Heat Sink Basics

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Objectives of this Course

By the end of this course you will be able to:

- Understand the difference between forced air and natural convection heat sinks.
- Identify different heat sink active and passive construction types and thermal conductivity.
- List different heat sink fin types, finishes and their performance characteristics.
- List the different thermal interface materials, applications and various heat sink attachments.
- Differentiate pricing between low, medium and high power heat sinks.

Agenda

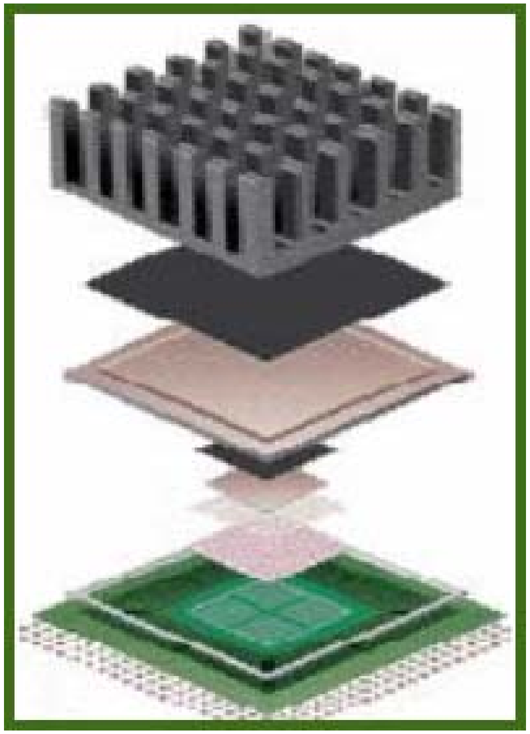
- Introduction to Heat Sinks
- Active and passive construction
- Fin designs and performance characteristics
- Thermal Interface Materials (TIMs) and heat sink attachments
- Heat sink cost strategy
- Key takeaways and additional information

Heat Sink Basics

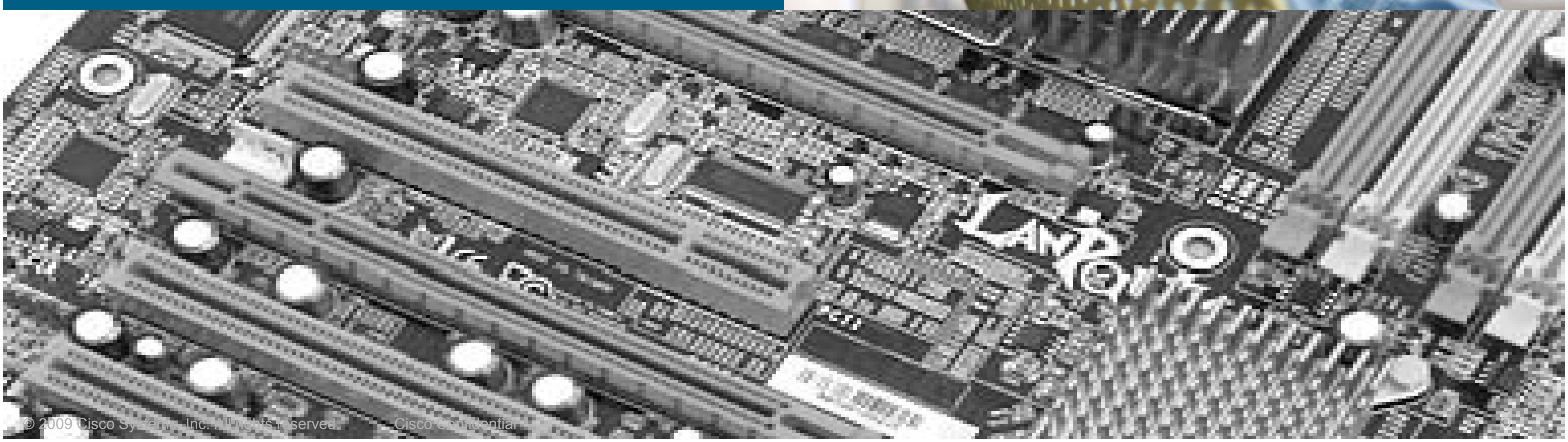
Heat Sink

Thermal Interface Materials (TIMs)

Component



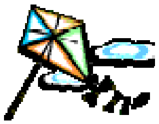
Natural and Forced Convection Heat Sinks



Natural/Forced Convection

Natural Convection

Air movement with out an air mover (typically a fan), key factors are:



Fin Surface Area — More is better

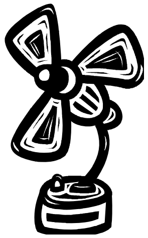
Fin Spacing — Fins must be spaced apart, low back pressure needed

Fin Finish — Radiation can be up to 25%of the heat dissipation, surface emissivity of the finish is important, typically parts should be anodized.

Fin Orientation — Fins must not prevent airflow

Forced Convection

Powered air flow, cooling is further enhanced by:



Ducting — Keep the air flow in the heat sink, limit by-pass air

Fin Orientation — Fins must not prevent air flow

Fan Back Pressure — Design the heat sink that is optimized for airflow and pressure drop

No Air Shadow — Do not block airflow in front or behind the heat sink

More Air, More Air — More air is good, more air is good, more air is good

Parallel not Series — Heat sinks need to be placed in parallel not in series

Go Wider — Wider heat sinks are usually better than taller or longer designs

Heat Sinks

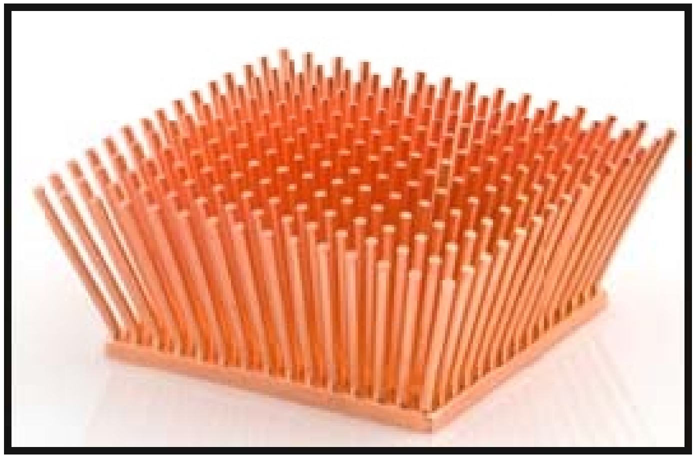
Aluminum Extruded Heat Sinks –
Natural Convection

Copper Heat Sink
w/Fan

Heat Sinks

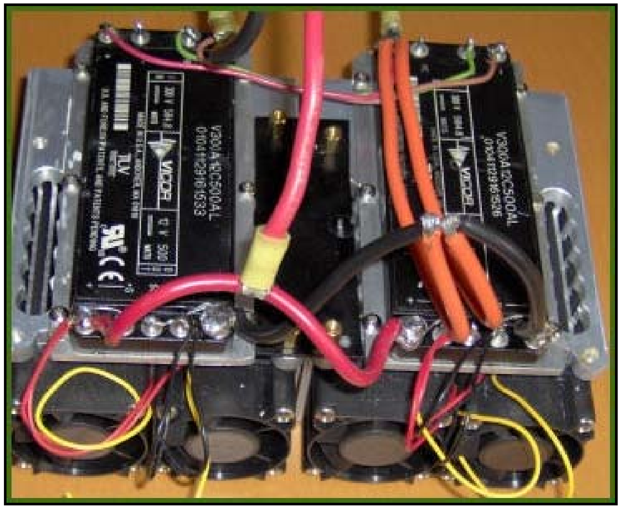
Heat Sinks w/air ducts

Heat Sink w/pins in a "Splayed" Orientation

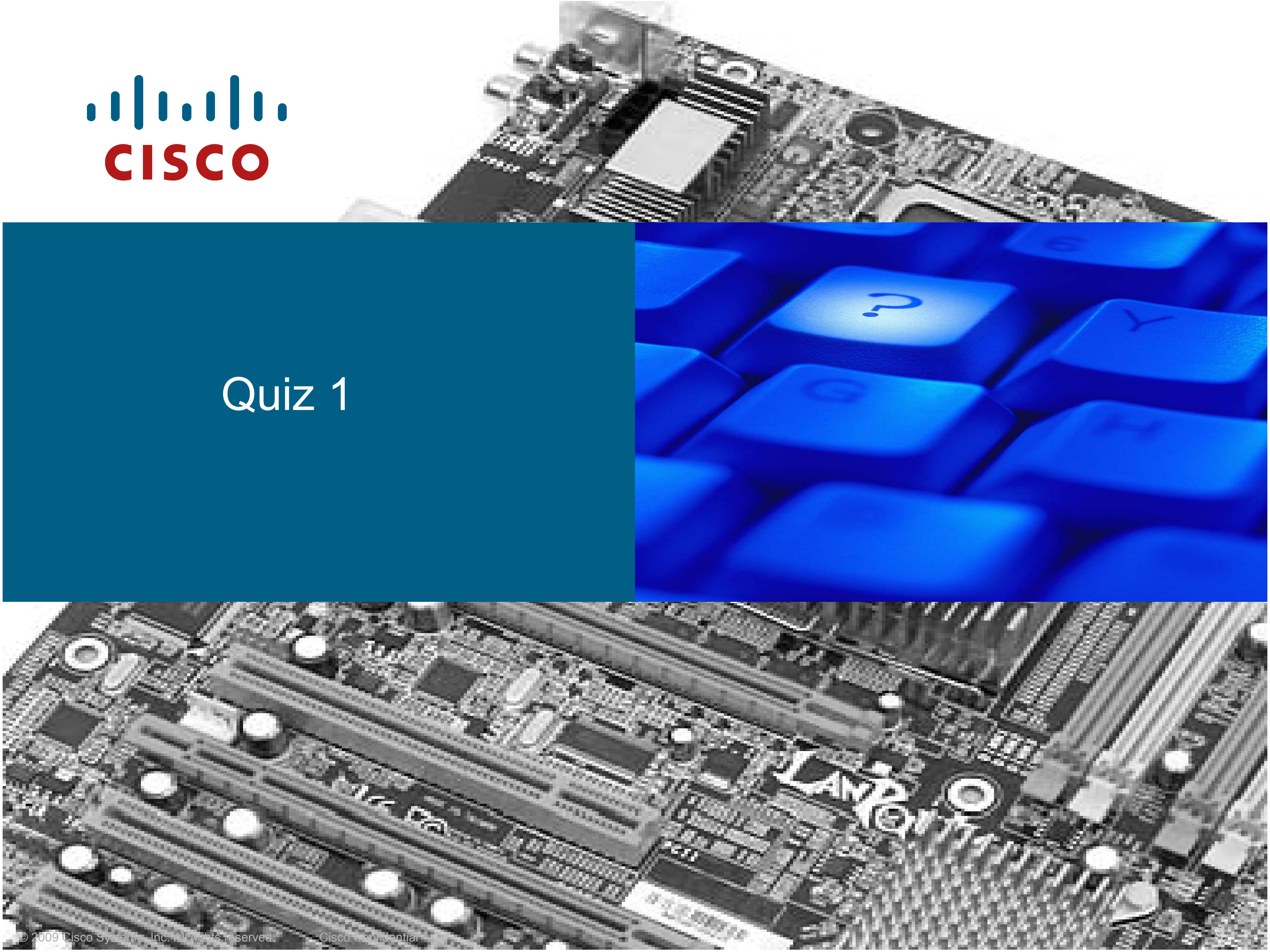


Heat Sinks in Parallel

Fans

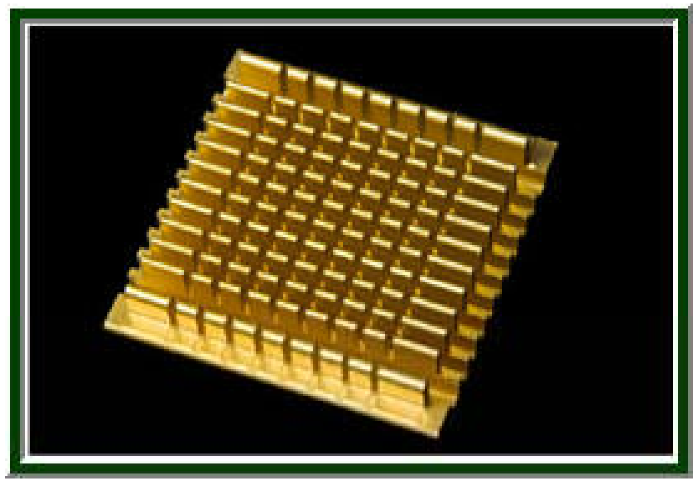


Quiz 1



Question 1
What type of heat sink is pictured here?

- A) Fan sink
- B) Passive
- C) Active
- D) Pipe sink



Correct - Click anywhere to continue

You answered this correctly!

