

# SI-PI Calculator User's Manual

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## 1. Introduction

This SI-PI Calculator is intended as a tool to assist design Signal Integrity and Power Integrity engineers in their initial stages of the design process. In many of the calculations it is essentially a numerical instantiation of some of Eric Bogatin's "Rules of Thumb" [1] and is in no means a substitute for actual simulations. Many of these calculators can also be found on any number of web sites, but have been consolidated here for convenience of use.

This shareware program is provide "As Is" and free for use by any and all, but comes with no warranty and is not claimed to be free of defects. The author assumes no liability of any kind for the use of this product.

The Saturn PCB Design tool is another very handy tool for the SI and PI engineer. However, at least as of Version 7.03, the tool does not account for any of the work Douglas Brooks, et al., have done in the area of high currents in PCB traces, and lacks a number of the calculators found here-in.

# SI Calculators

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# SI Calculators

## 3. SI Calculators

### 3.1. Impedance Calculators

#### 3.1.1. Single Ended Microstrip

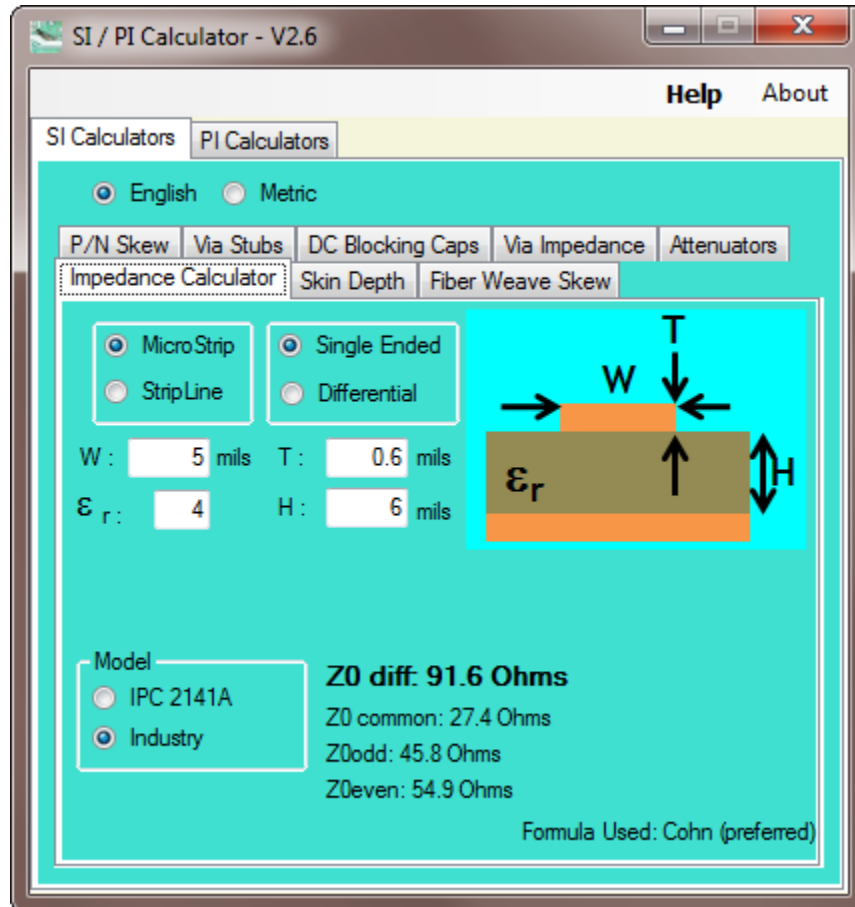


Figure 1: Impedance Calculator Tab – Single Ended Microstrip

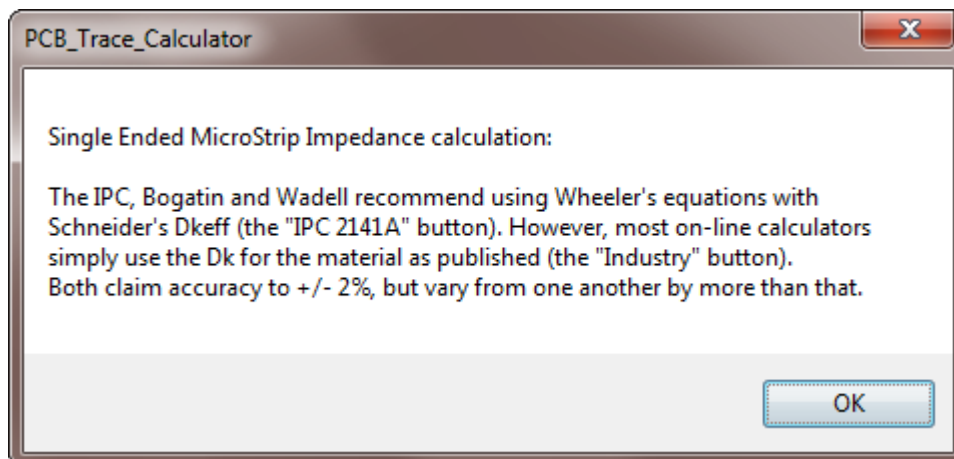


Figure 2: Information on Single Ended Microstrip Impedance Calculations

[2], [3], [4], [5], [6], [7]

## SI Calculators

### 3.1.2. Single Ended Stripline

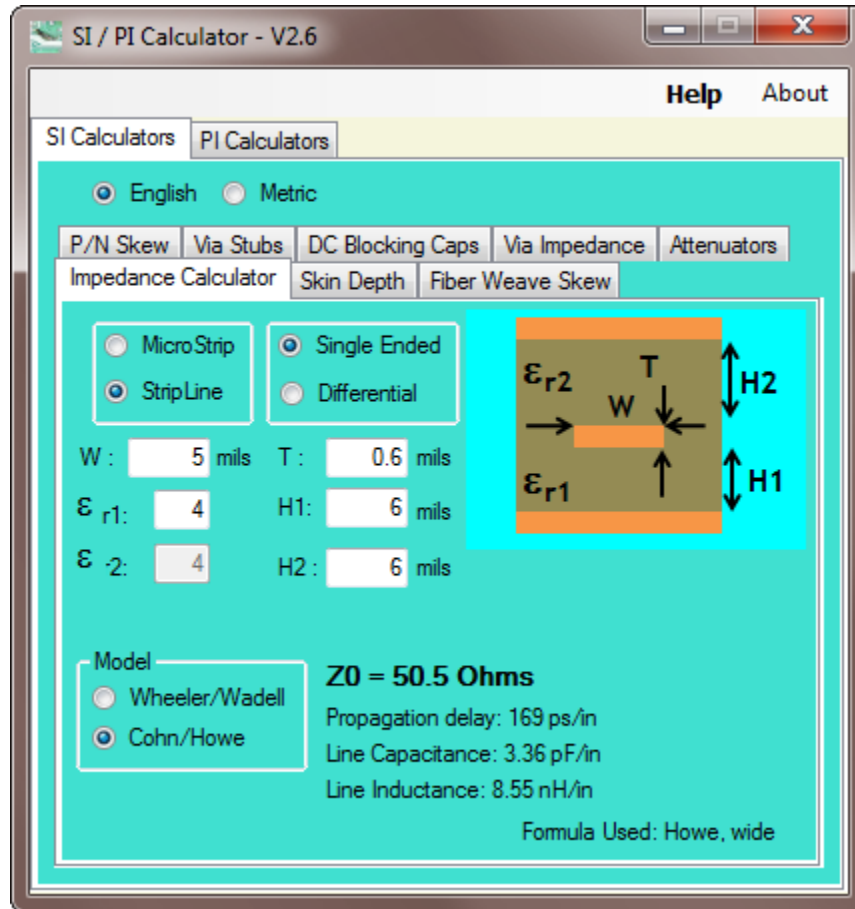


Figure 3: Impedance Calculator Tab – Single Ended Stripline

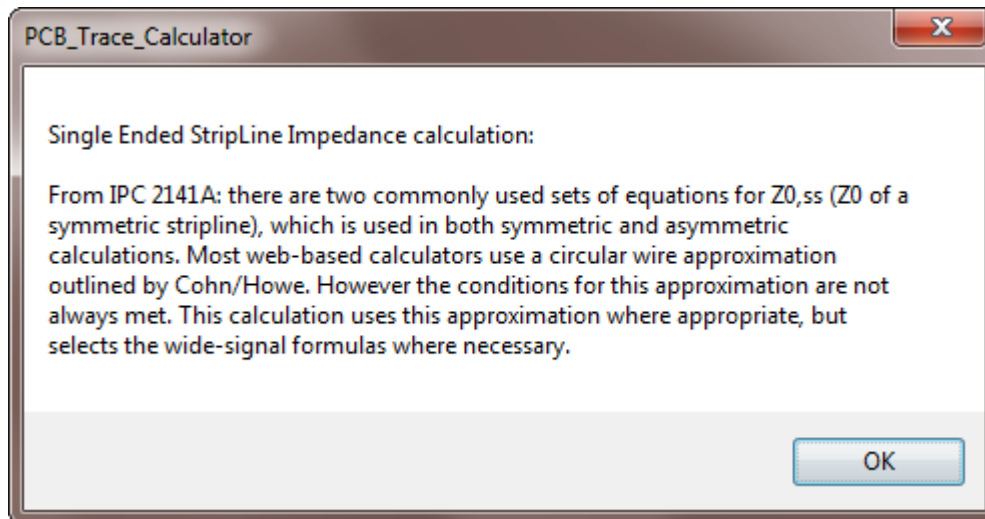


Figure 4: Information on Single Ended Stripline Impedance Calculations

[2], [8], [9], [10]

