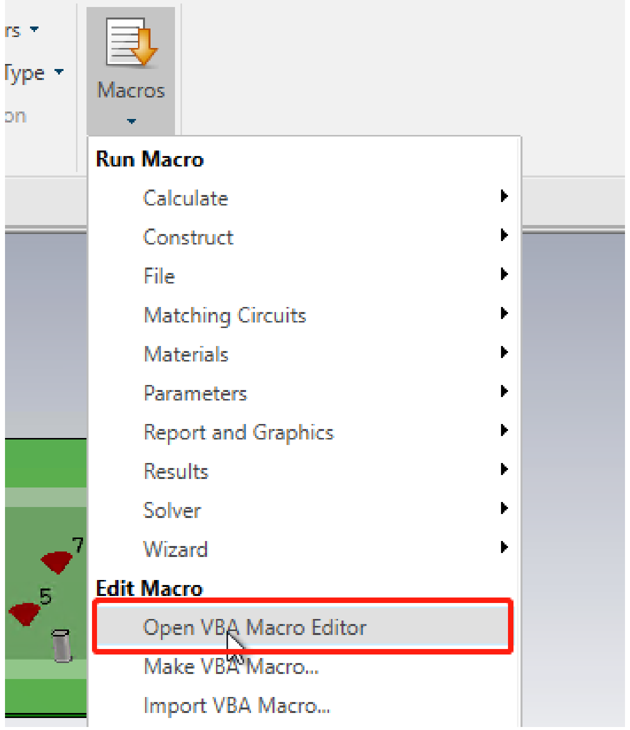
Select the FSM file

Convert FSM to NFS File

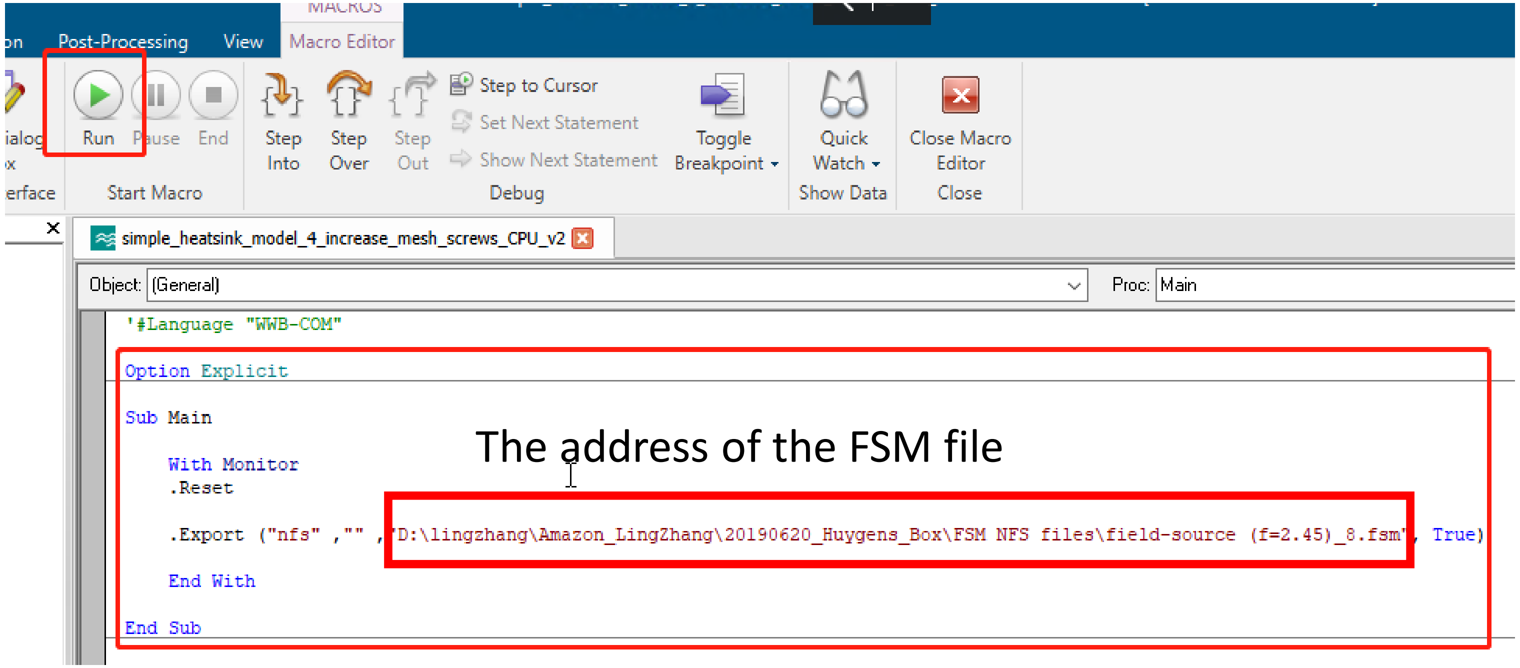
```
With Monitor
  .Reset

  .Export ("nfs" ,"" ,"c:\dummy\my_monitor_file.fsm", True)

End With
```



