# microwave software®

## Utilities+® User Manual

**RF/Microwave Design Utility Programs**

## Utilities Manual
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# INTRODUCTION

## Overview of Program

The best way to learn how to use a program is by ***using*** it, so we've created many many examples for you. **Utilities+** is a collection of useful programs for the RF/Microwave systems and circuit design engineer. Whether you are new to the RF/Microwave field, or a seasoned professional, you'll find Utilities+ a valuable tool!

Some of the routines are what the typical "hands on" engineer uses every day, others are not. There are some *very* unique programs within **Utilities+**. Among them are the "Fano Bandwidth" and "Waveguide" utilities - both of which are extremely valuable for those among us engaged in broadband design. All things considered, this program *should* be in your personal tool box.

This **User Manual** will introduce you to **Utilities+** by working thru many detailed examples. Some topics may be ***new*** to you, and you can *add* them to your "bag of tricks." You'll learn how to enter data and output the results.

# SYSTEM REQUIREMENTS

This program is for use on a Windows PC, where it will run *in a DOS window*. You will receive information on how to download a self-extracting file named Utilities+_INSTALL.exe via E-Mail, after making a purchase. The current size of the download file, as of the latest revision date, is *about* 230 KB. For our automated installer routine to work, you need to be using Windows 95, 98, 98SE, Me, NT, or XP operating in 32-bit mode.

To output data to either a parallel port, or a USB printer in Windows, from within a program running in a DOS window, you *first* need to place the data in the Windows Clipboard. There are *two* ways to do this:

Method #1: First, to get the data in to the Windows Clipboard, press the 4th icon from the left, at the top of the small DOS window, marked '**Full screen.**' Now, in full screen mode, press, on your keyboard, '**Alt + Print Scrn**' to transfer the data to the clipboard. To *return* to the original small DOS window, press, on your keyboard, '**Alt + Enter.**' Open Windows Notepad, press '**Edit**' and then '**Paste.**' Now you can direct the data to your printer.

Note: Windows Notepad will *only* accept input from a *full screen* DOS window, and not a small screen, using '**Alt +Print Scrn.**' if you try to transfer data to Notepad from a small DOS window, the '**Paste**' option will be greyed out.

Method #2:
In a normal small DOS window, use the two icons on the *left*, at the *top* of the DOS window. First, press '**Mark,**' then left-click & drag the small white cursor to *highlight* all the data you wish to transfer to the Windows Clipboard. Now, with the data highlighted, press '**Copy**' to transfer the data to the clipboard. Now you *can*paste in to Windows Paint, Wordpad, or Microsoft Word, and then on to your printer.

# INSTALLATION

## Introduction

This program is for use on Windows PC's, where the programs run *in a DOS window*.

When we receive confirmation of your order, from either Google, PayPal, or Kagi, we will send you an acknowledgement E-Mail. It will contain a software download link and Registration Code. The current size of the "auto install" **Utilities+** file is *about* 230 KB. To "extract" the compressed files, you need to be using a 32-bit Windows PC.

Before the **Utilities+** program can be run, it must be *installed*. The installation does *NOT* write to your system registry, autoexec.bat, config.sys, or any *other* place on your PC. It is *totally* self-contained within a directory named c:\mwsoft\utilitie.

Note: If you already *have* one or more of our software products, the directory c:\mwsoft will *already* exist. In that event, the installation routine will create sub-directories within c:mwsoft named c:\mwsoft\utilitie, while all data and support files are placed in a sub-directory just *below* c:\mwsoft; its path is c:\mwsoft\utilitie\mwdata5. The installer will *also* create an attractive desktop shortcut icon for your use.

## How to Install Utilities+ to a Windows PC

To begin the automatic installation process, double-click on the Utilities+_INSTALL.exe file, (its a black disk shaped icon), which you have downloaded to your desktop.

The install routine will first de-compress the files, create *three* directories (if needed), in your c:\ root, and then *transfer* all files to it. The main program file, named utilitie.exe, is placed within c:\mwsoft\utilitie, while all data and support files are placed in a sub-directory just *below* c:\mwsoft; its path is c:\mwsoft\utilitie\mwdata5. The installer will *also* create an attractive desktop shortcut icon for your use.

The *first* time you run the program you'll be asked to enter your 17 character Registration Code. Be *careful* as it is a *mix* of upper/lower case letters and numbers, and is *case* sensitive. If you make an entry error, you'll be asked again to enter the code.

The **Utilities+** program is now *ready* to run!

## How to Uninstall Utilities+

In Windows, using 'My Computer,' or 'Explorer,' navigate to c:\mwsoft. Now, if this is the ONLY program of ours that you have, delete the c:\mwsoft folder. If you also have *other* programs, and only want to delete this program, open c:\mwsoft and delete \utilitie.

# UTILITIES+ MODULE

## Introduction

You will enter the **Utilities+ Module** from the **Main Menu**. Note that ***all*** the menu choices are attached to "hot keys." All you need do is enter the letter, either lower or upper case, corresponding to your choice of program, and you'll go there immediately.

Please *carefully* follow the data input format used in the examples, and place ***commas*** between numbers as shown; use ***no*** spaces. In every case, thanks to "hot keys," you may press **<Enter>** to ***quit*** a program and return to the **Main Menu**.

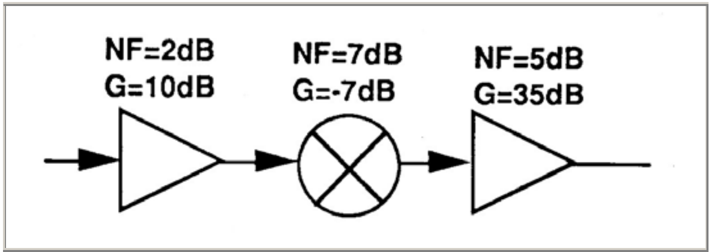
# CASCADE NOISE FIGURE

The sketch below shows a three-stage cascade of two amplifiers and a mixer. Each element is specified in terms of noise figure and gain. Note that the *gain* of a ***passive*** element, in this case a mixer, is actually a ***loss*** so its gain is entered as a ***negative*** number.

**Cascade Noise Figure**

**Calculate the noise figure and noise temperature of a cascaded network**

**Enter # of Stages [<Enter>=Quit] ? _**




In answer to the question up above, specify "**3**" stages and press **<Enter>**.

**Enter NF and Gain of Stage 1 : ? _**

Enter NF and gain of Stage 1 as "**2,10**" (note the ***comma*** between the two numbers) and press **<Enter>**.