## SI Calculators

### 3.1.3. Differential Microstrip

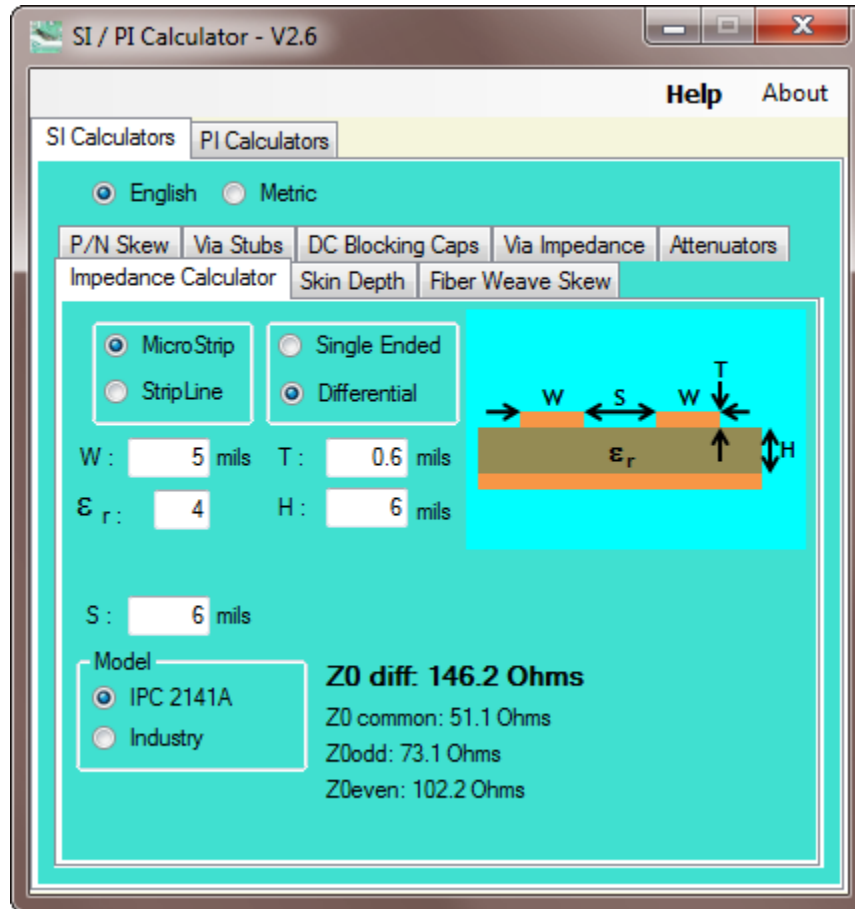


Figure 5: Impedance Calculator Tab – Differential Microstrip

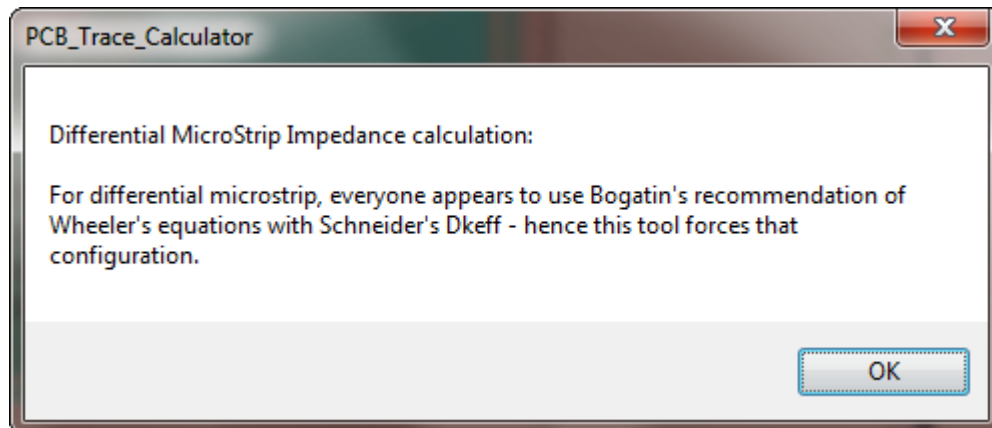


Figure 6: Information on Differential Microstrip Impedance Calculations

[3], [5], [6]

## SI Calculators

### 3.1.4. Differential Stripline

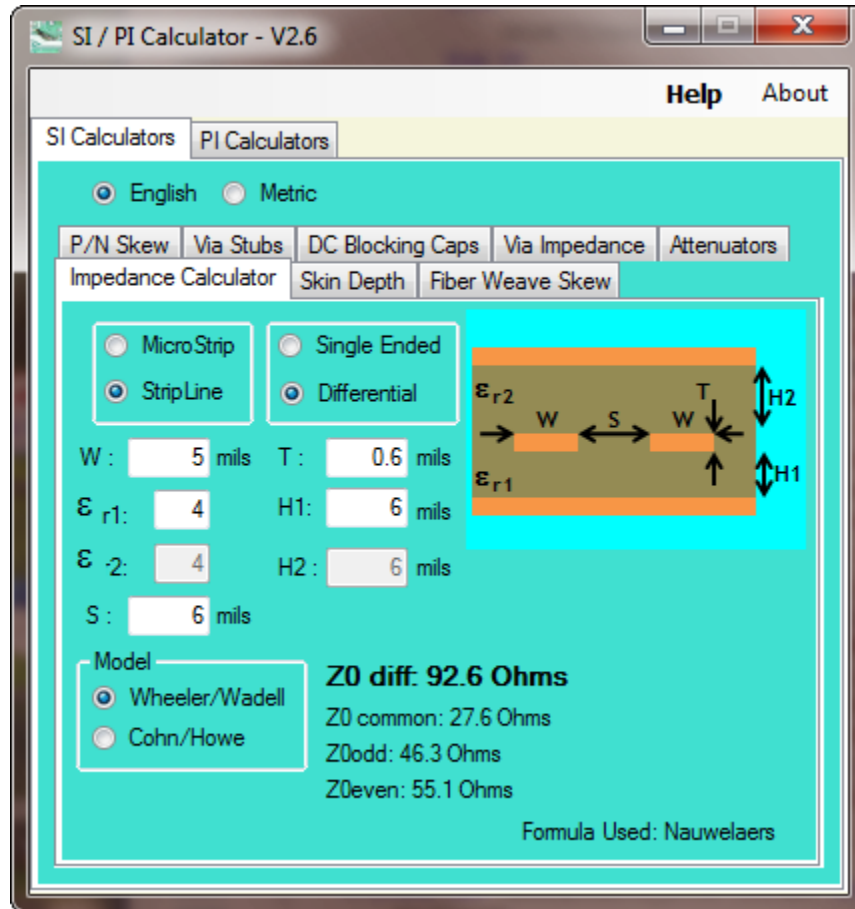


Figure 7: Impedance Calculator Tab – Differential Stripline

#### Differential StripLine Impedance calculation:

The IPC2141A references Wheeler, which in itself references Cohn ("Shielded Coupled-Strip Transmission Line", 1954). Both the IPC2141A and Wheeler have typos and errata associated with them (and the errata itself has some errors). Hence, we go back to the source - Cohn. Additionally, Cohn first presents a calculation/formula for both the odd and even impedance, then provides a "manipulation" of this formula to put it in more common terms - it is this manipulated approximation that shows up in Wadell and IPC 2141A.

Selecting Wheeler/Wadell uses the errata corrected IPC 2141A formulas. Selecting Cohn uses the non-manipulated original Cohn formulas.

Also note, closed formula expressions for asymmetrical differential striplines do not (yet) exist. As such, we only allow for symmetrical differential striplines.

Figure 8: Information on Differential Stripline Impedance Calculations

[2], [4], [10], [11], [12], [13]

