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Assembly – Understanding the HARD(ware) Side of IPC-A-610

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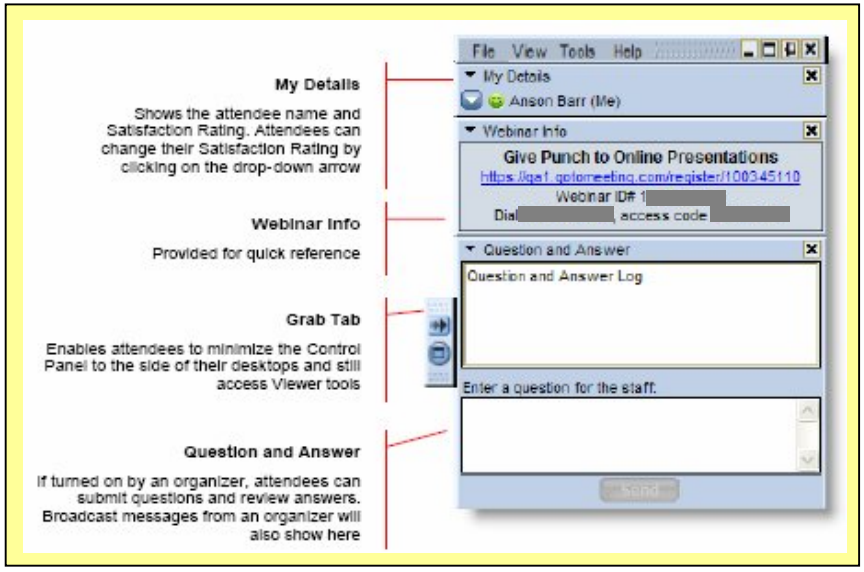

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The Assembly of Hardware

- What does minimum electrical spacing mean?
- How tight is tight for screws, nuts and bolts?
- What is Torque and how is it measured?
- What is the assembly sequence for lockwashers and flat washers?

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What is Violations of Conductor Spacing?

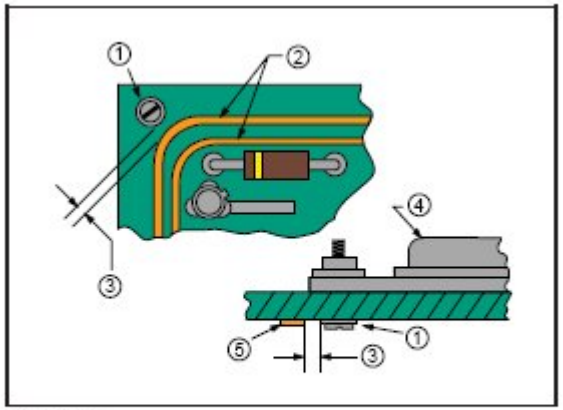

Figure 4-1
1. Metallic hardware
2. Conductive pattern
3. Specified minimum electrical clearance
4. Mounted component
5. Conductor

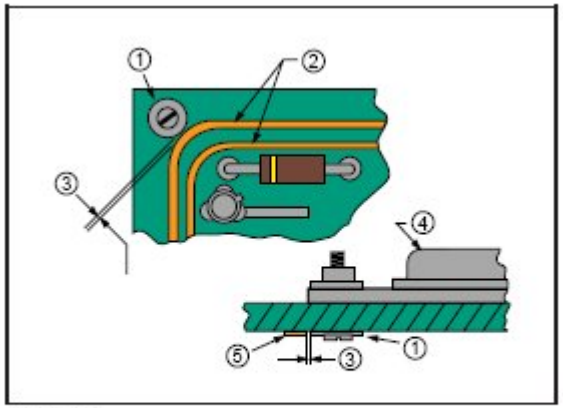

Figure 4-2
1. Metallic hardware
2. Conductive pattern
3. Spacing less than electrical clearance requirements
4. Mounted component
5. Conductor

Adapted from IPC-A-610

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What is Minimum Conductor Electrical Spacing?