In similar fashion, enter the NF and gain of the remaining two stages. Note that the entry for *Stage 2* should be "**7,-7**" because it's a *passive* element.

Here is the output calculation for the three-stage cascade:

**Noise Figure = 4.871 dB**
**Noise Temp = 600.238 deg K**

Press **<Enter>** to return to the **Main Menu**.

# BOND WIRES

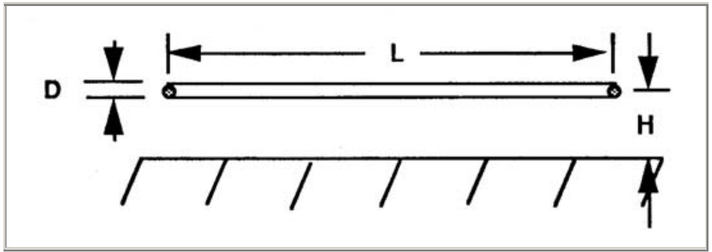
The sketch below shows a gold bond wire suspended in air above a ground plane. Note: 1 mil = 1/1000 in.

See Reference 4 in Appendix C for additional information. If you visit Appendix C, press *BACK* on your browser to return here.

**Bondwire**

**Calculate the inductance, resistance, and Q of a gold wire**
**above ground.**

**L,D,H (mils), F(GHz) [<Enter>=Quit] ? _**




Assume a 1 mil bond wire 125 mils long and 50 mils above ground at a frequency of 10 GHz. Input data as "**125,1,50,10**" and press **<Enter>**.

Here is the output calculation for the gold bondwire:

| | | |
|---|---|---|
| **Inductance** | **=** | **2.954 nH** |
| **Impedance** | **=** | **185.592 ohms** |
| **Resistance** | **=** | **1.235 ohms** |
| **Q** | **=** | **150.318** |

Note: "Q" = Quality Factor

Press **<Enter>** to return to the **Main Menu**.

# PI-NETWORK MATCHING

The sketch below shows a Pi-Network match between R1 to R2.

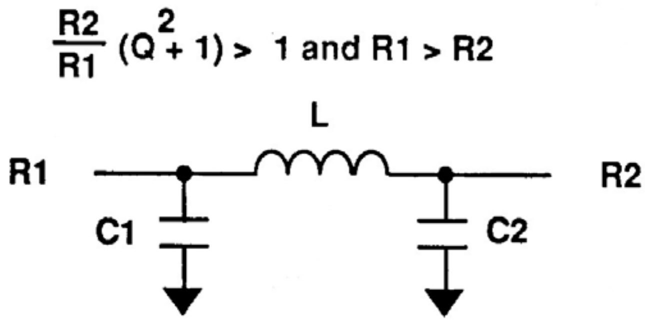
**PI-Network Matching**

**Calculate a network to match between two resistive loads,**
**R1 and R2.**

**R1,R2,Q,F(MHz) [<Enter>=Quit] ? _**

**Note: R1 > R2     Units: ohms, MHz**

**You should choose R1, R2, and Q such that:**




Let's design a network to match a 100 ohm load to a 50 ohm source at 150 MHz with the quality factor Q=4. Input data as "**100,50,4,150**" and press **<Enter>**.

Here is the output calculation for the Pi-Network impedance match network:

> **C1 = 4.2441E-11  F    (42.441 pF)**
> **C2 = 5.8115E-11  F    (58.115 pF)**
> **L = 4.2058E-08 H      (42.058 nH)**

Press **<Enter>** to return to the **Main Menu**.

# WYE/DELTA TRANSFORMATIONS

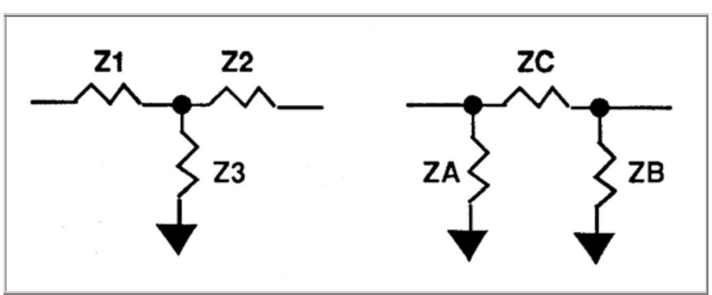
The sketch below identifies the Wye Network & Delta Network (T or Pi) elements.

**Wye/Delta Transformations**

**Convert a Wye-network to a Delta and vice versa.**

**Note: Elements are either resistive *OR* reactive.**

**Wye/Delta or Delta/Wye (1 or 2) [<Enter>=Quit] ? _**



Let's convert a T-Pad to a Pi-Pad. A 3 dB 50 ohm T-Pad has Z1=Z2=8.550 ohms, and Z3=141.926 ohms. First, in answer to the question up above, choose "**1**" and then input "**8.550,8.550,141.926**" and press **<Enter>**.

Here is the output calculation for the T to Pi conversion:

**ZA = ZB = 292.402 ohms (270 ohms 5%)**
**ZC = 17.615 ohms (18 ohms 5%)**

Press **<Enter>** to return to the **Main Menu**.

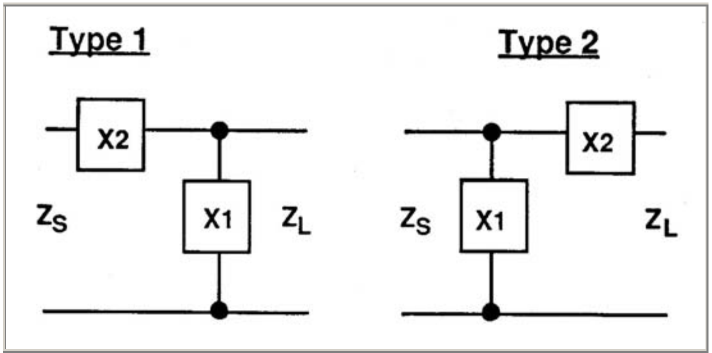
# L-MATCH NETWORKS

In general, there are ***four*** two-element networks. However, in actual practice, usually only two are realizable. The sketch below identifies a **Type 1** and a **Type 2** form. Each creates ***two*** circuits.

**L-Match Networks**

**Given the source and load impedance, calculate reactance**
**values for impedance match networks.**

**Enter Load Z (RL,XL) [<Enter>=Quit] ? _**




Let's match a 50 ohm source to a 100+j20 load. In answer to the *above* question, enter "**100,20**" (make sure you put a ***comma*** between the two numbers) and press **<Enter>**. Next input "**50,0**" and press **<Enter>** again.

