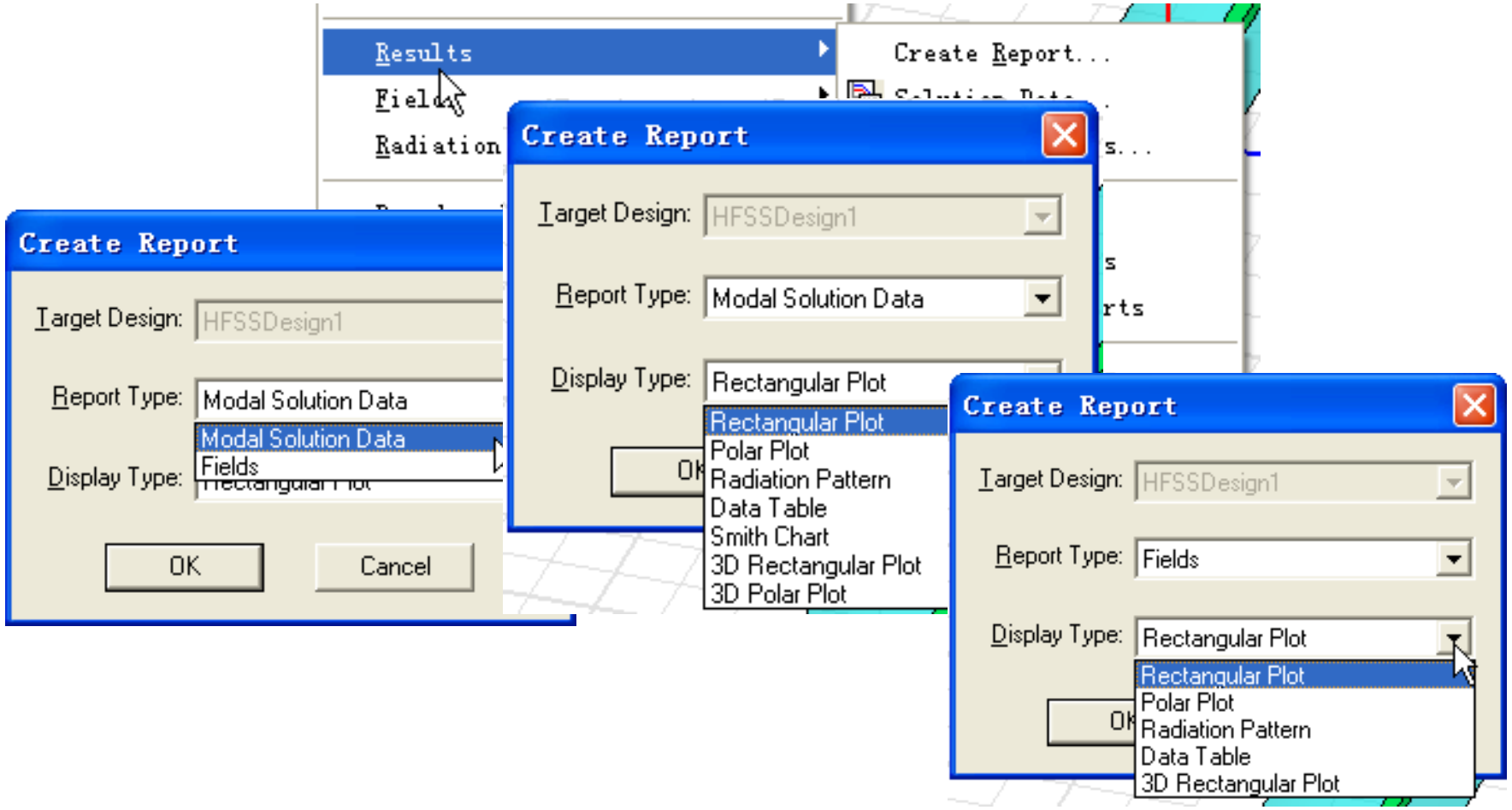
HFSS的后处理及场计算器入门

电子科技大学

贾宝富

Ansoft HFSS的后处理（Results）

- Create Report



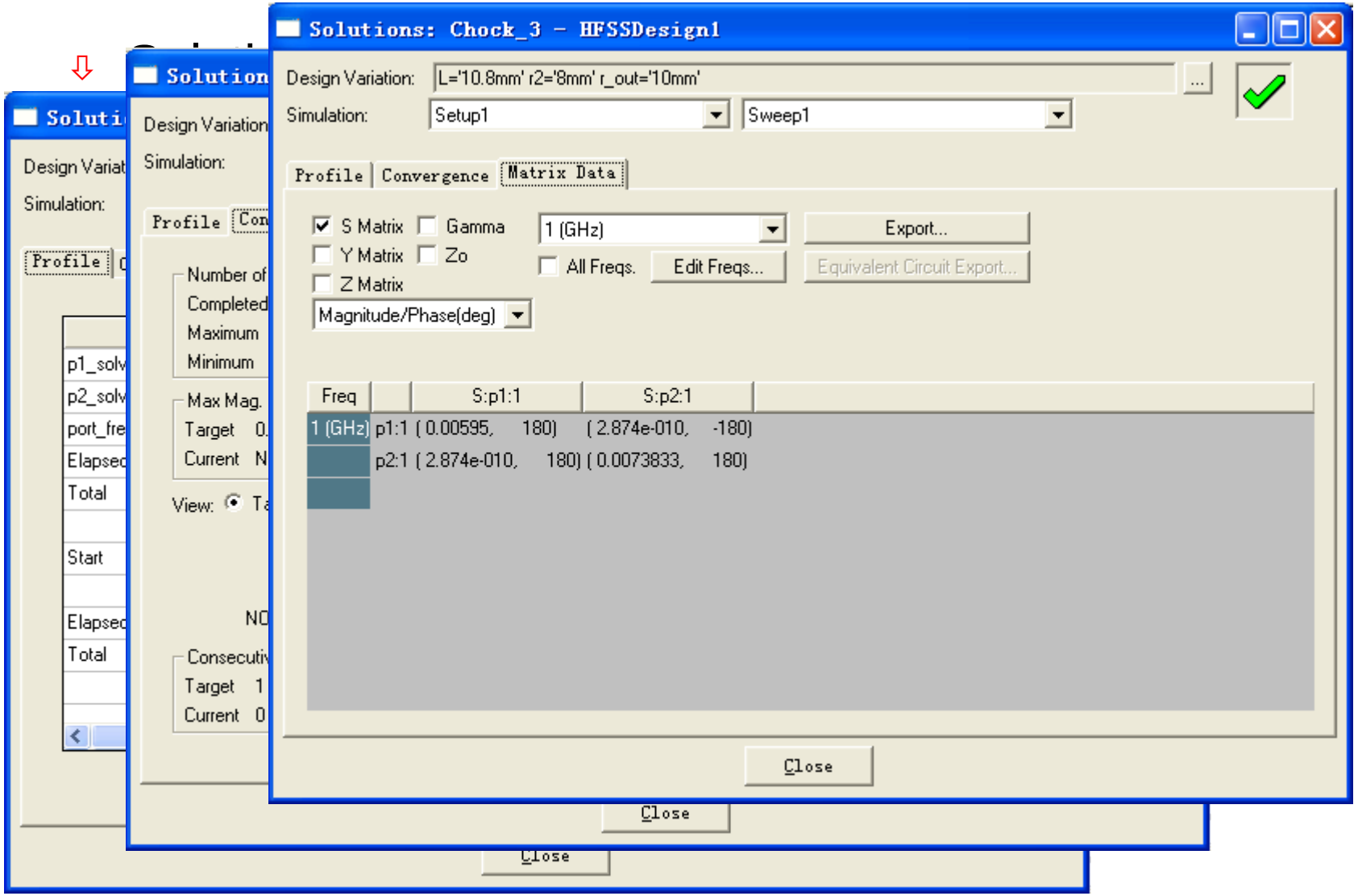
可绘制图形

- **Eigenmode solution（本征模解）**
  - Eigenmode Parameters (modes)（本征模参数图形）
- **Driven Modal Solution（驱动模式解）**
  - S-parameters（S参数图形）
  - Y-parameters（Y参数图形）
  - Z-parameters（Z参数图形）
  - VSWR（驻波比）
  - Gamma (complex propagation constant)（复数形式的传播常数）
  - Port Zo（端口波阻抗）
- **Driven Terminal Solution（终端驱动解）**
  - S-parameters（S参数图形）
  - Y-parameters（Y参数图形）
  - Z-parameters（Z参数图形）
  - VSWR（驻波比）
  - Power（功率）
  - Voltage Transform matrix (T)（电压传输矩阵）
  - Terminal Port Zo（端口波阻抗）

