The GOLD Twitter Ultra Hi Current, Ultra Efficient

Thermal Management

Servo Drive Power Dissipation

$$Losses(watts) = Conduction\_Losses + Switching\_Losses =$$
$$K_{C(conduction)} * \boldsymbol{I^2_{RMS(Motor)}} + K_{S(switching)} * \boldsymbol{V_{DC(bus)}} * \boldsymbol{I_{RMS(Motor)}} + \boldsymbol{Control\_Losses}$$

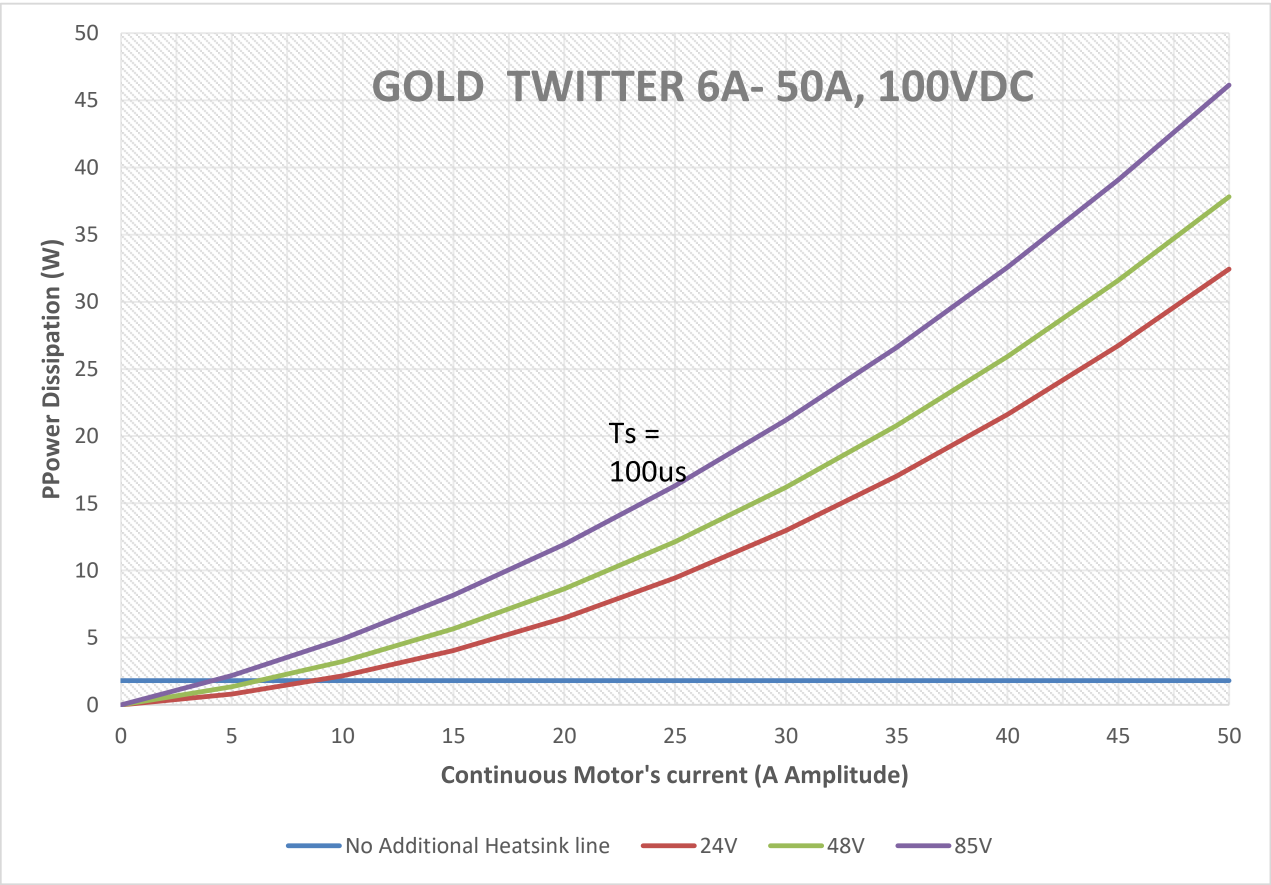
Power Losses of a Servo Drive are function of **Motor's current** and the **DC supply Bus**