The correct answer is:

You did not answer this

You must answer the question before continuing

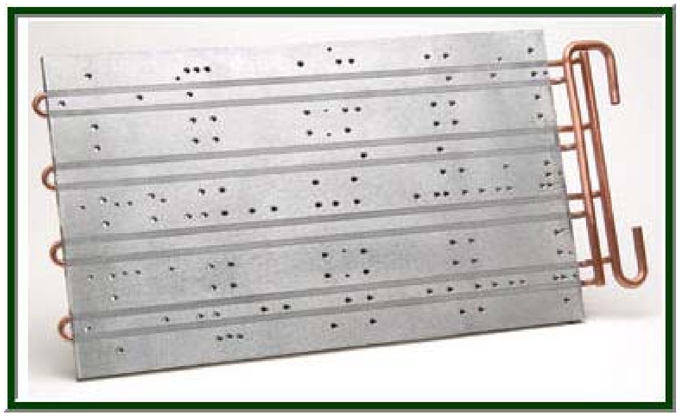
Your answer:

Submit

Clear

True or false: Is this an active sink?

- ◉ A) True
- ○ B) False



Correct - Click anywhere to conti

Incorrect - Click anywhere to

Your answer:

You did not answer this

You must answer the question before continuing

Submit | Clear

Quiz 1

Your Score	{score}
Max Score	{max-score}
Number of Quiz Attempts	{total-attempts}

Question Feedback/Review Information Will Appear Here

Continue **Review Quiz**

type the question here

- A) type the answer here
- B) type the answer here

Correct - Click anywhere to conti

Incorrect - Click anywhere to

Your answer:

You did not answer this

You must answer the question before continuing

Submit

Clear

Quiz 1

Your Score	{score}
Max Score	{max-score}
Number of Quiz Attempts	{total-attempts}

Question Feedback/Review Information Will Appear Here

Continue **Review Quiz**

Quiz 1: Natural and forced Convection

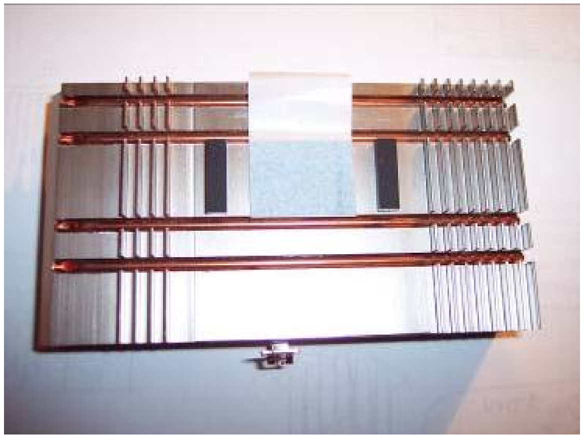
1. From the list below, select the 3 basic areas regarding heat sink basics.
   - **a. The component**
   - **b. The heat sink**
   - c. The fin surface area
   - **d. The thermal interface materials**
2. Select from the list below the single choice which best describes forced convection.
   - a. Blocked air flow in front of a heat sink
   - b. Parallel heat sinks
   - c. Air movement without an air mover
   - **d. Powered air flow**
3. What type of heat sink is pictured here?
   - a. Fan Sink
   - **b. Passive**
   - c. Active
   - d. Pipe Sink

Active and Passive Heat Sinks

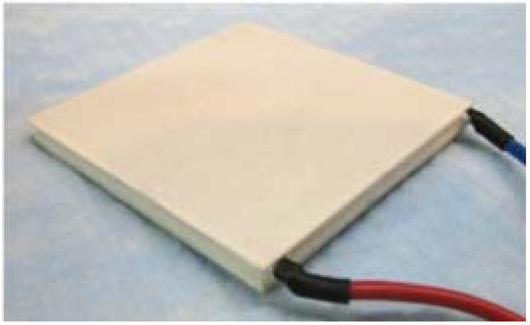
Active Heat Sink Construction

Type	Power	Applications
Fan Sink	< 40W	Typical applications are old processors, fan mounted directly on heat sink
Zipper Fan Sink	<80W	Microprocessor applications
Heat Pipe	<140W	Microprocessor applications •Straight Fin: used with known airflow direction. •Pin Fin: used with natural convection or unknown low, or turbulent airflow
Vapor Chamber	<80W	heat sink with heat pipe type function but the base typically contains the working fluid, hardly used
LCS (Liquid Cooling)	<200W	High heat flux applications, expensive, typically 10X the cost of a heat pipe solution
Thermal Siphon	<1000W	Extreme power applications
Peltier Devices	<80W	Inefficient, limited cooling, expensive
New Stuff	<??W	New ideas every day but not always cost efficient or practical

Active Heat Sink Examples



Heat Pipe



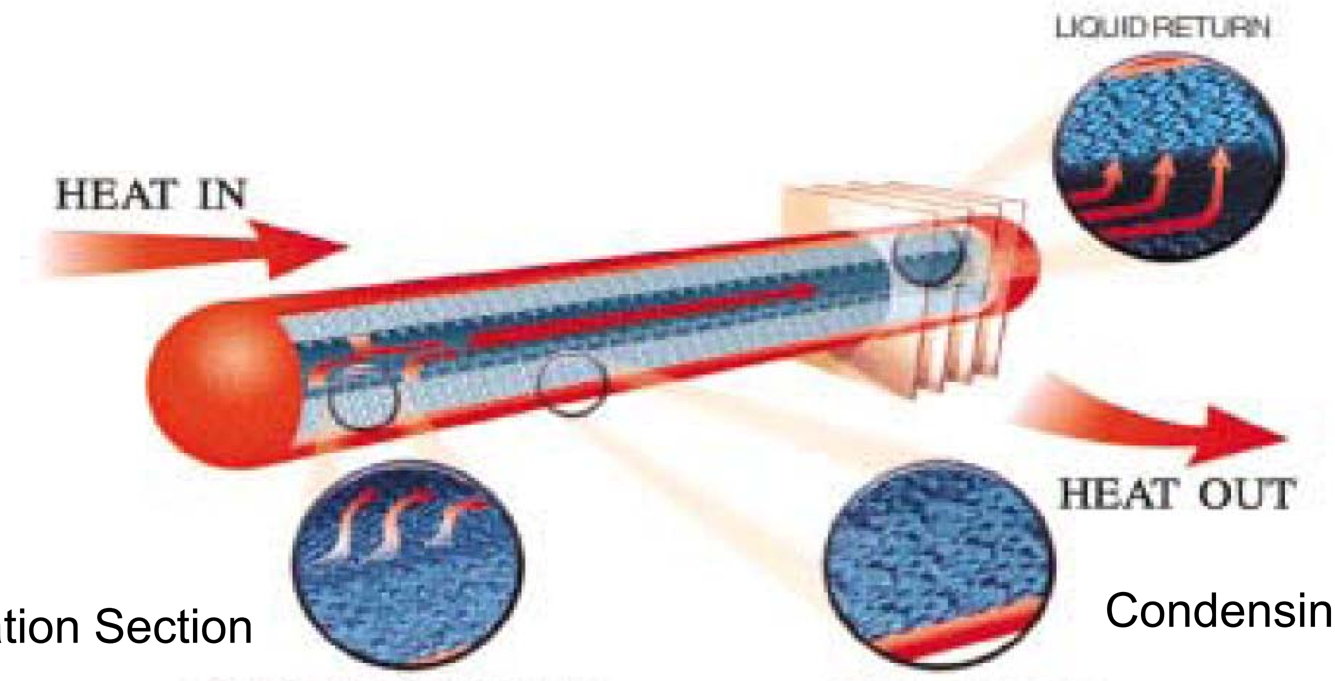
Peltier Device

Liquid Cooling

Fan Sink

Heat Pipe Construction

<u>Heat pipes do not dissipate heat they move it to another location</u>



Evaporation Section

Condensing Section

Heat Pipe Construction

Sintered Copper

- Best Performance
- Sintered copper balls wicking mechanism
- Best for formed heat pipe shapes (bending and flattening)
- Low internal back pressure as core area is wide open
- Wicking action 360 degrees around inside of the heat pipe

Copper Powder

- Alternate name for sintered copper

Heat Pipe Construction (Cont'd)

Grooved

- Low cost
- Part has internal groves for wicking action
- Groves can be distorted if pipes are bent or formed, however…
- Suitable for straight pipe and horizontal solutions
- Limited wicking action

Other slightly inferior pipe designs include:

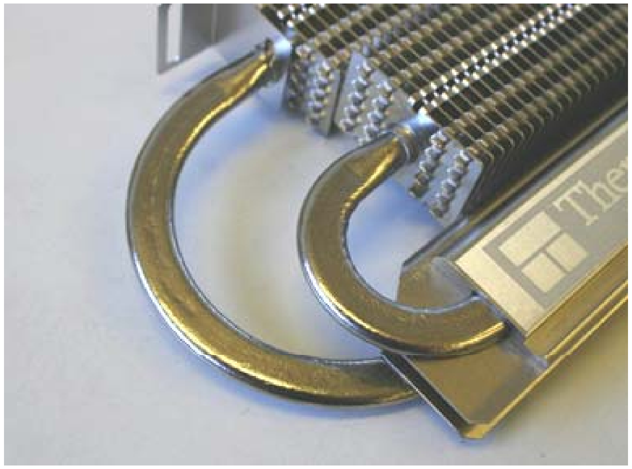
- Wick
- Fiber
- Spring
- Mesh
- Hybrid

Heat Pipe Examples

Sintered Copper

Copper Powder Pipe
Cross Cut Section

Grooved Pipe
Cross Cut Section



Bent Flat Pipe

Heat Pipe Features

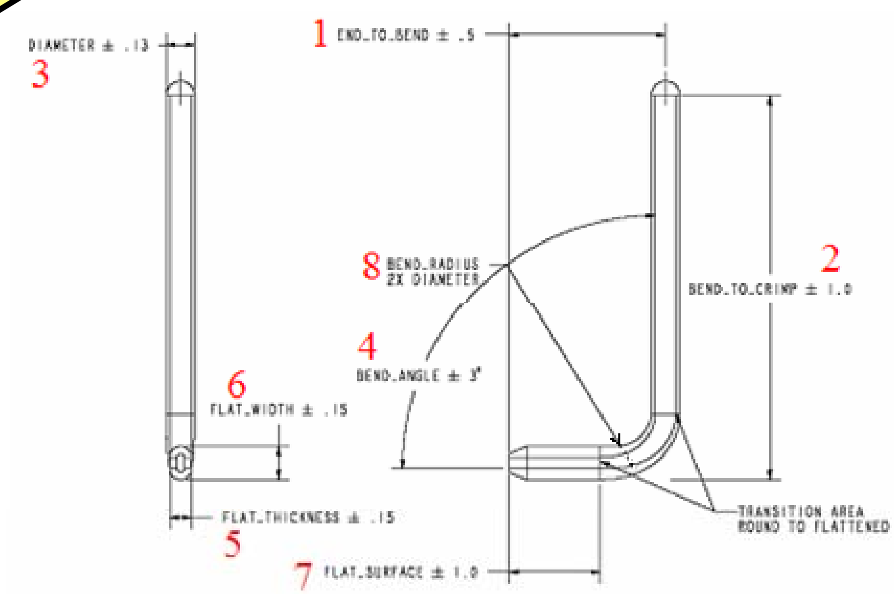
Tolerance Summary

Item	Feature	Units	Tolerance	Notes
1	Length (end of Pipe-to-bend)	mm	±0.50	-
2	Length (Bend-to-crimp)	mm	±1.00	-
3	Diameter of Pipe	mm	±0.13	-
4	Bend Angle	°	±3.0	-
5	Flattened Pipe (thickness)	mm	±0.15	-
6	Flattened Pipe (width)	mm	±0.15	-
7	Flatten Surface	mm	±1.00	-
8	Inside bend radius (minimum)		2 X Ø	-

Notes:

1. Conversion: 1.0” = 25.4mm

Feature Diagram



Passive Heat Sink Construction

Type	Power	Applications
Stampings	< 5W	Typical applications are TO-220's , parts stamped form sheet metal, low cost
MicroForged	<30W	High NRE and part cost
Small Extrusions	<30W	Board level such as BGA, Northbridge chip sets, DC/DC •Straight Fin: used with known airflow direction. •Pin Fin: used with natural convection or unknown low, or turbulent airflow
Medium Extrusions	<60W	Heat sinks with maximum volume, fin area, large heat sources, lots of airflow
Large Extrusions	<200W	Very large components, IGBT's, SCR's, UPS
Zipper Fin	<150W	High fin density parts such a microprocessors.
Skived Fin	<80W	Alternate to Zipper fin, low NRE, higher cost, design limits
Bonded Fin	<200W	High fin density for large components, usually in power applications

