IC Test Thermal Management

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Smiths Interconnect

TestConX™
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smiths interconnect
bringing technology to life

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- Pros and Cons of Present Day Approaches
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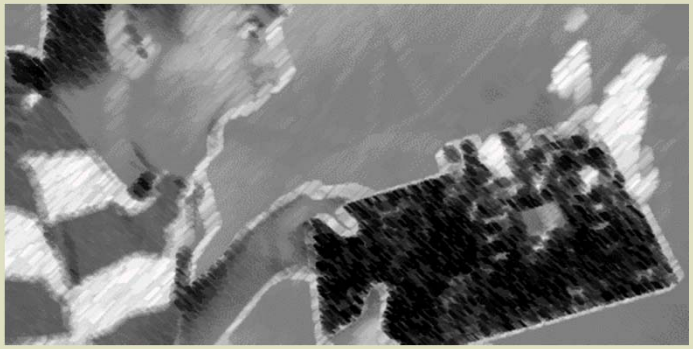
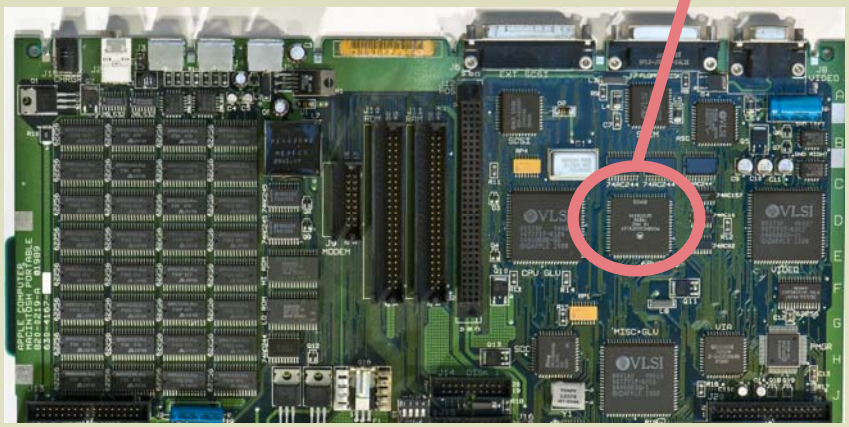


UFD tech: How to Not Overclock!-RIP CPU

The Forgotten

- 1989 Macintosh Portable
  - CPU 16MHz 68000 (Motorola)
  - 1 MB SRAM (9MB)
  - 9.8 BW LCD screen
  - 4.05 x 15.25 x 14.42 in.
  - ~16 lbs
- CPU
  - 33 MHz
  - 32 Bit
  - 256 Bytes Cache

~ 2W

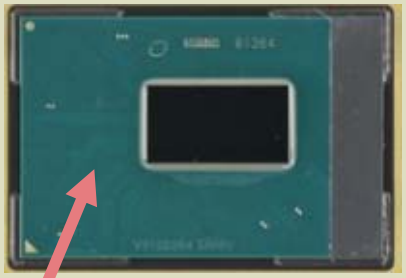


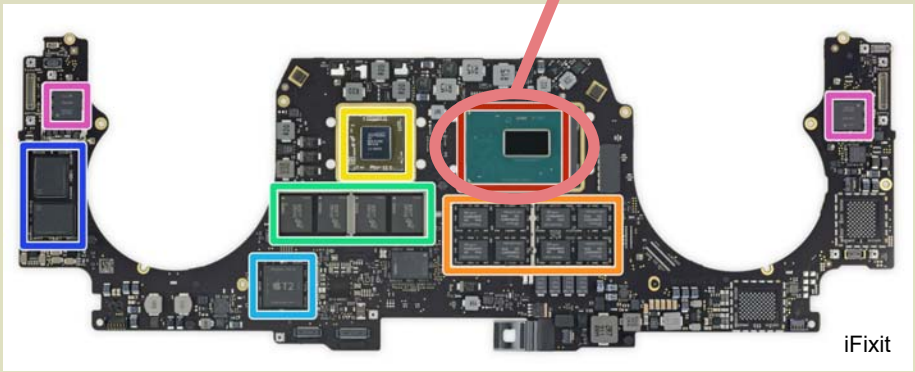
https://apple-history.com/portable
https://www.theregister.co.uk/2010/11/09/macintosh_portable/?page=6