可绘制图形

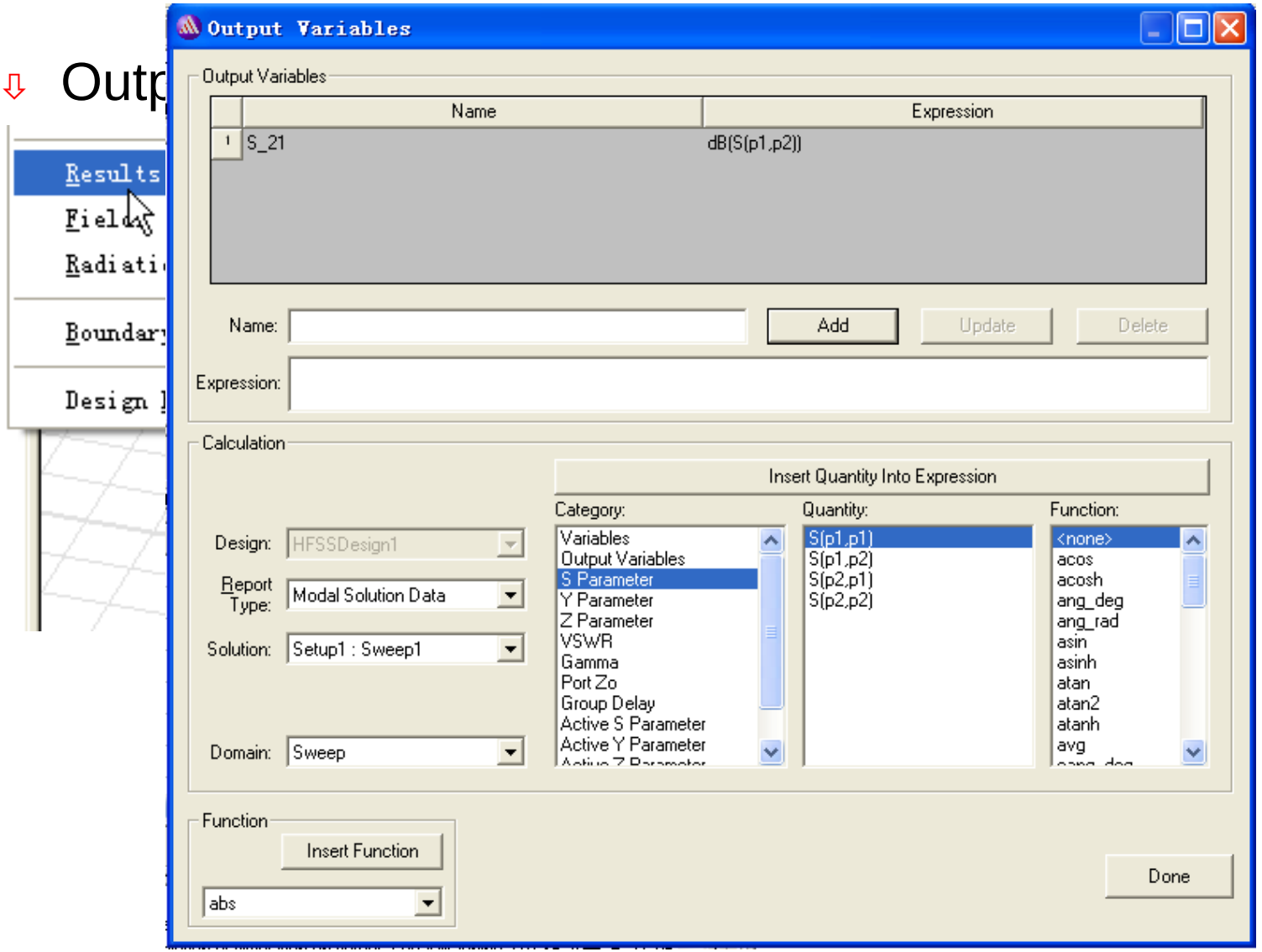
- Fields(场)
  - Mag_E
  - Mag_H
  - Mag_Jvol
  - Mag_Jsurf
  - ComplexMag_E
  - ComplexMag_H
  - ComplexMag_Jvol
  - ComplexMag_Jsurf
  - Local_SAR (Specific Absorption Rate)
  - Average_SAR
- 注：在绘制场图前必须先选择一个面或者一个多点线。