Zipper Fin

Zipper Fin Features

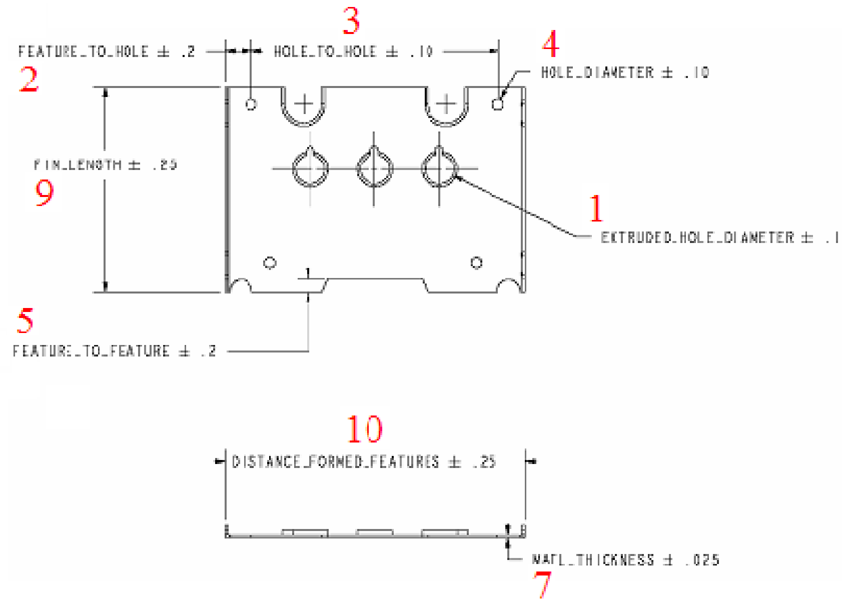
Feature Tolerance Guideline

Tolerance Summary

Item	Feature	Units	Tolerance	Notes
1	Extruded Hole (Ø)	mm	±0.13	1
2	Non-Hole, Feature-to-Feature Location	mm	±0.20	1
3	Hole-to-Hole Location	mm	±0.10	1
4	Hole Size (Ø)	mm	±0.10	1
5	Feature Dimension (non-hole)	mm	±0.25	1
6	Solder Asembly (base edge-to-fin)	mm	±0.50	1
7	Fin Material Thickness	mm	±0.025	1
8	Assemblied Fin Pack Width (stack)	mm	±0.50	1
9	Stamped Fin Length (height or length)	mm	±0.25	1
10	Distance between formed features	mm	±0.25	1

Notes:
1. Tolerances valid for base material < 1.0mm
2. Conversion: 1.0” = 25.4mm

Feature Diagram



Finishes

Anodizing

- Aluminum oxide finish
- Excellent emissivity (important for natural convection)
- Very tough finish and low cost
- Electrically non-conductive
- Colors are dyed in (black and clear are standard) and do not effect emissivity
- RoHS compliant

Finishes (Cont'd)

Chromate (aka Chemfilm, Irridite, Aludyne)

- Dip type finish that seals the pores in the metal (can be rubbed off)
- Low cost
- Available in clear and yellow
  - Clear is RoHS compliant
  - Yellow is non RoHS compliant
- Electrically conductive
  - –Hexavalent Chromate, Cr-6 is non RoHS compliant, do not use
  - –Trivalent Chromate, Cr-3 is RoHS compliant
  - –McDermitt Process, non Chromate

Finishes (Cont'd)

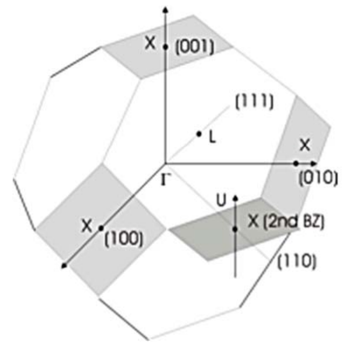
Mill (aka plain)

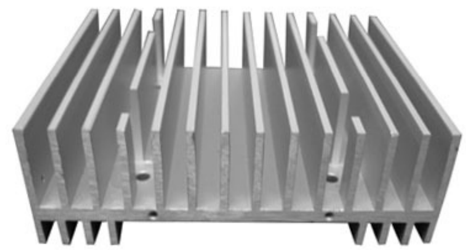
- Wash
- Bare
- Plain
- Wash and debur

Nickel

- Solderable, may be needed depending on HS construction,
- Good for tough environments

Thermal Conductors





Common Materials	W/m ° K.	Common Materials	W/m ° K.	Common Materials	W/m ° K.
Diamond	1,000	AL (Pure)	225	Iron	76
Graphite	500	AL 1100	218	Tin	63
Copper	385	AL 6063	203	Lead	33
Brass	120	AL 6061	167	Zinc	112
Nickel	61	AL 210 (cast)	121	Air	<.03

Materials & Treatments for Pipes

Sheet & Extrusion Alloys

Aluminum

- Sheet & Coil: 1050, 1100 or 5052
- Extrusion: 6063-T5
- Cast Alloy: ADC10, ADC12

Copper

- Sheet & Extrusion: C1100

Stainless Steel

- Sheet
- SK-7 (heat treatable, S410)
- 301

Thickness & Diameter

Sheet & Plate

- Thickness up to 1.0mm (0.2, 0.3, 0.5, 0.6, 0.8, 1.0)
- Thickness *1.0 ~ 5.0mm* (1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0)

Wire

- Diameters up to 1.0mm (0.2, 0.3, 0.4, 0.5, 0.8, 1.0)
- Diameters 1.0 ~ 3.0mm (1.0, 1.5, 2.0, 2.5, 3.0)

RoHS Surface Treatments

Anodizing

- Standard Colors: Black & Clear
- Available: Blue, Green, Red, Gold

Trivalent Chromate

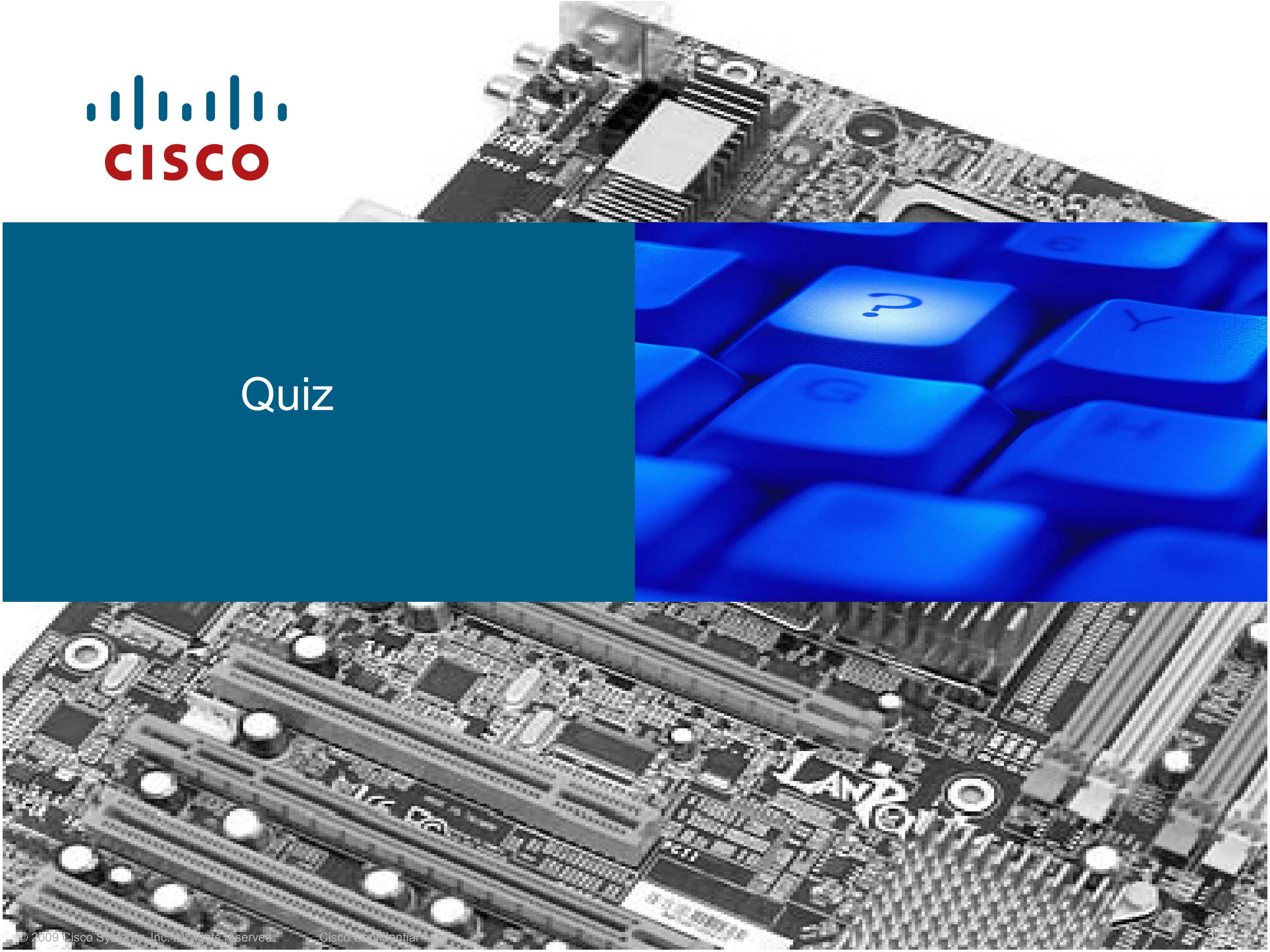
Standard Color: Clear

Other Treatments

- Bare (aka Wash or Plain)
- Electroless Nickel
- Copper Passivation (Anti-oxidant)

Finishes

- Mill Finish aka “as extruded”
- Bead Blast
- Grain aka Sanded
- Polish aka Mirror Finish

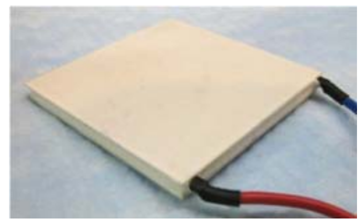


Quiz

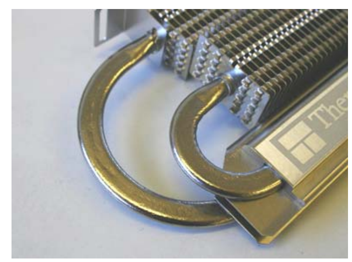
 Cisco Confidential

Quiz 2: Active and Passive Heat Sinks

1. True or False: Is this a picture of an active heat sink?
    - **a. True**
    - b. False
2. Select one of the choices below which best describe vapor chamber heat sink.
    - **a. The base typically contains the working fluid**
    - b. A fan is mounted directly on the heat sink
    - c. Also known as a zipper fan heat sink
    - d. None of the above
3. What type of heat sink is this? (photo of a Peltier device).
    - a. Zipper fin
    - b. Fan sink
    - c. Bent flat sink
    - **d. Peltier device**



4. True or False: Heat pipes do not dissipate heat; they move it to another location.
    - **a. True**
    - b. False
5. What type of pipe construction would be used in this heat sink? (photo of heat sink with a flat pipe)
    - a. Grooved
    - b. Spring
    - **c. Sintered copper or copper powder**
    - d. Zipper fan



6. Most heat sinks are made of (choose one below):
    - a. Brass
    - **b. Aluminum**
    - c. Nickel
    - d. Copper

Heat Sink Fin Design and Performance

Fin Notes

Straight Pin

- Best thermal performance, lowest cost, low back pressure, airflow to be in the fin direction

Pin Fin

- Good performance, higher back pressure, best for unknown/turbulent/ natural convection airflows

Round Pin Fin

- Usually on die cast or MicroForged parts, usually more costly and lower performing

Elliptical / Tapered Fin

- Good for very low back pressure, high NRE, high part cost. MicroForged parts can have very thin fins.

Too Many Fins

- High back pressure, air may not flow through the parts.

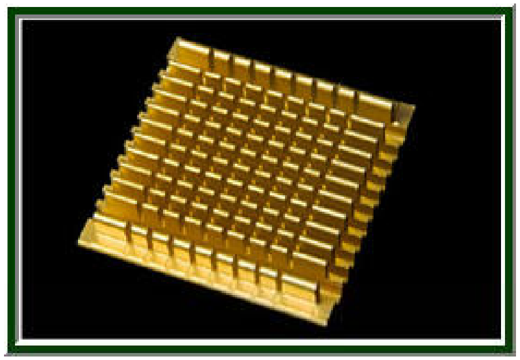
Natural Convection

- Fins must be widely spaced, ex .200 inch or heat will radiate from one fin to the next.

Cross Cuts

- Break the static air flow boundary later

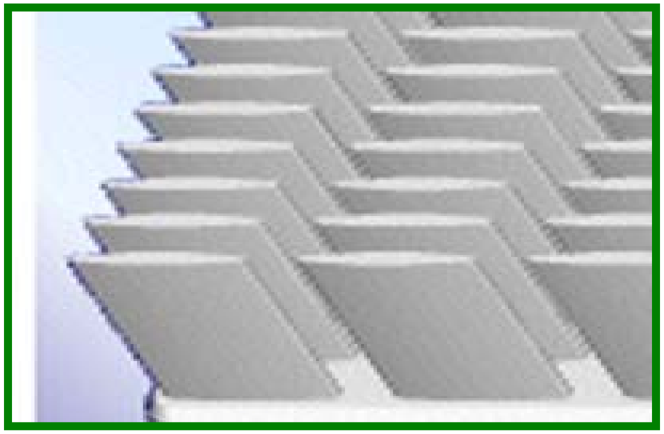
Heat Sink Examples



Cross cut Heat sink

Round Pin Fins

Pin Fin



Elliptical/Tapered

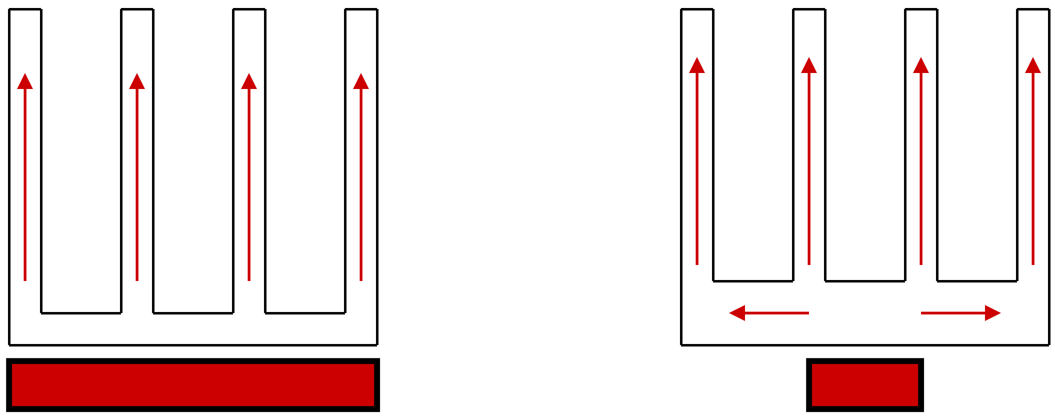
Straight Fin

Base Spreading

Base Spreading

When the heat source is smaller than the heat sink, the heat sink base thickness must be optimized to allow heat to flow through the base to the outer fins.

