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EEsoF MICAD and ACADEMY Macro Files for Coplanar Waveguide and Finite Ground Plane Coplanar Waveguide

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ABSTRACT

A collection of macro files is presented which when appended to either the EEsoF MICAD.ELE or EEsoF ACADEMY.ELE file permits the layout of coplanar waveguide and finite ground plane coplanar waveguide circuits.

INTRODUCTION

Coplanar waveguide (CPW) and finite ground plane coplanar waveguide (FGPCPW) transmission lines allow both series and shunt electric circuit elements to be easily incorporated into the circuit without via holes or wrap arounds. Compared to microstrip, CPW has lower radiation into both free space and the substrate. Therefore, coupling between CPW circuit elements is reduced which permits closer line spacing and smaller circuit sizes. In addition, the propagation constant and characteristic impedance of CPW is not strongly dependant on the substrate thickness. These advantages permit microwave and millimeter wave circuits to be fabricated at lower cost.

The major difficulty in using CPW has been the lack of circuit models and CAD layout tools. Therefore, most CPW circuit designers have generated their own CPW circuit models and incorporated them into existing CAD packages such as EEsoF Touchstone or Libra. In addition to circuit design, circuit layout is also possible using the EEsoF family of software packages. Within EEsoF MICAD and ACADEMY, two members of the EEsoF software family, there is the capability to create templates to describe CPW circuit elements. This is accomplished by writing macro files and incorporating them into the MICAD.ELE or the ACADEMY.ELE file. The macro files are mini-programs which describe the circuit element in Cartesian coordinates. Once the circuit elements have been incorporated into the MICAD.ELE or the ACADEMY.ELE file, they may be used to layout complex CPW integrated circuits.

An earlier paper [1] presented coplanar waveguide macro files which could be used in MICAD or ACADEMY. This paper expands on the earlier paper with the addition of more CPW macros and macros for FGPCPW. A diagram of each element, an example of how to incorporate the element into the EEsoF circuit file, and the macro program are presented.

USE OF MACRO PROGRAMS

The first choice the user must make is whether to use the CPW circuit elements or the FGPCPW circuit elements. Although a CPW and a FGPCPW macro has been written for each circuit element, the user cannot use a mix of CPW and FGPCPW in the circuit layout. For most circuit designs the ground plane width is finite, but infinite ground plane width CPW is a realistic representation of the transmission line since the ground planes are usually large compared to the strip

and slot width. FGPCPW has lower coupling between circuit elements than CPW and is therefore a good candidate for antenna feed networks.

An additional distinction between the two transmission lines has less to do with the circuit design but rather the circuit layout. The macros are designed to work on plotting tables so that rubylith masks can be made. Not all of the CPW macros will work with other mask making systems. This is because the CPW macros assume semi-infinite ground planes which are not closed surfaces. Therefore, the ground planes are defined as open surfaces in the macros. The circuit boundaries must be added after the layout and drawing has been generated. In addition, MICAD and ACADEMY demand that the element nodes be placed on closed polygon surfaces. For other transmission line types, this is not a problem, but for some CPW circuit elements such as the short circuit which terminate the closed surface center conductor onto the open surface ground plane, problems occur. For these structures, an unwanted line will be plotted or cut into the rubylith. If care is taken not to peel the rubylith at this unwanted cut, and a mask reduction is performed, the problems created by the additional line can usually be ignored.

The FGPCPW macros define the finite width ground planes as closed polygons. Therefore, no open surfaces exist and the layout is compatible with both plotting table generated masks as well as Calma or other mask generation formats. Unfortunately, unwanted lines are generated in the ground planes at the reference plane. Although this line has no effect when the layout is used to generate a Calma or other standard mask file, it will result in an extra cut in a rubylith mask. The disadvantage in using the FGPCPW macros is that the reference planes are not always placed at the normal location but may be shifted for some of the circuit elements to account for the ground planes. In all elements where this occurs, a note has been made describing how to determine the amount of reference plane shift. In most cases, the reference plane shift can be compensated for by other circuit elements and should not be a serious problem.

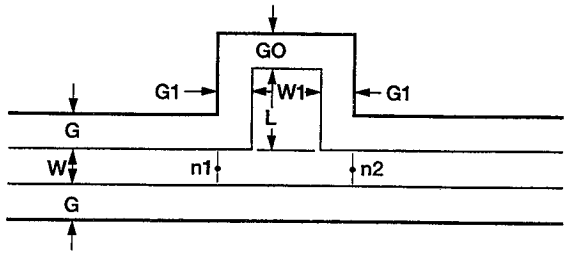
The macros defined in this paper must be appended to the MICAD.ELE or the ACADEMY.ELE file using a standard text editor with an ASCII save feature. Although not stated in the EEsoF manuals, there appears to be a maximum size limit to the MICAD.ELE and ACADEMY.ELE files. Therefore, if the program fails to run properly after appending the macros to the files, try commenting out unneeded macro elements.

REFERENCES

1. Ponchak, G. E. and Visic, Nikola, "Coplanar waveguide EEsoF MICAD macros make circuit layout easy," NASA Technical Memorandum 103272, Sept., 1990.

Coplanar Waveguide Asymmetric Open Ended Stub

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
GO=Open end width
L=Stub length

Syntax:

CASTBO n1 n2 W=x1 G=x2 W1=x3 G1=x4 GO=x5 L=x6

Example:

CASTBO 2 3 W=25 G=10 W1=20 G1=10 GO=10 L=50

Notes:

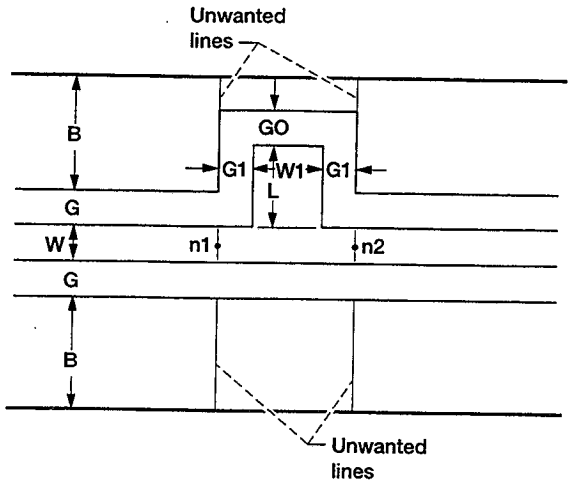
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
 defelem "CASTBO",2,"W","G","W1","G1","GO","L"
    dim OS5,OS6
    OS5=W1+2.0*G1
    OS6=W1+G1
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,OS5,-W/2.0
    node n2,OS5,0
    point 8,OS5,W/2.0
    point 8,OS6,W/2.0
    point 8,OS6,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 11,OS5,-(W/2.0+G)
    point 3,OS5,(W/2.0+G)
    point 8,OS5,(W/2.0+GO+L)
    point 8,0,(W/2.0+GO+L)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Asymmetric Open Ended Stub with finite ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
GO=Open end width
L=Stub length
B=Finite ground plane width

Syntax:

CASTBOB1 n1 n2 W=x1 G=x2 W1=x3 G1=x4 GO=x5 L=x6 B=x7

Example:

CASTBOB1 2 3 W=25 G=10 W1=20 G1=10 GO=10 L=50 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This open ended asymmetric stub assumes that the stub length is less than the finite ground plane width or (GO+L-G)<B (where B is the ground plane width of the element connecting to this element). If this is not true, use CASTBOB2 which gives a ground plane width to the stub also.

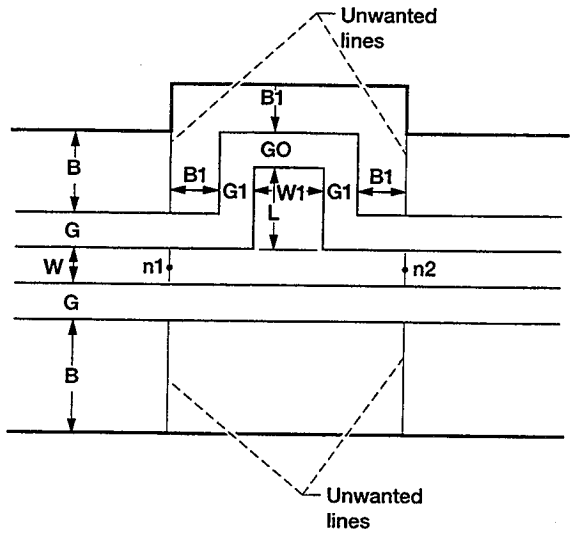
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CASTBOB1",2,"W","G","W1","G1","GO","L","B"
    dim OS5,OS6
    OS5=W1+2.0*G1
    OS6=W1+G1
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,OS5,-W/2.0
    node n2,OS5,0
    point 8,OS5,W/2.0
    point 8,OS6,W/2.0
    point 8,OS6,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,OS5,-(W/2.0+G+B)
    point 8,OS5,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,0,(W/2.0+GO+L)
    point 8,OS5,(W/2.0+GO+L)
    point 8,OS5,(W/2.0+G)
    point 8,OS5,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Asymmetric Open Ended Stub with finite ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
B=Finite ground plane width of connecting element
W1=Strip width of stub
G1=Slot width of stub
GO=Open end width
L=Stub length
B1=Finite ground plane width of the stub

Syntax:

CASTBOB2 n1 n2 W=x1 G=x2 B=x3 W1=x4 G1=x5 GO=x6 L=x7 B1=x8

Example:

CASTBOB2 2 3 W=25 G=10 B=100 W1=20 G1=10 GO=10 L=150 B1=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element shifts the reference plane at nodes 1 and 2 by B1 compared to the reference plane location used in CASTBO and CASTBOB1. Since this is generally not desirable, the circuit must account for this additional 2*B1 in extra line length.

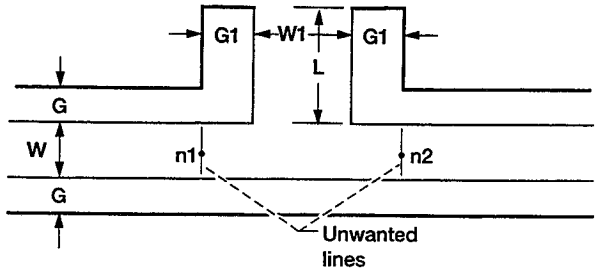
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CASTBOB2",2,"W","G","B","W1","G1","GO","L","B1"
    dim OS5,OS6,OS7
    OS5=W1+2.0*G1+B1
    OS6=W1+G1+B1
    OS7=W1+2.0*G1+2.0*B1
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,OS7,-W/2.0
    node n2,OS7,0
    point 8,OS7,W/2.0
    point 8,OS6,W/2.0
    point 8,OS6,(W/2.0+L)
    point 8,(B1+G1),(W/2.0+L)
    point 8,(B1+G1),W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,OS7,-(W/2.0+G+B)
    point 8,OS7,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,B1,(W/2.0+G)
    point 8,B1,(W/2.0+GO+L)
    point 8,OS5,(W/2.0+GO+L)
    point 8,OS5,(W/2.0+G)
    point 8,OS7,(W/2.0+G)
    point 8,OS7,(W/2.0+L+GO+B1)
    point 8,0,(W/2.0+L+GO+B1)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Asymmetric Short Circuit Terminated Stub

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
L=Stub length

Syntax:

CASTBS n1 n2 W=x1 G=x2 W1=x3 G1=x4 L=x5

Example:

CASTBS 2 3 W=25 G=10 W1=16 G1=8 L=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

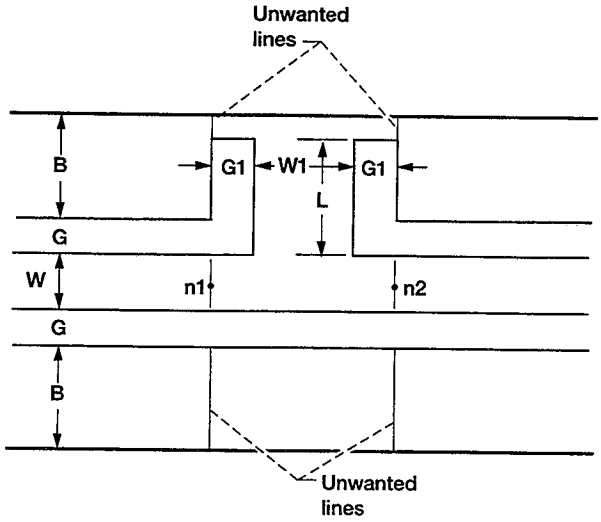
2. This macro will draw two unwanted lines at the nodes. If care is taken not to lift the rubylith mask at these lines and a mask reduction is performed, then these lines should not effect the final mask.

```
defelem "CASTBS",2,"W","G","W1","G1","L"
    dim X
    level lmet1
    X=2.0*G1+W1
    point 4,0,W/2.0
    node n1,0,0
    point 12,0,-W/2.0
    point 4,X,-W/2.0
    node n2,X,0
    point 12,X,W/2.0
    point 3,0,(W/2.0+G)
    point 8,0,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 8,0,W/2.0
    point 8,0,-W/2.0
    point 8,X,-W/2.0
    point 8,X,W/2.0
    point 8,(G1+W1),W/2.0
    point 8,(G1+W1),(W/2.0+L)
    point 8,X,(W/2.0+L)
    point 11,X,(W/2.0+G)
    point 3,0,-(W/2.0+G)
    point 11,X,-(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Asymmetric Short Circuit Terminated Stub with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
L=Stub length
B=Finite ground plane width

Syntax:

CASTBSB1 n1 n2 W=x1 G=x2 W1=x3 G1=x4 L=x5 B=x6

Example:

CASTBSB1 2 3 W=25 G=10 W1=16 G1=8 L=50 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to verify that (L-G)<B (where B is the ground plane width of the element connecting to this element). If (L-G)>B, then use CASTBSB2 which gives a ground plane width to the stub also.

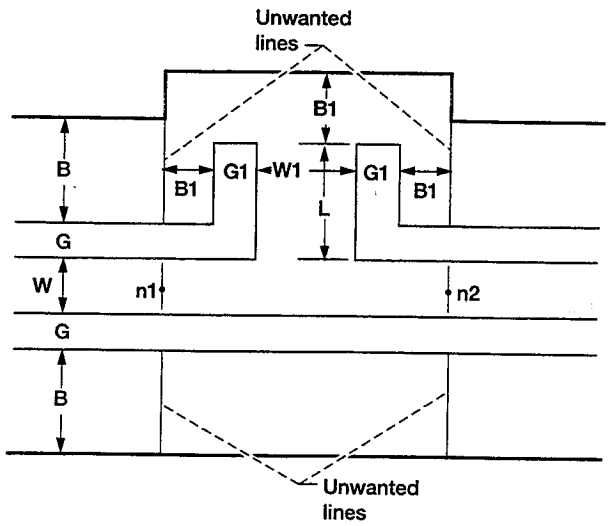
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CASTBSB1",2,"W","G","W1","G1","L","B"
    dim X
    level lmet1
    X=2.0*G1+W1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,X,-W/2.0
    node n2,X,0
    point 8,X,W/2.0
    point 8,(G1+W1),W/2.0
    point 8,(G1+W1),(W/2.0+L)
    point 8,X,(W/2.0+L)
    point 8,X,(W/2.0+G)
    point 8,X,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 8,0,(W/2.0+G)
    point 8,0,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,X,-(W/2.0+G+B)
    point 8,X,-(W/2.0+G)
   point 12,0,-(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Asymmetric Short Circuit Terminated Stub with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
B=Finite ground plane width of connecting element
W1=Strip width of stub
G1=Slot width of stub
L=Stub length
B1=Finite ground plane width of the stub

Syntax:

CASTBSB2 n1 n2 W=x1 G=x2 B=x3 W1=x4 G1=x5 L=x6 B1=x7

Example:

CASTBSB2 2 3 W=25 G=10 B=100 W1=16 G1=8 L=150 B1=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element shifts the reference plane at nodes 1 and 2 by B1 compared to the reference plane location used in CASTBS and CASTBSB1. Since this is generally not desirable, the circuit must account for this additional 2*B1 in extra line length.

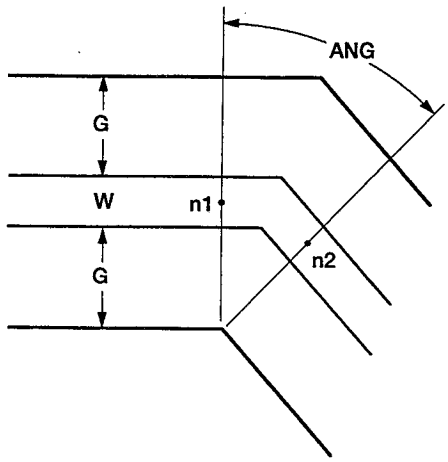
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CASTBSB2",2,"W","G","B","W1","G1","L","B1"
    dim X
    level lmet1
    X=2.0*G1+W1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,(X+2.0*B1),-W/2.0
    node n2,(X+2.0*B1),0
    point 8,(X+2.0*B1),W/2.0
    point 8,(G1+W1+B1),W/2.0
    point 8,(G1+W1+B1),(W/2.0+L)
    point 8,(X+B1),(W/2.0+L)
    point 8,(X+B1),(W/2.0+G)
    point 8,(X+2.0*B1),(W/2.0+G)
    point 8,(X+2.0*B1),(W/2.0+L+B1)
    point 8,0,(W/2.0+L+B1)
    point 8,0,(W/2.0+G)
    point 8,B1,(W/2.0+G)
    point 8,B1,(W/2.0+L)
    point 8,(B1+G1),(W/2.0+L)
    point 8,(B1+G1),W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,(X+2.0*B1),-(W/2.0+G+B)
    point 8,(X+2.0*B1),-(W/2.0+G)
    point 12,0,-(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Bend

Physical layout:



Data:

W=Strip width
G=Slot width
ANG=Angle of bend in degree

Syntax:

CBEND n1 n2 W=x1 G=x2 ANG=x3

Example:

CBEND 2 3 W=25 G=10 ANG=40

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

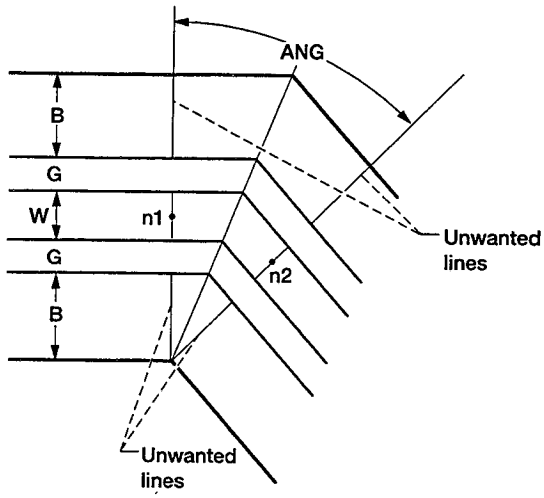
2. The program is valid for $0 \leq ANG \leq 180$ degree.