Here is the **Type 1** circuit calculation:

**Ckt #1: X1 = 123.923 ohms, X2 = -51.962 ohms**

**Ckt #2: X1 = -83.923 ohms, X2 = 51.962 ohms**

Press **<Enter>** to return to the **Main Menu**.

## REF/MISMATCH/VSWR

**<u>Ref/Mismatch/VSWR</u>**

**Convert between Reflection Coefficient, VSWR, Return Loss,
and Mismatch loss.**

**Note: Enter R.L.(dB) and M.L.(dB) as *positive* values.**

**1. Ref/VSWR**
**2. VSWR/Ref**
**3. RL/Ref**
**4. Ref/RL**
**5. ML/Ref**
**6. Ref/ML**

**Choose (1-6) [<Enter>=Quit] ? _**

Let's try the Ref/VSWR conversion. Choose "**1**" from the list above and press **<Enter>**. Input "**.333**" and press **<Enter>** once again.

Here is the output calculation:

**VSWR = 1.999**

Try the RL/Ref conversion. Choose "**3**" from the list and press **<Enter>**. Input "**15**" and press **<Enter>** once again.

Here is the output calculation:

**Ref. Coeff. = 0.178**

Press **<Enter>** to return to the **Main Menu**.

## Z/REF - REF/Z

**Z/Ref - Ref/Z**

**Convert between impedance and reflection coefficient.**

**1. Z to Ref. Coeff.**
**2. Ref. Coeff. to Z**

**Choose (1-2) [<Enter>=Quit] ? _**

Let's try the Z to Ref. Coeff. conversion. Choose "**1**" from the list above and press **<Enter>**. Input "**100,20,50**" to specify an impedance of 100+j20 ohms in a 50 ohm system, and press **<Enter>** once again.

Here is the output calculation:

**Ref. Coeff. = 0.356 at 14.207 deg.**

Try it back the ***other*** way using different data. Choose "**2**" and press **<Enter>**. Input "**2.149,148.3,50**" to specify the input reflection of a negative resistance oscillator as 2.149 at an angle of 148.3 degrees, in a 50 ohm system, and press **<Enter>** once again.

Here is the output calculation:

**Z = -18.505 +j 12.175 ohms**

Press **<Enter>** to return to the **Main Menu**.

## HYPERBOLIC FUNCTIONS.

**Hyperbolic Functions**

**Calculate normal and inverse hyperbolic functions.**

**1. Sinh (x)**
**2. Cosh (x)**
**3. Tanh (x)**
**4. Csch (x)**
**5. Sech (x)**
**6. Coth (x)**

**7. Sinh-1 (x)**
**8. Cosh-1 (x)**
**9. Tanh-1 (x)**

**Choose (1-9) [<Enter>=Quit] ? _**

Let's find Sinh(.2). Press "**1**" and then **<Enter>**, or use the "**F1**" function key. Enter "**.2**" and press **<Enter>** once again.

Here is the output calculation:

**Sinh( 0.2000) = 0.2013**

Let's try Tanh(3). Press "**3**" and then **<Enter>**, or use the "**F3**" function key. Enter "**3**" and press **<Enter>** once again.

Here is the output calculation:

**Tanh( 3.0000) = 0.9951**

Press **<Enter>** to return to the **Main Menu**.

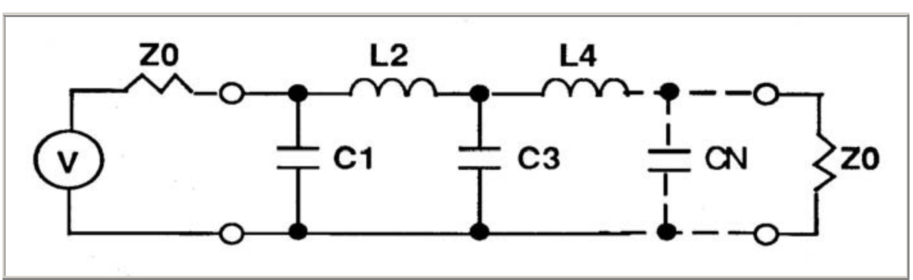
## BUTTERWORTH LOW-PASS FILTER

**<u>Butterworth Low-Pass Filter</u>**

**Calculate component and normalized 'g-values' for Butterworth low-pass filters between equal termination's given N, Z0, and Freq (10 element max.).**

**Enter N,Z0, and F(MHz) [<Enter>=Quit] ? _**

The sketch below identifies the Butterworth filter elements.



Let's design a 3 element 50 ohm low-pass filter with a 3 dB cut-off frequency of 10 MHz. In response to the question above, input "**3,50,10**" and press **<Enter>**

Here are the calculated component values and the normalized 1-ohm / 1 radian 'g-values.'

| | |
|---|---|
| | **[g( 0 ) = 1.00000]** |
| **C( 1 ) = 3.1831E-10 F** | **[g( 1 ) = 1.00000]** |
| **L( 2 ) = 1.5915E-06 H** | **[g( 2 ) = 2.00000]** |
| **C( 3 ) = 3.1831E-10 F** | **[g( 3 ) = 1.00000]** |
| | **[g( 4 ) = 1.00000]** |

Press **<Enter>** to return to the **Main Menu**.

# CHEBYSHEV LOW-PASS FILTER

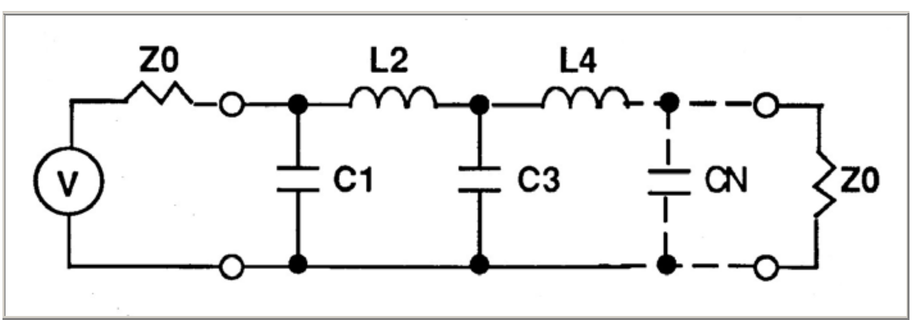
**<u>Chebyshev Low-Pass Filter</u>**

**Calculate component and normalized 'g-values' for Chebyshev low-pass filters between equal termination's given N, Z0, Ripple, and Freq (10 element max.).**

**Enter N,Z0,Rip, and F(MHz) [<Enter>=Quit] ?**

**_**

The sketch below identifies the Chebyshev filter elements.




