

1.0 PURPOSE/SCOPE

1.1 This document defines the design rules for laser trimming tantalum nitride resistors on thin film circuits.

1.2 This policy applies to all laser-trimmed resistors manufactured by Applied Thin-Film Products.

2.0 FUNDAMENTAL DESIGN RULES

2.1 Minimum nominal resistor width and length is 0.002” (5.08 microns)

2.2 The tantalum nitride resistor has a standard stabilized sheet resistance of 50, 75, or 100 ohms per square. Other values are available. Please contact the ATP for more information.

2.3 It is highly recommended that for all circuits utilizing integrated thin film resistors to have an isolated test resistor (If possible, the resistance value of the test resistor should equal the sheet resistance). This assists during the resistor stabilization process. This is especially important for designs with non-measurable resistors (e.g. Wilkinson style dividers, etc.).

2.4 The resistance of a specific resistor depends on its aspect ratio (the ratio of its length to width) expressed as a number of “squares” (note: the term “square” is dimensionless).

2.4.1 The basic equation for calculating resistance is:

$$R = s(L/W)$$

R = resistance in ohms
s = sheet resistance in ohms/square
L = length of the resistor
W = width of the resistor

2.4.2 Resistor “length” is always the dimension of the resistor parallel to the current flow.

2.4.2 The resistor “square” in the corner area(s) of a bent style resistor (e.g. an “L” shape or serpentine design) should be counted as one-half the value of the sheet resistance. See figure 1

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3.0 DETERMINING LASER TRIMMING REQUIREMENTS

3.1 Please refer to the Resistor Tolerance Requirements Chart to determine if laser trimming is required to achieve the resistor tolerance required. *See table A*

3.2 Resistor tolerances of $\pm 10\%$ or greater generally do not require laser trimming.

3.3 The smallest tolerance resistor on the circuit determines the processing requirements for the entire circuit.

4.0 RESISTOR TYPES

4.1 **Rectangular Configuration:** The most common type of resistor. *See figure 2*

4.2 **L or Bent Configuration:** The resistor “square” in the corner area of a bent style resistor should be counted as one-half the value of the sheet resistance. *See figure 3*

4.3 **Serpentine Configuration:** This resistor is typically used for high value resistors. The number of corners complicates calculation of the value. The resistor “square” in the corner areas of a serpentine style resistor should be counted as one-half the value of the sheet resistance. *See figure 4*

4.4 **Top-hat (lobe type) Configuration:** The advantage of a top hat design is its wide trim range. Figure 5 shows a five square resistor. By trimming with a single plunge cut of the laser, a nine square resistor can be created. The resistance can be manipulated between these values by limiting the amount of trim. Resistors with a trimmable range of more than 3x the initial value can be created using this technique. Resistors of this type must be trimmed regardless of tolerance requirements. *See figure 5*

5.0 LASER TRIM TYPES

5.1 Please refer to the Resistor Trim Types Chart for a table style comparison. *See table B*

5.2 **Plunge Cut:** The most economical laser trim type. This is primarily due to the minimum amount of time required to trim the resistor with this technique. Overall tolerance accuracy can be less than the other methods. This method is recommended for DC applications. *See figure 6*

5.3 **L Cut:** This method offers increased tolerance accuracy over the Plunge Cut. Due to longer time required to perform this cut, it is slightly more expensive. This method is recommended for DC applications. *See figure 7*

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5.4 **Serpentine Cut:** This trim type allows a wider final value flexibility than the Plunge or L Cut. However, due to the increased number of cuts per resistor required, the price can increase substantially. This method is recommended for DC applications. *See figure 8*

5.5 **Scan Cut:** This method offers both high accuracy and high frequency compatibility. The resistor material is removed from the edge of the resistor only. This technique typically requires considerably more time per resistor than the other trim types. It is also more expensive. This method is recommended for all applications. *See figure 9*

6.0 TOOLING REQUIREMENTS

6.1 Probe cards are required for all laser trimmed resistors.

6.2 The general rule of thumb to determine the required number of probes for a given layout is to multiply the quantity of resistors by 1.5.

6.3 Several factors (e.g. shadowing, pad size, resistor type, trim type, pattern density, etc.) affect the quantity of probes that can be placed on a probe card. Under optimum conditions, 30 probes can be mounted. The average number of probes is 15-20 per card.

6.4 Designs with high quantity and/or high density resistor requirements may require multiple cards to allow all the resistors to be properly trimmed into tolerance. This will affect the circuit, tooling, and (if required) set-up pricing.