```
defelem "CBEND",2,"W","G","ANG"
    dim ANGRAD,TN,CS,SN
    ANGRAD=ANGUNIT*ANG
    TN=TAN(ANGRAD/2.0)
    CS=COS(ANGRAD)
    SN=SIN(ANGRAD)
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,(G*TN),-W/2.0
    point 8,(G*SN),(-(W/2.0+G)+G*CS)
    node n2,((W/2.0+G)*SN),(-(W/2.0+G)+(W/2.0+G)*CS)
    point 8,((W+G)*SN),(-(W/2.0+G)+(W+G)*CS)
    point 8,((W+G)*TN),W/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 11,0,-(W/2.0+G)
    point 3,0,(W/2.0+G)
    point 8,((W+2.0*G)*TN),(W/2.0+G)
    point 11,((W+2.0*G)*SN),(-(W/2.0+G)+(W+2.0*G)*CS)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Bend with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
ANG=Angle of bend in degree
B=Finite ground plane width

Syntax:

CBENDB n1 n2 W=x1 G=x2 ANG=x3 B=x4

Example:

CBENDB 2 3 W=25 G=10 ANG=40 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program is valid for $0 \leq ANG \leq 180$ degree.

3. The physical length of this element is 2(G+B+W/2.0)*tan(ANG/2.0). This path length is 2*B*tan(ANG/2.0) longer than if the reference planes had been placed where they are in CBEND.

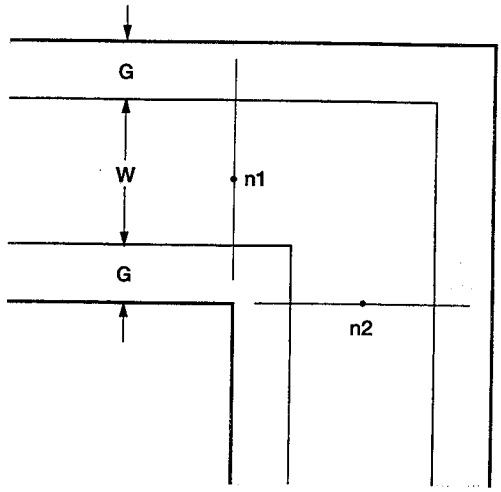
4. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CBENDB",2,"W","G","ANG","B"
    dim ANGRAD,TN,CS,SN,Q
    ANGRAD=ANGUNIT*ANG
    TN=TAN(ANGRAD/2.0)
    CS=COS(ANGRAD)
    SN=SIN(ANGRAD)
    Q=W/2.0+G+B
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,((B+G)*TN),-W/2.0
    point 8,(SN*(B+G)),(-Q+(B+G)*CS)
    node n2,(SN*Q),(Q*(CS-1))
    point 8,(SN*(B+G+W)),(-Q+(B+G+W)*CS)
    point 8,((B+G+W)*TN),W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-Q
    point 8,(B*SN),(-Q+B*CS)
    point 8,(B*TN),-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,Q
    point 8,0,(W/2.0+G)
    point 8,((B+2.0*G+W)*TN),(W/2.0+G)
    point 8,(SN*(B+2.0*G+W)),(-Q+(B+2.0*G+W)*CS)
    point 8,(SN*(2.0*B+2.0*G+W)),(-Q+(2.0*B+2.0*G+W)*CS)
    point 8,((2.0*B+2.0*G+W)*TN),Q
    point 12,0,Q
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Corner

Physical layout:



Data:

W=Strip width
G=Slot width

Syntax:

CCORN n1 n2 W=x1 G=x2

Example:

CCORN 2 3 W=25 G=10

Notes:

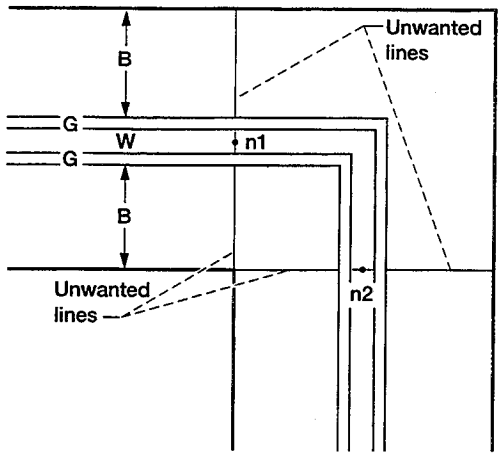
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
defelem "CCORN",2,"W","G"
    level lmet1
    point 4,0,W/2
    node n1,0,0
    point 8,0,-W/2
    point 8,G,-W/2
    point 8,G,-(W/2+G)
    node n2,(G+W/2.0),-(W/2+G)
    point 8,(G+W),-(W/2+G)
    point 8,(G+W),W/2.0
    point 12,0,W/2.0
    point 3,(W+2.0*G),-(W/2+G)
    point 8,(W+2.0*G),(W/2.0+G)
    point 11,0,(W/2.0+G)
    point 3,0,-(W/2.0+G)
    point 11,0,-(W/2.0+G)
end define
```

Program written by Nikola Visic

Coplanar Waveguide Corner
with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
B=Finite ground plane width

Syntax:

CCORNB n1 n2 W=x1 G=x2 B=x3

Example:

CCORNB 2 3 W=25 G=10 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element shifts the reference planes by B at nodes 1 and 2 compared to the reference plane location given for CCORN. Since this is generally not desirable, the extra 2*B in path length must be compensated for elsewhere in the circuit.

3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

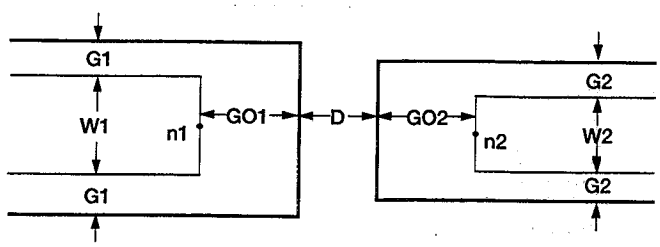
```
defelem "CCORNB",2,"W","G","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,(B+G),-W/2.0
    point 8,(B+G),-(W/2.0+G+B)
    node n2,(B+G+W/2.0),-(W/2.0+G+B)
    point 8,(B+G+W),-(W/2.0+G+B)
    point 8,(B+G+W),W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,B,-(W/2.0+G+B)
    point 8,B,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G+B)
    point 8,0,(W/2.0+G)
    point 8,(B+W+2*G),(W/2.0+G)
    point 8,(B+W+2*G),-(W/2.0+G+B)
    point 8,(2*B+W+2*G),-(W/2.0+G+B)
    point 8,(2*B+W+2*G),(W/2.0+G+B)
    point 12,0,(W/2.0+G+B)
end define
```

Program written by George E. Ponchak

CCP CCP

Coplanar Waveguide Connection Point

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
GO1=Open end length at node 1
D=Connection point length
W2=Strip width at node 2
G2=Slot width at node 2
GO2=Open end length at node 2

Syntax:

CCP n1 n2 W1=x1 G1=x2 GO1=x3 D=x4 W2=x5 G2=x6 GO2=x7

Example:

CCP 2 3 W1=25 G1=10 GO1=10 D=50 W2=20 G2=8 GO2=10

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element is useful for integrating circuit elements which require a ground connection such as transistors or microstrip based integrated circuits.

```
defelem "CCP",2,"W1","G1","GO1","D","W2","G2","GO2"
    level lmet1
    point 4,0,W1/2.0
    node n1,0,0
    point 12,0,-W1/2.0
    point 3,0,(W1/2.0+G1)
    point 8,GO1,(W1/2.0+G1)
    point 8,GO1,-(W1/2.0+G1)
    point 11,0,-(W1/2.0+G1)
    point 4,(GO1+D+GO2),-W2/2.0
    node n2,(GO1+D+GO2),0
    point 12,(GO1+D+GO2),W2/2.0
    point 3,(GO1+D+GO2),(W2/2.0+G2)
    point 8,(GO1+D),(W2/2.0+G2)
    point 8,(GO1+D),-(W2/2.0+G2)
    point 11,(GO1+D+GO2),-(W2/2.0+G2)
end define
```

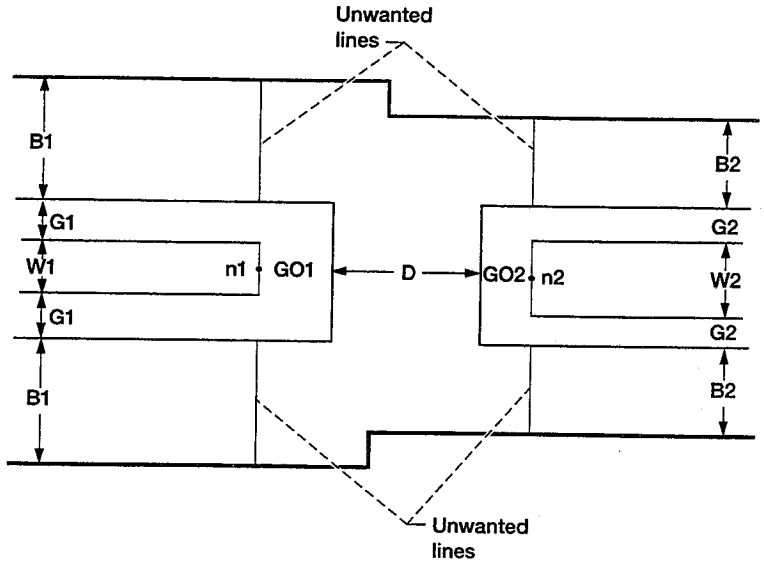
Program written by Nikola Visic

CCPB

CCPB

Coplanar Waveguide Connection Point with finite width ground plane

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
GO1=Open end length at node 1
B1=Finite ground plane width at node 1
D=Connection point length
W2=Strip width at node 2
G2=Slot width at node 2
GO2=Open end length at node 2
B2=Finite ground plane width at node 2

Syntax:

CCPB n1 n2 W1=x1 G1=x2 GO1=x3 B1=x4 D=x5 W2=x6 G2=x7 GO2=x8 B2=x9

Example:

CCPB 2 3 W1=25 G1=10 GO1=10 B1=100 D=50 W2=20 G2=8 GO2=10 B2=175

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element is useful for integrating circuit elements which require a ground connection such as transistors or microstrip based integrated circuits.

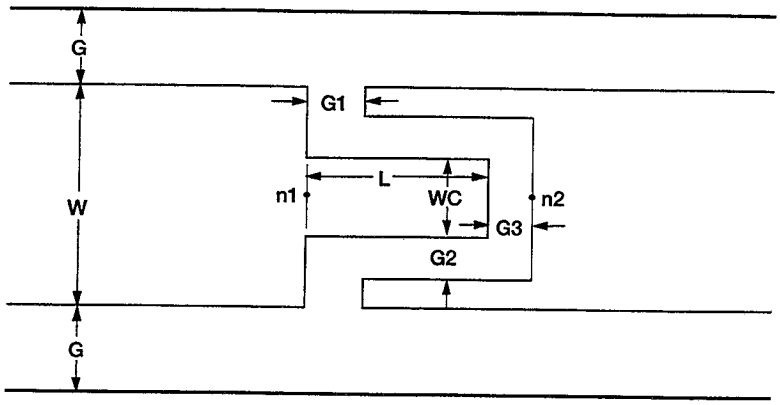
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CCPB",2,"W1","G1","GO1","B1","D","W2","G2","GO2","B2"
    level lmet1
    point 4,0,W1/2.0
    node n1,0,0
    point 12,0,-W1/2.0
    point 4,0,(W1/2.0+G1)
    point 8,GO1,(W1/2.0+G1)
    point 8,GO1,-(W1/2.0+G1)
    point 8,0,-(W1/2.0+G1)
    point 8,0,-(W1/2.0+G1+B1)
    point 8,(GO1+D/2.0),-(W1/2.0+G1+B1)
    point 8,(GO1+D/2.0),-(W2/2.0+G2+B2)
    point 8,(GO1+D+GO2),-(W2/2.0+G2+B2)
    point 8,(GO1+D+GO2),-(W2/2.0+G2)
    point 8,(GO1+D),-(W2/2.0+G2)
    point 8,(GO1+D),(W2/2.0+G2)
    point 8,(GO1+D+GO2),(W2/2.0+G2)
    point 8,(GO1+D+GO2),(W2/2.0+G2+B2)
    point 8,(GO1+D/2.0),(W2/2.0+G2+B2)
    point 8,(GO1+D/2.0),(W1/2.0+G1+B1)
    point 8,0,(W1/2.0+G1+B1)
    point 12,0,(W1/2.0+G1)
    point 4,(GO1+D+GO2),-W2/2.0
    node n2,(GO1+D+GO2),0
    point 12,(GO1+D+GO2),W2/2.0
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Interdigital Coupler

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Slot width in coupler
G2=Slot width in coupler
G3=Slot width in coupler
WC=Center conductor width in the coupler region
L=Length of the center conductor in the coupler region

Syntax:

CCPLR n1 n2 W=x1 G=x2 G1=x3 G2=x4 G3=x5 WC=x6 L=x7

Example:

CCPLR 2 3 W=25 G=10 G1=10 G2=5 G3=5 WC=8 L=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to check that (2*G2+WC)<W.

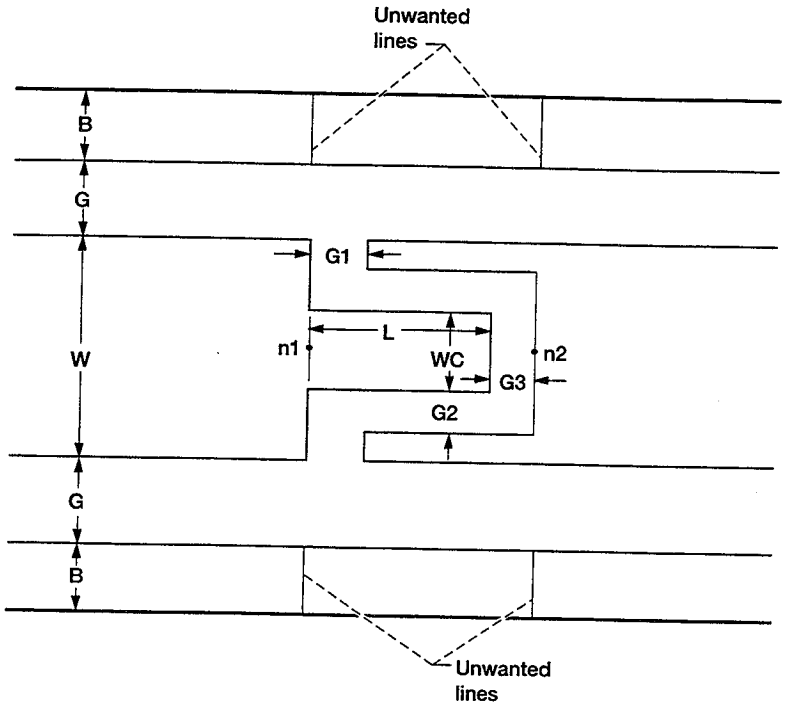
```
defelem "CCPLR",2,"W","G","G1","G2","G3","WC","L"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,0,-WC/2.0
    point 8,L,-WC/2.0
    point 8,L,WC/2.0
    point 8,0,WC/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 11,(L+G3),-(W/2.0+G)
    point 4,(L+G3),-W/2.0
    node n2,(L+G3),0
    point 8,(L+G3),W/2.0
    point 8,G1,W/2.0
    point 8,G1,(WC/2.0+G2)
    point 8,(L+G3),(WC/2.0+G2)
    point 8,(L+G3),-(WC/2.0+G2)
    point 8,G1,-(WC/2.0+G2)
    point 8,G1,-W/2.0
    point 12,(L+G3),-W/2.0
    point 3,(L+G3),(W/2.0+G)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