[THE Heat Sink Alloy – Aluminum 6063-T5](#)



Heat Sink = Heat Source Heat Sink > Heat Source

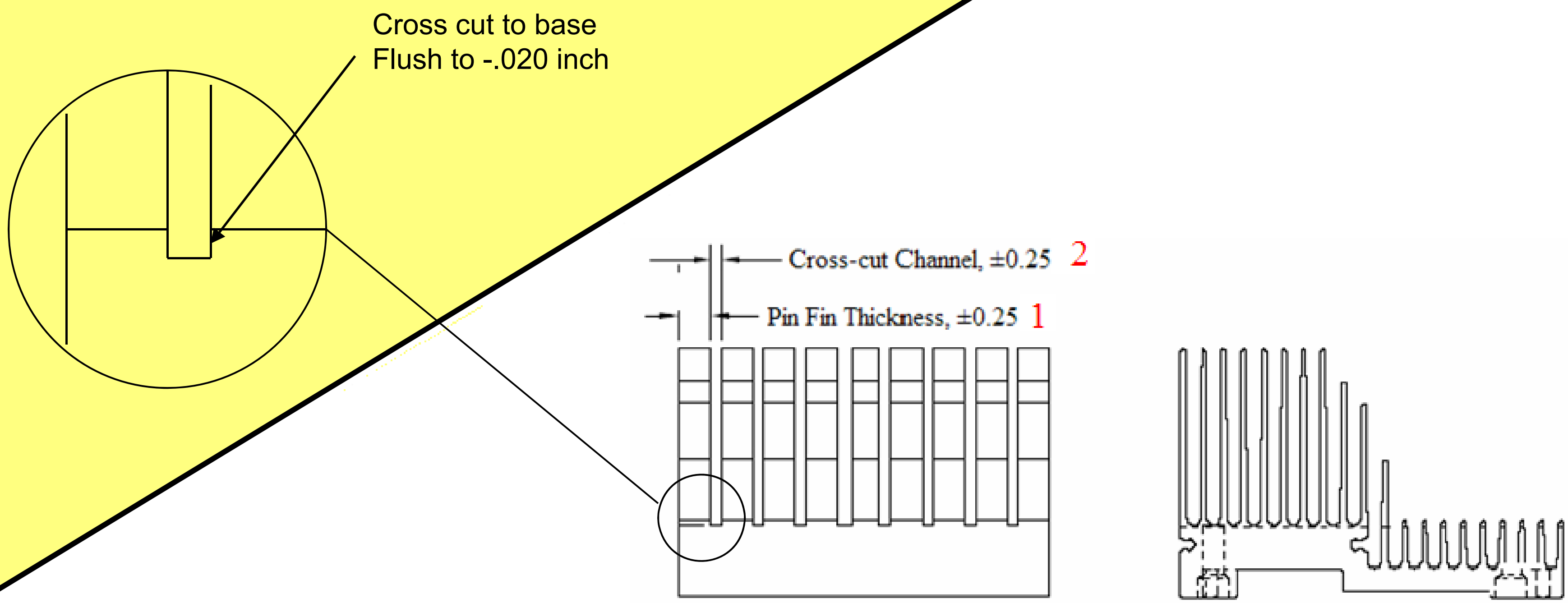
Cross-Cutting Features

Tolerance Summary

Item	Feature	Units	Tolerance	Notes
1	Pin Fin Thickness	mm	±0.25	1, 2
2	Cross-cut Channel	mm	±0.25	1, 2

Notes:
1. Tolerances valid for fin heights < 50mm
2. Tolerance valid for Cross-cut channels > 1.5mm
3. Conversion: 1.0” = 25.4mm

Feature Diagram



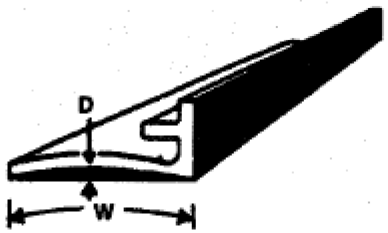
Flatness

Flatness = $$$ Specify the flatness that you need but only where you need it

Cisco Standard is .002"/" in the heat source area

TABLE 5 Flatness (Flat Surfaces)①—Bar, Solid Profiles and Semihollow Profiles

EXCEPT FOR PROFILES IN O ⑧, T3510, T4510, T6510, T73510, T76510 and T8510 TEMPERS ⑤



SURFACES WIDTHS UP THRU 1 INCH OR ANY 1 INCH INCREMENT OF WIDER SURFACES
Maximum Allowable Deviation D = TOLERANCE (in.)

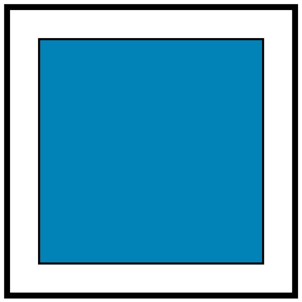
WIDTHS OVER 1 INCH
Maximum Allowable Deviation D = TOLERANCE x W (in.)

MINIMUM THICKNESS OF METAL FORMING THE SURFACE in.	SURFACE WIDTH—in.										
	UP TO 5.999	6.000 TO 7.999	8.000 TO 9.999	10.000 TO 11.999	12.000 TO 13.999	14.000 TO 15.999	16.000 TO 17.999	18.000 TO 19.999	20.000 TO 21.999	22.000 TO 23.999	24.000 AND UP
	TOLERANCE										
Up thru .0124	.004	.006	.010	.014	..	..	..	..	..	..	..
0.125-0.187	.004	.006	.008	.012	.014	.014	.014	..	..	..	..
0.188-0.249	.004	.006	.008	.010	.012	.012	.012	.014	.014	..	..
0.250-0.374	.004	.006	.006	.008	.010	.010	.012	.012	.012	.014	..
0.375-0.499	.004	.004	.006	.008	.008	.008	.010	.010	.010	.012	.014
0.500-0.749	.004	.004	.006	.006	.008	.008	.008	.008	.010	.010	.012
0.750-0.999	.004	.004	.006	.006	.008	.008	.008	.008	.008	.008	.010
1.000-1.499	.004	.004	.004	.006	.006	.008	.008	.008	.008	.008	.008
1.500-1.999	.004	.004	.004	.004	.006	.006	.006	.008	.008	.008	.008
2.000 and up	.004	.004	.004	.004	.004	.006	.006	.006	.008	.008	.008

For all numbered footnotes, see page 27.

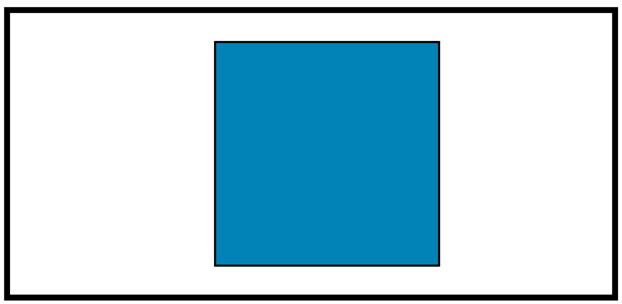
Flatness

Flatness = $$$



Single flatness callout is fine

Small parts will probably be < .002”/” as extruded



Specify flatness in heat source area

Go with standard callout on the rest of the part

Specify flatness in source areas

Do they need to be related ??

Standard callout on the rest of the part

Extrusion Aspect Ratios

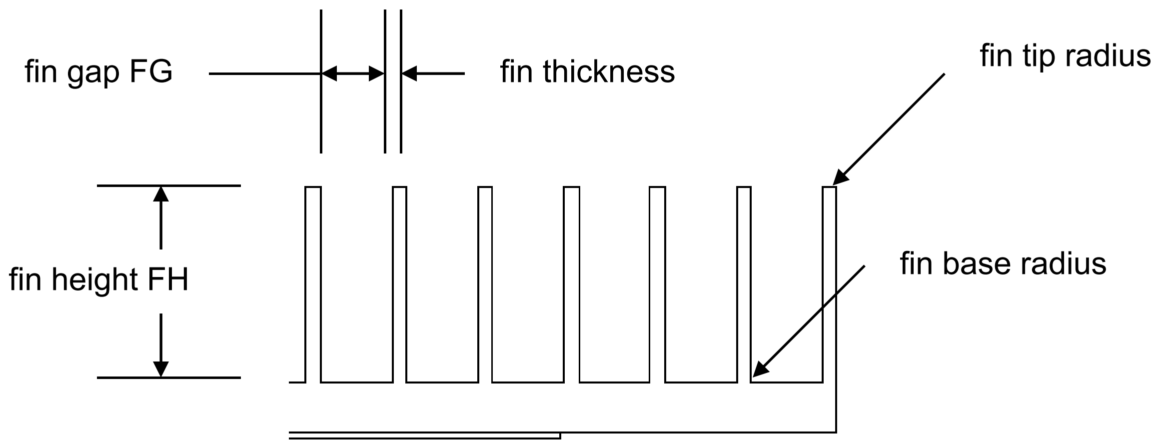
Aspect Ratio = Fin Height / Fin Gap = FH/FG

< 7:1 No problem
<10:1 Slower extrusion through put
<15:1 Selected balanced shapes only
<20:1 Consult factory
>20:1 Very Select shapes only

THE Heat Sink Alloy – Aluminum 6063-T5

Fin Features

.032” min thickness preferred for machining ease and speed, under .032” is a TFE (Thin Fin Extrusion)
.020” min thickness under most circumstances.
Tapered fins, preferred for strength, especially on thin fins parts.
Radii increase tool life, reduce part and tool stress
Serrated fins greatly increase tool back pressure, not recommended.



Extrusion Tolerance

Dimensional Tolerances for Aluminum Extrusions

VetteCorp's aluminum extrusion comply with the standard commercial tolerances established by The Aluminum Associations, INC. The tolerances for an extrusion dimension is a function of the die size of the particular dimension and the diameter of the extrusion die. Table B is a guide for most dimensional tolerances. The illustration shown is a typical flat back Extrusion. Tolerances for some extreme ration and some of the larger sizes tend to exceed the tolerances listed on this table and, conversely some of the Smaller (less than 7 inch diagonal) can be supplied slightly better than commercial
Tolerances.

When defining machined flatness, use the statement of .001"/in. to preclude steps allowable with other methods of defining flatness. See Table A.