IPC-2221 – **Table 6-1 Electrical Conductor Spacing**

Voltage Between Conductors (DC or AC Peaks)	Minimum Spacing						
	Bare Board				Assembly		
	B1	B2	B3	B4	A5	A6	A7
0-15	0.05 mm [0.00197 in]	0.1 mm [0.0039 in]	0.1 mm [0.0039 in]	0.05 mm [0.00197 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]
16-30	0.05 mm [0.00197 in]	0.1 mm [0.0039 in]	0.1 mm [0.0039 in]	0.05 mm [0.00197 in]	0.13 mm [0.00512 in]	0.25 mm [0.00984 in]	0.13 mm [0.00512 in]
31-50	0.1 mm [0.0039 in]	0.6 mm [0.024 in]	0.6 mm [0.024 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]	0.4 mm [0.016 in]	0.13 mm [0.00512 in]
51-100	0.1 mm [0.0039 in]	0.6 mm [0.024 in]	1.5 mm [0.0591 in]	0.13 mm [0.00512 in]	0.13 mm [0.00512 in]	0.5 mm [0.020 in]	0.13 mm [0.00512 in]
101-150	0.2 mm [0.0079 in]	0.6 mm [0.024 in]	3.2 mm [0.126 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.4 mm [0.016 in]
151-170	0.2 mm [0.0079 in]	1.25 mm [0.0492 in]	3.2 mm [0.126 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.4 mm [0.016 in]
171-250	0.2 mm [0.0079 in]	1.25 mm [0.0492 in]	6.4 mm [0.252 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.4 mm [0.016 in]
251-300	0.2 mm [0.0079 in]	1.25 mm [0.0492 in]	12.5 mm [0.4921 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]	0.8 mm [0.031 in]	0.8 mm [0.031 in]
301-500	0.25 mm [0.00984 in]	2.5 mm [0.0984 in]	12.5 mm [0.4921 in]	0.8 mm [0.031 in]	0.8 mm [0.031 in]	1.5 mm [0.0591 in]	0.8 mm [0.031 in]
> 500 See para. 6.3 for calc.	0.0025 mm /volt	0.005 mm /volt	0.025 mm /volt	0.00305 mm /volt	0.00305 mm /volt	0.00305 mm /volt	0.00305 mm /volt

B1 - Internal Conductors
B2 - External Conductors, uncoated, sea level to 3050 m [10,007 feet]
B3 - External Conductors, uncoated, over 3050 m [10,007 feet]
B4 - External Conductors, with permanent polymer coating (any elevation)
A5 - External Conductors, with conformal coating over assembly (any elevation)
A6 - External Component lead/termination, uncoated, sea level to 3050 m [10,007 feet]
A7 - External Component lead termination, with conformal coating (any elevation)

Adapted from IPC-2221

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Hardware Interference

- How can this impact the hardware installation?

4.1.2 Hardware Installation – Interference

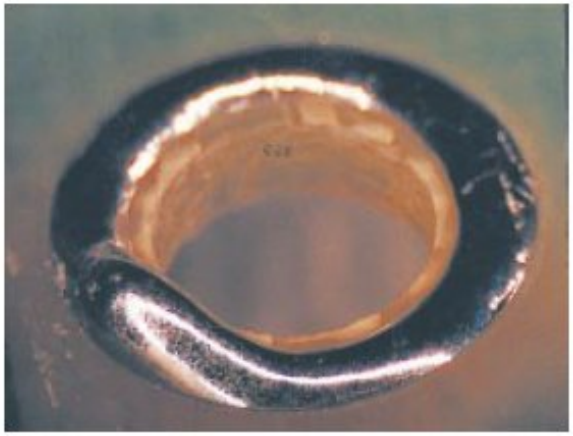

Figure 4-3

Acceptable - Class 1,2,3

- Mounting area clear of obstructions to assembly requirements.

Defect - Class 1,2,3

- Excess solder (uneven) on mounting holes where mechanical assembly will be affected.
- Anything that interferes with mounting of required hardware.

Adapted from IPC-A-610

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What is Torque?

● ***Torque* is a measure of how much a force acting on an object causes that object to rotate.** The object rotates about an axis, which we will call the **pivot point**, and will label 'O'. We will call the force '**F**'. The distance from the pivot point to the point where the force acts is called the **moment arm**, and is denoted by '**r**'. Note that this distance, '**r**', is also a vector, and points from the axis of rotation to the point where the force acts. (Refer to Figure 1 for a pictoral representation of these definitions.)