In a Constant VDC the losses are parabolic

$$W(t)_{Losses} = \mathrm{a} * I(t)^2 + b * I(t) + c$$

GTWI Power Dissipation Charts

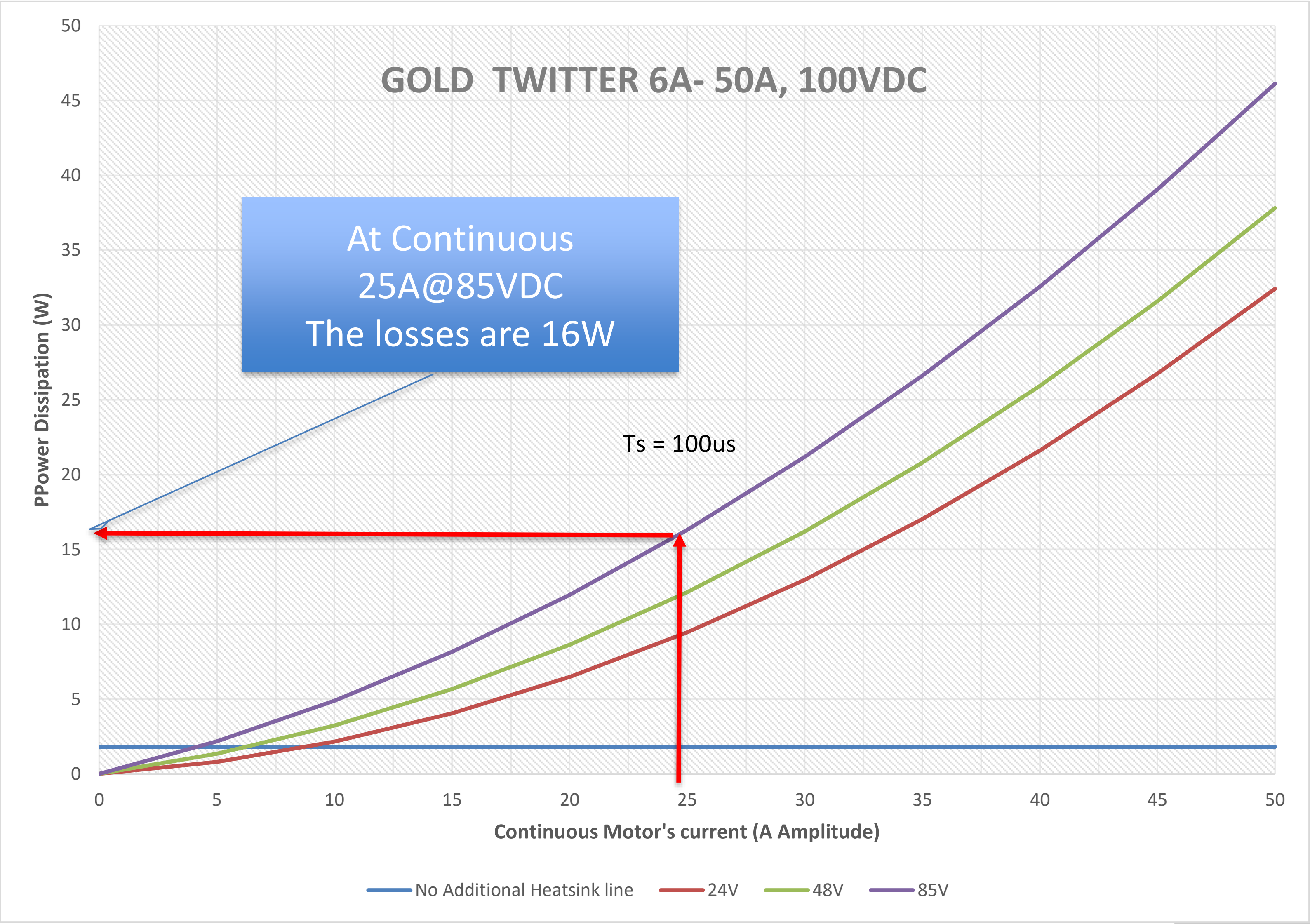
This chart shows the calculated heat dissipation as a function of The DC bus, Motor’s current and Ts



The calculated figures were verified and are periodically verified by thermal tests.

GTWI Power Dissipation Charts

How to use this chart?



GTWI Power Dissipation

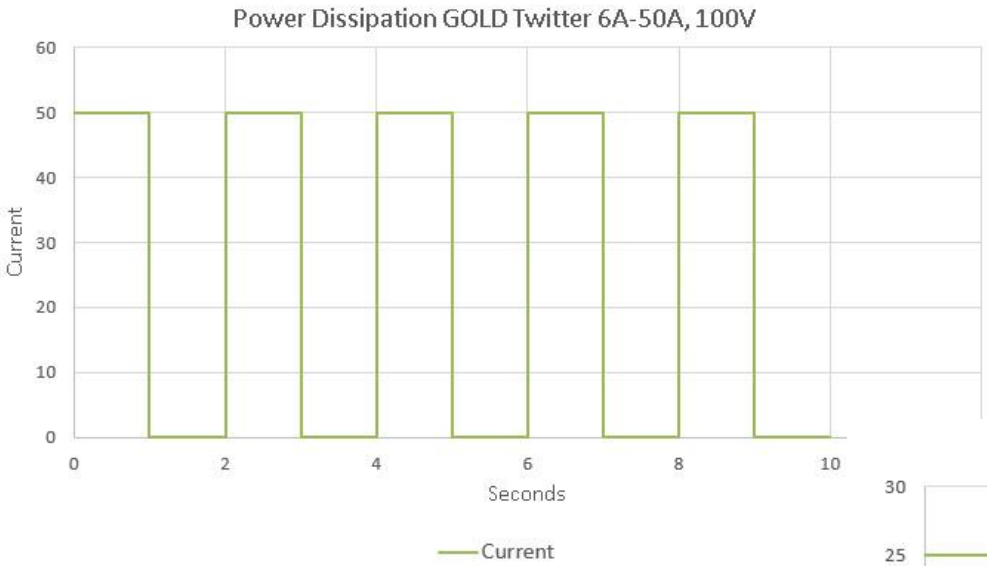
How accurate are those charts?

- For continuous current the chart are pretty close to the "worst case scenario".
- "Real Life" efficiency is better by 20% - 30%

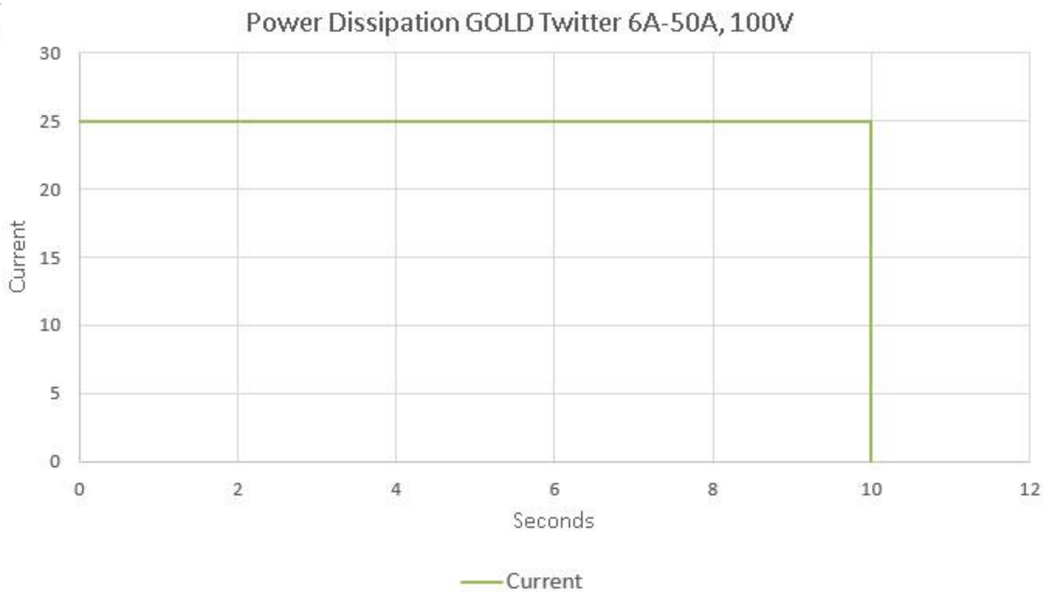
- But servo operation is seldom continuous current operation mode?
  - True, still the charts give good estimation on the thermal requirements.
  - The charts are very simple, easy to use and in most of the cases are answering the thermal dissipation needs.