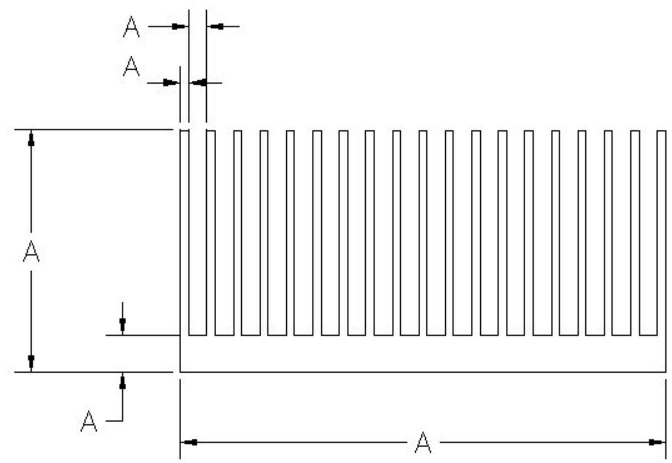


TABLE B
TYPICAL TOLERANCES FOR 6063-T5 EXTRUDED ALUMINUM ALLOY

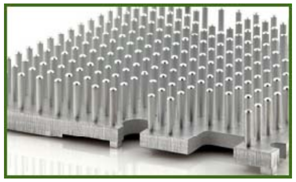
Dimension A (inches)/(mm)	**+/- Tolerance (up to 10" circle size) (inches)/(mm)**
0.000- 0.125 / 0.00-3.18	.006 / 0.15
0.125-0.249 / 3.18-6.35	.007 / 0.18
0.250-0.499 / 6.35-12.70	.008 / 0.20
0.500-0.749 / 12.70-19.05	.009 / 0.23
0.750-0.999 / 19.05-25.40	.010 / 0.25
1.000-1.499 / 25.40-38.10	.012 / 0.30
1.500-1.999 / 38.10-50.80	.014 / 0.35
2.000-3.999 / 50.80-101.60	.024 / 0.61
4.000-5.999 / 101.60-152.40	.034 / 0.86
6.000-7.999 / 152.40-203.20	.044 / 1.12
8.000-9.999 / 203.20-254.00	.054 / 1.37

TABLE A
TYPICAL TOLERANCES FOR FLATTNESS AND ROUGHNESS

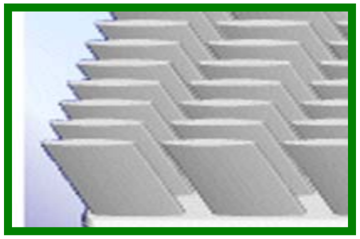
ALUMINUM SURFACE	FLATTNESS [IN/IN] (mm/25.4mm)	SURFACE ROUGNESS [RMS]
As Extruded	004 (0.10)	125-64 (3.2-1.6)
Sanding	.002-.003 (0.51-0.76)	64-32 (1.6-0.8)
Machined	.001 (.025)	64 - or better (1.6 -)

Quiz

Quiz 3: HS Fin design and performance

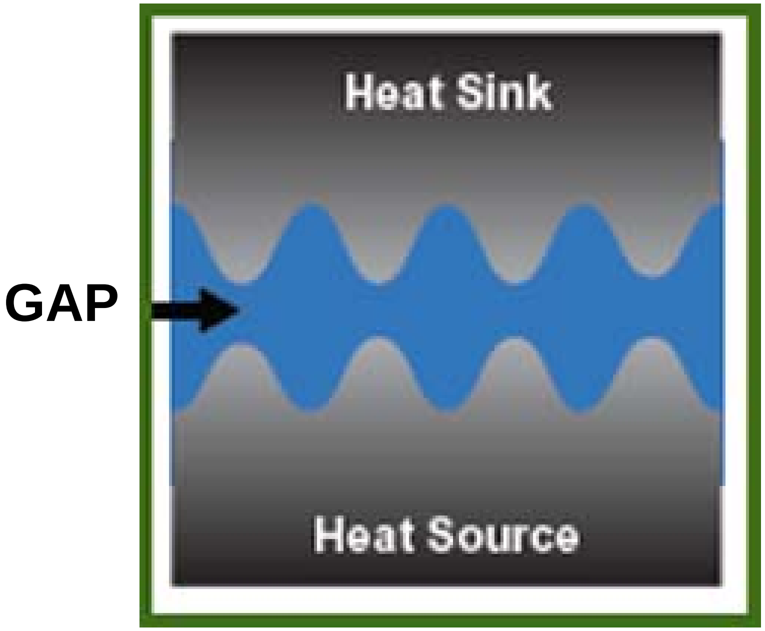


1. What type of heat sink fin design is this? (photo of a round pin HS)
2. What type of heat sink fin design is this? (Photo of pin fin)
3. What type of heat sink fin design is this? (Photo of elliptical/tapered)
4. True or False: When the heat source is smaller than the heat sink, the heat sink base thickness must be optimized to allow heat to flow through the base to the outer fins.
   - **a. True**
   - b. False
5. Which of the choices below should you consider when specifying flatness for your heat sink fins?
   - a. Specify flatness that you need but only where you need it
   - b. It is better to specify flatness in the heat source area
   - c. Remember: Flatness = $$$
   - **d. All of the above**



Thermal Interfaces and Heat Sink Attachment devices

Heat Sink Basics



Thermal Interface Types

Double Sided PSA

- Pressure Sensitive Adhesive used to adhere heat sink to the heat source
- Easy to assemble, pull tabs available on most materials
- Need to select a specific tape for mounting surface i.e. metal, plastic, ceramic, silicon, etc. Typically .005-.010" thick

Single Sided PSA (SSA Single Sided Adhesive, alternate terminology)

- Provides interface adhered to the heat sink only
- Mechanical fastening of the heat sink is needed i.e. push pins, wire clips, band clips, screws, plastic clip, etc. Typically .005-.010" thick
- Graphite - commonly used on AC/DC converters, usually .005" and .010" thick

PCM

- Phase Change Material, higher performance TIM that reflows with heat to fill all the interface voids, difficult to apply, usually supplied with a pull tab/release liner . Typically .002-.004" thick

Thermal Interface Types (Cont'd)

Gap Filler

- Typically .020" and thicker pad with some compressibility, used to fill varying gap sizes, mechanical fastening is required

Epoxy

- Thermally loaded filler adhesive system, provides permanent and strong mechanical attachment
- Often not favored by assemblers due to the possible prep work and inability to rework

Grease

- Excellent thermals, void filling capability and very thin interface, mechanical attachment required, but can be messy and is not favored by assemblers
- Can be silk screened on by the factory but parts need covers to prevent dust and dirt contamination. Typically .001"-.002" thick

Pull Tabs

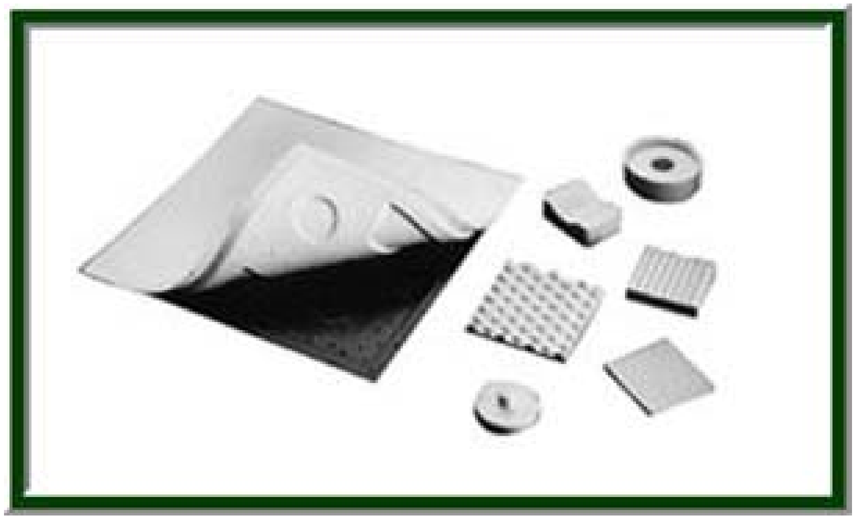
- Release liner feature which makes assembly much easier, not available on all TIMs

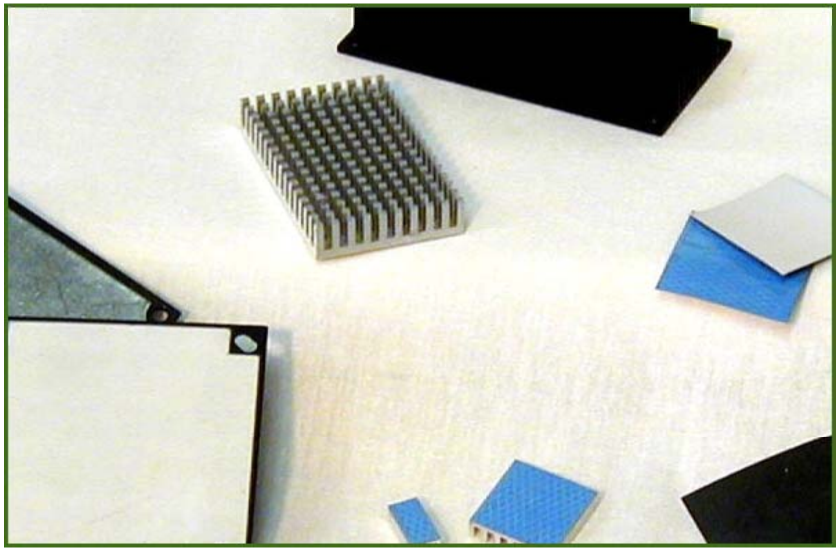
Urethane Gaskets

- Commonly used on small heat source flip chip parts to reduce chip breakage

Thermal Interface Materials

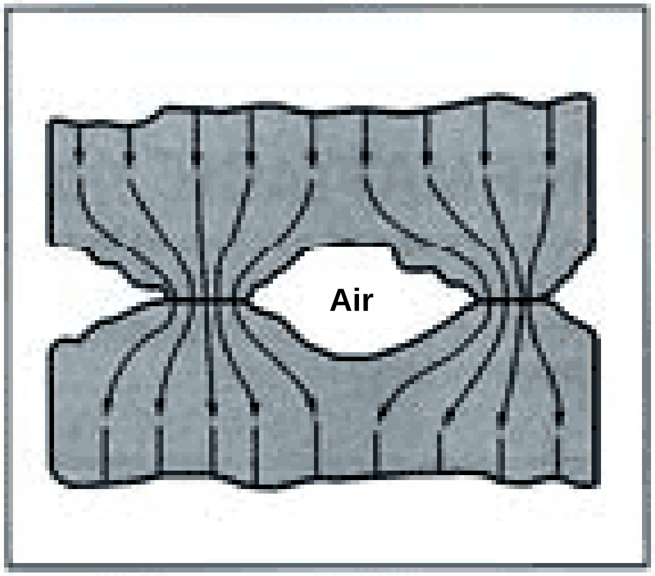
The images on this page represent various TIMs

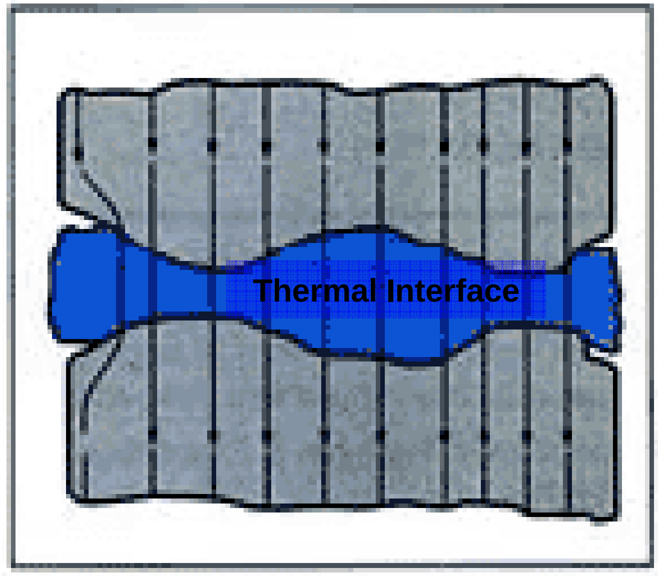




Why A Thermal Interface

Magnified Sketch of the Interface between Heat Source and Heat Sink





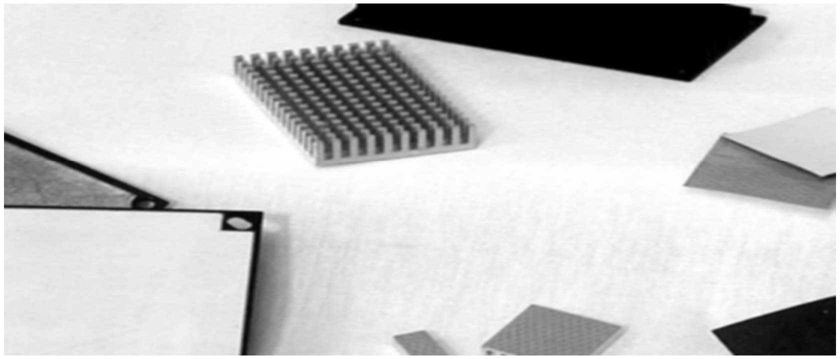
Poor Heat Transfer

Small heat conduction area and insulating air pockets

Good Heat Transfer

Larger heat conduction area and no air pockets (PCM example)

Thermal Conductors (TIMs)



Thermal Interface Materials	$W/m\ ^{\circ}K.$	Brand
Tapes	XXX	Chomerics T411
PCMs	0.73	Thermagon 105
Gap Fillers	11.0	FujiPoly 100Xe
Grease	>4.5	Shin Etsu G751
Graphite	4	Furon C695
Epoxy	0.76	Loctite 384

Thermal Interface Materials (TIMs)