Let's design a 3-element 50 ohm low-pass filter with a .1 dB ripple cut-off frequency of 10 MHz. In response to the question up above, input "**3,50,.1,10**" and press **<Enter>**.

Here are the calculated component values and the normalized 1-ohm / 1 radian 'g-values.'

**[g( 0 ) = 1.00000]**
**C( 1 ) = 3.2836E-10 F [g( 1 ) = 1.03156]**
**L( 2 ) = 9.1307E-07 H [g( 2 ) = 1.14740]**
**C( 3 ) = 3.2836E-10 F [g( 3 ) = 1.03156]**
**[g( 4 ) = 1.00000]**

Press **<Enter>** to return to the **Main Menu**.

# FANO BANDWIDTH LIMIT

For more information on the Fano Bandwidth Limit program, see Reference 2 in Appendix C. If you visit Appendix C, press *BACK* on your browser to return here.

**Fano Bandwidth Limit**

**Calculate the minimum theoretical VSWR across a band F1/F2**
**given a series or parallel RC or RL load.**

**Units: MHz,ohms,nH, and pF**

**Enter F1 and F2 (F1,F2) [<Enter>=Quit] ? _**

Let's determine the ***best*** match possible, using a network with an ***infinite*** number of elements, for a FET over the range of 8-18 GHz. The FET is modelled as a series RC network with R=15 ohms and C=0.5 pF. Input "**8000,18000**" and press **<Enter>**.

**Enter Load (PRC,SRC,PRL,SRL) ? _**

Type "**SRC**" and press **<Enter>** once again.

**Enter RC values (R,C) ? _**

Finally, enter the FET input values as "**15,.5**" and press **<Enter>**.

Here is the output calculation

**Min. VSWR across band = 1.269**

Press **<Enter>** to return to the **Main Menu**.

# LINE LENGTH

**Line Length**

**Calculate the electrical or physical length of a transmission**
**line given its dielectric constant (Er), frequency, and length in**
**either degrees or inches.**

**Units:  MHz,degrees,inches**

**Enter Elec. or Phys. length (E/P) [<Enter>=Quit] ? _**

Let's try a few simple conversions. Suppose you had a stripline stub at 4 GHz; its on Teflon (Er=2.5), and it is 0.233 in. long. What is its electrical length?

First, in answer to the question above, input "**P**," to specify the *physical* line length, and press **<Enter>.** Then input "**4000,.233,2.5**" (no spaces - just a comma between numbers) and press **<Enter>** once again.

Here is the output calculation

**Theta = 45.022 degrees**

Now let's try it another way. You need a quarter-wave stub on microstrip. The effective relative dielectric constant, Er', obtained from our **MStrip+** program, is 6.7, and the frequency is 2735 MHz. How *long* should the line be?

Here is the output calculation

**Length = 0.416 inches  (416 mils)**

Press **<Enter>** to return to the **Main Menu**.

# OST/SST STUBS

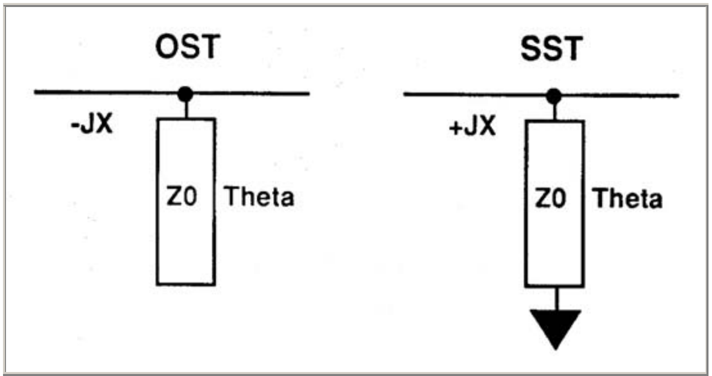
A stub is defined as a transmission line whose electrical length is < = 90 degrees. A sketch of an *open* stub. an **OST**, and a *shorted* stub, an **SST**, is shown below.

**OST/SST Stubs**

**Calculate the input impedance of open (OST), and shorted**
**(SST) stubs.**

**Units: ohms,degrees**

**Choose OST/SST (O or S) [<Enter>=Quit] ? _**




Assume you have a shorted 62 ohm microstrip stub that is 40 degrees long at its operating frequency. What is its input impedance?

First, in answer to the question above, input "**S**," to specify a *shorted stub*, an **SST**, and press **<Enter>.** Next, input "**62,40**" and press **<Enter>** once again.

Here is the output calculation

**Z in = +j 52.024 ohms**

Tip: Since Tan 45 & Cot 45 = +/-1, a 45 degree (eighth-wave) shorted stub whose Z0 is 50 ohms has Z in = +j 50 and an open stub has Z in = -j 50 ohms. By the *same* token, a 45 degree (eighth-wave) SST/OST whose Z0 is 30 ohms, has Z in = +j 30 and -j 30, respectively. Make sense?

Press **<Enter>** to return to the **Main Menu**.

# REACTANCE CHART

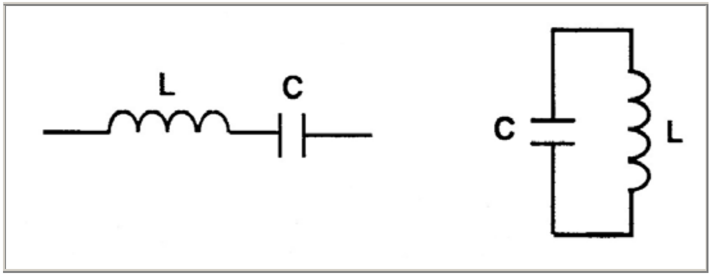
**<u>Reactance Chart</u>**

**Calculate any one value in a resonant circuit given the other two.**

**Units: MHz,nH,pF**

**1. L**
**2. C**
**3. F**

**Choose (1-3) [<Enter>=Quit] ? _**




As an example, assume you have a 22 pF mica capacitor in hand, and you want to wind a small toroid, maybe on a Micrometals core, and want to make a high-Q trap at 100 MHz, What inductance do you need?

In answer to the question up above the graphic, choose "**1**" and press **<Enter>.** Next, input "**22,100**" and press **<Enter>** once again.