6.5 Resistors with values of 50 ohms or less require Kelvin-style probing to insure accuracy. This technique requires 4 probe points per resistor.

6.6 It is recommended that the probe point locations be specified on the drawing for tight tolerance resistors with values of 50 ohms or less.

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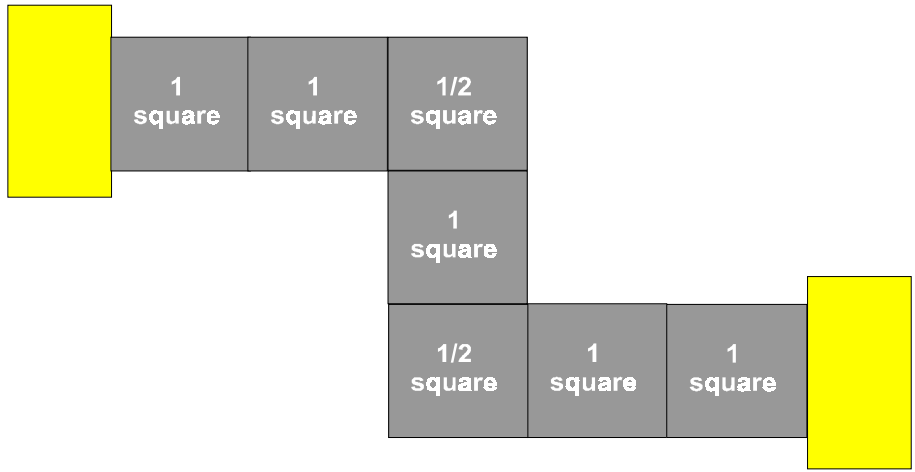
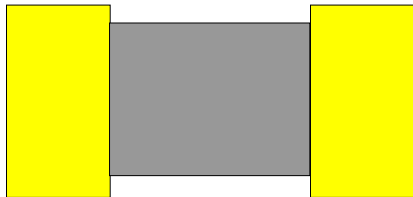
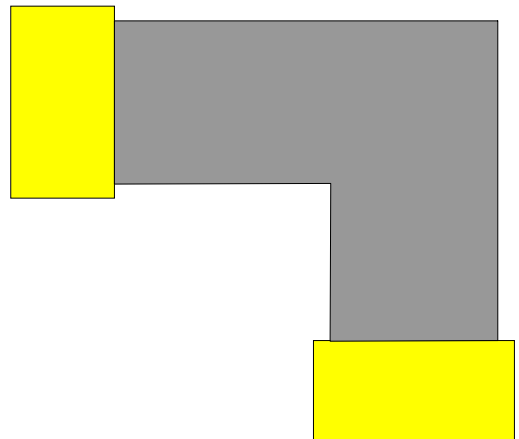