## SI Calculators

### 3.2. Skin Depth

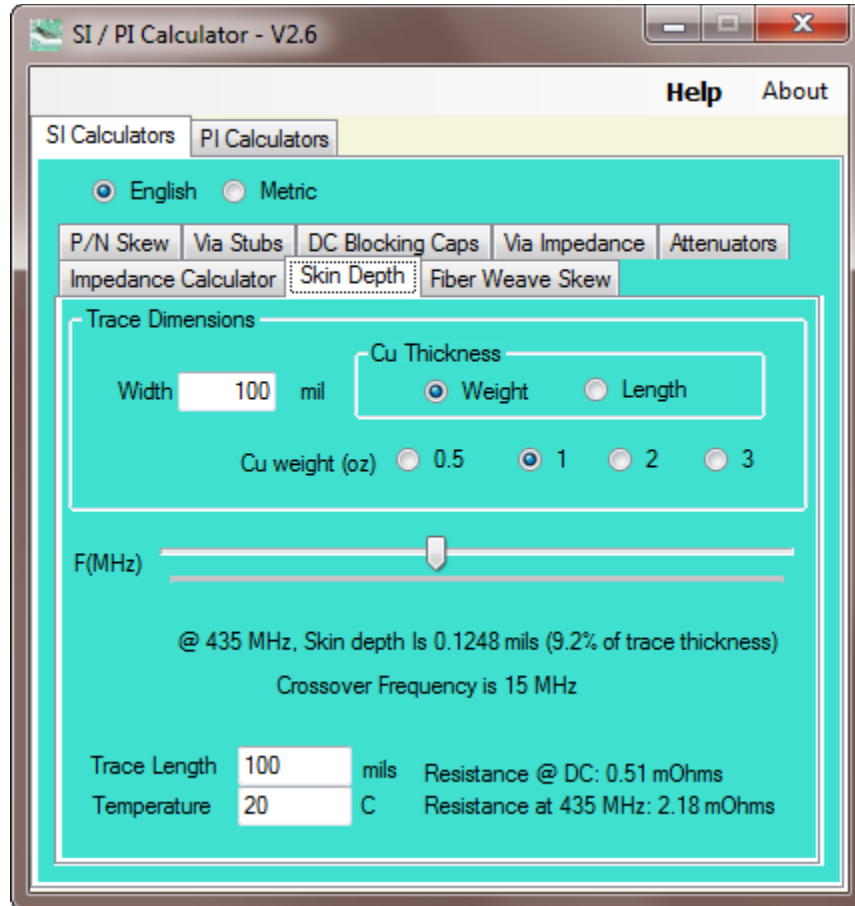


Figure 9: Skin Depth Tab

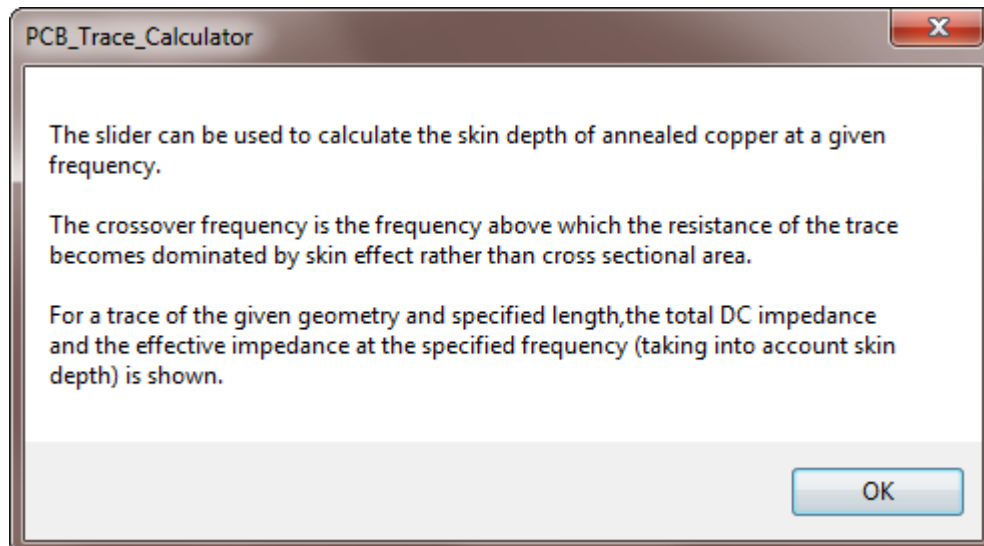


Figure 10: Information on Skin Depth calculations

## SI Calculators

### 3.3. Fiber Weave Skew

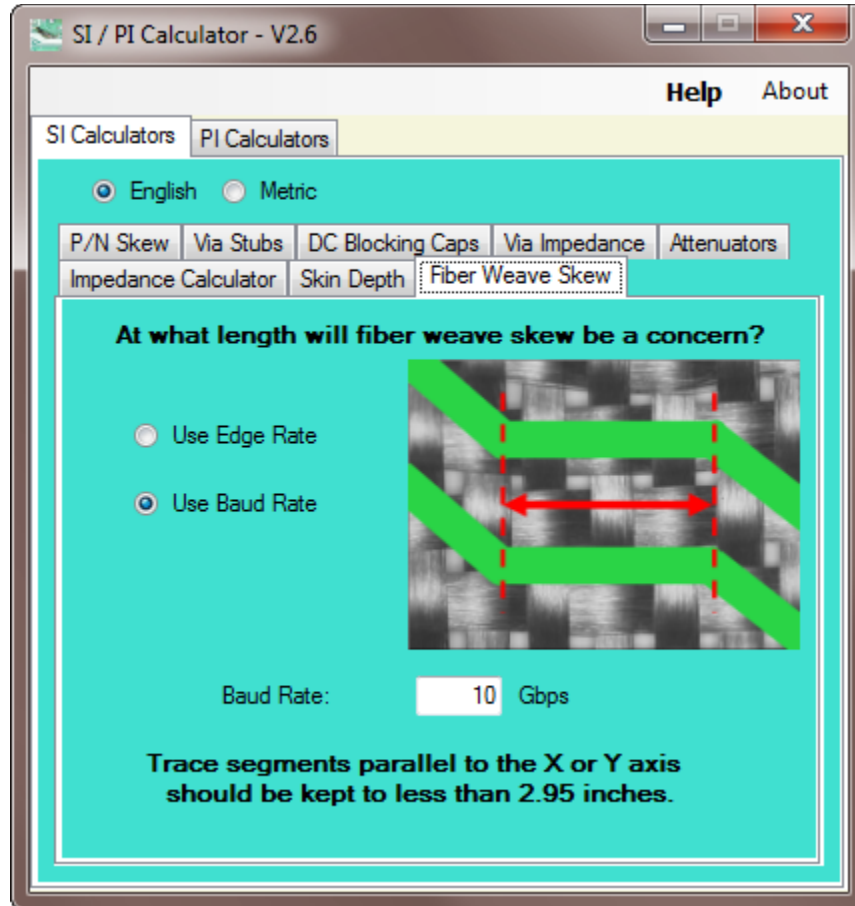


Figure 11: Fiber Weave Skew tab

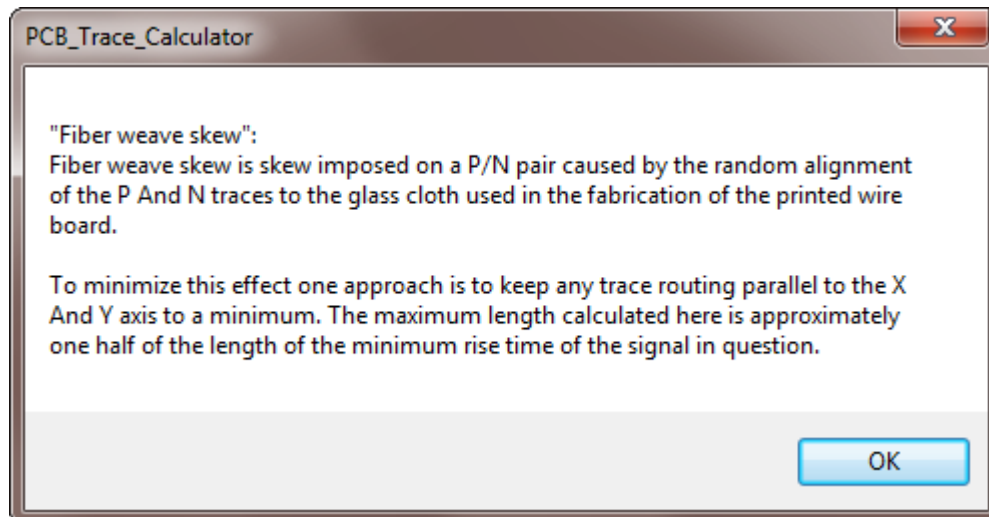


Figure 12: Information on Fiber Weave Skew



## SI Calculators

### 3.4. P/N Skew

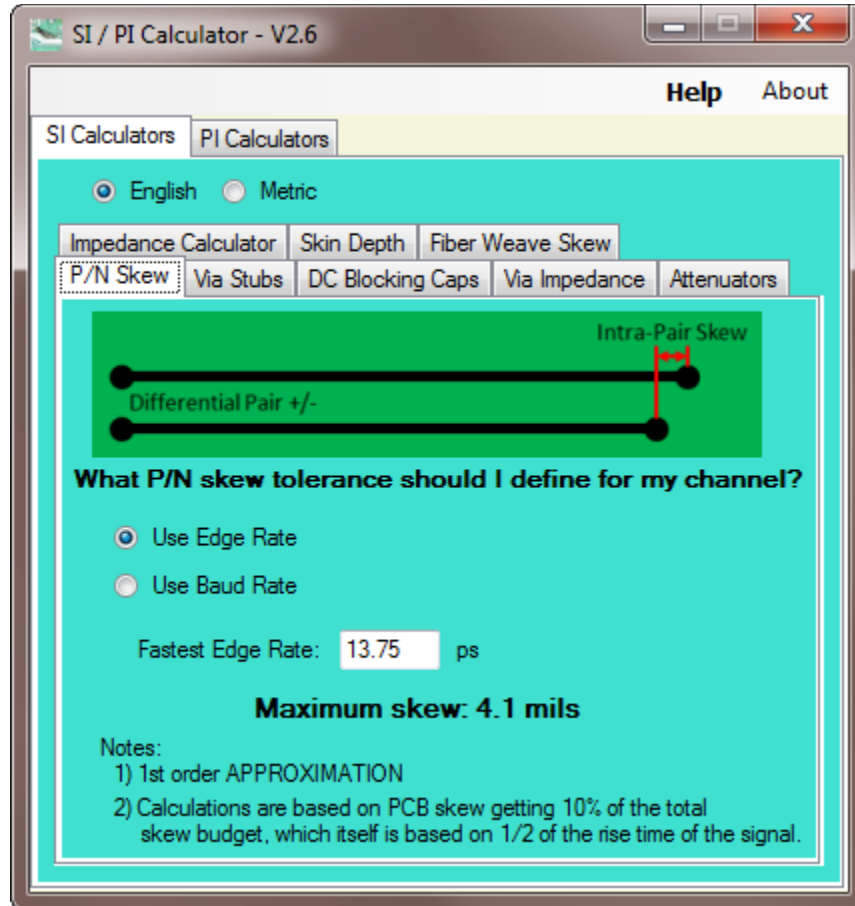


Figure 13: P/N Skew tab

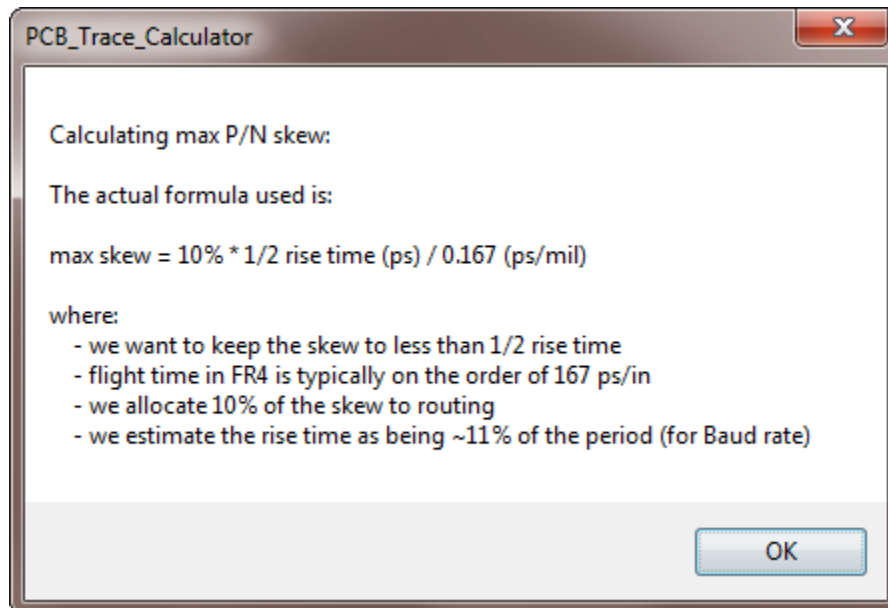


Figure 14: Information on P/N Skew