Ansoft HFSS的后处理（Results）



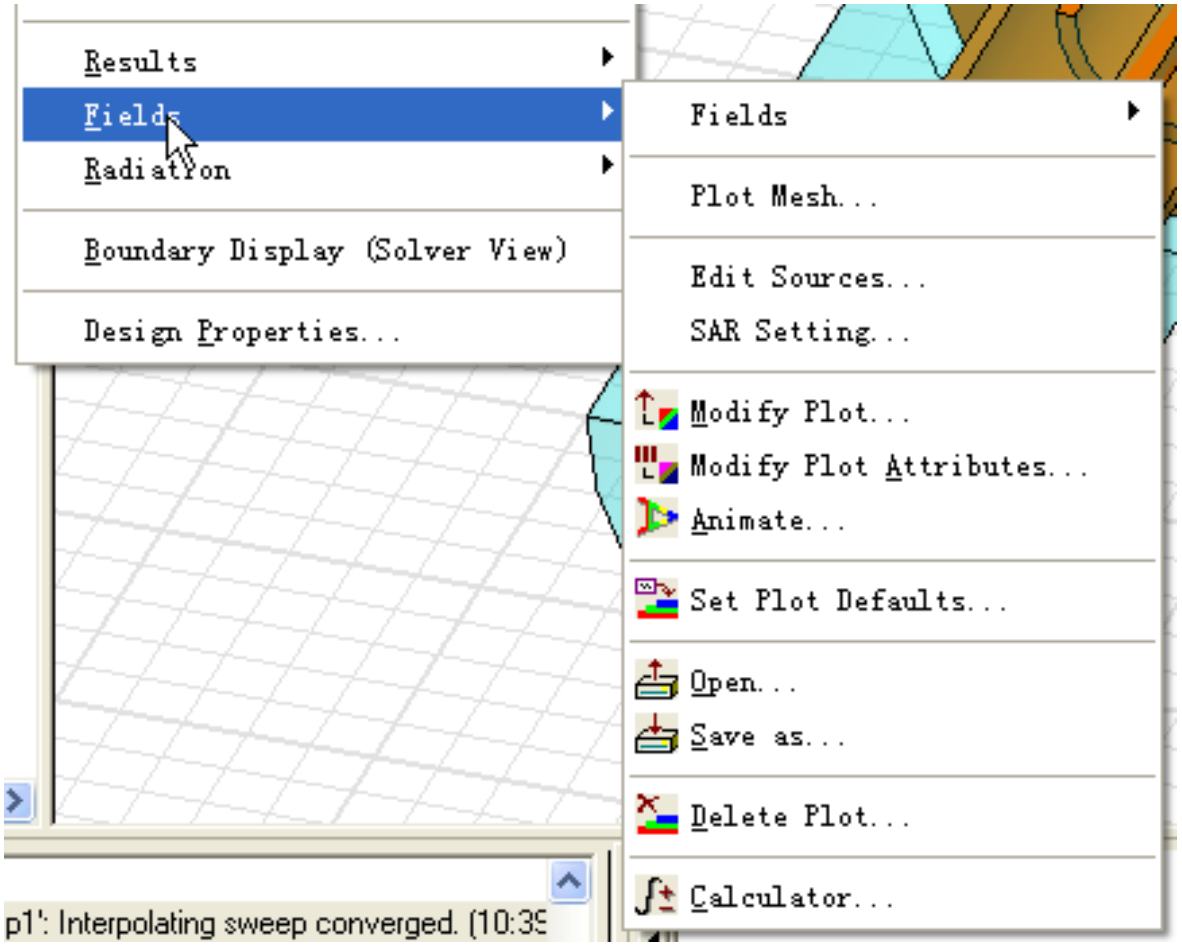
Ansoft HFSS的后处理（Results）

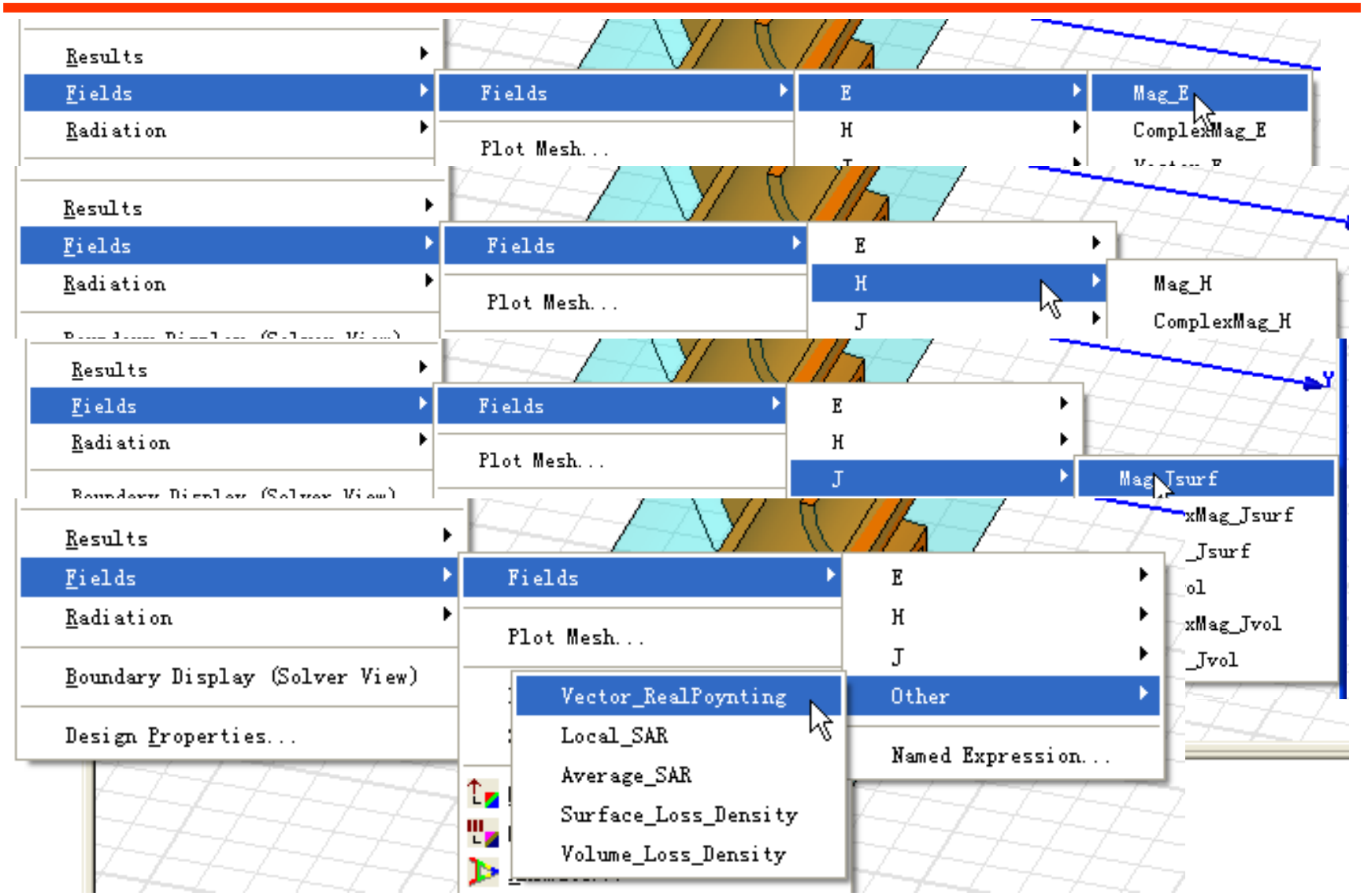
⇩ Outp



Ansoft HFSS的后处理（Fields）

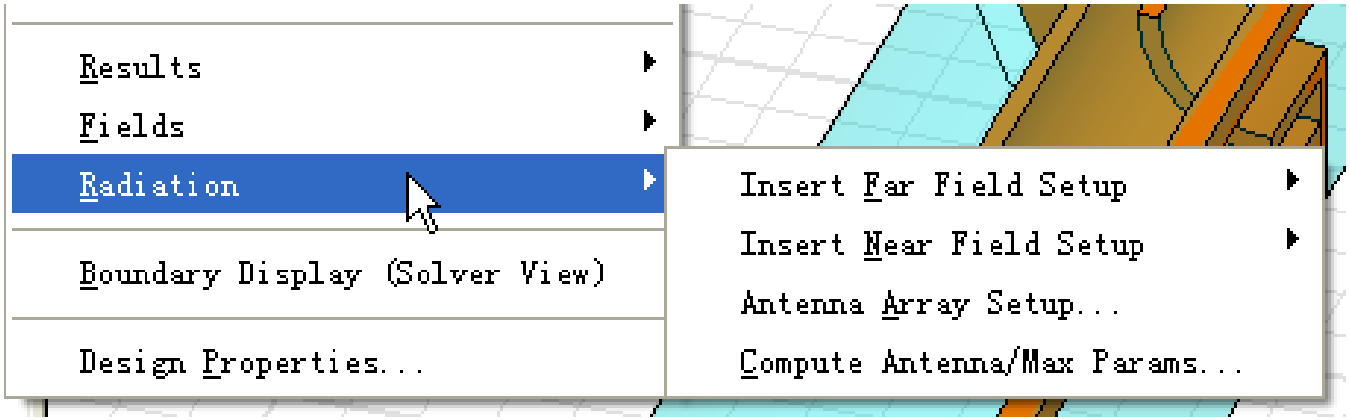
- Fields



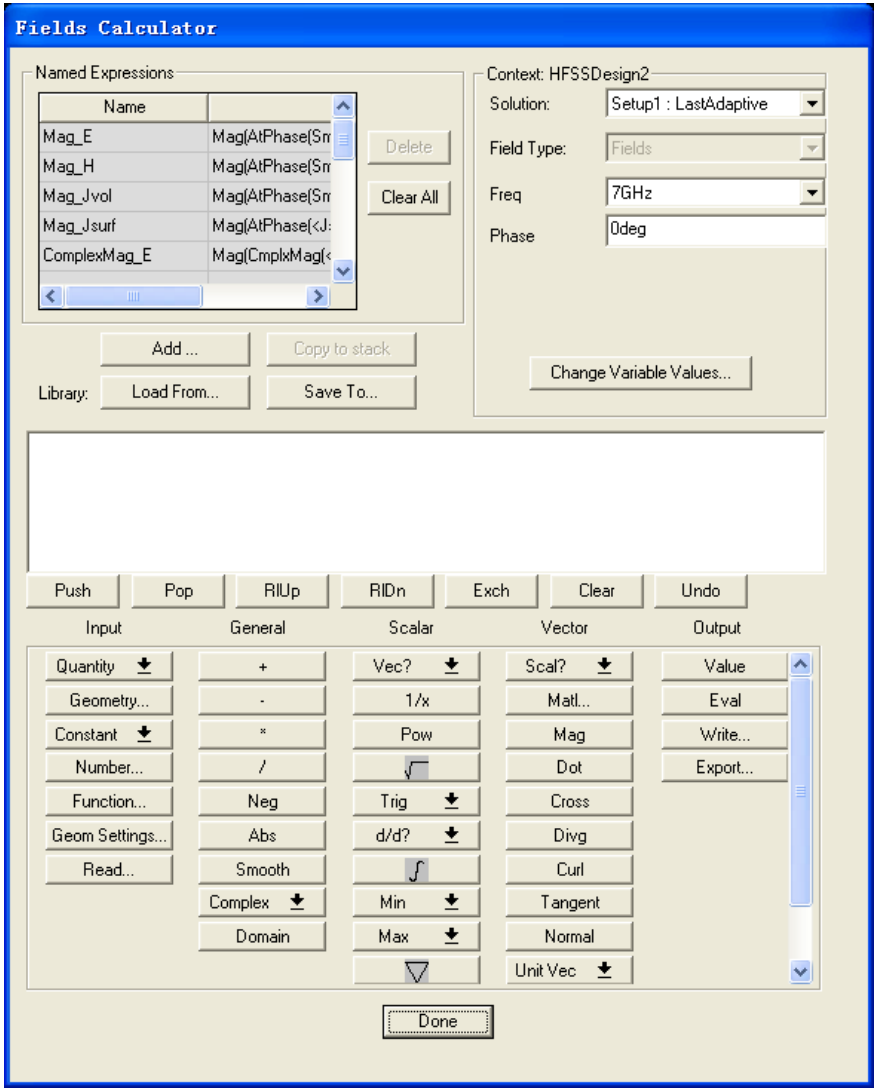

Results
Fields
Radiation
Plot Mesh...
E
H
J
Mag_E
ComplexMag_E
Mag_H
ComplexMag_H
Boundary Display (Solver View)
Design Properties...
Vector_RealPoynting
Local_SAR
Average_SAR
Surface_Loss_Density
Volume_Loss_Density
Other
Named Expression...

Ansoft HFSS的后处理（Radiation）

- Radiation



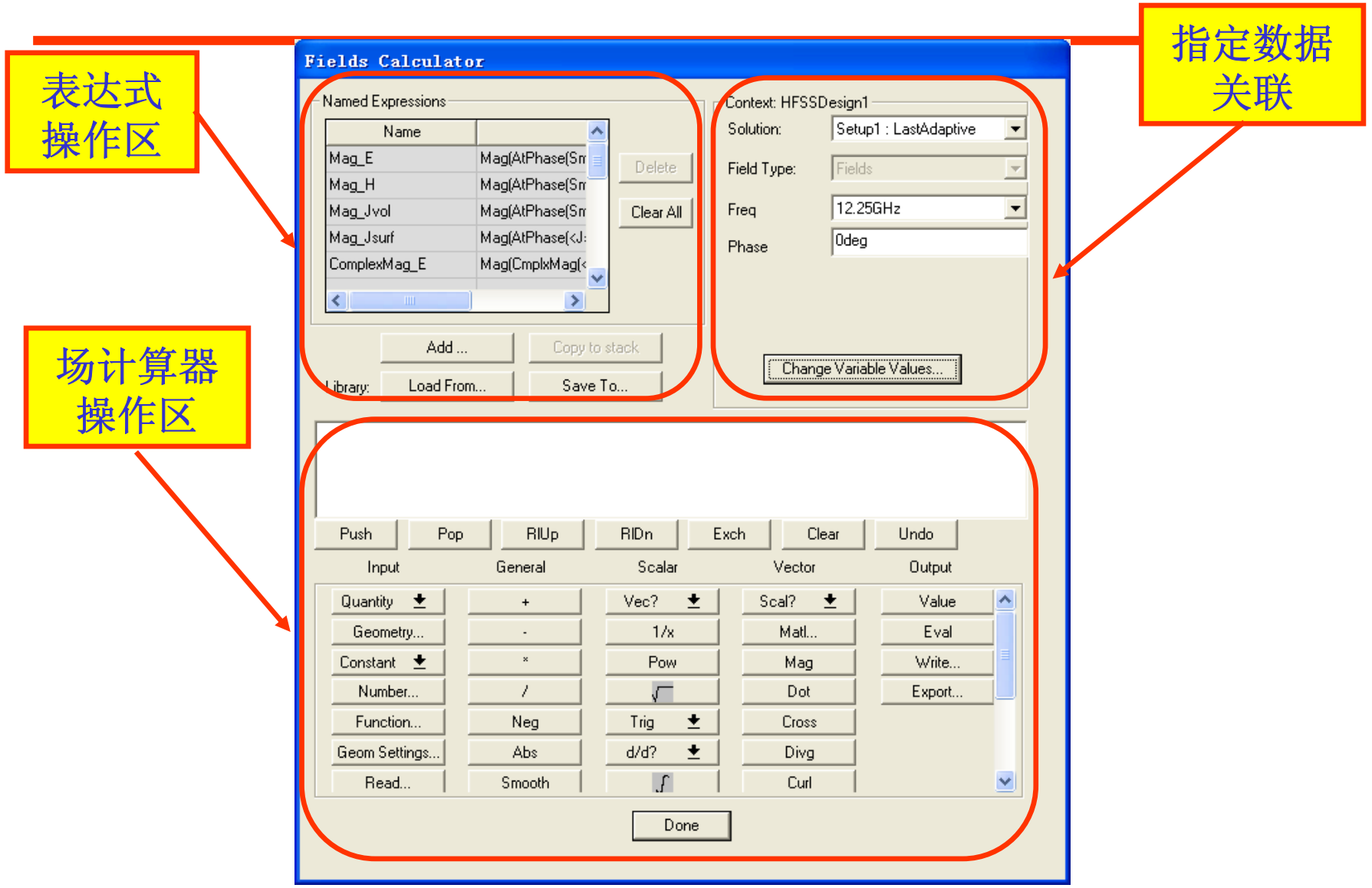
HFSS Field Calculator: Definition



A tool for performing mathematical operations on ***ALL*** saved field data in the modeled geometry

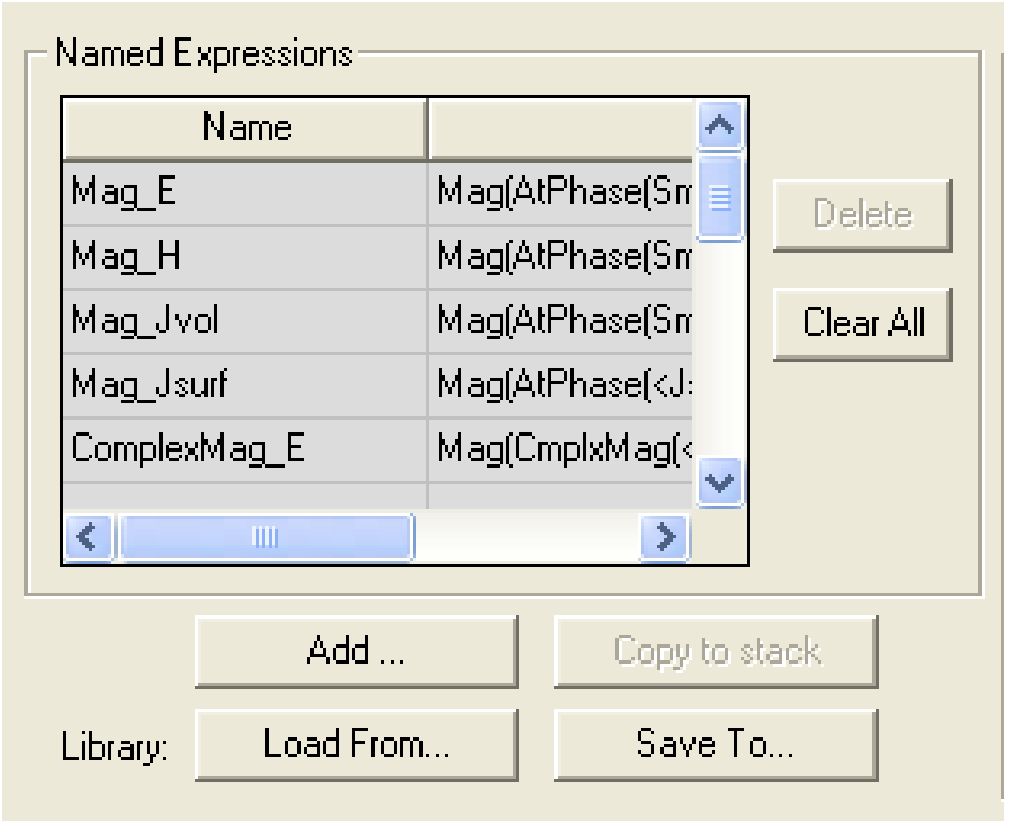
- **E**,**H**,**J**, and **Poynting** data available
- Perform operations using drawing geometry or new geometry created in **Post3**
- Perform operations at single frequency (interpolating or discrete sweeps) or other frequencies (fast sweep)
- Generate numerical , graphical, geometrical or exportable data
- Macro-enabled