GTWI Power Dissipation

Continuous Vs Pulses



Peak current = 50A
Average (RMS) current= 25A
Power Dissipation= ?

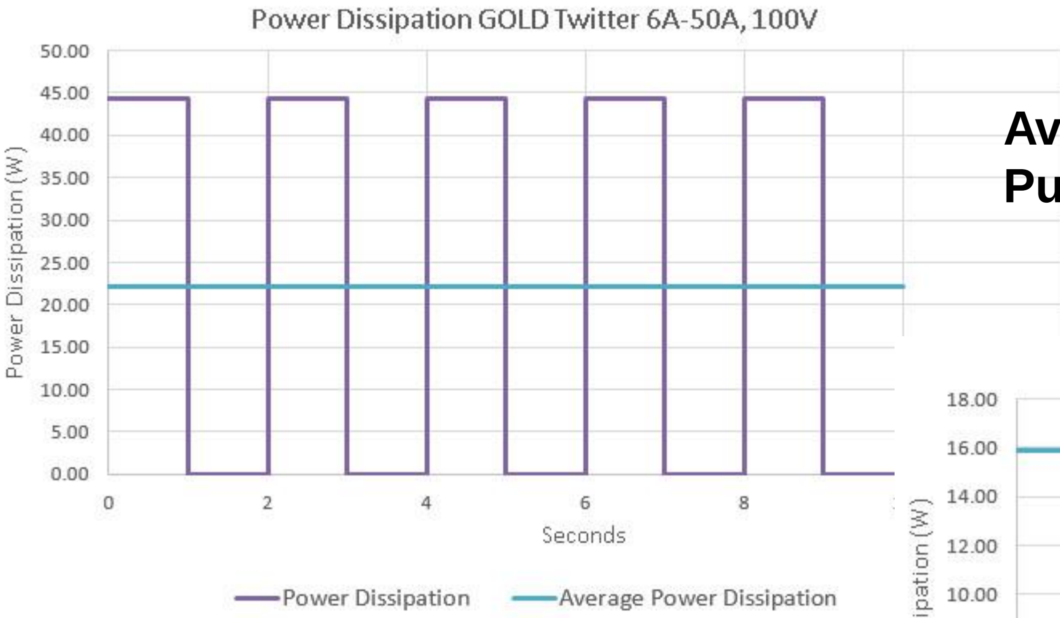


Average (RMS) Current= 25A
Power Dissipation= ?

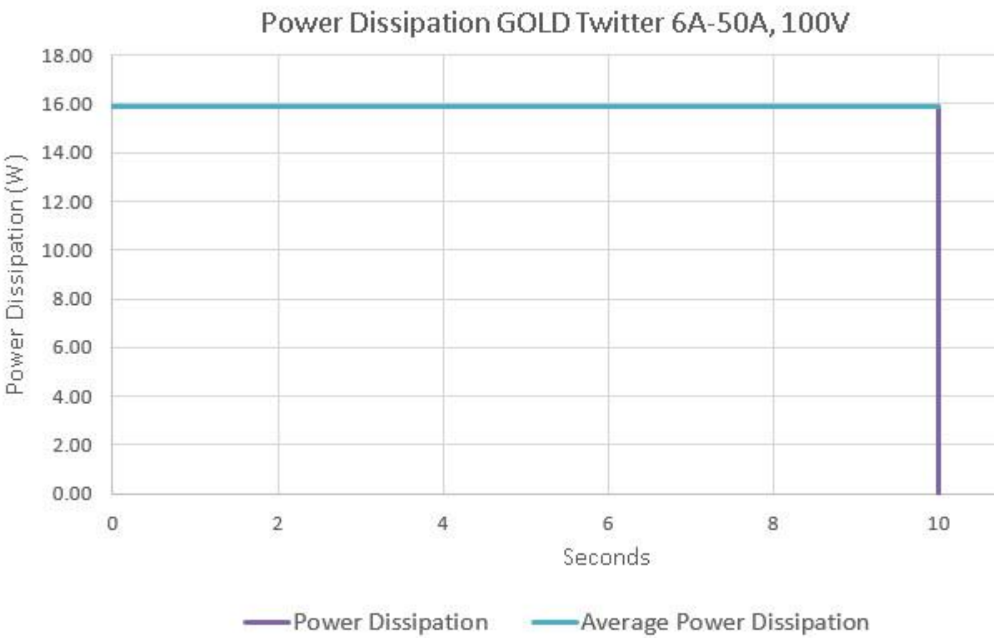
The Average (RMS) currents are the same,
What about the Power Dissipation?

GTWI Power Dissipation

Power Dissipation Continuous Vs Pulses



Average Power Dissipation 22.2W
Pulse Power Dissipation = 44.4W



Average Power Dissipation= 16W

Heat dissipation must be calculated separately for each current pulse and then the power losses are averaged..