## SI Calculators

### 3.5. Via Stubs

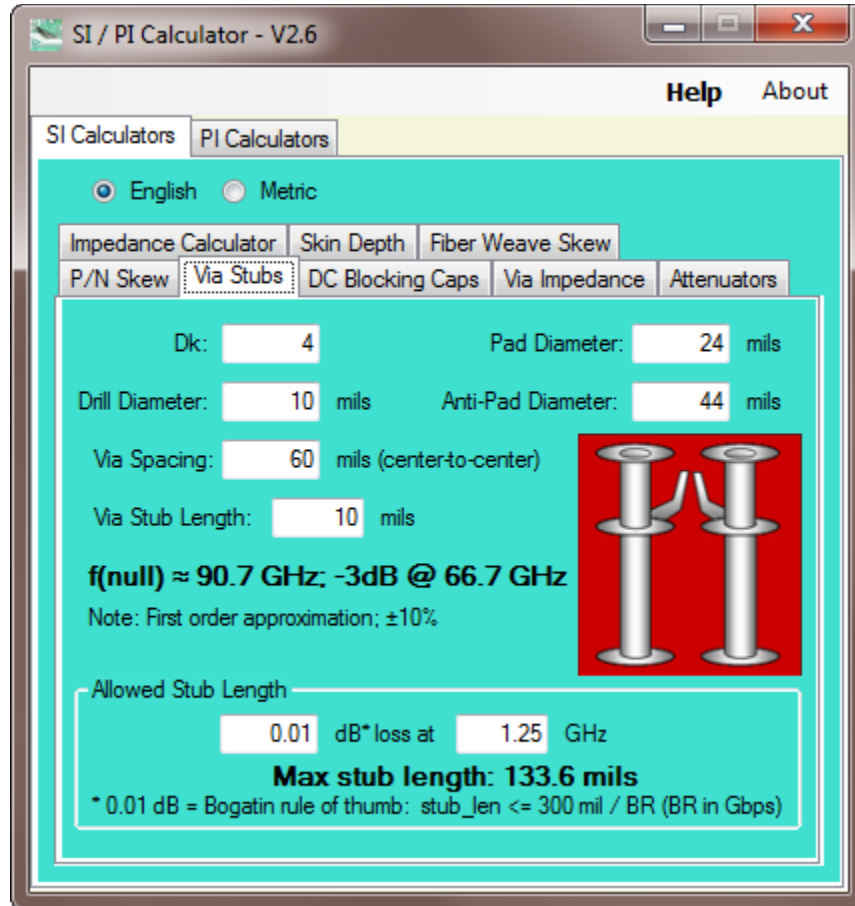


Figure 15: Via Stubs tab

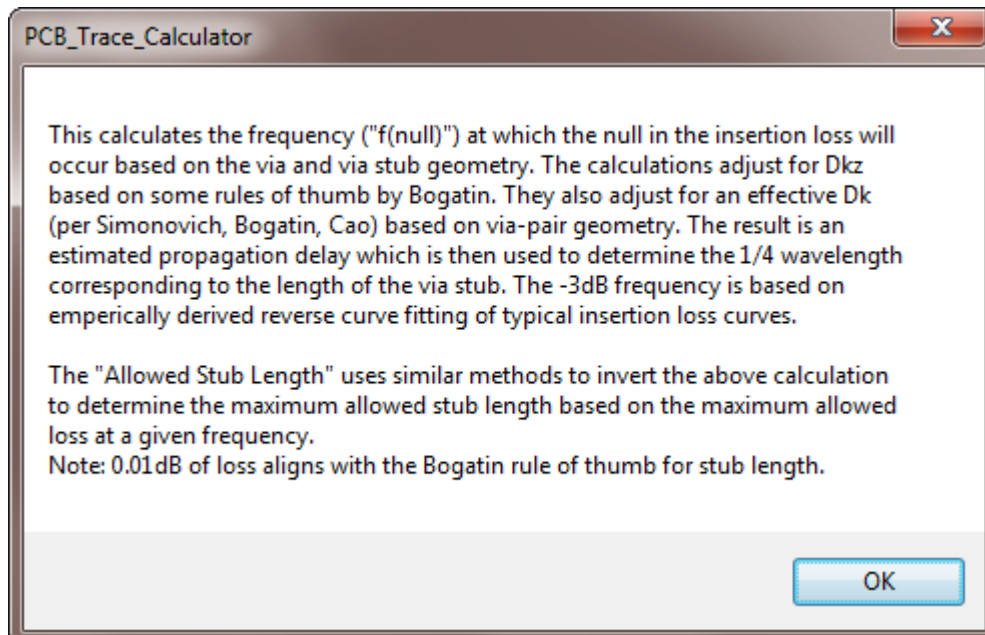


Figure 16: Information on Via Stubs

## SI Calculators

### 3.6. DC Blocking Caps

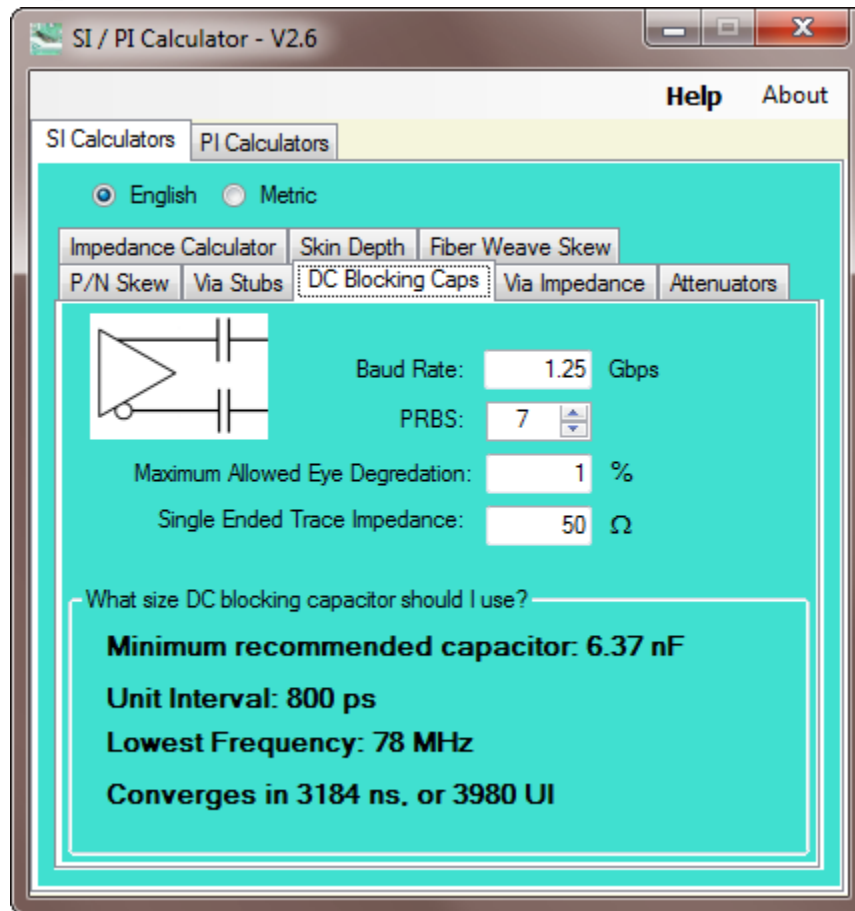


Figure 17: DC Blocking Caps tab

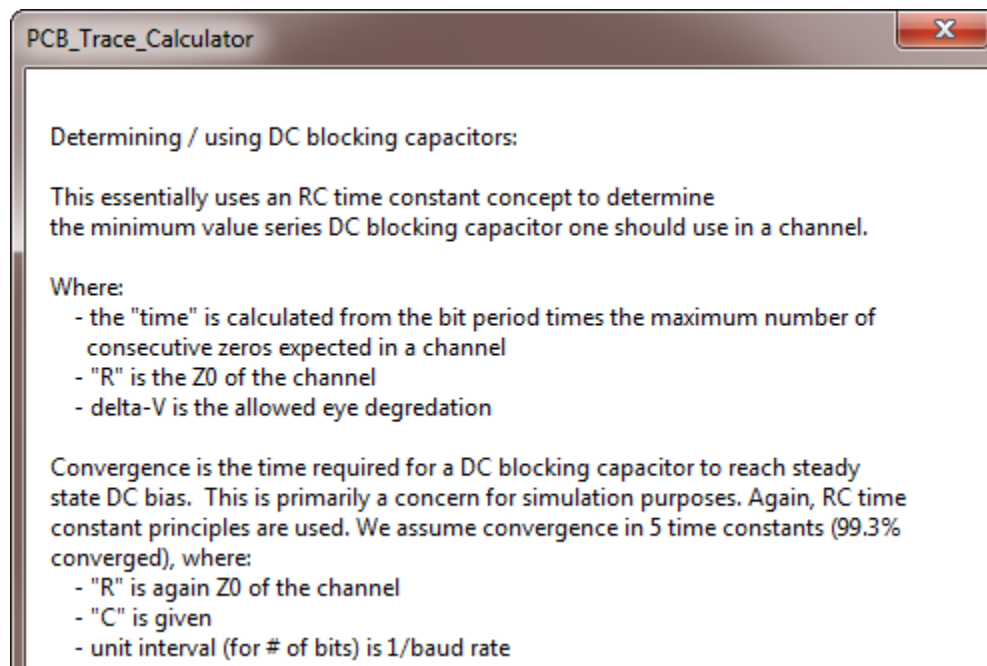


Figure 18: Information on DC Blocking Caps

## SI Calculators

### 3.7. Via Impedance

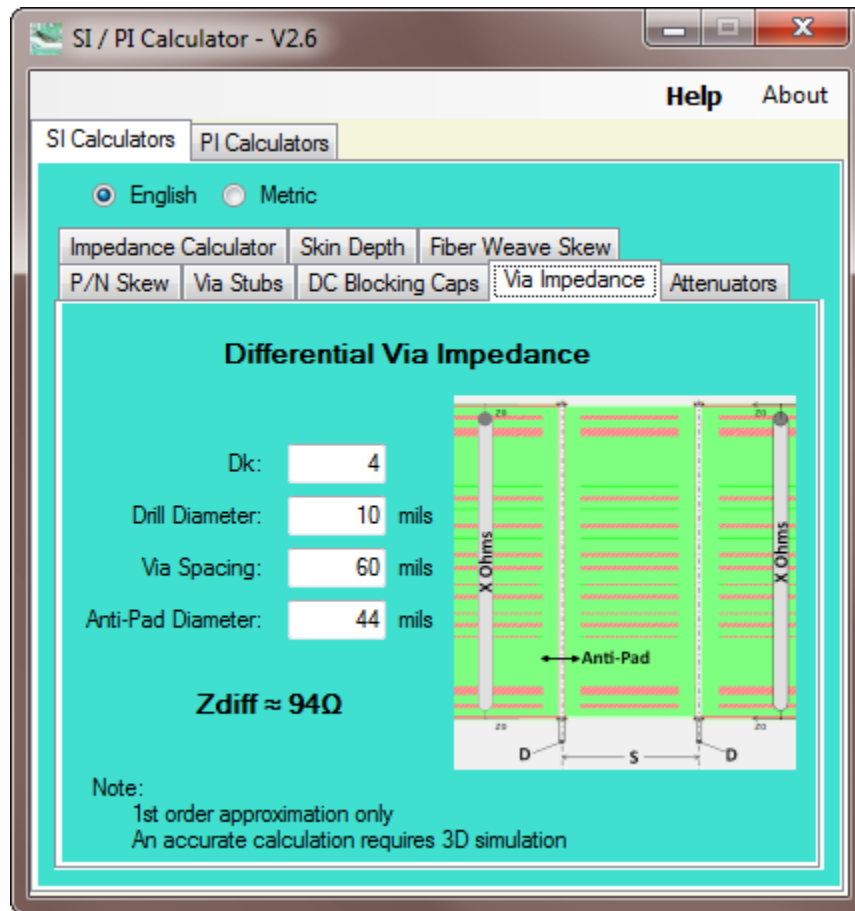


Figure 19: Via Impedance tab

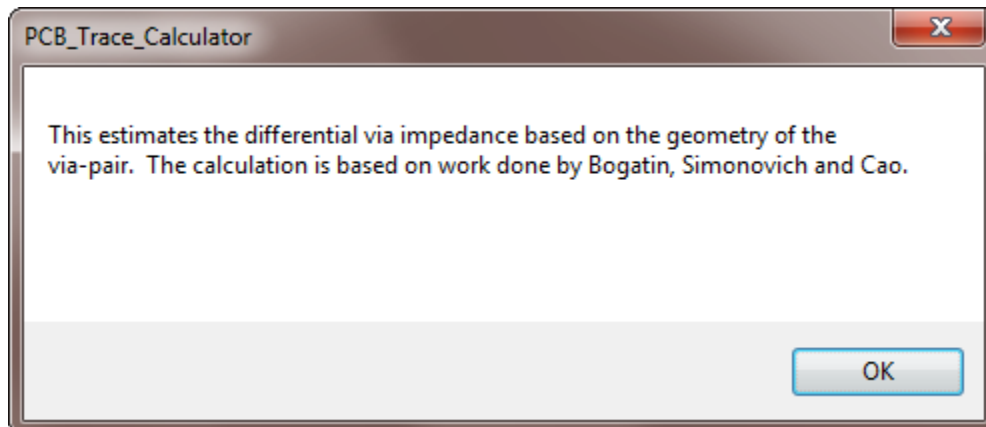


Figure 20: Information on Via Impedance

[14], [15]