Here is the output calculation

**L = 115.138 nH**
**XL = 72. 343 ohms**

Press **<Enter>** to return to the **Main Menu**

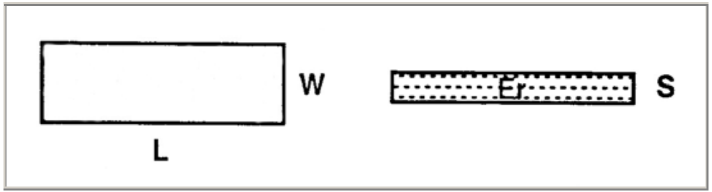
# PARALLEL PLATE CAPACITANCE

**Parallel Plate Capacitance**

**Calculate the capacity of parallel plates or thin strips given length (L), width (W), spacing (S), and Er.**

**Units: inches**

**Enter W,L,S, and Er (W,L,S,Er) [<Enter>=Quit] ? _**




You're trying to improve your *real world* circuit schematic by "sucking in" the capacitance of circuit board mounting pads. What is the parasitic capacity of a 1/8 inch square pad on a piece of .062 in. thick teflon-glass with Er=2.55 ?

In answer to the data input request above, input "**.125,.125,.062,2.55**" and press **<Enter>.**

Here is the output calculation:

**C = 0.145 pF**

Press **<Enter>** to return to the **Main Menu**.

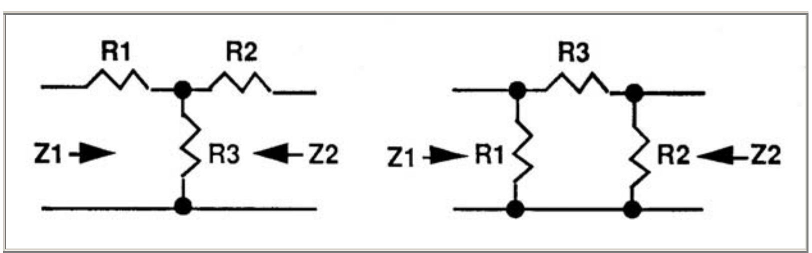
# T/PI PADS

**<u>T/Pi Pads</u>**

**Calculate the minimum loss and resistance values for T**
**and Pi pads.**

**Units: ohms,dB**

**Choose T or Pi (T or P) [<Enter>=Quit] ? _**




What are the resistor values needed to make a 3 dB T-Pad to use in a 50 ohm system?

Type "**T**" above, and press **<Enter>.**

**Z1,Z2 [Z1>=Z2] ? _**

Input "**50,50**" and press **<Enter>.**

Here is the first output calculation

**Min. Loss = 0.000 dB**

**Desired Loss (dB): ? _**

Input "**3**" as the desired pad loss and press **<Enter>.**

Note: Always enter the ***desired*** pad loss as a ***positive*** number.

Here are the resistor calculations for the 3 dB T-Pad:

**R1 = 8.550 ohms**
**R2 = 8.550 ohms**
**R3 = 141.926 ohms**

Note 1: If the above pad was fabricated for use at low frequencies, using standard 5% resistors, the *closest* values would be: 10, 10, and 150 ohms. This would introduce a *small* error. Theoretically, as can be determined using our **Sceptre** program, the loss would be 3.17 dB and would introduce a VSWR of 1.057.

Note 2: If **Z1>Z2**, i.e., there is a ***mismatch*** in resistance at each end, then there is a certain ***minimum*** attenuation that can be achieved. Try a Pi-Pad with Z1=75 and Z2=50 (Z1 *must* be > Z2). Note that the ***minimum*** loss is 5.719 dB, so, practically speaking, a 6 dB pad is the *nominal* minimum sized pad because of the additional requirement to "match" between 75 and 50 ohms.

Press **<Enter>** to return to the **Main Menu**.

# SINGLE-LINE MATCHING

This is a space saving narrow band technique for matching between two *complex* impedances, such as usually found in an interstage network. For information on *how* the closed form design equations came about, see Reference 1, by Microwave Software President, James J. Lev, in Appendix C. Note: Use the *BACK* button on your browser to return to this page.

**Single-Line Matching**

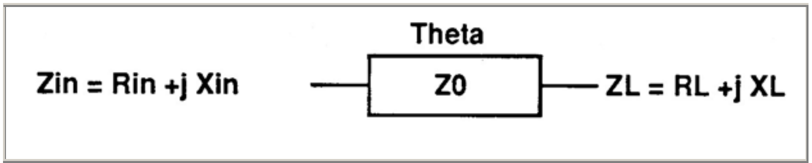
**Calculate the Z0 and electrical length of a *single* transmission**

**line to match between two different complex impedances.**

**Units: ohms,degrees**

**Note: Re Zin <> Re Z Load *and* both > 0.**

**Enter RL,XL (Z Load) [<Enter>=Quit] ? _**




Let's match a complex load impedance of 100+j25 ohms to a complex source of 30+j20 ohms.

Type "**100,25**" when asked to enter "**RL,XL (Z Load)**" up above, and press **<Enter>**. You'll next be asked:

**Enter RI,XI (Z in)**

Be ***careful*** here, its *easy* to jump too quick: If the source impedance is really 30+j20 ohms, we want Zin of the single-line match circuit to equal its ***complex conjugate*** impedance.

Note the use of a ***minus*** sign below to specify the conjugate impedance:

Input "**30,-20**" and press **<Enter>**.

Here is the output calculation:

**Z0 = 51.927 ohms**
**Theta = 71.022 deg.**

Press **<Enter>** to return to the **Main Menu**.

# WAVEGUIDE CALCULATIONS

An important use for this program is to determine the proper housing size for an amplifier, or any other network that exhibits gain. The housing size chosen should function as a *waveguide below cut-off*, with the attenuation ***greater*** than the gain within the housing.

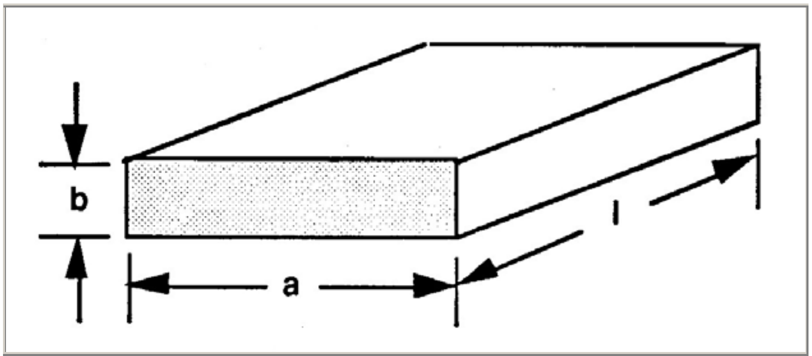
Also, check carefully that there are ***no*** cavity resonances anywhere near or within the band of use.