The Present

- 2019 MacBook Pro
  - 9th Gen Intel Core i7
  - 32 GB
  - 16 in. Retina
  - 0.61 x 13.75 x 9.48 in.
  - ~4 lbs
- CPU
  - 4.5 GHz
  - 6 Cores, 64 Bit
  - 12 MB Smart Cache

~ 45W





iFixit

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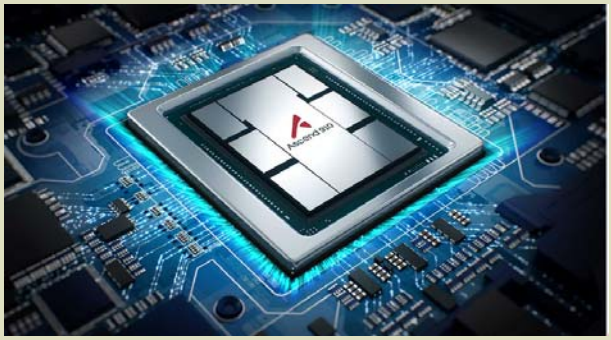
The Evolution

≤10W

45W

165W

≥300W



350W

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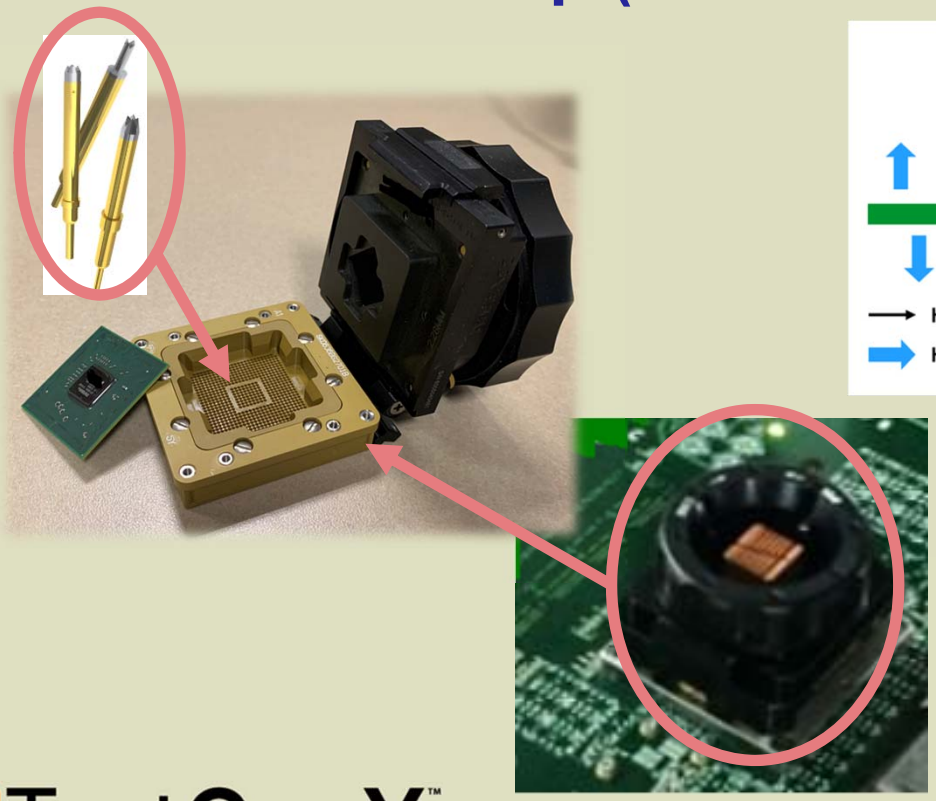
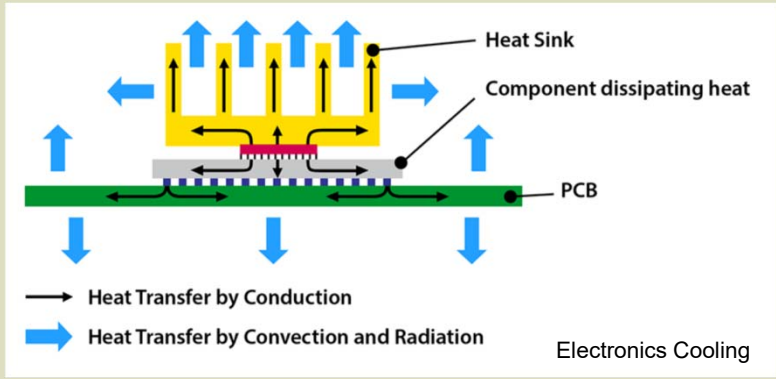
The Setup (Manual/Bench test)