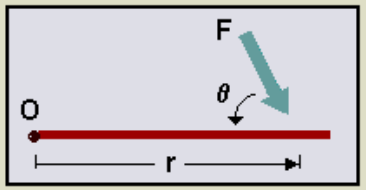

Figure 1 *Definitions*

Torque is defined as

$\tau = \mathbf{r} \times \mathbf{F} = \mathbf{r}\,\mathbf{F}\sin(\theta)$.

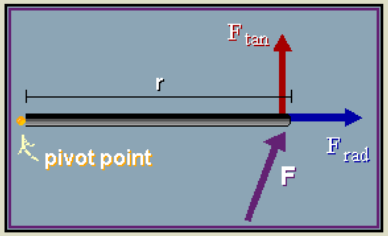

Figure 2 *Tangential and radial components of force F*

Or simply stated, it is a force applied over a distance.

Adapted from http://www.physics.uoguelph.ca/tutorials/torque/Q.torque.intro.html

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Torque Table

Material Strength - 60,000 psi
J82 60M or Grade 1 or Class 4.8

Size	Dia.	Stress Area	Tensile Str. Lbs	Proof Load Str. Lbs	Dry Parts K=.2		Lubricated Parts K=.15	
					Min Break Str. (in/lbs)	Max Torque Value (in/lbs)	Min Break Str, (in/lbs)	Max Torque Value (in/lbs)
8-32	0.1640	0.01400	840	462	20.7	11.4	15.5	8.5
10-24	0.1900	0.01750	1,050	578	29.9	16.5	22.4	12.3
10-32	0.1900	0.02000	1,200	660	34.2	18.8	25.7	14.1
1/4-20	0.2500	0.03180	1,908	1,049	71.6	39.4	53.7	29.5
1/4-28	0.2500	0.03637	2,182	1,200	81.8	45.0	61.4	33.8
5/16-18	0.3125	0.05240	3,144	1,729	147.4	81.1	110.5	60.8
5/16-24	0.3125	0.05800	3,480	1,914	163.1	89.7	122.3	67.3

Adapted from http://www.precisionscrewandbolt.com/strength.htm

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Hardware Installation

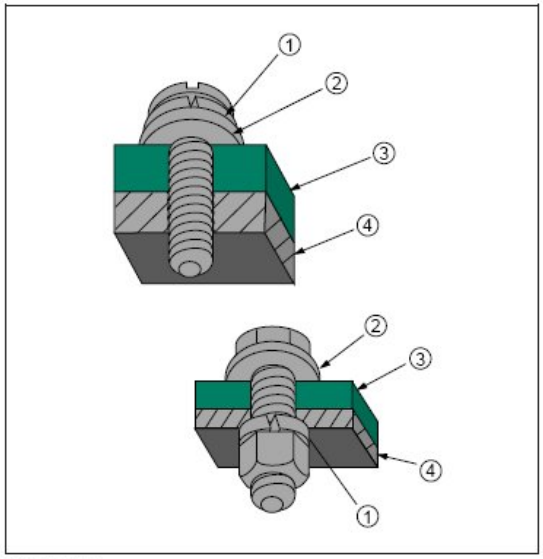

Figure 4-4
1. Lock washer
2. Flat washer
3. Nonconductive material (laminate, etc.)
4. Metal (not conductive pattern or foil)

Acceptable - Class 1,2,3

- Proper hardware sequence.
- Slot is covered with flat washer, Figure 4-5.
- Hole is covered with flat washer, Figure 4-5.

Acceptable - Class 1
Defect - Class 2,3

- Less than one and one-half threads extend beyond the threaded hardware, (e.g., nut) unless thread extension would interfere with other component.
- Thread extension more than 3 mm [0.12 in] plus one and one-half threads for bolts or screws up to 25 mm [0.984 in].
- Thread extension more than 6.3 mm [0.248 in] plus one and one-half threads for bolts or screws over 25 mm [0.984 in].
- Bolts or screws without locking mechanisms extend less than one and one half threads beyond the threaded hardware.