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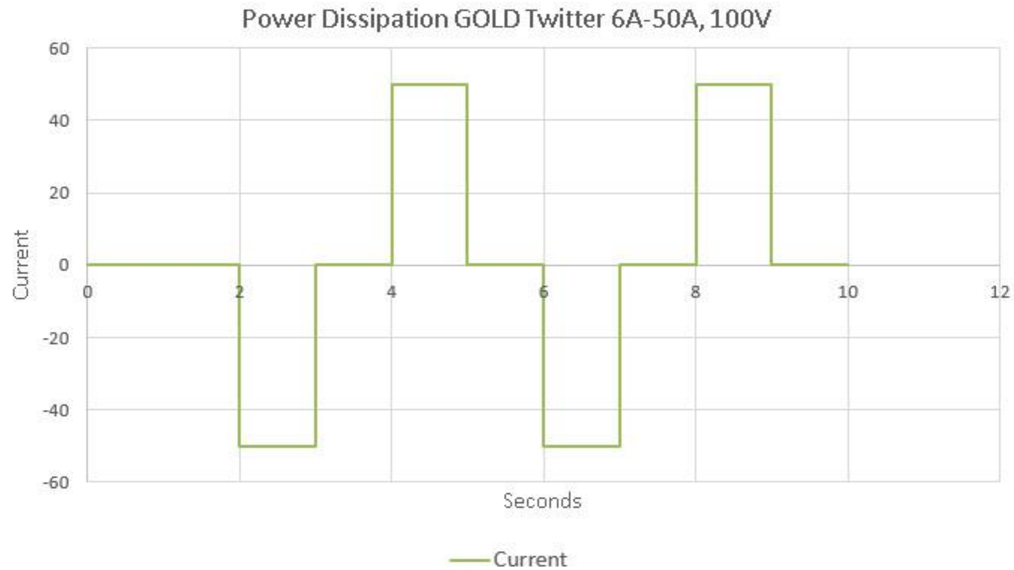
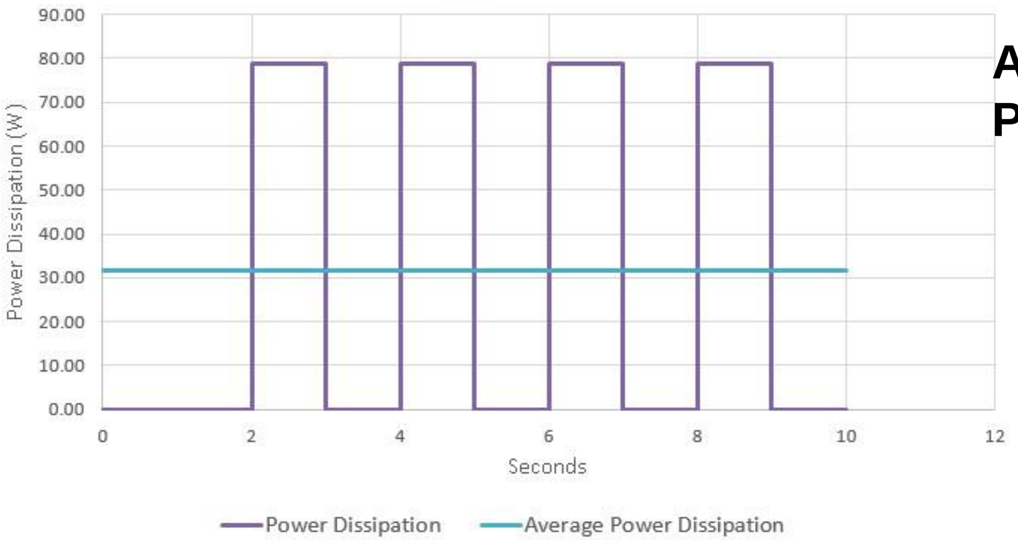
GTWI Power Dissipation

Positive & Negative Current Pulses



Average Current = 0
Average Absolute Current = 20A
Peak Current = 50A & -50A



Average Power Dissipation =17.7W
Peak Power Dissipation= 44.4W

Heat dissipation depends on the absolute Current values.

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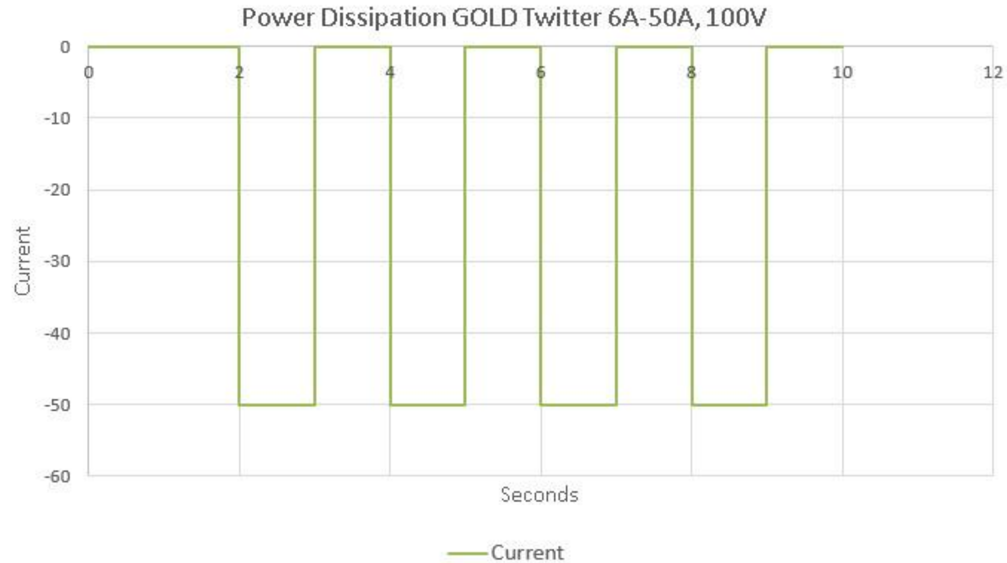
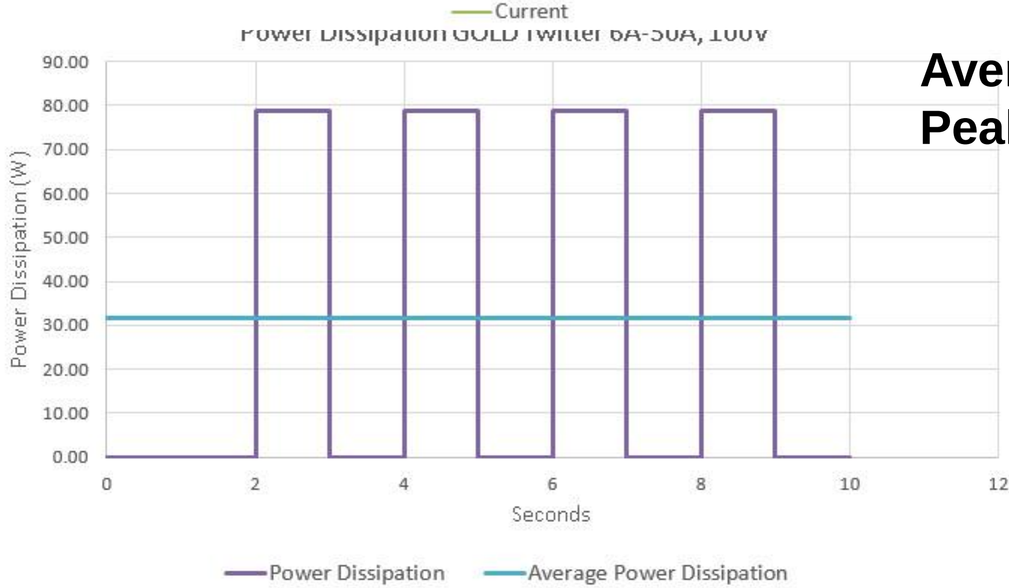
GTWI Power Dissipation