**<u>Waveguide Calculations</u>**

**Calculate the waveguide cut-off frequency given the wide and narrow dimensions, plus the attenuation and lowest cavity resonance mode given *housing* length, if the "box" were closed at *both* ends as in an amplifier housing.**

**Units: MHz,dB,inches**

**Enter Wide and Narrow dim (W,N) [<Enter>=Quit] ? _**




**Note: a = wide dimension, b = narrow dimension, and l = length**

Let's look at a housing for a 30 dB gain narrow band microstrip amplifier operating in the range of 2100-2300 MHz. Our mechanical draftsman would ***like*** to use a 1.5 X 0.5 X 2.0 inch box. Will it work?

Type "**1.5,.5**" above, and press **<Enter>** to calculate the lowest order cut-off frequencies - there are *two* different modes. Since screen space is limited, what we show below is similar to what you'll see:

Here are the results of the first calculation:

**TE10 Cutoff = 3924.333 MHz**
**TE01 Cutoff = 11803.000 MHz**

The next question asked of you will be:

**Compute attenuation/in. (Y/N): ? _**

Type "**Y**" to answer the above and press **<Enter>**. You'll then be asked to input the frequency. Use the high end amplifier frequency of 2300 MHz, or a higher one if there is still *significant* gain, and then press **<Enter>** once again.

Here is your ***simulated*** input of "**2300**" below along with the continuing output calculations:

**Enter Freq (MHz): ?** 2300

**TE10 Att. @ 2300.000 MHz = 14.759 dB/in.**

**TE01 Att. @ 2300.000 MHz = 53.5299 dB/in.**

The next question will be:

**Calc TE101 cavity resonance (Y/N): ? _**

Continue the calculations by answering "**Y**" to the above and pressing the **<Enter>** key. Now you'll be asked to enter the *length* of the waveguide, i.e., the box. We've ***simulated*** your data input of "**3**" representing the length of the box below:

**Enter length of guide: ?** 3

**TE101 cavity resonance @ 4398.718 MHz**

**Att. = 44.278 dB @ F = 2300.000 MHz**

The attenuation thru the box, from end to end, at 2300 MHz, will be slightly ***higher*** than theory predicts due to surface roughness inside the box. Also, the cut-off and cavity resonance frequencies may be slightly ***lower*** due to dielectric loading.

Press **<Enter>** to return to the **Main Menu**.

## SERIES/PARALLEL CONVERSION

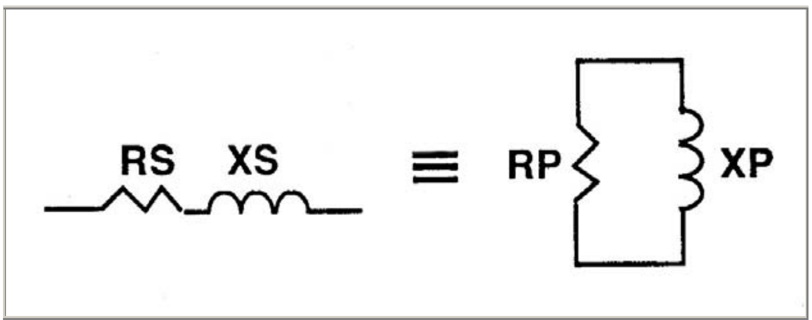
At any one frequency, a series impedance may be converted to its ***equivalent*** parallel form, and vice versa. This is a very handy tool for match network design.

**Series/Parallel Conversion**

**Convert impedances between their Series and Parallel forms.**

**Units: ohms**

**Input Ser or Par Z (S or P) [<Enter>=Quit] ? _**




Let's do a series to parallel conversion and find the parallel equivalent of a series impedance of 25 + j30 ohms. Enter "**S**" at the prompt up above and press **<Enter>**.

**Enter RS,XS: ? _**

Type "**25,30**" above and press **<Enter>** once again.

Here is the output calculation:

**RP = 61.000 ohms**
**XP = 50.833 ohms**

Press **<Enter>** to return to the **Main Menu**.

# TRL2 MATCH

It's a *well known* fact that a 45 degree (eighth-wave) length of transmission line will translate any ***real****complex impedance* to a pure *real* resistive value. It's *also* well known that a 90 degree (quarter-wave) transmission line will translate one real value into another real value. A really ***nice*** narrow band match scheme is to use a *tandem* connection of quarter-wave and eighth-wave lines to translate a complex impedance into a real one.

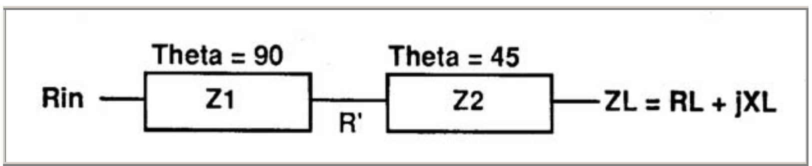
In the sketch below, section Z2 is the eighth-wave transmission line section. It translates ZL, which is complex, into R', the mid-point pure resistance. Line section Z1, a quarter-wave long transmission line, then translates R' to Rin.

**TRL2 Match**

**Match a complex load ZL = RL + jXL to a real input, Rin,**
**using eighth-wave and quarter-wave lines.**

**Units: ohms,degrees**

**Enter Rin,RL,XL [<Enter>=Quit] ? _**




As an example, consider a need to match a 10+j15 ohm load to a 50 ohm source. At the prompt above, enter "**50,10,15**" and then press **<Enter>**.

Here is the output calculation:

**Z1 = 55.358 ohms**
**Z2 = 18.028 ohms**

**R' = 61.290 ohms**

Press **<Enter>** to return to the **Main Menu**.

# LINEAR FIT

This program does a straight line linear interpolation between two points, identified as ordered pairs, (X1,Y1) and (X2,Y2). You then input X and it calculates the corresponding value of Y.

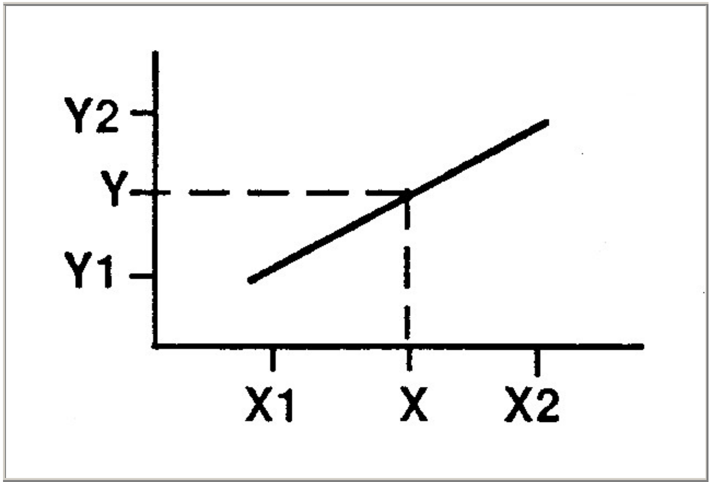
**Linear Fit**

**Straight line linear interpolation between two points (X1,Y1)**

**and (X2,Y2).**

**Note: X1 *must* be < X2**

**Enter X1,Y1 [<Enter>=Quit] ? _**




Given the two ordered pairs (1.5,.8) and (4,3.1), what is Y for X=3 ?