Open VBA Macro Editor to convert FSM to NFS file



Input VBA commands and run

NFS File

There will be a folder in the same folder with the FSM file

Name	Date modified	Type	Size
field-source (f=2.45)_8	11/20/2019 10:46 ...	File folder	
field-source (f=2.45)_8.fsm	7/4/2019 12:17 PM	FSM File	953 KB

data_Ex_ymax.dat	11/20/2019 10:46 ...	DAT File	277 KB
data_Ex_ymin.dat	11/20/2019 10:46 ...	DAT File	275 KB
data_Ex_zmax.dat	11/20/2019 10:46 ...	DAT File	528 KB
data_Ex_zmin.dat	11/20/2019 10:46 ...	DAT File	528 KB
data_Ey_xmax.dat	11/20/2019 10:46 ...	DAT File	141 KB
data_Ey_xmin.dat	11/20/2019 10:46 ...	DAT File	141 KB
data_Ey_zmax.dat	11/20/2019 10:46 ...	DAT File	528 KB
data_Ey_zmin.dat	11/20/2019 10:46 ...	DAT File	528 KB
data_Ez_xmax.dat	11/20/2019 10:46 ...	DAT File	128 KB
data_Ez_xmin.dat	11/20/2019 10:46 ...	DAT File	128 KB
data_Ez_ymax.dat	11/20/2019 10:46 ...	DAT File	250 KB
data_Ez_ymin.dat	11/20/2019 10:46 ...	DAT File	244 KB
data_Hx_ymax.dat	11/20/2019 10:46 ...	DAT File	283 KB
data_Hx_ymin.dat	11/20/2019 10:46 ...	DAT File	285 KB
data_Hx_zmax.dat	11/20/2019 10:46 ...	DAT File	834 KB
data_Hx_zmin.dat	11/20/2019 10:46 ...	DAT File	858 KB
data_Hy_xmax.dat	11/20/2019 10:46 ...	DAT File	141 KB
data_Hy_xmin.dat	11/20/2019 10:46 ...	DAT File	147 KB
data_Hy_zmax.dat	11/20/2019 10:46 ...	DAT File	822 KB
data_Hy_zmin.dat	11/20/2019 10:46 ...	DAT File	855 KB
data_Hz_xmax.dat	11/20/2019 10:46 ...	DAT File	145 KB
data_Hz_xmin.dat	11/20/2019 10:46 ...	DAT File	145 KB
data_Hz_ymax.dat	11/20/2019 10:46 ...	DAT File	280 KB
data_Hz_ymin.dat	11/20/2019 10:46 ...	DAT File	280 KB
Ex_ymax	11/20/2019 10:46 ...	XML Document	6 KB
Ex_ymin	11/20/2019 10:46 ...	XML Document	6 KB
Ex_zmax	11/20/2019 10:46 ...	XML Document	7 KB
Ex_zmin	11/20/2019 10:46 ...	XML Document	7 KB
Ey_xmax	11/20/2019 10:46 ...	XML Document	4 KB
Ey_xmin	11/20/2019 10:46 ...	XML Document	4 KB
Ey_zmax	11/20/2019 10:46 ...	XML Document	7 KB

DAT file

XML file

DAT File

Contains coordination and field information. Can be edited

x y z Real part of field

Imaginary part of field

```
0.042 0.12 0.001 0 0
0.0424915 0.12 0.001 0 0
0.042983 0.12 0.001 0 0
0.0434745 0.12 0.001 0 0
0.043966 0.12 0.001 0 0
0.0444575 0.12 0.001 0 0
0.044949 0.12 0.001 0 0
0.0454405 0.12 0.001 0 0
0.045932 0.12 0.001 0 0
0.0464235 0.12 0.001 0 0
0.046915 0.12 0.001 0 0
0.0474065 0.12 0.001 0 0
0.047898 0.12 0.001 0 0
0.0483895 0.12 0.001 0 0
0.048881 0.12 0.001 0 0
0.0497375 0.12 0.001 0 0
0.0507205 0.12 0.001 0 0
0.0517036 0.12 0.001 0 0
0.0526866 0.12 0.001 0 0
0.0536696 0.12 0.001 0 0
0.0546527 0.12 0.001 0 0
```