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Hardware Installation

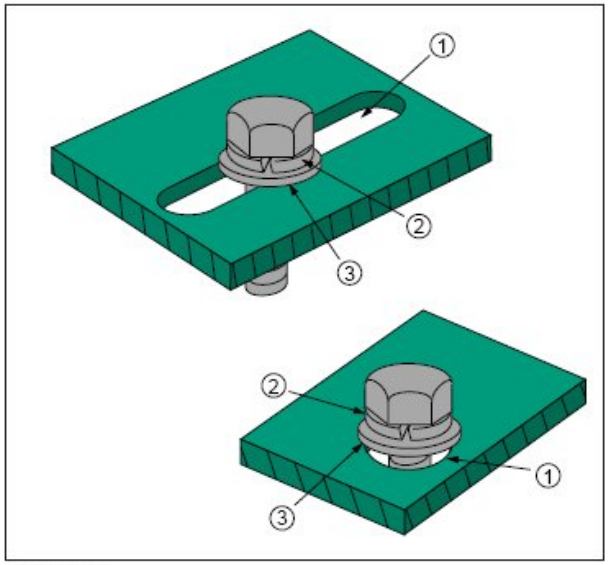

Figure 4-5
1. Slot or hole
2. Lock washer
3. Flat washer

- Flat washer shall be against the laminate surface.
- Lock washer shall be against the flat washer.
- Nut shall be against the lock washer.

Adapted from IPC-A-610

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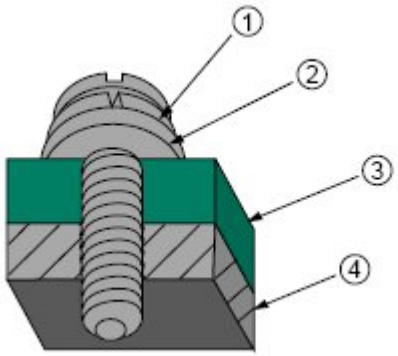
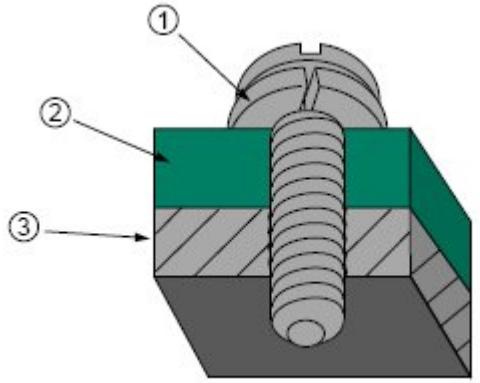
Hardware Assembly

The correct and incorrect hardware assembly sequence



Correct Assembly



Incorrect Assembly

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Hardware Assembly

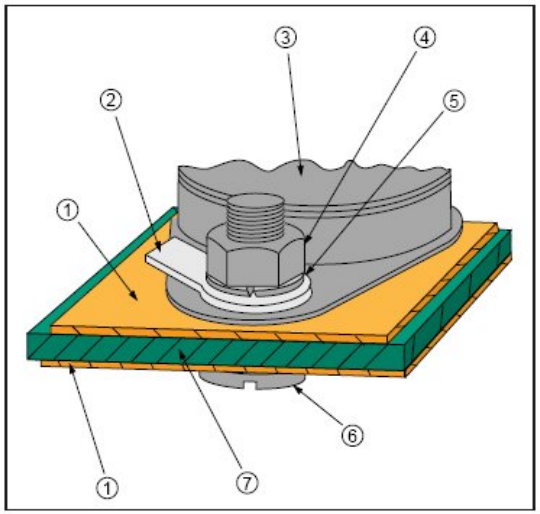

Figure 7-46
1. Metal
2. Terminal lug
3. Component case
4. Nut
5. Lock washer
6. Screw
7. Nonmetal

Acceptable - Class 1,2,3

- Hardware in proper sequence.
- Leads on components attached by fastening devices are not clinched (not shown).
- Insulating washer provides electrical isolation when required.
- Thermal compound, if used, does not interfere with formation of required solder connections.

Note: Where a thermal conductor is specified, it must be placed between mating surfaces of the power device and the heat sink. Thermal conductors may consist of a thermally conductive washer or of an insulating washer with a thermally conductive compound.