- Mode of Cooling
  - Conduction
  - Convection
    - Natural
    - Force
  - Radiation is mostly negligible

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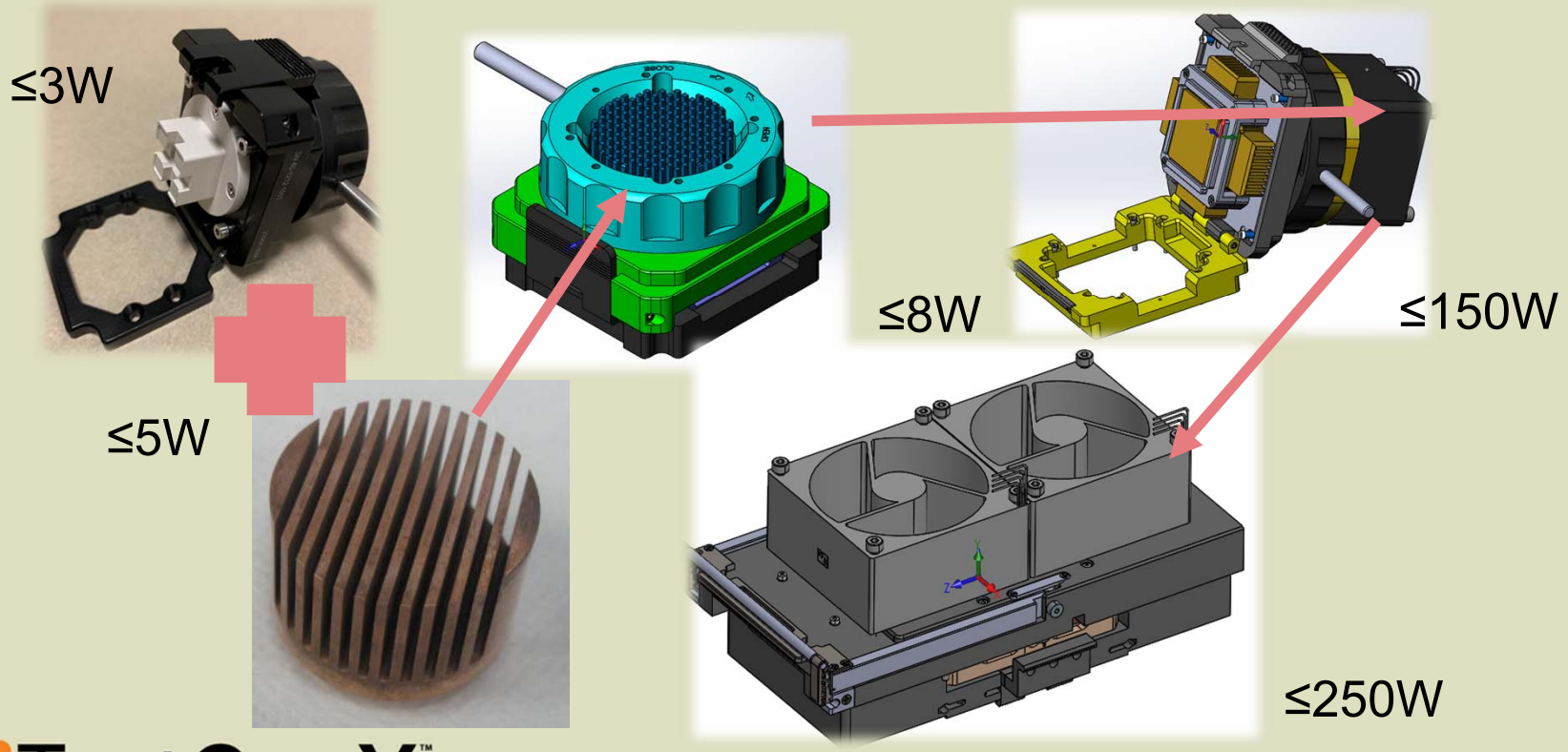
The Conventional