XML File

XML file can be edited

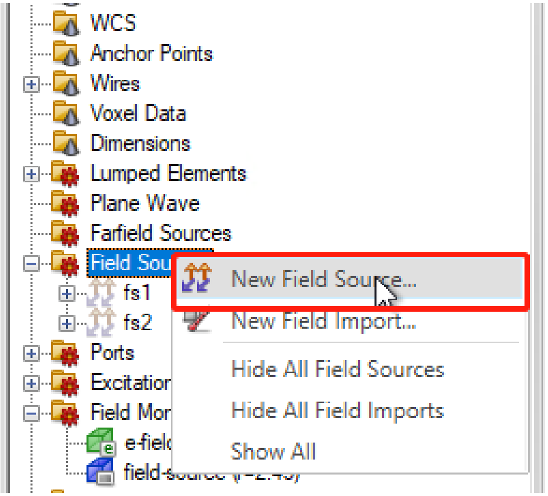
Coordination information. Must match with the corresponding DAT file

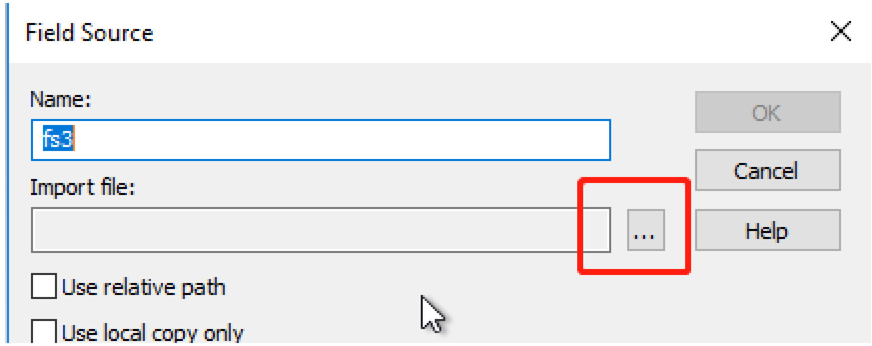
Frequency

Point to the right DAT file that contains the coordination and field information


```
<?xml version="1.0"?>
- <EmissionScan>
    <Nfs_ver>1</Nfs_ver>
    <Filename>Ex_ymax.xml</Filename>
    <File_ver>1</File_ver>
    <Date>November 20, 2019</Date>
    <Source>Generated by CST MICROWAVE STUDIO</Source>
  - <cst:box xmlns:cst="http://www.cst.com/2014/export/nfs/20140228">
      <cst:size zmax="0.0060000000000000001" zmin="0.001" ymax="0.12" ymin="0.020000000000000004" xmax="0.14200000000000002" xmin="0.042000000000000003"/>
    - <cst:face position="max" direction="y" type="cartesian">
        <cst:gridlines axis="z">0.001 0.0014187027388316339 0.0018374054776632684 0.0022492866726876197 0.0023519260225450416 0.0024523864844580778 0.0025528469463711122
          0.0026533074082841475 0.0027537678701971182 0.0028542283321102177 0.0029546887940232253 0.0030551492559362891 0.0031556097178493249 0.0032560701797623558
          0.0033565306416753942 0.0034569911035884295 0.0035574515655014643 0.0036579120274144996 0.0037583724893275358 0.0038810447376232148 0.0040032966020513748
          0.0041037570639644097 0.0042042175258774454 0.0043046779877904812 0.0044051384497035160 0.0045055989116165526 0.0046060593735295884 0.0047073498986443555
          0.0050011349627094364 0.0054975196010294946 0.0060000000000000001 </cst:gridlines>
        <cst:gridlines axis="x">0.042000000000000003 0.0424914970430675940 0.042982994086135193 0.043474491129202777 0.043965988172270376 0.044457485215337961 0.044948982258405545
          0.045440479301473137 0.045931976344540722 0.046423473387608362 0.046914970430676009 0.047406467473743656 0.047897964516811310 0.048389461559878902 0.048880958602946299
          0.049737472446262886 0.050720515859187437 0.051703559272111732 0.052686602685036034 0.053669646097960329 0.054652689510884631 0.055946507217103252 0.057424086977074122
          0.058901666737044986 0.060464315137396203 0.062041012586476756 0.063546589907619605 0.065024169667590476 0.065796914887555444 0.065902691531455837 0.066000792172919986
          0.066098892814384122 0.066196993455848258 0.066295094097312379 0.066393194738776529 0.066491295380240678 0.066589396021704814 0.066687496663168949 0.066785627832721225
          0.066883923295547987 0.066982218758374762 0.067080514221201523 0.067178809684028284 0.067275476140638973 0.067367628079241806 0.067459780017844653 0.067551931956447486
          0.067644083895050333 0.067736235833653166 0.067828387772256027 0.067920539710858860 0.068012765194254685 0.068110631405516250 0.068209360716957254 0.068983406280483245
          0.070399273344003102 0.071855386705149613 0.073357694547268329 0.075043498302700504 0.076573985408157047 0.078036913799933313 0.079493027161079852 0.079827269135629819
          0.079927317524849856 0.080025388804881400 0.080123460084912917 0.080221531364944448 0.080319602644975993 0.080417673925007524 0.080515745205039041 0.080613816485070586