Adapted from IPC-A-610

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Improper Torque of Hardware

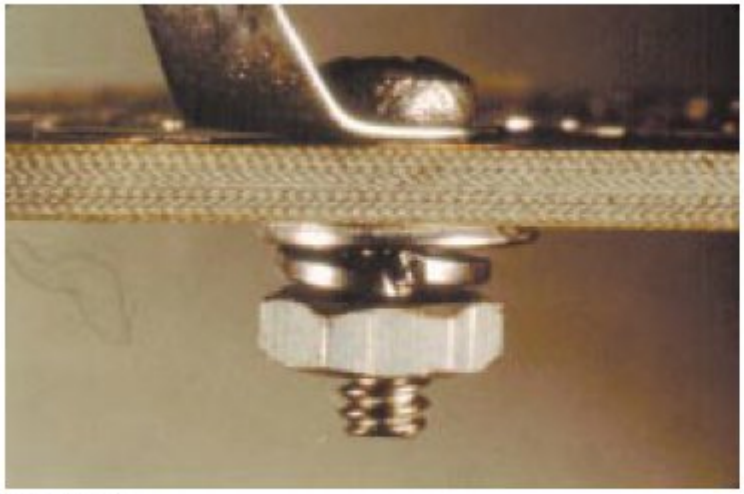

Figure 4-9

Defect - Class 1,2,3

- Lock washer not compressed.

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Threaded Fastener Requirements

- Minimum of 1½ threads must extend beyond nut.
- Machine bolts and screws may be flush with the end of the nut only when it interferes with other components or when lock mechanisms are used.

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Connectors, Handles, Extractors, Latches

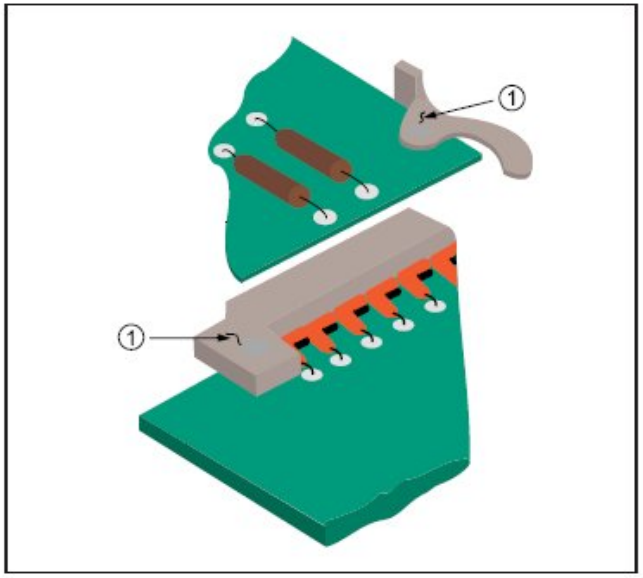

Figure 4-15
1. Crack

- The target condition is no damage.
- Cracks are allowed but not more than 50% of the distance from the mounting hole to the edge of the part.
- Many times this hardware is attached with rivets.

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Types of Torque Wrenches

Precision Torque Wrenches

Dial Torque Wrenches

Click Type Torque Wrenches

Adapted from http://www.torquetools.com/torquewrenches.shtml

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Alignment and Polarity Requirements

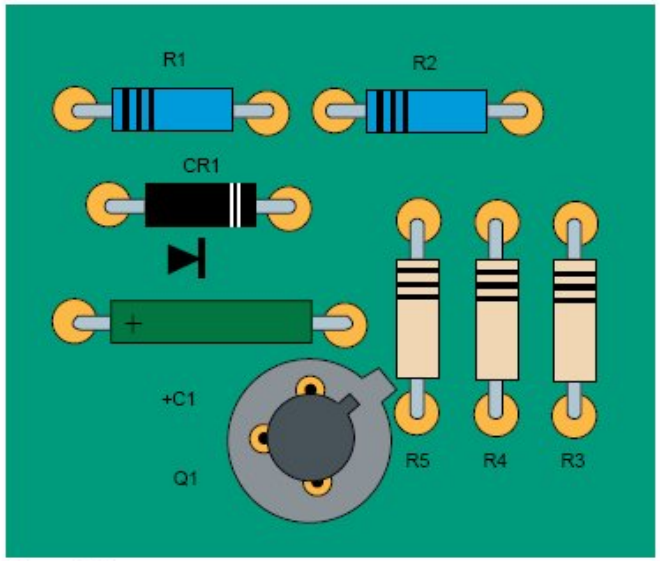

Figure 7-1

Target - Class 1,2,3

- Components are centered between their lands.
- Component markings are discernible.
- Nonpolarized components are oriented so that markings all read the same way (left-to-right or top-to-bottom).