Figure 1



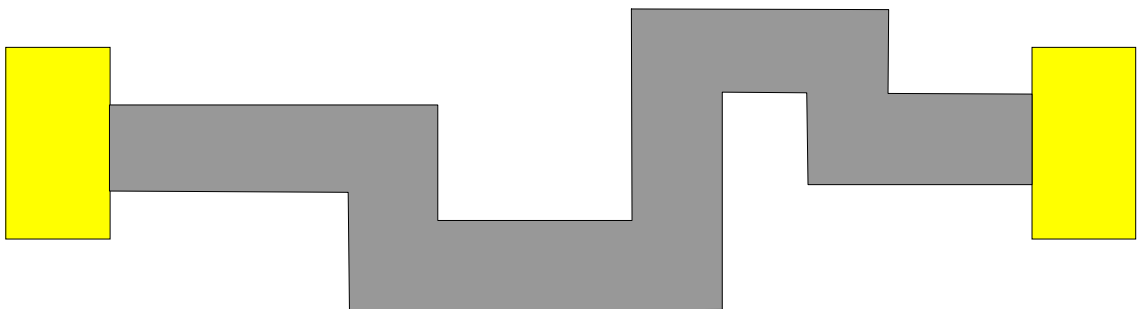
Rectangular Configuration

Figure 2



L or Bent Configuration

Figure 3



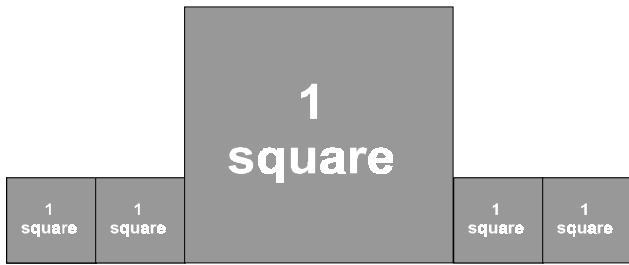
Serpentine Configuration

Figure 4

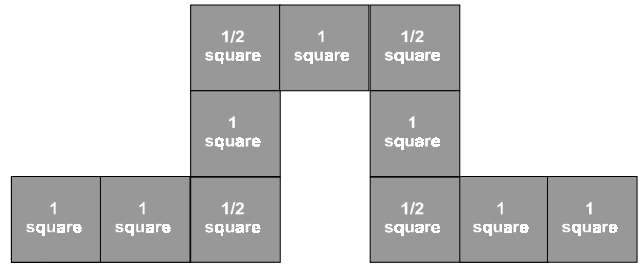
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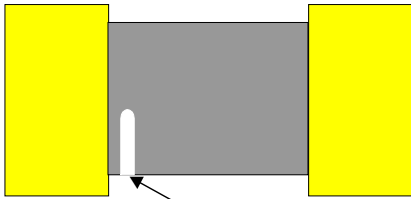


Before Trimming
(five square example)

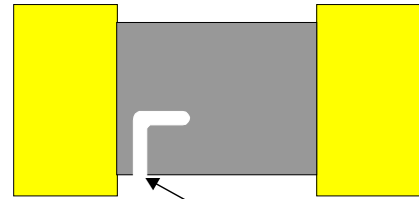


After Trimming
(nine square example)
Note: Trim area is exaggerated

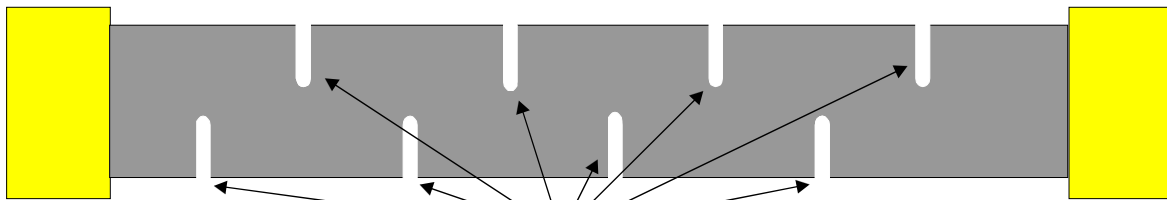
Top Hat Configuration
Figure 5



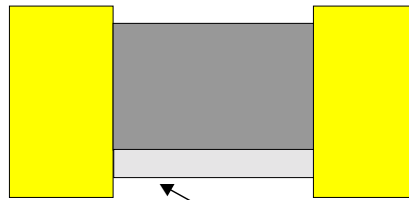
Plunge Cut
Figure 6



L Cut
Figure 7



Laser Cuts
Serpentine Cut
Figure 8



Scan Cut
Figure 9

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Resistor Tolerance Requirements

Quantity of Resistors Per Circuit	Resistor Value(s)	Required Tolerance			
		$\geq 15\%$	10%	5%	$< 5\%$
5 or less	≤ 50	NR	NR	POS	REQ
6 or greater	≤ 50	NR	POS	REQ	REQ
5 or less	> 50	NR	NR	POS	REQ
6 or greater	> 50	NR	NR	REQ	REQ

Legend

NR	Laser Trim not required
POS	Laser Trim may be required. Design dependent
REQ	Laser Trim required

Resistor Value vs. Laser Trim Tolerance Capabilities

Required Resistor Value	Standard Tolerance	Minimum Tolerance
> 50 Ohms	1-2%	0.10%
10-50 Ohms	1-2%	0.25%
2-9 Ohms	2-5%	1.00%
< 2 Ohms	CALL	CALL

Note: All tolerances are based on absolute resistor values

Table A

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Resistor Trim Types

Resistor Trim Type	Recommended Application	Advantages	Disadvantages
Plunge Cut (Figure 6)	DC	Minimum Cost	Typically applicable only for DC applications. Limited tolerance capability
L Cut (Figure 7)	DC	Increased Accuracy - Lower tolerances	Typically applicable only for DC applications. Slightly higher cost than Plunge cut.
Serpentine Cut (Figure 8)	DC - High value resistors	Increased Accuracy - Lower tolerances. Wider final value flexibility.	Typically applicable only for DC applications. Higher cost than Plunge or "L" cut (depends on quantity of cuts required).
Scan Cut (Figure 9)	All	Compatible with high frequency applications. Excellent tolerance accuracy	Highest cost

Table B

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