CSI10

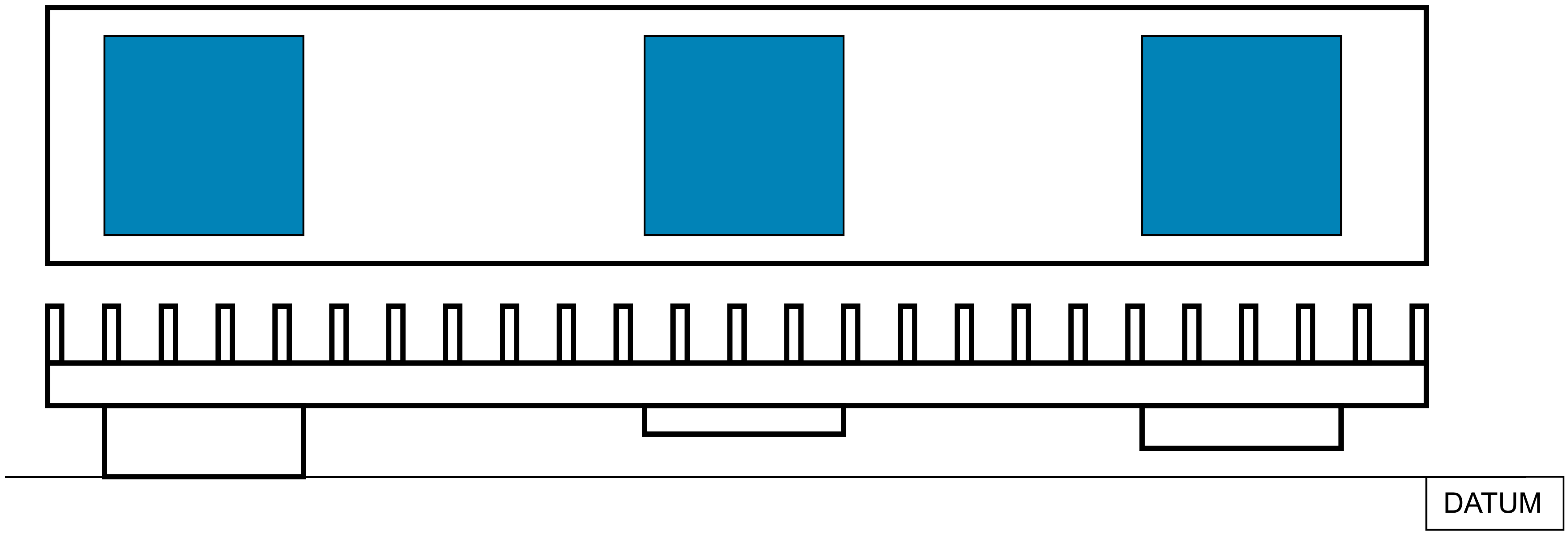
Interface Materials	W/m ° K.		Interface Materials	W/m ° K.
Tapes	XXX		Chomerics T411	>.7
PCM	0.73		Thermagon 105	>.7
Gap Fillers	11.0		FujiPoly 100Xe	11
Grease	>4.5		Shin Etsu G751	>.7
Graphite	4		Furon C695	>.7
Epoxy	0.76		Loctite 384	>.7

TIMs are usually rated by thermal resistance, thickness, pressure and area

Slide 52

CSI10 I believe the previous slide is a more accurate representation that this one. Please advise.
Cisco Systems, Inc., 2/4/2009

Pedestals and Datums



1. Parts are CNC machined from the bottom.
2. Datum the lowest machined pedestal surface NOT the base of the heat sink.
3. Will the center heat source always contact the heat sink ??
4. Gap filler TIMs (.020”+) are expensive.
5. Machined standoffs have the same dimensioning problems.
6. We machine it flat but when we open the vise, the part may spring back.
7. Thin base parts flex, how do we measure a part with flex ??

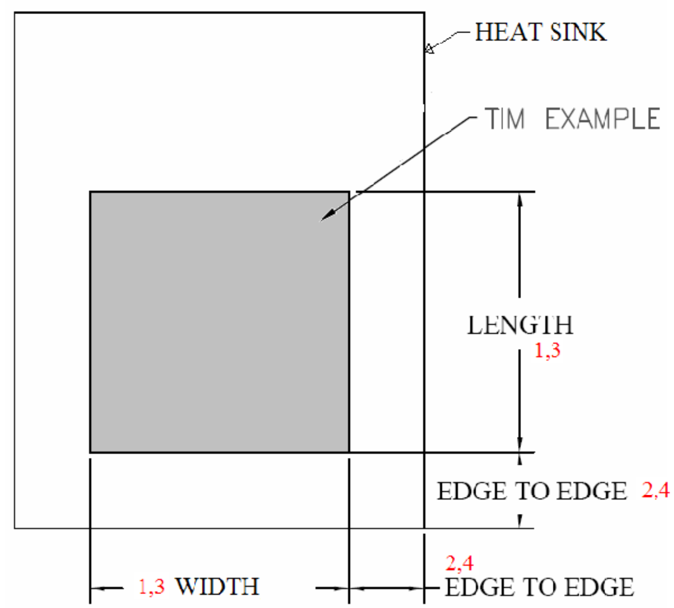
Thermal Interface

Tolerance Summary

Item	Feature	Units	Tolerance	Notes
1	TIM Pad Size (length or width)	mm	±0.25	1
2	TIM Pad Position (edge-to-edge)	mm	±0.50	1
3	TIM Grease Size (length or width)	mm	±0.50	1
4	TIM Grease Location (edge-to-edge)	mm	±0.50	1

Notes:
1. Tolerance reflects material state at point of manufacture.
2. Conversion: 1.0” = 25.4mm

Feature Diagram



Heat Sink Attachments

Push Pins

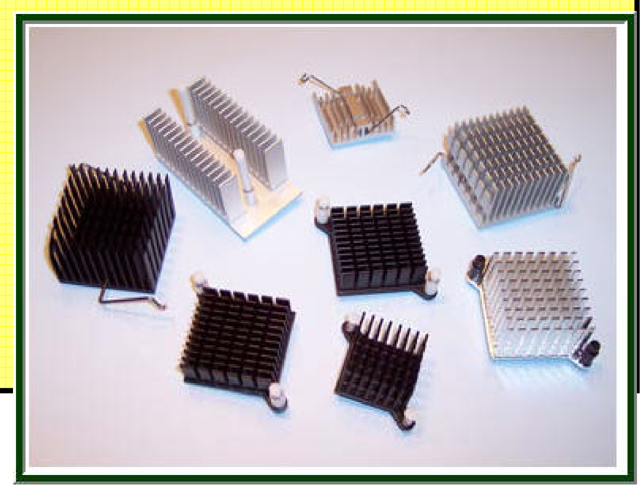
- Plastic
  - Low cost, 0-3 lbs per pin, use Nylon 66, requires holes in PCB
- Brass
  - For heavier parts to meet drop test, 4x times cost of a plastic pin

Wire Clips

- Low cost, 0-6 lbs, need PCB anchors (solder or omega pin)

Band Clips

- High force, high cost, high NRE



Screws/Springs

- Good solution on custom parts, requires inserts in PCB

Plastic Clips

- No board space required but high NRE and no flexibility

Push Pin Design

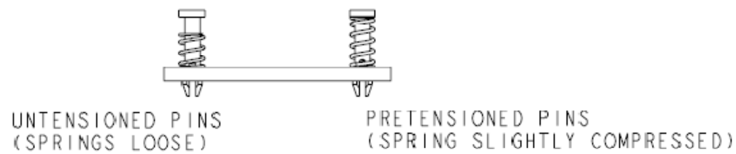
<u>Materials and Tolerances</u>

Springs

- Music Wire
- Stainless Steel

Tolerances

- **Free Length ±.050" (1.27mm)**
- Wire Diameter ±.002" (.05mm)
- Spring Rate ± 15% of stated value



Design Criteria:
Pins should always be pre-tensioned

<u>Determining spring length</u>:

• Deflection 4mm, desired force 9N

• Heat sink base 3mm ± .25mm

• Choose a pin length so that the pin head is level to or below heat sink height after installation. Working length= 14mm ±.2mm

• Using a plastic Pin calculate required spring rate: force/deflection =2.25N/mm

• Do a tolerance study to determine best/worst case free length

Working length + tol – heatsink - tol = XXmm

Working length - tol – heatsink + tol = XXmm

CSI7

Refer to standard spring catalogs (www.leespring.com/www.asraymond.com) to find next **longest** spring with **closest** spring rate. In this case C0180-022-0500M or LC-022-5-M.

Slide 56

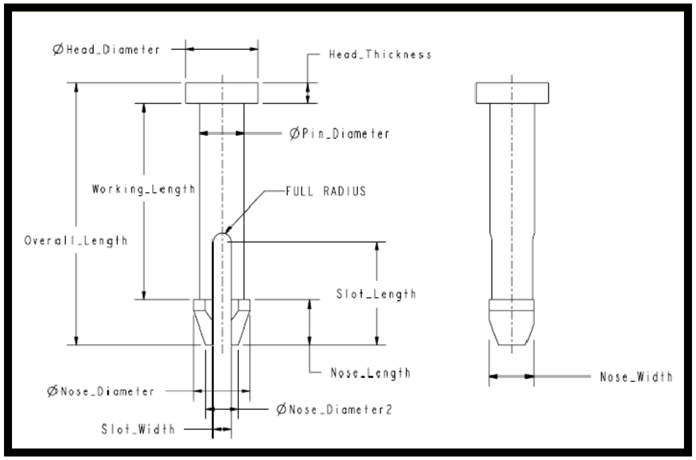
CSI7 Do we need this url?
Cisco Systems, Inc., 12/19/2008

Push Pin Design

Materials and Recommended Forces

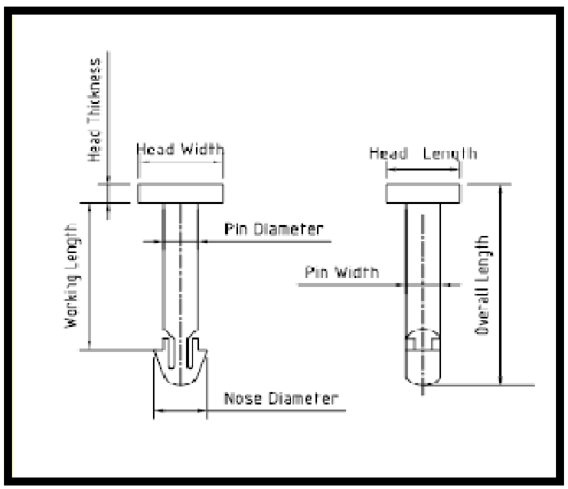
Pins

- Plastic (Nylon based) Forces 0-3lbs (0-13.5 N)
- Metal (Brass) Forces 0-5 lbs (0 – 22N)



Metal Pin Definition and Tolerances

•Head Diameter should be equal to or greater then the spring outer diameter
•Pin Diameter should be less then the spring inner diameter
•Nose Length should be at least .080”(2mm), the longer the better
•Nose Diameter should be .140”(3.56mm) for PCB holes of .118”(3.0mm) to .125”(3.2mm)
•Nose Diameter2 should be about .04”(1mm) smaller then PCB hole size
•Slot Width should be sized to allow Nose Diameter to fit into the PCB hole
•Slot Length should be determined via mechanical analysis to determine yield stress of the pin
•Nose Width should be equal to Pin Diameter
• Tolerances: all tolerances typically ± .005”(.13mm)



Plastic Pin Definition and Tolerances

•Head Width/Head Length should be equal to or greater then the spring outer diameter
•Pin Diameter should be less then the spring inner diameter
•Nose Diameter should be .140”(3.56mm) for PCB holes of .118”(3.0mm) to .125”(3.2mm)
•Nose Width should be equal to Pin Diameter
• Tolerances: all tolerances typically ± .008”(.20mm)

Wire Clip Features

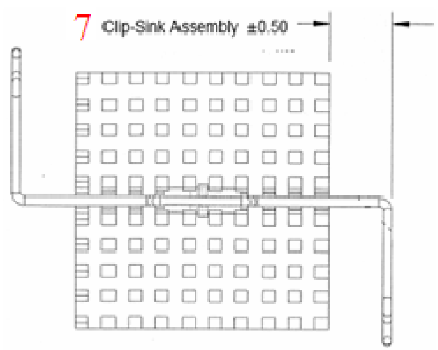
Tolerance Summary

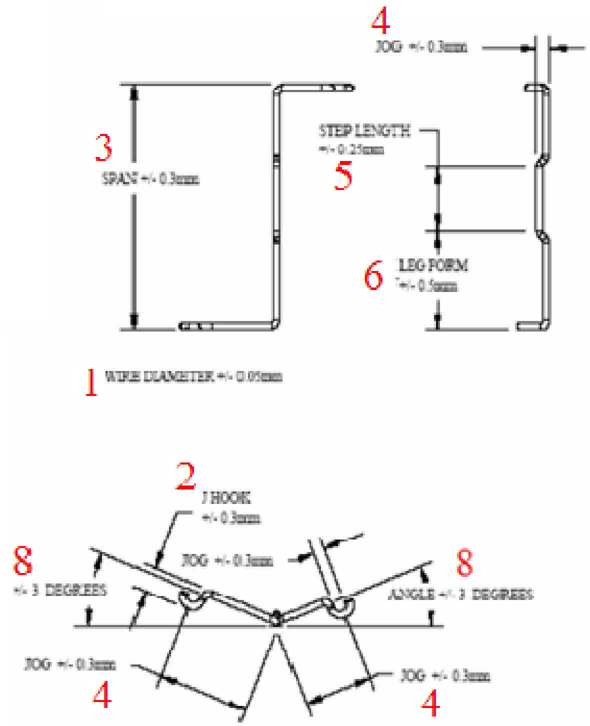
Item	Feature	Units	Tolerance	Notes
1	Wire Dia	mm	±0.05	-
2	J Hook	mm	±0.30	-
3	Total Span	mm	±0.30	-
4	Clip Jogs	mm	±0.30	-
5	Step Length	mm	±0.25	1
6	Leg Form	mm	±0.50	2
7	Assembly to heat sink	mm	±0.50	-
8	Bend Angle	°	±3.0	-

Notes:

1. Tolerance is of straight section only, radii not included
2. Tolerance does include radii
3. Conversion: 1.0” = 25.4mm