场计算器分区


表达式操作区
场计算器操作区
指定数据关联
Fields Calculator
Named Expressions
Name
Mag_E
Mag_H
Mag_Jvol
Mag_Jsurf
ComplexMag_E
Delete
Clear All
Add ...
Copy to stack
Library:
Load From...
Save To...
Context: HFSSDesign1
Solution:
Setup1 : LastAdaptive
Field Type:
Fields
Freq
12.25GHz
Phase
0deg
Change Variable Values...
Push
Pop
RlUp
RlDn
Exch
Clear
Undo
Input
General
Scalar
Vector
Output
Quantity
Geometry...
Constant
Number...
Function...
Geom Settings...
Read...
+
-
*
/
Neg
Abs
Smooth
Vec?
1/x
Pow
Trig
d/d?
Scal?
Matl...
Mag
Dot
Cross
Divg
Curl
Value
Eval
Write...
Export...
Done

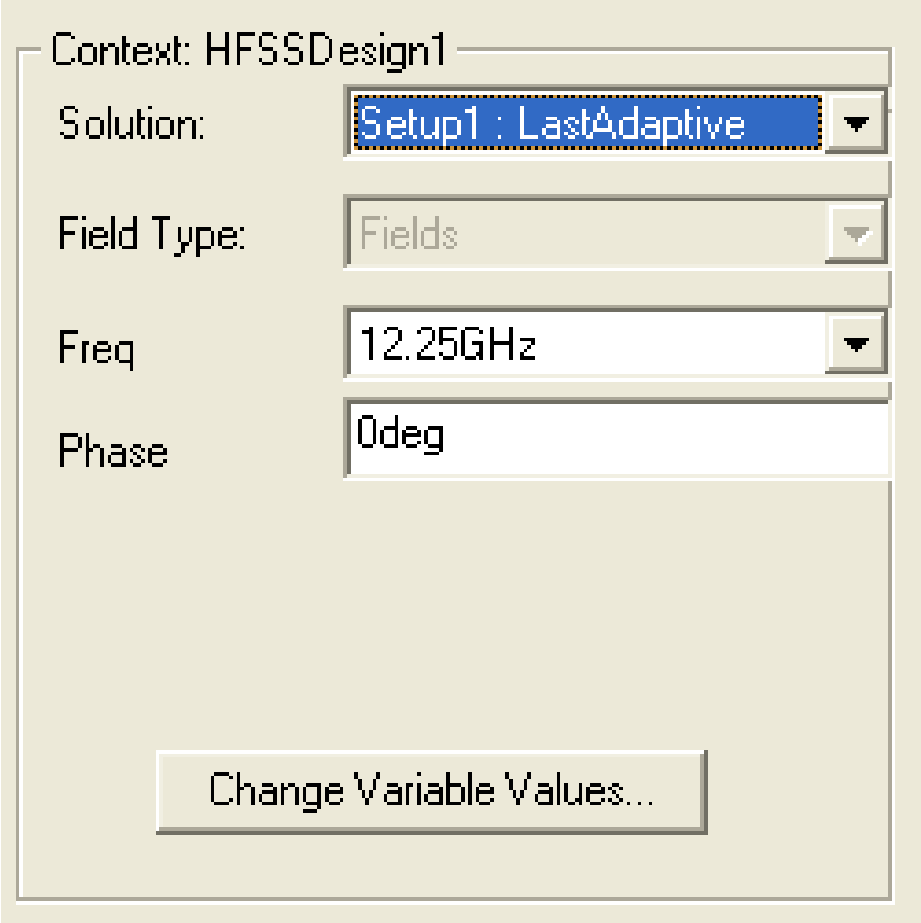
表达式操作区

- 建立表达式
  - 使用“Add”键，由场计算器堆栈导入表达式；
  - 使用“Load From”键，由场计算器表达式文件（*.clc）导入表达式；
- 输出表达式
  - 使用“Copy to stack”键，将已存在的表达式导出到场计算器堆栈；
  - 使用“Save to”键，将已存在的表达式保存成场计算器表达式文件（*.clc）；



指定关联区

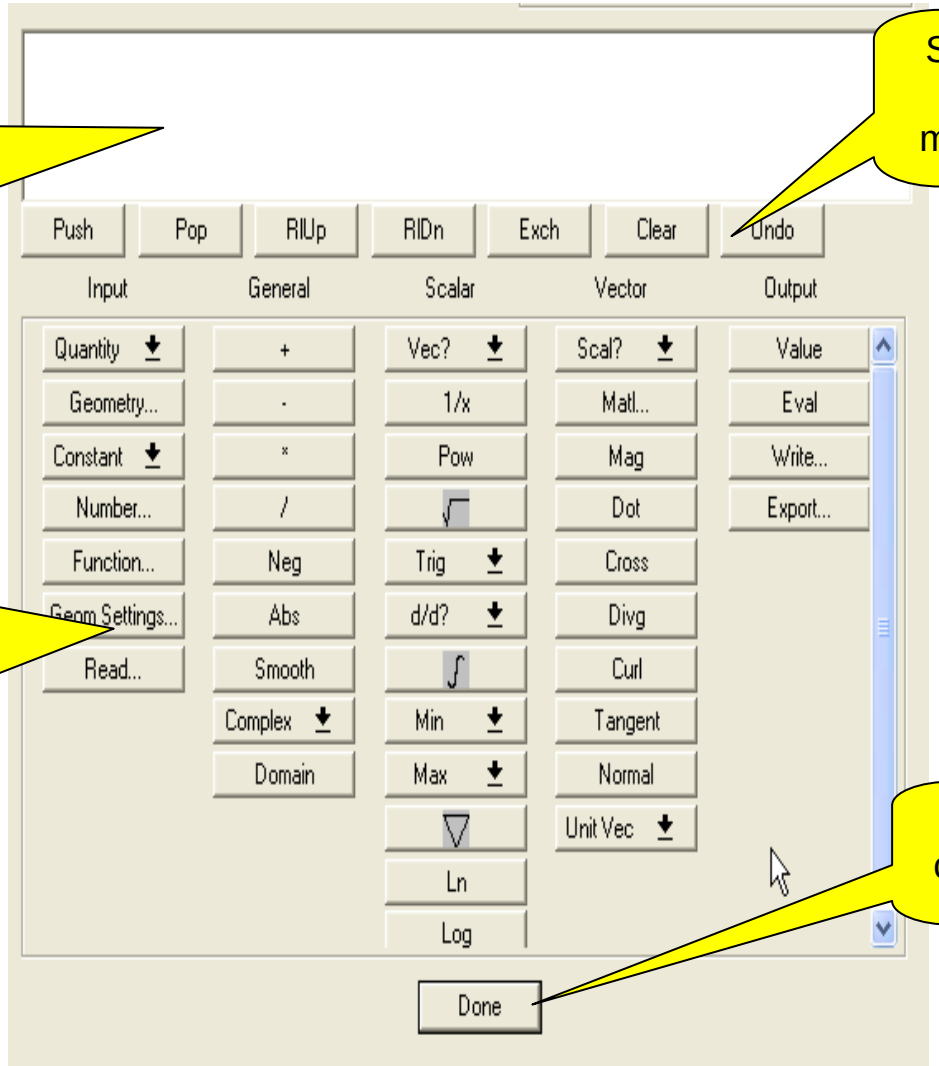
- 指定场计算器使用数据的出处。
  - 指定求解设置
  - 指定场类型；
  - 指定频率
  - 指定相位



HFSS Field Calculator: Basic Layout

Data stack: Contains current and saved entries in a scrolling stack similar to a hand-held scientific caculator.

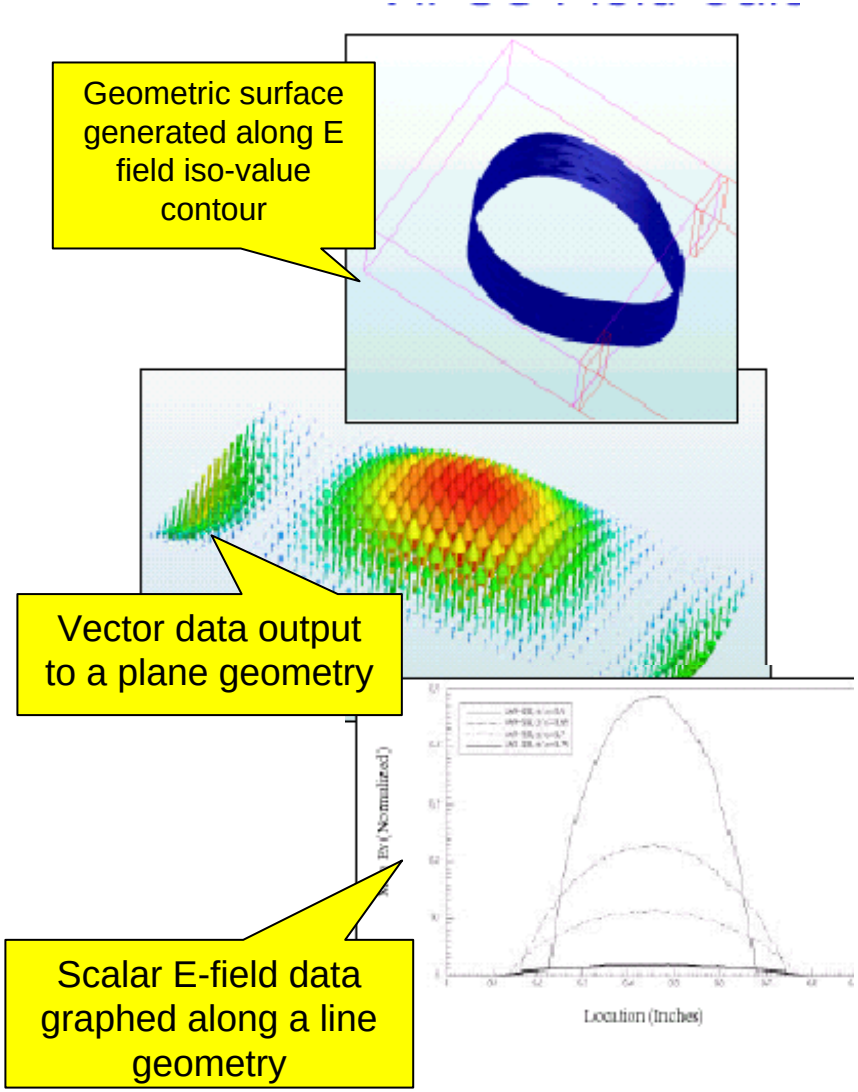
Stack Operations: Button for manipulating stack