Enter X1,Y1 above as "**1.5,.8**" at the prompt up above and then press **<Enter>**. At the second prompt, enter "**4,3.1**" and press **<Enter>** once again.

Next, you're asked to enter a value for X:

**Enter X: ? _**

Input "**3**" and press **<Enter>**.

Here is the output calculation:

**Y = 2.1800**

Press **<Enter>** to return to the **Main Menu**.

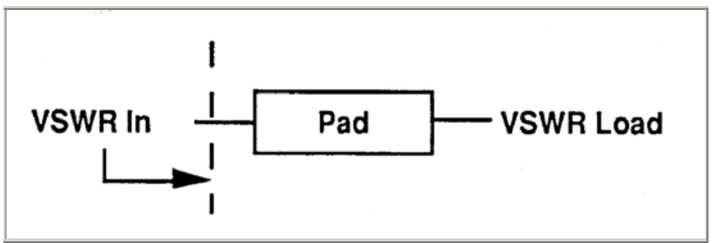
# VSWR VS. PAD

This program lets you calculate the VSWR you get when a resistive pad is inserted ***ahead*** of a high VSWR load - Case 1. Or, it lets you determine the size of T-pad or Pi-Pad required to reduce a given VSWR to a specified lower level - Case 2.

**VSWR vs. Pad**

**Calculate VSWR with a pad inserted ahead of a high VSWR**
**load: Case 1**
*-or-*
**Determine the pad required to attain a specific input VSWR:**
**Case 2**

**Case 1 or 2 (1 or 2) [<Enter>=Quit] ? _**




Let's assume we have a load VSWR of 5. If we insert a 3 dB pad ahead of the load, what will the input VSWR be?

Choose Case 1 by typing a "**1**" at the prompt above and then press **<Enter>**.

Answer the ***next*** two questions about load VSWR and pad size by entering "**5**" and then "**3**." Press **<Enter>** after *each* entry.

Here is the output calculation:

**VSWR in = 2.004**

Press **<Enter>** to return to the **Main Menu**.

# WIRE TABLE

For more information about this program, see Reference 3 in Appendix C. Be sure to press the *BACK* button on your browser to return to this page.

**Wire Table**

**Convert AWG wire gauge to diameter in mils, (1000's of an**
**inch), and compute nominal turns/inch**

**Enter AWG# [<Enter>=Quit] ? _**

What is the diameter and turns/inch of American Wire Guage, AWG #20 buss wire?

Input "**20**" above and then press **<Enter>**.

Here is the output calculation:

**Diameter = 32.0 mils**
**Turns/in. = 27.1**

Press **<Enter>** to return to the **Main Menu**.

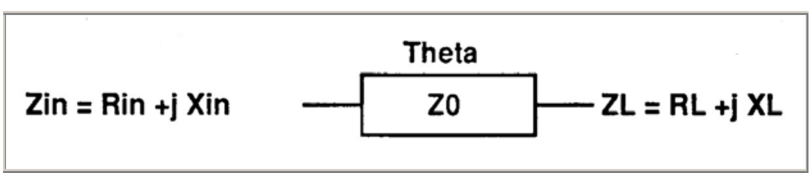
# T-LINE Z TRANSFORMATION

**T-Line Z Transformation**

**This program calculates the input Z of a lossless transmission line given the Z0, electrical line length, theta, and the load Z = RL +j XL.**

**Units: ohms,degrees**

**Enter Z0,Theta,RL and XL [<Enter>=Quit] ? _**




This program is *very* easy to use, just enter the four parameters asked for above, each separated by a ***comma***, and press **<Enter>**.

As an example, consider a 50 ohm transmission line that is a quarter-wave, (90 degrees), long at its operating frequency. If the load impedance is 75+j10, what is the input impedance?

Input "**50,90,75,10**" at the prompt up above and then press **<Enter>**.

Here is the output calculation:

**Rin = 32.751 ohms**
**Xin = -j4.367**

Press **<Enter>** to return to the **Main Menu**.

## AIR COILS

**Air Coils**

**Calculate the inductance, # of turns, radius, or wire diameter of an air coil given any 3 of the 4 coil parameters.**

**Units: uH,inches**

**1. L (uH)**
**2. # Turns**
**3. Radius (in.)**
**4. Wire diam. (in.)**

**Choose (1-4) [<Enter>=Quit] ? _**

As an example, calculate the inductance of a 0.25 in. radius coil wound with 4 full turns, thru the middle, of AWG #34 gauge wire (diameter = 6.3 mils = 0.0063 in.).

Note: If you don't ***know*** the diameter of a given AWG, (American Wire Guage), wire size, use the **Utilities+ Wire Table** routine first, and then come back here.

To find the unknown inductance, enter "**1**" at the prompt above, then, when asked, input "**4,.25,.0063**" and press **<Enter>**.

Here is the output calculation:

**L = 0.372 uH**

Press **<Enter>** to return to the **Main Menu**.

## MISMATCH ERROR LIMITS

**Mismatch Error Limits**

**This program calculates the +/-(dB) uncertainty in the power**
**transfer between a source and load given the reflection coeffi-**
**cient magnitude of each.**

**Enter S,L Ref.  [<Enter>=Quit] ? _**

Given that the reflection coefficient of a source and a load are >0, or that, alternately, the VSWR is >1, (which is ***always*** the case in the real world), there ***will*** be an uncertainty in the power transfer between the two due to relection.

This program lets you *quantify* that error. If you don't ***know*** the reflection coefficients, but you do have the VSWR, use the **Utilities+** **Ref/MM/VSWR** program *first* to convert VSWR to reflection coefficient magnitude. Press *BACK* on your browser to return to this page.

Assume that we have a VSWR = 1.35 source driving a VSWR = 1.5 load. The reflection coefficients of the source and load are, respectively, 0.15 and 0.2. What is the mismatch uncertainty?