          0.080711887765102103 0.080810048015577590 0.080908343478404351 0.081006638941231141 0.081104934404057916 0.081203229866884691 0.081301154845913243 0.081398717150794997
          0.081496279455676723 0.081593841760558491 0.081691404065440218 0.081788966370321986 0.081886528675203699 0.081984090980085453 0.082081653284967193 0.082179215589848975
          0.082493550685165631 0.083618988237726219 0.084780875397437852 0.085772692822713201 0.085970286429104883 0.086053449716129188 0.086122995498753477 0.086192500708966668
          0.086262005893000371 0.086331511077034045 0.086401016261067692 0.086470521445101381 0.086540026629135069 0.086609531813168730 0.086679036997202419 0.086748542181236080
          0.086818047365269754 0.086887552549303429 0.086957057733337104 0.087026562917370792 0.087096068101404397 0.087171091826396610 0.087241305079759274 0.087310810263792962
          0.087380315447826623 0.087449820631860326 0.087519325815893986 0.087588830999276750 0.087658336183961363 0.087727841367995038 0.087798229669719119 0.087874574246943130
          0.087959505541805122 0.088234579933085922 0.089086901008339076 0.090417676657735604 0.091748452307132133 0.093079227956527483 0.094495559579826360 0.096109663775274717
          0.097723767970723061 0.099404387359835325 0.101301669438873890 0.103234237182576090 0.105166804926278280 0.107099372669980490 0.109031940413682690 0.110929563353119600
          0.112622432776812910 0.114236345467021270 0.115695192575019350 0.115764780681090530 0.115834285865124220 0.115903791049157850 0.115973296233191570 0.116042801417225230
          0.116112306601258920 0.116181811785292620 0.116251316969326280 0.116320822153359970 0.116390327337393610 0.116459832521427290 0.116529337705460990 0.116598842889494680
          0.116668348073528340 0.116737853257561640 0.116807807812318360 0.116878018655887690 0.116948229499457050 0.117018440343026370 0.117088651186595730 0.117158862030165070
          0.117229072873734390 0.117298727209858280 0.117368232393891940 0.117439314487600780 0.117521380981497520 0.117619439509813130 0.117717498038128730 0.117815556566444300
          0.117913615094759890 0.118011673623075480 0.118109732151391080 0.118276046954700380 0.118919485718031500 0.120366465341389140 0.121834693553716480 0.123374441286014190
          0.124916195745843740 0.126363175369201390 0.127810154992558960 0.129173461507539470 0.130156504920465290 0.131139548333391060 0.132122591746316830 0.133152165298028420
          0.134626804415023120 0.136101443532017840 0.137576082649012550 0.139050721766007250 0.140525360883001940 0.142000000000000020 </cst:gridlines>
      </cst:face>
    </cst:box>
  - <Probe>
      <Field>Ex</Field>
    </Probe>
  - <Data>
      <Coordinates>xyz</Coordinates>
    - <Frequencies>
        <List>2450000000 </List>
      </Frequencies>
    - <Measurement>
        <Format>ri</Format>
        <Unit>V/m</Unit>
        <Data_files>data_Ex_ymax.dat </Data_files>
      </Measurement>
    </Data>
</EmissionScan>
```