## SI Calculators

### 3.8. Attenuators

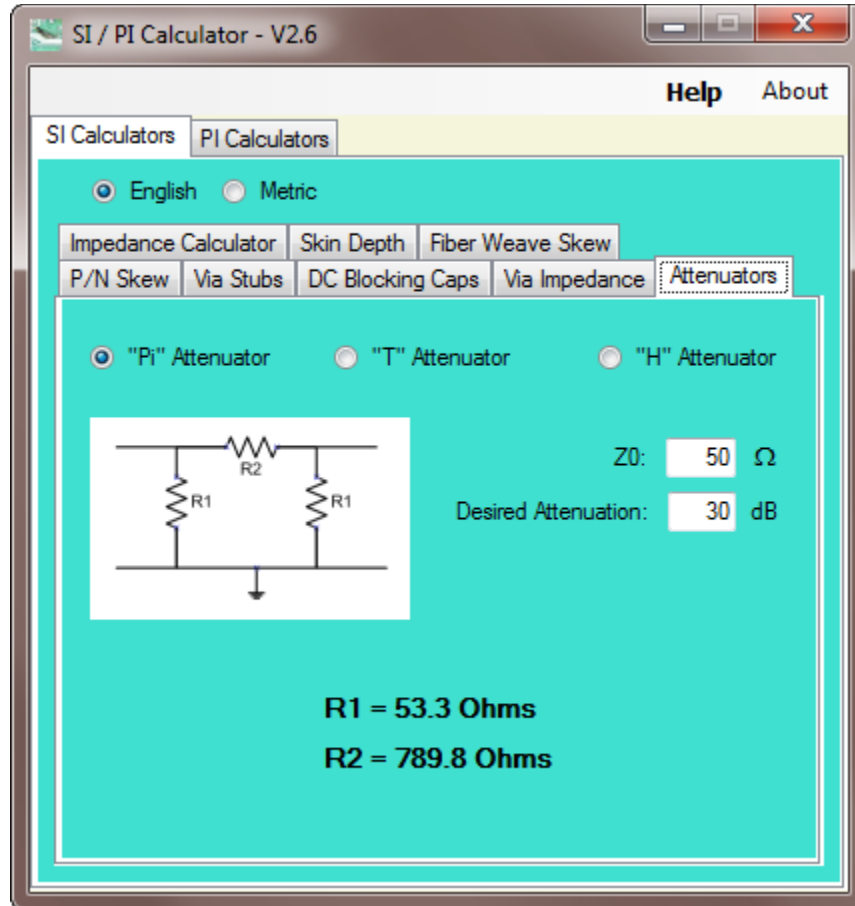


Figure 21: Attenuators tab

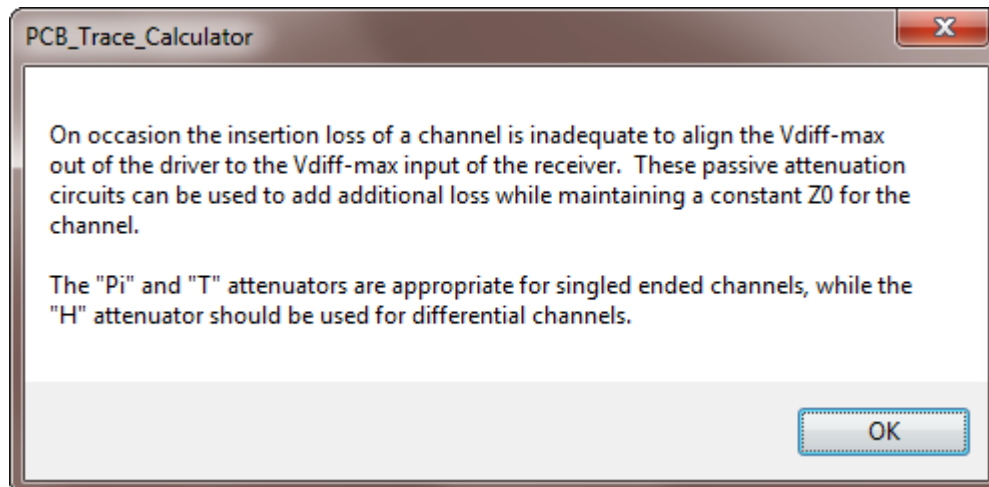


Figure 22: Information on Attenuators

## PI Calculators

### 4. PI Calculators

#### 4.1. Trace Temperature

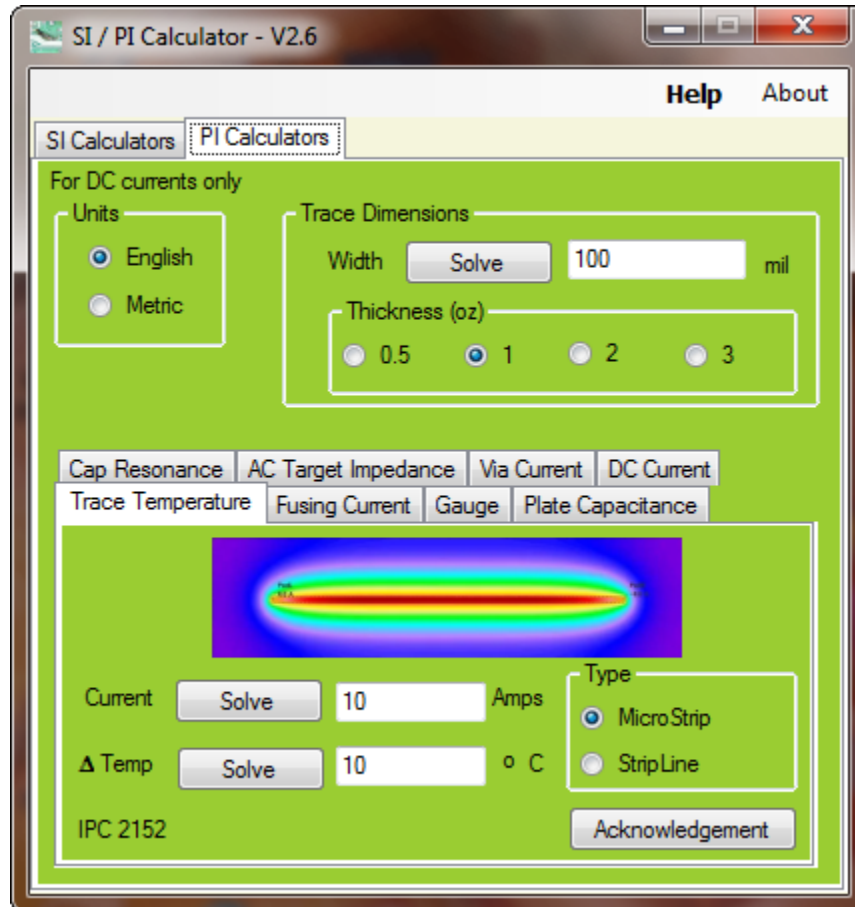


Figure 23: Trace Temperature tab

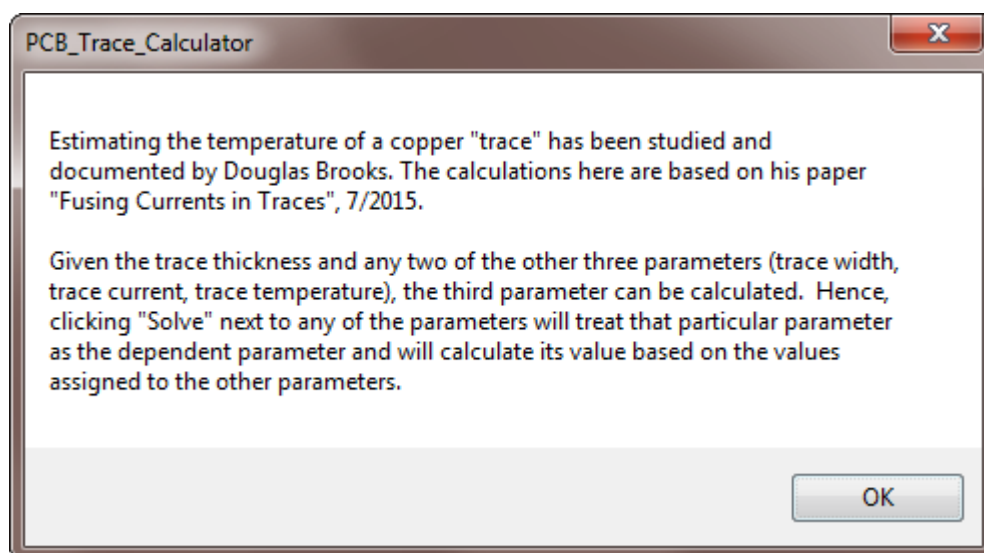