Negative Current Pulses



Average Current = -20A
Average Absolute Current = 20A
Peak Current = -50A



Average Power Dissipation =17.7W
Peak Power Dissipation= 44.4W

Heat dissipation depends on the absolute Current values

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GTWI Power Dissipation

So, how to derive the heat dissipation of current pulses?

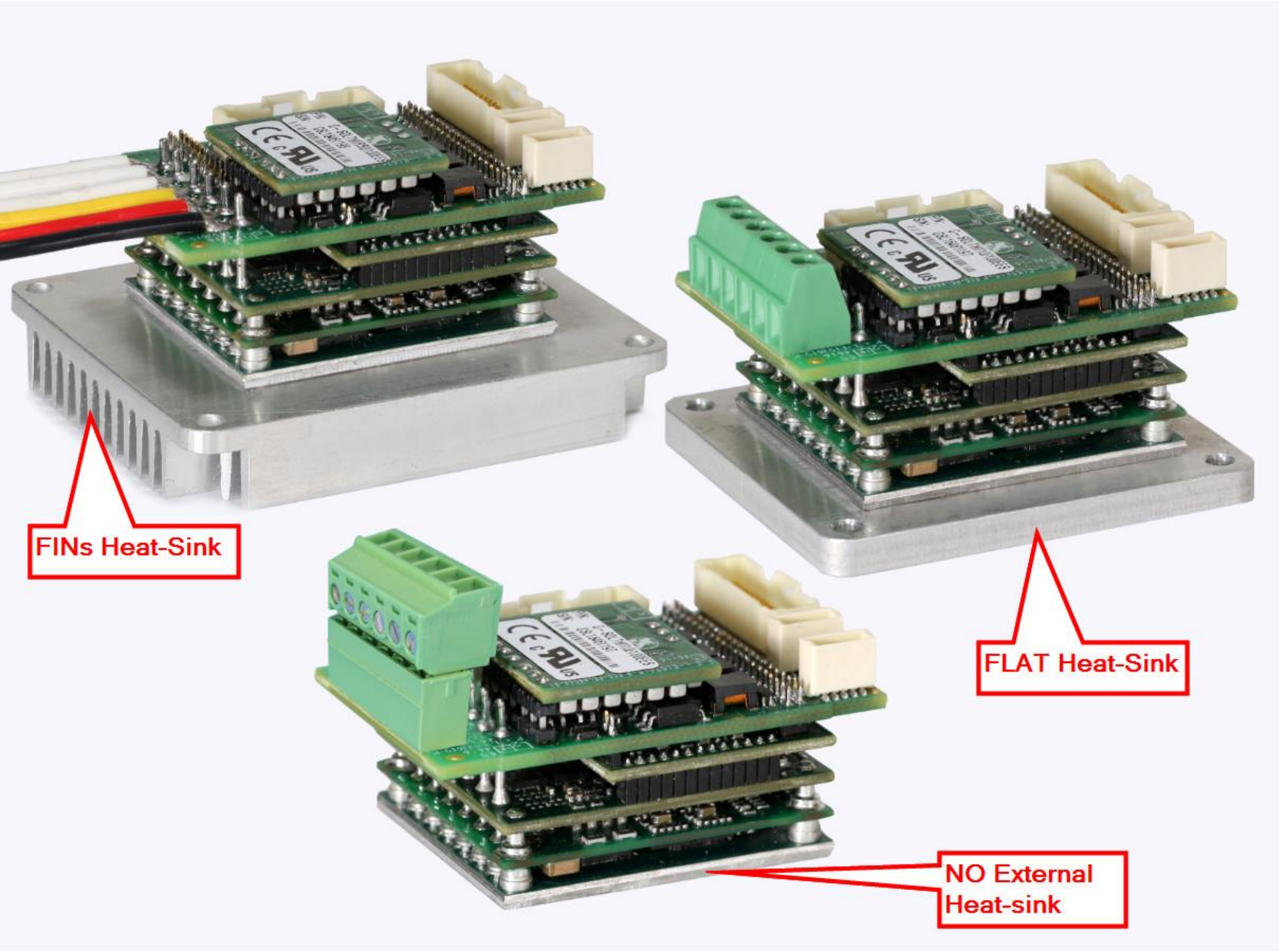
The simplest is to add to pulsed current scenario 25% -30% to the chart's power dissipation by the average (RMS) current.

The accuracy is moderate, but it is good enough for most of the applications.

A better accuracy is achieved by drawing from the curves the heat dissipation of each pulse(interval), and then average the power dissipation.

GTWI, Heat Expelling

In many applications getting rid of the heat can be accomplished quite simply.