Calculator Functions: Orgnized groupings of all the avaliable calculator functions in button format. Some buttons contain further options as drop-down menus

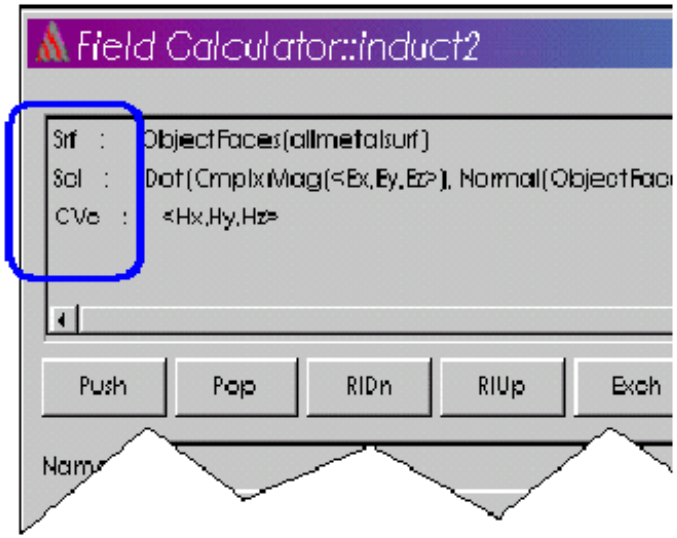
Status Bar(not currently shown):

HFSS Field Caculator: Data Types



- The calculatiorv can manipulate many different types of data
  - Geometric
  - Complex
  - Vector
  - Scalar
- Data types are indicated in the calculator stack for each entry
- Most calculator operations are only available on the appropriate data type(s)

HFSS Field Calculator: Data Indicators



CACULATOR USAGE HINT: Most data input types will be self-explanatory, e. g. ***E*** and ***H*** fields being phasor quantities will be Complex Vector (CVc). The only exception to this rule is the ***Poynting*** input, Which will show up as a "CVc" even though ***E X H**** should have no imaginary component. The calculator only knows that two complex vector were crossed, and does not know ahead of time that the imaginary component has been zeroed.

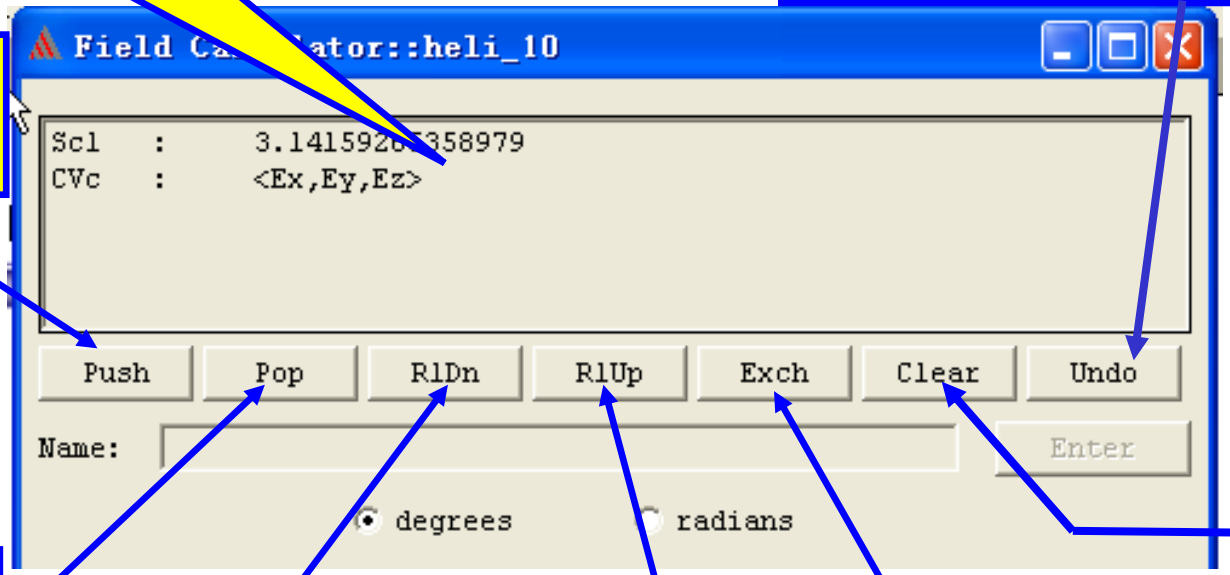
- Each stack entry will be preceded by a unique code denoting its data type
  - Mathematical:
    - CVc: Complex Vector
    - Vec: Vector
    - CSc: Complex Scalar
    - Scl: Scalar
  - Geometric:
    - Pnt: Point
    - Lin: Line
    - Srf: Sourface
    - Vol: Volume
  - Combinations can also exist
    - E.g. "SclSrf": Scalar data distributed on a Surface geometry

HFSS Field Calculator: Detail Layout-Stack

As data is entered into the calculator it appears at the ***TOP*** of the stack, pushing older entries ***DOWN***

UNDO attempts to take back the last operation between stack enties. It may not work for all data types (e.g. the result of a pure math operation cannot be reversed)

PUSH duplicates the top stack entry



CLEAR deletes ***ALL*** entries from the stack upon confirmation

POP deletes the top entry off the stack

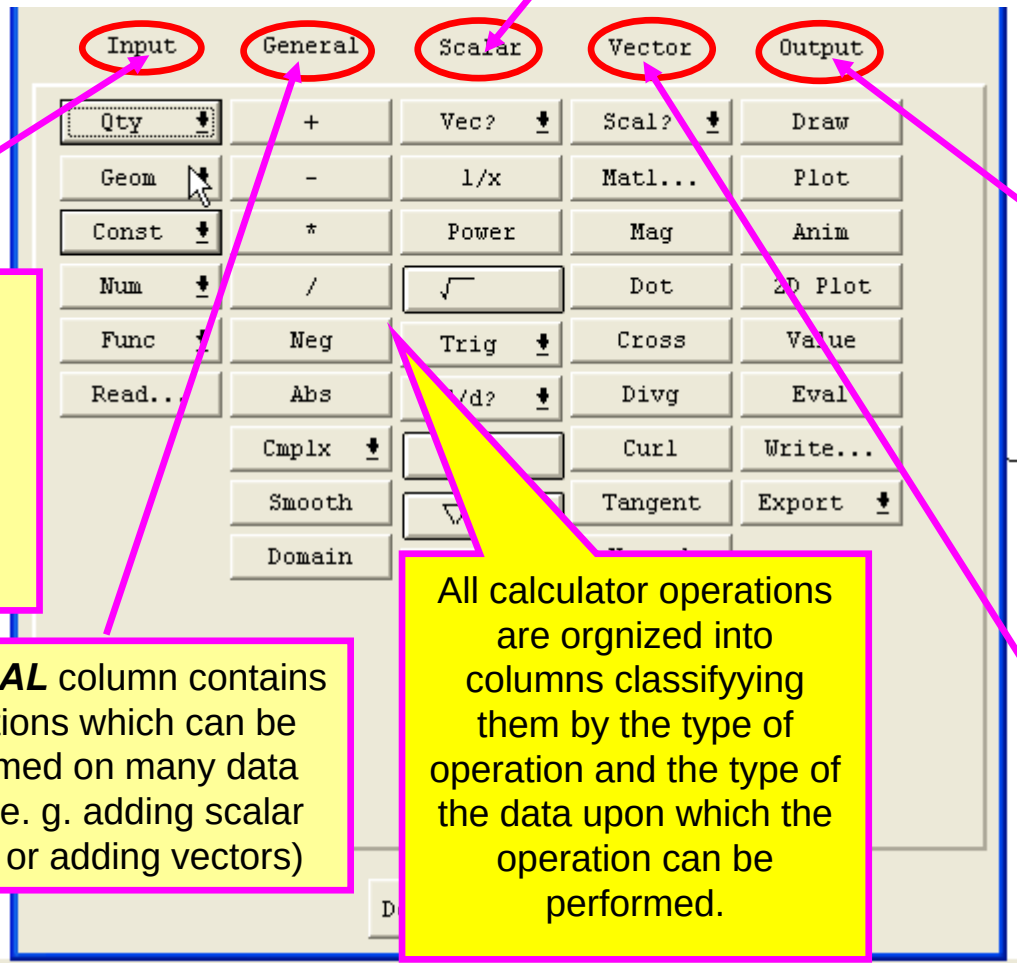
RLDN "rolls" the stack downward, moving the top entry to the bottom

RLUP "rolls" the stack upward, moving the bottom entry to the top

EXCH exchanges or swaps the top two stack entries

HFSS Field Calculator: Detail Layout-Operations

SCALAR column operations can only be performed on ***Scalar*** data (not complex or vector data), such as finding the ***Cosine*** of a value using the trig functions.



OUTPUT column operations result in the generation of calculator outputs, in either numerical, graphical (displayed as 2D graphs or in the 3Dview), or exported form.