CCPLRB

Coplanar Waveguide Interdigital Coupler with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Slot width of coupler
G2=Slot width of coupler
G3=Slot width of coupler
WC=Center conductor width in the coupler region
L=Length of the center conductor in the coupler region
B=Finite ground plane width

Syntax:

CCPLRB n1 n2 W=x1 G=x2 G1=x3 G2=x4 G3=x5 WC=x6 L=x7 B=x8

Example:

CCPLRB 2 3 W=25 G=10 G1=10 G2=5 G3=5 WC=8 L=150 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to check that (2*G2+WC)<W.

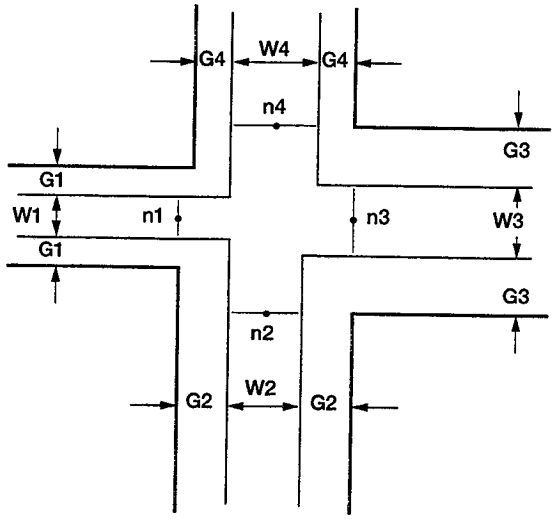
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CCPLRB",2,"W","G","G1","G2","G3","WC","L","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,0,-WC/2.0
    point 8,L,-WC/2.0
    point 8,L,WC/2.0
    point 8,0,WC/2.0
    point 12,0,W/2.0
    point 4,(L+G3),-W/2.0
    node n2,(L+G3),0
    point 8,(L+G3),W/2.0
    point 8,G1,W/2.0
    point 8,G1,(WC/2.0+G2)
    point 8,(L+G3),(WC/2.0+G2)
    point 8,(L+G3),-(WC/2.0+G2)
    point 8,G1,-(WC/2.0+G2)
    point 8,G1,-W/2.0
    point 12,(L+G3),-W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,(L+G3),-(W/2.0+G+B)
    point 8,(L+G3),-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,(L+G3),(W/2.0+G)
    point 8,(L+G3),(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Cross Junction

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
W3=Strip width at node 3
G3=Slot width at node 3
W4=Strip width at node 4
G4=Slot width at node 4

Syntax:

CCROSS n1 n2 n3 n4 W1=x1 G1=x2 W2=x3 G2=x4 W3=x5 G3=x6 W4=x7 G4=x8

Example:

CCROSS 2 3 4 5 W1=25 G1=10 W2=10 G2=10 W3=10 G3=10 W4=50 G4=25

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

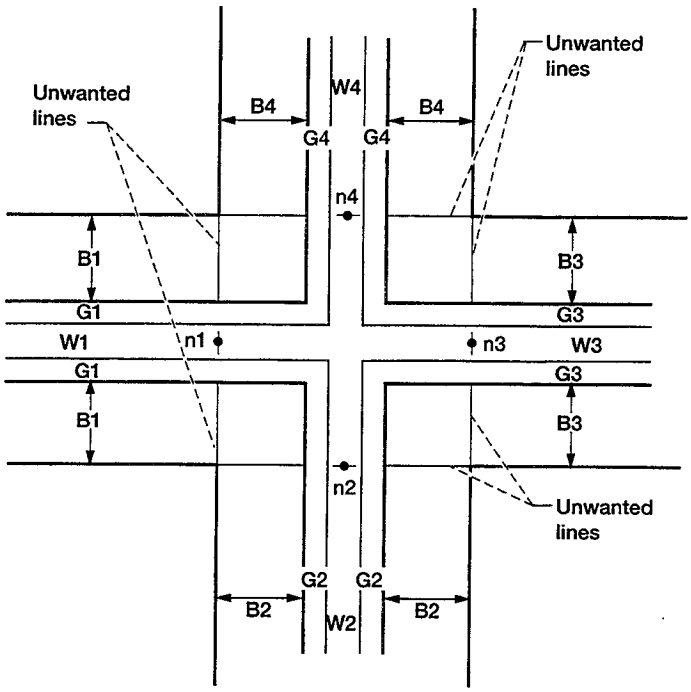
2. The element aligns nodes 1 and 3 and nodes 2 and 4.

```
defelem "CCROSS",4,"W1","G1","W2","G2","W3","G3","W4","G4"
   dim C1,C2,C3,C4,A,B
   level lmet1
   C1=G1+W1/2.0
   C2=G2+W2/2.0
   C3=G3+W3/2.0
   C4=G4+W4/2.0
   if C2>C4 then
   A=C2
   else
   A=C4
   end if
   if C1>C3 then
   B=C1
   else
   B=C3
   end if
   point 4,0,W1/2.0
   node n1,0,0
   point 8,0,-W1/2.0
   point 8,(A-W2/2.0),-W1/2.0
   point 8,(A-W2/2.0),-B
   node n2,A,-B
   point 8,(A+W2/2.0),-B
   point 8,(A+W2/2.0),-W3/2.0
   point 8,(2.0*A),-W3/2.0
   node n3,(2.0*A),0
   point 8,(2.0*A),W3/2.0
   point 8,(A+W4/2.0),W3/2.0
   point 8,(A+W4/2.0),B
   node n4,A,B
   point 8,(A-W4/2.0),B
   point 8,(A-W4/2.0),W1/2.0
   point 12,0,W1/2.0
   point 3,0,-C1
   point 8,(A-C2),-C1
   point 11,(A-C2),-B
   point 3,(A+C2),-B
   point 8,(A+C2),-C3
   point 11,2.0*A,-C3
   point 3,2.0*A,C3
   point 8,(A+C4),C3
   point 11,(A+C4),B
   point 3,(A-C4),B
   point 8,(A-C4),C1
   point 11,0,C1
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Cross Junction with finite width ground plane

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
B1=Finite ground plane width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
B2=Finite ground plane width at node 2
W3=Strip width at node 3
G3=Slot width at node 3
B3=Finite ground plane width at node 3
W4=Strip width at node 4
G4=Slot width at node 4
B4=Finite ground plane width at node 4

Syntax:

CCROSSB n1 n2 n3 n4 W1=x1 G1=x2 B1=x3 W2=x4 G2=x5 B2=x6 W3=x7 G3=x8 B3=x9 W4=x10 G4=x11 B4=x12

Example:

CCROSSB 2 3 4 5 W1=25 G1=10 B1=100 W2=10 G2=10 B2=175 W3=10 G3=10 B3=150 W4=50 G4=25 B4=225

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The element aligns nodes 1 and 3 and nodes 2 and 4.

3. This element shifts the reference planes compared to the element CCROSS. The excess path lengths which must be accounted for are:
node 1 and 3: The greater of (B4+G4+W4/2.0) and (B2+G2+W2/2.0) minus the greater of (G4+W4/2.0) and (G2+W2/2.0).
node 2 and 4: The greater of (B1+G1+W1/2.0) and (B3+G3+W3/2.0) minus the greater of (G1+W1/2.0) and (G3+W3/2.0).

4. There are an extra set of lines generated in the ground planes at the reference plane of the element.

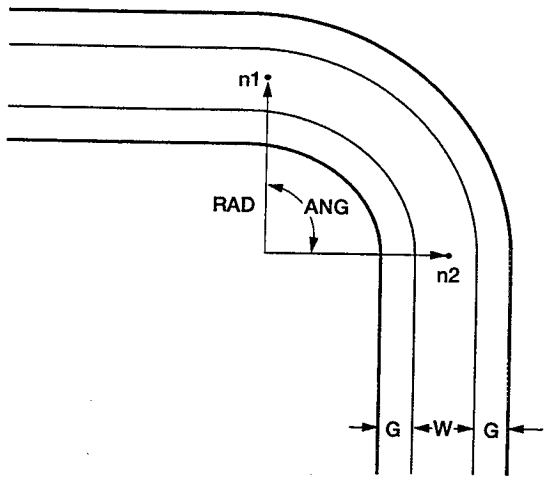
```
defelem "CCROSSB",4,"W1","G1","B1","W2","G2","B2","W3","G3","B3","W4","G4","B4"
   dim C1,C2,C3,C4,A,B
   level lmet1
   C1=B1+G1+W1/2.0
   C2=B2+G2+W2/2.0
   C3=B3+G3+W3/2.0
   C4=B4+G4+W4/2.0
   if C2>C4 then
   A=C2
   else
   A=C4
   end if
   if C1>C3 then
   B=C1
   else
   B=C3
   end if
   point 4,0,W1/2.0
   node n1,0,0
   point 8,0,-W1/2.0
   point 8,(A-W2/2.0),-W1/2.0
   point 8,(A-W2/2.0),-B
   node n2,A,-B
   point 8,(A+W2/2.0),-B
   point 8,(A+W2/2.0),-W3/2.0
   point 8,(2.0*A),-W3/2.0
   node n3,(2.0*A),0
   point 8,(2.0*A),W3/2.0
   point 8,(A+W4/2.0),W3/2.0
   point 8,(A+W4/2.0),B
   node n4,A,B
   point 8,(A-W4/2.0),B
   point 8,(A-W4/2.0),W1/2.0
   point 12,0,W1/2.0
   point 4,0,-C1
   point 8,(A-C2),-C1
   point 8,(A-C2),-B
   point 8,(A-W2/2.0-G2),-B
   point 8,(A-W2/2.0-G2),-(W1/2.0+G1)
   point 8,0,-(W1/2.0+G1)
   point 12,0,-C1
   point 4,(A+C2),-B
   point 8,(A+C2),-C3
   point 8,2.0*A,-C3
   point 8,2.0*A,-(W3/2.0+G3)
   point 8,(A+W2/2.0+G2),-(W3/2.0+G3)
   point 8,(A+W2/2.0+G2),-B
   point 12,(A+C2),-B
```

```
    point 4,2.0*A,C3
    point 8,(A+C4),C3
    point 8,(A+C4),B
    point 8,(A+W4/2.0+G4),B
    point 8,(A+W4/2.0+G4),(W3/2.0+G3)
    point 8,2.0*A,(W3/2.0+G3)
    point 12,2.0*A,C3
    point 4,(A-C4),B
    point 8,(A-C4),C1
    point 8,0,C1
    point 8,0,(W1/2.0+G1)
    point 8,(A-W4/2.0-G4),(W1/2.0+G1)
    point 8,(A-W4/2.0-G4),B
    point 12,(A-C4),B
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Curve

Physical layout:



Data:

W=Strip width
G=Slot width
ANG=Angle through which the curve turns in degree
RAD=Radius of curve

Syntax:

CCURVE n1 n2 W=x1 G=x2 ANG=x3 RAD=x4

Example:

CCURVE 2 3 W=25 G=10 ANG=70 RAD=30

Notes:

1.This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

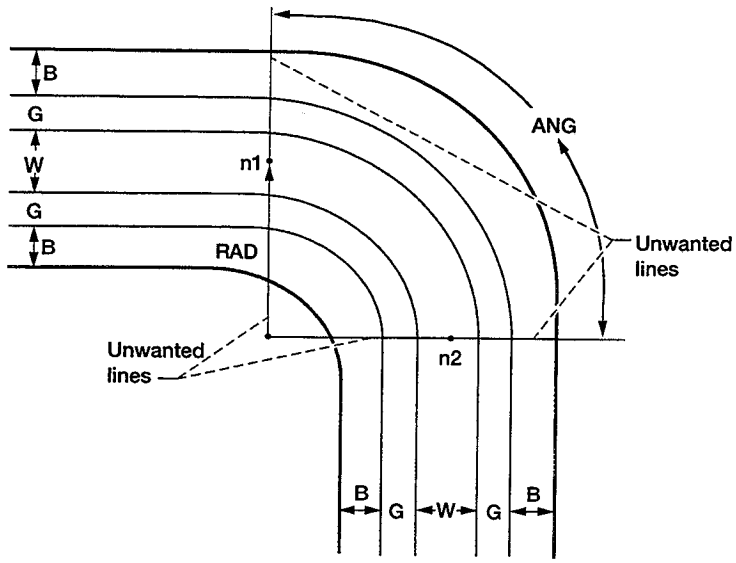
2.The program does not check the validity of the data. It is up to the user to check that 0<ANG<180 degrees and RAD>W/2.0+G.

```
defelem "CCURVE",2,"W","G","ANG","RAD"
    dim PI,RADTODEG,ANGRAD,ANGDEG,RADGIN,RADWIN
    dim SN,CS,RADWOUT,RADGOUT
    level lmet1
    PI=3.141592654
    RADTODEG=360./(2.0*PI)
    ANGRAD=ANGUNIT*ANG
    ANGDEG=ANGRAD*RADTODEG
    RADGIN=RAD-(W/2.0+G)
    RADWIN=RAD-W/2.0
    RADWOUT=RAD+W/2.0
    RADGOUT=RAD+(W/2.0+G)
    SN=SIN(ANGRAD)
    CS=COS(ANGRAD)
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 9,RADWIN,-ANGDEG
    point 10,0,-RAD
    point 8,(RADWIN*SN),(-RAD+RADWIN*CS)
    node n2,(RAD*SN),(-RAD+RAD*CS)
    point 8,(RADWOUT*SN),(-RAD+RADWOUT*CS)
    point 9,RADWOUT,ANGDEG
    point 10,0,-RAD
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 9,RADGIN,-ANGDEG
    point 10,0,-RAD
    point 11,(RADGIN*SN),(-RAD+RADGIN*CS)
    point 3,0,(W/2.0+G)
    point 9,RADGOUT,-ANGDEG
    point 10,0,-RAD
    point 11,(RADGOUT*SN),(-RAD+RADGOUT*CS)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Curve
with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
ANG=Angle through which the curve turns in degree
RAD=Radius of curve
B=Finite ground plane width

Syntax:

CCURVEB n1 n2 W=x1 G=x2 ANG=x3 RAD=x4 B=x5

Example:

CCURVEB 2 3 W=25 G=10 ANG=70 RAD=200 B=100

Notes:

1.This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2.The program does not check the validity of the data. It is up to the user to check that 0<ANG<180 degrees and RAD>W/2.0+G+B.

3. Physical path length of element from node 1 to node 2 is (RAD*Pi*ANG)/180 where ANG is in degree.

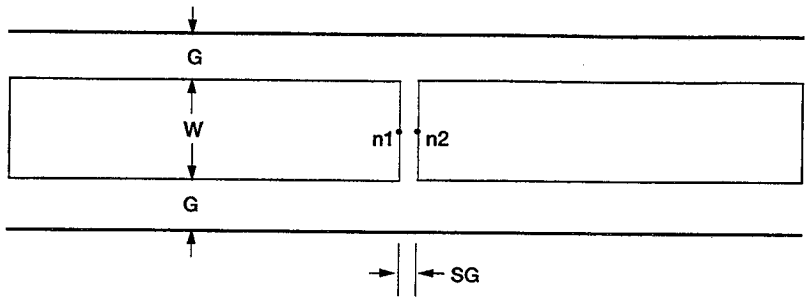
4. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CCURVEB",2,"W","G","ANG","RAD","B"
   dim PI,RADTODEG,ANGRAD,ANGDEG,RADGIN,RADWIN
   dim SN,CS,RADWOUT,RADGOUT,RADBOUT,RADBIN
   level lmet1
   PI=3.141592654
   RADTODEG=360./(2.0*PI)
   ANGRAD=ANGUNIT*ANG
   ANGDEG=ANGRAD*RADTODEG
   RADGIN=RAD-(W/2.0+G)
   RADWIN=RAD-W/2.0
   RADWOUT=RAD+W/2.0
   RADGOUT=RAD+(W/2.0+G)
   RADBOUT=RAD+(W/2.0+G+B)
   RADBIN=RAD-(W/2.0+G+B)
   SN=SIN(ANGRAD)
   CS=COS(ANGRAD)
   point 4,0,W/2.0
   node n1,0,0
   point 8,0,-W/2.0
   point 9,RADWIN,-ANGDEG
   point 10,0,-RAD
   point 8,(RADWIN*SN),(-RAD+RADWIN*CS)
   node n2,(RAD*SN),(-RAD+RAD*CS)
   point 8,(RADWOUT*SN),(-RAD+RADWOUT*CS)
   point 9,RADWOUT,ANGDEG
   point 10,0,-RAD
   point 12,0,W/2.0
   point 4,0,(W/2.0+G+B)
   point 8,0,(W/2.0+G)
   point 9,RADGOUT,-ANGDEG
   point 10,0,-RAD
   point 8,(RADGOUT*SN),(-RAD+RADGOUT*CS)
   point 8,(RADBOUT*SN),(-RAD+RADBOUT*CS)
   point 9,RADBOUT,ANGDEG
   point 10,0,-RAD
   point 12,0,(W/2.0+G+B)
   point 4,0,-(W/2.0+G)
   point 8,0,-(W/2.0+G+B)
   point 9,RADBIN,-ANGDEG
   point 10,0,-RAD
   point 8,(RADBIN*SN),(-RAD+RADBIN*CS)
   point 8,(RADGIN*SN),(-RAD+RADGIN*CS)
   point 9,RADGIN,ANGDEG
   point 10,0,-RAD
   point 12,0,-(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Gap

Physical layout:



Data:

W=Strip width
G=Slot width
SG=Gap width

Syntax:

CGAP n1 n2 W=x1 G=x2 SG=x3

Example:

CGAP 2 3 W=25 G=10 SG=15

Notes:

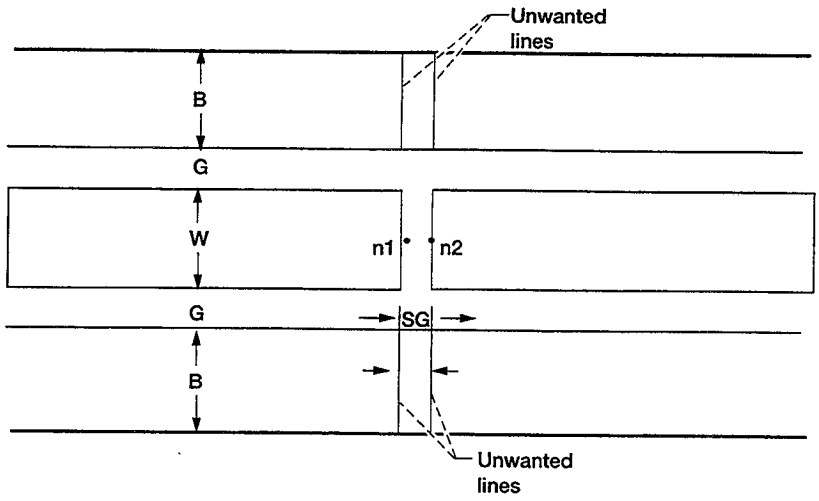
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
defelem "CGAP",2,"W","G","SG"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 12,0,-W/2.0
    point 3,0,-(W/2.0+G)
    point 11,SG,-(W/2.0+G)
    point 4,SG,-W/2.0
    node n2,SG,0
    point 12,SG,W/2.0
    point 3,SG,(W/2.0+G)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Gap with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
SG=Gap width
B=Finite ground plane width

Syntax:

CGAPB n1 n2 W=x1 G=x2 SG=x3 B=x4

Example:

CGAPB 2 3 W=25 G=10 SG=15 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

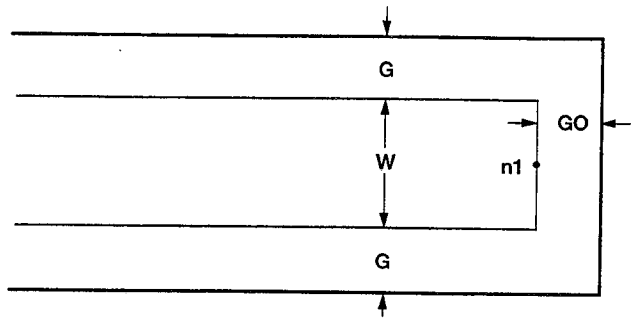
2. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CGAPB",2,"W","G","SG","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 12,0,-W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,SG,-(W/2.0+G+B)
    point 8,SG,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,SG,-W/2.0
    node n2,SG,0
    point 12,SG,W/2.0
    point 4,0,(W/2.0+G)
    point 8,SG,(W/2.0+G)
    point 8,SG,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Open Circuit

Physical layout:



Data:

W=Strip width
G=Slot width
GO=Open end gap width

Syntax:

COPEN n1 W=x1 G=x2 GO=x3

Example:

COPEN 2 W=25 G=10 GO=100

Notes:

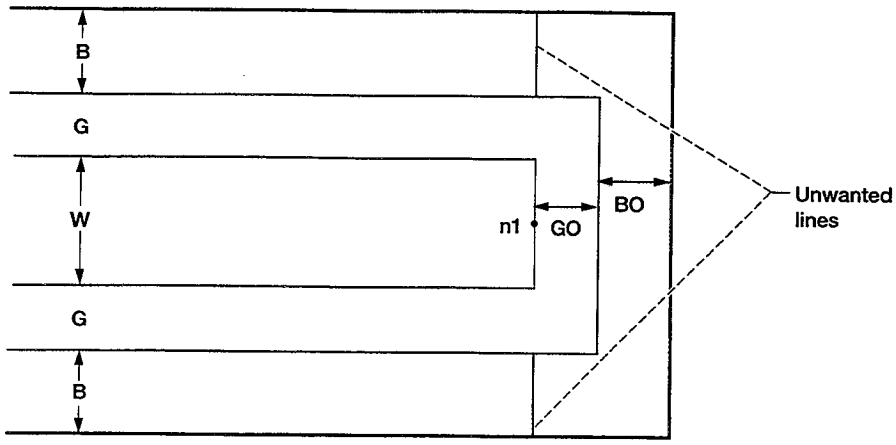
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
defelem "COPEN",1,"W","G","GO"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 12,0,-W/2.0
    point 3,0,-(W/2.0+G)
    point 8,GO,-(W/2.0+G)
    point 8,GO,(W/2.0+G)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Open Circuit
with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
B=Finite ground plane width
GO=Open end gap width
BO=Open end ground plane width

Syntax:

COPENB n1 W=x1 G=x2 B=x3 GO=x4 BO=x5

Example:

COPENB 2 W=25 G=10 B=100 GO=10 BO=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

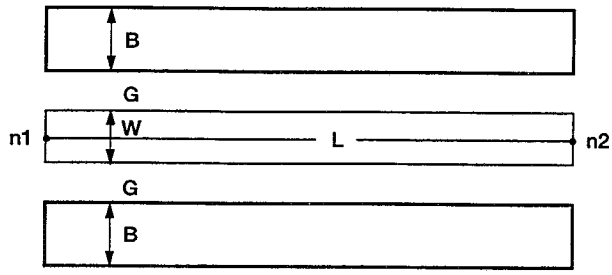
2. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "COPENB",1,"W","G","B","GO","BO"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 12,0,-W/2.0
    point 4,0,(W/2.0+G+B)
    point 8,0,(W/2.0+G)
    point 8,GO,(W/2.0+G)
    point 8,GO,-(W/2.0+G)
    point 8,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,(GO+BO),-(W/2.0+G+B)
    point 8,(GO+BO),(W/2.0+G+B)
    point 12,0,(W/2.0+G+B)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide
with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
B=Finite ground plane width
L=Length of line

Syntax:

CPWB n1 n2 W=x1 G=x2 B=x3 L=x4

Example:

CPWB 2 3 W=25 G=10 B=100 L=500

Notes:

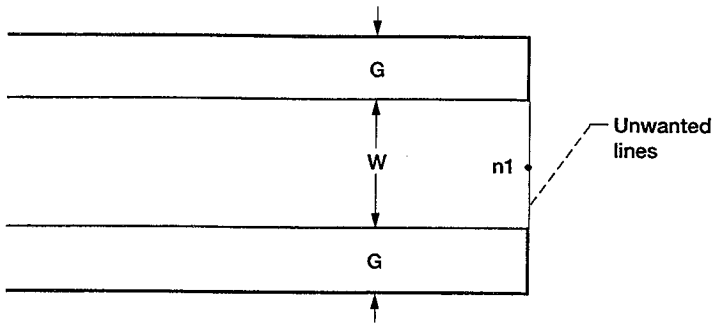
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
defelem "CPWB",2,"W","G","B","L"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,L,-W/2.0
    node n2,L,0
    point 8,L,W/2.0
    point 12,0,W/2.0
    point 4,0,(W/2.0+G)
    point 8,L,(W/2.0+G)
    point 8,L,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,L,-(W/2.0+G+B)
    point 8,L,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Short Circuit

Physical layout:



Data:

W=Strip width
G=Slot width

Syntax:

CSHORT n1 W=x1 G=x2

Example:

CSHORT 3 W=25 G=10

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

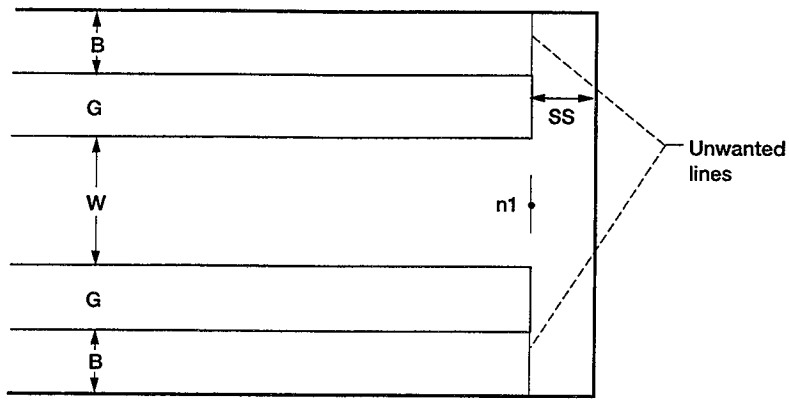
2. This macro will draw an unwanted line at the node. If care is taken not to lift the rubylith mask at this line and a mask reduction is performed, then the line should not effect the final mask.