Elmo Offers 3 simple to mount Heat-sinks that can suit most of the applications

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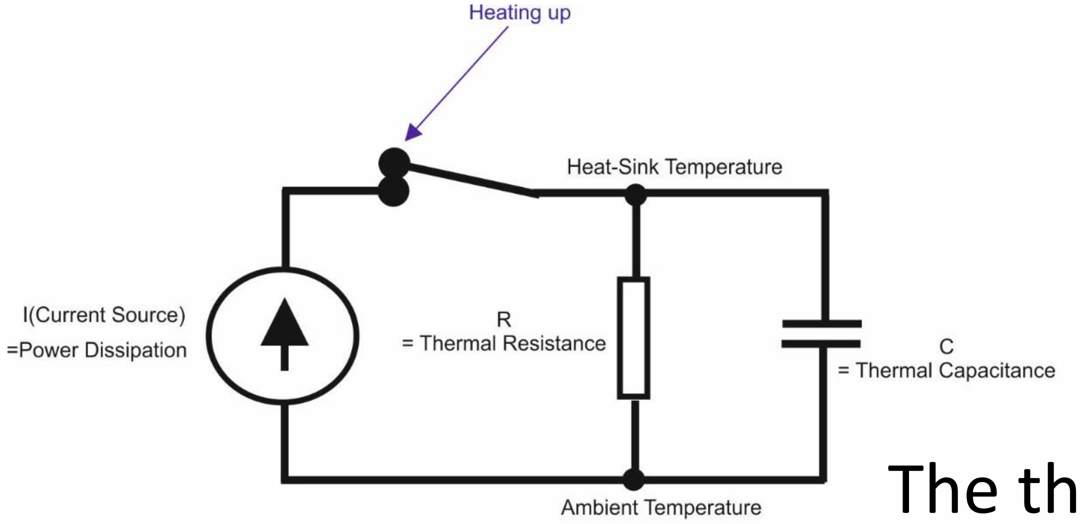
GTWI, Heat Expelling

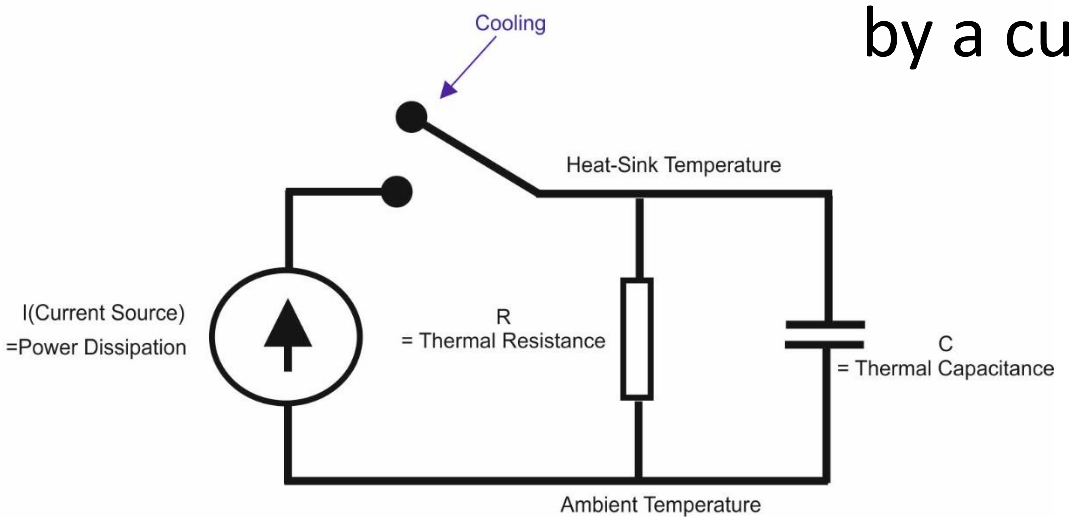
Heat-sink	Thermal Resistance °C/W	Thermal Time Constant τ Seconds
No External	22	180
FLAT	13	220
FINs	9	360

How this data can be used?

GTWI, Heat Expelling

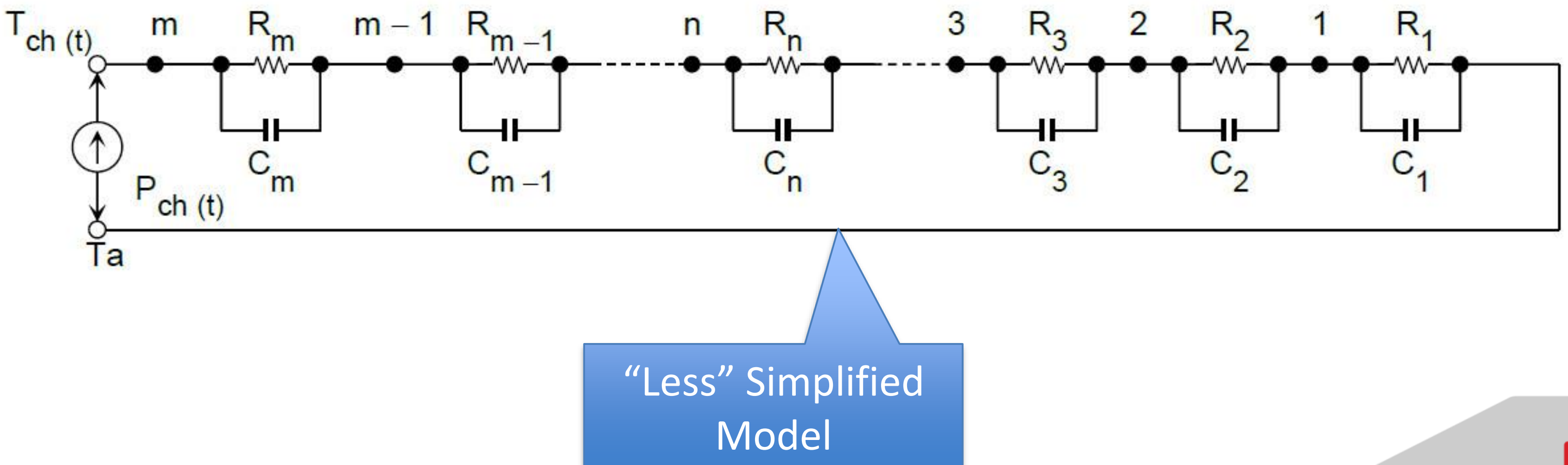


The thermal model is equivalent to charging RC by a current source



GTWI, Heat Expelling

The "real" model is much more complicated,
But, for the G-TWI this simple model is very accurate as all the rest of network is negligible.
This is due to the advance thermal design that eliminates all the unwanted thermal impedances and the parasitic effects.