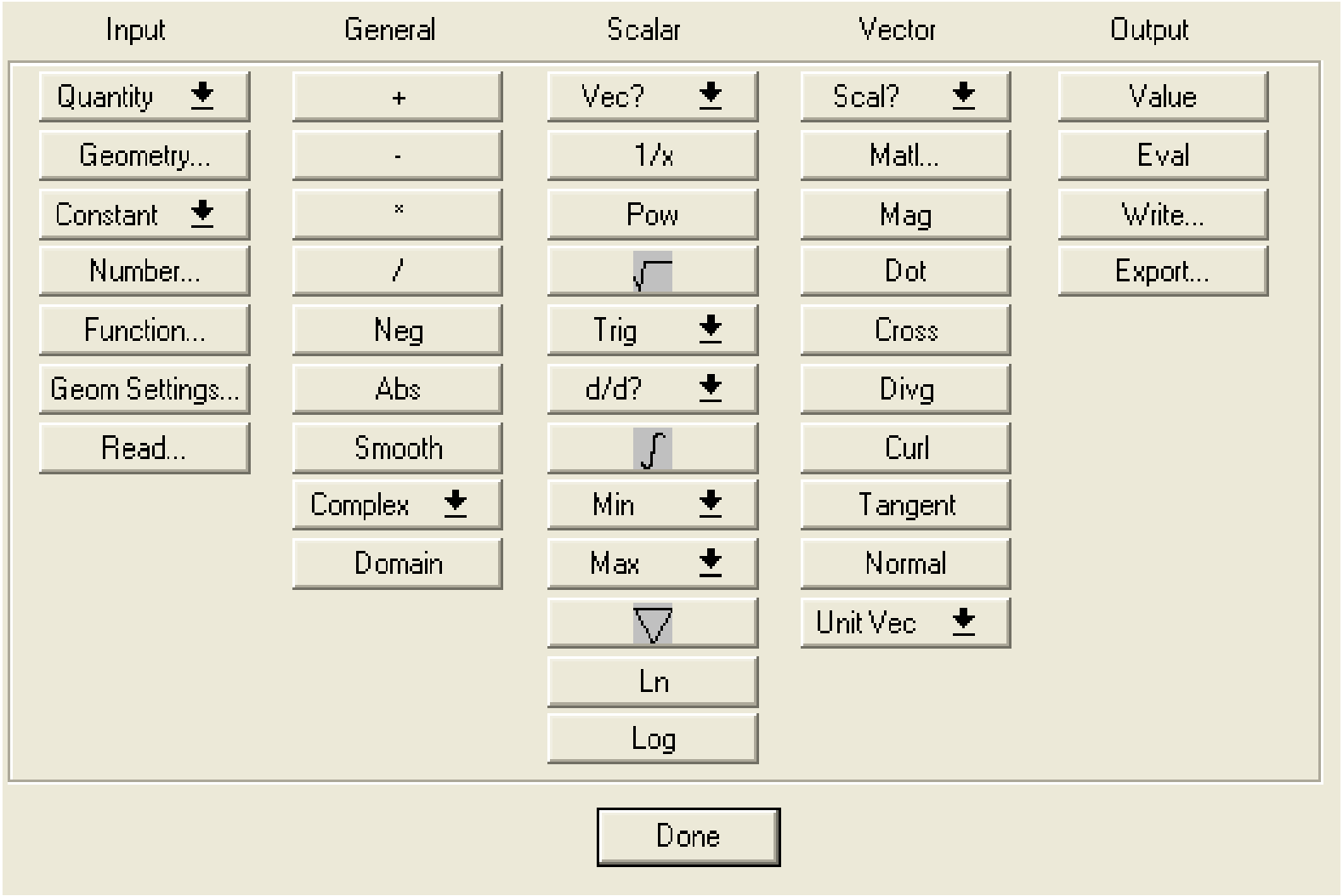
INPUT column contain all operations which input new data into the stack (field data, constant, user-entered vector or complex numbers, etc.

GENERAL column contains operations which can be performed on many data types (e. g. adding scalar values or adding vectors)

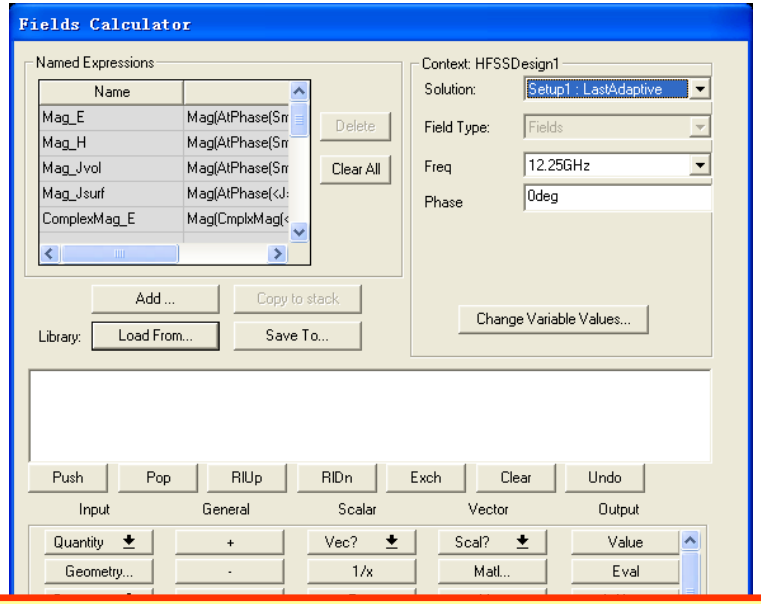
All calculator operations are orgnized into columns classifyying them by the type of operation and the type of the data upon which the operation can be performed.

VECTOR column contains operations to be performed on vector data such as converting to scalar, ***Dot*** and ***Cross*** products,and ***Unit Vector*** computations

HFSS Field Calculator: Detail Layout-Exploded View



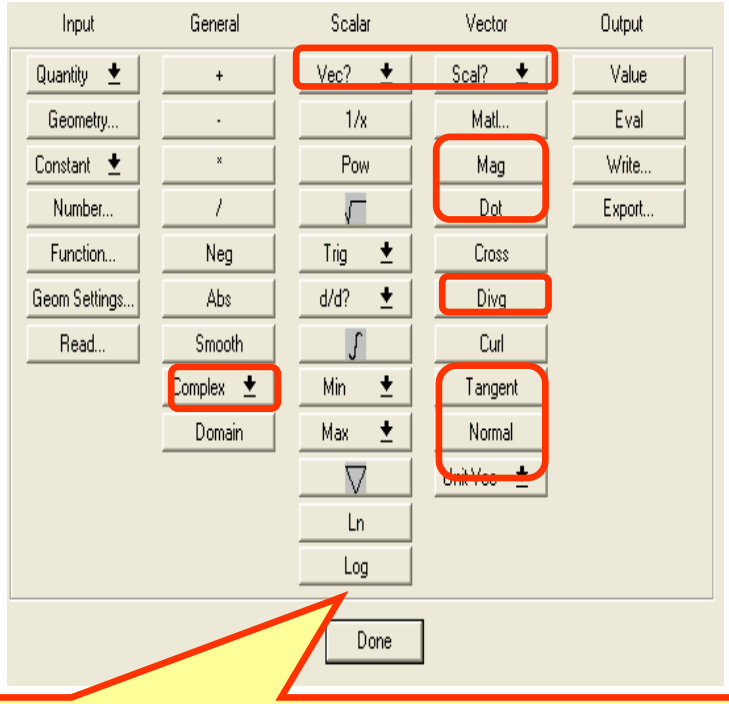
HFSS Field Calculator: Usage-Overview



Calculator Usage HINT: Any Time you use the field post –processor to plot a quantity (Plot→Fields), you are actually performing operations using the calculator!! To see the steps that went into the generating the plot you just created, open the calculator interface and view the stack contents. This can often help guide you as you try to use the calculator to created your own custom outputs.

- Use just like a scientific calculator
  - Similar to HP scientific calculators
    - "First Quantity", "Second Quantity" Then "Operation"
  - Remember stack fills from the ***Top*** and pushes older contents below.
- General use progresses from left to right
  - Input quantity or quantities at left
  - Perform operations in middle
    - Operate between quantities; apply quantities to geometries, etc.
  - Define desired output type at right.

HFSS Field Calculator: Usage-Changing Data Types



Always think of what type of data you are working with and whether or not it is compatible with your desired operation .For example, not the INTEGRAL sign is in the Scalar column, implying that to integrate complex numbers you will have to integrate the real and imaginary components separately, performing an integration by parts.

- As discussed previously, Many operations must be on the correct data type.
- Many operations result in a different data type than the inputs.
  - Ex1:The *Dot* product of two *Vector* is a *Scalar*.
  - Ex2:Obtaining the *Unit Vec*→*Normal* to a *Surf* Generates a *Vector*.
- Some calculator buttons exist primarily to assist in type conversion.
  - *Vec?* Converts *Scl* to *Vec* data
  - *Scal?* Does the reverse
  - *Cmplx*→*Real* or *Cmplx*→*Imag* takes a *Scl* component from a *CSc* or *CVc*.
  - *Cmplx*→*CmplxR* or *Cmplx*→*CmplxI* take a *Vec* or *Scl* component and make it the real or imaginary part of a complex value *CVc* or *CSc*, respectively.

HFSS Field Calculator: Usage-Input Types

E
H
Jsurf
Jvol
Poynting

E and ***H*** are Peak Phasor representation of the steady state fields. Therefore the current representation J derived from $n \times H$ or σE are also peak phasor quantities. The ***Poynting Vector*** input is a time-averaged quantity.

- The available field inputs are
  - ***E***: The complex vector E field data everywhere in the modeled geometry;
  - ***H***: The complex vector H field data everywhere in the modeled geometry;
  - ***Poynting***: The time-average Poynting vector computed from above as $(E \times H^*)$:
  - ***Jvol***: Current density in a volume, computed as $(\sigma + j\omega\varepsilon'')E$ which contain both conduction and displacement current ;
  - ***Jsurf***: Net surface current computed as $n \times (H|_{top\ tetrahedra} - H|_{bottom\ tetrahedra})$:
  - Unlike other quantities, ***Jsurf*** can only be output on an object surface geometry.