```
defelem "CSHORT",1,"W","G"
   level lmet1
   point 3,0,(W/2+G)
   point 11,0,-(W/2+G)
   point 4,0,W/2,0
   node n1,0,0
   point 12,0,-W/2.0
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Short Circuit
with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
B=Finite ground plane width
SS=Short circuit ground plane width

Syntax:

CSHORTB n1 W=x1 G=x2 B=x3 SS=x4

Example:

CSHORTB 3 W=25 G=10 B=100 SS=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

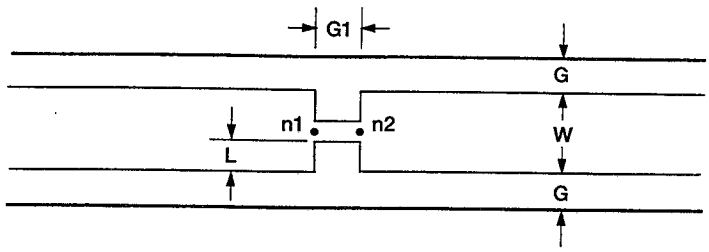
2. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSHORTB",1,"W","G","B","SS"
    level lmet1
    point 4,0,(W/2.0+G+B)
    node n1,0,0
    point 8,0,-(W/2.0+G+B)
    point 8,SS,-(W/2.0+G+B)
    point 8,SS,(W/2.0+G+B)
    point 12,0,(W/2.0+G+B)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Slot Stub in the Center Conductor

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Stub slot width
L=Stub slot length

Syntax:

CSLOTC n1 n2 W=x1 G=x2 G1=x3 L=x4

Example:

CSLOTC 2 3 W=25 G=10 G1=5 L=10

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

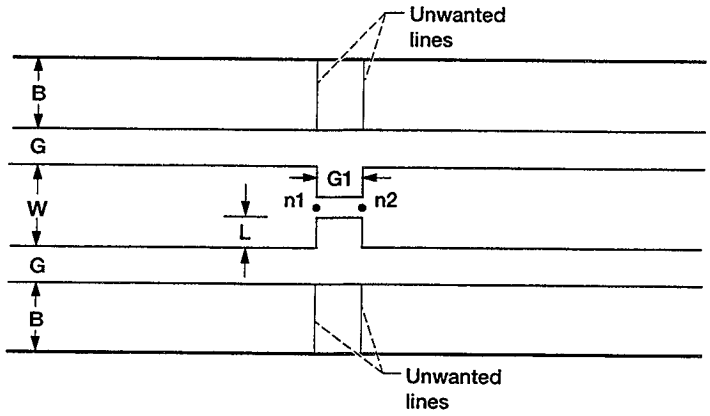
2. The program does not run a check on the validity of the data. It is up to the user to check that 2*L<W.

```
defelem "CSLOTC",2,"W","G","G1","L"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,0,(-W/2.0+L)
    point 8,G1,(-W/2.0+L)
    point 8,G1,-W/2.0
    node n2,G1,0
    point 8,G1,W/2.0
    point 8,G1,(W/2.0-L)
    point 8,0,(W/2.0-L)
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 11,G1,-(W/2.0+G)
    point 3,G1,(W/2.0+G)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Slot Stub in the Center Conductor with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Stub slot width
L=Stub slot length
B=Finite ground plane width

Syntax:

CSLOTCB n1 n2 W=x1 G=x2 G1=x3 L=x4 B=x5

Example:

CSLOTCB 2 3 W=25 G=10 G1=5 L=10 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to check that 2*L<W.

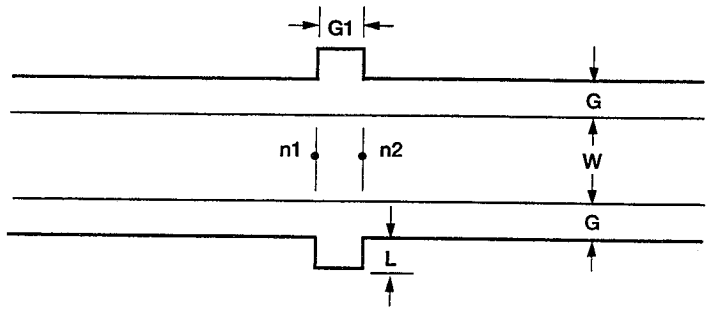
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSLOTCB",2,"W","G","G1","L","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,0,(-W/2.0+L)
    point 8,G1,(-W/2.0+L)
    point 8,G1,-W/2.0
    node n2,G1,0
    point 8,G1,W/2.0
    point 8,G1,(W/2.0-L)
    point 8,0,(W/2.0-L)
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,G1,-(W/2.0+G+B)
    point 8,G1,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,G1,(W/2.0+G)
    point 8,G1,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Slot Stub in the Ground Plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Stub slot width
L=Stub slot length

Syntax:

CSLOTG n1 n2 W=x1 G=x2 G1=x3 L=x4

Example:

CSLOTG 2 3 W=25 G=10 G1=5 L=40

Notes:

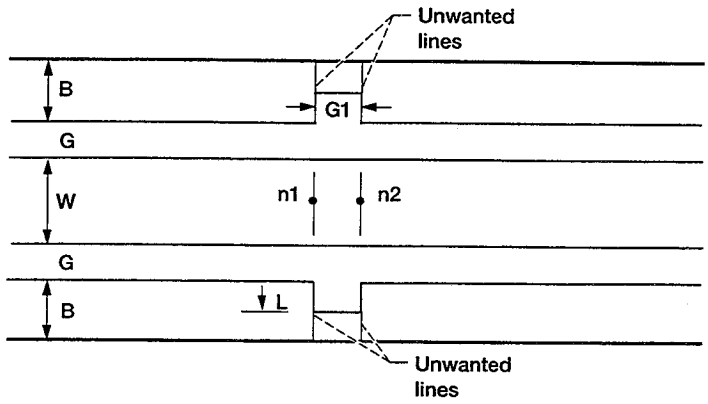
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
defelem "CSLOTG",2,"W","G","G1","L"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,G1,-W/2.0
    node n2,G1,0
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+L)
    point 8,G1,-(W/2.0+G+L)
    point 11,G1,-(W/2.0+G)
    point 3,G1,(W/2.0+G)
    point 8,G1,(W/2.0+G+L)
    point 8,0,(W/2.0+G+L)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Slot Stub in the Ground Plane with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Stub slot width
L=Stub slot length
B=Finite ground plane width

Syntax:

CSLOTGB n1 n2 W=x1 G=x2 G1=x3 L=x4 B=x5

Example:

CSLOTGB 2 3 W=25 G=10 G1=5 L=40 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to check that L<B.

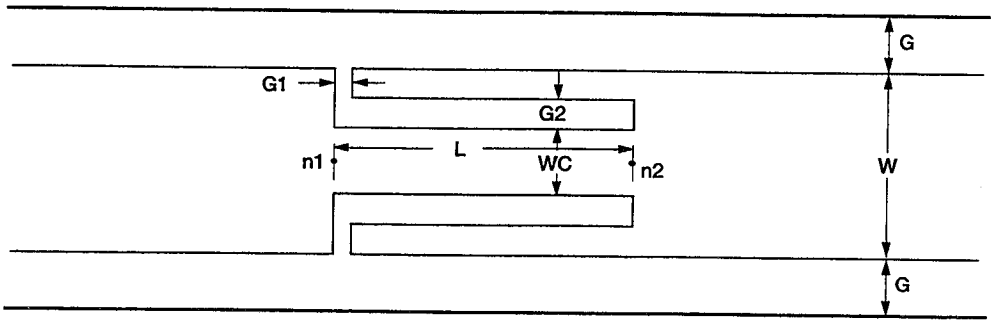
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSLOTGB",2,"W","G","G1","L","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,G1,-W/2.0
    node n2,G1,0
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,G1,-(W/2.0+G+B)
    point 8,G1,-(W/2.0+G)
    point 8,G1,-(W/2.0+G+L)
    point 8,0,-(W/2.0+G+L)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,0,(W/2.0+G+L)
    point 8,G1,(W/2.0+G+L)
    point 8,G1,(W/2.0+G)
    point 8,G1,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Spurline Filter in the Center Conductor

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Slot width of spur
G2=Slot width of spur
L=Length of the filter
WC=Center conductor width in the filter region

Syntax:

CSPURC n1 n2 W=x1 G=x2 G1=x3 G2=x4 L=x5 WC=x6

Example:

CSPURC 2 3 W=25 G=10 G1=10 G2=5 L=150 WC=8

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

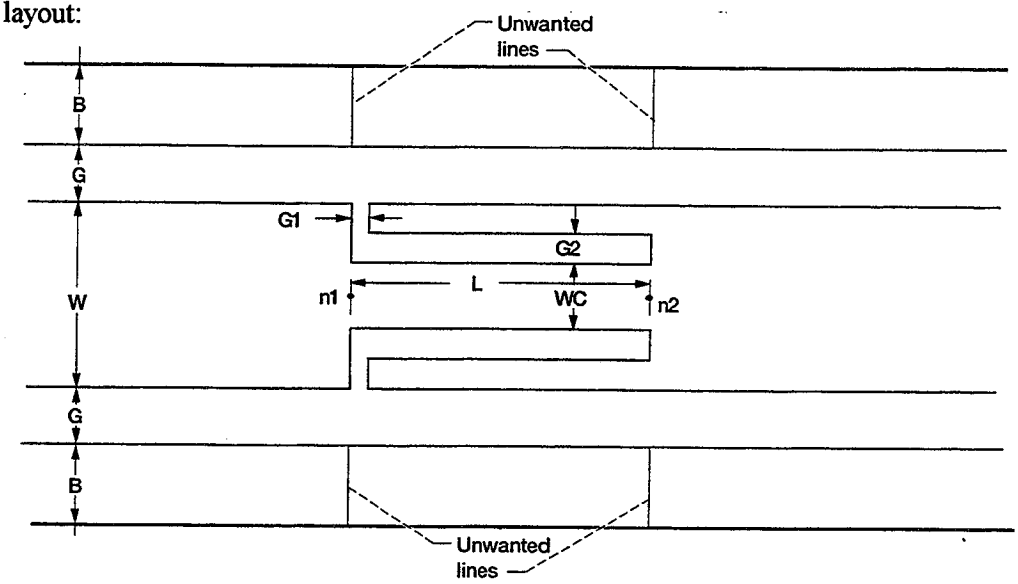
2. The program does not run a check on the validity of the data. It is up to the user to check that (2*G2+WC)<W.

```
defelem "CSPURC",2,"W","G","G1","G2","L","WC"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,0,-WC/2.0
    point 8,L,-WC/2.0
    point 8,L,-(WC/2.0+G2)
    point 8,G1,-(WC/2.0+G2)
    point 8,G1,-W/2.0
    point 8,L,-W/2.0
    node n2,L,0
    point 8,L,W/2.0
    point 8,G1,W/2.0
    point 8,G1,(WC/2.0+G2)
    point 8,L,(WC/2.0+G2)
    point 8,L,WC/2.0
    point 8,0,WC/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 11,L,-(W/2.0+G)
    point 3,L,(W/2.0+G)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Spurline Filter in the Center Conductor with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Slot width of spur
G2=Slot width of spur
L=Length of the filter
WC=Center conductor width in the filter region
B=Finite ground plane width

Syntax:

CSPURCB n1 n2 W=x1 G=x2 G1=x3 G2=x4 L=x5 WC=x6 B=x7

Example:

CSPURCB 2 3 W=25 G=10 G1=10 G2=5 L=150 WC=8 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to check that (2*G2+WC)<W.

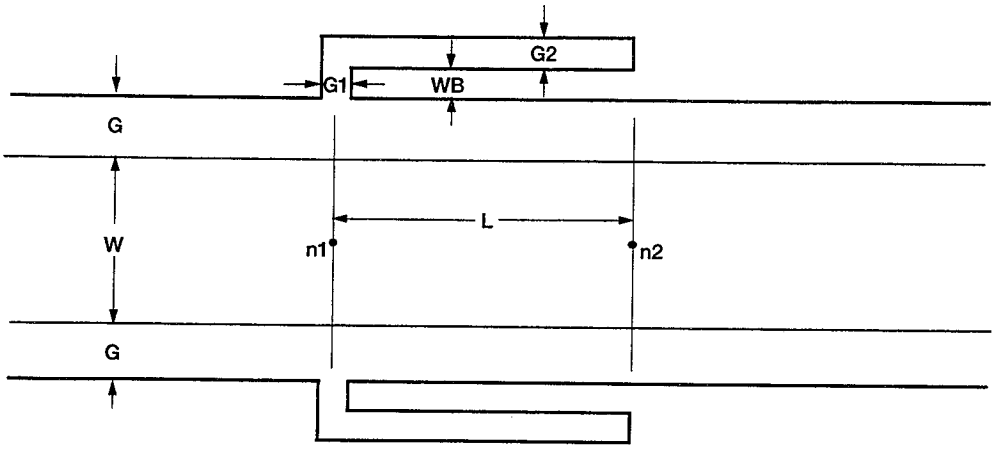
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSPURCB",2,"W","G","G1","G2","L","WC","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,0,-WC/2.0
    point 8,L,-WC/2.0
    point 8,L,-(WC/2.0+G2)
    point 8,G1,-(WC/2.0+G2)
    point 8,G1,-W/2.0
    point 8,L,-W/2.0
    node n2,L,0
    point 8,L,W/2.0
    point 8,G1,W/2.0
    point 8,G1,(WC/2.0+G2)
    point 8,L,(WC/2.0+G2)
    point 8,L,WC/2.0
    point 8,0,WC/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,L,-(W/2.0+G+B)
    point 8,L,-(W/2.0+G)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,L,(W/2.0+G)
    point 8,L,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Spurline Filter in the Ground Plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Slot width of spur
G2=Slot width of spur
WB=Distance between filter slot and CPW slot
L=Length of the filter region

Syntax:

CSPURG n1 n2 W=x1 G=x2 G1=x3 G2=x4 WB=x5 L=x6

Example:

CSPURG 2 3 W=25 G=10 G1=10 G2=8 WB=5 L=150

Notes:

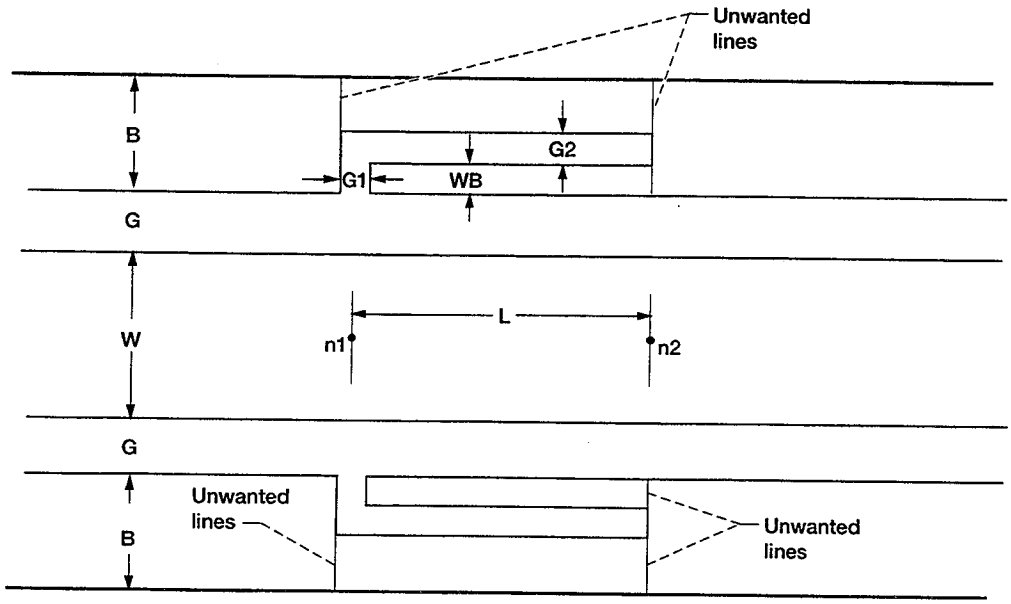
1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

```
defelem "CSPURG",2,"W","G","G1","G2","WB","L"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,L,-W/2.0
    node n2,L,0
    point 8,L,W/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+WB+G2)
    point 8,L,-(W/2.0+G+WB+G2)
    point 8,L,-(W/2.0+G+WB)
    point 8,G1,-(W/2.0+G+WB)
    point 8,G1,-(W/2.0+G)
    point 11,L,-(W/2.0+G)
    point 3,L,(W/2.0+G)
    point 8,G1,(W/2.0+G)
    point 8,G1,(W/2.0+G+WB)
    point 8,L,(W/2.0+G+WB)
    point 8,L,(W/2.0+G+WB+G2)
    point 8,0,(W/2.0+G+WB+G2)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Spurline Filter in the Ground Plane with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
G1=Slot width of spur
G2=Slot width of spur
WB=Distance between filter slot and CPW slot
L=Length of the filter region
B=Finite ground plane width

Syntax:

CSPURGB n1 n2 W=x1 G=x2 G1=x3 G2=x4 WB=x5 L=x6 B=x7

Example:

CSPURGB 2 3 W=25 G=10 G1=10 G2=8 WB=5 L=150 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to check that (G2+WB)<B.

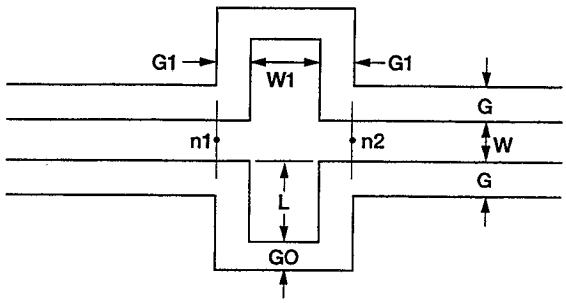
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSPURGB",2,"W","G","G1","G2","WB","L","B"
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,L,-W/2.0
    node n2,L,0
    point 8,L,W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,L,-(W/2.0+G+B)
    point 8,L,-(W/2.0+G)
    point 8,G1,-(W/2.0+G)
    point 8,G1,-(W/2.0+G+WB)
    point 8,L,-(W/2.0+G+WB)
    point 8,L,-(W/2.0+G+WB+G2)
    point 8,0,-(W/2.0+G+WB+G2)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,0,(W/2.0+G+WB+G2)
    point 8,L,(W/2.0+G+WB+G2)
    point 8,L,(W/2.0+G+WB)
    point 8,G1,(W/2.0+G+WB)
    point 8,G1,(W/2.0+G)
    point 8,L,(W/2.0+G)
    point 8,L,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Symmetric Open Ended Stubs

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
GO=Open end width
L=Stub length

Syntax:

CSSTBO n1 n2 W=x1 G=x2 W1=x3 G1=x4 GO=x5 L=x6

Example:

CSSTBO 2 3 W=25 G=10 W1=20 G1=10 GO=10 L=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

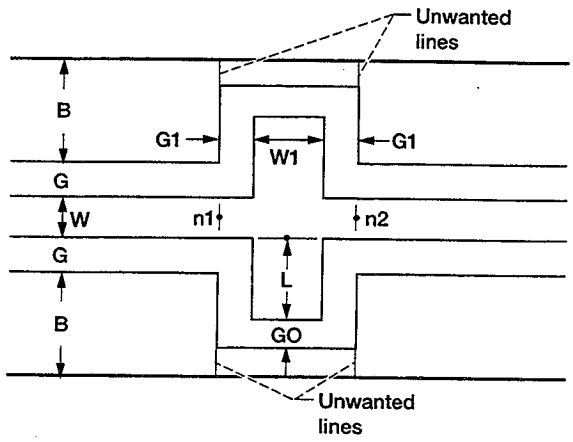
```
defelem "CSSTBO",2,"W","G","W1","G1","GO","L"
    dim OS5,OS6
    OS5=W1+2.0*G1
    OS6=W1+G1
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,G1,-W/2.0
    point 8,G1,-(W/2.0+L)
    point 8,OS6,-(W/2.0+L)
    point 8,OS6,-W/2.0
    point 8,OS5,-W/2.0
    node n2,OS5,0
    point 8,OS5,W/2.0
    point 8,OS6,W/2.0
    point 8,OS6,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 3,0,-(W/2.0+G)
    point 8,0,-(W/2.0+GO+L)
    point 8,OS5,-(W/2.0+GO+L)
    point 11,OS5,-(W/2.0+G)
    point 3,OS5,(W/2.0+G)
    point 8,OS5,(W/2.0+GO+L)
    point 8,0,(W/2.0+GO+L)
    point 11,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

CSSTBOB1

Coplanar Waveguide Symmetric Open Ended Stubs with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
GO=Open end width
L=Stub length
B=Finite ground plane width

Syntax:

CSSTBOB1 n1 n2 W=x1 G=x2 W1=x3 G1=x4 GO=x5 L=x6 B=x7

Example:

CSSTBOB1 2 3 W=25 G=10 W1=20 G1=10 GO=10 L=50 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This open ended symmetric stubs assumes that the stub length is less then the finite ground plane width or (GO+L-G)<B. If this is not true, use CSSTBOB2 which gives a ground plane width to the stub also.

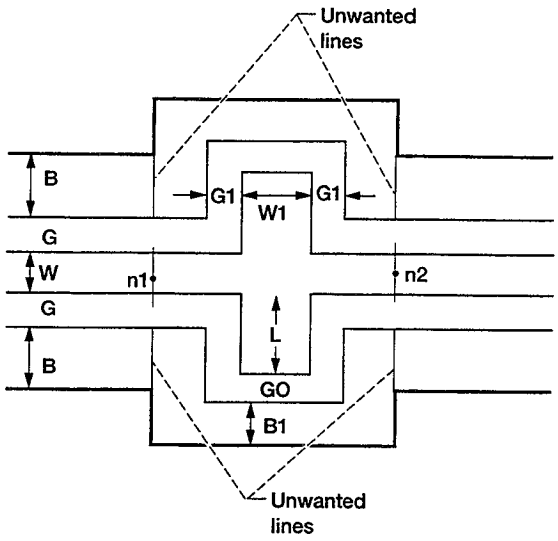
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSSTBOB1",2,"W","G","W1","G1","GO","L","B"
    dim OS5,OS6
    OS5=W1+2.0*G1
    OS6=W1+G1
    level lmet1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,G1,-W/2.0
    point 8,G1,-(W/2.0+L)
    point 8,OS6,-(W/2.0+L)
    point 8,OS6,-W/2.0
    point 8,OS5,-W/2.0
    node n2,OS5,0
    point 8,OS5,W/2.0
    point 8,OS6,W/2.0
    point 8,OS6,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 12,0,W/2.0
    point 4,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,OS5,-(W/2.0+G+B)
    point 8,OS5,-(W/2.0+G)
    point 8,OS5,-(W/2.0+GO+L)
    point 8,0,-(W/2.0+GO+L)
    point 12,0,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    point 8,0,(W/2.0+GO+L)
    point 8,OS5,(W/2.0+GO+L)
    point 8,OS5,(W/2.0+G)
    point 8,OS5,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Symmetric Open Ended Stubs with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
GO=Open end width
L=Stub length.
B1=Finite ground plane width of the stub

Syntax:

CSSTBOB2 n1 n2 W=x1 G=x2 W1=x3 G1=x4 GO=x5 L=x6 B1=x7

Example:

CSSTBOB2 2 3 W=25 G=10 W1=20 G1=10 GO=10 L=150 B1=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element shifts the reference plane at nodes 1 and 2 by B1 compared to the reference plane location used in CSSTBO and CSSTBOB1. Since this is generally not desirable, the circuit must account for this additional 2*B1 in extra line length.

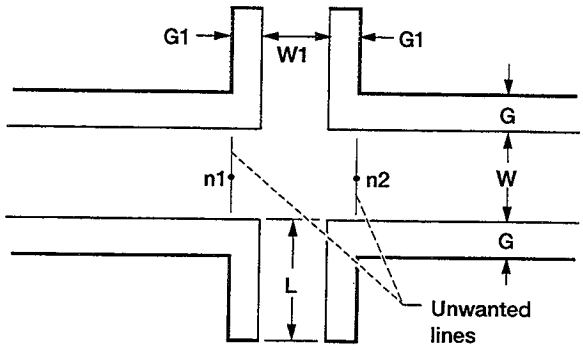
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSSTBOB2",2,"W","G","W1","G1","GO","L","B1"
   dim OS5,OS6,OS7
   OS5=W1+2.0*G1+B1
   OS6=W1+G1+B1
   OS7=W1+2.0*G1+2.0*B1
   level lmet1
   point 4,0,W/2.0
   node n1,0,0
   point 8,0,-W/2.0
   point 8,B1+G1,-W/2.0
   point 8,B1+G1,-(W/2.0+L)
   point 8,OS6,-(W/2.0+L)
   point 8,OS6,-W/2.0
   point 8,OS7,-W/2.0
   node n2,OS7,0
   point 8,OS7,W/2.0
   point 8,OS6,W/2.0
   point 8,OS6,(W/2.0+L)
   point 8,B1+G1,(W/2.0+L)
   point 8,B1+G1,W/2.0
   point 12,0,W/2.0
   point 4,0,-(W/2.0+G)
   point 8,0,-(W/2.0+L+GO+B1)
   point 8,OS7,-(W/2.0+L+GO+B1)
   point 8,OS7,-(W/2.0+G)
   point 8,OS5,-(W/2.0+G)
   point 8,OS5,-(W/2.0+GO+L)
   point 8,B1,-(W/2.0+GO+L)
   point 8,B1,-(W/2.0+G)
   point 12,0,-(W/2.0+G)
   point 4,0,(W/2.0+G)
   point 8,B1,(W/2.0+G)
   point 8,B1,(W/2.0+GO+L)
   point 8,OS5,(W/2.0+GO+L)
   point 8,OS5,(W/2.0+G)
   point 8,OS7,(W/2.0+G)
   point 8,OS7,(W/2.0+L+GO+B1)
   point 8,0,(W/2.0+L+GO+B1)
   point 12,0,(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Symmetric Short Circuit Terminated Stubs

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
L=Stub length

Syntax:

CSSTBS n1 n2 W=x1 G=x2 W1=x3 G1=x4 L=x5

Example:

CSSTBS 2 3 W=25 G=10 W1=8 G1=16 L=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