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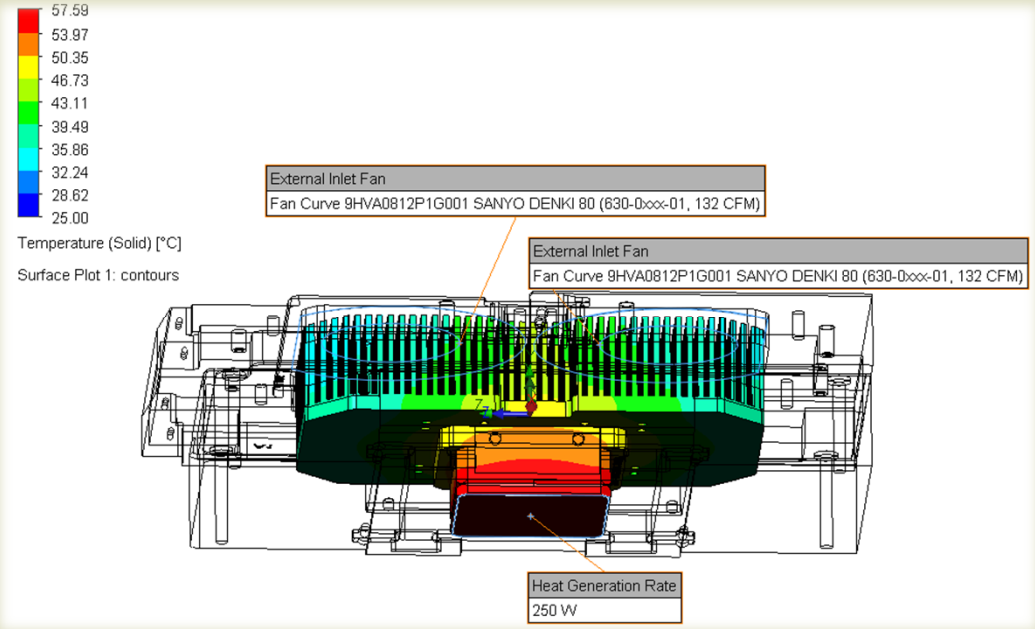
The Conventional (simulation)



Requirements:

- 250W
- Tcase 85°C

Assumptions:

- 25°C Ambient Temp
- Steady State

Result:

- 57.6°C Pedestal Temp
- 0.1°C/W Heatsink Theta
  (with thermal interface material)
- Tcase is 83°C

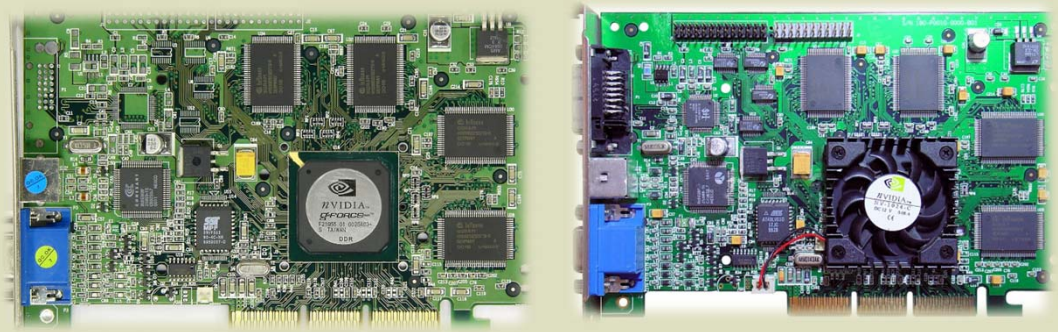
The Conventional

Pros:

- Cooling for up to 8W with no fan for device size ≤ 25x25mm
- Cooling up to 250W with fan for device size ≤ 50x50mm
- Short lead time
- Lowest cost

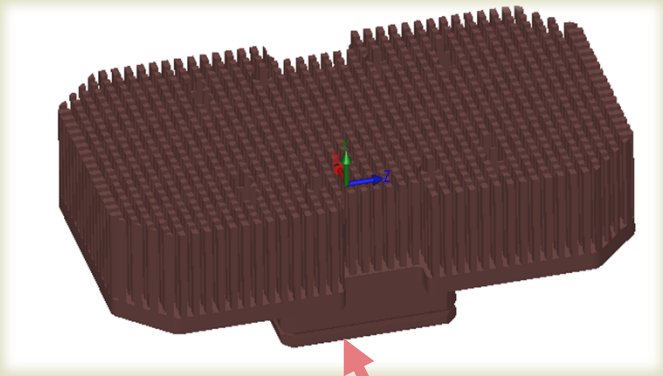
Cons:

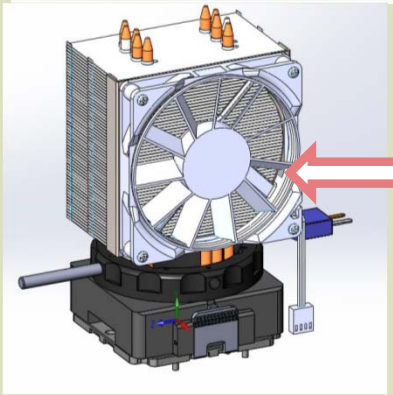
- Limited dissipation capability up to 250W
- Space limitation
- Weight / Ergonomics
- Fan noise 76dBA

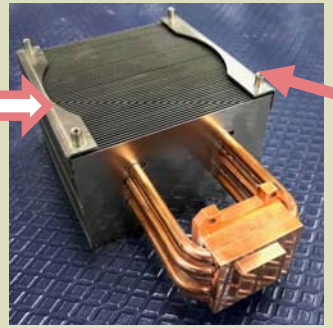


GeForce 256 https://www.teckknow.com/msi-geforce-rtx-2080-ti-gaming-x-trio-review/

Present Day- Heatpipe/Vapor chamber



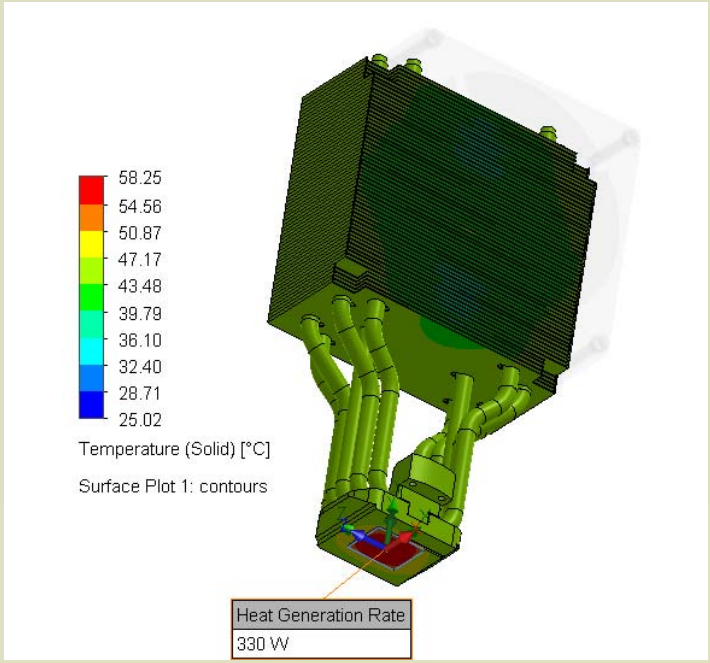




Heatpipe vs Conventional Heatsink

– 330W	250W
– 95x95x160mm	77x135x50mm
– 53 dBA	76 dBA

Present Day- Heatpipe Heatsink (simulation)