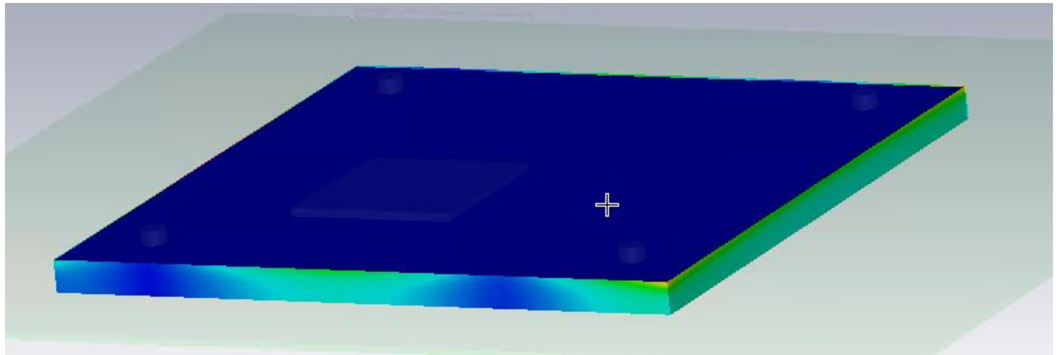
Import XML File





The XML files can be imported as field source

Field distribution can also be viewed



The XML and DAT file can be edited. Therefore, measured field can also be imported into CST through this way.