Figure 24: Information on Trace Temperature

## PI Calculators

### 4.2.Fusing Current

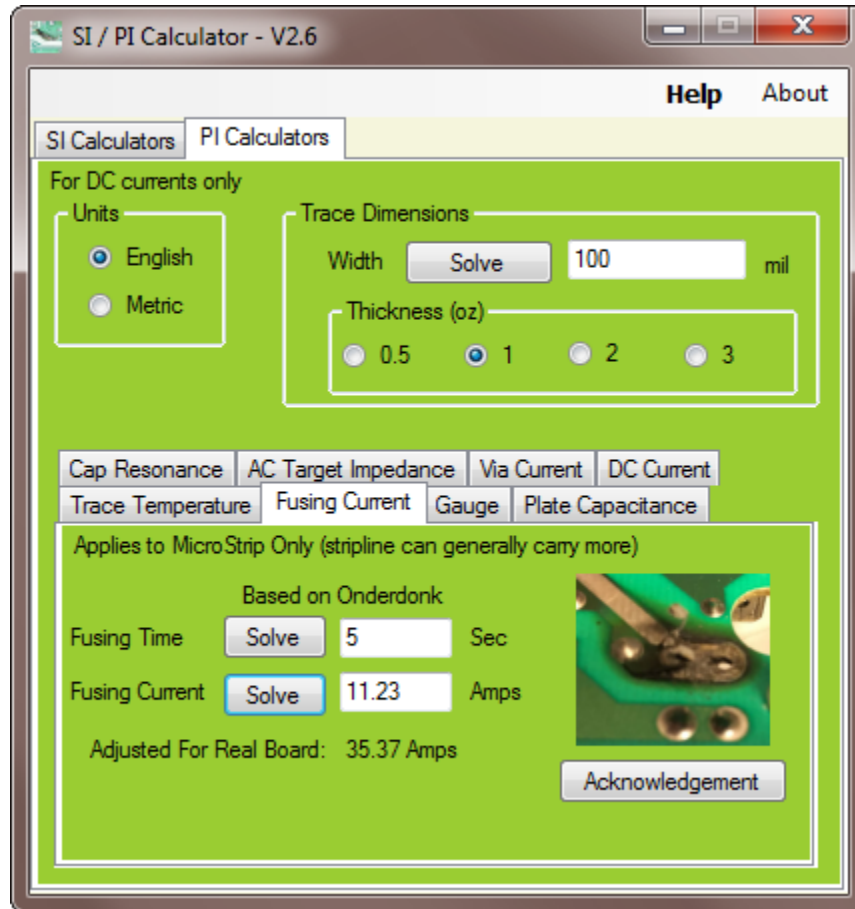


Figure 25: Fusing Current tab

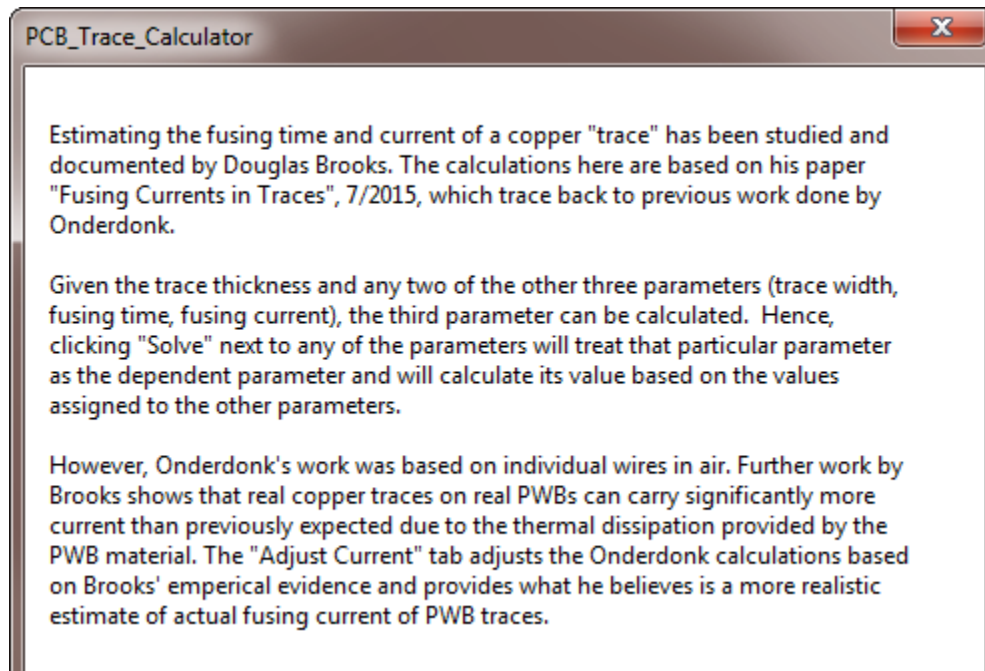


Figure 26: Information on Fusing Current

## PI Calculators

### 4.3.Gauge

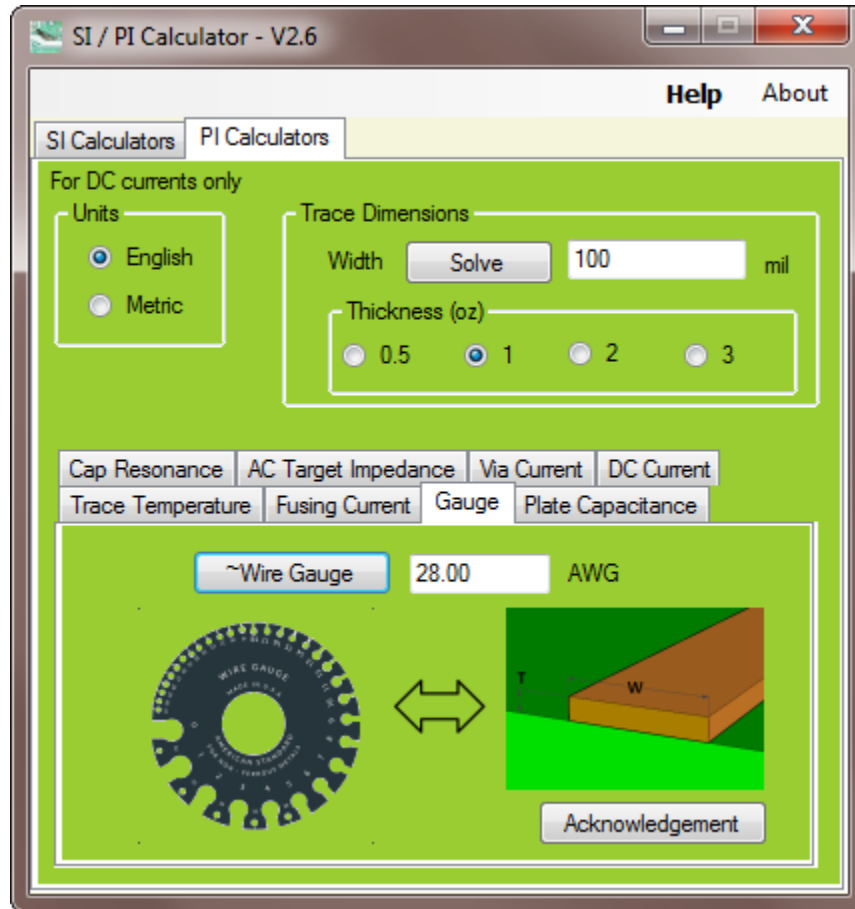


Figure 27: Gauge tab

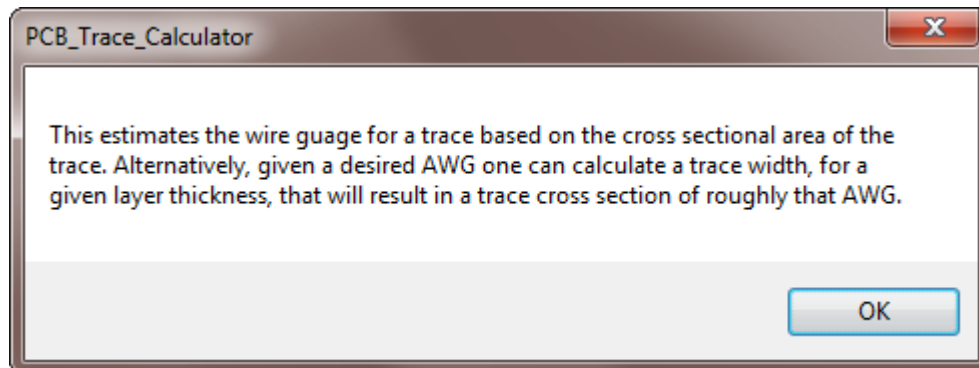


Figure 28: Information on Gauge

[19]