Requirements:

- 330W
- Tjunction 100°C

Assumptions:

- 25°C Ambient Temp
- Steady State

Result:

- 58.3°C Pedestal Temp
- 0.1°C/W Heatsink Theta (with thermal interface material)
- 0.03°C/W Theta jc
- Tjunction is 101°C

Present Day- Heatpipe Heatsink Lab Test

Tjunction
95°C

Power
Input
335W

Lid with
heat pipe
heatsink

Present Day- Heatpipe/Vapor Chamber

Pros:

- High thermal conductivity
- Cooling >300W for device size ≤ 45x45mm
- Design flexibility due to bendability
- Lowest cost for high volume
- Weight / Ergonomics (page 10)
- Lower noise (53 vs 76 dBA)

Cons

- Limited dissipation capability up to 400W
- Space limitation (more Z, than X,Y)
- Lead time is longer for Heatpipe tooling
- High cost for low volume

GeForce RTX 2080

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Present Day- Liquid-Cooled

Liquid-Cooled heatsink connects to waterline in lab

Liquid-Cooled Heatsink connects to radiator

CorSair

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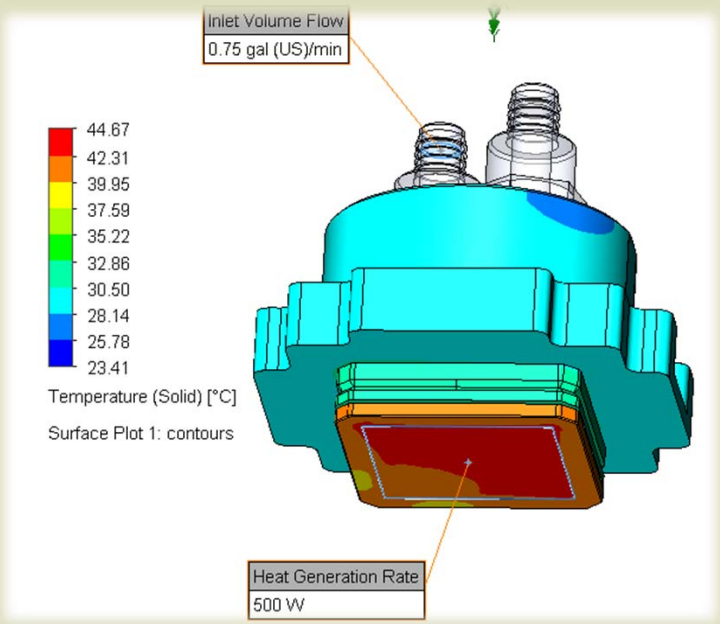
Present Day- Liquid-Cooled Simulation



Requirements:

- 500W
- Tcase 85°C

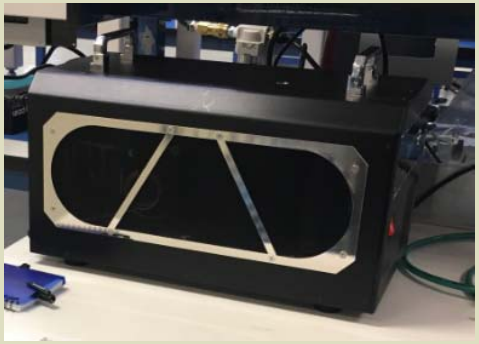
Assumptions:

- 0.75g/min
- 25°C fluid inlet / Ambient Temp
- Steady State

Result:

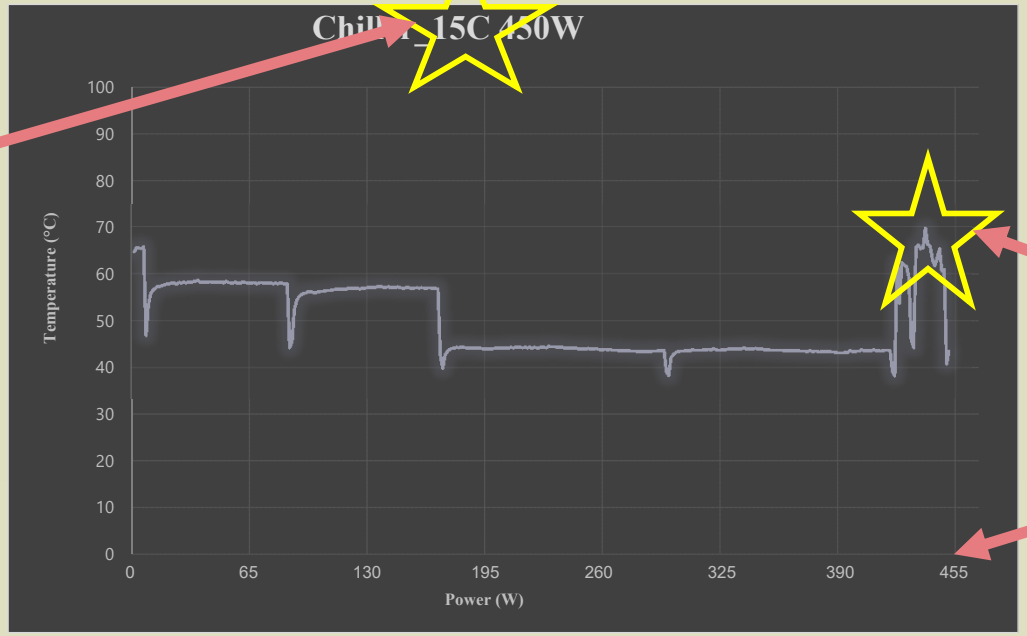
- 44.7°C Pedestal Temp
- 0.08°C/W Heatsink Theta (with thermal interface material)
- Tcase is 85°C

Present Day- Liquid-Cooled with Chiller



- Liquid-cooled heatsink connects to chiller
  - Set point
- Insulated hoses for low set point
- One chiller can support multiple heatsinks

Present Day- Liquid-Cooled with Chiller Lab Test



Set Point

Tjunction 70°C

Power Input 450W

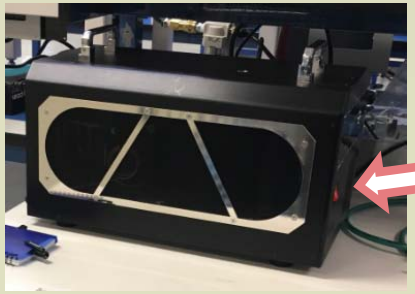
Present Day- Liquid-Cooled

Pros:

- Cooling for up to 500W for device size ≤ 55x55mm
- Set Point (Chiller)
- Lower cost than heat pipe for low volume
- Ease of maintenance
- Lower weight (lid portion) compared to conventional
- Low / no noise

Cons:

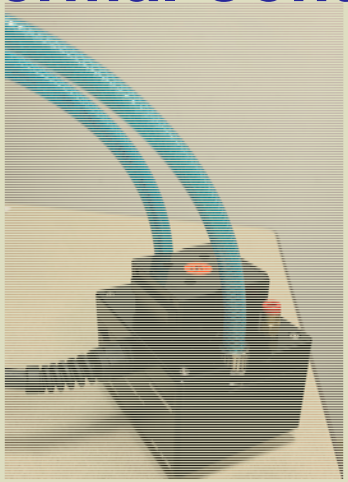
- Water/Coolant Source
- Fix flow rate
- Fix fluid temperature
- Radiator: Fluid temperature is higher than ambient
- Potential Leaks

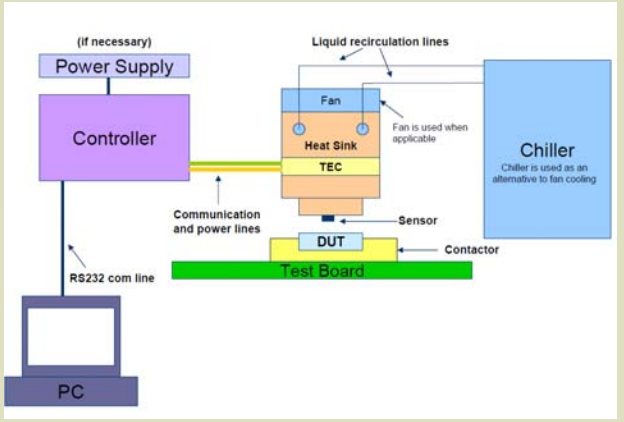


EVGA GeForce RTX 2080 Ti KingPin

Present Day- Liquid-Cooled (Active Thermal Control Unit)