Feature Diagram





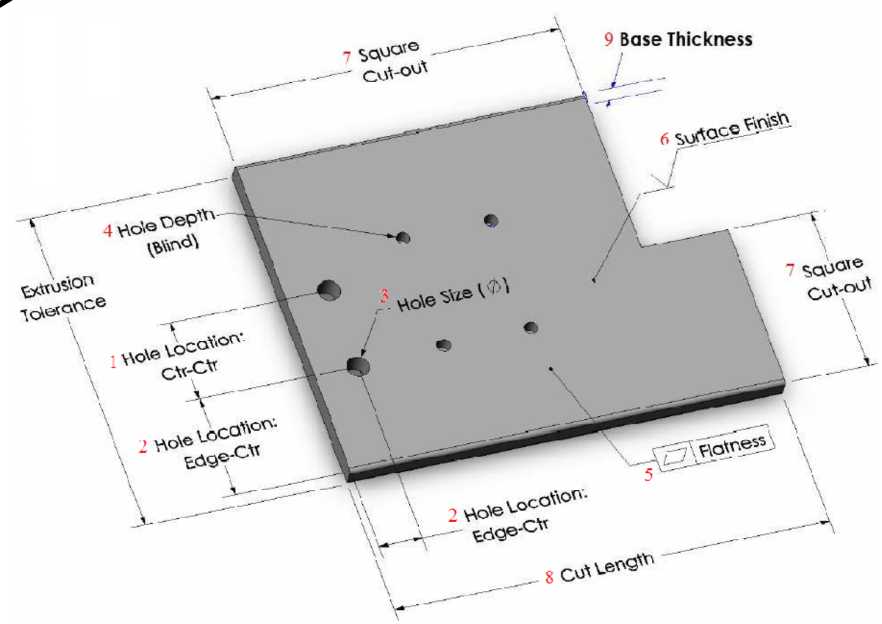
General Features

Tolerance Summary

Item	Feature	Units	Tolerance		Notes
			Precision	Economy	
1	Hole Location: Ctr-to-Ctr	mm	±0.15	±0.30	-
2	Hole Location: Edge-to-Ctr	mm	±0.25	±0.30	-
3	Hole Size (Ø)	mm	±0.10	±0.15	1, 2
4	Hole Depth (Blind)	mm	±0.30	±0.50	-
5	Surface Flatness	mm/mm	0.002	0.005	1, 2
6	Surface Roughness/Finish	RMS, µm	0.8~1.6	1.6~3.2	2
7	Square Cut-out	mm	±0.15	±0.40	-
8	Cut to Length	mm	±0.25	±0.38	-
9	Base Thickness	mm	±0.15	±0.25	3

Notes:
1. Process tolerance may vary with material type & temper.
2. Process capability will vary with thickness
3. Bases thickness over 12.7mm may have increased associated tolerance
4. Conversion: 1.0" = 25.4mm

Feature Diagram



Quiz

Quiz 4: TIMs and HS attachment devices

1. Thermal Interface Materials consist of (select one):
   - **a. Grease, graphite, tapes, and other materials**
   - b. Components, heat sinks and air flow
   - c. Liquid coolants, solder and Chemfilm
   - d. None of the above
2. Identify from the list below TIM that is of high performance, reflows with heat to fill all the interface voids but can be difficult to apply.
   - a. Single sided PSA
   - b. Double sided PSA
   - c. Grease
   - d. PCM
3. True or False: Air pockets or gaps between the heat sink and the component provide good insulators.
   - **a. True**
   - b. False

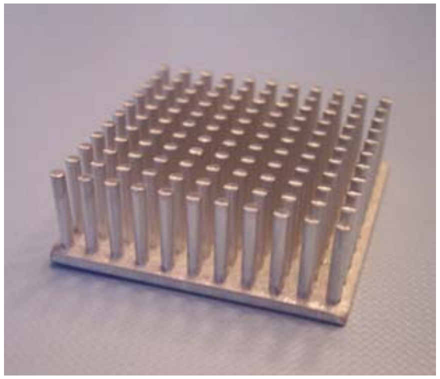
4. What type of heat sink attachment is this? (photo of push pins)
   - a. Band clip
   - b. Push pin
   - c. Screw/springs
   - d. Plastic clips

5. What type of heat sink is this?
   - a. Passive
   - b. Active
   - c. Pin fin
   - d. None of the above

Thermal Cost Strategy

Cost Modeling (Should Cost Structure)

Typical Heat Sink Examples

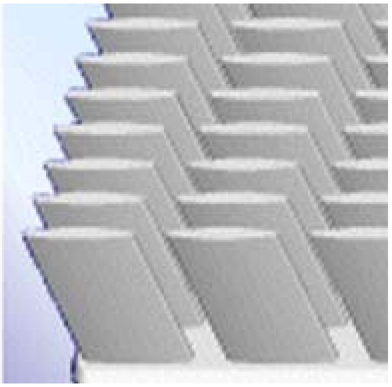


Die Cast

$.65 ea & $4000 NRE

Micro Forged

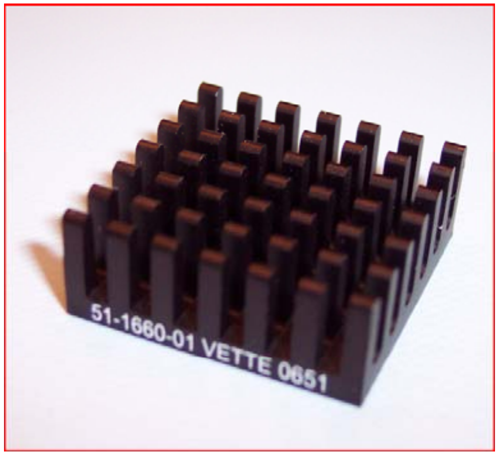
$2.50 ea & $4000 NRE



Micro Forged

Elliptical Fins

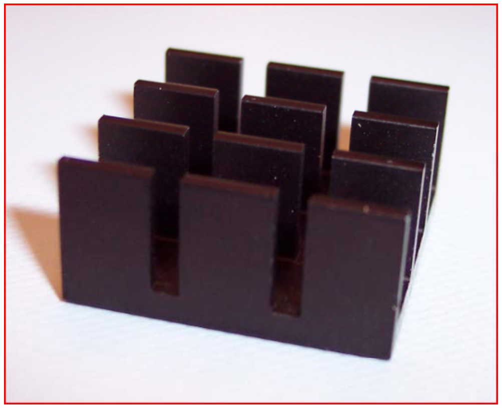
$3.50 ea & $4000 NRE



Lower Cost

Extruded Square Pin Fin Version

$.30 ea & $535 NRE



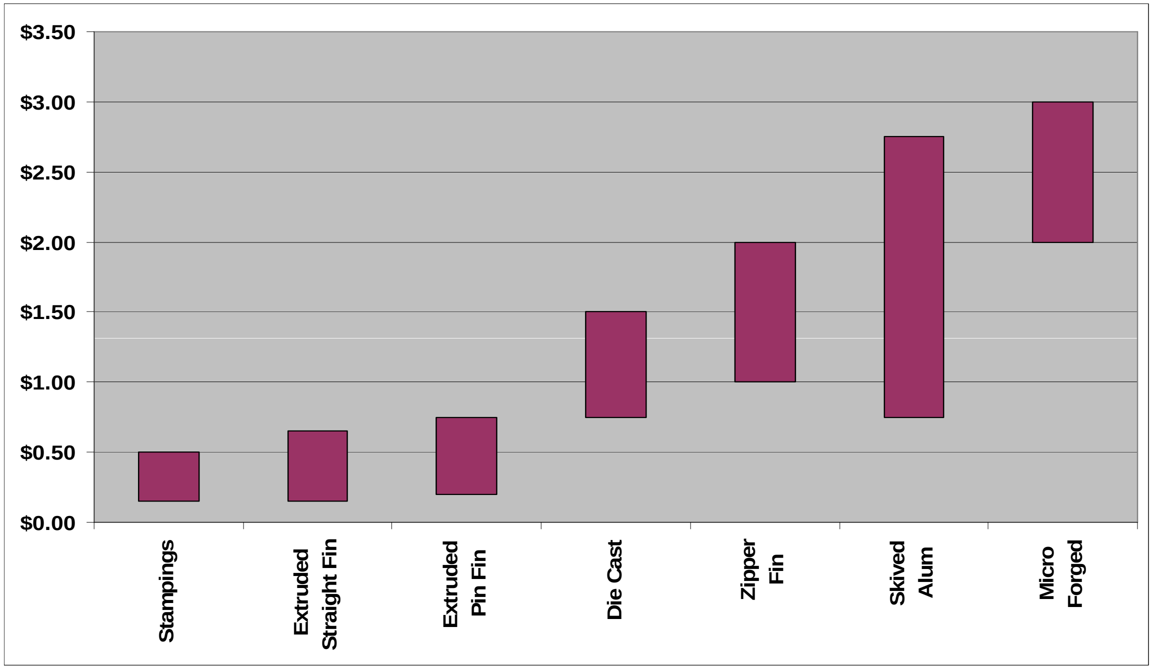
Lower Cost

Extruded Rectangular Pin Version

$.45 ea & $710 NRE

Cost Modeling (Should Cost Structure)

Unit Price Range By Type

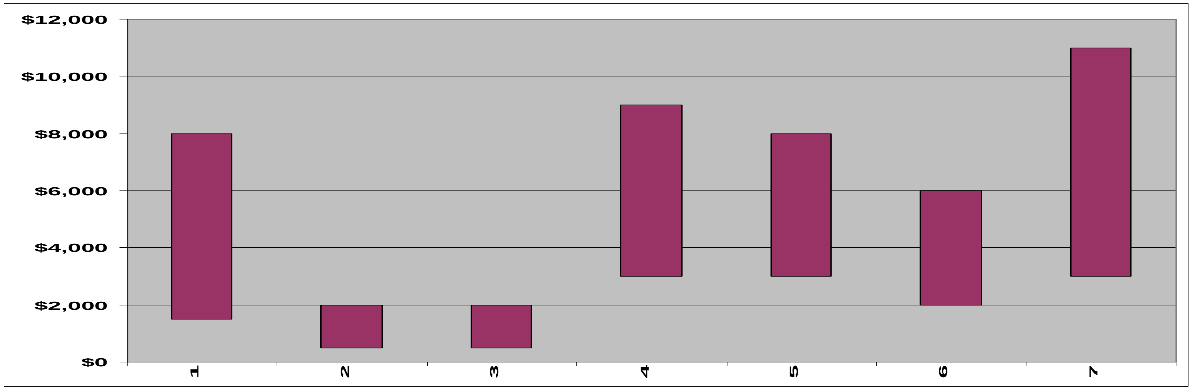


Low Power

Heat Sinks

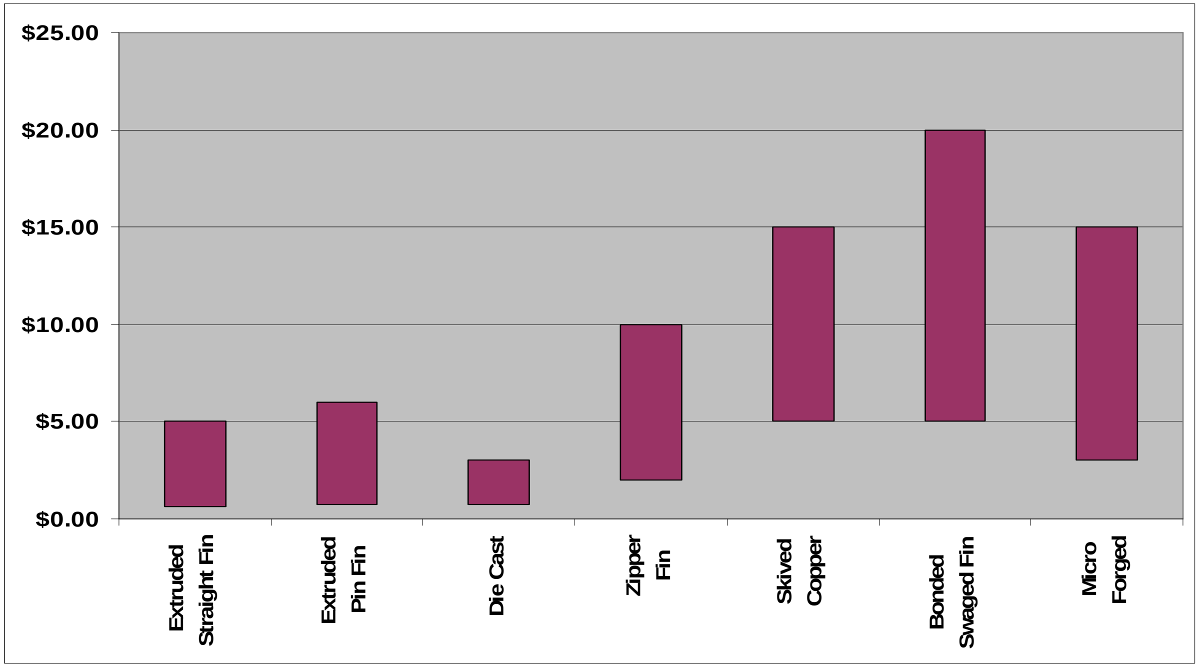
1 – 20 Watts

NRE Range By Type



Cost Modeling (Should Cost Structure)