## PI Calculators

### 4.4. Plate Capacitance

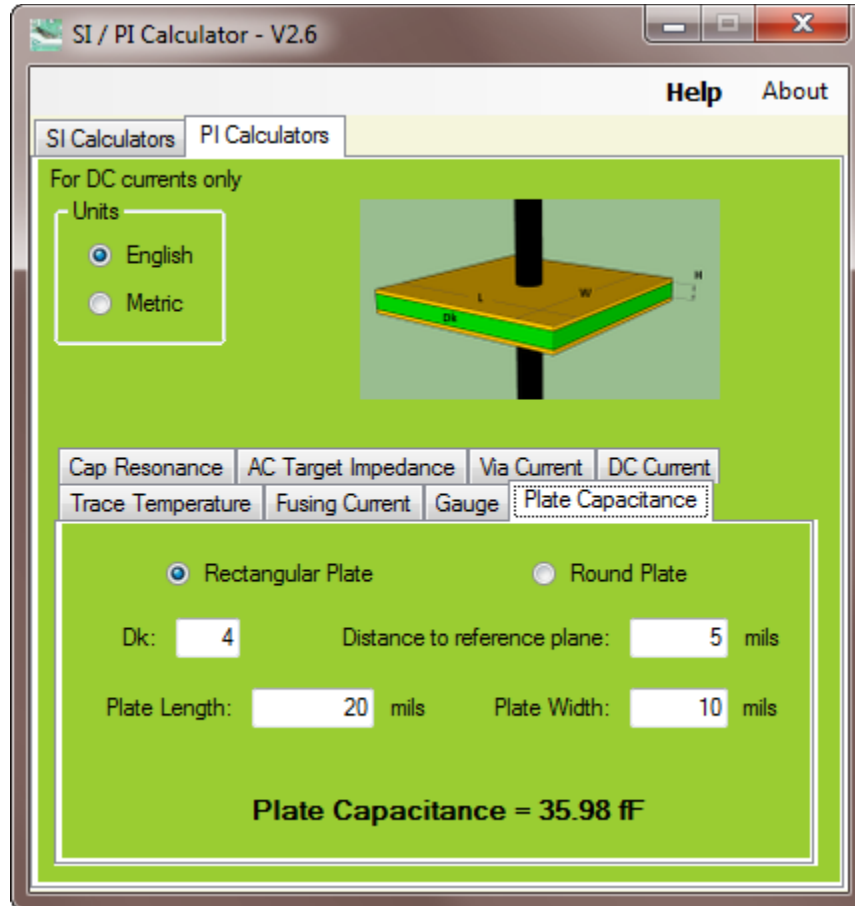


Figure 29: Plate Capacitance tab

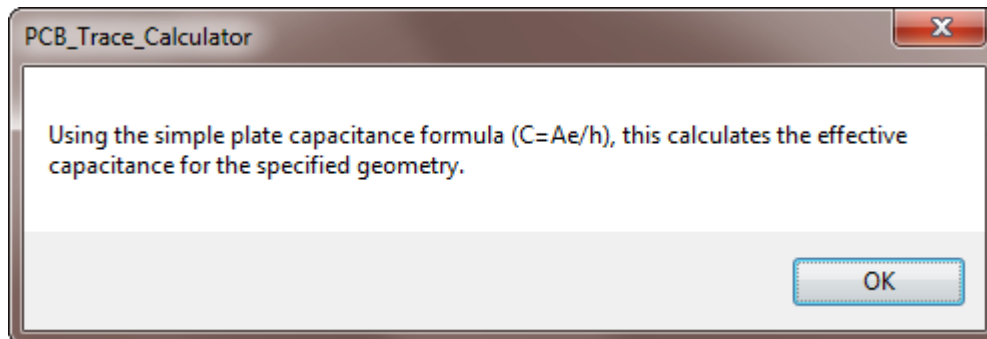


Figure 30: Information on Plate Capacitance

This particular calculation can be useful when trying to design a decoupling circuit to meet the target impedance of a power net. The power/ground coupling can serve as a contributor to the decoupling circuit at high frequencies, but often requires considerable area in order to be a **significant** contributor.

# PI Calculators

## 4.5. Cap Resonance

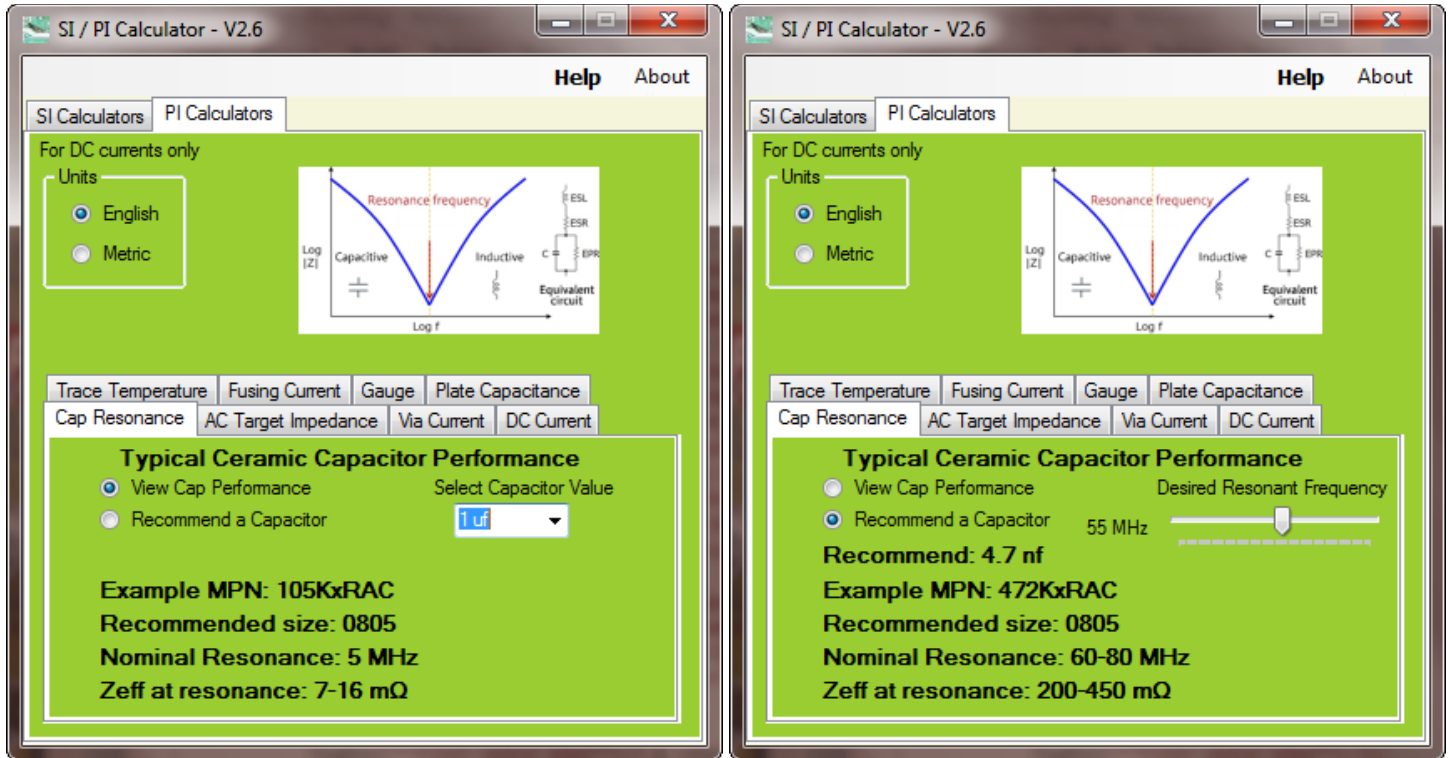


Figure 31: Cap Resonance tab

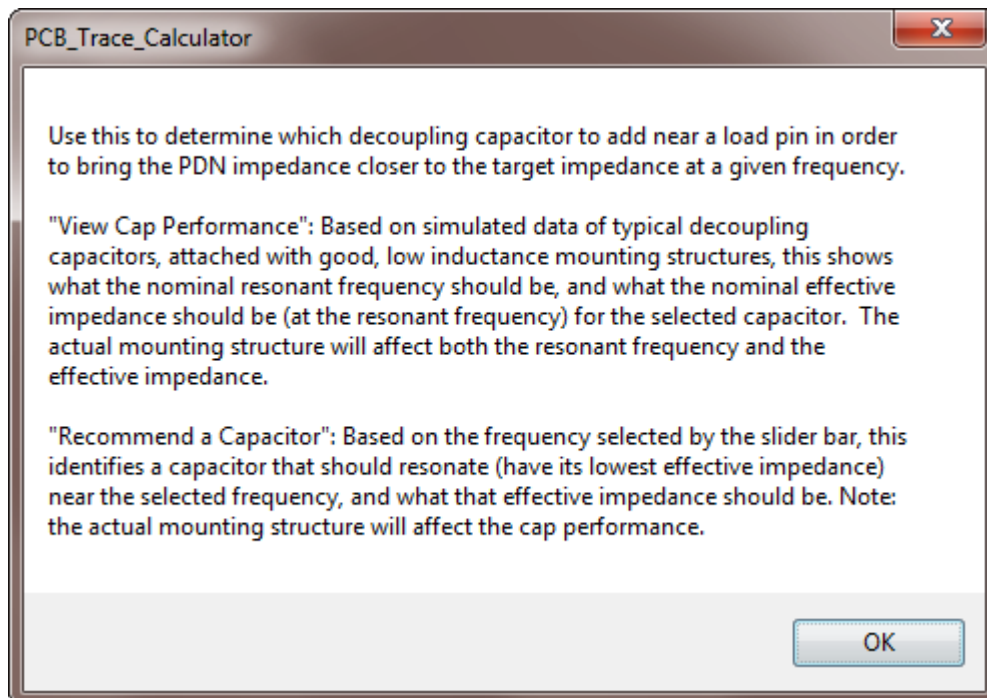


Figure 32: Information on Cap Resonance

Note: the recommended cap size is based on standard ceramic capacitors and simulations done by the author using best current practice for mounting structures. For each cap value, various sizes were simulated (0201, 0402, 0603, 0805, and 1206) with the "best" being selected based on which size resulted in the smallest  $Z_{\text{eff}}$  at resonance. Different values and better performance may be found by using low ESR caps.