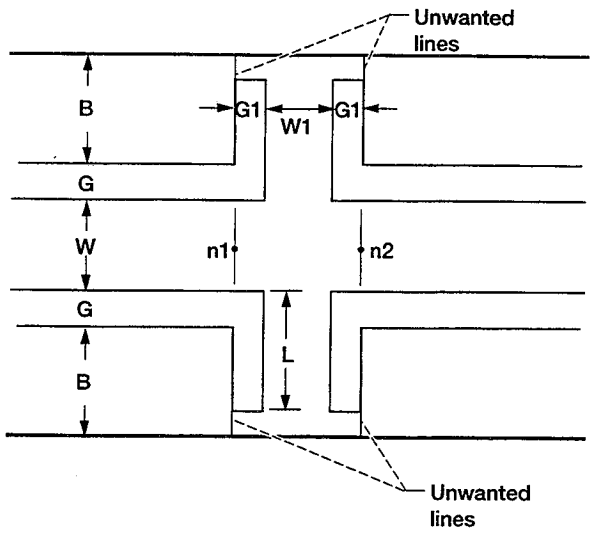
2. This macro will draw two unwanted lines at the nodes. If care is taken not to lift the rubylith mask at these lines and a mask reduction is performed, then these lines should not effect the final mask.

```
defelem "CSSTBS",2,"W","G","W1","G1","L"
    dim X
    level lmet1
    X=2.0*G1+W1
    point 4,0,W/2.0
    node n1,0,0
    point 12,0,-W/2.0
    point 4,X,-W/2.0
    node n2,X,0
    point 12,X,W/2.0
    point 3,0,-(W/2.0+G)
    point 8,0,-(W/2.0+L)
    point 8,G1,-(W/2.0+L)
    point 8,G1,-W/2.0
    point 8,0,-W/2.0
    point 8,0,W/2.0
    point 8,G1,W/2.0
    point 8,G1,(W/2.0+L)
    point 8,0,(W/2.0+L)
    point 11,0,(W/2.0+G)
    point 3,X,(W/2.0+G)
    point 8,X,(W/2.0+L)
    point 8,(G1+W1),(W/2.0+L)
    point 8,(G1+W1),W/2.0
    point 8,X,W/2.0
    point 8,X,-W/2.0
    point 8,(G1+W1),-W/2.0
    point 8,(G1+W1),-(W/2.0+L)
    point 8,X,-(W/2.0+L)
    point 11,X,-(W/2.0+G)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Symmetric Short Circuit Terminated Stubs with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
L=Stub length
B=Finite ground plane width

Syntax:

CSSTBSB1 n1 n2 W=x1 G=x2 W1=x3 G1=x4 L=x5 B=x6

Example:

CSSTBSB1 2 3 W=25 G=10 W1=8 G1=16 L=50 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. The program does not run a check on the validity of the data. It is up to the user to verify that (L-G)<B. If (L-G)>B, then use CSSTBSB2 which gives a ground plane width to the stub also.

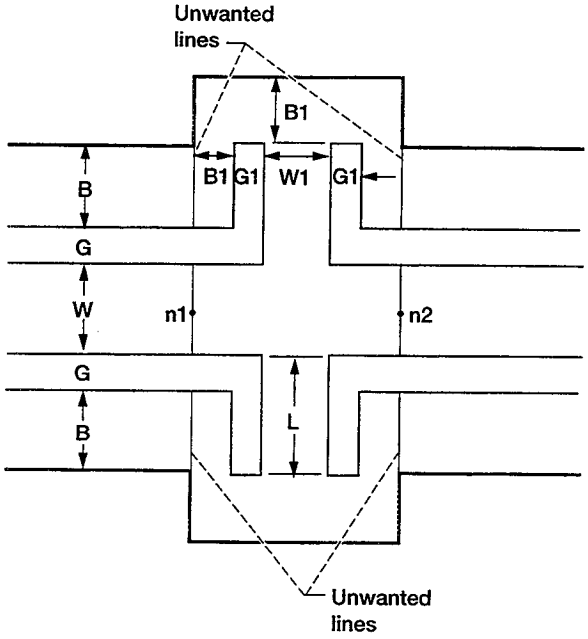
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSSTBSB1",2,"W","G","W1","G1","L","B"
    dim X
    level lmet1
    X=2.0*G1+W1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,G1,-W/2.0
    point 8,G1,-(W/2.0+L)
    point 8,0,-(W/2.0+L)
    point 8,0,-(W/2.0+G)
    point 8,0,-(W/2.0+G+B)
    point 8,X,-(W/2.0+G+B)
    point 8,X,-(W/2.0+G)
    point 8,X,-(W/2.0+L)
    point 8,(G1+W1),-(W/2.0+L)
    point 8,(G1+W1),-W/2.0
    point 8,X,-W/2.0
    node n2,X,0
    point 8,X,W/2.0
    point 8,(G1+W1),W/2.0
    point 8,(G1+W1),(W/2.0+L)
    point 8,X,(W/2.0+L)
    point 8,X,(W/2.0+G)
    point 8,X,(W/2.0+G+B)
    point 8,0,(W/2.0+G+B)
    point 8,0,(W/2.0+G)
    point 8,0,(W/2.0+L)
    point 8,G1,(W/2.0+L)
    point 8,G1,W/2.0
    point 12,0,W/2.0
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Symmetric Short Circuit Terminated Stubs with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
W1=Strip width of stub
G1=Slot width of stub
L=Stub length
B1=Finite ground plane width of the stub

Syntax:

CSSTBSB2 n1 n2 W=x1 G=x2 W1=x3 G1=x4 L=x5 B1=x6

Example:

CSSTBSB2 2 3 W=25 G=10 W1=8 G1=16 L=150 B1=50

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This element shifts the reference plane at nodes 1 and 2 by B1 compared to the reference plane location used in CSSTBS and CSSTBSB1. Since this is generally not desirable, the circuit must account for this additional 2*B1 in extra line length.

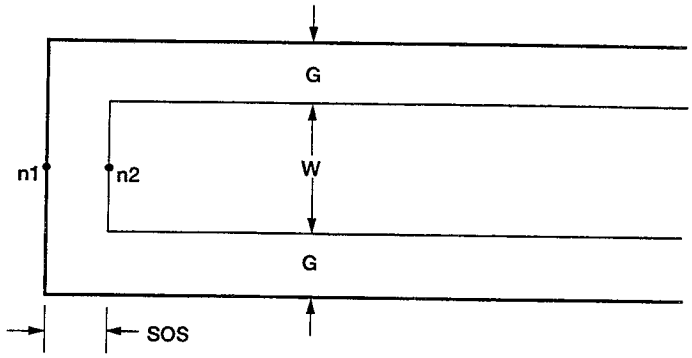
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSSTBSB2",2,"W","G","W1","G1","L","B1"
    dim X
    level lmet1
    X=2.0*G1+W1
    point 4,0,W/2.0
    node n1,0,0
    point 8,0,-W/2.0
    point 8,(B1+G1),-W/2.0
    point 8,(B1+G1),-(W/2.0+L)
    point 8,B1,-(W/2.0+L)
    point 8,B1,-(W/2.0+G)
    point 8,0,-(W/2.0+G)
    point 8,0,-(W/2.0+L+B1)
    point 8,(X+2.0*B1),-(W/2.0+L+B1)
    point 8,(X+2.0*B1),-(W/2.0+G)
    point 8,(X+B1),-(W/2.0+G)
    point 8,(X+B1),-(W/2.0+L)
    point 8,(G1+W1+B1),-(W/2.0+L)
    point 8,(G1+W1+B1),-W/2.0
    point 8,(X+2.0*B1),-W/2.0
    node n2,(X+2.0*B1),0
    point 8,(X+2.0*B1),W/2.0
    point 8,(G1+W1+B1),W/2.0
    point 8,(G1+W1+B1),(W/2.0+L)
    point 8,(X+B1),(W/2.0+L)
    point 8,(X+B1),(W/2.0+G)
    point 8,(X+2.0*B1),(W/2.0+G)
    point 8,(X+2.0*B1),(W/2.0+L+B1)
    point 8,0,(W/2.0+L+B1)
    point 8,0,(W/2.0+G)
    point 8,B1,(W/2.0+G)
    point 8,B1,(W/2.0+L)
    point 8,(B1+G1),(W/2.0+L)
    point 8,(B1+G1),W/2.0
    point 12,0,W/2.0
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Open at Input

Physical layout:



Data:

W=Strip width
G=Slot width
SOS=Open end gap width at input

Syntax:

CSTART n1 n2 W=x1 G=x2 SOS=x3

Example:

CSTART 1 2 W=25 G=10 SOS=55

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

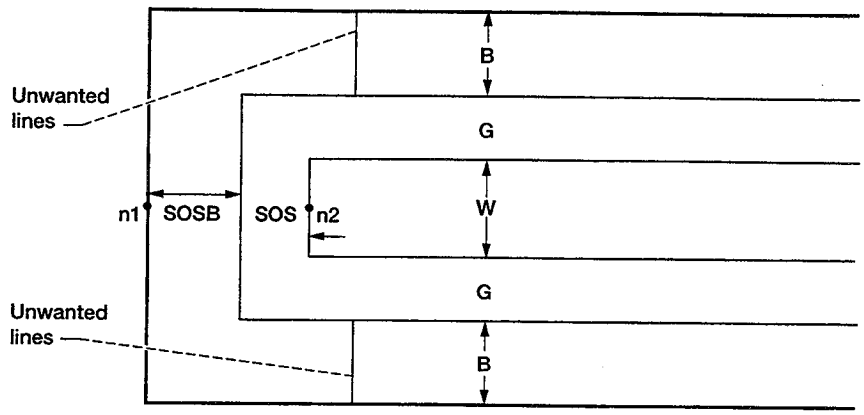
2. This structure is useful for wafer probing CPW circuits and for starting CPW circuits in the interior of a substrate which is entirely metalized.

```
defelem "CSTART",2,"W","G","SOS"
    level lmet1
    point 3,SOS,(W/2.0+G)
    point 8,0,(W/2.0+G)
    point 8,0,-(W/2.0+G)
    point 11,SOS,-(W/2.0+G)
    point 4,0,(W/2.0+G)
    node n1,0,0
    point 12,0,-(W/2.0+G)
    point 4,SOS,-W/2.0
    node n2,SOS,0
    point 12,SOS,W/2.0
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Open at Input with finite width ground plane

Physical layout:



Data:

W=Strip width
G=Slot width
SOS=Open end gap width at input
SOSB=Finite ground plane width at open end
B=Finite ground plane width

Syntax:

CSTARTB n1 n2 W=x1 G=x2 SOS=x3 SOSB=x4 B=x5

Example:

CSTARTB 1 2 W=25 G=10 SOS=55 SOSB=50 B=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This structure is useful for wafer probing CPW circuits and for starting CPW circuits in the interior of a substrate.

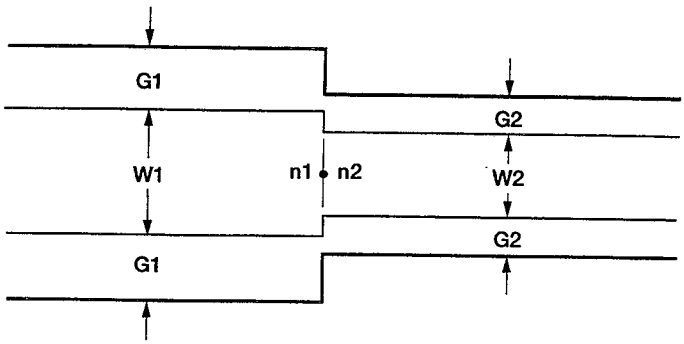
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSTARTB",2,"W","G","SOS","SOSB","B"
    level lmet1
    point 4,0,(W/2.0+G+B)
    node n1,0,0
    point 8,0,-(W/2.0+G+B)
    point 8,(SOSB+SOS),-(W/2.0+G+B)
    point 8,(SOSB+SOS),-(W/2.0+G)
    point 8,SOSB,-(W/2.0+G)
    point 8,SOSB,(W/2.0+G)
    point 8,(SOSB+SOS),(W/2.0+G)
    point 8,(SOSB+SOS),(W/2.0+G+B)
    point 12,0,(W/2.0+G+B)
    point 4,(SOS+SOSB),-W/2.0
    node n2,(SOS+SOSB),0
    point 12,(SOS+SOSB),W/2.0
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Step

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
W2=Strip width at node 2
G2=Slot width at node 2

Syntax:

CSTEP n1 n2 W1=x1 G1=x2 W2=x3 G2=x4

Example:

CSTEP 2 3 W1=25 G1=10 W2=15 G2=20

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

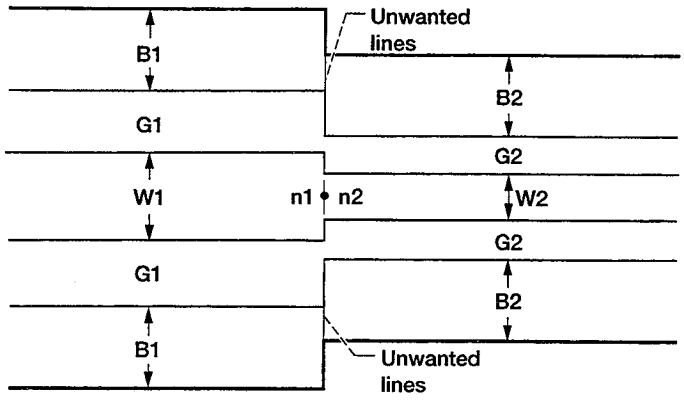
2. There are no limitations on W1, W2, G1, or G2. Any of the data inputs may be varied to create a step in the center conductor, the ground planes, or both although it is up to the user to verify that W1<(W2+2*G2) and W2<(W1+2*G1).

```
defelem "CSTEP",2,"W1","G1","W2","G2"
   level lmet1
   point 4,0,W1/2.0
   node n1,0,0
   point 8,0,-W1/2.0
   point 8,0,-W2/2.0
   node n2,0,0
   point 8,0,W2/2.0
   point 12,0,W1/2.0
   point 3,0,-(W1/2.0+G1)
   point 11,0,-(W2/2.0+G2)
   point 3,0,(W1/2.0+G1)
   point 11,0,(W2/2.0+G2)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Step with finite width ground plane

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
B1=Finite ground plane width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
B2=Finite ground plane width at node 2

Syntax:

CSTEPB n1 n2 W1=x1 G1=x2 B1=x3 W2=x4 G2=x5 B2=x6

Example:

CSTEPB 2 3 W1=25 G1=10 B1=100 W2=15 G2=20 B2=175

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. There are no limitations on W1, W2, G1, G2, B1, or B2. Any of the data inputs may be varied to create a step in the center conductor, the ground planes, or both although it is up to the user to verify that W1<(W2+2*G2), W2<(W1+2*G1), (W1+2*G1)<(W2+2*G2+2*B2), and (W2+2*G2)<(W1+2*G1+2*B1).

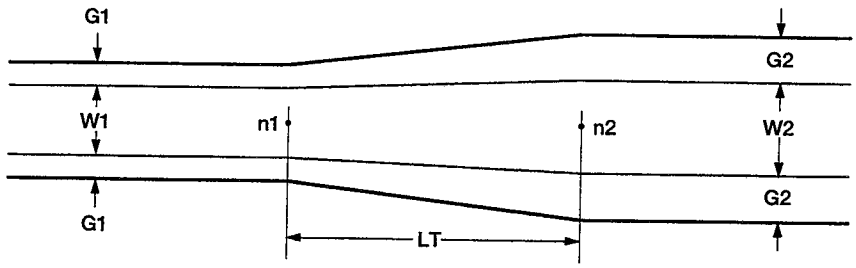
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CSTEPB",2,"W1","G1","B1","W2","G2","B2"
    level lmet1
    point 4,0,W1/2.0
    node n1,0,0
    point 8,0,-W1/2.0
    point 8,0,-W2/2.0
    node n2,0,0
    point 8,0,W2/2.0
    point 12,0,W1/2.0
    point 4,0,-(W1/2.0+G1)
    point 8,0,-(W1/2.0+G1+B1)
    point 8,0,-(W2/2.0+G2+B2)
    point 8,0,-(W2/2.0+G2)
    point 12,0,-(W1/2.0+G1)
    point 4,0,(W1/2.0+G1)
    point 8,0,(W2/2.0+G2)
    point 8,0,(W2/2.0+G2+B2)
    point 8,0,(W1/2.0+G1+B1)
    point 12,0,(W1/2.0+G1)
end define
```

Program written by George E. Ponchak

CTAPER Coplanar Waveguide Taper CTAPER

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
W2=Strip width at node 2
G2=slot width at node 2
LT=Taper length

Syntax:

CTAPER n1 n2 W1=x1 G1=x2 W2=x3 G2=x4 LT=x5

Example:

CTAPER 2 3 W1=25 G1=10 W2=50 G2=20 LT=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