Unit Price Range By Type

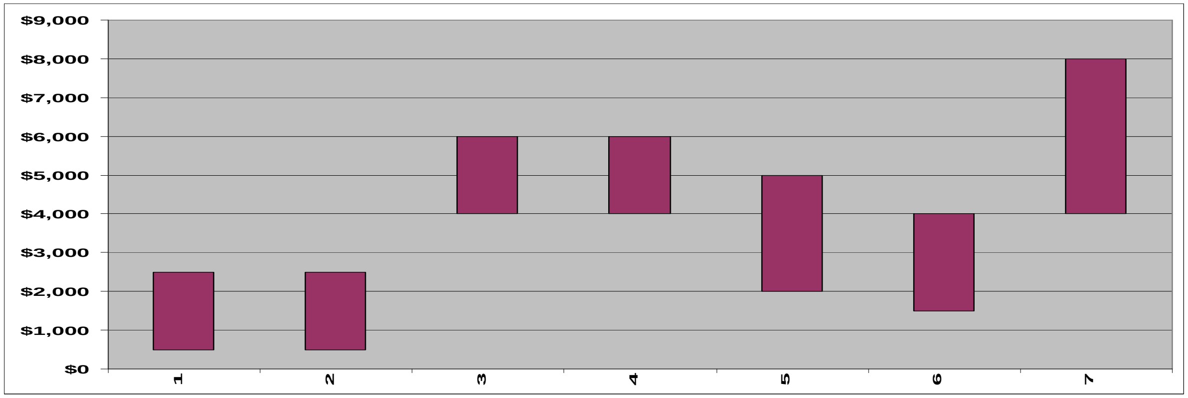


Medium Power

Heat Sinks

20 – 80 Watts

NRE Range By Type



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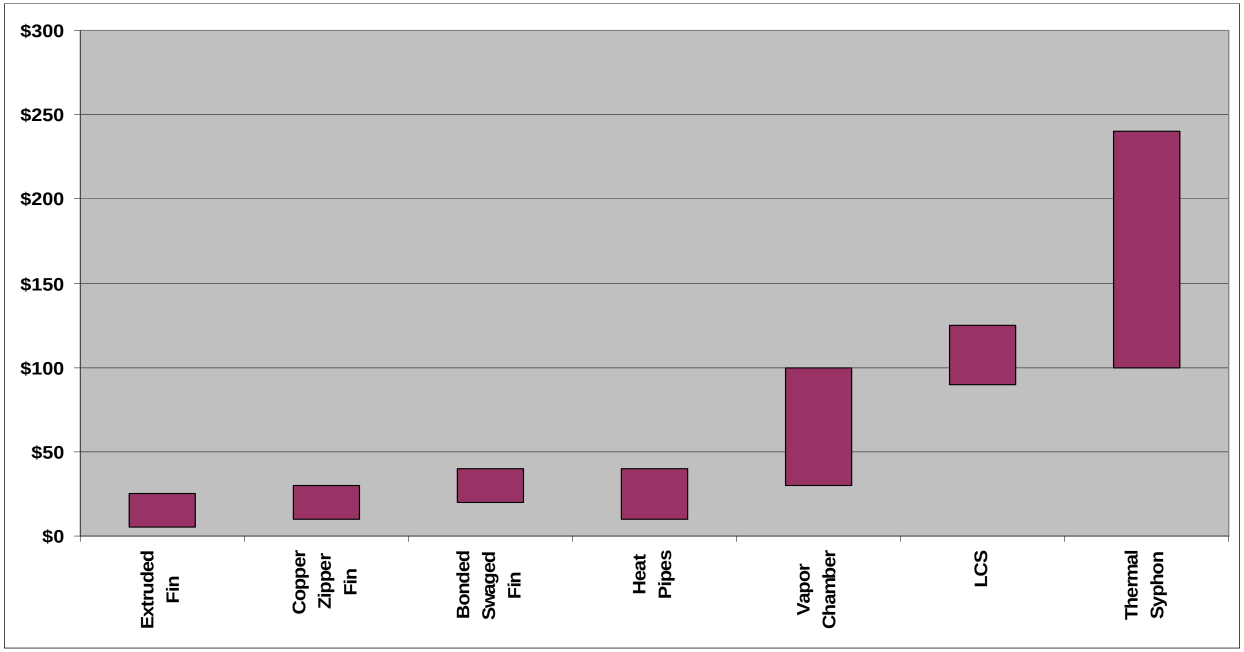
Cost Modeling (Should Cost Structure)

Unit Price Range By Type

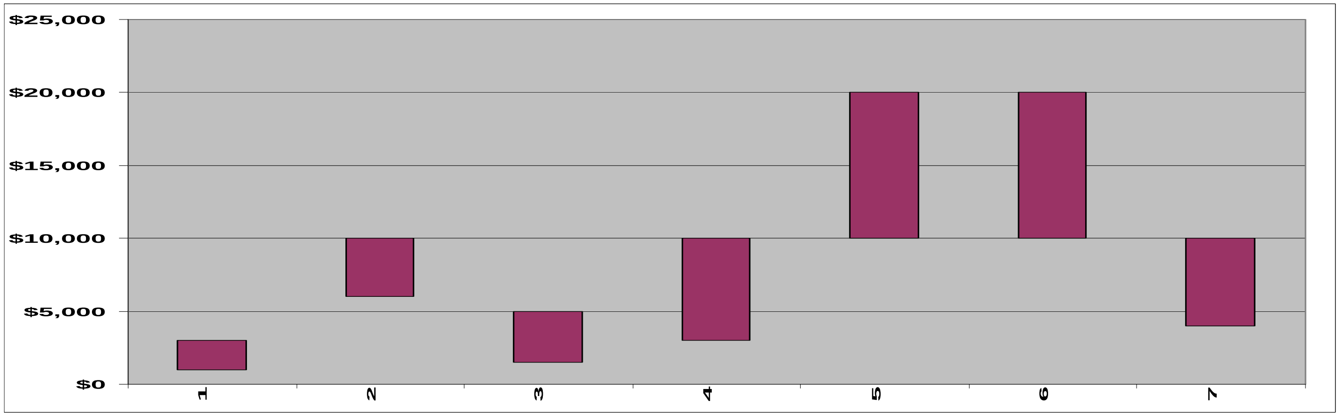


High Power

Heat Sinks

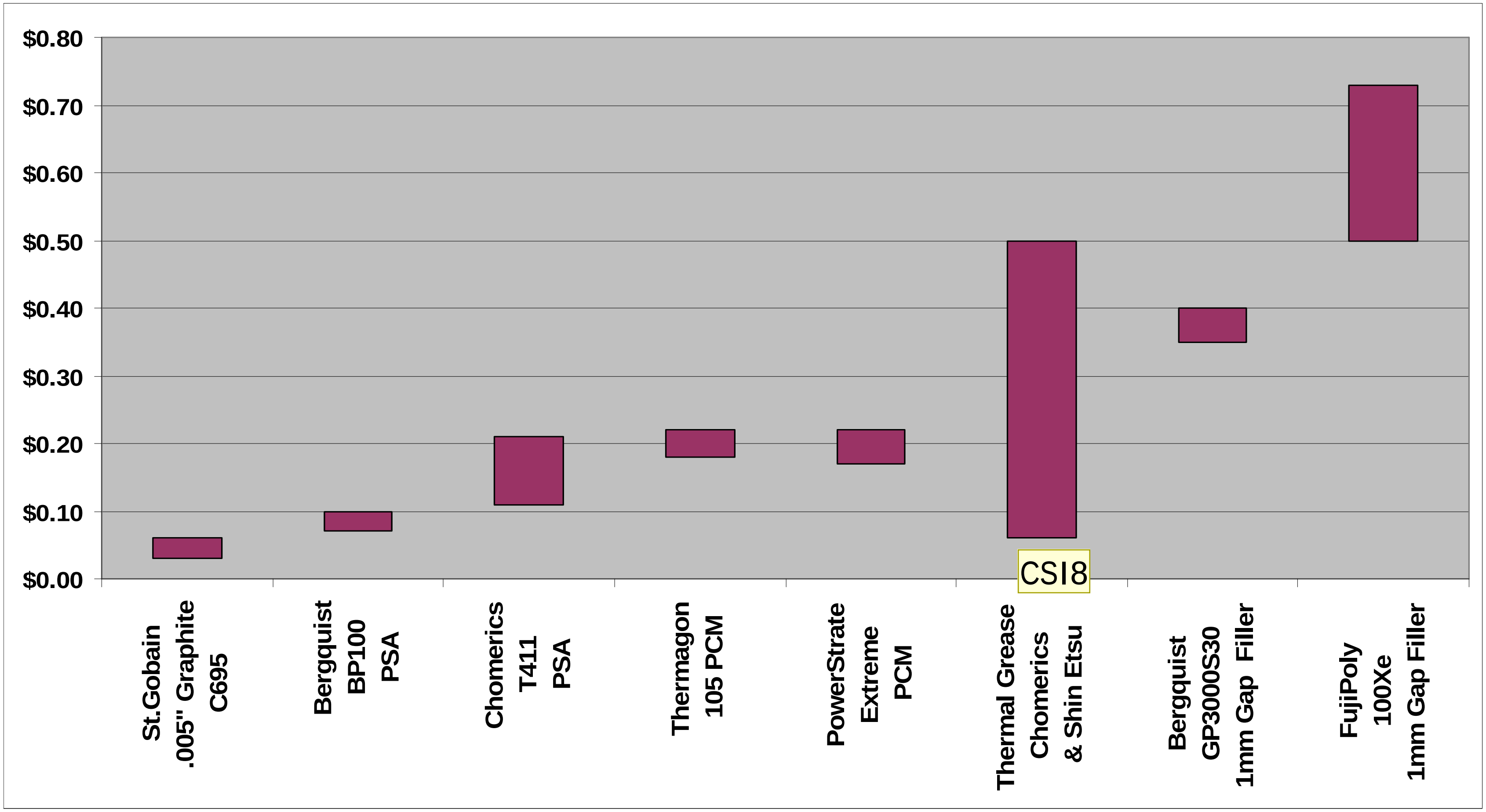
80+ Watts

NRE Range By Type



Cost Modeling (Should Cost Structure)

TIM –Thermal Interface Materials $\$/in^2$



Slide 67

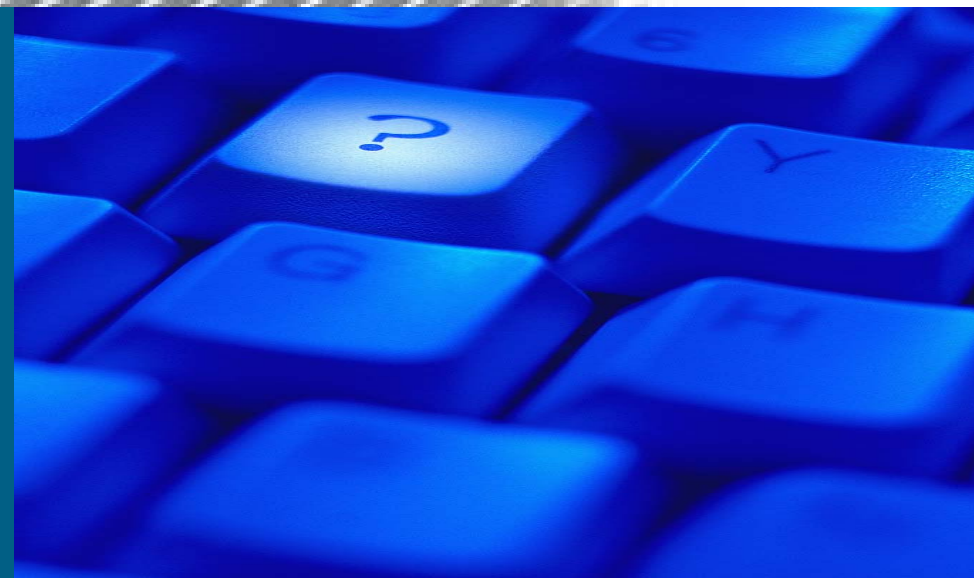
CSI8 Chomerics (sp??)
Cisco Systems, Inc., 1/5/2009

Key Takeaways

- Understand the basics of how heat sink technologies are utilized in our product space
- Understand the key cost drivers when selecting heat sinks
- Understand the elements that can increase the efficiency of heat sinks in specific applications. ie airflow, orientation, etc
- Be able to select the appropriate heatsink based on your application and requirements for cost and efficiency

Additional Information

Quiz



Quiz 5: Thermal cost strategy

1. What is the least expensive heat sink design (select one)?
   a. Die cast
   b. Micro forged
   c. Extruded square pin version
   d. Extruded square pin fin version
2. Medium heat sinks run in which of the following wattage range?
   a. 1-20
   b. 20-30
   c. 20-80
   d. 80 +
3. The most expensive TIM per square inch is which of the following (select one)?
   a. Chomerics T411
   b. PowerStrate Extreme PCM
   c. Bergquist GP3000S30
   d. FujiPoly 100xe

Thanks to the Vette Corporation for the Content Provided in this Course!

Thank You!