An Example of Using Huygens Box in CST **with multiple frequency points**

XML File – Multiple Frequency Points


```
  <?xml version="1.0"?>
- <EmissionScan>
    <Nfs_ver>1</Nfs_ver>
    <Filename>Ez_ymin.xml</Filename>
    <File_ver>1</File_ver>
    <Date>December 14, 2019</Date>
    <Source>Generated by CST MICROWAVE STUDIO</Source>
  - <cst:box xmlns:cst="http://www.cst.com/2014/export/nfs/20140228">
      <cst:size zmax="0.006000000000000001" zmin="0.001" ymax="0.12" ymin="0.020000000000000004" xmax="0.14200000000000002" xmin="0.042000000000000003"/>
    - <cst:face position="min" direction="y" type="cartesian">
        <cst:gridlines axis="z">0.001 0.0014187027388316339 0.0018374054776632684 0.0022492866726876197 0.0023519260225450416 0.0024523864844580778 0.0025528469463711122 0.0026533074082841475
          0.0027537678701971182 0.0028542283321102177 0.0029546887940232253 0.0030551492559362891 0.0031556097178493249 0.0032560701797623358 0.0033565306416753942 0.0034569911035884295 0.0035574515655014643
          0.0036579120274144996 0.0037583724893275358 0.0038810447376232148 0.0040032966020513748 0.0041037570639644097 0.0042042175258774454 0.0043046779877904812 0.004405138449703516
          0.0045055989116165526 0.0046060593735295884 0.0047073498986443555 0.0050011349627094364 0.0054975196010294946 0.006000000000000001 </cst:gridlines>
        <cst:gridlines axis="x">0.042000000000000003 0.042491497043067594 0.042982994086135193 0.043474491129202777 0.043965988172270376 0.044457485215337961 0.044948982258405545 0.045440479301473137
          0.045931976344540722 0.046423473387608362 0.046914970430676009 0.047406467473743656 0.047897964516811131 0.048389461559878902 0.048880958602946299 0.049737472446262886 0.050720515859187437
          0.051703559272111732 0.052686602685036034 0.053669646097960329 0.054652689510884631 0.055946507217103252 0.057424086977074122 0.058901666737044986 0.060464315137396203 0.062041012586476756
          0.063546589907619605 0.065024169667590476 0.065796914887555444 0.065902691531455837 0.066000792172919986 0.066098892814384122 0.066196993455848258 0.066295094097312379 0.066393194738776529
          0.066491295380240678 0.066589396021704814 0.066687496663168949 0.066785627832721225 0.066883923295547987 0.066982218758374762 0.067080514221201523 0.067178809684028284 0.067275476140638973
          0.067367628079241806 0.067459780017844653 0.067551931956447486 0.067644083895050333 0.067736235833653166 0.067828387772256027 0.067920539710858860 0.068012765194254685 0.06811063140551625
          0.068209360716957254 0.068983406280483245 0.070399273344003102 0.071855386705149613 0.073357694547268329 0.075043498302700504 0.076573985408157047 0.078036913799933313 0.079493027161079852
          0.079827269135629819 0.079927317524849856 0.0800253888048814 0.080123460084912917 0.080221531364944448 0.080319602644975993 0.080417673925007524 0.080515745205039041 0.080613816485070586
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    </Data>
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```


Define multiple frequencies

DAT File – Multiple Frequencies

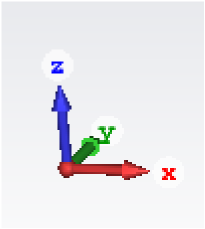
x, y, z location

Real and imaginary part of field at different frequencies

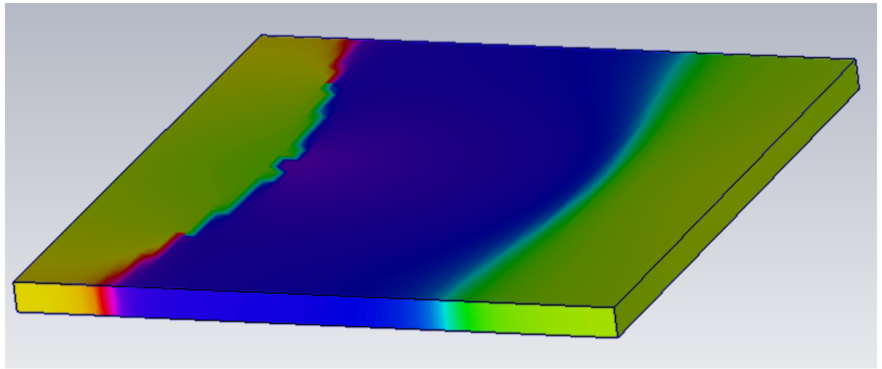
```
x0 y0 z0 Re(freq1) Im(freq1) Re(freq2) Im(freq2) Re(freq3) Im(freq3) ...
x1 y0 z0 Re(freq1) Im(freq1) Re(freq2) Im(freq2) Re(freq3) Im(freq3) ...
x0 y1 z0 Re(freq1) Im(freq1) Re(freq2) Im(freq2) Re(freq3) Im(freq3) ...
...
```

Remember to **flip the phase** on xmin and ymin side

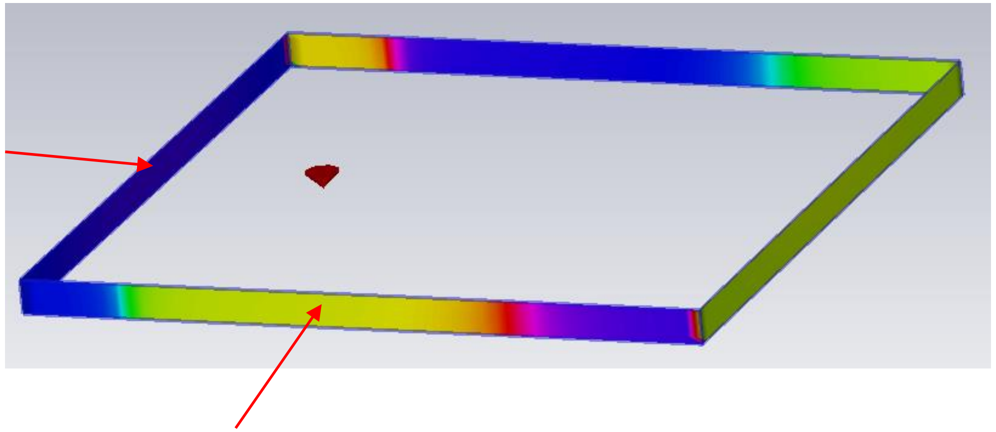
Flip Phase on xmin and ymin



Original Ez phase on Huygens box



Ez phase on multiple planes



When importing source into CST using multiple planes, we can find that **the phase on xmin and ymin plane is flipped**, compared with the original phase distribution on Huygens box.

The reason is:

From CST help file:
When describing a box using multiple planes, be aware that the plane normal vector is always assumed to point to the positive coordinate axis direction on all box planes. **Change the phase of the data on the lower box planes to account for the change of the normal orientation.**

So remember to flip the phase on xmin and ymin side when dealing with DAT files!!!