GTWI, Heat Expelling

As a rule of thumb each Heat-sink can dissipate:

Heat-sink	Heat Dissipation Capability	
No External	1W- 1.5W	Net Power Losses Excluding control dissipation
FLAT	4W -5W	
FINs	6W-7W	

Isn’t it too little for a drive that can output 5KW?

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GTWI, Heat Expelling, No External Heat-Sink

What can we run with only “1W -1.5W” power dissipation?

Heat-sink	Continuous Output Current	Bus Voltage	
GTWI 60V	6A – 7A	24VDC	
GTWI 60V	3.5A – 4.5A	48VDC	
GTWI 100	2.5A- 3A	85VDC	
GTWI 200	0.7A -0.8A	170VDC	

This covers motors rated for 100W – 130W

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GTWI, Heat Expelling, No External Heat-Sink

What can we run with only “1W -1.5W” power dissipation?

NO Heat-sink	Pulsed Current	Bus Voltage	
GTWI 60V	15A	24VDC	50% Duty Pulse duration<50 Sec
GTWI 60V	10A	48VDC	
GTWI 100	6A	85VDC	
GTWI 200	1.2A	170VDC	

This covers motors rated peak for 300W- 400W

GTWI, Heat Expelling, FLAT Heat-Sink

Heat-sink	Continuous Output Current	Bus Voltage	
GTWI 60V	20A	24VDC	
GTWI 60V	12A	48VDC	
GTWI 100	7A	85VDC	
GTWI 200	2.5A	170VDC	

This covers motors rated for 300W – 400W

GTWI, Heat Expelling, FLAT Heat-Sink

NO Heat-sink	Pulsed Current	Bus Voltage	
GTWI 60V	40A	24VDC	50% Duty Pulse duration<50 Sec
GTWI 60V	25A	48VDC	
GTWI 100	15A	85VDC	
GTWI 200	5A	170VDC	

This covers motors rated peak for 600W- 900W

GTWI, Heat Expelling, FINs Heat-Sink

Heat-sink	Continuous Output Current	Bus Voltage	
GTWI 60V	25A	24VDC	
GTWI 60V	20A	48VDC	
GTWI 100	12A	85VDC	
GTWI 200	5A	170VDC	

This covers motors rated for 400W – 500W

GTWI, Heat Expelling, FINs Heat-Sink

NO Heat-sink	Pulsed Current	Bus Voltage	
GTWI 60V	50A	24VDC	50% Duty Pulse duration<50 Sec
GTWI 60V	40A	48VDC	
GTWI 100	25A	85VDC	
GTWI 200	9A	170VDC	

This covers motors rated peak for 700W- 1500W

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GTWI, Max current

At what conditions the max current can be achieved with those Heat-Sinks

NO Heat-sink	Pulsed Current	Bus Voltage	No External Duty Cycle	FLAT Duty Cycle	FINs Duty Cycle
GTWI 60V	60A	24VDC	9%	25%	33%
GTWI 60V	60A	48VDC	5%	15%	25%
GTWI 100	50A	85VDC	3%	10%	15%
GTWI 200	20A	170VDC	3%	9%	12%

Any limitations on the Duty Cycle ON period? OFF period?

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GTWI, Max current

The “efficient” thermal design & the “smart” structure allow very long high current pulses duration.

Max. Current pulses duration can last as long as “tens” of seconds with “NO Heat- Sink”, and even hundreds seconds with the FLAT or the FINs heat-Sink.

What will happen if the duty cycle will be higher than the recommended? What is the risk?

GTWI, Thermal Runaway

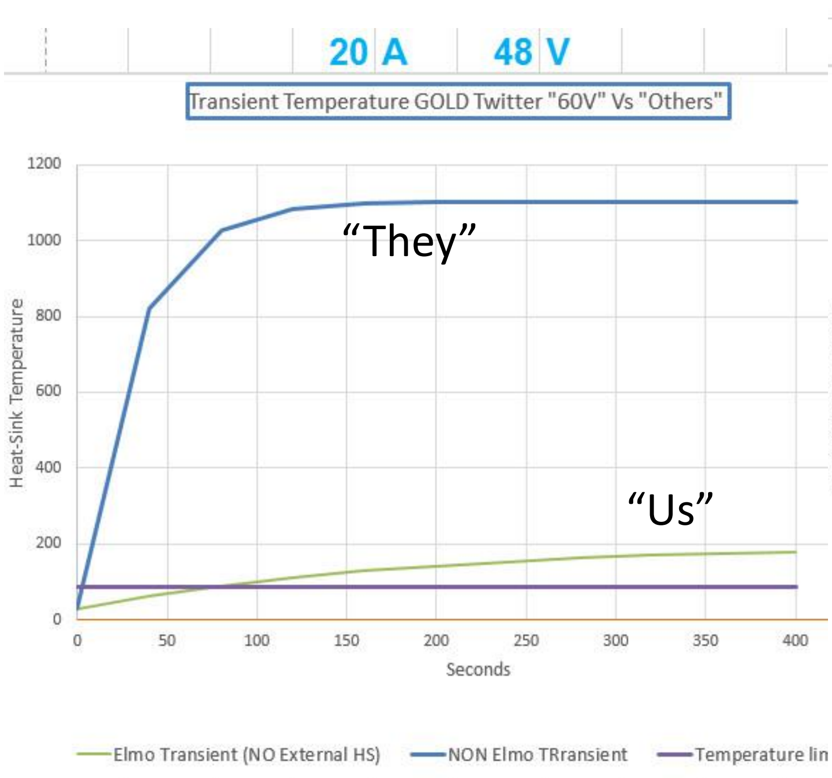
The risk is “thermal runaway”.
The huge amount of delivered power creates a peak of heat dissipation that in a very small and light package will results a very sharp, fast and non-homogeneous temperature rise within the drive.