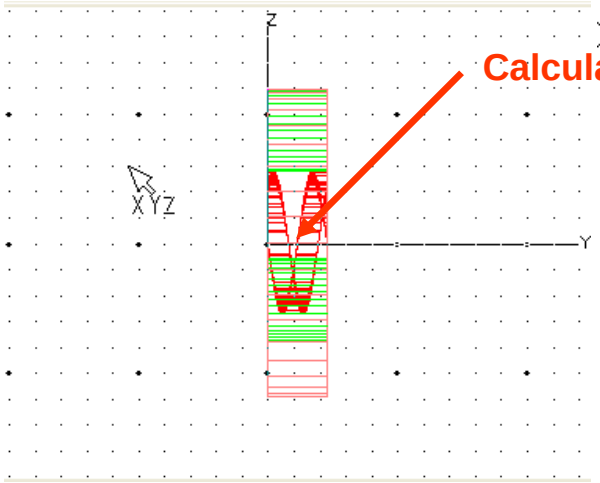
HFSS Field Calculator: Usage-Output Types

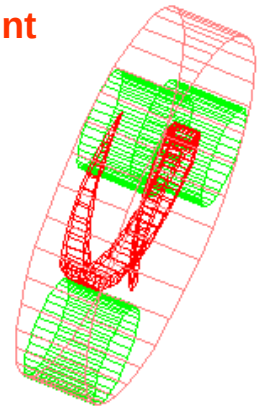
- Different data output can be generated depending on selected Output column button and stack content(s):
  - ***Value*** is used to take the “value” of a field stack entry on a specific geometry;
  - ***Eval*** turn stack placeholder text into final numerical answer;
  - ***Write*** and ***Export*** outputs stack data to output file formats for use outside the calculator or current project.

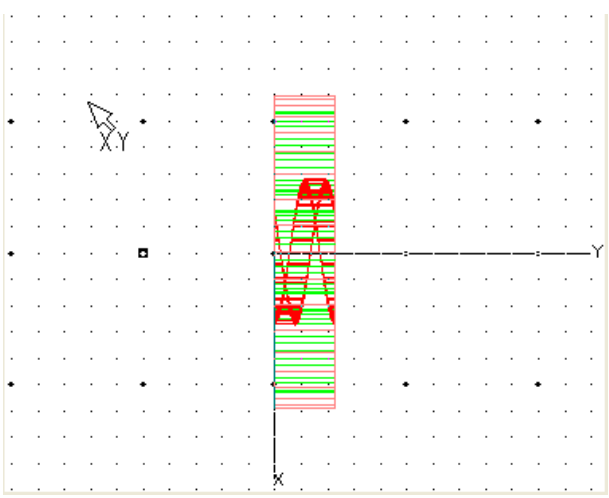
HFSS Field Calculator: Usage-Possible Operations

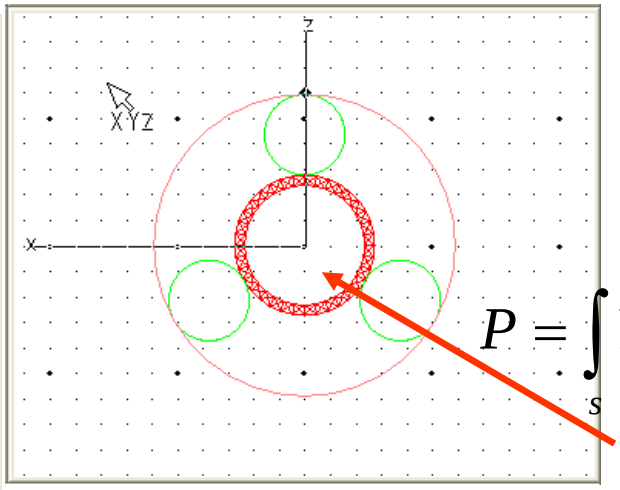
- As long as you can perform the math using the interface, there is ***no restriction*** on the possible calculator operations available:
  - Outputs derived can be other than "Electromagnetic" in nature;
    - Pure Geometric operations (vector and surface cross and dot products, generation of iso-surface contours from any scalar data field imported into the geometry, etc)
    - Thermal heating computations derived from field values combined with thermal mass characteristics and equations;
    - Integrations to obtain summary quantities such as Quanlity factors, power dissipation or flux,etc.

Post-Processor Exercise : Helix









Interaction Impedance:

$$K = \frac{|E_z|^2}{2\beta_z{}^2 P}$$

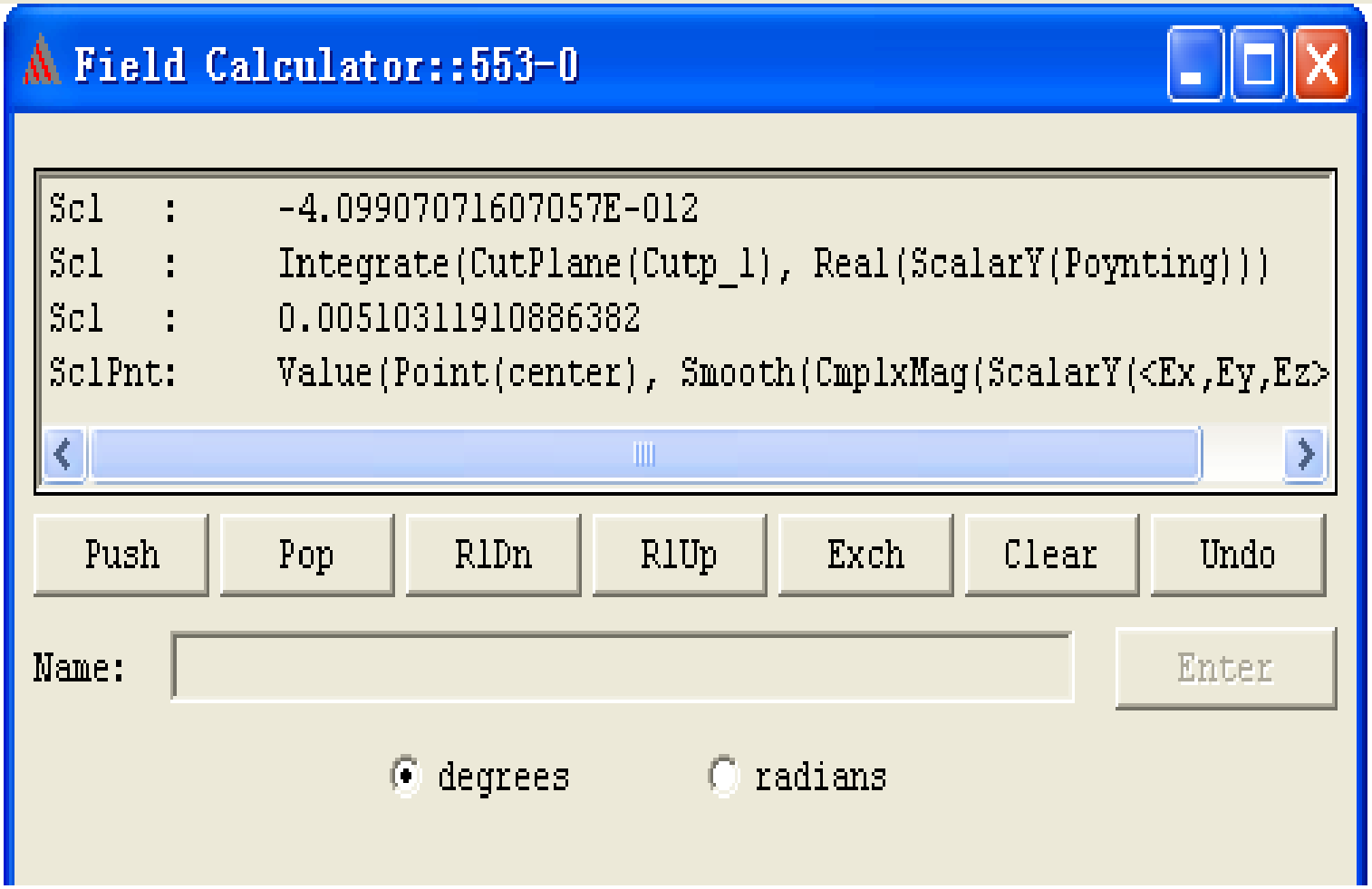
$$\phi = \beta_z L$$

$$\beta_Z = 2\pi / \lambda_g$$

$$\lambda_g = v_p / f$$

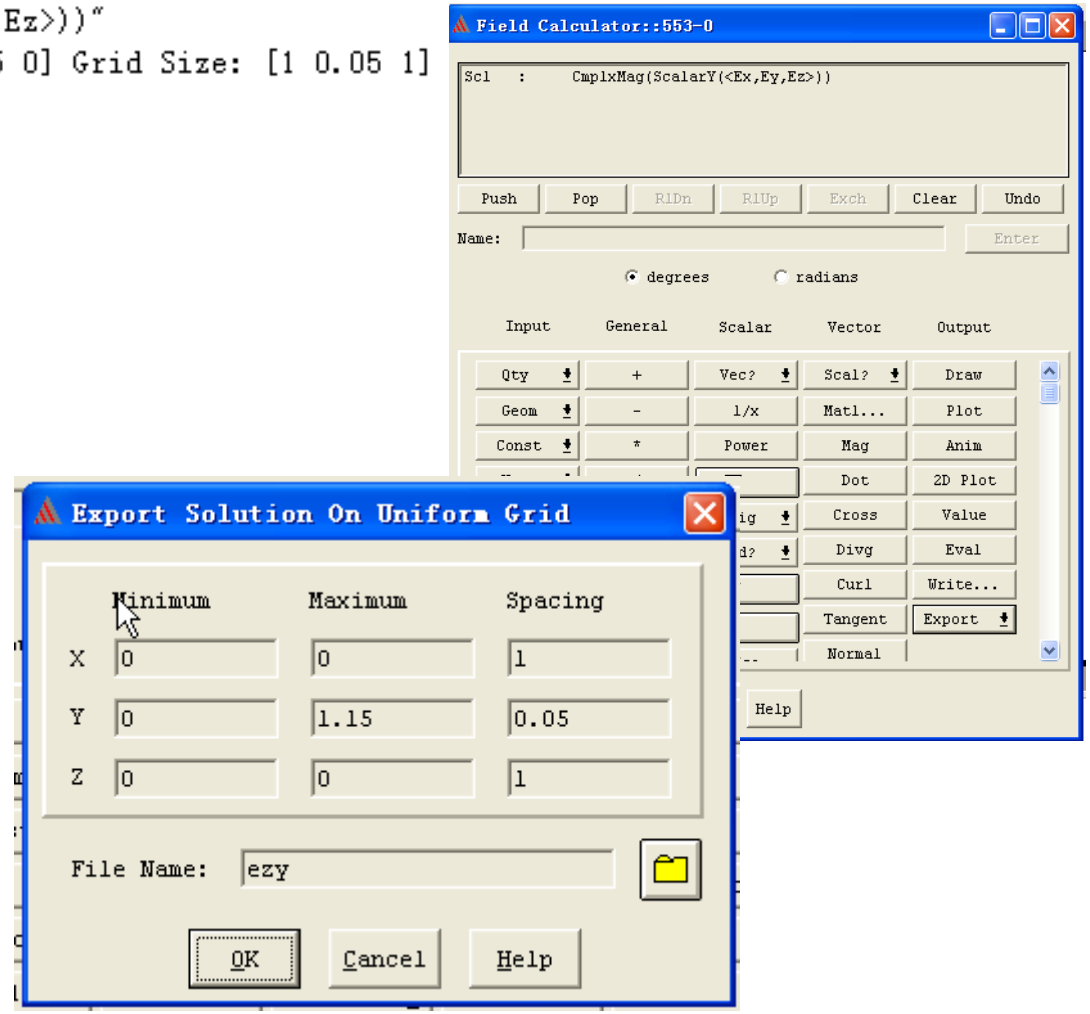
$$P = \int_s \mathrm{Re}\,al(Poynting|_y)ds$$