## PI Calculators

### 4.6.AC Target Impedance

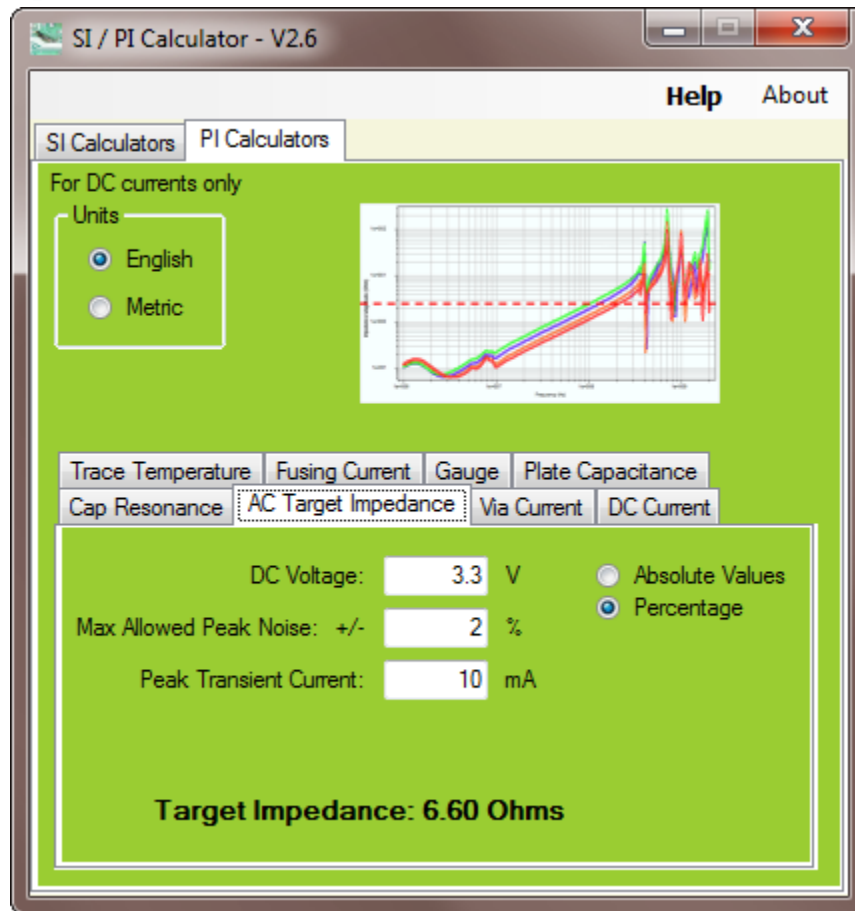


Figure 33: AC Target Impedance tab

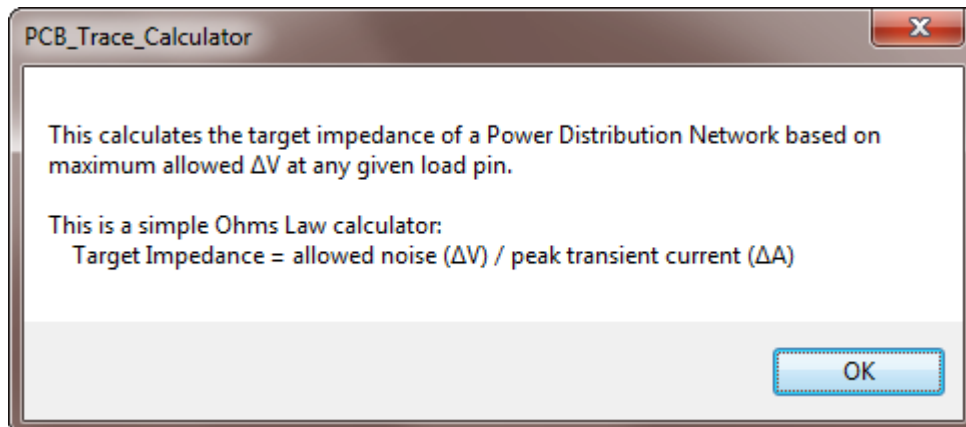


Figure 34: Information on AC Target Impedance

## PI Calculators

### 4.7.Via Current

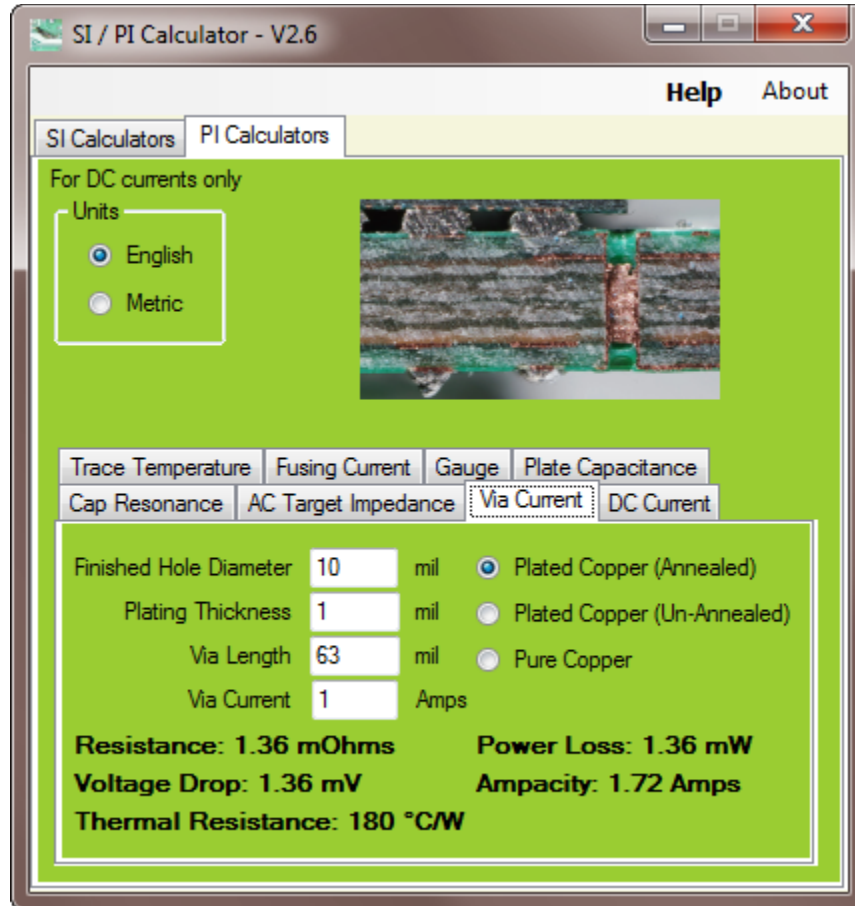


Figure 35: Via Current tab

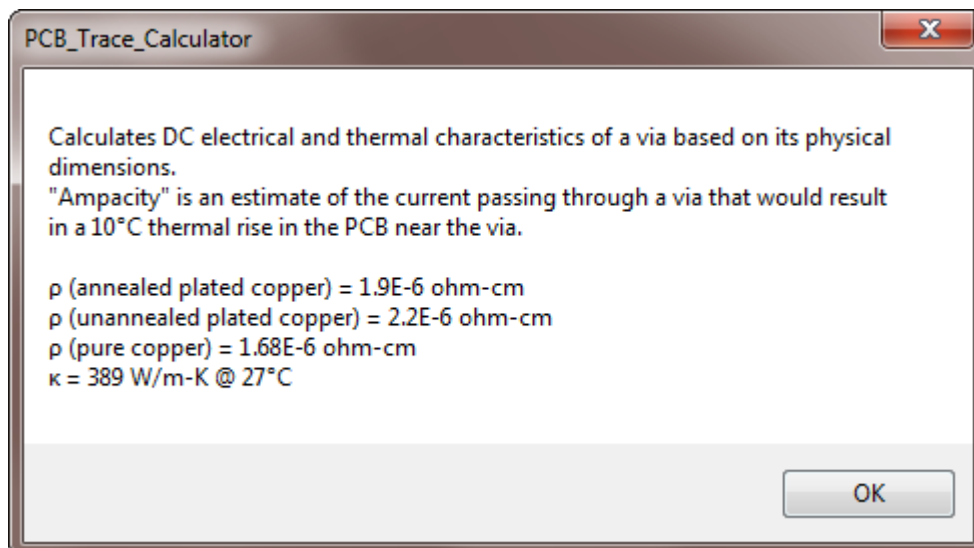


Figure 36: Information on Via Current

# PI Calculators

## 4.8.DC Current

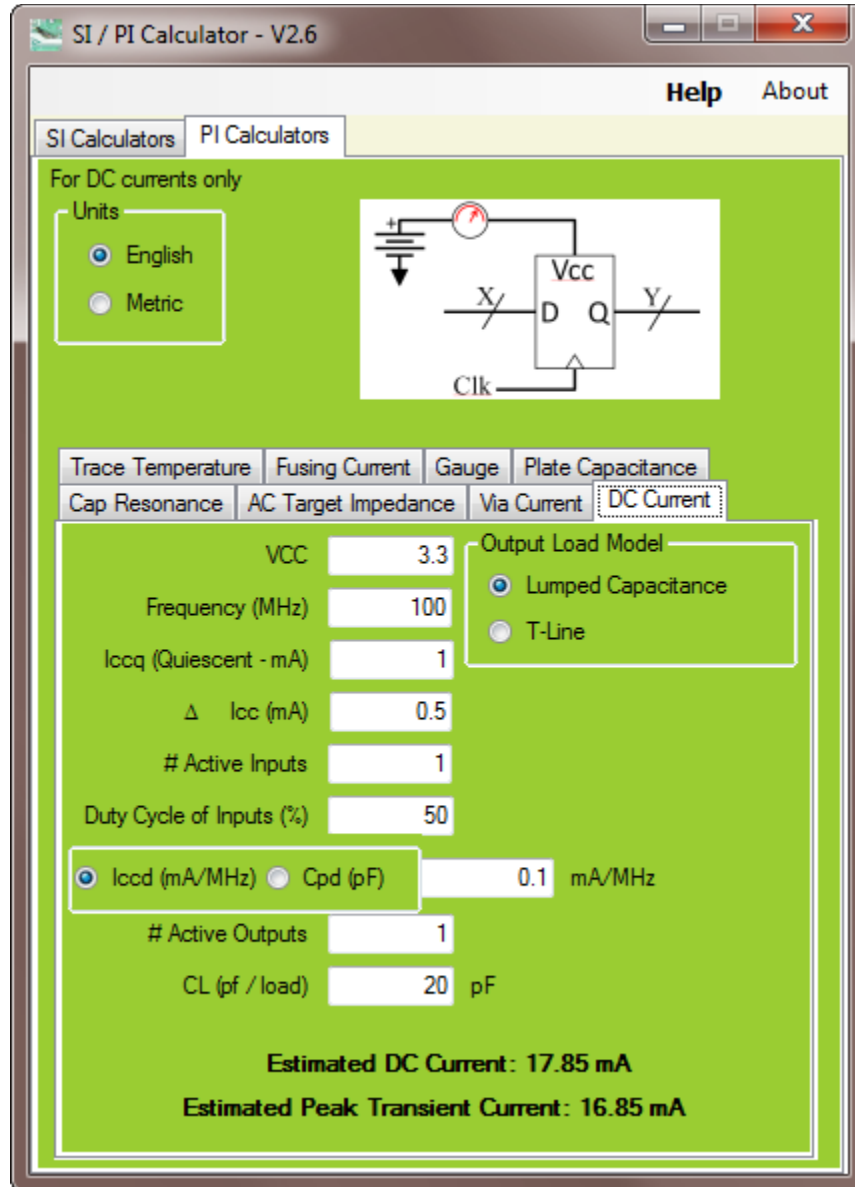


Figure 37: DC Current tab

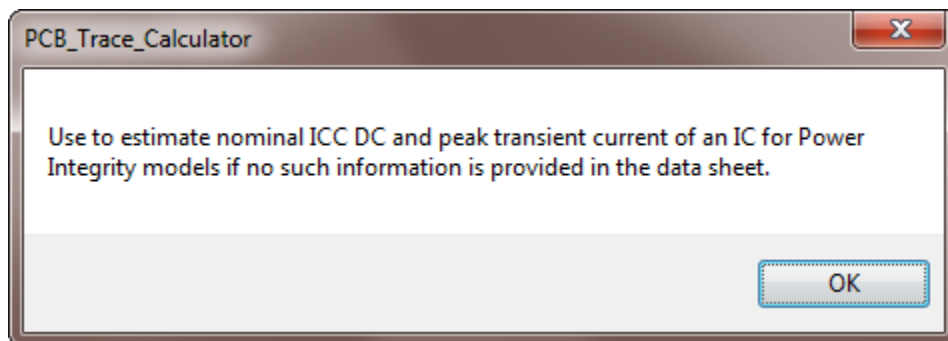


Figure 38: Information on DC Current

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