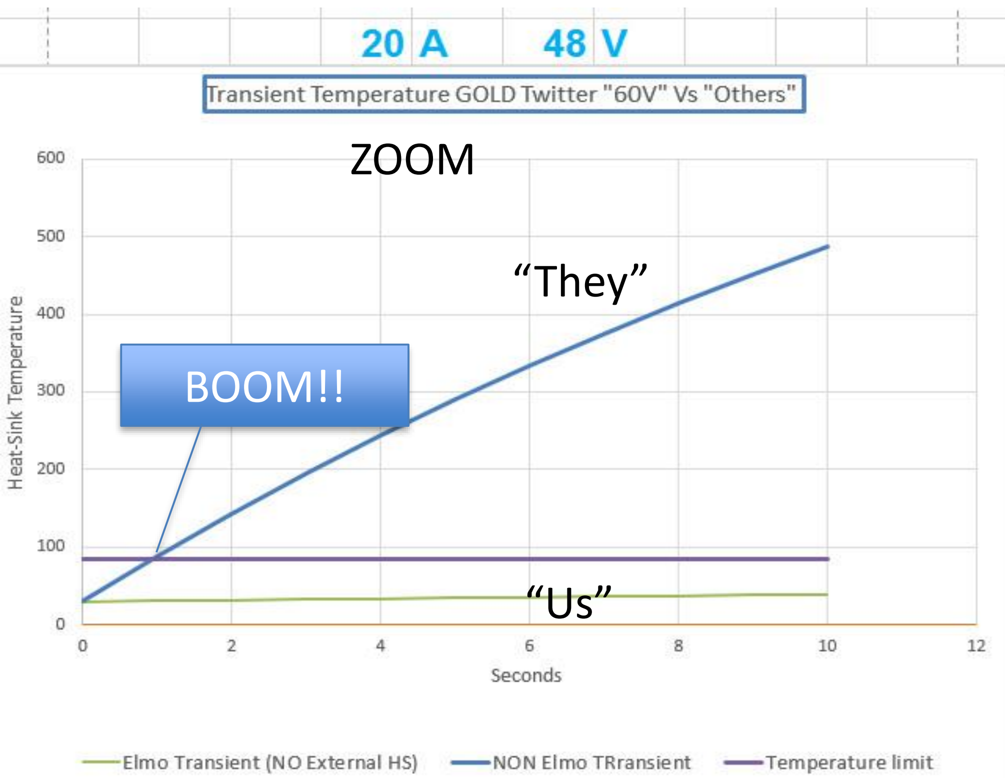
This might destroy power devices.
Reducing the runaway risk is usually done by increasing the size, reducing the current rating, shorting the Ipeak, “softening” (slowing done) the peak power capabilities.

No “Thermal Runaway” Risk with Elmo Drives!

Thermal “Runaway”

What is it?





At similar conditions of output power, Bus Voltage, current, size of drives’ heat sink, at “Others” the Junction temperature of the FET will probably rise very fast and will exceed the limits in less than a second

Thermal "Runaway"

The rate of the temperature rise of the FET's Junction depends on:

- The power dissipation of the FET.
- The FET's Junction to heat-sink thermal resistance.
- The FET's Junction to heat-sink thermal transient response

In all those 3 parameters the G-TWI is better by 3 -7 times than the "others'"

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GTWI, Max current Vs Duty Cycle

The G-TWI overcomes "Thermal Runaway" risks by the very "tight" thermal structure that together with the "real time" and accurate sensing managed by the smart control eliminates the "Thermal Runaway" risks.

With Elmo Drives, even if the actual duty cycle limit is exceeded the "tight" thermal design that prevents thermal runaway and the very long thermal time constant allow reliable operation at any condition.

In extreme cases the "over temperature" protection will be activated, **that's all!**

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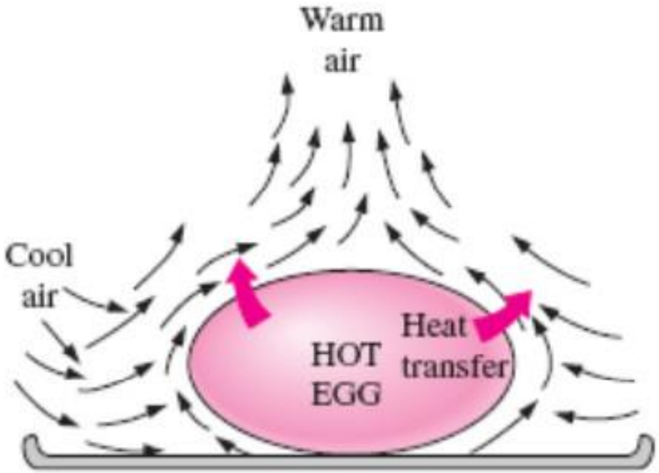
Natural Air Convection

To guarantee the performance of heat dissipation of the Heat-sinks there must be "Natural Air Convection"

What is it?

Natural Convection cooling is done under conditions that there is no forces air flow or any other means, but only by free air movement.

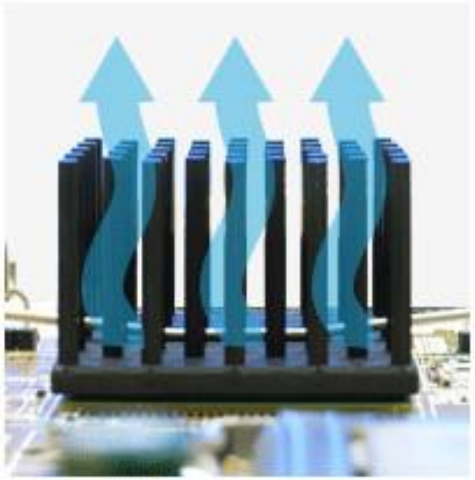


Natural Air Convection

The higher temperature air is less dense than the surrounding air and thus rises up out of the heat sink. This movement will generate a small amount of airflow within the heat sink, cooling the heat sink.

The free air movement must be guaranteed to allow the hot stream “get out” of the drive’s environment.

If the air is “locked” in the surrounding the temperature will keep on increasing till a thermal shut down will be activated.



GTWI, Thermal Verification Tests

The thermal data was verified by thousands of hours of intensive testing, at any scenario, at extreme load conditions, at extreme environmental conditions.
Measurements were done at numerous points “around” the GTWI, at room temperature, at maximum operating temperature (+50C), and at -30C, At “still air”, at natural convection, at Fanned air”, etc….