Single-Value Outputs



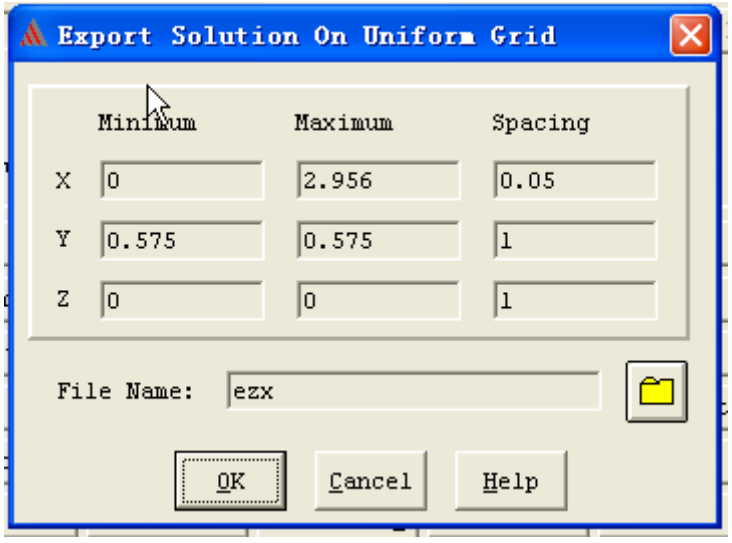
Export the field solution to a uniform grid

```
Scalar data "CmplxMag(ScalarY(<Ex,Ey,Ez>))"
Grid Output Min: [0 0 0] Max: [0 1.15 0] Grid Size: [1 0.05 1]
0 0 0          0.00513664750886491
0 0.05 0       0.00510774452057406
0 0.1 0        0.00512244432394645
0 0.15 0       0.00510610478962333
0 0.2 0        0.00510478946637589
0 0.25 0       0.00509992367429622
0 0.3 0        0.00511437310001486
0 0.35 0       0.00509609534486608
0 0.4 0        0.00510067582448828
0 0.45 0       0.00510350535610744
0 0.5 0        0.005106736393418
0 0.55 0       0.00511036893641995
0 0.6 0        0.00511335126933346
0 0.65 0       0.00510578515915208
0 0.7 0        0.00509909064783668
0 0.75 0       0.00510108352165014
0 0.8 0        0.00510852071425746
0 0.85 0       0.00511459391372891
0 0.9 0        0.00509093751842637
0 0.95 0       0.00510189930106718
0 1 0          0.00511536416226567
0 1.05 0       0.00509564255920793
0 1.1 0        0.00509069839674182
```



Export the field solution to a uniform grid

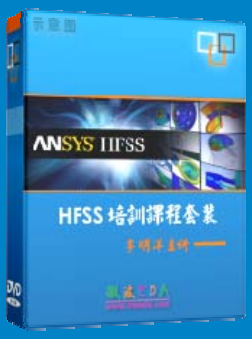
```
Scalar data "CmplxMag(ScalarY(<Ex,Ey,Ez>))"
Grid Output Min: [0 0.575 0] Max: [2.956 0.575 0] Grid Size: [0.05 1 1]
0 0.575 0       0.00511741852057388
0.05 0.575 0    0.00511252561204791
0.1 0.575 0     0.00511233926824336
0.15 0.575 0    0.00511143048449333
0.2 0.575 0     0.0051218063295534
0.25 0.575 0    0.00513190552846835
0.3 0.575 0     0.00514850715936431
0.35 0.575 0    0.00516945130712064
0.4 0.575 0     0.00519037159846748
0.45 0.575 0    0.0052117931650361
0.5 0.575 0     0.00524011755929773
0.55 0.575 0    0.00526935506822138
0.6 0.575 0     0.00531867936564101
0.65 0.575 0    0.00540434330254435
0.7 0.575 0     0.00553167980458839
0.75 0.575 0    0.00567312262326743
0.8 0.575 0     0.00624482109861772
0.85 0.575 0    0.00636260325256065
0.9 0.575 0     0.00677198490825187
0.95 0.575 0    0.00776059621801223
1 0.575 0       0.00991409675002645
1.05 0.575 0    0.0119580423012717
1.1 0.575 0     0.0130806786315589
1.15 0.575 0    0.014221019980028
1.2 0.575 0     0.01566510783893
1.25 0.575 0    0.0170570895504028
1.3 0.575 0     0.0189987201645405
1.35 0.575 0    0.0193564825825521
1.4 0.575 0     0.0166738973168224
1.45 0.575 0    0.0195776367480214
1.5 0.575 0     0.0111053293584035
1.55 0.575 0    0.00773357358764654
```




```
1.6 0.575 0     0.00487427390498961
1.65 0.575 0    0.00545895738989621
1.7 0.575 0     0.00502999910201662
1.75 0.575 0    0.00462492886739922
1.8 0.575 0     0.00424374668604402
1.85 0.575 0    0.00318425121026784
1.9 0.575 0     0.00298037805734178
1.95 0.575 0    0.00277648756339887
2 0.575 0       0.0025725797284391
2.05 0.575 0    0.00236865455246248
2.1 0.575 0     0.00213485307014358
2.15 0.575 0    0.00198060710379856
2.2 0.575 0     0.00184455226180707
2.25 0.575 0    0.00171226673937501
2.3 0.575 0     0.00158375053650239
2.35 0.575 0    0.0014590036531892
2.4 0.575 0     0.00133802608943544
2.45 0.575 0    0.00122081784524112
2.5 0.575 0     0.00112004836347342
2.55 0.575 0    0.00102663141227942
2.6 0.575 0     0.000942471295117462
2.65 0.575 0    0.000867568011987533
2.7 0.575 0     0.000583327537419671
2.75 0.575 0    0.000483967457383399
2.8 0.575 0     0.000366642143199432
2.85 0.575 0    0.000249225473068016
2.9 0.575 0     0.00013171744698915
2.95 0.575 0    1.41180649628328E-005
```

微波 EDA 网视频培训教程推荐

微波 EDA 网(www.mweda.com)成立于 2004 年底，并于翌年与易迪拓培训合并，专注于微波、射频和硬件工程师的培养，现已发展成为国内最大的微波射频和无线通信人才培养基地。先后与人民邮电出版社、电子工业出版社合作出版了多本专业图书，成功推出了多套微波射频经典培训课程和 ADS、HFSS 等软件的使用培训课程，广受工程技术学员的好评，帮助数万名工程师提升了专业技术能力。客户遍布中兴通讯、研通高频、埃威航电、国人通信等多家国内知名公司，以及台湾工业技术研究院、永业科技、全一电子等多家台湾地区企业。



HFSS 中文视频培训课程套装

国内最全面和专业的 HFSS 培训教程套装，包含 5 套视频教程和 2 本教材，李明洋老师讲解；结合最新工程案例，视频操作演示，让 HFSS 学习不再难。购买套装更可超值赠送 3 个月免费学习答疑，让您花最少的成本，以最快的速度自学掌握 HFSS… 【点击浏览详情】

两周学会 HFSS —— 中文视频教程

李明洋主讲，视频同步操作演示，直观易学。课程从零讲起，通过两周的课程学习，可以帮助您快速入门、自学掌握 HFSS，真正做到让 HFSS 学习不再难…【点击浏览详情】

HFSS 微波器件仿真分析实例 —— 中文视频教程

HFSS 进阶培训课程，中文视频，通过十个 HFSS 仿真设计工程应用实例，带您更深入学习 HFSS 的实际应用，掌握 HFSS 高级设置和应用技巧…【点击浏览详情】

HFSS 天线设计入门 —— 中文视频教程

HFSS 是天线设计的王者，该教程全面解析了天线的基础知识、HFSS 天线设计流程和详细操作设置，让 HFSS 天线设计不再难…【点击浏览详情】

PCB 天线设计和 HFSS 仿真分析实例 —— 中文视频教程

详细讲解了 PCB 天线的工作原理和设计方法、如何使用 HFSS 来设计分析 PCB 天线，以及如何借助于 Smith 圆图工作来调试天线的匹配电路，改善天线性能…【点击浏览详情】

了解详情，请查看微波 EDA 网（www.mweda.com/eda/hfss.html）

微波射频测量仪器培训课程套装合集

搞射频微波，不会仪器操作怎么行！矢量网络分析仪、频谱仪、示波器、信号源是微波射频工程师最常用的测量仪器。该培训套装集合了直观的视频培训教程和详尽的图书教材，旨在帮助您快速熟悉和精通矢网、频谱仪、示波器等仪器的操作…【点击浏览详情】

Agilent ADS 学习培训课程套装

国内最全面和权威的 ADS 培训教程，详细讲解了 ADS 在微波射频电路、通信系统和电磁仿真设计方面的应用。课程是由具有多年 ADS 使用经验的资深专家讲解，结合工程实例，直观易学；能让您在最短的时间内学会 ADS，并把 ADS 真正应用到研发工作中去… 【点击浏览详情】

我们的课程优势：

※ 成立于 2004 年，一直专注于射频工程师的培养，行业经验丰富，更了解您的需求

※ 视频课程、既能达到现场培训的效果，又能免除您舟车劳顿的辛苦，学习工作两不误

※ 经验丰富的一线资深专家主讲，结合实际工程案例，直观、实用、易学

※ 更多实用课程，欢迎登陆我们的官方网站 http://www.mweda.com，或者登陆我们的官方淘宝店 http://shop36920890.taobao.com/