To find the uncertainty, enter the "**S,L Ref.**" reflection data as ".**15,.2**" at the prompt up above, and then press **<Enter>**.

Here is the output calculation:

**+ Error = 0.257 dB**
**- Error = -0.265 dB**

Press **<Enter>** to return to the **Main Menu**.

## PRODUCT SUPPORT

If you think of something we could *add* to this program to make it *better*, please let us know. If we *use* your suggestion, you'll get credit for it, and our sincere thanks. We'll also send you a free up-grade!

### Product Upgrades

From time to time we *up-grade* our software. We do this so we can offer a *better* product, ***and*** because *we* use it ourselves, on a day to day basis, in our RF/Microwave engineering consulting practice.

As a *registered* User of our software, when an up-date becomes available, its FREE, and we'll post information about it on our web site.

## Technical Support

We will help you with problems involving the installation and use of our software, via e-mail, and free of charge.

If you wish *design assistance* with a task you're working on, tell us about it, and we will give you a fixed price quote for a specific task.

Contact Technical Support

## On-Site Support

We can provide on-site support ***and*** training, at ***your*** facility, for all of our software products. When we say support, we ***mean*** support. We'll do a lot *more* than just show you how to install the software, we'll walk you thru trial designs. When we leave, you'll have a good idea as to *how* to design an amplifier, compute line dimensions for a directional coupler, or *how* to synthesize a match network for an antenna, etc. Contact us for availability and details.

Contact Sales

## Software "Bugs"

Bugs happen, even to the best of us. Usually, they come about as a result of a software change that wasn't thoroughly "beta tested,' (our fault), ***or***, because ***you*** did something that none of us ever *thought* you might do, (our fault again). If, by chance, you should uncover a bug, please let us know immediately. We'll correct it, up-date your software, and offer our apologies.

# APPENDIX A

## Directories & Files

Our installation software creates ***three*** directories for use by the ***first*** program of ours that you install. The *top* directory, just off the root, is C:\MWSOFT, the second is the program folder \UTILITIE, and the last, (see about 14 lines below), is \MWDATA5. The tree structure is like what's shown below: However, once you have *one* of our programs, each additional install only creates a *program folder*, and a *datasub-directory* for that software program.

So, if you have all *six* programs, you will have one main directory, six program folders, and *six* sub-directories.


Here are the *names*, below \MWSOFT, of our various program folders and their corresponding data sub-directories:

| | | |
|---|---|---|
| \SMITHMAT | \MWDATA1 | SmithMatch |
| \SCEPTRE | \MWDATA2 | Sceptre |
| \MSTRIP | \MWDATA3 | MStrip+ |
| \OPTIMATC | \MWDATA4 | OptiMatch |
| **\UTILITIE** | **\MWDATA5** | **Utilities+** |
| \SDATA | \MWDATA6 | SData+ |

In the above sketch, your hard drive "Root" is C: Below, (or aside it)  are your system, program, and User created directories. We use the \MWSOFT directory for *all* of our main program .exe files. Its "path" on your hard drive is c:\mwsoft.

In the sketch, only *one* sub-directory named MWDATA is shown for simplicity. In reality, we use a separate data directory for each of our programs. If you have all *six* programs, you will have *six* sub-directories.

A significant advantage to this directory scheme is that, to access a file, you do not need to type a path, just a file name. Each of our programs "knows" that the data files are one level below the program folder.

## Support Files

For **Utilities+**, there currently is no need for support files. However, future revisions of the program *may* require them, so we're creating a \MWDATA5 sub-directory, in advance, during the installation, to simplify your possible up-grade.

Typical support files perform a number of functions. At a minimum, they record program usage, and whether or not you have an on-board clock. In the case of **SmithMatch**, this file records **AR**, your screen aspect ratio. In **OptiMatch**, the files store your preferred unit set, and changes made to algorithm variables.

## .IMP Files

These are impedance files that are used by **SmithMatch**, **Sceptre**, **OptiMatch**, and the **SData+** programs. They are in simple ascii text format and contain three entries per line. These are frequency, Re (Z), and Im(Z). A maximum of *ten* lines of data are allowed.

## .CKT Files

This file type is *only* used by **Sceptre**, our frequency domain analysis program. Like a .IMP file, it is in simple ascii format. However, unlike a .IMP file, it can have any number of lines, and each line carries more data. Parameters like frequency, an s-data matrix, stability factor elements K & B1, gain, etc.

## .S2P Files

This file type is *only* used by **SData+**. It's a *special* type widely used in the industry and may contain s-data, noise data, or both.

# APPENDIX B

## DOS Window Error Messages

Since our programs run in a DOS Window, you may at times get an error message. The most typical one is "File not found," or some such. Not to worry, our DOS Error Handler routine will deal with it.

In DOS, if you make a typing mistake, and enter the name of a file that doesn't exist, or leave a drive door open, etc., your PC will ***beep*** and you'll get an error message on-screen. It can look like the one shown *below*. To cause this error, we tried to compute Tanh-1 (-5) while using the Hyperbolics Functions routine.

**Sorry! Error in the Hyperbolics Program**

**DOS Error Code # 5**
**Reference Line # 821**

**See your DOS Manual for an explanation of the error. A short list of *typical* DOS errors is given below:**

| Error | Translation |
|---|---|
| 5 | Illegal function call |
| 7 | Out of memory |

| | |
|---|---|
| **11** | **Division by zero** |
| **27** | **Out of paper** |
| **53** | **File not found** |
| **61** | **Disk full** |
| **64** | **Bad file name** |
| **71** | **Disk not ready** |
| **76** | **Path not found** |

In the example we show above, DOS Error Code 5 means "**Illegal function call.**" The reference line number refers to our *internal code*, and is only listed in the unlikely event that you come across an error you cannot resolve.

To *recover* from a DOS Window error, follow the on-screen instruction to "**Press any Key**," and you will be returned to the module where the error occurred.

# APPENDIX C

## References

The following technical articles are referred to in the text or may be of general interest to you.

1. Lev, James J., "Microstrip matching networks can be designed fast with a Basic program," ***Electronics***, Pgs. 127-129, December 6, 1973.

2. Lev, James J., "Calculator program finds Fano bandwidth," ***Microwaves & RF***, Pgs. 153-155, September 1985.

3. Siebert, Bill, "Basic program calculates wire sizes," ***Electronic Design***, Pg. 172, February 3, 1983.

4. Theriault, G.E., "LOSLIN," ***Microwave Journal***, Microwave Engineers Handbook & Buyers Guide, Pg. 18, 1975.