- Liquid-cooled heatsink connects to chiller for cooling
  - Thermoelectric cooler or Heater Cartridge for heating
  - Resistance temperature detector/ Thermocouple and thermostat for temperature feedback





Present Day- Liquid-Cooled (Active Thermal Control Unit)

Pros:

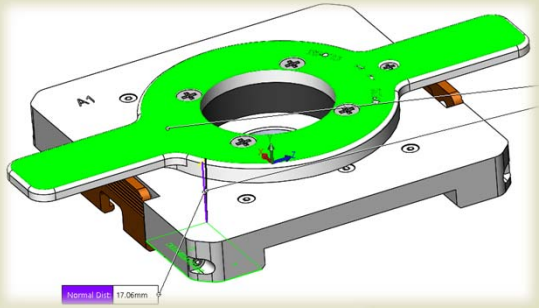
- Cooling for >500W
- Set point
- Tri-temp (Active Thermal Control Unit)
- Ease of maintenance (Coolant)
- Lower weight (lid portion) compared to conventional
- Low / no noise compared to conventional / heat pipe

Cons:

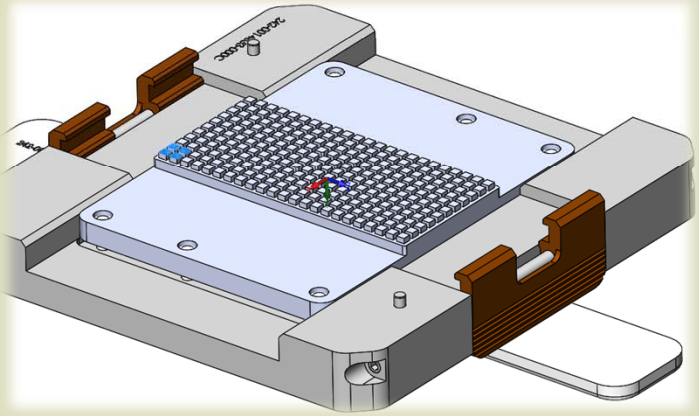
- Higher cost
- Setup
- High Maintenance (Thermoelectric cooler)
- Potential Leaks

Present Day- Thermal Bath (Data Center)

GigaByte



- Non-conductive fluid
  - 3M Novec 7500 Engineering Fluid
- Enclosed system
- Cooled by facility water



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Present Day- Thermal Bath (Data Center)

Pros:

- 1000x better than air cooled
- Less noise
- No hose routing
- Lower maintenance cost

Cons:

- Mainly used for Data Center
- High cost for setup/hardware
- Spillage / Safety

Summary

	Conventional	Heatpipe	Liquid-Cooled	Liquid-Cooled (Chiller)	Liquid-Cooled Active TCU
Cost	Lowest	Higher	Lower	High	Highest
Wattage	≤ 250W	≤ 400W	≤ 500W	≤ 650W	≥ 650W
Leadtime	Shortest	Long	Short	Short	Long
Noise Level	Up to ~76dBA	Up to ~53dBA	No noise/Low	45 dBA	45 dBA
Fluid Medium	Air	Air	DI water/Coolant*	Coolant	Coolant
Maintenance	No	No	No/Coolant	Coolant	Coolant & Heater
Stand Alone	Yes	Yes	Water line/Radiator	Chiller	Chiller, Controller
Space Limitation	Heatsink Size	Heatsink Size	No/Radiator Size	Chiller Size	Chiller Size
Ergonomic	Heatsink Weight	Heatsink Size	No	No	Weight of hoses, cables

Outlook

Challenges:

- Junction temperature reducing from 105°C to 60°C ≥ 300W
- ≥ 1kW dissipation

Areas for focus:

- New heatsink material / heatsink concept
- Active liquid-cooled heatsink with purge
- Steady State vs Transient