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Heat Sinks

- Examples of electronic component heat sinks

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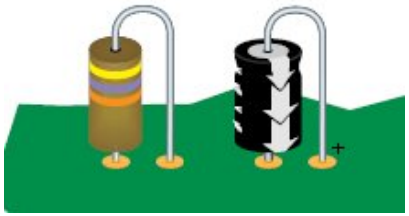
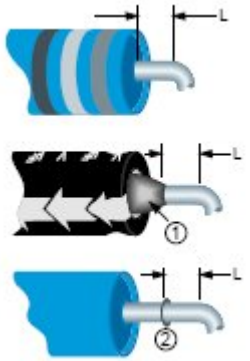
Types of Component Lead Forming

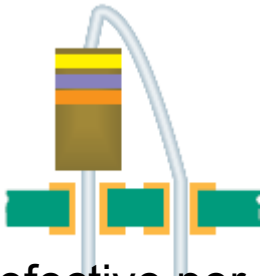


Acceptable per 7.1.1.2

Acceptable per 7.1.2.1



Acceptable per 7.1.2.1



Defective per 7.1.2.1

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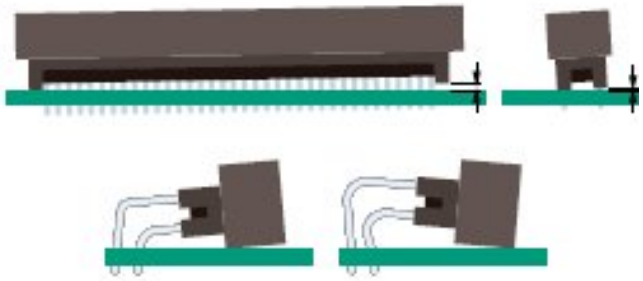
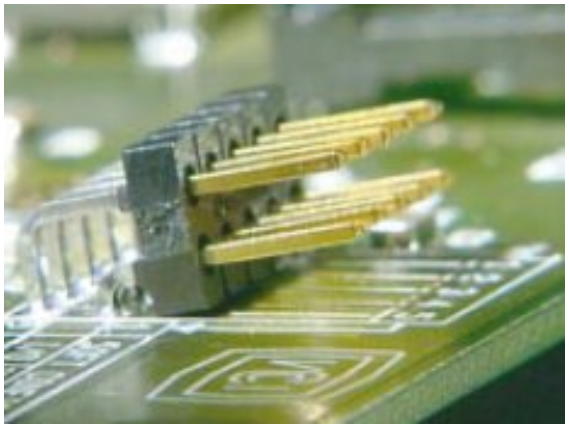
Component Mounting Connector 7.1.8





- This will create an improper fit of the boards into the final assembly if the connectors are off by too much. They should be flat to the board for ease of product assembly.

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Bow and Twist, 10.2.7

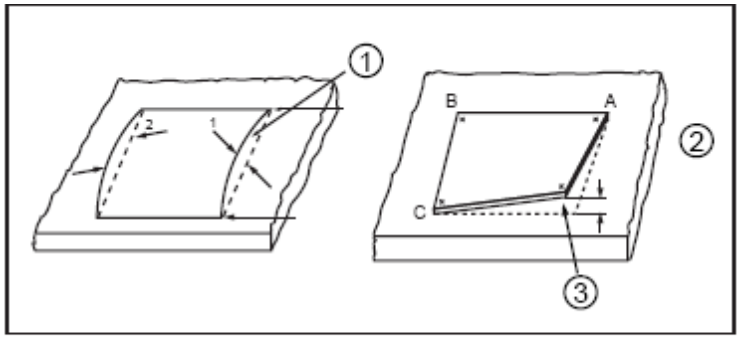

Figure 10-29
1. Bow
2. Points A, B and C are touching base
3. Twist

- Bow and Twist does not cause damage during post solder assembly operations or end use. Consider, “Form, Fit, Function” and product reliability.

Criteria is 1.5% for PTH and .75% for SMT

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Upcoming . . April 16th Boards

- What's involved in inspecting raw boards?
- What is the specification to use?
- Why should we be inspecting them?
- What is the specification trail to get boards made by the board house?
- Provide a list of the documents from design to manufacturing and discuss some common board problems affecting manufacturing.
- Process changes due to the introduction on RoHS and WEEE and how to address these.

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