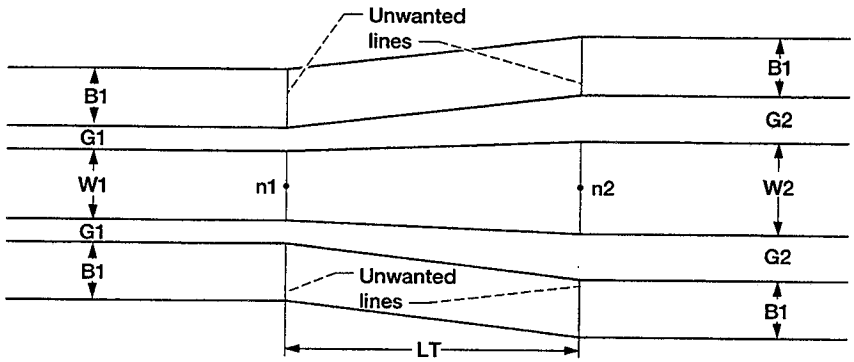
2. There are no limitations on W1, W2, G1, or G2. Any of the data inputs may be varied to create a taper of the center conductor, the slots, or both.

```
defelem "CTAPER",2,"W1","G1","W2","G2","LT"
    level lmet1
    point 4,0,W1/2.0
    node n1,0,0
    point 8,0,-W1/2.0
    point 8,LT,-W2/2.0
    node n2,LT,0
    point 8,LT,W2/2.0
    point 12,0,W1/2.0
    point 3,0,-(W1/2.0+G1)
    point 11,LT,-(W2/2.0+G2)
    point 3,LT,(W2/2.0+G2)
    point 11,0,(W1/2.0+G1)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide Taper
with finite width ground plane

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
B1=Finite ground plane width at node 1
W2=Strip width at node 2
G2=slot width at node 2
B2=Finite ground plane width at node 2
LT=Taper length

Syntax:

CTAPERB n1 n2 W1=x1 G1=x2 B1=x3 W2=x4 G2=x5 B2=x6 LT=x7

Example:

CTAPERB 2 3 W1=25 G1=10 B1=100 W2=50 G2=20 B2=150 LT=100

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. There are no limitations on W1, W2, G1, G2, B1, or B2. Any of the data inputs may be varied to create a taper of the center conductor, the slots, or both.

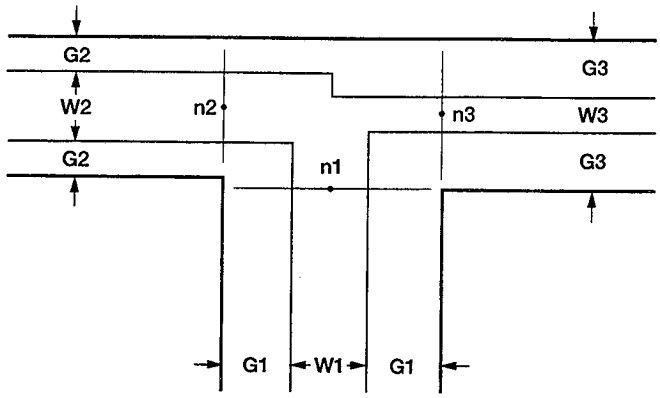
3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CTAPERB",2,"W1","G1","B1","W2","G2","B2","LT"
   level lmet1
   point 4,0,W1/2.0
   node n1,0,0
   point 8,0,-W1/2.0
   point 8,LT,-W2/2.0
   node n2,LT,0
   point 8,LT,W2/2.0
   point 12,0,W1/2.0
   point 4,0,(W1/2.0+G1)
   point 8,LT,(W2/2.0+G2)
   point 8,LT,(W2/2.0+G2+B2)
   point 8,0,(W1/2.0+G1+B1)
   point 12,0,(W1/2.0+G1)
   point 4,0,-(W1/2.0+G1)
   point 8,0,-(W1/2.0+G1+B1)
   point 8,LT,-(W2/2.0+G2+B2)
   point 8,LT,-(W2/2.0+G2)
   point 12,0,-(W1/2.0+G1)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide T Junction

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
W3=Strip width at node 3
G3=Slot width at node 3

Syntax:

CTEE1 n1 n2 n3 W1=x1 G1=x2 W2=x3 G2=x4 W3=x5 G3=x6

Example:

CTEE1 2 3 4 W1=25 G1=10 W2=50 G2=20 W3=10 G3=15

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

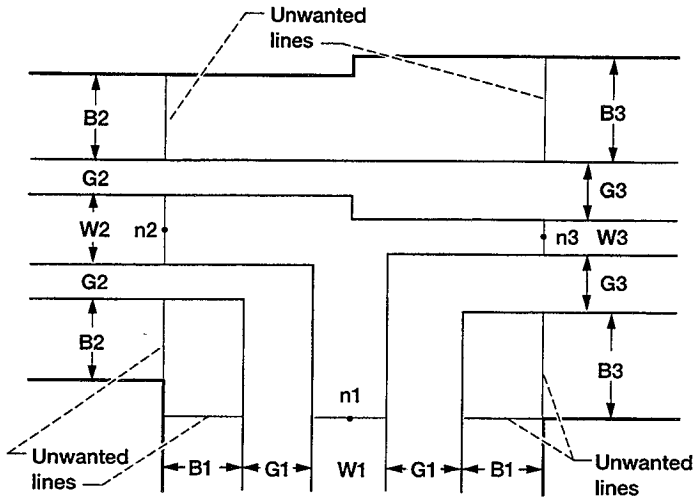
2. This Tee junction aligns the slot opposite node 1. Nodes 2 and 3 may not be aligned.

```
defelem "CTEE1",3,"W1","G1","W2","G2","W3","G3"
    dim d
    if 2*G3+W3-2*G2-W2 > 0 then
    d=0.0
    else
    d=2*G3+W3-2*G2-W2
    end if
    level lmet1
    point 4,-W1/2.0,d
    node n1,0,d
    point 8,W1/2.0,d
    point 8,W1/2.0,G3
    point 8,(W1/2.0+G1),G3
    node n3,(W1/2.0+G1),(G3+W3/2.0)
    point 8,(W1/2.0+G1),(G3+W3)
    point 8,0,(G3+W3)
    point 8,0,(2.0*G3+W3-G2)
    point 8,-(W1/2.0+G1),(2.0*G3+W3-G2)
    node n2,-(W1/2.0+G1),(2.0*G3+W3-G2-W2/2.0)
    point 8,-(W1/2.0+G1),(2.0*G3+W3-G2-W2)
    point 8,-W1/2.0,(2.0*G3+W3-G2-W2)
    point 12,-W1/2.0,d
    point 3,(W1/2.0+G1),d
    point 11,(W1/2.0+G1),0
    point 3,-(W1/2.0+G1),(2.0*G3+W3-(2.0*G2+W2))
    point 11,-(W1/2.0+G1),d
    point 3,(W1/2.0+G1),(2.0*G3+W3)
    point 11,-(W1/2.0+G1),(2.0*G3+W3)
end define
```

Program written by Nikola Visic

Coplanar Waveguide T Junction with finite width ground plane

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
B1=Finite ground plane width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
B2=Finite ground plane width at node 2
W3=Strip width at node 3
G3=Slot width at node 3
B3=Finite ground plane width at node 3

Syntax:

CTEE1B n1 n2 n3 W1=x1 G1=x2 B1=x3 W2=x4 G2=x5 B2=x6 W3=x7 G3=x8 B3=x9

Example:

CTEE1B 2 3 4 W1=25 G1=10 B1=100 W2=50 G2=20 B2=175 W3=10 G3=15 B3=125

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This Tee junction aligns the slot opposite node 1. Nodes 2 and 3 may not be aligned.

3. This element shifts the reference plane at nodes 1, 2, and 3 compared to the reference plane locations given in CTEE1. Node 1 is shifted by the greater of (B2+2*G2+W2) and (B3+2*G3*W3) minus the greater of (2*G2+W2) and (2*G3+W3). Nodes 2 and 3 are shifted by B1. Since this is generally not desirable, this reference plane shift must be compensated for elsewhere in the circuit.

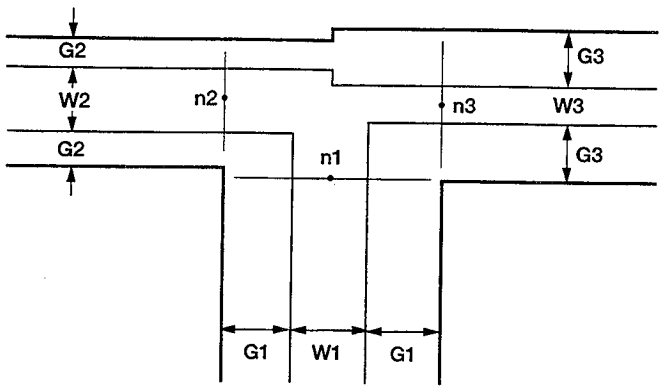
4. There are an extra set of lines generated in the ground planes at the reference plane of the element.

```
defelem "CTEE1B",3,"W1","G1","B1","W2","G2","B2","W3","G3","B3"
    dim d1,d3,d
    d3=2.0*G3+W3+B3
    d1=W1/2.0+G1+B1
    if d3-(2*G2+W2+B2) > 0.0 then
    d=0
    else
    d=d3-(2*G2+W2+B2)
    end if
    level lmet1
    point 4,-W1/2.0,d
    node n1,0,d
    point 8,W1/2.0,d
    point 8,W1/2.0,(B3+G3)
    point 8,d1,(B3+G3)
    node n3,d1,(B3+G3+W3/2.0)
    point 8,d1,(B3+G3+W3)
    point 8,0,(B3+G3+W3)
    point 8,0,(d3-G2)
    point 8,-d1,(d3-G2)
    node n2,-d1,(d3-(G2+W2/2.0))
    point 8,-d1,(d3-(G2+W2))
    point 8,-W1/2.0,(d3-(G2+W2))
    point 12,-W1/2.0,d
    point 4,(W1/2.0+G1),d
    point 8,d1,d
    point 8,d1,B3
    point 8,(W1/2.0+G1),B3
    point 12,(W1/2.0+G1),d
    point 4,-(W1/2.0+G1),d
    point 8,-(W1/2.0+G1),(d3-(W2+2.0*G2))
    point 8,-d1,(d3-(W2+2.0*G2))
    point 8,-d1,d
    point 12,-(W1/2.0+G1),d
    point 4,d1,d3
    point 8,d1,(d3+B3)
    point 8,0,(d3+B3)
    point 8,0,(d3+B2)
    point 8,-d1,(d3+B2)
    point 8,-d1,d3
    point 12,d1,d3
end define
```

Program written by George E. Ponchak

Coplanar Waveguide T Junction

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
W3=Strip width at node 3
G3=Slot width at node 3

Syntax:

CTEE2 n1 n2 n3 W1=x1 G1=x2 W2=x3 G2=x4 W3=x5 G3=x6

Example:

CTEE2 2 3 4 W1=25 G1=10 W2=20 G2=15 W3=30 G3=35

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This Tee junction aligns nodes 2 and 3.

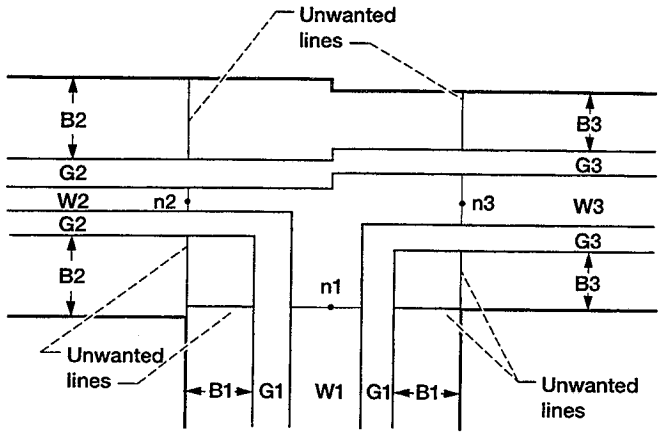
3. It is up to the user to verify that W3<(W2+2*G2), W2<(W3+2*G3), (W2+2*G2)<(W3+2*G3+2*B3), and (W3+2*G3)<(W2+2*G2+2*B2).

```
defelem "CTEE2",3,"W1","G1","W2","G2","W3","G3"
    dim d2,d3,d
    d=G2+W2/2.0-(G3+W3/2.0)
    if d<=0 then
    d2=-d
    d3=0.0
    else
    d2=0.0
    d3=d
    end if
    level lmet1
    point 4,0,W1/2.0
    node n1,0,0
    point 8,0,-W1/2.0
    point 8,(d3+G3),-W1/2.0
    point 8,(d3+G3),-(W1/2.0+G1)
    node n3,(d3+G3+W3/2.0),-(W1/2.0+G1)
    point 8,(d3+G3+W3),-(W1/2.0+G1)
    point 8,(d3+G3+W3),0
    point 8,(d2+G2+W2),0
    point 8,(d2+G2+W2),(W1/2.0+G1)
    node n2,(d2+G2+W2/2.0),(W1/2.0+G1)
    point 8,(d2+G2),(W1/2.0+G1)
    point 8,(d2+G2),W1/2.0
    point 12,0,W1/2.0
    point 3,0,(W1/2.0+G1)
    point 11,d2,(W1/2.0+G1)
    point 3,0,-(W1/2.0+G1)
    point 11,d3,-(W1/2.0+G1)
    point 3,(d3+2.0*G3+W3),-(W1/2.0+G1)
    point 8,(d3+2.0*G3+W3),0
    point 8,(d2+2.0*G2+W2),0
    point 11,(d2+2.0*G2+W2),(W1/2.0+G1)
end define
```

Program written by George E. Ponchak

Coplanar Waveguide T Junction with finite width ground plane

Physical layout:



Data:

W1=Strip width at node 1
G1=Slot width at node 1
B1=Finite ground plane width at node 1
W2=Strip width at node 2
G2=Slot width at node 2
B2=Finite ground plane width at node 2
W3=Strip width at node 3
G3=Slot width at node 3
B3=Finite ground plane width at node 3

Syntax:

CTEE2B n1 n2 n3 W1=x1 G1=x2 B1=x3 W2=x4 G2=x5 B2=x6 W3=x7 G3=x8 B3=x9

Example:

CTEE2B 2 3 4 W1=25 G1=10 B1=100 W2=20 G2=15 B2=225 W3=30 G3=35 B3=125

Notes:

1. This is a macro program in the MICAD.ELE or ACADEMY.ELE file.

2. This Tee junction aligns nodes 2 and 3.

3. This element shifts the reference plane at nodes 1, 2, and 3 compared to the reference plane locations given in CTEE2. Node 1 is shifted by the greater of (B2+G2+W2/2.0) and (B3+G3*W3/2.0) minus the greater of (G2+W2/2.0) and (G3+W3/2.0). Nodes 2 and 3 are shifted by B1. Since this is generally not desirable, this reference plane shift must be compensated for elsewhere in the circuit.

3. There are an extra set of lines generated in the ground planes at the reference plane of the element.

4. It is up to the user to verify that W3<(W2+2*G2), W2<(W3+2*G3), (W2+2*G2)<(W3+2*G3+2*B3), and (W3+2*G3)<(W2+2*G2+2*B2).

```
defelem "CTEE2B",3,"W1","G1","B1","W2","G2","B2","W3","G3","B3"
   dim d,d1,d2,d3
   d1=W1/2.0+G1+B1
   d=(B2+G2+W2/2.0)-(B3+G3+W3/2.0)
   if d<=0 then
   d2=-d
   d3=0.0
   else
   d2=0.0
   d3=d
   end if
   level lmet1
   point 4,0,W1/2.0
   node n1,0,0
   point 8,0,-W1/2.0
   point 8,(d3+B3+G3),-W1/2.0
   point 8,(d3+B3+G3),-d1
   node n3,(d3+B3+G3+W3/2.0),-d1
   point 8,(d3+B3+G3+W3),-d1
   point 8,(d3+B3+G3+W3),0
   point 8,(d2+B2+G2+W2),0
   point 8,(d2+B2+G2+W2),d1
   node n2,(d2+B2+G2+W2/2.0),d1
   point 8,(d2+B2+G2),d1
   point 8,(d2+B2+G2),W1/2.0
   point 12,0,W1/2.0
   point 4,0,-(W1/2.0+G1)
   point 8,0,-d1
   point 8,(d3+B3),-d1
   point 8,(d3+B3),-(W1/2.0+G1)
   point 12,0,-(W1/2.0+G1)
   point 4,0,(W1/2.0+G1)
   point 8,(d2+B2),(W1/2.0+G1)
   point 8,(d2+B2),d1
   point 8,0,d1
   point 12,0,(W1/2.0+G1)
   point 4,(d3+B3+2.0*G3+W3),-d1
   point 8,(d3+2.0*B3+2.0*G3+W3),-d1
   point 8,(d3+2.0*B3+2.0*G3+W3),0
   point 8,(d2+2.0*B2+2.0*G2+W2),0
   point 8,(d2+2.0*B2+2.0*G2+W2),d1
   point 8,(d2+B2+2.0*G2+W2),d1
   point 8,(d2+B2+2.0*G2+W2),0
   point 8,(d3+B3+2.0*G3+W3),0
   point 12,(d3+B3+2.0*G3+W3),-d1
end define
```

Program written by George E. Ponchak

REPORT DOCUMENTATION PAGE

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13. ABSTRACT (*Maximum 200 words*)

A collection of macro files is presented which when appended to either the EEsoF MICAD.ELE or EEsoF ACADEMY.ELE file permits the layout of coplanar waveguide and finite ground plane coplanar waveguide circuits.

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